METROPOLITAN WATER AND SEWERAGE BOARD

THIRD ANNUAL REPORT

JANUARY 1, 1904

COMPLIMENTS OF . . .

METROPOLITAN WATER AND SEWERAGE BOARD.

HENRY H. SPRAGUE, CHAIRMAN.
HENRY P. WALCOTT.
JAMES A. BAILEY, JR.

1 ASHBURTON PLACE,

BOSTON.

WILLIAM N. DAVENPORT, Secretary.

DARK HOLLOW POND, ADJOINING SPOT POND, SHOWING LANDSCAPE TREATMENT.

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OF THE

METROPOLITAN WATER AND SEWERAGE BOARD.

JANUARY 1, 1904.

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Metropolitan Water and Sewerage Board.

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The Metropolitan Water and Sewerage Board, established under the provisions of chapter 168 of the Acts of the year 1901, has already presented to your Honorable Body an abstract of the account of its doings, receipts, expenditures, disbursements, assets and liabilities for the calendar year ending December 31, 1903, and now presents a detailed statement of the operations for the year, being its

THIRD ANNUAL REPORT

made since the consolidation of the Metropolitan Water Board and the Board of Metropolitan Sewerage Commissioners on March 20, 1901.

I. ORGANIZATION AND ADMINISTRATION.

(1) Board, Officers and Employés.

The membership of the Board has continued as last year, namely: Henry H. Sprague, chairman, Henry P. Walcott, M.D., and James A. Bailey, Jr. William N. Davenport has continued as secretary and executive officer of the Board, and Alfred F. Bridgman as auditor and purchasing agent.

The administrative office force has comprised a book-keeper, an assistant book-keeper, an assistant in auditing, a paymaster, a supply clerk, three general clerks, four stenographers, a telephone operator, two messengers, a janitor and a watchman.

The work of conveyancing has continued in charge of Alfred C. Vinton, conveyancer, and George D. Bigelow, assistant conveyancer, who have been assisted by Miss Alline E. Marcy, title examiner, by one stenographer, and by Miss Celia M. Tibbetts, who is employed a part of the time for service at the Worcester Registry of Deeds.

Frederic P. Stearns has continued as chief engineer of the Board, with special charge of the Water Works. Joseph P. Davis and

Hiram F. Mills are retained to act as consulting engineers when their services are required; Alphonse Fteley, who had been employed as consulting engineer of the Water Works from the organization of the Metropolitan Water Board, and who had had a large previous experience in the construction of the Boston Water Works, deceased during the year.

The various departments of the Water Works are, subject to the Chief Engineer, in charge of the following: Dexter Brackett, engineer of the Distribution Department; Thomas F. Richardson, engineer of the Dam and Aqueduct Department; Horace Ropes, engineer of the Weston Aqueduct Department; Charles E. Wells, engineer of the Reservoir Department; Frank T. Daniels, principal office assistant. Hiram A. Miller occupied the position of engineer of the Reservoir Department until his resignation on September 20, 1903.

The engineering force employed on the Water Works, in construction and maintenance, has, upon the average during the year, comprised, in addition, 14 division engineers, 18 assistant engineers, and others in various engineering capacities and as sanitary inspectors, clerks, stenographers and messengers, to the number of 146, — in all, 178. The maximum engineering force employed at any one time during the year on construction and maintenance was 197.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 19. Day-labor forces under the general supervision of the engineers and the immediate direction of foremen, varying in numbers from time to time, have been employed in pipe laying, in general improvements and repairs and in the performance of minor operations.

In addition, a regular maintenance force, numbering, upon the average during the year, 193, has been required at the pumping stations and upon the reservoirs, aqueducts, pipe lines and other works. This force at the end of the year numbered 157, and was distributed among the various departments as follows: Distribution Department, 100; Dam and Aqueduct Department, 15; Sudbury Department, 41; Reservoir Department, 1.

The maximum number of men employed upon contracts by the various contractors upon the Water Works during the year was for the week ending June 6, when the number amounted to 3,067.

William M. Brown, engineer of the Sewerage Works, has been in charge of both construction and maintenance upon these works.

He has been assisted during the larger part of the year by 6 division engineers, who have been in charge of the various sections of sewer construction, 11 assistant engineers, and 40 others, who have been employed in various engineering capacities, and as clerk, stenographer and messenger in the department. The maximum engineering force employed at any one time during the year on construction and maintenance of the Sewerage Works was 57. On account of the completion of several of the contracts for the High-level Sewer, the force has been reduced to 37.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 17. Day-labor forces, under the general supervision of the engineers and the immediate direction of foremen, have been employed in the construction of the tunnel forming a part of Section 73 in Jamaica Plain; on parts of Section 70 in the crossings of Washington Street and Roslindale Branch Brook in West Roxbury, all for the High-level Sewer; on Section 61 and parts of Section 62 of the Revere Extension in Chelsea, and in other minor work.

The regular maintenance force required for the pumping stations, sewers and other parts of the Sewerage Works, exclusive of engineers and day-labor construction forces before enumerated, has upon the average numbered 90. This force at the end of the year numbered 84, and was distributed between the two systems as follows: North Metropolitan System, 73; South Metropolitan System, 11.

The maximum number of men employed upon contracts by the various contractors and upon day-labor construction upon the Sewerage Works during the year was for the week ending October 31, when the number amounted to 853.

(2) Offices and Buildings.

The office of the Metropolitan Water and Sewerage Board is in the buildings numbered 1 and 3 Ashburton Place, at the corner of Somerset Street, in which are also located the offices of the secretary, the auditor and the conveyancers, and the main engineering offices of both the Water Works and the Sewerage Works. The engineering department of the Sewerage Works had occupied rooms in the Pemberton Building in Pemberton Square, but in the month of December these rooms were relinquished, and the department was removed to Ashburton Place.

The headquarters of the Wachusett Reservoir and Wachusett Dam and Aqueduct departments of the Water Works have been maintained in the office building in Clinton. Branch offices of the Reservoir Department have been maintained, two in West Boylston and one in Oakdale; the office at the North Dike in Clinton was discontinued June 30, and the office at Sawyer's Mills in Boylston has also been discontinued. A branch office of the Dam and Aqueduct Department has been maintained at the Dam. The main office of the Weston Aqueduct Department has remained in Saxonville, and branch offices have been located in Framingham Centre, Wayland and Weston. Headquarters of the Distribution Department have been maintained in the central office in Boston. For the Sudbury Department an office has been maintained at South Framingham. The headquarters of the maintenance force of the Water Works in the northern part of the District have been in buildings in the Glenwood Pipe Yard in Medford, where there are offices, shops, store rooms and stables. The maintenance force for the southern part of the District has its headquarters in buildings at the Chestnut Hill Reservoir.

There are also maintained, in connection with the Water Works, the Chestnut Hill high-service and low-service pumping stations; the Spot Pond, Arlington and West Roxbury pumping stations; the Clinton sewerage pumping station at Clinton; the Pegan Brook pumping station at Natick; the Mystic pumping station at Medford, not now operated; as well as the gate-houses at the several reservoirs, dwellings for attendants, and various other buildings for operating purposes.

There have been maintained, in connection with the construction of the Sewerage Works, branch engineering offices at Hough's Neck, Jamaica Plain and Roxbury, and for a portion of the year at East Milton, Hyde Park and Chelsea. In addition to the above, fifteen portable booths have been in use along the line of the work. For the operation of the works there have been maintained the Deer Island, East Boston, Charlestown, Alewife Brook and Quincy pumping stations.

(3) Conveyancing.

A considerable portion of the work of the conveyancers of the Board during the past year has been devoted, under the settlement of the claims for damages to real estate, to examining the records and bringing up to date the titles at the registry of deeds, and the preparation and drafting of deeds and other necessary instruments. Many of the settlements were on account of claims for lands taken or affected by the construction of the Weston Aqueduct, and the relocation of the Central Massachusetts Railroad. Others were for later settlements for lands taken for the Wachusett Reservoir, and a large number were in settlement of claims for depreciation of lands in Sterling and West Boylston.

Settlement has been effected in 127 cases, for which titles were completed and the necessary papers drafted. Of these settlements, 109 were made on account of the Water Works and 18 on account of the Sewerage Works. The 109 cases on account of the Water Works affected 1,317.124 acres, and the 18 cases on account of the Sewerage Works affected 41.272 acres. Of the cases which were considered, 22 cases were pending January 1, 1904.

A larger amount of work than in previous years has been required for the preparation of reports on land titles, and on other information for the purposes of the Attorney-General's office, to be used in cases pending in court. This is in addition to a large amount of special work which has been required in regard to the titles of lands about Spot Pond, formerly belonging to the cities of Malden, Medford and Melrose.

There have been drafted 9 instruments of takings of lands and rights in lands, 6 for the Water Works and 3 for the Sewerage Works. Of these takings, 2 were of easements for the construction of pipe lines, 4 of lands for the Wachusett Reservoir, 1 for the High-level Sewer and 2 for the North Metropolitan System, one being for the Revere Extension and one for the Belmont Extension.

There have also been drafted 1 road location, being a location of 2 roads to be connected, and 10 discontinuances of roads, and 1 discontinuance of a part of the location of the Central Massachusetts Railroad.

A detailed statement of the various takings and settlements is given hereafter.

II. WATER WORKS — CONSTRUCTION.

(1) Wachusett Dam and Reservoir.

(a) *Wachusett Dam.*

The construction of the Wachusett Dam has been carried on through the year. Excavation both of earth and rock has been made so as to extend the masonry structure into the banks at each end. The main dam, which had reached at the beginning of the year a height of about 96 feet above the bed rock, or elevation of 304 feet above the Boston City Base, has been raised to an average of 137 feet above bed rock, or elevation of 345 feet, about 41 feet of masonry having been added during the past year. The length of the masonry dam at its present height is about 739 feet. The work of the past year has required the excavation of 68,800 cubic yards of earth and 18,800 cubic yards of rock, and stone masonry has been laid to an extent of 71,571 cubic yards.

A considerable amount of the earth and rock excavated has been deposited directly above and below the dam. All of the stone for the dam up to the level of the earth as deposited has been taken from the quarry upon land of the Commonwealth near the dam, and above this level all but the ashlar masonry required for the up-stream and down-stream faces has also been taken from this quarry. For stone of suitable shape and proper quality for the ashlar masonry above the height to which the earth has been deposited, resort has been had to a quarry at West Chelmsford, Mass.

The temporary dam has been done away with, and the water of the river is carried through the pipes in the dam into the completed substructure of the gate-house, whence it is drawn into the aqueduct, or is allowed to escape down the river. All water not drawn out through the pipes will be stored in the reservoir, and it is anticipated that during the coming spring a large amount of water will be so stored in the reservoir for use during the coming drier season.

The pool below the dam, into which the waste water is to be brought from the gate-chamber, has been nearly completed.

A large amount of excavation has been done for the preparation of the waste channel or spillway at the western end of the dam, through which the water may be wasted in case there is an overflow from the reservoir, after the completion of the dam.

WACHUSETT DAM AT END OF 1903—RAILROAD CUT AT RIGHT.

The dam of the Lancaster Mills, which was removed before the beginning of excavations for the Wachusett Dam, in order to draw off the water of the mill-pond, has been rebuilt during the past year.

(*b*) *Wachusett Reservoir.*

The stripping of the soil from the bed of the Wachusett Reservoir has been continued during the past year. The work of removal has been carried on somewhat in Boylston, but largely in West Boylston. A total of 809,485 cubic yards of soil was removed during the year from 405.4 acres. It is estimated that 82 per cent. of the total amount of the soil has been removed, and that 3,236.4 acres of the total 4,200 acres to be stripped have been stripped.

While the larger part of the material removed has been deposited at the North Dike, as formerly, considerable portions have been taken for the building of road embankments and for shallow flowage.

Considerable work has been done in the building of slope paving or riprap for the protection of the water side of the North Dike.

The contract was made late in December for the construction of the South Dike, about half a mile south of the Wachusett Dam, in order to prevent the overflow of water through a depression of the land into the watershed of the Assabet River. This dike, which is much smaller than the North Dike, has a length of about half a mile. For a considerable portion of its length there is a ridge containing rock, the top of which will be but a short distance below the surface of the reservoir when full. At the lowest point the ground falls to a level of about 30 feet below the water surface of the reservoir when filled. The dike is to be constructed of earth and soil excavated from the reservoir, and it will be built with a cut-off trench in a manner similar to the construction of the North Dike. It is provided by the contract that the dike shall be completed during the coming year.

During the past year 34 dwelling houses, 7 barns, 2 shops, 1 store, 3 schoolhouses, 1 hotel and store combined, 1 business block, 1 depot, — a total of 50 buildings in West Boylston, — have been torn down or removed, making a total of 259 destroyed or removed since the beginning of the work in that town.

A considerable number of houses have been left standing in the reservoir site, and have been occupied by employés of the Board and contractors engaged upon the work.

The raising of seedlings, principally pine and maple, and the planting of them about the margins of the reservoir, have been continued. The pines have also been planted at short intervals along the sides of the public roads which have been built by the Board through the lands of the Commonwealth. New cart roads have been constructed and old ones have been repaired, and large numbers of undesirable trees have been cut out.

Levels of the ground in the portions of the reservoir which have been completed have been obtained for about 2,070 acres. Measurements are taken for the purpose of determining the capacity of the reservoir at different levels, so that a ready determination can be made of the amount of water in storage at all periods.

(c) *Location, Construction and Discontinuance of Roads.*

A large amount of work has been done during the past year in the building of roads at the upper end of the reservoir, to take the place of those within the basin which have been discontinued. The building of a highway across the reservoir at West Boylston has been vigorously prosecuted, and a considerable portion of the new channel which is made for the Nashua River at the crossing of the highway has been excavated and a great amount of soil has been deposited in the embankment upon which the road is to be built.

A determination has been made for the relocation of the highway on the northerly side of the reservoir from West Boylston village to Oakdale and through the village of Oakdale, for a road on the southerly side of the reservoir from Newton Street to Crescent Street, and for the widening of Crescent Street to the new West Boylston village, in all a distance of 3.2 miles. In the construction of the highway a three-arch stone bridge has been built over the Quinepoxet River and a single-arch bridge over the Stillwater River. and two steel highway bridges across the railroads have been built.

During the year the following-named streets have been discontinued in whole or in part: —

In West Boylston, all of Beaman Street, Union Street and Cross Street; East Main Street between Beaman Street and Clarendon Street; all of Clarendon Street; Prospect Street between East Main Street and the southwesterly line of the Boston & Maine Railroad, Worcester, Nashua & Portland Division; Newton Street between Holden Street and land of P. Arvid Lundgren; Holbrook Street between North Main Street and Prospect Street; all of the short town way connecting Holbrook Street and North Main Street; Worcester Street between Prospect Street and the southwesterly line of said railroad; all of Highland Street; North Main Street in Oakdale between the new highway and Pleasant Street, and North Main Street between East Main Street and said connecting town way; Central Street, between Holbrook Street and the southwesterly line of said railroad; all of Howe Street and Fletcher Street, not within the new highway; all of Thomas, Pierson, Wheeler and Grove streets south of the new highway; and all of Liberty Street;

In West Berlin, a small part of the road leading from Berlin to Boylston, crossed by the new location of the Central Massachusetts Railroad;

In Clinton, a small part of South Meadow Road between the new highways.

The total length of the roads discontinued during the year was about 3.7 miles.

There has also been discontinued a portion of the Central Massachusetts Railroad, extending from a point in the easterly part of Boylston to the intersection of the railroad with the Worcester, Nashua & Rochester Railroad in Oakdale.

The following is a list of roads which have been relocated or altered, with dates of the determinations made, since the beginning of the year: —

Location of Roads.

No.	Location.	Description.	Date of Acceptance.
12	West Boylston,	Two roads to be connected and widening of Crescent Street. (1) One running from the westerly end of the new highway in the centre of the old village, northwesterly, nearly parallel with North Main Street, to Oakdale, crossing Pleasant Street, Stillwater River and the Boston & Maine Railroad, and then southwesterly, crossing North Main, Pierson, Thomas, Lawrence and Wheeler streets, to a point about 125 feet westerly from Wheeler Street. (2) The other running from land late of Samuel Bullard, southeasterly, through both sides of and crossing Newton Street and into Crescent Street, to land of Mary J. Warner. (3) Widening of Crescent Street on both sides from end of second way above described to Central Street.	May 26, 1903.

During the year 1903, 8 roads and parts of 15 roads have been discontinued on account of the work of construction of the Wachusett Reservoir, as follows: —

No.	Location.	Description.	Date of Discontinuance.
13	West Boylston Village.	(1) All of Beaman Street. (2) All of Union Street. (3) All of Cross Street. (4) That small part of East Main Street which lies between Beaman Street and Clarendon Street. (5) All of Clarendon Street. (6) The northerly part of Prospect Street, extending southwesterly from East Main Street to the new highway.	March 25, 1903.
14	West Boylston.	The northerly part of Newton Street, extending southeasterly from Holden Street to land of P. Arvid Lundgren, at the beginning of the widening of Newton Street.	April 9, 1903.
15	West Boylston Village.	(1) The northerly part of Holbrook Street, extending southwesterly from North Main Street to land late of Addie H. Rice, near Central Street. (2) All of the short town way extending southerly from North Main Street to Holbrook Street.	May 15, 1903.
16	West Boylston Village.	(1) The northeasterly part of Worcester Street, extending southerly from Prospect Street, above described, across and to the southwesterly line of the location of the Boston & Maine Railroad, Worcester, Nashua & Portland Division. (2) All of Highland Street. (3) The southeasterly part of Holbrook Street, extending southeasterly from Prospect Street to Worcester Street, above described (except that part within the limits of the new highway). (4) That small part of Prospect Street which extends southwesterly from the new highway across and to the southwesterly line of said railroad location.	May 22, 1903.
17	West Boylston, Oakdale Village.	That part of North Main Street which extends southeasterly from the new highway to Pleasant Street.	June 8, 1903.
18	West Boylston and Boylston.	All that part of the Central Massachusetts Division of the Boston & Maine Railroad between a point in Oakdale near its intersection with the Worcester, Nashua & Portland Division of the Boston & Maine Railroad and a point in Boylston about 1,000 feet westerly from the new highway from Clinton to West Boylston.	June 16, 1903.
19	Berlin, West Berlin Village.	That small part of the public way from Berlin to Boylston extending northwesterly from the southwesterly line of the new highway built in place of this discontinued portion over the new location of the railroad to the southeasterly line of said highway.	July 7, 1903.
20	West Boylston Village.	(1) That part of Holbrook Street extending southeasterly from the part thereof above discontinued to that part of Prospect Street last above described. (2) The northerly part of Central Street, extending southerly from Holbrook Street across and to the southwesterly line of the location of the Boston & Maine Railroad, Worcester, Nashua & Portland Division.	Aug. 1, 1903.
21	West Boylston Village.	(1) The residue of East Main Street, extending northwesterly from the part thereof above discontinued, between Beaman and Clarendon streets, to North Main Street (except those portions thereof which lie within the location of the new highways). (2) All of Howe Street not lying within the location of the new highway. (3) All of Fletcher Street not lying within the limits of the new highway. (4) The southeasterly part of North Main Street, being that small part between East Main Street and the short town way to Holbrook Street, above described.	Aug. 27, 1903.
22	West Boylston, Oakdale.	(1) The southerly end of Pierson Street, being the small part thereof between the new highway and Thomas Street. (2) The easterly part of Thomas Street, extending westerly from that part of North Main Street, above described, to the new highway. (3) The southerly part of Wheeler Street, extending southerly from the new highway to Grove Street (4) All of Liberty Street (5) All of Grove Street not within the limits of the new highway.	Oct. 6, 1903.
23	Clinton.	That small part of South Meadow Road which extends northerly from the new highway to West Boylston, across the new location of the Boston & Maine Railroad, to another new highway, built in place of this discontinued portion.	Nov. 11, 1903.

(*d*) *Relocation of the Central Massachusetts Railroad.*

The relocation of the Central Massachusetts Railroad was substantially completed in the past summer, and the running of trains upon the portion of the railroad relocated through Clinton and on the northerly side of the reservoir was begun on June 15. The length of the relocation is 8.87 miles, being but about one-third of a mile longer than the old location which has been superseded. By arrangement with the Boston & Maine Railroad, the Board constructed the new road from West Berlin, at a point near the crossing of the Central Massachusetts Railroad over the New York, New Haven & Hartford Railroad, to a junction with the Worcester, Nashua & Rochester Railroad in Clinton, a distance of nearly 4 miles, as well as the branch line toward the Clinton railroad station, for a distance of about three-quarters of a mile. This work was of unusual difficulty, involving the excavation of a tunnel of about 1,080 feet in length; the construction of a steel viaduct across the valley of the river below the dam, 921 feet in length, and having a height above the valley of 133 feet; and the excavation of a rock cut of a maximum depth of 56 feet through the ledge at the westerly end of the dam.

The Board was also required to relocate the tracks of both the Worcester, Nashua & Rochester Railroad and the Central Massachusetts Railroad in Oakdale, and to carry the highways, by the building of high embankments and steel bridges, over the railroads.

In the relocating of the railroads, all grade crossings have been abolished.

The old track of the Central Massachusetts Railroad has been surrendered to the Commonwealth, and such progress has been made in the interchange of lands and completing of the arrangements required, as promises a settlement early in the coming year.

The relocation of the railroad has required thus far the expenditure of $681,017.02.

(*e*) *Clinton Catholic Cemetery.*

Although all of the bodies have been transferred from the St. John's Catholic Cemetery in Clinton to the new cemetery in Lancaster, and the soil has been entirely removed, in accordance with the tripartite agreement between the Board, the Roman Catholic Bishop of Springfield and the St. John's Catholic Cemetery Association, no final settlement has been made with these parties. There is a considerable balance due from the Commonwealth, and the Board has stood ready to pay over this balance, in accordance with the agreement, and to convey the lands of the new cemetery, to which it has held the title, to the St. John's Catholic Cemetery Association, as provided in the agreement, upon the conveyance to the Commonwealth of the old cemetery lot and a release of all claims and damages. No action, however, has been taken by either of the other parties during the past year, in order to effect the final settlement.

(2) Improvement of Lake Cochituate.

The improvement of Lake Cochituate, in accordance with the requirements of chapter 509 of the Acts of the year 1901, by which the Snake Brook and Pegan Brook meadows were excavated to the depth of about 10 feet below high water, was substantially completed in the year 1902. The grading of the tops of the embankments and the dressing of the slopes of the Pegan Brook Meadow were completed early in the present year.

The total cost of the improvement was $103,537.29.

The Board deemed it wise in connection with this improvement to substitute for the old pumping plant in use at Pegan Brook a new pumping station. This has been erected at a cost of $4,390.53. More efficient machinery was also installed. By the construction of the intercepting ditch around the north side of the meadow and of the receiving reservoir near the mouth of Pegan Brook, which were accomplished the preceding year, and the installation of the new machinery, the polluted water from the ditch and the brook is now satisfactorily collected and pumped into the existing filter-beds. The expenditures for the purpose were deemed chargeable to maintenance rather than to additional construction.

(3) Weston Aqueduct and Reservoir.

The Weston Aqueduct and the Weston Reservoir were so far completed during the present year that the mains were opened and water was delivered into the Metropolitan Water District on December 29. Though the aqueduct is for all practical purposes completed, considerable remains to be done during the coming season in the way of finishing the embankments of the aqueduct and the margins of the reservoir.

WESTON AQUEDUCT—TERMINAL CHAMBER IN WESTON, OPPOSITE NORUMBEGA PARK.

The work of construction was begun on May 22, 1901, and has been constantly urged, in order to relieve the District from the over-crowding and insufficiency of the Cochituate and Sudbury aqueducts. Notwithstanding the many difficulties which were encountered through unexpected physical features of the work, and the unfortunate industrial situation by which it was impossible at times to secure the proper number and quality of employés, the work was practically finished with a delay of only about four months beyond the time set for its completion.

The entire length of the aqueduct is 13.44 miles, of which 2.30 miles are in tunnel, 9.14 miles are in masonry aqueduct, 1.02 miles are in open channel and reservoir, and 0.98 of a mile is in steel and cast-iron siphon pipes. The aqueduct in tunnel masonry and open channel has a daily capacity of 300,000,000 gallons.

The Weston Reservoir, which is built near the end of the aqueduct as an equalizing reservoir, has an area of 66.6 acres, and will have a capacity exceeding 200,000,000 gallons.

The crossing of the valley of the Sudbury River and Happy Hollow, so-called, in Wayland, required the laying of steel siphon pipes 7½ feet in diameter. Three lines of these pipes will ultimately be required, though at present only one has been laid.

The purposes of the aqueduct have required the construction of head and meter, screen, gaging, siphon and terminal chambers, which have required the building of 11 substantial structures. The buildings are all of stone, with tile roofs.

The cost of the aqueduct, reservoir and the supply pipe lines connected, thus far has been $3,150,909.98.

Various lines of pipes will be laid from the terminal chamber, which is situated in the border of Weston, overlooking the Charles River, to the various portions of the District.

On account of the character of the region through which the aqueduct has been built, the land damages have been considerable, but the larger portion of these has been settled without suits.

Effort has been made so to carry on the construction as to avoid marring the surface of the country through which it has been carried. In the construction of the reservoir, the dam has been so built and the surface soil excavated has been so distributed under the direction of landscape architects that the reservoir will be an attractive feature of the town of Weston.

(4) Bear Hill Reservoir.

The Bear Hill Reservoir, which was built about half a mile west of Spot Pond, for the purpose of supplying water at high pressure to the town of Stoneham, was substantially completed and was put into operation the preceding year. There remained, however, to be built the superstructure for the gate-chamber, which has been erected during the past year, and some further improvements have been made. The entire cost of the reservoir, including the gate-chamber, was $38,155.80.

(5) Pipe Laying.

The principal work of pipe laying has been the completion of the supply pipe line running from the terminal chamber of the Weston Aqueduct to Chestnut Hill Reservoir. This, the first of the supply mains to be constructed in connection with the Weston Aqueduct, having a length of 7.4 miles, was completed and put into operation on December 29, 1903.

The second line of distribution pipes to connect the Chestnut Hill pumping station with Spot Pond, which had been nearly finished, was completed at the beginning of the year.

During the year 2.1 miles of distribution pipes have been laid, so that a total of 84.19 miles is now operated by the Board in connection with the distribution system.

Several additional pipe lines will be required from time to time to convey the water from the terminal chamber of the Weston Aqueduct into different portions of the District. In connection with the first line three 60-inch cast-iron pipes have been laid across the Charles River, for use in the future as they may be demanded.

(6) Venturi Meters.

The work of placing Venturi meters on the various connections supplying water to the District, so that the amount of water supplied to each municipality may be measured, was carried on by the Distribution Department. This work is more particularly described under Maintenance, and in the special report upon Water Consumption and Waste, which is published in the Appendix.

(7) Improvement of Spot Pond Brook.

The Board, in accordance with a resolve of the General Court, submitted to the Legislature of 1902 a report containing the results of its investigations concerning the condition of Spot Pond Brook in Stoneham, Melrose and Malden, together with its recommendations for the improvement of the brook and for remedying the troubles which existed by reason of the occasional overflows of the waters of the brook. The Board believed that the existing troubles could not be remedied by any partial or temporary works, but that a more extensive scheme was required for the general improvement of the district affected. It was estimated that the cost of the improvement would be about $275,000. On account of the large expense which attended the carrying out of the scheme, the Legislature, at its session in the year 1903, requested the Board, in conjunction with the cities of Malden and Melrose, to re-examine the subject, and to report to the next General Court what modifications, if any, could be made in the plans previously submitted, with a view to lessening the expense of the improvement, and what limitations should be made as to the amount of the expense to be assessed upon the cities of Malden and Melrose.

The Board again examined the subject, but its engineers were unable to offer any substantial modifications of the plan, nor were any suggested by the representatives of the two cities.

No satisfactory agreement could be reached limiting the amount of the assessments to be imposed for the improvement upon the cities of Malden and Melrose, and the Board renewed its recommendation that the apportionment of the expense of the improvement, if entered upon, should be made by some legal tribunal or commission appointed by the court.

The Board by request submitted a bill for the purpose of carrying out the recommendations contained in its report. The following is the report prepared by the Board: —

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The Metropolitan Water and Sewerage Board was requested, by chapter 105 of the Resolves of the year 1903, to re-examine the subject of the condition of Spot Pond Brook, in conjunction with the cities of Malden and Melrose, and to report to the present General Court what modifications could be made, if any, in the plan submitted by the Board in the year 1903, with a view to lessening the expense of the improvement suggested, and what limitations might be made as to the amounts of the expense therefor which should be assessed on the cities of Malden and Melrose.

The Board caused a careful re-examination to be made by its engineers of the plan which had been submitted to the General Court, and likewise requested both cities to submit any modifications which they would be able to suggest in the plan for the improvement. The Board had likewise conferences with the official representatives of the two cities, at which, however, no changes in the proposed plan were offered for the consideration of the Board. The engineers of the Board were likewise unable to offer any substantial modifications of the plan, as the Board was of the belief that any such plan should not only provide for immediate necessities, but should also meet the demands which are sure to arise in the near future, and it could not advise the building of works which would have to be superseded in a comparatively short period.

The Board and the representatives of the two cities were also unable to agree upon any apportionment of the expense of the improvement by which certain fixed sums should be contributed by the cities, and the balance be paid by the Commonwealth. For the reasons given in its report, the Board is of the opinion that the troubles which are to be remedied have arisen, to a very large extent, from conditions existing in these cities, and have not to a great degree been occasioned by the operations of the Board. A proper determination, however, of the respective responsibilities and liabilities of the cities and the Commonwealth depends largely upon evidence and upon the solution of legal questions. The Board believes that such a satisfactory determination can be reached only by resort to some legal tribunal or commission appointed by the court; and such tribunal or commission should not only apportion the expenses of the improvement between the two cities and the Commonwealth, in accordance with their just responsibilities and liabilities, but should also determine what sums abutting owners receiving benefits beyond the general advantage should be called upon to pay in betterments.

The Board was requested by the authorities of the city of Melrose to submit with its report a bill which would in its opinion carry out the recommendation of the report last year submitted to the General Court. The Board, therefore, respectfully submits to your consideration the accompanying bill.

Respectfully submitted,

HENRY H. SPRAGUE,
HENRY P. WALCOTT,
JAMES A. BAILEY, JR.,
Metropolitan Water and Sewerage Board.

JANUARY 15, 1904.

(8) Police Protection.

Police protection has been afforded, in accordance with the requirements of the Metropolitan Water Act, in places where active construction has been carried on. The police officers have been appointed by the various towns in which their services have been required, and they have been subject to the town authorities in the performance of their duties, but they have been paid for their services by the Board.

For the Wachusett Reservoir district there have been employed 13 officers (reduced to 8 in July) in the town of Clinton, 4 officers (reduced to 3 in May and further reduced to 2 in September) in the town of Boylston, 1 of whom is mounted, 3 officers (increased to 5 in May and further increased to 6 in June) in the town of West Boylston, 1 of whom is mounted, and 1 mounted officer in Sterling. The special police officers appointed in the town of Clinton have also been appointed special officers in the town of Boylston. The Boylston officers have been appointed special officers in the towns of Clinton and West Boylston. The West Boylston officers have been made special officers in the town of Boylston. The Sterling officer has been made a special officer in the towns of Boylston and West Boylston.

Along the line of the Weston Aqueduct, 6 police officers have been employed in Framingham, 5 in Wayland and 5 in Weston. On November 20 the police service in Framingham and Wayland was discontinued, and in Weston the force was reduced to 2 officers.

In Newton 1 officer was paid by the Board during the work on the contract for pipe laying.

(9) Purchases and Takings of Land.

Few lands were acquired by the Board during the past year, as substantially all the lands which are required for the general purposes of construction have now been either purchased or taken.

There were several takings, however, in West Boylston, for the purpose of constructing and widening highways which are required in place of those formerly in the basin which have been discontinued, and some addition was made to lands for the reservoir in West Boylston. There were two takings for the purposes of pipe lines in Newton and Brookline.

The takings of real estate for the Metropolitan Water Works during the year have numbered 9, affecting an area of 94.481 acres; 90.81 acres were taken in fee and easements, and other rights were taken in 3.671 acres.

List of Takings for Metropolitan Water Works for the Year 1903.

No.	Location and Description.	Former Owners.	Recorded.	Purpose of Taking.
			1903.	
100	Newton (from Centre Street westerly through Colby Street and southwesterly through Blake Street and land of the heirs of George S. Dexter to the northeasterly line of Mill Street). Area, easements in 0.845 acre; temporary rights to occupy 2.25 acres.	Heirs of George S. Dexter and streets.	April 30.	Pipe line.
101	West Boylston and Boylston (depot lot at Oakdale and location of the Boston & Maine Railroad from Worcester, Nashua & Portland Division in Oakdale to about 1,000 feet west of the new highway in Boylston). Area, 65.77 acres in fee.	Boston & Maine Railroad.	June 15.	Wachusett Reservoir.
102	West Boylston (both sides of Pleasant Street and east of North Main Street). Area, 4 06 acres in fee.	Worcester County Truant School and the heirs of Charles M. Harris.	June 22.	Wachusett Reservoir.
103	Brookline (between Boylston Street and Dudley Street). Area, easements in 0.23 acre.	City of Boston.	July 18.	Pipe line.
104	West Boylston (widening Crescent Street on both sides between Central Street and land late of Samuel Bullard). Area, easements in 0 346 acre.	Mary J. Warner *et al.*	Sept. 2.	Wachusett Reservoir.
105	West Boylston (both sides of North Main Street north of Holden Street). Area, 20.98 acres in fee.	Heirs of Armilla E. Harris *et al.*	Oct. 5.	Wachusett Reservoir.

Settlement has been effected with the owners of all the lands taken or purchased by the Board for the Metropolitan Water Works since the beginning of operations, aside from the works of the cities of Malden, Medford and Melrose, except for 341.84 acres, and in nearly all cases affecting private lands purchases have preceded the takings. Of the lands taken for the Wachusett Aqueduct, the time for bringing suits for two parcels, containing 5.08 acres, has expired. Of the lands taken for the Wachusett Reservoir, the time for bringing suits for four parcels, containing 68.55 acres, has expired.

Settlements under purchases and takings of land, for all purposes of the Water Works, have been effected in the past year in 51 cases, and for an aggregate of 548.11 acres, with the buildings thereon. The sums paid in these settlements have amounted to $145,670.62. In only 15 of these cases have the settlements been results of suits at law, and the total amount paid in the court settlements has been $37,597.71.

Since the beginning of operations upon the Metropolitan Water Works, the number of settlements of this kind effected for the purposes of the Water Works has amounted to 771, and under them the Board has acquired rights, in fee or in easements, in 11,734.39 acres, or 18.33 square miles, for which an aggregate of $3,783,447.91 has been paid. Only 32 of these cases have been settled by suits at law, and the total amount paid under judgments of the court has been $94,001.33, or less than 3 per cent. of the whole.

These purchases and takings include lands taken in fee, with the buildings thereon, and water and other rights connected therewith, and lands in which easements and other rights are taken; but they do not include settlements for diversion of water, depreciation and other damages connected with lands not acquired, and in which no fee or easement has been taken.

Summary of Land Settlements for Water Works to December 31, 1903.

LOCATION.	For the Year 1903.			From Beginning of Work.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
*Wachusett Reservoir.**						
Clinton,	58.58	30	$107,625 37	1,280.21	398	$2,782,332 67 †
Boylston,	327.99			3,900.34		
West Boylston,	19.75			1,627.67		
Sterling,	7.64			702.55		
Lancaster,	–			69.97		
Holden,	–			167.00		
Berlin,	1.49			1.49		
Total,	415.45	30	$107,625 37	7,749.23	398	$2,782,332 67
Wachusett Aqueduct.						
Berlin,	–	–	–	46.51	64	$72,487 40
Boylston,	–			.38		
Northborough,	–			96.07		
Southborough,	–			82.31		
Marlborough,	–			51.08		
Clinton,	–			13.51		
Total,	–	–	–	289.86	64	$72,487 40
Sudbury Reservoir.‡						
Southborough,	–	–	–	1,995.58	150	$658,318 75
Marlborough,	–			750.98		
Total,	–	–	–	2,746.56	150	$658,318 75
Improving Sudbury Watershed.						
Northborough,	16.58	1	$550 00	147.93	35	$13,499 10
Southborough,	–			2.66		
Westborough,	–			202.48		
Ashland,	–			.63		
Marlborough,	–			.74		
Total,	16.58	1	$550 00	354.44	35	$13,499 10

* Including payments on account of St. John's Catholic Cemetery.
† Including transfer of $75 from "real estate court expenses."
‡ Including settlements made by city of Boston.

Summary of Land Settlements for Water Works to December 31, 1903 — Concluded.

LOCATION.	For the Year 1903.			From Beginning of Work.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
Clinton Sewerage System.						
Clinton,	-	1	$7,250 00	5.32	36	$37,794 40
Lancaster,	21.14			129.86		
Total,	21.14	1	$7,250 00	135.18	36	$37,794 40
Weston Aqueduct.						
Newton,	.24	19	$30,245 25	.24	60	$110,004 71
Weston,	15.69			266.99		
Framingham,	44.69			114.73		
Wayland,	33.87			42.52		
Southborough,	.45			.45		
Total,	94.94	19	$30,245 25	424.93	60	$110,004 71
Distribution System.						
Boston,	-	-	-	.70	27	$107,410 88
Brookline,	-			.05		
Arlington,	-			1.80		
Malden,	-			.16		
Medford,	-			2.39		
Newton,	-			.06		
Quincy,	-			5.23		
Stoneham,	-			20.85		
Total,	-	-	-	31.24	27	$107,410 88
Improving Lake Cochituate.						
Natick,	-	-	-	2.95	1	$1,600 00
Total,	-	-	-	2.95	1	$1,600 00
Aggregates,	548.11	51	$145,670 62	11,734.39	771	$3,783,447 91

(10) Claims and Settlements for Loss of Business.

Additional claims for injury to business, caused by the carrying out of the Metropolitan Water Act in the towns of West Boylston and Boylston and portions of the towns of Sterling and Clinton, have been filed during the year ending December 31, 1903, to the number of 2. Settlements of such claims have been effected during the year in 28 cases, under which the sum of $32,359 has been paid. One claim has been disallowed. Of these claims, 4 have been settled in court. The number of claims of this class settled since the beginning of the water works is 264, and the total sum paid on account of such claims is $119,021.

(11) Claims and Settlements for Loss of Employment.

During the year ending December 31, 1903, 3 claims for damages for loss of employment by residents of West Boylston have been filed. Settlements have been made in 2 cases, the amount paid being $125. During the year 2 claims have been disallowed. The whole number of settlements effected is 471. The total amount paid on account of these claims is $85,684.16.

(12) Claims and Settlements for Depreciation of Real Estate.

Settlements in 57 cases of injury to real estate in the towns of Clinton, Sterling and West Boylston have been made during the year ending December 31, 1903, and the sum of $72,030.20 has been paid. Of these claims, 19 have been settled in the courts. The total number of claims of this class settled to December 31, 1903, has been 224, and the total amount paid thereon has been $218,244.60.

In all the remaining cases in West Boylston and Sterling, in which application has been made for damages by owners of such real estate, offers of settlement have been made by the Board.

In the Act providing for the payment of damages for depreciation in the value of real estate were included that part of the town of Boylston that is situated on the northerly side of the proposed reservoir, and that part of the town of Clinton on either side of River and Grove streets for a certain distance below the dam. The estates affected in Boylston have all become the property of the Commonwealth; and all suits brought for the recovery of damages by the owners of the estates in that part of the town of Clinton named in the Act have been settled with one exception.

(13) Claims on Account of Diversion of Water.

There has been paid during the past year, on account of judgments obtained for the diversion of water, the sum of $180,895.11.

The total sum paid under settlements and judgments for such claims since the beginning of the work on the Water Works has been $1,098,245.11. These claims do not, however, in these or in the preceding cases include amounts paid for expert services and court expenses.

III. WATER WORKS — MAINTENANCE.

The maintenance and operation of the Water Works within the Metropolitan Water District have been in charge of the engineer of the Distribution Department; the care and maintenance of the reservoirs within the Sudbury Department and of the Sudbury and Cochituate aqueducts have been assigned to Charles E. Haberstroh, assistant superintendent, who has reported directly to the Chief Engineer; and the work of maintenance in the other departments has been in direct charge of the respective department engineers.

(1) Operation of Works.

Through the operation of the Metropolitan Works water has been supplied during the entire past year to the cities of Boston, Chelsea, Everett, Malden, Medford, Melrose, Quincy, Somerville, and the towns of Arlington, Belmont, Lexington, Milton, Nahant, Revere, Stoneham, Swampscott, Watertown, Winthrop and a small portion of Saugus.

The town of Milton was supplied through the Milton Water Company until March 10, when the town was admitted into the District.

The town of Lexington was supplied with water during the entire year, though admitted into the District on February 13, but between January 1 and June 9 a small portion of its supply was also taken from local sources.

A small portion of the town of Saugus, containing a population of about 200, has been, as before, supplied with water through the Revere Water Company, on account of its peculiar position.

All the other municipalities named belong to the Metropolitan Water District, except the town of Swampscott, which is supplied with water under a special arrangement. The total population thus supplied was estimated to be 900,500.

The city of Newton and the town of Hyde Park, though belonging to the Metropolitan Water District, made no application for a supply of water, and the Board being still of the opinion that they had not reached the safe capacity of their own sources of supply in a dry year, they have not been supplied with water from the Metropolitan Water Works.

The city of Medford supplied from its local sources 44,530,000 gallons, and the town of Lexington 7,410,000 gallons. The remainder of the water supplied came from Metropolitan sources, and amounted to a total of 39,057,180,000 gallons, making an average daily supply of 107,006,000 gallons from Metropolitan sources, and of 107,148,000 gallons from all sources.

The water supplied is received from the Cochituate, the Sudbury and the Wachusett or Nashua watersheds into the various storage reservoirs, is thence conveyed through the aqueducts to the distributing reservoirs or directly to main pipes, and thence, by increased pressure through the pumping stations, is conveyed through the many main pipe lines and delivered to the cities and towns; and by local authorities is distributed to the individual water takers.

(2) Storage Reservoirs.

The storage reservoirs of the Cochituate and Sudbury watersheds have normal capacities amounting to 15,858,500,000 gallons, as follows: —

	Gallons.
Cochituate watershed: —	
Lake Cochituate, including Dudley Pond,	2,242,400,000
Sudbury watershed: —	
Sudbury Reservoir,	7,253,500,000
Framingham Reservoir No. 1,	287,500,000
Framingham Reservoir No. 2,	529,900,000
Framingham Reservoir No. 3,	1,183,500,000
Ashland Reservoir,	1,416,400,000
Hopkinton Reservoir,	1,520,900,000
Whitehall Reservoir,	1,256,900,000
Farm Pond,	167,500,000
Total,	15,858,500,000

A somewhat larger amount of water is, however, actually held by these reservoirs at the periods of the maximum height of the water.

The Wachusett Reservoir will, when completed, have a capacity of more than 63,000,000,000 gallons, and in June, July and during the latter part of the past year considerable quantities have been held in storage for use. On December 31, 1903, there were held in storage 1,760,100,000 gallons, and it is estimated that in the early part of the coming year the amount in storage in that reservoir for the use of the Metropolitan District will reach 10,000,000,000 gallons.

An average of 66,943,000 gallons per day was drawn from the Nashua River and conveyed through the Wachusett Aqueduct into the Sudbury Reservoir. There was drawn for the supply of the District from Framingham Reservoir No. 3, which receives the water directly from the Sudbury Reservoir, an average of 92,675,000 gallons per day; and from Framingham reservoirs Nos. 1 and 2, which are connected also with the Ashland, Hopkinton and Whitehall reservoirs of the Sudbury system, was drawn an average of 5,346,000 gallons per day. An average of about 10,619,000 gallons per day was drawn from Lake Cochituate. The Spot Pond watershed furnished 708,000 gallons per day, and an average of 142,000 gallons per day was supplied from the local sources of Medford and Lexington.

Owing to differences arising from the various measurements and undoubtedly to some leakages, the aggregate above given is slightly greater than the total amount supplied, according to the several measurements, to the cities and towns in the District.

While the main dependence is thus made upon the water from the Nashua River and from the Sudbury Reservoir, the smaller reservoirs, which in general afford water of a less satisfactory quality, are resorted to at such periods as the necessity for their use occurs and their waters are found in their best condition.

(3) Distributing Reservoirs.

No changes have been made during the year in the capacities of the distributing reservoirs, in which a large amount of water is stored within the Metropolitan District, both for facilitating distribution and affording protection in emergencies.

Their capacities are as follows: —

	Capacity in Gallons.
Spot Pond,	1,791,700,000
Chestnut Hill Reservoir,	300,000,000
Fells Reservoir,	41,400,000
Mystic Reservoir,	26,200,000
Waban Hill Reservoir in Newton,	13,500,000
Forbes Hill Reservoir in Quincy,	5,100,000
Bear Hill Reservoir,	2,450,000
Arlington Standpipe,	550,000
Forbes Hill Standpipe,	330,000
Total,	2,181,230,000

The distributing reservoirs are so situated within the District as to be attractive as places of resort. The Chestnut Hill Reservoir, Spot Pond, the Fells Reservoir and the Forbes Hill Reservoir attract many visitors, especially on Sundays and holidays during the summer season; and it has been the policy of the Board to afford the people the pleasure and benefit which may be derived from them, so far as is consistent with the necessity of keeping the grounds in proper order and preventing the pollution of the water. A considerable force is required for keeping the grounds in good condition and protecting them against injury.

(4) Aqueducts.

The Wachusett Aqueduct was in operation during 302 days of the year. It was shut off for cleaning during 11 days, and for different periods when the water in the reservoir was so turbid after storms as to make it undesirable to be introduced into the Sudbury Reservoir. It was also deemed advisable to enter the aqueduct with a considerable force, in order to repair the minute cracks which had developed since construction, principally in the concrete forming the upper part of the aqueduct. This work was satisfactorily accomplished, and the aqueduct is believed to be in excellent condition.

The Sudbury Aqueduct was in constant operation during the year, except for 4 days, when it was emptied for the annual cleaning. The aqueduct was so well maintained that it was enabled to carry 2,615,000 gallons per day more than in the preceding year.

The Cochituate Aqueduct was in operation 282 days out of the year, and with the annual cleaning has been kept in satisfactory condition.

(5) Pumping Stations.

Substantially all the water supplied to the Metropolitan District is pumped for distribution, and a considerable quantity is twice pumped. All but one per cent. of the entire quantity supplied was pumped from the Chestnut Hill pumping stations, a part from the low-service station to the low-service districts and to Spot Pond, whence it is pumped for the northern high service, and a part from the high-service station to the Waban Hill, the Fisher Hill and the Forbes Hill reservoirs, whence it is distributed to the higher regions of Boston and to other municipalities of the southern part of the Metropolitan District. Water is pumped the second time from Spot Pond, the West Roxbury and the Arlington pumping stations.

The various pumping stations, with their respective capacities for pumping and the quantities of water pumped by them, are as follows: —

Name.	Total Capacity of Pumps (Gallons per Day).	Average Number of Gallons pumped per Day.
Chestnut Hill, high service,	66,000,000	30,037,000
Chestnut Hill, low service,	105,000,000	76,091,000
Spot Pond,	30,000,000	7,531,000
Arlington,	1,500,000	484,000
West Roxbury,	2,000,000	422,000
	204,500,000	114,565,000

The average number of gallons pumped per day during the year was 114,565,000. The total number of gallons pumped during the year was 41,816,200,000.

The entire cost of operating the five stations was $117,430.55, equivalent to $2.81 per million gallons pumped. This is an increase in cost over that of the preceding year of 31 cents per million gallons, which is due in part to the cost of installing new boilers and steam apparatus in the Chestnut Hill stations, and in part to the increased cost of coal. The bituminous coal used in the high-service and low-service Chestnut Hill stations cost 57 cents and 75 cents per ton more than during the preceding year.

Tests have been made to determine the heating power and other properties of the coals used at the several stations, which will assist in the future in the selection of coals best adapted for use.

The lubricating oils in use have also been submitted to tests.

The cost per million gallons raised one foot was for the Chestnut Hill high-service station $0.037, for the Chestnut Hill low-service station $0.039, and for the Spot Pond station $0.036.

(6) Pipe Lines and Pipe Yards.

Considerable emergency and repair forces are kept at the Glenwood pipe yard for the northern district, and at the Chestnut Hill pipe yard for the southern district, at both of which considerable quantities of pipe, castings and other material necessary for the care and repair of the lines are kept. These forces are able to do the general repairs which are required along the pipe lines and in the Distribution Department, and also to do in general the smaller pieces of construction.

No serious breaks have occurred during the year. The most extensive repairs which have been required were at the crossings of the Charles River, but these were largely made for the purpose of preventing leaks in the future. For these repairs it was necessary to employ divers in conjunction with the regular forces. Considerable work has also been done at various portions of the pipe line in investigating the extent of the injury done by electrolysis, as in many cases pipes have been uncovered for examination.

(7) Clinton Sewerage and Filtration Works.

There has been a decrease of 3,000 gallons per day in the amount of sewage pumped and deposited upon the filter-beds, the amount so pumped and deposited being 783,000 gallons per day. It is probable that the extensive introduction of meters on house services by the Clinton Water Department has had much to do in bringing about this result.

The cost of pumping has been $9.37 per million gallons, and the cost of maintaining the filter-beds has been $7.82 per million gallons filtered, — an increase of $1.03 in pumping and a decrease of 47 cents in filtration. The total cost of pumping the sewage has been $2,678.35, and the cost of maintaining the filter-beds has been $2,235.04.

The efforts which have been made to improve the character of the effluent from the filter-beds have not been successful, and other means for the purpose will be adopted during the coming year.

(8) Sanitary Inspection and Regulations.

In carrying on the work of construction both of the Wachusett Reservoir and the Weston Aqueduct, medical inspectors have been employed under the supervision of engineers in charge, whose duty it has been to examine the camps which have been constructed for laborers and all other buildings in which laborers upon the works have been lodged, and to make constant effort to keep all such places in clean and sanitary condition. Dr. J. J. Goodwin of Clinton has continued as heretofore to make such inspection upon the Wachusett watershed, and the sanitary condition along the Weston Aqueduct has been in charge of L. M. Palmer, M.D., of Framingham, and Horace B. Frost, M.D., of Weston.

The general inspection of the Wachusett, Sudbury and Cochituate watersheds exercised by the Maintenance Department has been continued during the year under the supervision of William W. Locke, C.E., who has had the aid of two regular assistants, and has received more or less assistance from the engineers and others. There have been few cases of contagious disease upon the Wachusett watershed, and there has been but a single case among the laborers employed upon the works. There have been more cases of contagious disease upon the Sudbury and Cochituate watersheds, but so far as is known there has been from such sources no direct pollution of the water supply.

Inspection has been made of 1,534 premises in the Wachusett watershed. In like manner upon the Sudbury and Cochituate watersheds 907 premises, the condition of which was suspected as unsanitary, were inspected. In general slight work has been required in order to put the premises in satisfactory condition; and, of the above, 1,376 in the Wachusett watershed and 768 in the Sudbury and Cochituate watersheds were pronounced satisfactory.

Considerable work has been done in remedying troubles which existed along the Quinepoxet River in Holden, especially among the mills. The owner of one of the mills which was discharging polluting matter directly into the stream was enjoined by the Superior Court from continuing the pollution. An appeal has been made to the Supreme Judicial Court under the claim of a right by prescription to pollute the stream. In the mean time, the pollution is temporarily provided against.

Considerable works have been built in order to provide for the drainage of the Mt. Pleasant House in Holden and also to dispose of the sewage of the Worcester County Truant School in Oakdale.

In some other cases in the Wachusett watershed resort has been had to the courts; but in general, after inspection and the discovery of sources of pollution, the owners of the property have shown a readiness to comply with the regulations and to assist in the prevention of pollution.

It has been the policy of the Board to introduce at its own expense the works which are required for remedying causes of pollution when the sources existed prior to the operations of the Board. In cases where the sources of pollution have arisen since the operations of the Board began, it has been made the duty of the owner to pay the cost of such work.

Report has been made to the State Board of Health of the unsatisfactory condition of the drainage of private sanitariums for consumptives in Rutland, and that Board has ordered the owners of the premises to dispose of the sewage in a more satisfactory manner.

The owner of the Reservoir House in Woodville, in Hopkinton, has, through the efforts of the Board, constructed a filtration plant for the purification of the drainage from the hotel and livery stable, which formerly entered Whitehall Brook.

Through the co-operation of local boards of health, many troubles have been relieved by the making of sewer connections.

Very few additional ditches have been dug for the drainage of swamps during the year, but those which had previously been dug have remained in good condition. No repairs have been required, but the usual cleaning has been carried on.

The quality of the water as to the existence of any injurious elements has somewhat improved over that of last year, but the color of the water has remained about the same as last year. The water received from the Nashua River through the Sudbury Reservoir is notably superior in quality, while the water which is received from the older works is not of so good a quality. Samples of the water taken weekly from the various sources are examined in the biological laboratory of the Metropolitan Water Works, and samples taken less frequently are sent to the State Board of Health for chemical examination.

(9) Marlborough Brook.

Attempts have been made for several years both by the Board and by the authorities of the city of Marlborough to improve the condition of Marlborough Brook, which flows through a portion of that city and empties into the Sudbury Reservoir through the Marlborough filter-beds. In times of heavy rains there was an overflow from the city's sewers into the brook, and at times the brook was swollen beyond the capacity of the filter-beds.

The Legislature, by chapter 443 of the Acts of the year 1903, instructed the city of Marlborough to construct an additional main sewer from the part of the city where the trouble was caused to the sewage-disposal beds of the city, the plans of such sewer to be satisfactory to the Board, and the Commonwealth to reimburse the city for the reasonable cost of the construction. Subsequent investigations showed that it was feasible to convey the diluted sewage, thus overflowing during heavy storms, by the construction of a much shorter sewer to land of the Commonwealth adjoining the Sudbury Reservoir, and upon this land to construct additional filter-beds, in order to purify the overflow by filtration. As this plan seemed equally effective for the purpose sought, and was deemed more economical for both the Board and the city, an agreement was entered into by the Board and the city, by which it was stipulated that such substituted sewer should be constructed by the city at the expense of the Commonwealth, but maintained by the city, and that the necessary filter-beds should be constructed and maintained by the Board.

Both the sewer and the filter-beds have been constructed and made ready for operation. The new filter-beds have an area of 3.91 acres, and have been built so as to combine with filtration the advantages of a considerable reservoir.

It has been deemed desirable both by the Board and the city of Marlborough that the terms of the agreement should be ratified by the present General Court.

IV. WATER WORKS — FINANCIAL STATEMENT.

(1) Metropolitan Water Loan, Receipts and Assessments.

The appropriations for the construction and acquisition of the Metropolitan Water Works, the receipts which are added to these appropriations, the expenditures for the construction and acquisition of works, and the balance available on January 1, 1904, have been as follows: —

Appropriation under chapter 488 of the Acts of 1895, . . .	$27,000,000 00
Appropriation under chapter 453 of the Acts of 1901, . . .	13,000,000 00
	$40,000,000 00
Proceeds from the sales of property applicable to the construction and acquisition of works (of which $16,779.49 is for the year 1903), ...	74,977 25
	$40,074,977 25
Amount approved by the Metropolitan Water and Sewerage Board for payments to December 31, 1903 (of which $3,124,036.24 is for the year 1903), ...	36,213,757 57
Balance January 1, 1904, ...	$3,861,219 68

The Treasurer of the Commonwealth, under the authority given him to issue from time to time, on the request of the Board, negotiable bonds to an amount not exceeding $40,000,000, to be designated the "Metropolitan Water Loan," has sold bonds as follows: —

Date.	Bonds sold.	Rate (Per Cent.).	Time (Years).	Price.	Premiums (in Amount).
1895, . . .	$2,225,000	3½	40	$110 67	$237,407 50
1896, . . .	2,775,000	3½	40	110 67	296,092 50
1896, . . .	2,000,000	3½	39	106 76268	135,253 60*
1897, . . .	6,000,000	3½	38½	107 82	469,200 00
1898, . . .	2,000,000	3½	40	113 176	263,520 00
1898, . . .	2,000,000	3½	40	112 877	257,540 00
1899, . . .	3,000,000	3	40	100 64	19,200 00
1900, . . .	1,000,000	3	39	102 78	27,800 00
1901, . . .	3,000,000	3	40	102 155	64,650 00
1901, . . .	100,000	3	40	100 375	375 00
1901, . . .	150,000	3	40	100 10	150 00
1901, . . .	205,000	3	39½	100 25	512 50
1901, . . .	50,000	3	39½	100 25	125 00
1901, . . .	50,000	3	39½	100 50	250 00
1901, . . .	300,000	3	39½	100 10	300 00
1901, . . .	200,000	3	39½	100 25	500 00
1901, . . .	3,100,000	3½	39½	106 71	208,010 00
1901, . . .	1,345,000	3	39½	100 00	–
1901, . . .	1,500,000	3	39½	100 00	–
1902, . . .	3,000,000	3½	40	109 13	273,900 00
1902, . . .	500,000	3½	40	109 13	45,650 00
1903, . . .	250,000	3½	40	106 725	16,812 50
1903, . . .	1,250,000	3½	40	106 1329	76,661 25
1903, . . .	500,000	3½	39½	100 00	–
	$36,500,000				$2,393,909 85

* Including $18,673.60 from readjustment of rate made by the Treasurer in 1897.

The sinking fund established by the Treasurer of the Commonwealth has amounted at the end of each year to sums as follows: —

December 31, 1895, ...	$226,286 05
December 31, 1896, ...	699,860 70
December 31, 1897, ...	954,469 00
December 31, 1898, ...	1,416,374 29
December 31, 1899, ...	1,349,332 97
December 31, 1900, ...	1,573,619 72
December 31, 1901, ...	1,662,426 95
December 31, 1902, ...	2,256,803 81
December 31, 1903, ...	2,877,835 59

Allowances for water furnished from their own sources by cities and towns during the year ending May 31, 1903, were made, in accordance with the Metropolitan Water Act, as follows: —

Lexington, ...	$85 92
Medford, ...	534 36
Milton, ...	23 16

After deducting these allowances, the net assessments for the year 1903, made by the Treasurer of the Commonwealth, for the payment of the interest on the bonds issued by the Commonwealth, the sinking fund requirements and the expenses of operation and maintenance of the Water Works, were as follows: —

Arlington,	$11,549 55	Nahant,	$3,211 08
Belmont,	5,701 23	Newton,	9,252 87
Boston,	1,510,857 46	Quincy,	30,237 42
Chelsea,	39,877 54	Revere,	13,771 64
Everett,	29,794 15	Somerville,	77,288 43
Hyde Park,	2,749 92	Stoneham,	7,523 04
Lexington,	5,647 85	Watertown,	13,440 83
Malden,	41,635 31	Winthrop,	8,653 44
Medford,	24,120 50		
Melrose,	17,815 34		$1,867,917 64
Milton,	14,790 04		

The comparatively smaller sums assessed upon the city of Newton and the town of Hyde Park were owing to the fact that neither of these municipalities had reached the safe capacity of its sources, and consequently neither had been furnished with water.

The proceeds from the operations of the Board, exclusive of the proceeds from sales of property, have been, according to the provisions of the Water Act, applied to the payment of interest and sinking fund requirements, and the maintenance and operation of works, as follows: —

For the year 1903,	$11,483 49

The expenditures for the maintenance and operation of the Metropolitan Water Works have been as follows: —

For the year 1903,	$331,421 62

Sums have been received during the year 1903, under the provisions of the Metropolitan Water Act, for water furnished, as follows: —

Lexington,	$27,682 50
Milton,	10 00
Swampscott,	3,500 00
Framingham Water Company,	293 79
	$31,486 29

At the close of the year, the Treasurer, in accordance with the requirements of the Act, has distributed to the cities and towns of the District, in proportion to the annual assessments theretofore contributed by them, this amount, as follows: —

Arlington,	$171 90	Newton,	$152 73
Belmont,	92 55	Quincy,	498 60
Boston,	25,995 38	Revere,	218 79
Chelsea,	678 99	Somerville,	1,279 93
Everett,	473 48	Stoneham,	82 69
Hyde Park,	45 35	Watertown,	218 51
Malden,	693 33	Winthrop,	134 24
Medford,	405 34		
Melrose,	293 38		$31,486 29
Nahant,	51 10		

Copies of the Second Annual Report, Metropolitan Water and Sewerage Board, 4,500 in number, were printed, at a cost of $2,145.06; and 200 copies in paper, rebound in cloth, at a cost of $105.

Chapter 65 of the Acts of 1903 provides that these sums shall be assessed by the State Treasurer, one-half upon the Metropolitan Water District and one-half upon the Metropolitan Sewerage District.

(2) Expenditures for the Different Works.

The following is a summary of the expenditures made in the various operations for the different works: —

Construction and Acquisition of Works.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Administration applicable to all parts of the construction and acquisition of the works,		$22,790 81		$221,484 01
Wachusett Dam and Reservoir: —				
Wachusett Dam,	$475,960 63		$1,373,828 92	
North Dike,	73,740 05		683,488 17	
South Dike,	4,334 21		9,507 15	
Removal of soil,	341,041 51		1,943,570 15	
Relocation of railroads,	466,102 79		681,017 02	
Roads and bridges,	89,945 91		401,304 59	
Real estate,	133,865 46		3,078,896 72	
Damages, real estate not taken, business and loss of wages,	104,514 20		422,949 76	
Other expenses,	764 87	1,690,269 63	4,869 06	8,599,431 54
Amounts carried forward,		$1,713,060 44		$8,820,915 55

Construction and Acquisition of Works.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward,		$1,713,060 44		$8,820,915 55
Improving Wachusett watershed,		2,214 13		18,370 78
Wachusett Aqueduct,		347 50		1,788,258 87
Sudbury Reservoir,		-		2,922,445 21
Protection of Sudbury supply,		58 70		119,751 07
Improving Sudbury watershed,		662 54		91,475 74
Protection of Cochituate supply,		-		9,000 00
Improving Cochituate watershed,		77 64		8,860 68
Improving Lake Cochituate,		7,286 56		103,537 29
Pipe lines, Dam No. 3 to Dam No. 1,		-		48,471 48
Pipe line, Rosemary siphon,		-		23,142 98
Weston Aqueduct: —				
Aqueduct,	$796,821 46		$2,226,732 14	
Reservoir,	144,601 31		225,708 86	
Supply pipe lines,	190,055 29		574,569 32	
Real estate, taxes and other expenses,	33,912 36	1,165,390 42	123,899 66	3,150,909 98
Distribution system: —				
Low service: —				
Pipe lines and connections,	$19,058 98		$1,750,837 01	
Pumping station, Chestnut Hill,	1 00		459,251 97	
Reservoir, Spot Pond,	38 55		578,101 58	
Gate-house and connections, Chestnut Hill Reservoir,	-		65,480 88	
Real estate and other expenses,	341 50		84,553 11	
Northern high service: —				
Pipe lines and connections,	645 60		440,289 98	
Spot Pond pumping station,	1,500 00		291,829 35	
Fells Reservoir, Stoneham,	5 00		141,392 94	
Bear Hill Reservoir, Stoneham,	3,362 68		38,155 80	
Real estate and other expenses,	-		14,838 05	
Southern high service: —				
Pipe lines and connections,	1,167 16		504,415 55	
Pumping station, Chestnut Hill,	-		242,121 35	
Forbes Hill Reservoir, Quincy,	25 01		90,003 49	
Waban Hill Reservoir, Newton,	-		61,592 11	
Real estate and other expenses,	-		10,226 36	
Northern extra high service,	378 73		13,937 47	
Southern extra high service,	346 45		22,763 67	
Meters and connections,	43,430 83		74,088 54	
Improving Spot Pond Brook,	933 95		3,540 13	
Glenwood pipe yard,	-		33,100 59	
Chestnut Hill pipe yard,	245 00	71,480 44	11,311 26	4,931,831 19
Diversion of water, South Branch of Nashua River,*		198,241 25		1,310,707 90
Acquisition of existing water works: —				
Reimbursement city of Boston, partially constructed Sudbury Reservoir,	-		$1,157,921 59	
To Boston, for works taken Jan. 1, 1898,	-		12,768,948 80	
Amounts carried forward,	-	$3,158,819 62	$13,926,870 39	$23,347,678 72

* Of the total expenditures from the beginning of the work, the sum of $141,859.87 is for Clinton sewerage system.

Construction and Acquisition of Works.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward, . . .	-	$3,158,819 62	$13,926,870 39	$23,347,678 72
Acquisition of existing water works — *Con.*				
To Malden (on account), for taking of Spot Pond, ...	-		25,749 71	
To Newton, for Waban Hill Reservoir, .	-		60,000 00	
	-		$14,012,620 10	
Transfers of works acquired and other property to accounts for special works, . .	-		1,240,166 42	
	-		$12,772,453 68	
Engineering, conveyancing, etc., ...	-		24,107 60	12,796,561 28
		$3,158,819 62		
Pipes, Valves, Castings, etc., sent first to Storage Yards, and afterwards transferred as needed to Different Parts of the Work.				
Sent to storage yards, ...	$61,900 52		$2,083,459 14	
Transferred from storage yards to works, and included in costs above, ...	96,683 90		2,013,941 57	
Balance from beginning of work, . . .	. . .			69,517 57
Excess of transfers over purchases during the year 1903 (deducted), ...	. . .	34,783 38		
Total for constructing and acquiring of works, ...	. . .	$3,124,036 24		$36,213,757 57

Maintenance and Operation.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Administration, ...	. . .	$4,065 77		$42,148 61
General supervision, ...	. . .	3,197 12		16,725 11
Taxes and other expenses, ...	. . .	29,438 97		108,398 49
Wachusett Reservoir Department: —				
Sanitary inspection, ...	$1,070 40		$2,027 68	
Buildings, ...	8 00		594 94	
Reservoir, ...	1,462 75	2,541 15	2,087 78	4,710 40
Wachusett Dam and Aqueduct Department: —				
General superintendence, ...	$1,297 33		$9,010 92	
Dam and aqueduct, ...	8,099 12		43,689 86	
Clinton sewerage system: —				
Pumping station, ...	2,565 13		10,354 30	
Sewers, screens and filter-beds, . . .	2,245 56		9,632 41	
Sanitary inspection, ...	374 75	14,581 89	2,007 44	74,694 93
Sudbury Department: —				
General superintendence, ...	$3,204 57		$33,180 62	
Superintendence, Framingham office, . .	7,645 98		36,424 33	
Ashland Reservoir, ...	1,957 50		10,814 04	
Amounts carried forward, . . .	$12,808 05	$53,824 90	$80,418 99	$246,677 54

Maintenance and Operation.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward, . . .	$12,808 05	$53,824 90	$80,418 99	$246,677 54
Sudbury Department — *Con.*				
Hopkinton Reservoir, ...	2,062 35		13,011 79	
Whitehall Reservoir, ...	366 89		2,025 67	
Framingham Reservoirs, 1, 2 and 3, . .	5,197 15		29,750 03	
Sudbury Reservoir, ...	8,297 81		44,391 77	
Lake Cochituate, ...	5,849 67		20,403 21	
Marlborough Brook filters, ...	1,886 36		12,430 73	
Pegan filters, ...	21,099 79		38,423 66	
Sudbury and Cochituate watersheds, . .	503 36		2,619 18	
Sanitary inspection, ...	2,547 33		14,575 09	
Sudbury and Cochituate Aqueducts, . .	14,864 55		105,306 27	
Biological laboratory, ...	2,771 38	78,254 69	19,530 91	382,887 30
Distribution Department: —				
Superintendence, ...	$11,228 53		$47,578 23	
Arlington pumping station, pumping service,	5,612 21		17,044 52	
Chestnut Hill high-service pumping station, pumping service, ...	53,782 48		271,659 81	
Chestnut Hill low-service pumping station, pumping service, ...	42,609 66		137,087 17	
Spot Pond pumping station, pumping service, ...	13,369 20		52,246 00	
West Roxbury pumping station, pumping service, ...	6,108 15		31,061 02	
Temporary pumping stations, . . .	-		52,979 06	
Arlington standpipe, ...	36 25		455 18	
Bear Hill Reservoir, ...	375 89		691 48	
Chestnut Hill Reservoir, ...	9,705 88		65,854 54	
Fells Reservoir, ...	1,148 37		5,002 83	
Forbes Hill Reservoir, ...	1,353 49		3,273 83	
Mystic Lake, conduit and pumping station,	2,681 98		20,068 61	
Mystic Reservoir, ...	1,136 17		11,528 29	
Waban Hill Reservoir, ...	776 46		4,734 04	
Spot Pond, ...	4,741 62		18,296 79	
Buildings at Spot Pond, ...	63 62		987 90	
Pipe lines: —				
Low service, ...	16,465 39		109,402 98	
Northern high service, ...	2,318 65		25,419 74	
Southern high service, ...	2,560 38		15,946 65	
Supply pipe lines, ...	68 30		68 30	
Buildings at Chestnut Hill, ...	1,445 09		9,347 58	
Chestnut Hill pipe yard, ...	1,814 06		4,953 06	
Glenwood pipe yard and buildings, . .	5,344 29		21,965 12	
Stables, ...	6,609 05		28,652 59	
Waste prevention, ...	7,327 87		10,226 48	
Venturi meters, ...	658 99	199,342 03	658 99	967,190 79
Total for maintaining and operating works,	. . .	$331,421 62		$1,596,755 63

(3) Detailed Financial Statement.

The Board herewith presents, in accordance with the Metropolitan Water Act, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the year 1903.

(a) *Expenditures and Disbursements.*

The total amount of the expenditures and disbursements on account of construction and acquisition of works for the year beginning January 1, 1903, and ending December 31, 1903, is $3,124,036.24; and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1903, is $36,213,757.57.

For maintenance and operation the expenditures for the year have been $331,421.62, and from the beginning of the work $1,596,755.63.

The salaries of the commissioners, and other expenses of administration, have been apportioned to the construction of the works and to the maintenance and operation of the same, and appear under each of those headings.

The following is a division of the expenditures according to their general character: —

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
I. Construction of Works and Acquisition by Purchase or Taking.				
Administration.				
Commissioners,	$8,166 66		$95,143 59	
Secretary and auditor,	3,729 16		41,220 88	
Clerks and stenographers,	6,262 86		44,290 27	
Legal services,	-		2,359 00	
Travelling,	647 97		2,920 18	
Stationery and printing,	1,060 38		7,384 27	
Postage, express and telegrams,	296 51		2,339 62	
Furniture and fixtures,	114 60		4,089 29	
Alterations and repairs of buildings,	17 78		5,740 86	
Telephone, lighting, heating, water and care of building,	1,115 43		8,711 84	
Rent and taxes, main office,	940 40		3,252 80	
Miscellaneous expenses,	439 06		4,031 41	
		$22,790 81		$221,484 01
Engineering.				
Chief engineer and department engineers,	$20,179 78		$176,248 57	
Principal assistant engineers,	14,616 02		125,222 43	
Engineering assistants,	96,016 25		877,828 31	
Amounts carried forward,	$130,812 05	$22,790 81	$1,179,299 31	$221,484 01

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward,	$130,812 05	$22,790 81	$1,179,299 31	$221,484 01
Engineering — Con.				
Consulting engineers,	250 00		23,437 07	
Inspectors,	47,624 81		259,038 27	
Architects,	3,151 47		29,411 94	
Railroad and street car travel,	1,886 39		25,829 05	
Wagon hire,	5,956 10		38,464 32	
Stationery and printing,	2,154 63		23,891 90	
Postage, express and telegrams,	529 58		6,889 75	
Engineering and drafting instruments and tools,	301 38		19,176 51	
Engineering and drafting supplies,	1,413 45		23,018 31	
Books, maps and photographic supplies,	741 80		6,013 13	
Furniture and fixtures,	25 76		14,830 24	
Alterations and repairs of building, — main office,	350 34		13,466 04	
Alterations and repairs of building, — sub-offices,	11 82		2,748 57	
Telephone, lighting, heating, water and care of building, — main office,	3,202 83		17,085 12	
Telephone, lighting, heating, water and care of building, — sub-offices,	2,772 82		15,367 64	
Rent and taxes, — main office,	2,821 20		9,526 75	
Rent of sub-offices and other buildings,	554 00		4,261 74	
Field offices and sheds,	24 65		1,261 19	
Clinton office building,	-		9,866 87	
Unclassified supplies,	459 28		7,586 22	
Miscellaneous expenses,	270 24	205,314 60	7,932 01	1,738,401 95
Construction.				
Preliminary work (borings, test pits and other investigations): —				
Advertising,	$244 56		$6,105 95	
Labor,	6 83		118,758 32	
Professional services, medical services, analyses, etc.,	-		711 33	
Travelling,	-		1,648 98	
Rent,	-		37 00	
Water rates,	-		2,094 79	
Freight and express,	-		484 00	
Jobbing and repairing,	-		559 07	
Tools, machinery, appliances and hardware supplies,	-		15,880 30	
Castings, iron work and metals,	-		207 85	
Iron pipe and valves,	-		3,386 31	
Blasting supplies,	-		41 29	
Paint and coating,	-		142 98	
Fuel, oil and waste,	-		1,977 86	
Lumber and field buildings,	-		6,670 02	
Drain pipe,	-		41 10	
Amounts carried forward,	$251 39	$228,105 41	$158,747 15	$1,959,885 96

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward, . . .	$251 39	$228,105 41	$158,747 15	$1,959,885 96
Construction — Con.				
Preliminary work, etc. — *Con.*				
Brick, cement and stone, ...	-		242 71	
Sand, gravel and filling, ...	-		269 45	
Municipal and corporation work, . . .	-		220 29	
Unclassified supplies, ...	-		1,499 57	
Miscellaneous expenses, ...	-	251 39	583 44	161,562 61
Contracts, Wachusett Reservoir: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-		$784,458 30	
Nawn & Brock, excavating soil, Sect. 6, and building easterly portion of North Dike, .	$45,296 12		1,014,712 74	
Busch Bros., excavating soil, Sect. 6, and building road, West Boylston and Boylston, — $600 due, deducted from estimate September 5, 1900, ...	-		34,560 63	
Newell & Snowling Construction Co., excavating soil from Sect. 8, and completing westerly portion of North Dike, . .	114,922 73		268,869 28	
Bruno, Salomone & Petitti, Sect. 10, Wachusett Reservoir. Boylston and West Boylston, ...	166,769 17		166,769 17	
Newell & Snowling Construction Co., excavating soil, Sect. 12, ...	5,649 56		5,649 56	
Auguste Saucier, excavating soil and building a part of Worcester Street, West Boylston, ...	12,384 35		12,384 35	
Crary Construction Co., building Sect. 1 of the Relocation of Central Massachusetts Railroad, ...	16,496 44		40,908 81	
McArthur Bros. Co., building Sect. 2 of the Relocation of Central Massachusetts Railroad, ...	138,631 68		246,439 34	
Nawn & Brock, building Sect 3 of the Relocation of Central Massachusetts Railroad,	17,682 28		41,983 14	
G. M. Atkins & Co , building Sect. 4 of the Relocation of Central Massachusetts Railroad, ...	17,032 62		48,112 82	
American Bridge Co. of New York, steel bridges on the Relocation of Central Massachusetts Railroad, ...	90,803 90		90,803 90	
The George M. Atkins Co , arch bridges and abutments at Oakdale, ...	32,792 59		32,792 59	
Eastern Bridge and Structural Co., steel highway bridges at Oakdale, . . .	4,198 00		4,198 00	
McArthur Bros. Co., Wachusett Dam, .	411,007 12		927,412 24	
William H. Ward, rebuilding Lancaster Mills dam, ...	5,321 47		5,321 47	
Amounts carried forward, . . .	$1,078,988 03	$228,356 80	$3,725,376 34	$2,121,448 57

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward, . . .	$1,078,988 03	$228,356 80	$3,725,376 34	$2,121,448 57
Construction — Con.				
Contracts, Wachusett Reservoir — *Con.*				
McArthur Bros. Co., placing riprap on the westerly portion of the North Dike, . .	16,735 44		16,735 44	
Coffin Valve Co., sluice gates for Wachusett Dam, ...	6,200 00		6,200 00	
*Coffin Valve Co., valves and iron work, .	100 00		3,841 00	
Coffin Valve Co., composition stop plank grooves, sills and bolts, ...	10,012 00	1,112,035 47	10,012 00	3,762,164 78
Contracts, Wachusett Aqueduct: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-			1,447,208 55
Contracts, Sudbury Reservoir: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-			1,545,028 33
Contracts, improving Lake Cochituate: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-		$14,196 49	
Auguste Saucier, Pegan Brook Meadow, .	$6,907 07	6,907 07	46,460 96	60,657 45
Contracts, protection Cochituate Supply: —				
Town of Framingham, low-level sewer, .	-			9,000 00
Contracts, Rosemary siphon: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-			5,916 96
Contracts, pipe line, Dam No. 3 to Dam No. 1: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-			17,240 22
Contracts, Clinton sewerage system: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-			66,878 22
Contracts, Weston Aqueduct: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-		$77,940 35	
T. H. Gill, ... Sect. 1,	$16,056 47		34,455 27	
Shanahan, Casparis & Co., . . Sect. 2,	64,816 48		197,645 17	
Sundry bills paid under this contract, .	514 18		514 18	
Shanahan, Casparis & Co., . . Sect. 3,	36,096 76		122,280 42	
Sundry bills paid under this contract, .	417 34		417 34	
Bruno, Salomone & Petitti, . . Sect. 5,	13,768 84		128,101 35	
Shanahan, Casparis & Co., . . Sect. 6,	29,906 10		106,805 66	
E. Kendall & Sons, steel pipe, Sects. 7 and 9,	33,163 02		135,752 56	
Winston & Co., . . Sects. 8 and 10,	69,737 53		144,552 09	
Winston & Co., ... Sect. 11,	66,655 40		154,634 20	
Shanahan, Casparis & Co., . . Sect. 12,	40,983 63		135,181 78	
Michael H. Keefe, ... Sect. 13,	-		11,206 05	
Columbus Construction Co., . . Sect. 13,	176,004 46		393,573 80	
Amounts carried forward, . . .	$548,120 21	$1,347,229 34	$1,643,060 22	$9,035,543 08

* Including some iron work for Weston Aqueduct.

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward, . . .	$548,120 21	$1,347,299 34	$1,643,060 22	$9,035,543 08
Construction — Con.				
Contracts, Weston Aqueduct — *Con.*				
Nawn & Brock, ... Sect. 14,	28,788 92		55,630 60	
Winston & Co , ... Sect. 15,	72,921 54		161,642 96	
Nawn & Brock, Weston Reservoir, Sect. 1,	48,890 75		57,344 00	
Nawn & Brock, Weston Reservoir, Sect. 2,	60,116 56		92,516 07	
Ward & Cummings, supply pipe lines, Sect. 1,	17,285 96		36,838 94	
Dennis F. O'Connell, supply pipe lines, Sect. 2, ...	10,486 76		69,787 87	
Dennis F. O'Connell, supply pipe lines, Sect. 3, ...	32,271 11		32,271 11	
Thomas F. Moore, supply pipe lines, Sect. 4,	4,476 25		27,468 48	
Connery & Wentworth, superstructure of the terminal chamber, ...	19,743 00		19,743 00	
C. A. Dodge & Co , superstructures of the head and meter chambers, ...	6,064 00		6,064 00	
Norcross Bros., superstructures of siphon and gaging chambers, ...	27,352 00		27,352 00	
Woodbury & Leighton, superstructures of channel and screen chambers, . . .	7,704 00		7,704 00	
Builders Iron Foundry, Venturi meters, .	1,020 00		7,200 00	
Taunton Locomotive Manufacturing Co., special castings and flanged pipe, . .	-	885,241 06	1,891 58	2,246,514 83
Contracts, Distribution System: —				
Contracts completed and final payments made prior to January 1, 1903, . . .	-		$3,931,823 05	
Coleman Bros., pipe laying, . . Sect. 12,	$14,739 99		60,727 03	
McNeil Bros., high-service pumping station,	1,500 00		90,619 85	
C. H. Eglee, Bear Hill Reservoir, . . .	50 00		50 00	
Woodbury & Leighton, superstructure of Bear Hill Reservoir gate-house, . . .	2,750 00		2,750 00	
Builders Iron Foundry, Venturi meters, .	21,458 13		31,120 08	
Builders Iron Foundry, Venturi meters, .	2,583 00		2,583 00	
*G. F. Blake Mfg. Co., special castings, .	6,231 12		18,120 92	
Camden Iron Works, special castings, .	5,654 21		16,826 61	
*United States Cast Iron Pipe and Foundry Co., cast-iron pipe and special castings, .	50,000 11		225,495 11	
R. D. Wood & Co., special castings, . .	1,636 66		1,636 66	
Coffin Valve Co., valves, ...	1,620 00	108,223 22	1,620 00	
Deduct value of pipes, valves, etc., included in above list, transferred to maintenance account December 31, 1900, and shown on page 44, ...	-		$4,383,372 31 3,139 77	4,380,232 54
Additional work: —				
Labor, ...	$67,630 38		$574,047 25	
Professional services, medical services, analyses, etc., ...	41 00		1,527 99	
Amounts carried forward, . . .	$67,671 38	$2,340,763 62	$575,575 24	$15,662,290 45

* Including some iron work for other departments.

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward,	$67,671 38	$2,340,763 62	$575,575 24	$15,662,290 45
Construction — Con.				
Additional work — *Con.*				
Travelling,	304 00		1,392 22	
Rent,	169 36		3,556 73	
Water rates,	52 91		1,375 17	
Freight and express,	1,148 09		10,342 39	
Jobbing and repairing,	281 24		8,017 21	
Tools, machinery, appliances and hardware supplies,	2,240 96		67,122 61	
Electrical supplies,	9 99		4,785 99	
Castings, iron work and metals,	6,827 03		56,584 41	
Iron pipe and valves,	1,822 62		51,804 13	
Blasting supplies,	78 66		1,217 14	
Paint and coating,	180 94		3,890 90	
Fuel, oil and waste,	598 32		10,047 13	
Lumber and field buildings,	3,615 06		76,284 78	
Drain pipe,	647 63		7,424 92	
Brick, cement and stone,	3,721 47		18,285 02	
Sand, gravel and filling,	937 89		5,752 26	
Municipal and corporation work,	20,823 18		104,854 35	
Police service,	31,461 11		187,403 33	
Sanitary inspection,	2,247 31		10,117 18	
Judgments,	3,225 00		35,253 94	
Unclassified supplies,	2,718 45		11,736 59	
Miscellaneous expenses,	209 60	150,992 20	2,901 13	1,255,724 77
Legal and expert: —				
Legal services,	-		$4,668 82	
Expert services,	$46 87		522 74	
Court expenses,	34 53		809 04	
Miscellaneous expenses,	-	81 40	49 05	6,049 65
Real Estate.				
Legal and expert: —				
Legal services,	-		$4,736 31	
Conveyancer and assistants,	$8,334 31		93,821 47	
Experts,	398 00		17,571 58	
Appraisers,	1,662 75		19,122 09	
Court expenses,	1,157 60		5,012 80	
Counsel expenses,	-		43 25	
Conveyancing supplies,	116 40		3,105 62	
Conveyancing expenses,	396 07		5,432 26	
Miscellaneous expenses,	-		3,591 32	
Settlements made by Board,	108,072 91		3,157,840 58	
Judgments,	37,597 71		94,001 33	
Taxes and tax equivalents,	423 92		67,917 07	
Care and disposal,	8,960 41	167,120 08	60,529 56	3,532,725 24
Amounts carried forward,		$2,658,957 30		$20,456,790 11

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward, . . .	. . .	$2,658,957 30		$20,456,790 11
Damages to Real Estate not taken, to Business and on Account of Loss of Wages.				
Legal and expert: —				
Legal services, ...	-		$1,130 67	
Expert services, ...	$762 92		847 92	
Court expenses, ...	4,819 44		9,079 99	
Settlements, ...	74,714 00		342,016 16	
Judgments, ...	29,800 20	110,096 56	80,933 60	434,008 34
Claims on Account of Diversion of Water.				
Legal and expert: —				
Legal services, ...	-		$3,774 98	
Expert services, ...	$1,006 16		18,943 38	
Court expenses, ...	8,081 11		17,670 44	
Miscellaneous expenses, ...	-		1,222 63	
Settlements, ...	-		917,350 00	
Judgments, ...	180,895 11	189,982 38	180,895 11	1,139,856 54
Purchase of Existing Water Works.				
Legal and expert: —				
Legal services, ...	-		$1,878 89	
Expert services, ...	-		2,650 65	
Miscellaneous expenses, ...	-		952 94	
Settlements and judgments, ...	-		14,012,620 10	14,018,102 58
Relocation Central Massachusetts Railroad				
Settlements, ...	. . .	165,000 00		165,000 00
Total amount of construction expenditures,	. . .	$3,124,036 24		$36,213,757 57
II. Maintenance and Operation of Works.				
Administration: —				
Commissioners, ...	$1,166 66		$11,899 99	
Secretary, auditor and assistants, . . .	1,856 03		20,941 90	
Postage, printing, stationery and other supplies, ...	290 92		2,753 10	
Travelling, ...	34 03		1,035 91	
Telephone, heating, lighting and care of building, ...	538 44		2,918 35	
Alterations and repairs of building, . .	52 82		1,607 50	
Rent and taxes, office building, . . .	75 00		530 60	
Miscellaneous expenses, ...	51 87		461 26	
Supervision and general superintendence: —				
Chief engineer and department engineers, .	7,523 76		42,111 74	
Engineering and clerical assistants, . .	8,585 93		42,246 95	
Postage, printing, stationery and office supplies, ...	559 58		4,248 48	
Telephone, heating, lighting and care of offices, ...	1,151 97		6,506 50	
Travelling and incidental expenses, . .	241 96		2,581 82	
Alterations and repairs of buildings, . .	240 14		5,717 18	
Amounts carried forward, . . .	$22,369 11		$145,561 28	

General Character of Expenditures.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Amounts brought forward,	$22,369 11		$145,561 28	
Maintenance, etc. — *Con.*				
Supervision, etc. — *Con.*				
Rent and taxes, main office,	225 00		1,394 59	
Miscellaneous expenses,	399 21		1,687 62	
Pumping service: —				
Labor,	48,079 70		232,489 16	
Fuel,	56,764 47		220,732 61	
Oil, waste and packing,	1,039 82		7,960 36	
Repairs and renewals,	11,635 50		36,812 09	
Small supplies and expenses,	3,212 56		15,399 91	
Pumping by municipalities,	-		45,273 80	
Rent, West Roxbury pumping station,	749 65		3,409 65	
Superintendents and assistant superintendents,	2,825 27		18,169 93	
Engineering assistants,	14,500 04		52,010 37	
Laboratory force,	2,118 49		14,558 09	
Sanitary inspectors,	2,430 81		15,127 97	
Recording and scientific instruments and supplies,	46 10		2,463 94	
Labor and teaming,	99,362 60		463,794 52	
Tools, machinery and appliances,	4,884 42		13,776 67	
Lumber and hardware supplies,	2,840 32		15,237 39	
Jobbing and repairing,	880 62		10,269 64	
Travelling,	4,171 54		17,755 68	
Horses, vehicles and stable expenses,	3,465 38		20,680 77	
Fuel, lighting and telephone,	5,312 39		19,399 12	
Municipal and corporation work,	98 71		4,193 30	
Alterations and repairs of buildings,	-		429 45	
Settlements of claims,	-		1,000 00	
Unclassified supplies,	4,265 71		25,773 59	
Miscellaneous expenses,	1,425 22		6,830 32	
Conveyancer and assistants,	298 74		662 58	
Taxes and tax equivalents,	29,135 23		107,727 79	
Contracts and agreements,	8,671 96		67,427 88	
Contracts for pipes, valves, etc., bought from construction work since January 1, 1901,	213 05		5,605 79	
Contracts for pipes, valves, etc., originally charged to construction, transferred to maintenance previous to January 1, 1901 (included in list, page 41),	-		3,139 77	
Total expenditures for maintenance and operation,		$331,421 62		$1,596,755 63

(*b*) *Receipts.*

The total amount of receipts from rents, sales of property, etc., for the year beginning January 1, 1903, and ending December 31, 1903, is $59,749.27; and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1903, is $339,519.89. The general character of these receipts is as follows: —

General Character of Receipts.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
For distribution back to District: —				
District entrance fees,	$27,260 00		$92,265 00	
Supplying water outside of District,	3,932 50		32,338 14	
Water furnished to water companies,	293 79	$31,486 29	35,946 23	$160,549 37
To the credit of the loan fund: —				
Real estate and buildings,	$2,930 43		$14,764 26	
Labor, tools and supplies,	13,849 06	16,779 49	60,212 99	74,977 25
To the credit of the sinking fund: —				
Forfeiture for contracts awarded but not executed,	-		$500 00	
Rents,	$5,972 90		76,096 97	
Land products,	5,505 23		26,999 89	
Unclassified receipts,	5 36	11,483 49	396 41	103,993 27
Total receipts,	. . .	$59,749 27		$339,519 89

The foregoing receipts have been credited to the various objects or works, as follows: —

Receipts from Different Works.	For the Year ending December 31, 1903.		From Beginning of Work, and ending December 31, 1903.	
Distribution back to District: —				
Admission into Metropolitan Water District (Nahant, Quincy, Stoneham, Arlington, Milton and Lexington),	$27,260 00		$92,265 00	
Supplying water to towns outside of Water District (Swampscott and Lexington),	3,932 50		32,338 14	
Water furnished to water companies,	293 79	$31,486 29	35,946 23	$160,549 37
Construction and acquisition of works: —				
Administration,	-		$0 75	
Wachusett Dam,	-		4,897 09	
Wachusett Reservoir,	$12,780 63		96,712 18	
Wachusett Aqueduct,	-		5,204 70	
Weston Aqueduct,	963 64		2,181 92	
Sudbury Reservoir and watershed,	-		7,255 16	
Distribution system,	11,821 43		43,132 26	
Diversion of water, Clinton sewerage system,	-		656 91	
Purchase of existing water works,	536 37	26,102 07	6,909 49	166,950 46
Maintenance and operation of works: —				
Wachusett Aqueduct,	$444 75		$2,542 94	
Sudbury system,	892 45		5,914 09	
Distribution system,	426 07		1,946 77	
Clinton sewerage system,	397 64	2,160 91	1,616 26	12,020 06
Total receipts,	. . .	$59,749 27		$339,519 89

(c) *Assets.*

The following is an abstract of the assets of the Water Works, a complete schedule of which is kept on file in the office of the Board: —

Office furniture, fixtures and supplies; engineering and scientific instruments and supplies; police supplies; horses, vehicles, field machinery, etc.; machinery, tools and other appliances and supplies; real estate connected with works not completed; completed works, including real estate and buildings connected therewith.

(d) *Liabilities.*

There are liabilities as follows: —

Current bills unpaid,	$12,887 52*
Due on monthly pay rolls,	5,100 00
	$17,987 52

Amounts reserved on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

Name.	Work.	Amount.
McArthur Bros. Co.,	Wachusett Dam,	$60,000 00
Busch Bros.,	Building road, Wachusett Reservoir,	600 00
Newell & Snowling Construction Co.,	Wachusett Reservoir, Sect. 8,	23,918 11
Bruno, Salomone & Petitti,	Wachusett Reservoir, Sect. 10,	17,500 00
The Geo. M. Atkins Co.,	Arch bridges, Wachusett Reservoir,	5,786 93
McArthur Bros. Co.,	Riprap on North Dike, Wachusett Reservoir,	2,953 31
McArthur Bros. Co.,	Relocation Central Massachusetts Railroad, Sect. 2,	10,000 00
Shanahan, Casparis & Co,	Weston Aqueduct, Sect. 2,	1,929 08†
Shanahan, Casparis & Co.,	Weston Aqueduct, Sect. 3,	988 03†
Shanahan, Casparis & Co.,	Weston Aqueduct, Sect. 6,	1,265 71†
Winston & Co.,	Weston Aqueduct, Sects. 8 and 10,	2,147 43
Winston & Co.,	Weston Aqueduct, Sect. 11,	2,123 68
Shanahan, Casparis & Co.,	Weston Aqueduct, Sect. 12,	3,096 78†
Columbus Construction Co.,	Weston Aqueduct, Sect. 13,	5,000 00
Nawn & Brock,	Weston Aqueduct, Sect. 14,	993 64
Winston & Co.,	Weston Aqueduct, Sect. 15,	2,607 58
C. A. Dodge & Co.,	Weston Aqueduct, superstructures of head and meter chambers,	1,516 00
Woodbury & Leighton,	Weston Aqueduct, superstructures of channel and screen chambers,	1,926 00
Nawn & Brock,	Weston Reservoir, Sect. 1,	1,296 00
Nawn & Brock,	Weston Reservoir, Sect. 2,	1,032 25
		$146,680 53

* Miscellaneous current bills of 1903, including those coming in from time to time after January 1, 1904, have since been paid.

† Labor and other claims exceed this amount.

Amounts have been agreed upon in the following cases, but the deeds have not yet passed : —

Godfrey Fuller, $20; Winthrop Parker *et al.*, trustees, $425; Margaret A. White, $100; Martha E. Prescott, estate of, $400; Frances A. Davis, $550; Austin Warfield, $35,000; heirs of Charles W. Harris, $8,500; Edmund F. Brigham *et als.*, $400; Andrew Boyd, estate of, $2,000; Charlotte W. Young, $1,700; Charles Goodale, estate of, $650.

On the claims of the following it is impossible to state the amounts due for land damages and water rights, as no sums have been agreed upon, and suits are now pending in the courts for the determination of most of them : —

Estate of William H. Buck, estate of Henrietta M. Johnson, Charles L. Johnson, Charles B. Sawin, J. M. Sears, city of Malden, balance, city of Medford, city of Melrose, Boston & Maine Railroad, American Telephone and Telegraph Company, Boston & Albany Railroad Company, Emory A. Bacon, Candace Chase *et als.*, James Dorr, Charles U. Cotting *et als.*, Framingham Water Company, Charles W. Felt, Robert F. Perkins, Francis Shaw, town of West Boylston, James B. Marsh, Eliza M. Childs *et al.*, Robert Cumming, Charles J. Paine, George H. Thompson, Benjamin W. Clemmons, town of Framingham, Henry S. Milton *et al.*, trustees, Ralph L. Perry, Walter E. Reeves, Marion Preston, George A. Ward *et al.*, Edward Dooley, Harry Dutton, Francis A. Foster, Thomas Irving *et al.*, Elmira S. Walker, Charles A. Warren, Charlotte W. Young, Ida M. Tay.

V. SEWERAGE WORKS — CONSTRUCTION.

The Metropolitan Sewerage Works embrace the North Metropolitan System and the South Metropolitan System.

(1) North Metropolitan System.

The North Metropolitan System provides for a district situated in the Charles River and Mystic River valleys, lying wholly north of the Charles River, whose sewage is carried to Deer Island and thence conveyed and emptied into Boston harbor. The town of Revere was annexed in the past year to this district, which now comprises the cities and towns of Arlington, Belmont, Cambridge, Chelsea, Everett, Malden, Medford, Melrose, Revere, Somerville, Stoneham, Wakefield, Winchester, Winthrop, Woburn, a part of the town of Lexington and the parts of the city of Boston known as East Boston and Charlestown.

The area of the North Metropolitan District has been increased during the year to 90.5 square miles, with 56.79 linear miles of sewers, to which an estimated population of 369,797 contributes sewage.

The Legislature of 1903 authorized the building of a branch sewer to the town of Revere, to provide for the sewage of the whole of that town; and the extension of the branch sewer in the city of Cambridge to a corner of the town of Belmont, in order to relieve a district in the southeasterly portion of that town not otherwise provided for. The sums of $200,000 and $50,000 were respectively appropriated for these purposes.

The work of construction of the Revere branch, involving the crossing of salt marshes and a tidal inlet and the building of a tunnel through clay, was of so uncertain a nature, and the bids offered so large in amount, that the Board determined to prosecute the work principally by day labor. This work, requiring the building of 7,306 feet of sewer, has progressed satisfactorily, and will probably be finished during the first half of the coming year.

The extension to Belmont requires the building of 6,367 feet of sewer, and the work has proceeded so far towards completion that it is expected that the sewer will be finished at an early date. The sewer is designed also to provide for the sewage of the portion of Cambridge through which it is built.

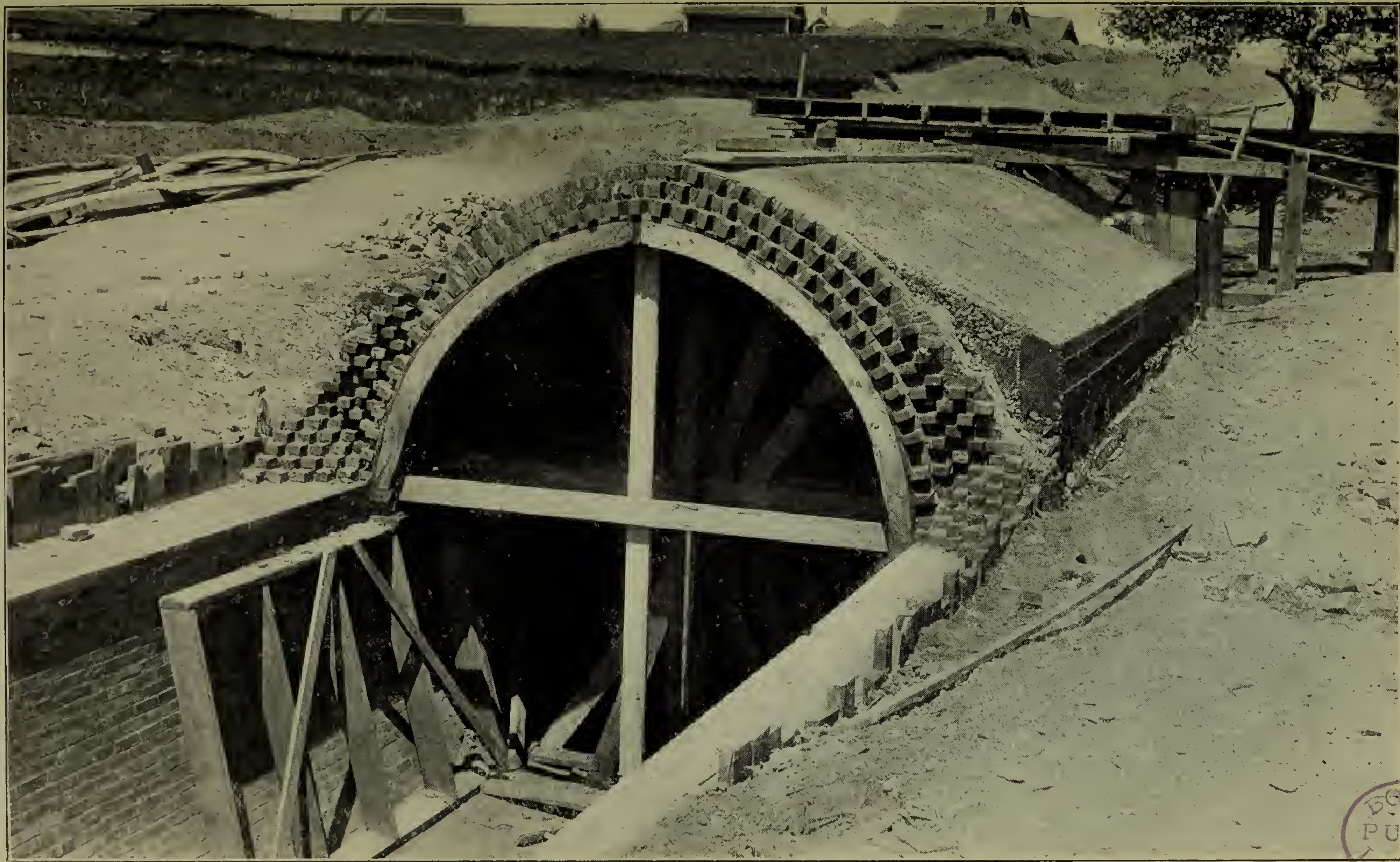
The Legislature also authorized the issue, at the request of the Board, of bonds to an amount not exceeding $250,000, in addition to the amounts hitherto authorized, on account of old claims for damages and liabilities incurred for past construction on the North Metropolitan System.

Considerable progress was made in the settlement of old suits which had been pending several years.

The cost of the North Metropolitan System of sewerage up to the present date has been $5,901,914.09.

(2) South Metropolitan System.

No additions to the area of the South Metropolitan System were made during the past year. The system provides for the sewage of a portion of the Charles River valley which lies south of the



HIGH-LEVEL SEWER IN QUINCY IN CONSTRUCTION.

Charles River, and the city of Waltham and the town of Watertown, which are situated on the north side of the river. It also provides for the sewage of a portion of the Neponset River valley. Beside the city of Waltham and the town of Watertown, it provides for the sewage of the cities and towns of Brookline, Hyde Park, Newton, Milton, Quincy, part of the town of Dedham, the Brighton district and portions of the Back Bay, Dorchester, Roxbury and West Roxbury districts of the city of Boston.

The area of the South Metropolitan District comprises, as last year, 102.55 square miles, having now 37.07 miles of sewers and a contributive population of 140,501. The sewage of the District, which has for several years been disposed of by an arrangement with the city of Boston through the Moon Island sewer, is to be carried into Boston harbor, off Nut Island, through the High-level Sewer, so called, now under construction.

During the past year the work upon the High-level Sewer has been rapidly pushed toward completion, nearly the entire length of 16.83 miles, from the Ward Street pumping station to Nut Island, having been completed. The work has required the laying of two lines of submarine 60-inch cast-iron pipe, from Nut Island to points a little more than one mile beyond the low-water mark, and at the end of the lines the building of outfalls for the sewer.

The westerly line of submarine pipe has been laid during the past year, and nearly two-fifths of the easterly line has also been laid. The laying of these pipes has necessarily been attended with considerable difficulty, but the work has so far been satisfactorily accomplished. The foundations for the screen chamber and sand-catcher on Nut Island have been laid, and the contract has been made for building the superstructure of the screen chamber. The building for this purpose will be about 80 feet long by 60 feet wide and 40 feet high, and will be built of brick with granite trimmings.

The Ward Street pumping station, which is approaching completion, covers an area of about 16,000 square feet, and has an engine house about 65 by 120 feet, with a height of about 40 feet to the main roof, and a boiler room and accessories 38 by 105 feet. It is constructed of brick with granite trimmings, and with foundations of Portland concrete. Two pumping engines, having each a daily capacity of 50,000,000 gallons, are building, and a small portion of the parts of the engines, boilers and other machinery has already been delivered.

There also remain to be completed connections by force mains with the Ward Street pumping station. A force-main line is to be laid so as to connect the Quincy sewerage system with the High-level Sewer, and connections are also to be made with the Charles River valley system and the Neponset River valley system.

It is expected that all these works may be completed, and that the High-level Sewer may be put in operation by the end of the coming summer. The Board has used every effort to bring this work to completion, not only in the interests of economy, but also to provide for the connecting sewers which have already been built by the city of Boston and other sections of the District, which are awaiting connections with the High-level Sewer for the purpose of relieving their systems from overcharging. The necessity of putting the High-level Sewer into operation at the earliest possible date is also especially demanded for the sanitary welfare of the District.

The expenditures upon the High-level Sewer during the past year have amounted to $1,389,627.83, and the entire amount so far expended upon its construction has been $5,231,615.84. The cost of the whole South Metropolitan System up to the present date, including the Charles River valley system and the Neponset River valley system, has been $6,934,976.37.

The Legislature of 1903 authorized the issue of an additional loan to the amount of $996,000 for the High-level Sewer, and also to the amount of $4,000 for the settlement of the remaining land damages on account of the Neponset River valley system. The Board has asked for an additional sum of $385,000, in order to complete the High-level Sewer and to make the connections which are necessary.

(3) Purchases and Takings of Land.

Only three takings of real estate, covering an area of 17.63 acres, have been made for the Metropolitan Sewerage Works, one for the purposes of the High-level Sewer in the South Metropolitan System, one for the purposes of the Revere Extension, and one for the Belmont Extension in the North Metropolitan System, all the takings being of easements.

HIGH-LEVEL SEWER—CONSTRUCTION IN EMBANKMENT ON NUT ISLAND BAR.

List of Takings for Metropolitan Sewerage Works for the Year 1903.

No.	Location and Description.	Former Owners.	Recorded.	Sections and Purpose of Taking.
8	Roxbury (in Ward, St. Alphonsus, Smith, Oregon, Conant and Phillips streets and Longwood Avenue). Area, easements in 3.13 acres.	City of Boston.	1903. Mar. 5.	Section 76, High-level Sewer.
9	Chelsea (from Revere and Chelsea boundary lines southwesterly through Crescent Avenue, Eastern Avenue, Willoughby Street and land of the Boston & Maine Railroad to existing sewer). Area, easements in 5.52 acres.	Boston & Maine Railroad *et al.*	Sept. 1.	North Metropolitan System, Revere Extension.
10	Cambridge (from existing sewer in Mt. Auburn Street, at Lowell Street, westerly through Mt. Auburn Street, Brattle Street, Aberdeen Avenue, Dundee Street, private owners, Homer Avenue, private owners, crossing Watertown Branch Railroad, Holworthy Place and Holworthy Street, private owners, Cushing Street and Cushing Avenue to the Cambridge and Belmont boundary lines). Area, easements in 8.98 acres.	Alexander McDonald *et al.*	Sept. 26.	North Metropolitan System, Belmont Outlet.

The above acreage in which easements were taken includes 16.74 acres in streets.

Since January 1, 1903, settlements have been effected on account of the takings made in the North Metropolitan District in three cases, involving a payment of $184,075.19; and in cases in the South Metropolitan District fifteen settlements have been effected, under which payments have been made amounting to $57,781.52.

Summary of Land Settlements for the Year 1903.

Location.	Area in Acres.	Number of Settlements.	Payments.
North Metropolitan District.			
Malden, ...	0.390	1	$33 33
Boston (Deer Island), ...	30.660	1	181,041 86
Boston (Charlestown), ...	–	1	3,000 00
Total, ...	31.050	3	$184,075 19
South Metropolitan District.			
Newton, ...	0.980	2	$425 00
Hyde Park, ...	0.470	2	525 00
Boston (West Roxbury), ...	1.377	4	2,612 00
Quincy, ...	8.409	7	54,219 52
Total, ...	10.813	15	$57,781 52
Aggregates, ...	41.863	18	241,856 71

VI. SEWERAGE WORKS — MAINTENANCE.

The engineer of the Sewerage Works has, with his assistants, the charge of the operation of all of the completed sewers and sewer outlets, as well as the maintenance of the various pumping stations, and in all respects the supervision over the disposal of the sewage of the Metropolitan Sewerage District.

There are employed in the sewerage maintenance force 47 engineers and other employés at the various pumping stations, and 37 men in the general care of the sewers and pumping station grounds.

(1) North Metropolitan System.

There are in the North Metropolitan System 542.56 miles of local sewers, from which the sewage is received into the North Metropolitan System, and into which the sewage of the different municipalities is discharged by 57,039 connections. There has been an increase during the past year of 39.10 miles of local sewers and of 3,185 connections. Five pumping stations are maintained for this system, and during the year 50,702,428,000 gallons of sewage have been pumped. Of the total, 1,396,128,000 gallons have been pumped at the Alewife Brook pumping station in Somerville; 10,903,100,000 gallons at the Charlestown pumping station; 18,804,000,000 gallons at the East Boston pumping station, and 19,599,200,000 gallons at the Deer Island pumping station.

The average cost for pumping per million gallons raised one foot, including labor at the screens, was $0.345 at the Alewife Brook station, $0.206 at the Charlestown station, $0.086 at the East Boston station and $0.114 at the Deer Island station.

The cost of pumping has considerably increased during the past year, the increase being almost entirely on account of the larger cost of coal.

A single larger boiler has been substituted at the Alewife Brook pumping station for the two smaller boilers which were originally installed, both for convenience of operation and economy in maintenance.

A considerable quantity of riprap has been deposited on the Deer Island Spit over the pipe line leading to the outfall, for the protection of the sewer against the violence of the waves, and to repair the losses which had been sustained since its original construction ten years ago.

(2) South Metropolitan System.

The local sewers from which sewage is received into the South Metropolitan System have a total length of 391.56 miles, and have 19,104 connections.

The Quincy pumping station is the only one yet operated for the South Metropolitan System. There have been pumped at this station 1,109,811,000 gallons of sewage, at an average cost of $0.197 per million gallons raised one foot.

Upon the completion of the High-level Sewer, the Ward Street pumping station will be put into operation, for which an appropriation has been requested from the Legislature.

VII. SEWERAGE WORKS — FINANCIAL STATEMENT.

(1) Construction Loans and Receipts.

The appropriations for the construction of the Metropolitan Sewerage Works, the receipts which are added to the appropriations, and the expenditures for construction, have been as follows: —

(*a*) *North Metropolitan System.*

Appropriations under various acts of the Legislature (given in detail in preceding report),	$6,105,865 73
Proceeds from sales of property and from other sources to December 31, 1903,	16,526 73
	$6,122,392 46
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1903 (of which $280,044.57 is for the year 1903),	5,901,914 09
Balance, North Metropolitan System, January 1, 1904,	$220,478 37

(*b*) *South Metropolitan System.*

Charles River Valley Sewer.

Appropriations under the Acts of the years 1889 and 1900,	–	$800,046 27
Amount approved by the Metropolitan Sewerage Commission for payment to December 31, 1903,	$800,046 27	

Neponset River Valley Sewer.

Appropriations under various acts of the Legislature (given in detail in preceding reports),	–	900,000 00
Appropriation, chapter 315, Acts of 1903,	–	4,000 00
Proceeds from pumping ground water,	–	109 50
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1903 (of which $3,316.44 is for the year 1903),	903,314 26	

High-level Sewer.

Appropriation under chapter 424 of the Acts of 1899, original loan,	-	$4,600,000 00
Appropriation, chapter 356 of the Acts of 1903,	-	996,000 00
Proceeds from sales of property to December 31, 1903 (of which $1,550.10 is for the year 1903),	-	3,145 81
		$7,303,301 58
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1903 (of which $1,389,627.83 is for the year 1903),	$5,231,615 84	
		6,934,976 37
Balance, South Metropolitan System, January 1, 1904,		$368,325 21

(c) *Metropolitan Sewerage Loans Sinking Fund.*

Under authority of chapter 122 of the Acts of 1899, and section 14 of chapter 424 of the Acts of 1899, the Treasurer of the Commonwealth was required to consolidate the sinking funds of all the Metropolitan sewerage loans into one fund, to be known as the Metropolitan Sewerage Loans Sinking Fund.

The sinking fund as thus established has amounted at the end of each year to sums as follows: —

December 31, 1899,	$361,416 59
December 31, 1900,	454,520 57
December 31, 1901,	545,668 26
December 31, 1902,	636,084 04
December 31, 1903,	754,690 41

(2) Annual Appropriations and Receipts.

The annual appropriations for the maintenance of the Metropolitan Sewerage Works, the receipts of the Board which are added to the appropriations for maintenance, and the expenditures for maintenance for the year ending December 31, 1903, have been as follows: —

North Metropolitan System.

Balance January 1, 1903,	$5,910 16
Appropriation under chapter 71 of the Acts of 1903,	122,600 00
Receipts from pumping and from other sources,	2,541 46
	$131,051 62
Amount approved by the Board for payment,	121,274 04
Balance January 1, 1904,	$9,777 58

South Metropolitan System.

Balance January 1, 1903,	$5,539 77
Appropriation under chapter 74 of the Acts of 1903,	101,491 82
Receipts from sales of property and from pumping,	79 96
	$107,111 55
Amount approved by the Board for payment,	102,089 49
Balance January 1, 1904,	$5,022 06

The Board has also received, from rentals and from other sources, to be applied by the Treasurer of the Commonwealth to the Metropolitan Sewerage Loans Sinking Fund requirements, $204.68.

(3) Annual Assessments.

The amounts assessed by the State Treasurer upon the cities and towns of the Metropolitan Sewerage Districts, to meet interest and sinking fund requirements and to defray the cost of maintenance and operation of works, in accordance with the ratios * determined by the apportionment commissioners appointed under chapter 439 of the Acts of the year 1889 and chapter 424 of the Acts of the year 1899, are as follows: —

North Metropolitan Sewerage System.

Arlington,	$7,436 89	Somerville,	$46,588 33
Belmont,	4,232 97	Stoneham,	4,590 37
Boston,	60,069 98	Wakefield,	7,010 10
Cambridge,	79,836 65	Winchester,	7,071 55
Chelsea,	22,735 32	Winthrop,	5,496 56
Everett,	17,028 61	Woburn,	9,939 86
Lexington,	2,239 34	Revere,	8,221 81
Malden,	26,643 14		
Medford,	16,440 51	Total,	$336,390 83
Melrose,	10,808 84		

South Metropolitan Sewerage System.

Boston,	$79,108 32	Quincy,	$14,307 10
Brookline,	23,854 07	Waltham,	14,528 71
Dedham,	4,835 17	Watertown,	6,047 02
Hyde Park,	7,941 65		
Milton,	7,469 10	Total,	$184,371 69
Newton,	26,280 55		

* Given in previous reports.

(4) Expenditures for the Different Works.

The following is a summary of the expenditures made in the various operations for the different works: —

Construction.	For Year ending December 31, 1903.		From Beginning of Work to December 31, 1903.	
North Metropolitan System.				
Original system, main line and branches,	$188,049 29		$5,378,423 97	
Lexington branch,	-		68,585 15	
Everett branch,	-		54,877 12	
Wakefield branch,	-		35,698 29	
Stoneham branch,	-		11,574 10	
Chelsea and Everett outlets,	15 00		71,016 41	
Wakefield branch extension,	125 00		189,883 77	
Revere extension,	60,609 59		60,609 59	
Belmont extension,	31,245 69		31,245 69	
Total, North Metropolitan System,		$280,044 57		$5,901,914 09
South Metropolitan System.				
Charles River valley sewer,	-			$800,046 27
Neponset River valley sewer, main line,	$1,162 00		$866,495 66	
Brookline branch,	2,154 44		36,818 60	
Total,		$3,316 44		903,314 26
High-level Sewer: —				
Section 43, Quincy,	$112,580 57		$244,245 02	
Section 44, Quincy,	92,529 92		187,304 53	
Section 45, Quincy,	63,781 58		76,139 36	
Section 46, Quincy,	28,577 09		56,175 61	
Section 47, Quincy,	5,144 38		109,668 58	
Section 48, Quincy,	235,004 40		246,218 16	
Sections 48 and 49, Quincy,	3,736 90		81,548 64	
Section 49, Quincy,	58,232 77		164,325 90	
Section 50, Quincy,	5,081 49		109,350 35	
Section 51, Quincy,	51 78		87,028 63	
Section 52, Quincy,	21,877 90		155,720 12	
Section 53, Quincy,	13,532 48		98,042 42	
Section 54, Quincy,	4,797 74		101,908 39	
Section 55, Quincy and Milton,	7,234 90		303,526 29	
Section 56, Milton,	79 57		104,913 79	
Section 57, Milton,	3,572 78		68,711 11	
Section 58, Milton,	2,651 54		94,059 87	
Section 59, Milton,	4,318 34		104,386 62	
Section 60, Milton,	3,601 02		60,706 76	
Section 61, Milton,	35,984 62		129,485 83	
Section 62, Milton,	68 25		129,326 52	
Section 63, Milton,	279 65		126,877 33	
Section 64, Neponset River crossing,	3,403 75		47,399 40	
Section 65, Hyde Park,	33 96		40,645 84	
Section 66, Hyde Park,	35,328 23		252,861 72	
Section 67, Hyde Park, Stony Brook crossing,	995 87		32,135 33	
Section 68, Hyde Park and Roxbury,	9 56		78,441 38	
Section 69, West Roxbury,	8 04		101,971 18	
Section 70, West Roxbury,	19,765 88		131,374 05	
Section 71, West Roxbury,	59 30		91,888 22	
Section 72, West Roxbury,	85 84		122,314 72	
Section 73, West Roxbury,	262,760 20		493,189 86	
Section 74, West Roxbury and Roxbury,	363 86		147,244 27	
Section 75, Roxbury,	15,061 86		133,501 68	
Section 76, Roxbury, cast-iron force main,	63,625 54		71,098 05	
Section 77, Roxbury, Ward Street pumping station,	195,012 06		221,537 92	
Section 78, Roxbury, connecting sewer,	23,579 60		31,572 20	
Quincy force main,	117 03		117 03	
Real estate,	57,671 15		349,052 26*	
Apportionment Commission,	-		2,000 00	
Administration,	9,026 43		43,600 90	
Total,		1,389,627 83		5,231,615 84
Total, South Metropolitan System,		$1,392,944 27		$6,934,976 37
Total for construction, both systems,		$1,672,988 84		$12,836,890 46

* Including $61,300.20 paid for Ward Street pumping station lot, and estimated amount of $14,000 for part of Adams estate purchase on account of sand for use in connection with construction of Section 48.

Maintenance.	For Year ending December 31, 1903.	From Beginning of Work to December 31, 1903.
North Metropolitan System, ...	$121,274 04	$783,214 42
South Metropolitan System, ...	102,089 49	650,639 39
Total for maintenance, both systems, ...	$223,363 53	$1,433,853 81

(5) Detailed Financial Statement.

The Board herewith presents, in accordance with the Metropolitan Sewerage Acts, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the year ending December 31, 1903: —

(*a*) *Expenditures and Disbursements.*

General Character of Expenditures.	For Year ending December 31, 1903.
North Metropolitan System — Construction.	
Commissioners, ...	$791 67
Secretary, engineer and auditor, ...	375 00
Clerical services, ...	253 34
Rent of office, Ashburton Place, ...	300 00
Engineering supplies, ...	459 69
Office supplies, ...	150 81
Engineers, inspectors, rodmen, laborers and others, . . .	33,118 71
Advertising, ...	129 25
Postage, telephone and telegrams, ...	25 85
Books, maps, plans, blue prints and photography, . . .	166 51
Carriage hire and travelling expenses, ...	183 25
Teaming and express, ...	33 65
Tools and repairs of same, ...	289 78
Brick, cement, lumber and other field supplies, ...	21,398 49
Contracts: —	
Revere Extension: —	
Mayo Contracting Co., Sects. 61 and 62, ...	4,402 73
Charles A. Haskin, Sect. 62, ...	2,840 70
Belmont Extension: —	
Gow & Palmer, Sect. 63, ...	26,997 39
Land takings, purchase and recording, ...	184,083 65
Experts and appraisers, ...	2,984 10
Legal services, ...	1,060 00
Total, ...	$280,044 57
Neponset River Valley Sewer — Construction.	
Carriage hire and travelling expenses, ...	$2 50
Brick, cement, lumber and other field supplies, ...	25 00
Contracts: —	
Brookline branch: —	
Thos. J. Kelley, Sect. 30, ...	1,551 94
Land takings, purchase and recording, ...	1,537 00
Experts and appraisers, ...	200 00
Total, ...	$3,316 44

General Character of Expenditures.	For Year ending December 31, 1903.
High-level Sewer — Construction.	
Commissioners,	$3,500 01
Secretary, engineer and auditor,	5,954 16
Clerical services,	2,382 79
Engineers, inspectors, rodmen, laborers and others,	156,458 21
Advertising,	79 99
Office supplies,	863 60
Postage, telephone and telegrams,	523 81
Books, maps, plans, blue prints and photography,	411 59
Engineering instruments and repairs of same,	68 71
Engineering supplies,	1,384 06
Carriage hire and travelling expenses,	3,115 73
Repairs, fittings and supplies, main office,	175 63
Rent of office, Pemberton Building,	3,125 00
Rent of sub-offices,	185 50
Water rates and connections,	2,749 40
Rent of office, Ashburton Place,	600 00
Rent of wharf, Quincy,	1,125 00
Teaming and express,	3,123 50
Brick, cement, lumber and other field supplies,	93,377 15
Boats and boat hire,	10 00
Contracts: —	
United States Cast Iron Pipe and Foundry Co., Sect. 43,	31,320 63
Hiram W. Phillips, Sect. 43,	72,445 30
Wm. H. Ellis, Nut Island Wharf,	539 21
Wm. H. Ellis, Nut Island Embankment,	3,882 07
Wm. H. Ellis, Sect. 44,	81,244 46
Latta & Terry Co., Sect 45,	59,089 60
John Cashman, Sect. 46, embankments,	1,099 23
Wm. H. Ellis, Sect. 46,	24,481 75
Chas. G. Belden & Co., Sect. 47,	4,914 37
Chas. G. Belden & Co., Sect. 48,	225,243 25
Chas. G. Belden & Co., Sects. 48, 49, embankments,	3,577 90
Chas. G. Belden & Co., Sect. 49,	53,430 45
Chas. G. Belden & Co., Sect. 50,	4,865 36
National Contracting Co., Sect. 52,	21,742 98
National Contracting Co., Sect. 53,	13,371 85
National Contracting Co., Sect. 54,	4,674 56
H. P. Nawn, Sect. 55,	2,783 88
John W. Bustin & Co., Sect. 57,	2,910 20
Latta & Terry Co., Sect. 58,	2,000 00
H. P. Nawn, Sect. 59,	4,171 84
John W. Bustin & Co., Sect. 60,	2,619 27
Chas. G. Belden & Co., Sect. 61,	33,432 75
United States Cast Iron Pipe and Foundry Co., Sect. 64,	501 60
E. W. & J. J. Everson, Sect. 66,	32,468 92
Charles Linehan, Sect. 70,	5,095 37
H. P. Nawn, Sect. 73 (part),	82,908 79
James Russell Boiler Works Co., Sect. 73 (part),	19,676 69
E. W. Everson & Co., Sect. 75,	13,298 16
H. P. Nawn, Sect. 76,	21,374 83
Warren Foundry & Machine Co., Sect. 76, iron pipe,	36,355 27
Amount carried forward,	$1,144,734 38

General Character of Expenditures.	For Year ending December 31, 1903.
Amount brought forward,	$1,144,734 38
High-level Sewer — Construction — Continued.	
Contracts — *Continued.*	
L. P. Soule & Son, Sect. 77, building,	162,151 89
Patrick McGovern, Sect. 78,	21,565 69
Land takings, purchase and recording,	56,319 25
Experts and appraisers,	940 00
Legal services,	411 90
Claims and allowances on contracts,	3,504 72
Total,	$1,389,627 83
North Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$2,134 16
Postage, printing, stationery and office supplies,	69 08
Rent, telephone, heating, lighting and care of offices,	397 07
Miscellaneous expenses,	2 65
General superintendence: —	
Engineer and assistants,	4,119 17
Postage, printing, stationery and office supplies,	102 50
Rent, telephone, heating, lighting and care of offices,	424 50
Miscellaneous expenses,	110 03
Deer Island pumping station: —	
Labor,	11,174 28
Coal,	10,919 90
Oil and waste,	552 67
Water,	1,258 80
Packing,	134 25
Repairs and renewals,	717 45
Telephones and office supplies,	318 07
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	3,635 27
Salt water suction pipe,	224 70
East Boston pumping station: —	
Labor,	10,450 91
Coal,	13,190 93
Oil and waste,	327 89
Water,	856 80
Packing,	74 84
Repairs and renewals,	1,737 03
Telephones and office supplies,	278 85
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	2,189 24
Charlestown pumping station: —	
Labor,	10,301 32
Coal,	5,038 81
Oil and waste,	385 23
Water,	399 60
Packing,	110 56
Repairs and renewals,	1,331 86
Amount carried forward,	$82,968 42

General Character of Expenditures.	For Year ending December 31, 1903.
Amount brought forward,	$82,968 42
North Metropolitan System — Maintenance — Continued.	
Charlestown pumping station — *Continued.*	
Telephones and office supplies,	282 13
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	2,188 82
Alewife Brook pumping station: —	
Labor,	3,144 99
Coal,	2,209 46
Oil and waste,	264 25
Water,	225 06
Packing,	54 32
Repairs and renewals,	2,820 87
Telephones and office supplies,	248 70
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	1,140 79
Sewer lines, labor,	15,268 58
Supplies and expenses,	5,619 77
Horses, vehicles and stable account,	4,837 88
Total,	$121,274 04
South Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$300 00
Postage, printing, stationery and office supplies,	22 02
Rent, telephone, heating, lighting and care of building,	156 84
General superintendence: —	
Engineer and assistants,	800 00
Postage, printing, stationery and office supplies,	15 42
Rent, telephone, heating, lighting and care of offices,	36 15
Miscellaneous expenses,	224 40
Charles River valley sewer: —	
Sewer lines, labor,	3,141 64
Supplies and expenses,	26 38
City of Boston, for pumping and interest,	63,013 00
Neponset River valley sewer: —	
Sewer lines, labor,	1,894 98
Supplies and expenses,	248 59
City of Boston, for pumping and interest,	23,167 00
Quincy pumping station: —	
Labor,	3,736 18
Coal,	2,914 73
Oil and waste,	39 21
Water,	231 41
Packing,	29 99
Repairs and renewals,	442 73
Telephones and office supplies,	132 35
Care and repairs of building and grounds, lighting and miscellaneous expenses,	516 47
City of Boston, for discharge of sewage,	1,000 00
Total,	$102,089 49

(b) *Receipts.*

The receipts from the sales of property, from rents and from other sources have been credited as follows: —

	For Year ending December 31, 1903.	From Beginning of Work to December 31, 1903.
North Metropolitan System, — construction,	-	$16,526 73
Neponset River Valley Sewer, — construction,	-	109 50
High-level Sewer, — construction,	$1,550 10	3,145 81
North Metropolitan System, — maintenance,	2,541 46	4,491 91
South Metropolitan System, — maintenance,	79 96	112 56
Metropolitan Sewerage Loans Sinking Fund,	204 68	685 20
Totals,	$4,376 20	$25,071 71

(c) *Assets.*

The following is an abstract of the assets of the Sewerage Works, a complete schedule of which is kept on file in the office of the Board: —

Office furniture, fixtures and supplies; engineering and scientific instruments and supplies; horses, vehicles, field machinery, etc.; machinery, tools and other appliances and supplies; real estate connected with works not completed; completed works, including real estate connected therewith.

(d) *Liabilities.*

There are liabilities as follows: —

Current bills unpaid,	$17,755 34*
Due on monthly pay rolls,	1,500 00
	$19,255 34

* Miscellaneous current bills of 1903 and those coming in from time to time after January 1, 1904, have since been paid.

Amounts on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.

Name.	Work.	Amount.
North Metropolitan Construction: —		
Jones & Meehan,	Original work, Sect. 44,	$32 00
H. A. Hanscom & Co.,	Sect. 56, held for claims,	200 00
Charles A. Haskin,	Sect. 62,	1,686 60
Mayo Contracting Co.,	Sects. 61 and 62, pile driving,	776 95
Gow & Palmer,	Sect. 63,	4,764 25
Neponset Valley System: —		
E. W. Everson & Co.,	Original work, Sect 25,	50 00
High-level Sewer: —		
Hiram W. Phillips,	Sect. 43, outlet, pipe laying,	15,826 22
Wm H. Ellis,	Sect. 44,	15,005 30
Wm H. Ellis,	Sect. 46,	4,320 29
Charles G. Belden & Co.,	Sect. 48,	39,748 85
Charles G. Belden & Co.,	Sect. 49, second part,	4,312 58
H. P. Nawn,	Sect. 55,	1,500 00
J. W. Bustin & Co,	Sect. 57, reserved for repairs,	100 00
E. W. Everson & Co.,	Sect. 62, reserved for repairs,	100 00
E. W. & J. J. Everson,	Sect. 66,	1,000 00
National Contracting Co.,	Sect 73, contract abandoned,	5,516 17
H. P. Nawn,	Sect. 73, part,	604 12
E. W. Everson & Co.,	Sect. 75,	4,648 88
H. P. Nawn,	Sect. 76,	4,082 52
* L. P. Soule & Son,	Sect. 77, Ward St., building,	29,958 64
Total,		$134,233 37

On the claims of the following it is impossible to state the amounts due for land and other damages, as no sums have been agreed upon, and suits are now pending in the courts for the determination of most of them: —

Holyhood Cemetery Association, Mary C. Eichorn, Clemence W. Hasenfus, Jackson *et al.*, trustees, Caroline S. Skinner, Alexander McDonald, heirs of John Friel, H. L. Rice, Boston Elevated Railway Company, heirs of John Gilmore, Boston & Maine Railroad, Annie E. McBride, Ella Norris, Charles C. Hodgkinson, Mary Rohan, Mary E. Connolly, city of Boston, National Contracting Company, Jacob M. Mason, Martin Dings, Bernard Duffy, Anna L. Dunican, Edward Duffy, Joseph H. Duffy, Mary R. Duffy, William J. Duffy, Maurice Duffy, Bernard Duffy, administrator, Emma Dings, Carrie S. Urquhart, N. Jefferson Urquhart, Edwin N. Urquhart, Mary Doherty, Mary E. Doherty, Richard Jones, J. Edwin

Jones *et al.* (Jones & Meehan), James Doherty, Michael Niland, Fred W. Baker, Catherine A. Baker, Walter J. Baker, Freda E. Baker.

VIII. ADMISSION OF OTHER MUNICIPALITIES INTO THE METROPOLITAN WATER DISTRICT.

The towns of Lexington and Milton have been admitted into the Metropolitan Water District during the past year, so that the District now comprises 9 cities and 10 towns, with an estimated population of 953,600.

The town of Lexington was admitted into the District on February 13, 1903. The sum of $27,250 was paid by the town to the Commonwealth, and the town entered into an agreement with the Board, that, in the furnishing of water to the town, water should be delivered at or near the boundary line between the towns of Lexington and Arlington.

The town of Milton made a formal application for admission on March 3, 1903, and on March 10 the town was admitted into the District, having entered into an agreement that the Board, in furnishing water to the town, should not be required, in order to supply water to the high lands near or adjacent to the Blue Hill Reservation, to pump water to greater heights than water was previously pumped; and that the town, until and including the year 1911, should maintain meters on all water services, and should furnish water at meter rates. The sum previously paid by the Milton Water Company was understood to be a consideration in part for the later admission of the town into the District.

IX. CONSUMPTION OF WATER.

While the total rainfall for the year was a little less than the average of past years, the yield of the watersheds for the year was, owing to the more even distribution of the rainfall, about the same as the average yield for many years past.

The cities and towns supplied wholly or in part by the Metropolitan Water Works during the year consumed an average of 107,148,000 gallons of water per day. This consumption is a trifle less than that of last year, which was 107,268,000 gallons daily. The decrease has occurred notwithstanding the District was enlarged early in the year by the admission of the town of Lexington. The consumption per inhabitant, which was last year 123 gallons per day, has been reduced to 119 gallons per day in the district supplied. This is the first time that it has been possible to indicate a decrease in the total annual consumption, although this rate is far in excess of the reasonable requirements of the District.

There was, however, an increase in consumption in the district which embraces the low-service portions of Boston (except Charlestown and East Boston) ; a small increase in the high-service district embracing the higher portions of West Roxbury and Milton ; and an increase in the high-service district embracing the towns of Arlington and Lexington, due entirely to the addition of Lexington to the District. There was on the other hand a considerable decrease in most of the municipalities situated in the northern part of the Metropolitan District.

The decrease in the total quantity supplied may in part be attributed to the lack of any considerable long spells of very hot weather during the summer, and to less extreme cold weather in the winter seasons of the year ; but an examination of the results shows also that a considerable portion of the decrease must be due to the saving in waste effected on account of and through the special investigations of consumption and waste which have been carried on during the past year. These investigations show that, especially in the portions of the District where there has been a decrease of consumption, many leaks were detected, which, upon being reported to the local authorities, were promptly stopped by them.

The efforts which have been made in detecting violations of the rules adopted for regulating the use of hand-hose and the restriction of such use to certain hours, as well as the prohibition of automatic or rotary lawn-sprinklers unless the water is metered, has resulted in decreasing the number of violations of the rules from that of the previous year. These violations occurred to the largest extent in the town of Swampscott and the city of Medford, where the violations per 1,000 inhabitants were, respectively, 16.16 and 9.29. The cities of Melrose and Quincy were the next most frequent offenders.

X. THE MEASUREMENT OF WATER SUPPLIED TO THE VARIOUS MUNICIPALITIES AND THE INVESTIGATION OF UNNECESSARY AND IMPROPER USE OR WASTE.

The Board has, in accordance with the provisions of chapter 391 of the Acts of the General Court of the year 1902, installed 42 Venturi meters, in addition to the 3 which had been placed before the passage of the Act, for the purpose of measuring the water supplied to the Metropolitan Water District. The cost of the introduction of these meters has been $74,088.54.

The Board has consequently been able, during the latter half of the past year, through the operation of these meters, to measure the quantities of water supplied to the various cities and towns in the District.

These measurements and the investigations made show that the consumption of water greatly varies in the different municipalities; that a large proportion of the water supplied, amounting from one-third to one-half of the entire quantity supplied, is unnecessarily used or wasted; that such unnecessary use and waste are largely preventable, and can be greatly reduced by proper effort on the part of the local authorities, who have the entire control of the distribution of the water supply; that the introduction of meters, and vigorous inspection, have been invariably accompanied by greatly reduced consumption; that such inspection and measurement by meters can be best secured by making the assessments upon the municipalities dependent in part, at least, upon the quantities of water respectively consumed; and that the individual water taker can only be made to interest himself in the checking of waste and excessive use by making his water rates depend upon the amount of water which he consumes.

The Board earnestly renews its former recommendations, that the annual assessments upon the municipalities of the District for the costs of construction and maintenance of the water works shall, in part, at least, be made proportional to the quantities respectively supplied to them. Unless action is taken for reducing the consumption of water, the District will in a comparatively short period be called upon for large additional expenditures.

The Board requests a careful consideration of its special report, containing the results of the investigations by Mr. Brackett, the engineer of the Distribution Department, who conducted the investigations, which is published as the last appendix of this report.

The Board will continue its efforts, with the more efficient means now afforded, to detect waste and loss, and to secure by all proper methods a reduction in the quantity of water consumed in the District to a reasonable rate of consumption.

XI. ELECTROLYSIS AFFECTING WATER PIPES.

A more vigorous investigation has been made of the effects of the electric currents which have been found to follow the water pipes in the Metropolitan District. The results show that considerable injury is already done, especially in the vicinity of the power stations of the various electric railway companies. At several points the pipes have been uncovered and examined, so as to ascertain how far the deterioration caused by electricity has progressed.

In general, the trouble has not gone to the extent of rendering the pipes immediately unsafe for use, but in one case at least pipes will have to be taken up and renewed in the coming year. The railway companies have been notified regarding the extent of the injuries. The companies to which attention has been specially called have manifested a disposition to co-operate in a careful investigation, and also to apply such means as may be found efficient for preventing further injurious electrolytic action. The legal questions involved have been referred to the Attorney-General.

XII. RECOMMENDATIONS FOR ADDITIONAL APPROPRIATIONS FOR SEWERAGE WORKS.

The Board, in a special report laid before the Legislature at the beginning of its session, represents that the amounts of the appropriations previously authorized for the building of the High-level Sewer are not, as had been anticipated by the Metropolitan Sewerage Commission, sufficient to complete the sewer and provide for its operation, owing to the fact that the cost of all labor and materials had greatly increased, that some unexpected difficulties had arisen, and that works essential to the complete operation of the sewer had not been included in the estimates formerly made.

The statement and recommendations of the Board relative to the High-level Sewer were as follows: —

In the South Metropolitan Sewerage District a large amount of work, involving the expenditure of about $1,400,000, has been performed during the past year upon the High-level Sewer, and it has been the purpose of the Board so to carry forward the construction that the sewer may be completed and put into operation during the coming summer. The interests of the District urgently call for the speedy use of the sewer.

Almost the entire length of the High-level Sewer proper has been built, and there chiefly remain to be completed the outfall pipes from Nut Island into the harbor, the screen chamber at Nut Island, and the Ward Street pumping station, in which also pumping engines are to be installed.

It is estimated that amounts will be required for the completion of the High-level Sewer, the connection with it of the other sewers, and for other work necessary in the South Metropolitan Sewerage District, as follows: —

Completion of contracts and payment of reserves held on account of completed contracts for sewer sections of High-level Sewer,	$67,286 28
Laying of outfall pipes in harbor from Nut Island,	168,321 40
Construction of screen chamber and other works on Nut Island,	92,755 54
Construction of Ward Street pumping station, and pumping engines and appliances and force mains,	312,141 23
Connections of High-level Sewer with Charles River, Neponset valley and Quincy systems,	38,006 00
Unsettled suits and claims and bills on hand on account of the South Metropolitan System,	27,000 00
Engineering expenses,	25,000 00
Total,	$730,510 45

The balance which will be available after the payment of amounts approved by the Board to December 31, 1903, is $368,325.21. The Board, therefore, respectfully represents that in its opinion authority should be given for the issue of bonds to an amount not exceeding $385,000 to defray expenses of construction of the South Metropolitan System.

A larger sum has been found necessary for putting the High-level Sewer into complete operation for the purposes for which it was designed than has been estimated; but many changes and enlargements have been called for as the work has advanced, and some unexpected difficulties have been met in its prosecution. The cost of the High-level Sewer as now estimated will be about $6,000,000.

XIII. NECESSITY OF SEPARATE SEWER SYSTEMS FOR SEWAGE AND SURFACE DRAINAGE.

The Board in its last annual report called attention to the great necessity which existed from both sanitary and economical conditions for the building of separate sewers, so called; that is, sewers in which the sewage proper only should be received, and that other drains or works should be constructed by which the rainfall or surface waters might be conveyed in separate conduits to the streams.

The Legislature of 1903 passed an Act providing that the owners of estates abutting on any public way, in which had been built by the city or town both a sewer for sewage and a drain for surface or storm water, should make or change the plumbing of his estate so that the sewage should be kept separate from the surface waters; and that the owner of every estate whose sewage was to be taken into any Metropolitan sewer should thereafter in plumbing his estate so arrange the plumbing as to keep the sewage from other waters. The Act also provided for the building of both such separate sewers and drains in streets.

The High-level Sewer has been built for receiving only sewage proper, and it will be impossible to receive in general the surface water. Many of the municipalities, particularly in the Northern Sewerage Districts, are already provided with the combined systems; and it is apparent that it will be necessary throughout the Sewerage District to make separation of sewers and drains, as provided by the Act, in order to make the present Metropolitan sewers capable of disposing of the sewage for the period of time for which they are designed, as well as to protect the public health by preventing the overflow of sewage into the reservoirs and streams in times of heavy rainfall.

XIV. FUTURE WORK.

Although the amount of construction, both upon the Metropolitan Water Works and upon the Metropolitan Sewerage Works, reached its maximum in the year 1902, the expenditures upon both have been large during the last year, the sum of $3,124,036.24 having been expended for construction of Water Works and $1,672,988.84 for construction of Sewerage Works. The cost of maintenance, which will naturally increase year by year, has been $331,421.62 for the Water Works and $223,363.53 for the Sewerage Works.

The completion of the Weston Aqueduct and Reservoir and of the relocation of the Central Massachusetts Railroad will considerably diminish the amount of construction necessary for the Water Works in the coming year. The work upon the Wachusett Dam will be carried forward as vigorously as possible; the stripping of the soil in the upper part of the Wachusett Reservoir will be continued, and it is anticipated that the highway across the reservoir at West Boylston will be constructed and that the South Dike, flanking the main dam on the southerly side of the river, will be essentially completed. Work upon the waste-way at the dam will be prosecuted near to completion, and the superstructure of the large gate-house and power-house just below the dam will be erected.

Continued attention will be given to the abatement of sources of pollution of the water supply, and measures for the purpose of improving the quality of the water will be carried out; investigations will be continued with a view to the stopping of improper and unnecessary consumption of water through waste and leakage; and further attention will be given to the deterioration which is found to exist in various water mains from electrolytic action.

It is probable that the Board will be able, in court or by voluntary settlement, to dispose of the larger part of the remainder of the cases for the taking of lands and other rights for the Wachusett Reservoir and of the various claims for the depreciation of lands in West Boylston and Sterling.

It is expected, if the additional appropriation asked for is made, that the High-level Sewer will be completed and put into operation for the benefit of the South Metropolitan District during the year. This will require the building of the large screen-house and other works on Nut Island, the completion of the laying of submarine pipes for the outlet off Nut Island, and the completing and equipment of the large pumping station at Ward Street in Roxbury.

The extensions authorized by the preceding Legislature of the North Metropolitan System to Revere and to Belmont will undoubtedly be completed.

The report of the Chief Engineer, relating to the Metropolitan Water Works, and the report of the Engineer of the Sewerage Works, are herewith presented.

Respectfully submitted,

HENRY H. SPRAGUE.
HENRY P. WALCOTT.
JAMES A. BAILEY, Jr.

Boston, March 7, 1904.

REPORT OF THE CHIEF ENGINEER.

To the Metropolitan Water and Sewerage Board.

GENTLEMEN: — The following is a report of the operations of the Engineering Department of the Metropolitan Water Works for the year ending December 31, 1903.

ORGANIZATION.

Hiram A. Miller, Engineer of the Reservoir Department, having been selected for the position of Chief Engineer of the Charles River Basin Commission, tendered his resignation, to take effect September 21, and one of his assistants, Charles E. Wells, division engineer, was promoted to the position left vacant.

John N. Ferguson, office assistant, in charge of the general office, resigned to accept a position with the Charles River Basin Commission, his resignation taking effect September 8. The vacancy was filled by the promotion of Samuel E. Killam, his principal assistant.

Charles W. Sherman, in addition to his former duties, now assists the Chief Engineer in miscellaneous matters.

The list of assistants reporting directly to the Chief Engineer at the end of the year is as follows: —

DEXTER BRACKETT, . .	. *Engineer of Distribution Department.*
THOMAS F. RICHARDSON, .	. *Engineer of Dam and Aqueduct Department.*
HORACE ROPES, . . .	. *Engineer of Weston Aqueduct Department.*
CHARLES E. WELLS, . .	. *Engineer of Reservoir Department.*
CHARLES E. HABERSTROH,	. *Assistant Superintendent, Sudbury Department.*
CHARLES W. SHERMAN, .	. *Division Engineer, Sudbury Department.*
FRANK T. DANIELS, . .	. *Principal Office Assistant.*
SAMUEL E. KILLAM, . .	. *Office Assistant.*

It is with much regret that I record the death, on June 11, of Mr. A. Fteley, who has been one of the consulting engineers from the beginning of the work. For more than three years he had been too ill to attend to work which required physical exertion, but his mental powers remained undiminished, and he gave valuable advice with regard to the design of the Wachusett Dam as late as the summer of 1900.

Joseph P. Davis and Hiram F. Mills have continued as consulting engineers throughout the year, and have been called upon to advise with regard to the design of the South Dike of the Wachusett Reservoir.

John W. Lynch has continued in direct charge of the pumping stations at Chestnut Hill, and in general charge of the mechanical work at all other pumping stations of the Distribution Department.

George E. Wilde has continued as assistant superintendent in the Distribution Department, in immediate charge of the maintenance and operation of the pipe lines and other works within the Metropolitan District, with the exception of the pumping stations, and is also engaged much of the time upon new construction.

At the beginning of the year the engineering force, including both those engaged upon the construction and maintenance of the works, numbered 196, and at the end of the year 153.

In addition to the engineering force, which included the engineers engaged upon the inspection of the work, other inspectors have been employed upon masonry, earth work and pipe laying. The maximum number so employed at any one time during the year was 19.

Gangs of men, under the immediate direction of foremen and under the general direction of the engineers, have been employed from time to time to do minor work, the more important items of which were the grading of roads and small portions of the Wachusett Reservoir at Oakdale ; the cleaning of the lower portions of the Wachusett Reservoir, preparatory to filling them with water ; the final cleaning and applying of cement wash to the interior of the Weston Aqueduct ; and the placing of Venturi meters and register chambers in the Metropolitan Water District.

There has also been a maintenance force, averaging 193, employed at the pumping stations and in connection with the maintenance of reservoirs, aqueducts, pipe lines, swamp ditches and other work.

Force Employed on Works.

The force employed upon the works in 1903 was large, although somewhat smaller than the force employed in 1902.

The largest force employed upon the works at any one time during the year was for the week ending June 6, as follows : —

	Men.		Horses.	
Contractors' force: —				
Reservoir Department,	847		110	
Dam and Aqueduct Department,	571		28	
Weston Aqueduct Department,	1,379		255	
Distribution Department,	270		23	
		3,067		416
Day-labor force, construction,		109		11
Engineering force, including engineer inspectors and those engaged upon maintenance,		191		-
Inspectors not engineers,		17		-
Maintenance force, not including civil engineers,		182		-
		3,566		427

Arrangement of Report.

In continuing this report, it is the purpose to separate the work charged to the construction account from that charged to the maintenance account; but, as the work of construction and maintenance is supervised by the same principal engineers, and in very many cases the assistants are engaged upon both classes of work, it is not feasible to make a complete separation.

CONSTRUCTION.

Contracts.

A detailed statement of the contracts made and pending during the year is given in Appendix No. 1. The following statement gives a summary of all the contracts charged to construction from the beginning of the work to the end of 1903: —

Portion of Work.	Number of Contracts.	Approximate Amount.
Wachusett Reservoir,	31	$2,779,835 23
Wachusett Dam,	7	1,657,484 25
Relocation Central Massachusetts Railroad,	6	496,006 67
Wachusett Aqueduct and Clinton sewerage,	19	1,516,259 67
Sudbury Reservoir, the portions of contracts not performed at the time they were assumed from the city of Boston,	11	583,220 54
Sudbury Department, reservoir, filter-beds, pipe lines and improvement of Lake Cochituate, Metropolitan Water Works contracts,	22	956,508 17
Weston Aqueduct and Reservoir,	26	2,175,746 99
Distribution Department, including pipes, valves and special castings purchased for other departments,	159	4,523,456 17
Totals,	281	$14,688,517 69

Number of contracts made in 1903,	15
Number of contracts completed in 1903,	28
Total number of contracts made to December 31, 1903,	281

Amount of contracts made and assumed in 1896, including only the portions of contracts assumed from the city of Boston, performed under the direction of the Board,	$3,893,934 31
Amount of contracts made in 1897,	1,271,960 64
Amount of contracts made in 1898,	743,748 75
Amount of contracts made in 1899,	2,298,327 36
Amount of contracts made in 1900 (approximate),	1,751,176 10
Amount of contracts made in 1901 (approximate),	2,875,831 13
Amount of contracts made in 1902 (approximate),	1,521,633 19
Amount of contracts made in 1903 (approximate),	331,906 21
	$14,688,517 69
Amount of contracts completed to December 31, 1902,	$8,389,783 55
Amount of contracts completed in 1903,	2,135,939 09
	$10,525,722 64
Amount of 22 contracts unfinished December 31, 1903 (approximate),	4,674,795 05
	$15,200,517 69
Deduct for work done on 11 Sudbury Reservoir contracts by city of Boston,	512,000 00
	$14,688,517 69
Value of work done by contract to December 31, 1896,	$2,061,910 38
Value of work done by contract from January 1, 1897, to December 31, 1897,	2,647,063 53
Value of work done by contract from January 1, 1898, to December 31, 1898,	703,141 71
Value of work done by contract from January 1, 1899, to December 31, 1899,	1,206,791 72
Value of work done by contract from January 1, 1900, to December 31, 1900,	927,034 80
Value of work done by contract from January 1, 1901, to December 31, 1901,	1,067,540 70
Value of work done by contract from January 1, 1902, to December 31, 1902,	2,940,261 46
Value of work done by contract from January 1, 1903, to December 31, 1903,	2,040,664 78
	$13,594,409 08
Value of work remaining to be done on 22 unfinished contracts December 31, 1903 (approximate),	1,094,108 61
	$14,688,517 69

In the case of all contracts completed up to the present time final settlements have been made without any legal controversy. The first strike upon the works which went beyond an incipient stage or lasted more than two or three days occurred during the past year upon the Wachusett Dam, where there was a strike of the masons, which lasted eight days and involved all labor at the dam for one day and a portion of the labor for two or three days longer.

RESERVOIR DEPARTMENT.

Hiram A. Miller, *Department Engineer to September 21.*
Charles E. Wells, *Department Engineer after September 21.*

(The statement of the work of this department has been prepared by Mr. Wells.)

Several changes have been made in the organization of the engineering force during the year. Hiram A. Miller, department engineer, resigned September 21, to become Chief Engineer of the Charles River Basin Commission, and was succeeded by Charles E. Wells, division engineer. Charles A. Bowman, division engineer, has continued in charge of the force reports, measurements, estimates and miscellaneous engineering work connected with the removal of soil, and since August 1 in charge of maintenance and forestal work. Harry J. Morrison, division engineer, succeeded Mr. Wells in charge of the inspection of the removal of soil and the supervision of contractors on the Wachusett Reservoir. Ernest H. Baldwin, assistant engineer, has continued in charge of the work connected with the relocation of roads and railroads at Oakdale. Owing to the larger amount of contract and other work in progress near Oakdale this year, Mr. Baldwin's duties were considerably increased, and he was therefore advanced to the grade of division engineer from June 1 to December 1. Frederick W. Harris, assistant engineer, succeeded Mr. Morrison in charge of work at the North Dike and the construction of Section 3 of the relocated Central Massachusetts Railroad. Arthur W. Tidd, assistant engineer, in charge of work connected with the relocation of roads and removal of soil at West Boylston, resigned on March 1, and was succeeded by Edwin J. Pickwick, assistant engineer.

The total engineering force of this department has varied from 51 to 64.

The main office of this department is at Clinton. Three branch offices, two at West Boylston and one at Oakdale, have been continued throughout the year. The branch office at Sawyer's Mills was discontinued April 30, and the one near the North Dike June 30.

North Dike.

Work upon the North Dike has been in progress during the year under the contractors, Nawn & Brock, the Newell & Snowling Construction Company and McArthur Brothers Company.

The total amount of work done during the year, with the total amount to date of the portions of work not completed in previous years, is given in the following statement: —

	To December 31, 1902.	For the Year 1903.	Total to December 31, 1903.
Soil from reservoir deposited in cut-off trenches and in the dike (cubic yards),	4,508,466	256,867	4,765,333
Earth and gravel taken from borrow pits and deposited in the dike (cubic yards),	189,134	9,703	198,837
Screened gravel on the water slope of the dike as a foundation for riprap (cubic yards),	4,435	9,920	14,355

The present condition of the dike, relative to its completion, is as follows: —

At the beginning of 1903 the easterly portion of the dike was nearly completed. All the material except the riprap was placed in the dike before February 11, but on account of the difficulty of grading frozen material it was necessary to defer the finishing of the dike surface until spring; this was completed May 22. The facing of riprap on the easterly portion of the dike was completed May 16. Of the soil filling, which constitutes the principal part of the dike, 4,765,333 cubic yards have been deposited, which is 97 per cent. of the total amount required, as at present estimated.

The embankment of earth and gravel on the water slope of the dike is completed.

The depositing of screened gravel as a foundation for the riprap on the westerly portion of the dike has been completed for a distance of 5,000 feet from its easterly end, and riprap has been placed for a distance of 3,200 feet from the same point.

A day-labor force has been employed in removing property from the North Dike to the Wilson Street storage yard, grading the surface of the easterly portion of the dike at various points with surplus material, and mowing and burning weeds.

The maximum day-labor force employed at the dike was 14 men and 3 horses, for the week ending November 7.

Relocation and Construction of Roads.

Considerable work has been done on surveys and plans for the relocation of roads at the upper end of the reservoir, to take the place of those discontinued.

Nawn & Brock, under their contract for the relocation of the Central Massachusetts Railroad, have completed the new highway across the northerly slope of the easterly portion of the North Dike. The highway bridge over the Y of the railroad was constructed by the Boston & Maine Railroad, and the steel railroad bridge over the highway near the South Meadow Road by the American Bridge Company.

Surveys and plans were made for a new highway, extending from a point near Howe Street in West Boylston, on the northerly side of the reservoir, to and through Oakdale, thence southerly from Oakdale, crossing the Central Massachusetts Railroad and the Quinepoxet River, and following approximately along the line of Newton and Crescent streets to Prospect Street on the southerly side of the reservoir; also, for a highway extending westerly from that above described, at a point just south of the bridge over the Quinepoxet River, and making a connection with the portion of Holden Street which will not be discontinued.

The location of the portion of the main highway from the Central Massachusetts Railroad southerly to the southerly limit of the reservoir could not be definitely determined at the time the plans were made, as it depended upon the extent of a shallow flowage fill, consequently no precise plan of this portion of the highway could be prepared. The plans received the approval of the County Commissioners on May 26.

A part of the highway on the northerly side of the reservoir has been constructed by Auguste Saucier under his contract for excavating soil from the Wachusett Reservoir and building a road from Howe Street to Pleasant Street, in West Boylston, and is completed with the exception of the surface of broken stone, which will be placed under another contract.

Those portions of the highway between Pleasant Street and the Worcester, Nashua & Portland Division in Oakdale, and between the Central Massachusetts Railroad and the southerly limit of the shallow flowage fill in Oakdale, are in process of construction under the contract of Bruno, Salomone & Petitti; the part between the railroads has been built by day labor, and is completed with the exception of the broken-stone surface.

Masonry arches have been built over the Stillwater and Quinepoxet rivers, and steel highway bridges over the two railroads, which will be described subsequently.

Considerable progress has been made by Bruno, Salomone & Petitti in the construction of the high embankment where Worcester Street is to cross the reservoir at West Boylston Village.

So far as necessary the discontinued highways through the reservoir have been kept in condition to render them reasonably safe for travel. Some of the repairs have been made by the contractors and some by the day-labor forces of the Board.

In addition to work done on the construction of the highway at Oakdale, the day-labor forces have done a large amount of work, such as grading, seeding slopes, erecting and painting railings and guard fences along highways, repairing and planking bridges, setting stone bounds on road locations, grading and surfacing the road-bed of the new road leading from Clinton to West Boylston in the vicinity of the North Dike, and digging test pits to locate gravel deposits for use in surfacing highways; also, mowing weeds and cutting and burning brush along sides of highways, placing public watering trough at junction of Maple and Worcester streets in West Boylston, ditching and paving side drains to prevent washing of road slopes, and much other minor work.

The maximum force employed was 28 men and 3 horses, for the week ending October 24.

Removal of Soil.

Work upon the removal of soil from the reservoir has been in progress under the contractors, Nawn & Brock, the Newell & Snowling Construction Company, George M. Atkins & Co., Bruno, Salomone & Petitti, and Auguste Saucier. More detailed information in regard to each contract will be found under the head of Contracts.

The total amount of soil removed and to be removed from the Wachusett Reservoir is at present estimated to be about 6,900,000 cubic yards, from approximately 4,200 acres. Of this, the total amount removed from the reservoir in previous years was 4,835,579 cubic yards, from 2,831 acres; in 1903, 809,485 cubic yards were removed from 405.4 acres; making a total from the beginning of the work to the end of 1903 of 5,645,064 cubic yards, or 82 per cent. of the total as at present estimated, removed from 3,236.4 acres.

The above statement includes 24,504 cubic yards of soil stripped from 14.4 acres near South Clinton, under the direction of the Dam and Aqueduct Department, and deposited in temporary spoil banks within the limits of the reservoir.

The existing contracts provide for the removal of all the soil except a comparatively small quantity in and along the margins of the Oakdale mill-pond at the upper end of the reservoir.

Of the soil removed to the end of 1903, 318,780 cubic yards were used for road embankments, 404,666 cubic yards for filling shallow flowage areas, 131,781 cubic yards for railroad embankments, 24,504 cubic yards deposited in temporary spoil banks, and 4,765,333 cubic yards used for the North Dike. There have been during the year 146,267 cubic yards of earth used to cover deep muck to the depth of about 1 to 1½ feet; this amount, added to the 83,744 cubic yards used for the same purpose during previous years, gives a total of 230,011 cubic yards.

The day-labor forces under the direction of the engineering force have performed the following work: —

A large amount of miscellaneous material resulting from the destruction of buildings has been removed from the former site of the West Boylston Manufacturing Company's property at Oakdale, and either burned or placed in highway embankments; the old canal at Oakdale has been refilled. An important work was the final cleaning of the reservoir bottom on the area to be flooded up to elevation 330; the wooden bridges, ties, telegraph and telephone poles along the line of the Central Massachusetts Railroad in the district to be flooded were removed; the ties, telegraph and telephone poles were burned or sold for firewood, and the bridge lumber was either burned or hauled to a point above the flow line of the reservoir, and stored; the soil on the embankments of the railroad was cast to the foot of the slopes and covered with earth from the embankments to a depth of about 1 foot; all weeds and grass were mowed, and, together with the roots, etc., were burned over an area of 1,350 acres. A considerable force was employed for some time removing

WACHUSETT RESERVOIR — FINAL CLEANING OF BOTTOM.

stumps and driftwood from the channel of the Nashua River, between South Clinton and a point about 1 mile below West Boylston. Perennials have been pulled or grubbed on the areas in the basin from which the soil has been removed, and posts and guard rails on abandoned roads have been removed, over 100 stone monuments having been recut from old stone posts thus removed, and much other minor work has been done.

The maximum force employed was 101 men and 12 horses, for the week ending October 17.

In addition to the engineering work connected with the estimates and inspection of the removal of soil, the following work has been done: —

For the guidance of the inspectors, the organic matter in 467 samples of soil has been determined. There have been 130 construction benches established.

Relocation of Railroads.

Work upon the relocation of the railroads continued actively until June 15, when the work of construction was so far advanced that the line was opened for the running of trains. Considerable work has been done since this date to complete the work as far as it can be completed at the present time.

The contractor for Section 3, in addition to grading the main line and Y branch at and near the North Dike, has widened the embankment of the Worcester, Nashua & Portland Division for a distance of 1,700 feet westerly from Clinton Junction, and sidings have been laid on each side of the main tracks.

The Boston & Maine Railroad has furnished all of the rails and many of the ties for the new tracks, and has done the track laying; it has constructed a combined station and interlocking tower at Clinton Junction; removed and renovated the passenger station, freight house, engine house and minor buildings at Oakdale; reconstructed the water-works plant at Oakdale; and constructed the telegraph line, section houses, telegraph offices and other required appurtenances of the railroad.

Day-labor forces have performed the following work in connection with the relocation of railroads: —

Ties have been distributed for track laying for about 1½ miles easterly from Clinton Junction, and also in the vicinity of Oakdale;

11,470 feet of fence have been built; slopes have been graded and seeded; ditching and paving have been done at ends of culverts; and ½ mile of railroad right of way has been cleared of brush. At Oakdale, grading has been done preparatory to track laying; paving has been laid at various places on the railroad slopes; cellar foundations and platforms have been constructed for the station building; timber foundations have been placed for freight and engine houses; a coal bin has been constructed; a private way has been built from North Main Street to the freight house; various temporary roadways have been constructed; and the railroad bridges over Harris and Holden streets have been removed. In order to prevent undermining by the current of water, 375 cubic yards of paving have been placed at the arch bridge over the Stillwater River, requiring the excavation of 425 cubic yards of earth and the placing of 4,675 feet B. M. of spruce sheeting. The wing walls of the bridge below the water level have been grouted, 25 barrels of cement being used, and riprap has been placed on the down-stream side of the paving.

The maximum day-labor force employed was 33 men and 6 horses, for the week ending July 18.

Contracts, Wachusett Reservoir.

Contract 166, Nawn & Brock.

Excavating Soil from Section 6 of the Wachusett Reservoir, and building the Easterly Portion of the North Dike, in Boylston, Clinton and West Boylston.

The work of soil removal on this contract was substantially completed at the commencement of 1903, and was finished on January 8.

The deep deposits of muck at Dover Pond and along Muddy Brook, in the town of Boylston, have been covered with sand and gravel to the depth of about 1½ feet. This has necessitated the construction of a new channel for Muddy Brook, about 1⅓ miles in length, just outside the limits of the muck area; this channel was made 7 feet wide on the bottom, with slopes of 2 to 1. Whenever muck was encountered in the excavations for the channel, it was removed and replaced with gravel, so that the water flowing in the channel does not come in contact with muck.

Smaller areas of deep muck in kettle-holes and also on the south side of the Nashua River bottom, near the Boylston-West Boylston town line, were covered with sand and gravel to a depth varying from 1¼ to 1½ feet. A limited amount of covering, about 1 foot deep, was also placed on small areas between Sawyer's Mills and South Clinton.

In all there have been 127,993 cubic yards of sand or gravel deposited during the year as a covering over muck, which, added to the 8,353 cubic yards used for a similar purpose in previous years, makes a total of 136,346 cubic yards.

The number of carloads of soil hauled to the dike during the year has been 675, making a total of 856,291 carloads, amounting to 2,895,420 cubic yards hauled under this contract.

Earth has been deposited as needed to construct an embankment on the water side of the dike. There have been 2,742 cubic yards of earth used for this purpose during the year, which, added to the 64,672 cubic yards used in previous years, makes a total at the end of the year of 67,414 cubic yards.

The maximum amount of plant used by the contractors during 1903 included 6 12 to 16 ton locomotives, 100 3½ cubic yard dump cars and 5½ miles of 3-foot-gage track.

The total amount of work done under this contract, which was completed on October 10, has been: —

	To December 31, 1902.	In 1903.	Total.
Clearing and grubbing (acres), ...	919.6	13.867	933.467
Soil excavation (cubic yards), ...	2,909,398	11,028	2,920,426
Earth excavation (cubic yards), ...	73,153	128,531	201,684
Gravel excavation (cubic yards), ...	24,256	-	24,256

The total value of the work done, as shown by the final estimate, was $1,014,712.74.

The maximum force employed in 1903 was 169 men and 20 horses, for the week ending July 4.

Contract 210, Newell & Snowling Construction Company.

Excavating Soil from Section 8 of the Wachusett Reservoir, and building a Part of the Westerly Portion of the North Dike, in Clinton and Sterling.

On August 1, 1901, a contract was made with the Newell & Snowling Construction Company for removing soil from Section 8 to the westerly portion of the North Dike. This contract called for the removal of a sufficient amount of soil to complete the westerly portion of the dike, and also for the excavation of earth and gravel for the completion of the embankment along the water slope of the dike, and for the covering with sand or gravel of deep muck which it was not considered desirable to remove. A subsequent agreement was made with the contractors on May 13, 1903, for placing a layer of screened gravel from 6 to 18 inches in depth on the slope of the westerly portion of the dike, as a foundation for riprap. This work was commenced on May 30.

No soil has been hauled directly to the dike in carts during the year. During the early part of the season the soil removed was taken from areas in the vicinity of the West Boylston Road, above Sawyer's Mills, and was loaded into carts and thence by means of dumping platforms into cars. The cars were hauled by a locomotive to the foot of an incline having a grade of 10 per cent., thence hauled up the incline by the use of a stationary engine, and from the top of the incline hauled to the dike by locomotives. The incline and stationary engine were abandoned on September 2. During the latter part of the season the car plant was employed in a similar manner on the high ground between Sawyer's Mills and the North Dike.

By the operation of the railway and car plant, 71,861 carloads, containing 246,880 cubic yards of soil, were transported to the dike; this, added to the 108,652 carloads, containing 373,251 cubic yards, hauled during previous years, makes a total of 180,513 carloads, containing 620,131 cubic yards.

The plant consisted of 3 12-ton locomotives, 100 3 cubic yard dump cars, 1 70 horse-power hoisting engine and 5 miles of 3-foot-gage track.

The total amount of work done under this contract has been: —

	To December 31, 1902.	In 1903.	Total.
Clearing and grubbing (acres),	222.2	75.9	298.1
Soil excavation (cubic yards),	442,205	254,040	696,245
Earth excavation for embankment at dike (cubic yards),	13,372	1,543	14,915
Earth excavation for covering muck (cubic yards),	36,991	18,254	55,245
Gravel excavation for water slope of dike (cubic yards),	–	29,037	29,037
Screened gravel for foundation for riprap (cubic yards),	–	6,776	6,776

The amount of work done at the end of the year was slightly in excess of the requirements of the contract.

The maximum force employed was 175 men and 34 horses, for the week ending November 14.

Contract 246, Nawn & Brock.

Section 3 of the Relocation of the Central Massachusetts Railroad, in Clinton.

Work upon this contract was in progress at the beginning of the year, and at that time the work was substantially completed, except toward the extreme westerly portion near Clinton Junction, where a considerable amount of grading remained to be done. The whole work was finished on May 21.

The total amount of work done under this contract has been : —

	To December 31, 1902.	In 1903.	Total.
Earth excavation (cubic yards), ...	22,100	51,435	73,535
Rock excavation (cubic yards), ...	310	16	326
Soil taken from Section 6, measured in embankment (cubic yards).	53,100	1,212	54,312
Gravel for the water slopes of the embankment east of the dike, for ballast on the railroad and for surfacing the roads (cubic yards).	7,500	2,828	10,328
Screened gravel in place (cubic yards), ...	4,934	3,148	8,082
Concrete and stone masonry (cubic yards), ...	434	27.4	461.4
Cast-iron pipe in culverts (tons of 2,000 pounds), . . .	20	2.68	22.68

The amount of the final estimate was $41,983.14.

The maximum force employed was 137 men and 27 horses, for the week ending February 7.

Contract 247, George M. Atkins & Co.

Section 4 of the Relocation of the Central Massachusetts Railroad, in West Boylston.

On June 5, 1902, a contract was made with George M. Atkins & Co. for the work connected with the relocation of the railroads in and near the village of Oakdale, embracing a change in the location of the Worcester, Nashua & Portland Division, connecting curves between the two railroads, and slope paving along the railroad embankments where they will be flooded.

The material for the embankments, when not obtained from the railroad excavations, was obtained by taking the soil from the Wachusett Reservoir.

This work was commenced on June 11, 1902, and by far the larger part was completed at the beginning of 1903. The whole work was finished on August 8, 1903.

The total amount of work done under this contract has been : —

	To December 31, 1902.	In 1903.	Total.
Earth excavation (cubic yards), ...	100,654	22,428	123,082
Riprap and slope paving (cubic yards), ...	3,217	1,808.5	5,025.5
Masonry (cubic yards), ...	5	29.83	34.83
Cast-iron and sewer pipe culverts, 12 to 20 inches in diameter (linear feet), ...	70	109	179

The amount of the final estimate was $48,112.82.

The maximum force employed was 72 men and 30 horses, for the week ending April 18.

Contract 257, Bruno, Salomone & Petitti.

Section 10 of the Wachusett Reservoir, in Boylston and West Boylston.

On December 27, 1902, a contract was made with Bruno, Salomone & Petitti for the construction of what is known as Section 10 of the Wachusett Reservoir. This contract calls for clearing, grubbing and excavating soil from some 700 acres toward the upper end of the Wachusett Reservoir. It includes substantially all of the soil stripping westerly from that provided for under the contracts of Nawn & Brock and the Newell & Snowling Construction Company, and southerly from that provided for under the contract of George M. Atkins & Co. for constructing Section 4 of the Central Massachusetts Railroad. In addition, the contract provides for excavating earth and gravel from shallow portions of the reservoir at Oakdale; enlarging a portion of the channel of the Quinepoxet River, west of the Worcester, Nashua & Portland Division of the Boston & Maine Railroad; building a concrete dam across the Quinepoxet River, at the upper end of this channel; excavating gravel to obtain material for protecting the slopes of embankments; excavating — chiefly in rock, to a maximum depth of about 50 feet — a new channel for the Nashua River at the highway crossing the reservoir at West Boylston; and paving the slopes of embankments and the bottom and slopes of the new channel of the Quinepoxet River.

The excavated soil and other materials are deposited to fill a portion of the reservoir at Oakdale which would otherwise be very shallow, to build the embankment for a highway across the reservoir at West Boylston, and for embankments of other highways across and near the reservoir at Oakdale.

The preliminary estimate called for clearing and grubbing 100 acres; excavating 970,000 cubic yards of soil, 135,000 cubic yards of earth and 15,000 cubic yards of rock; laying 23,500 cubic yards of paving, and building 1,200 cubic yards of concrete masonry.

The contractors began the work of installing plant on January 16.

The soil from limited areas in the vicinity of the shallow flowage and highway embankments has been loaded into carts and deposited directly in the embankments. Soil from the comparatively level areas above and below West Boylston Village has been loaded directly into cars. On other portions of the work, where this method was impracticable, it was loaded into carts and thence by means of dumping platforms into cars. Soil transported by means of locomotives and cars has been deposited in shallow flowage embankments at Oakdale and highway embankments at Oakdale and West Boylston. Soil was first removed by carts on March 24, and by cars on April 14.

The contract provided for the use by the contractor of about three miles of the road-bed and tracks of the old location of the Central Massachusetts Railroad as soon as the running of trains by the railroad company ceased. It was expected that the running of trains would cease in the spring, and the contract provided that the contractor should receive a compensation of $40 per day for each and every day after June 1, 1903, that he was not permitted to use this portion of the railroad. It became evident in the spring that there would be some delay in the completion of the new line of the Central Massachusetts Railroad, and the contractor therefore built an independent railroad from Oakdale to a point below West Boylston. He was first permitted to use the Central Massachusetts Railroad on June 15, and he proceeded promptly to change the road from broad to narrow gage, and to excavate soil from the easterly portion of the territory included in his contract north of the railroad.

The total number of carloads hauled has been 138,543, amounting to 429,617 cubic yards.

Of the soil removed under this contract, 116,925 cubic yards were used in road embankments near Oakdale and West Boylston, and 379,336 cubic yards were used in shallow flowage embankments. A considerable quantity of earth has been excavated from the shallow flowage areas and the new channel for the Quinepoxet River at Oakdale and placed on the slopes of the embankments. About one-third of the rock has been excavated from the new channel for the Nashua River at West Boylston. The placing of slope paving on the highway and railroad embankments is also about one-third finished.

The plant used by the contractor included 7 10 to 12 ton locomotives, 80 2½ cubic yard dump cars, 40 3 cubic yard dump cars, 40 3½ cubic yard dump cars and 8.4 miles of 3-foot-gage track.

The total amount of work done under this contract has been : —

Clearing and grubbing (acres),	66.7
Soil excavation (cubic yards),	496,261
Earth excavation (cubic yards),	38,463
Rock excavation (cubic yards),	4,917
Slope paving (cubic yards),	8,362

The amount of work done at the end of the year was considerably in excess of the requirements of the contract.

The maximum force employed was 459 men and 72 horses, for the week ending October 17.

Contract 264, The George M. Atkins Company.

Constructing Arch Bridges and Abutments at Oakdale.

On April 16, 1903, a contract was made with the George M. Atkins Company for the construction of masonry arch bridges and abutments at Oakdale. This contract called for the construction of a 3-arch stone and concrete masonry highway bridge over the Quinepoxet River, a single-arch stone and concrete masonry highway bridge over the Stillwater River, and stone and concrete masonry abutments for two steel highway bridges, one over the tracks of the Central Massachusetts and Worcester, Nashua & Portland divisions of the Boston & Maine Railroad, and the other over the tracks of the Central Massachusetts division only. The work

WACHUSETT RESERVOIR — CONSTRUCTING NEW CHANNEL FOR RIVER AND HIGHWAY EMBANKMENT ACROSS RESERVOIR AT WEST BOYLSTON.

also included the building of concrete masonry retaining walls connected with the bridges, and the excavation of such material as might be necessary in order to prepare foundations for the bridges and retaining walls and to make a new channel for the Stillwater River.

Work was commenced on May 16, and was substantially completed on December 23.

The total amount of work done under this contract has been: —

Earth excavation (cubic yards),	2,824
Rock excavation (cubic yards),	896.2
Portland cement concrete masonry (cubic yards),	3,190.75
Stone masonry in abutments (cubic yards),	1,098.74
Ashlar masonry (cubic yards),	219.24
Dimension stone masonry (cubic yards),	119.06
Face dressing of pointed work (square feet),	2,961

The value of the work, as shown by the final estimate, was $38,578.22.

The maximum force employed was 45 men and 6 horses, for the week ending October 3.

Contract 268, McArthur Brothers Company.

Placing Riprap on the Westerly Portion of the North Dike, in Clinton and Sterling.

On May 16, 1903, a contract was made with the McArthur Brothers Company for using as riprap, on the westerly portion of the North Dike, granite to be excavated from the waste channel of the Wachusett Dam and in preparing the foundations for the dam, and a comparatively small amount of granite already excavated. The riprap consists of an inner layer of stones, each containing 1½ cubic feet or less, and an outer layer of stones, each containing more than 1½ cubic feet, placed upon a foundation of screened gravel on the slope of the embankment for its protection against the action of waves. The placing of the screened gravel is not included in this contract. The contract provides for the placing of about 46,840 cubic yards of the lighter and about 19,350 cubic yards of the heavier riprap. The stones are loaded into "skips," which are placed on cars by means of derricks. The cars are hauled by a locomotive, over a 3-foot-gage track, to the westerly portion of the dike, where the skips are again lifted by a derrick, and the stones deposited on the water slope. Some additional work is done by laborers to place the stones to the required line and grade. Work under this contract was commenced on June 18, and has continued to the end of the year.

The total amount of riprap placed to December 31 was 15,751 cubic yards, which is about one-half of the quantity required at that date under the contract.

The maximum force employed was 52 men, for the week ending June 13.

Contract 269, Auguste Saucier.

Excavating Soil from the Wachusett Reservoir, and building a Road from Howe Street to Pleasant Street, in West Boylston.

On June 11, 1903, a contract was made with Auguste Saucier for excavating soil from the Wachusett Reservoir and building a road from Howe Street to Pleasant Street, in West Boylston. The contract also covered the making of a small shallow flowage embankment, and the construction of culverts on the relocation of Worcester Street near the South Boylston Station on the Worcester, Nashua & Portland Division of the Boston & Maine Railroad. The soil removed from the reservoir was used in the construction of the highway and shallow flowage embankments.

Work on this contract was commenced on June 23, and completed on October 17.

The principal quantities of work performed were as follows: —

Earth excavation (cubic yards),	37,687
Rock excavation (cubic yards),	1,184
Slope paving (cubic yards),	194.6
Rubble masonry laid dry (cubic yards),	5.76
Rubble masonry laid in mortar (cubic yards),	85.37
Split stone masonry laid in mortar (cubic yards),	47.57
5-inch side drains (linear feet),	2,972
Sewer pipe culverts, 12 to 20 inches in diameter (linear feet),	661.9

Of the earth excavation given above, 8,497 cubic yards were soil removed from the Wachusett Reservoir, a large portion of which was used for dressing the slopes of the embankments.

The amount of the final estimate was $12,384.35.

The maximum force employed was 84 men and 44 horses, for the week ending July 4.

Contract 270, Eastern Bridge and Structural Company.

Steel Highway Bridges at Oakdale, West Boylston.

On June 16, 1903, a contract was made with the Eastern Bridge and Structural Company for the construction of two steel plate-girder highway bridges for the over-grade highway crossings of the Worcester, Nashua & Portland and Central Massachusetts divisions of the Boston & Maine Railroad, at Oakdale.

The work of erection was commenced on October 23, and completed on December 8.

The amount of the final estimate was $4,198.

Improving the Wachusett Watershed.

The following work has been done by a day-labor force, for the improvement of the sanitary condition of the watershed: —

Some drainage ditches have been constructed northwest of Sawyer's Mills, and also on the northerly slope of the reservoir near the Keyes place. Old cellars and areas around buildings have been cleaned up at Oakdale. A cesspool has been constructed at the Cutting place at Oakdale. Privies at Dorr's Mills have been reconstructed. Filter-beds have been graded for sewage disposal at the Worcester County Truant School at Oakdale, and a pipe has been laid from the school buildings to convey the sewage to the filter-beds.

The maximum day-labor force employed was 20 men, for the week ending October 3.

Land Surveys.

Surveys and plans of several properties have been made for the use of the Attorney-General and for the conveyancers of the Board.

Forestry.

The work of cutting out fruit and dead or undesirable trees, preparatory to planting, has been done over about 200 acres. The work of cutting out interior cart roads 15 feet wide has been continued; new cart roads have been graded, drained or improved for a length of 7½ miles, covering nearly all the roads called for by the forestal plan of the territory east of West Boylston; the necessary culverts on these roads were also constructed. An area of about 270 acres, mostly pasture land, has been planted with white pine seedlings. On the open portions of this area, chestnut, maple, and oak seedlings were used as fillers; on other portions, which were somewhat grown up with small brush, hickory nuts and acorns have been planted, for the purpose of providing fillers. In doing this work, 117,000 pine, 258,500 maple, 3,500 oak and 700 chestnut seedlings were planted, also about 3 bushels of hickory nuts and ½ bushel of acorns. White pines from the nursery were planted at intervals of 40 feet along the sides of public roads for a distance of 12½ miles; 1,600 trees were used in this way on the road between the dike and West Boylston, along Boylston Street between Mile Hill and Boylston Centre, and along the Shrewsbury Road. The necessary care has been given to the Lamson and Flagg nurseries during the year. These nurseries now contain 289,218 two and three year old pines. Eighty-four thousand natural seedling sugar maples have been taken up and heeled in at the Lamson nursery for spring planting. The seed beds at the Flagg nursery contain, approximately, 42,000 white pines, 14,000 Norway spruce, and from 300,000 to 400,000 arbor vitæ, sowed in May, 1903.

Engineering.

In addition to the engineering work already enumerated and that necessarily connected with the contract and day-labor work in progress, the engineering force of the Reservoir Department has performed the following work: —

Levels of the ground at the Wachusett Reservoir, taken after the completion of the excavation, have been entered on record sheets, and contour lines have been drawn, covering an area of some 550 acres, making a total area of 2,070 acres covered by these final records at the end of the year. Measurements have been made from these sheets, covering an area of 700 acres, for the purpose of determining the capacity of the reservoir, making a total area covered at the end of the year of 1,700 acres. Curves were plotted and tables prepared showing the capacity of the reservoir at each tenth of a foot, between elevations 285 and 305. Gage readings were taken twice in each month, to determine the heights of the storage reservoirs in the Wachusett watershed. Surveys and investigations were made in connection with the settlement of claims made by the Bigelow Carpet Company and Clinton Worsted Company for damages caused by the diversion of water and otherwise. Surveys were made of the Beaman Cemetery, preparatory to the removal of bodies to a lot adjoining the cemetery at West Boylston. Investigations have been made relative to the North Woods property of the West Boylston Manufacturing Company. An inventory has been made of the bridges, tracks, etc., on the Central Massachusetts Railroad between South Clinton and Oakdale, and considerable work has been done on various accounts between the Boston & Maine Railroad and the Board. Plans have been made showing the new location of the American Telephone and Telegraph Company and the New England Telephone and Telegraph Company lines, and work has been done preparatory to settlement between the telephone companies and the Board. Much other minor engineering work has also been done.

DAM AND AQUEDUCT DEPARTMENT.

(The statement of the work of this department has been prepared by Thomas F. Richardson, Department Engineer.)

The principal work in this department has been the construction of the Wachusett Dam and of a portion of the relocated line of the Central Massachusetts Railroad, the placing of riprap on the North Dike and the removal of soil from the Wachusett Reservoir near South Clinton. The department has also had charge of the operation of the Wachusett Aqueduct and the Clinton sewage-disposal system.

The organization of the force has continued practically the same as during the previous year. Chester W. Smith, division engineer, continued in charge of the work of the Wachusett Dam; and Moses J. Look, division engineer, has had charge of the construction of the railroad, of the removal of soil near South Clinton, of the rebuilding of the Lancaster Mills dam and of investigations for the South Dike. The work in the drafting office is in charge of Allen E. Shannan. Elliot R. B. Allardice has continued in charge of the river and aqueduct gagings, and has direct supervision of the maintenance of the Clinton sewage-disposal plant.

The engineering force has averaged 22 men for the whole year. There were also 7 masonry inspectors.

The main office of the department is in Clinton, and a branch office has been maintained near the Wachusett Dam.

Wachusett Dam.

The design of the Wachusett Dam, and the contract for its construction, which was made with the McArthur Brothers Company on October 1, 1900, were described in the annual report of January 1, 1901. The plant provided for the work and the methods of carrying on the work both at the quarry and at the dam were fully described in the annual report of January 1, 1902, and there has been no material change in the plant or in the methods.

The work has been carried on throughout the year, although work upon the masonry was suspended on account of cold weather from January 8 to March 21, and from December 8 to the close of the year. The progress on the work has been good, and rather more has been accomplished than during the previous year, although the work is still considerably behind the requirements of the contract, which provides that the whole work shall be finished on November 15, 1904.

Industrial conditions have been more favorable than during 1902, and sufficient supplies of all kinds have been readily obtainable. It has been difficult at times to obtain a sufficient number of masons.

On Monday, July 13, all the masons employed at the dam struck for higher wages, and for one day forced all work to stop; but as soon as sufficient police protection was provided, the laborers employed on excavation and at the quarry returned to work. On Tuesday, July 21, nearly all the masons returned to work at the rate of wages paid previous to the strike.

Main Dam and Gate-chambers.

At the beginning of the year, work on the masonry of the dam was still in progress. It was suspended on January 8, at which time the dam was built across the lower part of the valley for a length of 476 feet; and the average elevation of the top was 304, or 38 feet above the original river bed. There was a gap through the masonry at the site of the large flume, through which any water not diverted into the aqueduct could overflow. This gap was about 40 feet wide, and for this distance the masonry of the dam was built only to elevation 283. The flow of water was still regulated at the temporary dam. A part of the small flume was in use to convey the water to the 48-inch pipes through the masonry dam, by which it could be turned into the Wachusett Aqueduct, but not into the river below the dam. The large flume had been removed, except the portion through the temporary dam and a part of that below the main dam, and the latter was being removed. The 24-inch pipe supplying water to the Lancaster Mills passed through the gap in the main dam.

The excavation of earth and rock on the hillsides, to prepare a foundation for the dam with sufficient rapidity to accommodate the increasing length of the masonry as it was built up, has been a serious problem throughout the year. It has necessitated the use of the cableways in the daytime and sometimes at night during the winter, when the work upon the masonry was suspended, and at night during the remainder of the year, when they were fully occupied in the daytime in conveying stone and mortar for the masonry. There have been further complications at the easterly end, owing to the situation of the tracks and head towers of the cableway, which have added to the difficulty of this work.

Excavation and Incidental Work, Easterly End of Dam. — As soon as masonry work was suspended in January, work preparatory to moving the tracks over which stone is transported from the quarry to the cableway was begun, and later they were placed as near as possible to the cableway towers, to permit the extension of the excavation at the easterly end of the dam. This excavation was begun on January 29, and was continued with a day force until March 21, when work on the masonry of the dam was resumed. Night work on this excavation was commenced early in March, and was continued until October, when the excavation had been extended 105 feet easterly, and further extension was impossible until the quarry tracks were removed. The earth overlying the rock had a depth of between 30 and 40 feet. It was a boulder clay so hard and compact that at the end of the excavation adjoining the quarry tracks it was possible to excavate to a slope of 1 horizontal to 2 vertical, and this notwithstanding that the tracks were on the edge of the excavation, and heavy train loads of stone were brought over them to the dam.

The rock laid bare by this excavation was a soft, black schist, practically impervious to water. The average depth of the excavation in the portions of this rock which have been excavated this year was about 8 feet; a cut-off trench 20 feet wide was excavated to an additional depth of about 15 feet.

The earth and rock taken from this excavation have been removed largely by the aid of the cableways, and deposited on the down-stream side of the dam, for the purpose of grading near the lower gate-house and conduits to the pool. Much of the clayey earth, however, has been dumped against the up-stream face of the dam.

After masonry work was suspended on December 8, the tracks of the contractor's railway were removed from across the site of the dam, and the work of excavation for the easterly end of the dam was resumed. At the end of the year considerable progress had been made in excavating the clayey earth from beneath the former location of the tracks and from between the head towers of the cableways. Most of the earth removed was passed by derricks to the cableways, and disposed of in the same way as that from the earlier excavation at this end of the dam. That taken from between the cableway towers was deposited back of the towers to form a road-bed for the tracks which are to carry the towers after the span of the cableways has been lengthened.

Plans have been made for increasing the span of both cableways from 1,150 to 1,250 feet, and for other modifications of the plant. In accordance with these plans, the head towers will be moved back and will be raised about 21 feet; the length of the tracks on which the towers can travel up and down the valley will be reduced from 500 feet, as originally constructed, to about 150 feet. The quarry tracks are to be carried across the easterly end of that part of the dam already built, on a trestle about 25 feet high.

A trench in which to build a portion of the core wall which will form the easterly extremity of the dam was excavated back of the cableway tracks in September and October. This trench extended to the schist rock, and had a maximum depth of about 50 feet. It was excavated with vertical sides, and but little wider than the wall to be built in it. The new tracks for the cableway towers are to pass over this portion of the core wall.

Excavation, Westerly End of Dam. — Excavation at this end of the dam was resumed as soon as masonry work was suspended in January, and was continued with a small force for most of the year. The earth was excavated by a night force, and dumped, by means of the cableways, above the dam on the westerly side of the valley; the rock was excavated by a day force, loaded on cars by derricks and hauled to the North Dike for use as riprap. During the year the excavation for the dam has been extended about 215 feet westerly, and the excavation for this end of the dam is practically completed to the beginning of the waste-weir, with the exception of drilling and excavating about 25 feet of the cut-off trench. The sand and gravel overlying the rock had an average depth of about 20 feet. The rock at this place was a hard, brittle granite, somewhat seamy, especially near the surface. The excavation was carried to a sufficient depth to reach rock practically free from seams, the average depth of excavation in the rock being about 15 feet, and in the cut-off trench about 15 feet additional.

In excavating the cut-off trench on both sides of the valley the method adopted in previous years, of drilling 3-inch holes 6 inches apart on both sides of the trench, was followed.

Masonry. — As previously stated, the construction of the masonry of the dam was resumed on March 21 and was suspended on December 8, at which time the top of the masonry was at elevation 345, or about 79 feet above the original river bed, and about 137 feet above the lowest point of the foundation not in the cut-off trench. The masonry has been extended during the year for about 105 feet easterly and 158 feet westerly, and the length of the dam at the suspension of masonry work was 739 feet.

On March 27 the laying of masonry in the gap was begun ; it was several times interrupted by high water, and the gap was not closed until early in May. The top of this part of the dam was, however, kept at a lower elevation than elsewhere until September, after which the storage capacity behind the dam was sufficient, with the aid of the waste pipes, to control any probable freshet.

Short masonry cut-off walls have been built at both ends, to make connections from the up-stream face of the dam to the ledge rock at the side of the excavation, and thus prevent a flow around the ends of the dam when the water rises in the reservoir. The top of the wall at the easterly end is at elevation 338, and of that at the westerly end at elevation 342.

A section of rubble masonry core wall, 62 feet in length, was built in the trench excavated back of the cableway towers at the easterly end of the dam, and was finished on November 23. This core wall, which forms the extreme easterly end of the dam, is founded on the schist rock. Its easterly end abuts against compact clayey earth.

Above the earth filling, on both the up-stream and down-stream sides, the dam has been faced with ashlar built generally in 2-foot courses with ½-inch joints, and the top of the ashlar is now at about elevation 345.

Ports or openings have been built in the upper gate-chamber to admit water to the 48-inch pipes through the dam, the elevation of the bottom of the lowest port being 330, which is the lowest elevation from which water will be drawn from the reservoir when the dam is finished. At the lower gate-chamber the main walls have been raised about 3 feet, several retaining walls have been built and the concrete floors of the basement and coal vault have been constructed, substantially completing the concrete masonry of the substructure.

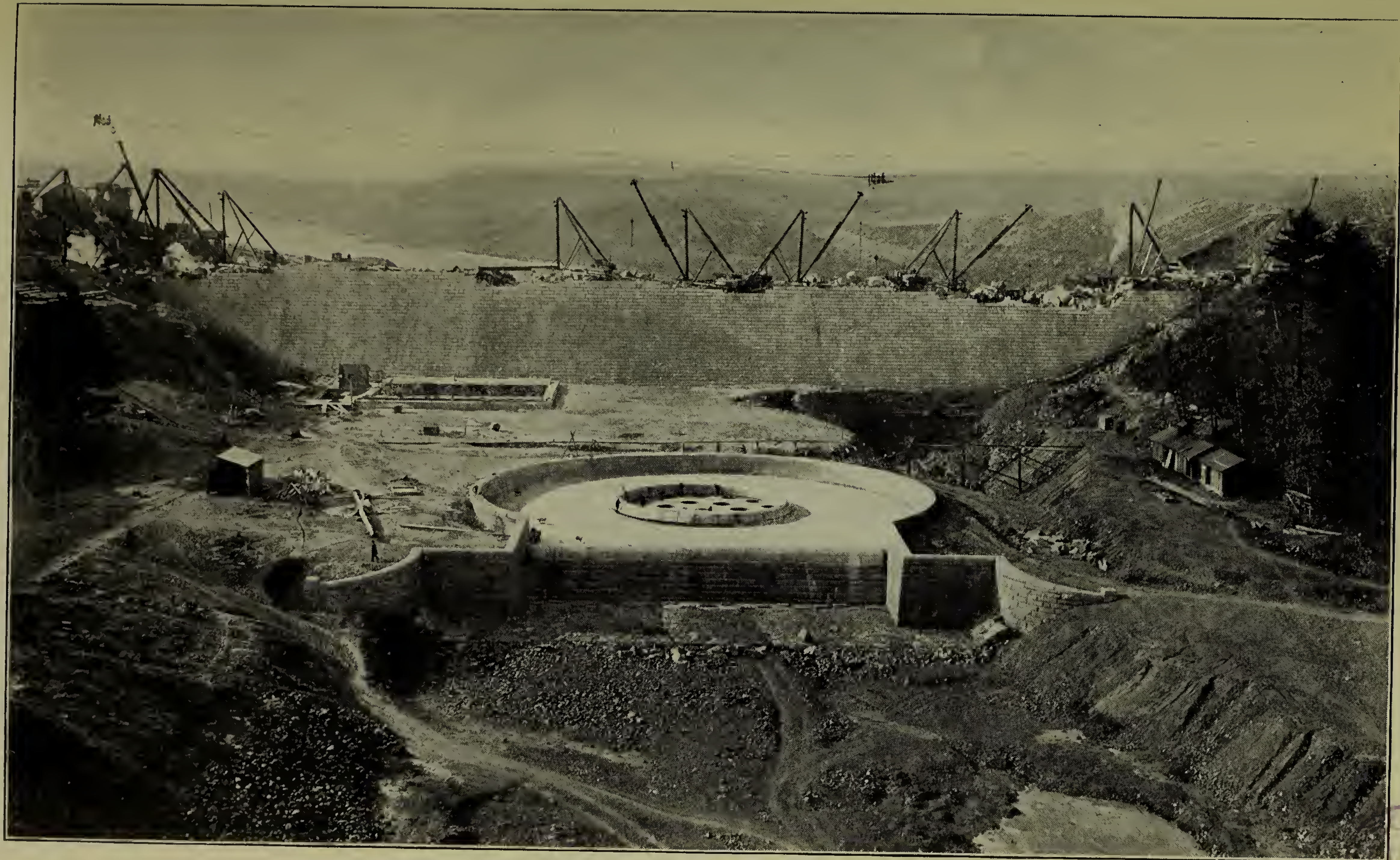
Waste Conduits, Pool and Spillway.

The four parallel 10-foot concrete waste conduits from the lower gate-chamber were constructed in 1902, and were described in the last annual report. They discharge into two concentric conduits, which form the substructure of the inner pool, and connect the two outer and two inner waste conduits, respectively. The roofs of these concentric conduits are pierced by large holes, through which the waste water will be discharged into the inner pool at low velocities; the outer circular conduit has 12 holes each 6 feet in diameter, and the inner conduit has 7 holes each 7 feet in diameter and 2 holes each 6 feet in diameter. The areas of the conduits are reduced as the holes in the top are reached, in such a manner that the water will be forced through all the holes at nearly equal velocities.

The inner pool, into which the water will rise through the holes in its bottom, is 56 feet in diameter, and surrounded by a stone curb 4 feet in height. The outer pool is concentric with the inner, and is 150 feet in diameter, and its floor is at the same level as that of the inner pool. It is surrounded by a retaining wall 7 feet in height, except on the down-stream side, where there is a spillway 110 feet long, over which the water will flow to the river below the dam.

This arrangement of discharge outlets, with the spillway and coping of the inner pool above the level of the backwater from the Lancaster Mills dam, makes it possible to obtain access to the conduits and waste gates at any time by merely pumping out the conduits, without the use of stop-planks or bulkheads.

The inner pool and the floor of the outer pool are constructed wholly of Portland cement concrete. Both floors are covered with a



WACHUSETT DAM WITH POOL AND SPILLWAY, AT END OF 1903.

granolithic surface 1 inch thick, composed of 1 part Portland cement and 1½ parts of coarse sand, trowelled hard and smooth on top. The retaining wall around the outer pool is also built of Portland cement concrete, but is faced with stone masonry with a face dressing of fine-pointed work. The spillway and the curved retaining walls at its ends are of quarry-faced ashlar, backed with rubble-stone masonry. The top surface of the crest stones of the spillway, which are curved in profile, is fine-pointed. These crest stones are nearly 6 feet long, and are all anchored to the concrete with ⅞-inch anchors.

During 1902 the waste conduits, some of the lower courses of the spillway and part of the pool were constructed; so much of the pool being then built as would serve, in connection with a wooden flume, to convey the water discharged by the four 48-inch pipes through the dam to the river below the spillway. During the latter part of March the wooden flume, which had a width of 40 feet and sides 8 feet in height, was constructed, connecting the masonry of the pool with that of the spillway; and after March 28 the surplus water of the river was, as far as possible, discharged through the 48-inch pipes and the flume, or the Wachusett Aqueduct, instead of through the gap in the dam. No water passed through the gap after April 11. On July 2, work was commenced on the curved retaining wall at the westerly end of the spillway, and was continued with 1 and 2 derricks until November 21, when the spillway, the curved retaining walls at both ends, the circular retaining wall around the outer pool, and the circular stone curb around the inner pool were finished.

On August 20, when the flow of the river was so small that it could all pass through the Wachusett Aqueduct, the flume was removed and work was commenced upon the concrete masonry of the inner pool, which was finished on November 14.

The inner pool, the spillway and the retaining walls at the ends of and below the spillway are founded directly on the old river bed, but under the circular retaining wall and the floor of the outer pool there is a filling of earth about 11 feet deep. Great care was taken in making this filling, selected gravel, free from stones over 3 inches in diameter, being spread in thin layers, which were watered and thoroughly rammed or rolled with a heavy grooved roller. Much of the material used for filling under the outer pool was obtained from the waste channel, but part of it was obtained from the excavations made to allow the placing of riprap around the pedestals for the railroad viaduct in the river bottom, and some from borrow-pits near the lower gate-chamber.

Waste Channel and Waste-weir.

Early in January earth excavation was commenced in the upper part of the waste channel and was continued until April. Most of the material excavated was used in the embankment for the temporary location of the Central Massachusetts Railroad. During August and September a considerable force of men and teams was engaged in excavating earth from the lower part of the waste channel, the material being hauled to the fill under the outer pool. A considerable amount of earth still remains to be removed, but it is situated largely under the tracks of the cableways or under the temporary track of the Central Massachusetts Railroad, and most of it cannot be excavated until the location of these tracks is changed.

Rock excavation was commenced early in August at the lower end of the waste channel, and has been continued with a small force to the end of the year. The rock excavated was at first used for riprap around the pedestals of the viaduct over the Nashua River, but was later hauled by means of a stationary engine up an incline about 600 feet long, the grade of which for about 400 feet was 14 feet per 100, and from the head of the incline was hauled by a locomotive to the westerly portion of the North Dike, a distance of nearly 2 miles, to be used as riprap. The rock has been excavated for about 280 feet at the lower end of the channel.

At the site of the waste-weir the earth has been excavated for nearly the whole length of the weir. The rock uncovered is generally freer from seams than that encountered in the lower part of the valley, and it will be necessary to excavate but very little of it to obtain a suitable foundation for the masonry. Detail plans of the masonry of the waste-weir have been prepared, and a considerable amount of the ashlar and dimension stone has been cut.

Amount of Work done and of Materials used.

The following table gives the amount of work done to the end of 1901, the amount of work done during 1902 and 1903, the total amount of work done to the end of 1903 and the total estimated amount required by the contract: —

	To December 31, 1901.	In 1902.	In 1903.	Total to December 31, 1903.	Total Estimated Amount.
Earth excavation (cubic yards), ...	43,000	31,900	68,800	143,700	267,300
Rock excavation (cubic yards), ...	24,370	12,020	18,800	55,190	100,000
Rubble stone masonry (cubic yards), . .	28,486	65,686	69,139	163,311	265,000
Ashlar masonry (cubic yards), ...	65	684	2,015	2,764	10,300
Dimension stone masonry (cubic yards), .	–	58	417	475	2,900
Brick masonry (cubic yards), ...	–	407	231	638	1,300
Concrete masonry (cubic yards), . . .	–	5,284	1,906	7,190	8,300
Iron and other metal work (tons), . .	–	582	71	653	1,000

The number of barrels of cement used in the work at the dam has been as follows: —

	To December 31, 1901.	In 1902.	In 1903.	Total to December 31, 1903.
Portland cement, ...	17,703	21,865	18,719	58,287
Natural cement, ...	8,892	52,896	51,533	113,321

Of the cements used during 1903, all of the natural cement has been of the Union brand, and all of the Portland cement, except 170 barrels, has been of the Giant brand, both cements being manufactured by the American Cement Company of Egypt, Pa.

The amount of cement used in the dam per cubic yard of each class of rubble masonry from the beginning of the work has been as follows: —

Composition of Mortar by Measure.	Barrels of Cement per Cubic Yard.	Cubic Yards built.
1 part natural cement to 1 part sand, ...	1.43	184
1 part natural cement to 2 parts sand, ...	0.99	111,718
1 part Portland cement to 2 parts sand, ...	1.08	25,855
1 part Portland cement to $2\frac{1}{2}$ parts sand, ...	0.86	8,926
1 part Portland cement to 3 parts sand, ...	0.76	14,836

The amount of cement used in the dam per cubic yard of each class of concrete masonry has been as follows: —

Composition of Concrete by Measure.	Barrels of Cement per Cubic Yard.	Cubic Yards built.
1 part natural cement, 2 parts sand and 5 parts stone, ...	1.36	726
1 part Portland cement, $2\frac{1}{2}$ parts sand and $4\frac{1}{2}$ parts stone, ...	1.43	5,517
1 part Portland cement, 3 parts sand and 6 parts stone, ...	1.06	947

Miscellaneous Notes.

All masonry built before April 6 and in the latter part of the season, in places where it was likely to be exposed to the action of frost, was laid in Portland cement mortar, mixed in the proportion of 3 parts of sand to 1 part of cement. After November 13 all masonry was so laid, and after November 16 the sand and water were heated and salt was added to the mortar in the proportion of 4 pounds of salt to each barrel of cement. The methods adopted for laying masonry in cold weather were described in the last annual report. Between April 6 and November 13 most of the masonry was laid in natural cement mortar, except in the cut-off trench, in other places immediately above the ledge rock, and in the upper gate-chamber, where Portland cement mortar, composed of 2 parts of sand to 1 part of cement, was used as heretofore.

The largest amount of rubble masonry laid in the dam during any week was during the week ending August 1, when 7 derricks were in operation on rubble masonry, and 2,612 cubic yards were laid. During that week considerable ashlar masonry was also laid.

The building of concrete masonry has been done almost entirely in the daytime, instead of at night as during the previous year, and the concrete has been mixed by hand.

The maximum force employed by the contractor, including the men employed at the Chelmsford quarry, was during the week ending September 26, when 764 men and 51 horses were employed.

The stone for rubble masonry is still obtained from the quarry about 1½ miles from the dam, which has been described in previous reports. During 1902 considerable difficulty was experienced in obtaining a sufficient quantity of stone for the ashlar masonry ; and, as this trouble would increase as the dam was built to higher elevations, it was decided to obtain stone for this work from some other source.

During the latter part of March and early part of April several quarries in southern New Hampshire and northeastern Massachusetts, which were accessible by rail, were visited ; and on April 20 arrangements were made for the use of the quarry of H. E. Fletcher & Co. at West Chelmsford, Mass., and since that date this quarry has furnished all stone used in the ashlar and dimension stone masonry. The stone is a gray granite, very similar in appearance to the stone from the quarry near the dam. About 175 men have been employed at the Fletcher quarry.

During June there was an exceptionally heavy rainfall, the record at Clinton for the two weeks ending June 22 being 11.78 inches, and the average for the whole watershed 10.28 inches. During the last two days of this period the rainfall was nearly 4 inches. The largest rainfall in a single month on the Sudbury watershed for the previous twenty-seven years was 10.68 inches, in October, 1895. Owing to this heavy rainfall the flow of water in the Nashua River reached a maximum rate of 1,900,000,000 gallons per twenty-four hours, while the capacity of the four 48-inch pipes through the dam was 800,000,000 gallons per twenty-four hours.

Previous to this time, water had been allowed to accumulate above the dam to a height of 4 feet below the lowest point in the masonry. The increased flow of the river caused the water to rise to a height of 5 inches above the lowest point in the masonry; and to prevent water flowing over the dam, a sand-bag dam was built. No serious damage would have resulted, however, if the water had been allowed to overflow.

The height of the water in the river was regulated at the temporary dam until April 19, and since that time it has been regulated by the gates in the lower gate-chamber of the dam, although for a few days in October and November the temporary dam was again used while parts of the two flumes and other temporary works were being removed. The removal of all the temporary works which it is feasible to remove was completed on November 7.

On April 19 the 24-inch pipe used for supplying water to the Lancaster Mills was connected with one of the 48-inch pipes in the lower gate-chamber by a smaller temporary pipe, which is carried along the lower face of the dam, and was suspended for a distance of 55 feet across the gap in the dam by steel rods fastened at their upper ends to high posts at the sides of the gap. Previous to this time the 24-inch pipe passed through the gap, and it was necessary to remove it in order to build the masonry. The pipe where it crossed the gap is now supported on the masonry of the dam.

Rebuilding Lancaster Mills Dam.

A part of the dam of the Lancaster Mills was removed in 1897 so as to draw off the water of the mill-pond, which was fully 20 feet deep at the site of the Wachusett Dam. An opening about 25 feet wide was carried nearly to the bottom of the dam, and it was given an additional width of 55 feet for 14 feet below the top of the dam. Work at the Wachusett Dam having so far advanced that the pond if filled would not interfere with operations there, and the water supply for the Lancaster Mills being more certain with the dam rebuilt, a contract for rebuilding the dam was let to William H. Ward of Lowell on October 3. Work was begun promptly and carried on energetically until its completion on November 19. The maximum force employed was 32 men and 8 horses, and the total amount of the contract was $5,421.47. A 12-inch pipe, with a suitable valve, was built through the masonry of the dam, for use in draining the mill-pond, the elevation of the bottom of the pipe being 272.0, or 15.6 feet below the crest of the dam.

Relocation of the Central Massachusetts Railroad.

The route adopted for the relocation of the Central Massachusetts Railroad and the work to be done were described in the last annual report. At the beginning of the year work was in progress on all the contracts which were under the direction of this department.

Section 1, Crary Construction Company.

Date of contract, May 26, 1902; amount of contract, $40,908.81; length of section, 7,740 feet.

This section is partly in Berlin and partly in Clinton, and extends from the end of the iron bridge at West Berlin to a point near the middle of a swamp a short distance easterly from the tunnel. At the beginning of the year all masonry work had been completed, but there remained a considerable amount of earth and rock work still to be done. Work was continued by the contractor until April 30, when the work was completed. The maximum force employed was 85 men and 10 horses, for the week ending January 3.

The principal quantities of work performed were as follows: —

Earth excavation (cubic yards),	18,276
Borrowed earth (cubic yards),	26,562
Rock excavation (cubic yards),	16,648
Concrete masonry (cubic yards),	727
Split stone masonry (cubic yards),	114
Dimension stone masonry (cubic yards),	33
Dry paving (cubic yards),	46

Section 2, McArthur Brothers Company.

Date of contract, April 18, 1902; amount of contract, $270,000; length of section, 5,860 feet.

This section is in Clinton, and extends from a short distance easterly from the tunnel to a point about 700 feet east of the easterly end of the North Dike. The principal work under this contract included the excavation of a tunnel for a distance of about 1,080 feet; the construction of 32 masonry pedestals and 2 abutments for the steel viaduct across the valley of the Nashua River, west of the tunnel; the excavation of the long and deep rock cut through the side of the hill west of the river; and the building of embankments with material from the tunnel, from the waste channel of the Wachusett Dam and from the cuts west of the river.

The contract also provided that most of the rock from the deep cut should be placed as riprap on the water side of the easterly portion of the North Dike, as described in the last annual report.

The excavation of the headings, which comprised the upper third of the tunnel, was finished for the whole length during the previous year; and at the beginning of the year the excavation of the bench, or lower two-thirds of the tunnel, was in progress at the westerly end.

On January 8 the excavation of the bench at the easterly end was begun, the material being hoisted out of the cut by a derrick installed at the portal of the tunnel. At this time nearly 200 feet of the rock cut at the easterly end of the tunnel had not been completed to grade. The derrick was continued in use until the latter part of March, when the cut had been excavated to grade for a sufficient width to permit the handling of the material directly from the tunnel. Bench excavation was finished on April 30, but the work of removing loose rock from the sides of the tunnel and cleaning up the bottom was continued until May 31. The rock cut at the easterly end of the tunnel was finished on May 25.

For about 25 feet at the easterly end and 350 feet at the westerly end the tunnel is lined with concrete masonry. The remaining 758 feet are unlined. The lined portions are 22 feet high and 16 feet wide inside of the masonry; in the unlined portions the cross-section excavated has been made large enough to permit of lining in the future, if necessary. The tunnel lining was extended about 10 feet outside of the tunnel at the easterly end and 43 feet at the westerly end, making the total length of the tunnel between masonry portals 1,133 feet.

The first concrete masonry was placed in the tunnel on February 23, and this work was finished during the week ending May 30.

As excavation was in progress in the tunnel at the same time that the lining was being placed, it was necessary to arrange the forms for the concrete so that the teams for hauling rock could pass through them. To accomplish this a staging about 16 feet high was erected, on the top of which a track was laid for the car carrying the concrete. This track was about on a level with the springing line of the arch.

As the lining of the tunnel was commenced while the weather was still cold, it was necessary to construct a building in which to mix the concrete, and to provide steam for taking the frost out of the sand and stone and heating the water. This building was erected at the westerly portal of the tunnel, and nearly on a level with the track for carrying the concrete.

The masonry lining was generally built to the rock sides of the tunnel and had a thickness of 24 inches at the crown of the arch. The space above was packed with stone. Before placing the lining all of the wooden lagging on the sides of the tunnel, which was in use while the excavation was in progress, was removed from below the springing line, also all posts intermediate between those 4 feet on centres. Above the springing line it was not usually possible to remove the lagging, but holes were cut through it as often as every second set of timbers, and the concrete was forced through these holes to the rock sides.

The tunnel portals are finished with head walls of granite masonry backed with concrete. At the easterly portal the head wall extends to the sides of the rock cut, and no wing walls were necessary; but at the westerly portal, where the excavation was in earth, wing walls were built nearly parallel to the track, the top of the walls being built to the slope of the original surface of the ground.

Work was commenced on the head walls on April 21, and was finished on May 30.

At a point a short distance east of the tunnel, where the railroad is in a 25-foot cut, a concrete masonry bridge, having a 20-foot arch, has been constructed to carry Clamshell Road over the railroad.

The masonry for the viaduct over the Nashua River, with the exception of four pedestals in the bottom of the valley, was finished during 1902; these pedestals were finished on January 29, 1903. The ten pedestals situated in the lower part of the valley have been protected with riprap about 5 feet thick, which extends from 10 feet up stream from the pedestals to 25 feet below. This riprap is placed below the bed of the river, the earth being excavated to admit of so doing. The lower slope of River Street, which runs to the river, and on which are situated two pedestals, has been protected with dry stone paving.

At the beginning of the year work was in progress with two derricks, excavating the long and deep rock cut on the westerly side of the river, the rock excavated being loaded into "skips," which were placed by the derricks on flat cars, and hauled by mules to the easterly portion of the North Dike, where the rock was used as riprap to protect the face of the dike. The length of the haul increased as the work progressed from 3,300 feet at the beginning of the year until it reached a maximum of 6,600 feet. After January 13 the rock was hauled by an 8-ton locomotive, instead of by mules. The total length of the riprap placed was about 4,260 feet.

Early in the year, in order to expedite the work, two additional derricks were installed in the cut, and the rock was raised by these derricks and placed in spoil banks near the cut. About 5,450 cubic yards of rock were disposed of in this way. This rock was subsequently hauled to the westerly portion of the dike and used for riprap. The excavation of the cut was practically finished on May 23.

As noted in the last annual report, the railroad could not be built upon its permanent location near the westerly end of the dam without interfering seriously with the use of the cableways; it has consequently been built upon a temporary location, with sharp curves, for a distance of 1,299 feet, so as to pass as far as practicable around the cableway tracks. The embankment on the temporary location, part of which is quite high, and so much of the embankment of the permanent location as it is at present feasible to build, have been constructed with earth excavated from the waste channel. It has been necessary to build two short timber trestle bridges on the temporary line, one for the track over which stone is hauled from the waste channel to the North Dike for riprap, and the other at the end of the westerly cableway tracks to reduce the shortening of these tracks as much as possible. These bridges have been built by a day-labor force.

The following table gives the total quantities of work done to the end of the year: —

Earth excavation (cubic yards),	25,500
Rock excavation (cubic yards),	55,500
Tunnel excavation (cubic yards),	18,800
Concrete masonry not in tunnel (cubic yards),	2,120
Concrete masonry in tunnel (cubic yards),	2,360
Dimension stone masonry (cubic yards),	740
Dry paving (cubic yards),	140

No work was done under this contract after November 7, as all of the work covered by the contract was then finished except those portions which cannot be done until the railroad can be built on its permanent location across the waste channel and cableway tracks.

The maximum force employed was 378 men and 42 horses, for the week ending March 28.

Steel Viaduct and Bridges, American Bridge Company of New York.

Date of contract, July 23, 1902; amount of contract, $90,803.90.

This contract included the steel viaduct over the Nashua River valley and Boylston Street in Clinton, the bridge over the highway in Berlin on Section 1 of the railroad, and the bridge over the West Boylston Road in Clinton on Section 3 of the railroad. The viaduct has a length of 921 feet between end pins, and a height above the lowest part of the valley of 133 feet. The two bridges over highways have spans of 30 and 43 feet, respectively. The bridges are all of plate-girder construction. The spans for the viaduct between the towers are 72 feet, and across the eight towers 38 feet. The spans to the abutments at the easterly and westerly ends are 60 and 53 feet, respectively. At the beginning of the year one of the small bridges had been completed at the works, but had not been shipped. Most of the remaining material had been rolled, and the shop work on the viaduct had been begun.

During the week ending February 7 the first steel for the viaduct was received. All the material for that part of the viaduct in the bottom of the valley and on the westerly slope was unloaded from the cars and transported to the bottom of the valley by the cableways, and moved to the site of the viaduct by cars running on a

VIADUCT across Nashua River on Relocation of Central Massachusetts Railroad.

short track. The material for the part on the easterly slope was delivered by teams on Boylston Street. The first steel was placed during the week ending March 7; all the steel was in place on May 29, and the riveting was completed on June 20. The first train passed over the viaduct on June 8, and trains began running regularly on June 15.

To erect the towers for the viaduct a very large derrick was set up on the ground or on timber cribbing near each tower, and the posts, which for the higher towers were in three sections, were usually bolted together and raised as one piece, each post as raised being secured by guy ropes until the remaining posts of the tower and the bracing were in place. To raise the spans a traveller, which was essentially a derrick with two booms, one 67 feet long and the other 57 feet long, was used. This was fastened by means of heavy bolts to the girders already in place, and was further secured by two steel cable guys which were anchored about 200 feet on either side of the viaduct. The field riveting was done by means of compressed air furnished by the compressors used in connection with work at the Wachusett Dam.

On March 25, while one of the 72-foot girders of the viaduct was being raised by the traveller, one of the guys broke, allowing the traveller and girder to fall from the viaduct, carrying with them one man, who was killed by the fall. The traveller at this time was located over the second tower from the westerly end, about 90 feet above the ground, and the girder had been raised nearly halfway to the top of the tower. Many of the struts and diagonal braces for the towers, which were stored in the bottom of the valley, were injured by the falling of the girder upon them, so that it became necessary to send more than 20 pieces, in addition to the girder, which was seriously distorted, to the shops in Pennsylvania for repairs. This accident seriously delayed the erection of the viaduct, the girder, which was the last of the injured pieces returned, not reaching the work until May 26. The steel work was erected by the McArthur Brothers Company of Chicago, as subcontractor. The maximum force employed was 47 men and 5 horses, for the week ending April 4.

The 30-foot bridge in Berlin was completed on March 14 and the 43-foot bridge in Clinton on March 21.

Track Laying.

By an arrangement made with the Boston & Maine Railroad, the work of laying tracks on the relocated line was done by the railroad, and the expense of the work was charged to the Board. This work began at the easterly end, in Berlin, on April 6. On May 20, when about 1½ miles of track had been laid, it became necessary to stop work on this portion, owing to the non-completion of the tunnel and of the embankment at its easterly end; and the force was transferred to the westerly end of the new location, at its junction with the Worcester, Nashua & Portland Division; work then continued without interruption until tracks had been laid to the westerly end of the viaduct. It was then possible to resume track laying at the easterly end of the tunnel. The work of laying tracks was entirely finished on June 8.

While this work was in progress, a steam shovel belonging to the railroad was used in connection with the ballasting and surfacing of the road-bed, and one work train, and for a portion of the time a second train, was also in use. The maximum force employed was 80 men, for the week ending June 6.

South Dike.

The South Dike of the Wachusett Reservoir is situated about three-quarters of a mile south of the Wachusett Dam, and is necessary in order to avoid the overflow of water from the reservoir through a depression into the watershed of the Assabet River. The dike, which will have a length of a little more than half a mile, may be divided into two principal parts: first, a section about 1,800 feet long, where a ridge containing rock only a short distance below the surface is almost high enough to form a natural dike; and, second, a section about 1,000 feet long, where the ridge disappears and the ground falls to a level 30 feet below the full-reservoir level.

The dike is to be constructed entirely of earth and soil excavated from the reservoir, except that certain portions which will be exposed to the action of waves, when the reservoir is full or nearly so, will be protected by a facing of riprap.

In order to prevent water from filtering through the dike, a cut-off trench will be excavated lengthwise of the dike down to the ledge rock at all places where the ledge rock is below full-reservoir level, except at the extreme southerly end, where hard, clayey material is encountered. At this place the trench will be excavated for a sufficient depth into the clayey material to ensure a satisfactory connection with the side hill.

The cut-off trench will be filled with practically impervious soil stripped from the reservoir, the filling to be carried above the level of the ground at the cut-off trench to a height of about 5 feet above the full-reservoir level. For about 1,000 feet near the southerly end the cut-off trench will have a width of 30 feet at the bottom; and at other portions of the dike, where the rock is higher, it will have a width of from 10 to 20 feet.

Contract 275, John F. Magee & Co.

Date of contract, December 26, 1903; amount of contract, $118,570.

This contract calls for the complete construction of the dike, except placing the heavier riprap upon the face. It includes the excavation of the cut-off trench, soil stripping from about 87 acres of the site of the reservoir, the excavation of soil and earth from spoil banks and borrow pits, and placing soil and earth in the dike.

The principal quantities of work to be done are as follows: —

Grubbing (acres),	52
Soil excavation (cubic yards),	141,000
Earth excavation (cubic yards),	42,000
Earth excavation from borrow pits (cubic yards),	170,000
Rock excavation (cubic yards),	1,000
Riprap (cubic yards),	6,500
Paving (cubic yards),	25

As the contract was made only a few days before the end of the year, no work has been done under it, but it provides that the whole work shall be completed by December 1, 1904.

Contract 273, Newell & Snowling Construction Company.

Excavating soil, Section 12, Wachusett Reservoir; date of contract, September 3, 1903; amount of contract, $5,649.56.

This contract called for the removal of soil from about 14 acres of the site of the Wachusett Reservoir, located in Boylston, about one mile above the Wachusett Dam. This area is a part of that reserved to furnish soil for the construction of the South Dike.

A large part of the area included in this contract will, it is expected, be submerged in the spring of 1904, since the Wachusett Reservoir is to be utilized for the storage of water as far as it can be done; and, as wave action at the shore line would wash away the soil, and, furthermore, a considerable part of this area is likely not to be again uncovered, it became necessary to remove the soil during the working season of 1903. This area is located so far from the South Dike that it would not be economical to transport the soil directly to the dike in carts, and it is too small to require the installation of a railroad plant for this contract.

The soil excavated was therefore deposited in two spoil banks so located that the material can subsequently be readily loaded into cars by a steam shovel for transportation to the dike. Work was begun on September 9 and was finished on November 9, 24,504 cubic yards of material having been removed. The average force employed was 46 men and 18 horses.

Mortar Experiments.

Mention was made in the last annual report of a series of experiments to determine the effect upon the strength of Portland cement mortar of the addition of salt in cold weather, and of the heating of the materials of which the mortar is composed; also to what extent the strength of such mortar is affected by freezing when mixed with fresh and salt water.

The mortar used in the experiments was composed of 1 part by measure of cement to 3 parts of sand. Salt was added to the mortar in the proportion of 4 pounds, 8 pounds and 16 pounds per barrel of cement. The briquettes were made to be broken 7 days, 28 days, 3 months, 6 months and 1 year after mixing. At the end of 1902 only a portion of the briquettes had been broken, but the remaining briquettes have been broken during this year. As noted in last year's report, the briquettes which were frozen, when broken at the end of 7 days, had less strength than the briquettes not frozen; but the briquettes which have been broken at the end of longer periods of time, especially those broken at the end of 1 year, do not show less strength than the briquettes not frozen, but generally show more strength, indicating that the mortar, if allowed sufficient time to set, is certainly not permanently injured by freezing. The experiments indicated that the heating of the ingredients of the mortar has but little if any effect upon the strength of the mortar, and that the addition of salt is certainly not detrimental, and possibly tends to improve the tensile strength of the mortar. Additional experiments have been made during the year to determine the effect of the addition of salt to mortar where not subjected to freezing, the salt being added in the proportion of 4 and 8 pounds per barrel of cement. In this series of experiments 360 briquettes were made, only a part of which have been broken; but those broken indicate that mortar to which salt has been added is stronger than that where salt has not been used.

Real Estate, Care and Disposal.

Rents have been collected and repairs made on the houses belonging to the Board in the neighborhood of the dam and South Dike, and of the Clinton sewerage filter-beds in Lancaster.

Cement Tests.

The usual tables of tests of cements used in the dam and other works at the Wachusett Reservoir may be found in Appendix No. 2.

SUDBURY DEPARTMENT.

Charles E. Haberstroh, *Assistant Superintendent.*
Charles W. Sherman, *Division Engineer.*

The work in this department relates mainly to the maintenance and operation of the Sudbury and Cochituate works, including the aqueducts.

The work of construction in this department during the year has been the completion of the improvement of certain shallow arms of Lake Cochituate, known as Pegan Brook and Snake Brook meadows, as required by chapter 509 of the Acts of the year 1901; and the construction of a sewer and filter-bed for the disposal of the overflow from the main sewer of the city of Marlborough.

During the greater portion of the year there has been no engineering force engaged upon construction; when such a force has existed it has varied from 2 to 4.

The offices of this department are in Boston and South Framingham.

Improvement of Lake Cochituate.

At the date of the last annual report the work required by the act of the Legislature had been substantially completed. During the year 1903 a small amount of work was done by a day-labor force in grading and seeding the tops of the embankments and dressing the slopes at Pegan Brook Meadow.

The total amount expended on this improvement has been $103,-535.54.

Overflow Sewer and Filter-bed for Disposal of Overflow from Marlborough Main Sewer.

By the terms of chapter 443 of the Acts of the General Court for the year 1903, the city of Marlborough was to construct an additional main sewer to the sewage-disposal area of the city, in order to provide sufficient capacity to prevent sewage from overflowing into Marlborough Brook, a feeder of the Sudbury Reservoir; and the Commonwealth was to repay to the city the reasonable cost of constructing such additional main sewer.

Investigations made after the passage of the act indicated that it would be feasible to dispose of the highly dilute sewage which overflows during heavy storms, by conveying the overflow to filter-beds upon land belonging to the Commonwealth adjoining the Sudbury Reservoir, which could be reached by the construction of a sewer less than 1 mile in length. The sanitary aspect of this plan was regarded as satisfactory, because the sewage, which would be purified by filtration before entering the reservoir, represents less than one-half of one per cent. of the total yearly sewage; and the expense of carrying out the plan would be very much less than for building the long additional outlet sewer, as provided in the act.

A conference with the officials of the city of Marlborough led to the conclusion that the new plan would be of mutual benefit to the city and the Commonwealth; and an agreement was accordingly entered into with the city, by which the sewer should be constructed by the city of Marlborough at the expense of the Commonwealth, and the filter-beds should be constructed and maintained by the Board.

Work on the construction of the sewer was begun on October 9 and it was completed on November 30. It is a 15 and 18 inch sewer, has a total length of 4,756 feet with 14 man-holes, and a capacity of about 5,300,000 gallons per day. The city of Marlborough has not yet submitted a bill for the construction of the sewer.

Work on the construction of the filter-bed was begun by a day-labor force on October 17, and it was completed on November 24.

As the overflows would usually occur at a time when the ground was frozen, the filter-bed was necessarily constructed to act also as a reservoir to hold the dilute sewage until it has time to thaw the ground so that filtration can begin. In other words, the filter-bed is a combined filter and reservoir. Its total area is 3.91 acres, and it will contain below its high-water line, which is at elevation 272.25, 6,700,000 gallons.

As a further precaution, an adjoining area has also been embanked in such a manner that, if the main filter-bed should overflow, it would store an additional million gallons without overflowing into the Sudbury Reservoir. The whole expense of constructing this filter-bed was $1,990.

WESTON AQUEDUCT DEPARTMENT.

(The statement of the work of this department has been prepared by Horace Ropes, Department Engineer.)

During the past year the work in this department has been the completion of the construction of the Weston Aqueduct, Weston Reservoir and smaller appertaining structures.

The organization of the engineering force has remained nearly the same as during the previous year, although the larger amount of work under way during the busy period necessitated some increase, at that time, in the number of engineering assistants and inspectors employed.

Division engineers Dan B. Clark, Marshall Nevers and George W. Booth have continued in charge of the first, third and fourth divisions, respectively. Frank E. Winsor, engineer of the second division, resigned on February 11, to accept a position with the Commission on Additional Water Supply, city of New York, and was succeeded by assistant engineer George A. Winsor. Walter W. Patch, assistant engineer, has remained in charge of the records, drafting and computing at the main office, and has also directed the work of cement testing. On August 11, John L. Howard, division engineer in the Distribution Department, was temporarily transferred to this department, and given supervision of the contract work on sections 1 and 2 of the reservoir and Section 15 of the aqueduct, continuing in that service until September 26, when he resigned to go to other work.

The engineering force at the beginning of the year was 53, and, in addition, there were 4 masonry inspectors and 4 laborers acting as assistants to the masonry inspectors. As the work increased, additions were made, until in June the engineering force reached the maximum of 55, including 11 engineers assigned to inspection of the work; there were also 10 masonry inspectors and 8 laborers, the latter observing concrete mixing at the mixing machines and at the tunnel portals. At the end of the year all the inspectors had been discharged, and the force had decreased to 36.

Gangs of men under the immediate direction of inspectors, and superintended by the engineers, have at different times been employed on miscellaneous work not covered by the contracts. For some weeks the force so employed varied from 63 to 147 men.

The main office of the department has been continued in Saxonville. The branch office at Framingham was abandoned October 31, and the party transferred to the Saxonville office. The branch offices in Wayland and Weston have been continued throughout the year.

Weston Aqueduct.

At the date of the last annual report the construction of the Weston Aqueduct had been in progress for nearly two years, and the Weston Reservoir for one year. All the principal contracts had been awarded, and about two-thirds of the work required by those contracts had been accomplished. The work remaining to be done, however, included some extensive and difficult excavation on sections where the contractors were already behind time on their contracts. Great energy and activity were therefore required to complete these sections within a reasonable time after the stipulated date, or even within the year, as was the case with the reservoir contracts.

The excavation and paving at the reservoir, which it was essential should be done before water was turned into it, was not finished until December 9. The last of the aqueduct masonry had been substantially completed by the contractors some ten weeks earlier, but it still required a thorough scraping and washing, an application of two coats of cement wash on the brick lining, and some trimming and plastering of the concrete lining masonry in the tunnels, to put the aqueduct in perfect condition for operation. Much time was consumed in this finishing process, so that the end of it all was not reached until December 12. On December 14 a small flow (20,000,-

000 gallons per twenty-four hours) was sent through the aqueduct, for the purpose of slowly filling the Weston Reservoir. Two days later, after the deeper portion of the reservoir had been filled, the supply was doubled; and for nearly two weeks the water was kept continuously flowing through the reservoir and wasting into the Charles River, the purpose being to thoroughly flush out the reservoir before putting it into service. The works were formally opened and the water delivered into the mains of the Metropolitan District on December 29.

While the completion of the work may be said to have been delayed about two months by the inability of some of the contractors to finish their work within the set time, extenuating circumstances are to be found in the industrial situation which has prevailed for two years past, and for which some allowance should be made. There has been so much construction work under way that the supply of laborers and teams has not been equal to the demand. Seldom have any of the contractors been able to secure as large a force as they needed, and much of the labor they had was below the ordinary standard of efficiency. Without an adequate force it was clearly impossible to finish the work on time; and, after giving due weight to the adverse conditions, it is rather a matter for congratulation that the completion of the works was not delayed for a still longer time.

The following table shows the progress made on the aqueduct during the three years it has been under construction, also a comparison of the value of the work done during 1903 and that done in the two previous years: —

SECTION.	Date of Contract.	Total Length (Feet).	Built in 1901 (Feet).	Built in 1902 (Feet).	Built in 1903 (Feet).	Value of Work to Dec. 31, 1902.	Value of Work done in 1903.
Weston Aqueduct.							
1,	June 19, 1902,	537	-	226	311	$20,500 00	$13,983 39
2,	May 9, 1901,	8,437	2,449	4,127	1,861	136,500 00	65,404 54
3,	May 9, 1901,	5,500	1,479	2,804	1,217	88,500 00	39,291 48
4,	May 6, 1901,	4,150	3,271	879	-	61,161 69	-
5,	May 8, 1901,	5,300	1,567	3,432	301	119,300 00	8,926 63
6,	May 9, 1901,	4,518	841	2,294	1,383	78,700 00	37,941 31
7 and 9,	March 8, 1902,	4,731	-	3,251	1,480	116,400 00	19,352 56
8 and 10,	Aug 28, 1901,	6,386	494	2,969	2,923	80,000 00	70,101 77
11,	Aug. 28, 1901,	6,585	-	3,951	2,634	95,000 00	64,892 59
12,	May 9, 1901,	6,500	1,264	3,149	2,087	95,900 00	46,121 55
13,	May 20, 1901,	7,300	751	3,586	2,963	253,800 00	163,452 64
15,	Aug. 28, 1901,	5,721	-	3,294	2,427	97,200 00	85,174 58
Weston Reservoir.							
14,	Nov. 26, 1901,	-	-	-	-	31,600 00	25,000 00
1,	Nov. 26, 1901,	-	-	-	-	9,900 00	48,700 00
2,	Nov. 26, 1901,	-	-	-	-	38,200 00	55,300 00
Totals,	. . . . .	65,665	12,116	33,962	19,587	$1,322,661 69	$743,643 04

Contracts, Weston Aqueduct.

Section 1. — Headworks and Connections at Sudbury Dam.

Contractor, T. H. Gill & Co.; date of contract, June 19, 1902; amount of contract, $34,-483.39; length of section, 537 feet, including three lines of 60-inch cast-iron pipes and 57 feet of masonry section in head-house and aqueduct.

Work on this section, which had been entirely suspended during the winter months, was resumed early in April.

The work done during the year comprises the granite-faced concrete arch of 29 feet span, carrying the carriage drive across the new channel; the digging of pipe trenches and laying of 780 feet of 60-inch cast-iron supply pipes and about 270 feet of 48-inch overflow pipe; the concrete head-chamber; the concrete foundation for the meter-chamber, and the final grading of the grounds.

The limits within which these operations had to be conducted were so narrow that only a small force could be employed to advantage, and the work proceeded slowly but satisfactorily, until its completion on August 26.

The maximum force engaged on this section was 48 men and 15 horses, for the week ending August 15.

Sections 2, 3, 6 and 12. — Masonry Aqueduct and Tunnels.

Contractor, Shanahan, Casparis & Co.; date of contracts, May 9, 1901; amount of contracts, $588,358.88; length of aqueduct, 24,955 feet, including 5,879 linear feet of tunnels. The aqueduct on sections 2 and 3 has a width of 10 feet, and on sections 6 and 12 a width of 13 feet 2 inches.

Tunnels.

On these four contracts work pertaining to the construction of aqueduct in open trench was practically abandoned during the winter, but in the tunnels excavation and concrete lining were continued without much interruption. This work, however, proceeded very slowly, suffering delays from several causes, the principal of which were lack of preparation to meet winter conditions, and imperfect arrangements and organization for continuing with the tunnel lining masonry after the work of tunnel excavation had been completed. Some difficulty was also experienced in maintaining a supply of coal for the compressor. About the middle of January the supply on hand was completely exhausted, and the compressor had to be shut down for eight days, resulting in a stoppage of all work in tunnels Nos. 2 and 3 for nearly two weeks, by the accumulation of water in these tunnels while the pumps were not running.

Tunnels Nos. 1 and 2 are located on Section 2, and tunnel No. 3 on Section 3. As stated in the last annual report, the excavation of tunnel No. 1 at the end of 1902 had been made for rather more than one-half its length, and the excavation of tunnels Nos. 2 and 3 was substantially completed.

Operations in tunnel No. 1, which were stopped on December 8, 1902, until proper facilities for mixing concrete in freezing weather could be provided, were again well under way by the first of the year. The material encountered in excavating the remaining portions of the tunnel was similar to that passed through in 1902. Wherever there was an appreciable quantity of water, the earth softened and settled heavily on the timbering, giving rise to dangerous conditions which had to be skillfully dealt with, and the same care had to be exercised as during the previous year to avoid accidents. There were only a few short spaces in the tunnel which could be regarded as dry, and the general presence of water greatly retarded the advancement of the work, so that the excavation was not finished until May 1. The excavation was carried on from both ends of the tunnel, and the lining masonry of Portland cement concrete, built in short stretches of 12 to 18 feet in length, followed the excavation in both headings very closely. As it was not convenient to build the invert masonry while the excavation was in progress, only the sidewalls and arch were built at that time. When the west drift had advanced 225 feet the excavation was stopped for two weeks, and the invert built through that portion to guard against any possible forcing in of the sidewalls. The invert through the remainder of the tunnel was not laid until after the rest of the work had been finished. The diameter of the tunnel was too small to permit excavation and masonry to go on at the same time, and this limited the progress for each class of work to a low rate. The rate of excavation for both drifts combined averaged 17 feet per week, and for two weeks it went as low as 5 feet. The progress on sidewalls and arch ranged from 8 to 32 feet per week. A rate of 150 feet of invert per week was easily maintained with one small gang, the excavation and shaping being done in advance by a night force. This tunnel was completed on June 6.

Tunnels Nos. 2 and 3, which are respectively 3,015 and 2,160 feet long, were driven through solid rock without meeting with any serious difficulties. At the beginning of the year the excavation of these tunnels was regarded as nearly finished. The headings in tunnel No. 2 met on the night of January 1, and tunnel No. 3 had already been holed through in December. Considerable work remained to be done, however, in the way of trimming projecting rock points from the sides and bottom of the tunnels, and in enlarging the excavation at some places to full size. No lining masonry had been built in tunnel No. 2, and only 240 linear feet had been built in tunnel No. 3. Before any rapid progress in the further construction of the lining masonry could be expected, it was necessary to build shelters for mixing concrete at the tunnel portals, to furnish means to heat the sand and water used on extremely cold days, to provide forms and centres in sufficient quantity, and to trim long enough sections of the tunnel in advance to make sure that the concrete forces would not overtake the trimming gangs, and suffer delay for want of space in which to work. In all these matters the contractor was delinquent, and much time was lost in reorganizing his force and completing the preparations needed for doing the work to the best advantage.

On January 5 a start was made on the masonry in tunnel No. 3, but the attempt was abandoned the same day, because of difficulty with the water supply due to frozen pipes. Another start was made on January 22, and on February 3 a small concrete force was started in tunnel No. 2. These forces were subject to many delays, and made comparatively small progress until late in March, when conditions had improved sufficiently to work three forces to fairly good advantage. Subsequently there was marked improvement in the rate of progress, as may be gathered from the record that only 1,300 feet were built during the first three months of the year, and 3,635 feet during the next three months. The rate of progress for the concrete fluctuated greatly from week to week, but whenever the conditions were favorable the weekly rate for sides and arch reached from 140 to 160 linear feet, and for invert from 500 to 600 linear feet for each working point. In these tunnels, as in tunnel No. 1, the invert was put in after the sides and arch were completed. The masonry in tunnel No. 2 was finished on August 4, and in tunnel No. 3 on August 15.

The general method adopted for mixing and placing concrete in the tunnels was as follows: The mixing of concrete was all done by hand on sheltered platforms so arranged that the concrete could be readily dropped through chutes into cars on a track below, except at the west portal of tunnel No. 3, where a machine mixer was in use. Adjacent to the platforms there were convenient storage bins for a liberal supply of sand and stone, and, when needed, provision was made for heating the materials by the use of steam coils or other suitable means. Cars with a low frame and long body, giving room for men to stand on them while shovelling, were used to transport the concrete to the place where it was needed.

The centres or forms for the sidewalls and arch were framed with ribs, built in two pieces, extending from the foot of the sidewalls to the crown of the arch, where they were spliced together with iron straps and bolts. At first these ribs were made of 4-inch steel channels bent to shape, but later wooden ribs of two thicknesses of 2-inch spruce plank, firmly spiked together, were substituted and found satisfactory. The ribs were spaced 6 feet apart, and supported curved panels 6 feet long and 24 to 30 inches wide. The panels were made of inch boards nailed to a stiffening frame of scantlings, and the side next to the concrete was covered with galvanized sheet iron. After the ribs had been set to line and grade, the lowest course of panels was put in place and the concrete filled in to their top, and then another course of panels was placed to receive more concrete. The widths of the panels were such that the space left for keying the arch was 32 inches wide. To fill this space short key panels were used, in the same manner as ordinary key blocks for a brick arch. A wet mixture of concrete was used, and worked into place with spades and rammers. Soft soap was applied to the panels, to prevent adhesion to the concrete. By means of wedges at the foot of the ribs and the splices at the top, the ribs were readily loosened and the forms taken down. The concrete in the invert was shaped to the required curve by wooden profiles spaced 10 feet apart, using a piece of steel rail as a straight edge.

The tunnels were lined with masonry for their entire lengths, without regard to the stability of the rock, although where the formation was firm the thickness of the lining was less than in portions through earth or seamy ledges, where the arch would have to bear greater loads. Concrete was generally used for this lining, the only exceptions being in tunnel No. 1, where about 32 feet of sides and arch were built of brick, and a few very short sections of brick arch at places where the timbers had settled and had to be removed. In tunnel No. 1 the concrete was all of one class, mixed in the proportions of 1 part by volume of Portland cement to 2½ parts of sand and 4½ parts of stone. In the other tunnels, concrete like the above was used in the invert, but the sidewalls and arch were mainly built of a mixture in the proportions of 1 part of cement to 3 parts of sand and 6 of stone; the richer mixture being occasionally substituted, however, in the arch for short spaces where greater strength seemed to be desirable. The rock sides of the tunnel were first washed free from dirt and slime, and then the masonry was filled in solidly against them to a point two-thirds of the way up on the arch.

The thickness of the arch at the crown varied from 7 inches in firm rock, to 18 inches and over in earth and shattered rock. The space between the top of the arch and the roof of the tunnel was filled with stone laid without mortar, but tightly packed.

The invert was designed not to exceed 6 inches at the thickest portions, and might be as little as 3 inches thick where built directly on solid ledge. If solid rock did not appear within 6 inches below grade, well-packed tunnel débris was regarded as a suitable foundation and was not removed from below that level, except when it occurred directly under the sidewalls. A wooden box drain, 4 inches square, was carried under the centre of the invert for nearly the full length of the tunnels, to facilitate the handling of water during construction; and later, by leaving frequent vents into the tunnel, to permanently relieve the masonry from any inward pressure of the ground water. Iron pipes were also built into the arch at intervals of 50 feet, to admit any water accumulating at that height. The lining, therefore, was intended only to support the ground and to give a smooth inside surface to the tunnel, and not to exclude water. To prevent loss of water from the aqueduct through the underdrains, care was taken to stop the drains before reaching the end of the tunnels, and then, by building the masonry tightly to the rock on sides and bottom, to block every outlet by which water could reach the open trench beyond.

Besides the 700 linear feet of timbering in tunnel No. 1, 332 linear feet of the other tunnels required timbering at the time of excavation, to keep the rock from falling. In these timbered sections the removal of the main timbers and top lagging was not attempted unless absolutely necessary to obtain the required minimum thickness of masonry; but sufficient of the side lagging was taken out before the masonry was built to have the thrust of the arch come against solid ground, instead of perishable timber.

Aqueduct in Open Trench.

As work on aqueduct masonry in open trench was prohibited during the winter, comparatively little could be accomplished towards advancing the outside work until spring opened.

On sections 2 and 3 excavation and other work were resumed late in March; but the actual building of masonry was not begun until April 18 on Section 3, and April 29 on Section 2. The work proceeded slowly during the season, as a large part of the contractor's force and equipment was employed in the tunnel work. The total length of aqueduct in open trench completed during the year was 616 feet on Section 2 and 604 feet on Section 3.

The work in the deep clay cut at the west end of tunnel No. 2 was difficult and tedious. The trench varied from 17 to 37 feet in depth, and the presence of considerable water gave rise to slips from the sides, and also made the material difficult to shovel. The excavation was made in lengths of 40 feet, and the masonry followed without delay. About 350 feet of this cut had to be sheeted and braced. Notwithstanding that two large derricks were used continuously for excavating and for placing concrete, it required twenty-one weeks to complete the work at this place. The trench work at other points developed nothing uncommon.

The last of the masonry on these sections was not finished until late in September, and another month elapsed before all the back-filling, loaming of slopes, cleaning of aqueduct and general cleaning up had been completed.

The contracts were regarded as fulfilled, and sections 2 and 3 were accepted October 9.

On Section 6 work preparatory to masonry construction was actively resumed about the middle of March. Masonry was started on March 30, and progressed smoothly until its completion on August 12. The further work of grading and loaming embankments, skim-coating the arch and cleaning the interior of the aqueduct, placing copings on the man-holes and headwalls of culverts, and general clearing up of the grounds, lasted until September 26, when the work was accepted as finished. The length of aqueduct built this year was 1,383 linear feet.

On Section 12 a small force was engaged during the winter months, hauling bricks and concrete materials, and distributing them at convenient points on the section. On March 9 the force was increased, and excavation was started again. The first masonry was laid April 2, and it was pushed steadily until finished on August 19. The remaining work of backfilling over arch, grading embankments and covering same with loam, building culvert masonry and skim-coating and cleaning of aqueduct, continued until October 7, when the work was accepted. The additional length of aqueduct built this year was 2,087 linear feet.

Work on this section has been conducted in much the same manner as during the previous year, the character of the excavation remaining the same as heretofore on different parts of the section. The use of the cableway was continued for the wet trench on the easterly portion, and machinery was used to a large extent in concrete operations. A statement of the plant used by the contractors has been given in previous reports. No change or increase in plant has been made during the season.

The maximum force employed on this section was 489 men and 104 horses, for the week ending May 16.

Section 5. — Masonry Aqueduct.

Contractor, Bruno, Salomone & Petitti; date of contract, May 8, 1901; amount of contract, $128,226.63; length of aqueduct, 5,300 feet, including crossing under the tracks of the New York, New Haven & Hartford Railroad at Nobscot Station; width of aqueduct, 13 feet 2 inches.

General work, which had been suspended since the beginning of the year, was resumed April 2 and pushed forward in the same satisfactory manner as in previous years. Masonry was started April 14 and completed May 29, a month in advance of the required date. The finishing of the grading, dressing the slopes with loam, skim-coating the unfinished portions of the arch and giving the aqueduct a final cleaning, proceeded until July 11, when every condition of the contract had been fulfilled, and the contractor withdrew his forces.

Only 300 linear feet of aqueduct was left to be built this season, and, as there was no need for haste, no larger force was maintained than could be employed to the best advantage to the contractor.

The maximum force employed on this section was 51 men and 8 horses, for the week ending May 16.

WESTON AQUEDUCT—7½-FOOT STEEL PIPE ARCH ACROSS SUDBURY RIVER.

Sections 7 and 9. — Riveted Steel Pipe Lines, including Bridge over Sudbury River.

Contractor, Edward Kendall & Sons; date of contract, March 8, 1902; amount of contract, $135,752.56; total length of pipe lines, 4,731 feet.

Except the hauling of 450 linear feet of pipe to Section 7, thereby completing the delivery of all the pipe to be laid except two short filler pieces, all field operations were discontinued from January 1 until April 27, when a small force began overhauling the air compressor and other machinery. On May 4 pipe laying was resumed and continued westerly, over the Sudbury River and up the steep slopes on the west side of the valley to siphon chamber No. 1, where the final connection was made on July 28.

The work done during the year was mainly the laying of 1,475 feet of riveted steel pipe, 7½ feet in diameter, and the riveting and calking of the field joints in 480 feet of other pipe which was only partially completed the previous year; also the necessary trenching and backfilling for the pipe, the completion of the granite and concrete masonry abutments for the Sudbury River bridge, and a very considerable modification of the highway at a point where more room was needed between it and the river for the location of pipes. All the work covered by this contract was finished on October 19.

An interesting feature on Section 7 is the pipe arch across the Sudbury River. The span between substantial masonry abutments is 80 feet in the clear and the rise 5½ feet. The plates of the pipes in the arch are $\frac{3}{16}$ of an inch thicker than in the rest of the pipe, making their thickness ⅝ of an inch; otherwise the arch is not stiffened or braced in any way. At the siphon chambers the steel pipe was inserted 5.5 inches into the bell of the casting, and the joint run with lead to its full depth. A concrete collar, to serve as an anchor, was then built around the pipe for a distance of 20 feet from the chamber.

Before the backfilling was wholly completed, sections of the pipe several hundred feet in length were exposed to the sun; but the changes in length due to variations in temperature were not very marked, and caused no trouble. Work on the bridge abutments and riveting of pipe joints was delayed for more than a week by high water from the freshet on June 21. Several hundred yards of material were washed from an unfinished embankment east of the bridge, and some unriveted pipe was undermined and caused to settle. The damage was not serious, and repairs were easily effected.

The maximum force employed on these sections was 56 men and 20 horses, for the week ending August 22.

Sections 8, 10, 11 and 15. — Masonry Aqueduct and Tunnel.

Contractor, Winston & Co.; date of contracts, August 28, 1901; amount of contracts, $492,368.94; length of aqueduct, 18,692 feet, inclusive of three siphon chambers on sections 8 and 10, and the screen and terminal chambers and 600 feet of tunnel on Section 15; width of aqueduct, 13 feet 2 inches.

The value of the work accomplished on these sections at the close of 1902 was much less than the amount required by the terms of the contracts; and, although there was comparatively little that could be done to advantage, it was essential that work should be continued throughout the winter wherever possible. Therefore a small force of about 65 men, working mainly on sections 10 and 11, was kept busy excavating trench and building portions of the aqueduct embankment required for track road-bed, where that was feasible; dismantling and moving the crushing, screening and mixing plant to a more convenient location; and skim-coating the interior of the concrete arch. With the coming of spring this force was rapidly augmented, and the construction of aqueduct masonry resumed on all the sections. The work was carried on very vigorously, and, although it was not possible to complete the contracts within the time limit, all these sections were finished a little in advance of some of the sections built by other contractors.

A full description of the plant and methods of doing the work on each section appeared in the last annual report. The same methods have been followed during the past season, with apparent advantage to the contractor. Delays to the work, due to breakage of machinery or because of inability to screen sand and gravel in wet weather, were insignificant, but the masonry suffered some serious delays on account of the backwardness of trench excavation at a few places.

Sections 8 and 10 are included in one contract. At the beginning of the year all the masonry on Section 8 had been finished, while nothing had been done on Section 10 except some clearing of trees and brush, stripping of loam and a small amount of excavation and preparatory work.

On Section 8 very little was done this year until the middle of March, when the grading of embankments and surfacing of same with loam was resumed, and carried on quite steadily throughout the summer. At times short interruptions were caused by the transfer of the force to work on Section 7. Other work consisted of skim-coating the arch, some heavy grading at crossings of the highway and farm roads, and the final cleaning of the aqueduct. This section was substantially completed on October 3.

On Section 10 a small force of men and teams was employed from the beginning of the year, excavating from the trench, most of the material being stored in piles for subsequent use in concrete or for backfilling. About April 1 the force was increased, and general work was actively resumed; but, as the contractor had been dilatory in transferring his crushing and mixing plant from Section 8, considerable time was lost before the concrete masonry could be started. This plant was not ready for operation until May 21, but by utilizing the plant on Section 11 the contractor had been enabled to start masonry on the easterly half of the section about a month earlier. All the aqueduct masonry, including the substructure of one siphon chamber, to the extent of 2,923 linear feet, was completed on September 24.

The earth excavation on this section was fine sand or loose gravel, which was very easy to handle; but in the deep cutting on the westerly half of the section ledge was encountered, necessitating the excavation of about 2,450 cubic yards of rock, and progress was necessarily slow. The commencement of the rock excavation having been deferred too long, the contractor was obliged to largely increase his force after the middle of July, and to work night and day in order to finish within a reasonable time.

On Section 11 about two-thirds of the work was accomplished at the close of 1902. During the winter a small force of 35 men continued excavation, and moved the crushing and mixing machinery to a new site convenient to the future work. Early in March the force was doubled, and the erection of mixing plant, derricks, track laying, etc., was pushed energetically, but they were not ready for use until April 11, when the mixer was put in operation. A small amount of concrete mixed by hand had been placed prior to that date. The aqueduct masonry was completed on September 12, 2,634 linear feet having been built during the season. The excavation was generally of an easy nature, except in one cut where there was a large amount of ledge. For a few weeks the grading force was inadequate, and the progress of the masonry was retarded by that cause. The best five weeks' record for masonry construction was made in May and the first week of June, when the average weekly rate was 248 feet of completed aqueduct. The greatest weekly rate for any week was 283 feet.

On Section 15 there was a suspension of work between January 1 and March 16, except for some repairs on machinery, cars, carts, etc.

Masonry was begun on March 28 and finished on September 29. The principal items of work done during the season comprise the completion of the terminal chamber; the screen chamber; 147 linear feet of concrete corewall and earth dam northerly from the screen chamber; 2,296 linear feet of aqueduct in open trench; 600 linear feet of tunnel lining; 1,600 linear feet of trench excavation, largely through ledge; and the backfilling and surfacing with loam over nearly the full length of the section; also stripping of loam and earth excavation from 3.8 acres included in the reservoir. It required great energy and activity on the part of the contractor to complete his contract before cold weather set in. The work was prosecuted diligently throughout the season, and for about 4 weeks gangs were worked night and day in the long, deep cut at Newton Street. The excavation on this section has been particularly hard and difficult, the larger part of the trench excavation being through trap rock ledges; and such material as came within the classification of earth excavation was almost without exception a cemented gravelly hard pan, containing many boulders.

After the completion of the masonry, much work remained to be done on each section in the way of backfilling, loaming of embankments, building masonry headwalls and paving at the inlets and outlets of culverts, setting ladders and covers at man-holes, skim-coating the arch, scraping and cleaning interior of aqueduct, removing camp buildings and plant, and a general cleaning up of the grounds, before the conditions of the contracts could be regarded as having been acceptably complied with. The work was satisfactorily completed and the sections accepted as follows: —

Sections 8 and 10 on November 21; Section 11 on November 14; Section 15 on November 28.

The maximum force employed on these sections was 400 men and 107 horses, for the week ending September 26.

Section 13. — Masonry Aqueduct and Tunnel.

Contractor, Columbus Construction Company, successor to Michael H. Keefe; date of contract, May 20, 1901; amount of contract, $417,252.64; length of aqueduct, 7,300 feet, of which 5,686 feet are tunnel and 53 feet are open channel; width of aqueduct, 13 feet 2 inches.

Work under this contract was continued practically without cessation, day and night, from the beginning of the year until the masonry had been finished. The 783 linear feet of tunnel remaining to be excavated at the beginning of the year was driven as rapidly as possible. This portion of the tunnel has been wholly through firm rock, which did not require timbering. The two headings came together with perfect accuracy on March 1, at a point 3,019 feet and 2,667 feet, respectively, from the east and west portals of the tunnel. Some further time was required for the removal of the bench, but the whole excavation, except some light trimming of sides and bottom, was completed three weeks before the expiration of the extension of time which had been granted the contractor.

While the tunnel excavation was going on, the construction of lining masonry also advanced at a fair rate, although the workmen were frequently hindered by the blasting, and much time was lost waiting for the powder smoke and gas to disperse sufficiently for work to be resumed. Other delays arose from the necessity of hauling the incoming concrete and outgoing tunnel débris over the same track, the width of the tunnel being too small to admit double tracks.

In the west drift 1,414 feet of masonry lining had been built before the end of 1902, and this work was extended as fast as could be expected under the unfavorable conditions which hampered it. On January 7 a second masonry force commenced work in the east drift. By March 10, when the tunnel excavation was completed, these two forces had built an additional 1,354 feet of concrete lining.

Upon completion of the excavation, the concreting and trimming gangs were increased and the masonry carried ahead as fast as possible with day shifts, although some keying of the arch and the filling in of voids over the arch with loose stone had to be done at night. All but 17 linear feet of sides and arch were finished by May 30, but up to that time only 30 feet of the tunnel invert had been laid, as this operation required the removal of considerable lengths of the track, and it was not considered expedient to take up the track while it was needed for the transportation of materials.

The building of the invert followed without delay, and progressed, with two gangs of men, at a rate varying from 600 to 690 feet per week. The best progress in building sides and arch was made during nine weeks in April and May, when an average rate of 283 feet per week was attained. The best progress for any one week was 330 feet. The methods used in building the concrete lining were substantially the same as those adopted on sections 2 and 3, as previously described in this report.

The open trench work on that portion of the section east of the tunnel was in a very backward condition at the first of the year. The work to be done on this portion comprised about 24,000 cubic yards of excavation, of which more than one-half was ledge, from a trench 900 feet long and 30 feet deep, and the construction of 1,100 linear feet of aqueduct, including the substructure of the chamber at the head of the open channel. It was evident that strenuous action was required to finish this work within a reasonable time, and the contractor was instructed to continue excavation throughout the winter. As much was done in that direction as was possible with the limited power and equipment at hand, but the work done was confined mainly to the removal of some of the earth overlying the ledge. About the middle of March the completion of the tunnel excavation released some of the machine drills, and made much of the power from the air compressors available for the outside work. A larger force was then promptly organized, and the one derrick in operation was quickly supplemented by the erection of three more, so distributed that the work would progress to good advantage at several points. As the trench advanced, the aqueduct masonry was built in sections 25 to 30 feet in length, and kept as close to the face of the cut as the heavy blasting would permit. This distance was usually about 50 feet.

Over the aqueduct the trench was refilled with earth and rock to the original surface of the ground. Because of the great depth and weight of this refilling, the thickness of the masonry in the walls and arch of the aqueduct was made greater than in the regular section, the arch being made 18 inches thick at the crown, instead of the 12-inch thickness used where the earth cover does not exceed 4 feet in depth. As this section of aqueduct east of the tunnel lies within the drainage basin of the reservoir just below, and any leakage would naturally find its way into the reservoir, it did not appear essential that this portion should be made water-tight; therefore the brick lining on the sides and invert was omitted, and the masonry was built entirely of concrete, mixed in the proportions of 1 volume of Portland cement to 2½ of sand and 4½ of crushed stone. The invert was only 6 inches thick, and was relieved from the upward pressure of the ground water by a wooden box underdrain with frequent vents into the aqueduct.

Work was not resumed in the open trench at the west portal of the tunnel until late in the summer; but, as only 162 linear feet of aqueduct remained to be built at that point, it was easily completed at the same time as the rest of the work. The last short gap in the tunnel masonry was closed on September 15, and the last arch in open trench was finished on October 1. Six weeks more were required to complete the grading, surfacing with loam and general cleaning up of the grounds. The section was accepted as finished on November 11.

The maximum force employed on this section was 291 men and 25 horses, for the week ending May 23.

Section 14, Open Channel. — Sections 1 and 2, Weston Reservoir.

Contractor, Nawn & Brock; date of contracts, November 26, 1901; amount of contracts, $218,077.50; length of three sections, 5,347 feet, including about 1,347 feet of open channel, 66.6 acres of reservoir and channel and an earth dam 900 feet long, with concrete corewall.

As stated in the last annual report, the work at the end of the year 1902 on each of these sections was far behind the contract requirements, and it was foreseen that extraordinary exertions would be necessary to finish anywhere near the prescribed date. Very little could be done during the winter on Section 2, where the work consisted mainly of shallow excavation, masonry construction and rolled embankment for the dam; but on sections 14 and 1, where the digging was in loose gravel from 10 to 20 feet deep, it was believed to be feasible to continue the steam-shovel excavation without intermission.

The contractor, being strongly impressed with the importance of doing whatever could be done, made earnest endeavors to forward the work; but the great depth of frozen ground, winter storms, the difficulty of shifting tracks and of maintaining water supply for engines, etc., presented so many discouraging obstacles that about the middle of February he was granted permission to stop work until the return of mild weather.

The steam-shovel excavation was resumed on Section 14 during the second week in March, and the following week a force started stripping loam on Section 1. The resumption of operations on Section 2 did not occur until the latter part of April, and even at that late date, and for several weeks after, the force was decidedly inadequate for the amount of work to be done. After the middle of July the greatest possible efforts were made, and considerable work was done at night; yet, owing to the early delays, it proved impossible to finish the contracts before winter set in. Fortunately, however, everything necessary for the operation of the reservoir was satisfactorily completed by December 16, early enough to give time for filling and flushing out the reservoir before the works were put into service. The amount of work remaining to be done is comparatively little, and consists mainly of spreading loam over portions of the dam and other places where filling has been made.

On Section 14 nearly one-half of the work remained to be done at the beginning of the year, and this has been completed, except a little ditching and some grading and surfacing with loam.

The work of the year has included the major part of the excavation of the open channel and the surfacing of its slopes above elevation 201 with loam to the depth of 18 inches, and below 201 with coarse gravel; the building of the masonry arch bridge for the Ash Street crossing over the open channel; the remainder of the reservoir excavation, the sloping of the shore and the placing of a protection of riprap; also the grading of a portion of Ash Street as relocated, and the spreading of large quantities of loam over the mounds north and south of the open channel.

On Section 1 only 17 per cent. of the value of the contract had been done the previous year. Nearly 200,000 cubic yards of earth have been excavated, and 3,500 feet of shore have been trimmed to slope and protected with riprap. Ash Street as relocated has been graded, and the shaping and surfacing of the large mound south of the reservoir is now substantially completed. The final cleaning up of the grounds is substantially all that will be required to complete this section.

On Section 2 at the beginning of the year more than one-half of the work remained to be done. This included 110,000 cubic

WESTON RESERVOIR IN CONSTRUCTION—DAM AND SCREEN CHAMBER IN BACKGROUND.

yards of soil stripping and other excavation to be removed from the reservoir and deposited as required in different portions of the dam and in the waste banks; about 2,000 cubic yards of rock to be blasted from the top of ledges where the depth of water would be less than 3 feet, and numerous boulders to be disposed of; 4,900 linear feet of shore to be sloped, and, where ledge did not outcrop, to be finished with riprap; 745 feet of concrete corewall masonry to be built at the dam to an average height of 15 feet, together with the portions of the earth dam on both sides of the corewall, which were made with selected earth, spread in layers, watered and rolled; about 70,000 cubic yards of filling of unsorted materials in parts of the dam outside of the carefully built portions adjacent to the corewall; 14,830 square feet of heavy split stone paving, 16 inches thick, bedded on a layer of screened gravel for protecting the water slope of the dam, and a dressing of loam, 18 inches deep, on the top and down-stream side of the dam; and 893 feet of concrete drain, 4 by 4 feet inside dimensions, built mostly in rock trench from 8 to 10 feet deep.

The excavation on this section proved much more difficult than had been anticipated. Below the surface layer of soil the digging was generally in a hard, compact material, containing many stones and boulders. Considerable areas of ledge were also exposed, the rough surfaces of which were almost inaccessible for carts, and the thorough stripping of the earth from all the pockets and crevices was consequently very laborious and troublesome. Contract work was suspended on the night of December 16, but a few men continued work until the end of the year, overhauling plant and preparing for its removal.

No unusual methods were employed in doing this work. Two 45-ton steam shovels worked throughout the year on all the sections at places where there was sufficient depth of cut to warrant their use. The material excavated by them was taken to the various waste dumps or to the dam, in trains of dump cars hauled by locomotives. Practically all the excavation on sections 14 and 1, excepting the preliminary stripping of soil, was steam-shovel and car work. Cart forces were used for shaping the shore of the reservoir, placing riprap, stripping soil and other work which could not be done by the steam shovels. On Section 2 only a small area was excavated by steam shovel, and this under trying conditions of very hard material and frequent outcrops of ledge, which retarded progress. Cart forces were therefore largely used. The material was either hauled directly to the dam or dumped from a raised platform into cars by which the further delivery at required points was effected. When feasible, earth was loaded by men shovelling directly into the cars, and considerable excavation was done in that manner.

The maximum force employed on these sections was 450 men and 119 horses, for the week ending October 10.

Buildings.

Eleven buildings have been erected over the several screening, gaging and gate chambers built in the course of the aqueduct, and each is designated by the name of the structure which it covers.

There are two buildings on Section 1: a meter chamber, 13 by 13 feet in outside dimensions, for housing the registers attached to the Venturi meters on two of the 60-inch pipes connecting the Sudbury Reservoir with the aqueduct; and a head chamber, 26 by 30 feet, equipped with screens and containing a weir for measuring the flow of water.

On Section 2, gaging chamber No. 1, 14 by 14 feet, covers a large opening where suitable apparatus will be installed for current meter measurements of the velocity of the water through this portion of the aqueduct where the slope is 4 feet in 5,000, and the width 10 feet.

On Section 5, gaging chamber No. 2, 16 by 16 feet, serves the same purpose as the preceding chamber, and it gives access to the larger section of the aqueduct, which is 13 feet 2 inches in width, with a slope of 1 foot in 5,000.

On sections 6, 8 and 10 there are four siphon chambers, each 21 by 21 feet, located at the ends of the Sudbury River and Happy Hollow siphons. These contain the hoists for the sluice-gates which will serve to exclude water from the siphons at times of inspection or repairs.

On Section 13, where the aqueduct enters the open channel, there is a channel chamber 17 by 24 feet in size, where provision has been made for closing the end of the aqueduct at times when it is desired to empty it without drawing down the reservoir.

On Section 15, where the water leaves the reservoir and re-enters the aqueduct, there is a screen chamber, 33 by 33 feet, containing appliances for screening and controlling the water. Also on Section 15, at the easterly end of the aqueduct, is the terminal chamber, 28 by 54 feet in size. This is a gate-chamber containing gates to control the flow of water into the pipes for conveying water into the Metropolitan District.

Messrs. Shepley, Rutan & Coolidge were the architects for these buildings, and furnished working plans and specifications for all of them. They are of stone, with red tile roofs. The designs are attractive and pleasing, and the materials and workmanship are of the best quality.

Head and Meter Chambers. — On July 6 a contract for these buildings was made with C. A. Dodge & Co. The erection of the meter chamber was begun on July 22, and both buildings were substantially finished on November 28. The amount of the contract was $10,804. The building force generally consisted of from 8 to 11 men.

Siphon Chambers and Gaging Chambers. — A contract for these six buildings was let to the Norcross Brothers Company on December 18, 1902, but it was agreed that only preparatory work should be done during the winter, and that building operations need not begin until April 10. The contractor began hauling tools and supplies to the site of the work on March 30. The buildings included in this contract are widely separated, and it appeared to be more economical to have only a limited number of men, and to complete the masonry at one building before moving to the next. In this way the work proceeded slowly but satisfactorily, until its completion on October 19. The amount of the contract was $27,352. The force employed varied from 16 to 28 men, and 1 or 2 teams were engaged in delivering materials.

Channel Chamber and Screen Chamber. — The contract for these structures was made with the Woodbury & Leighton Company on June 4. Tardy delivery of stone from the quarries delayed the beginning of construction until August 11. The erection of the channel chamber was then begun, but the force was small and the progress slow. It was finished on October 6, and the force then moved to the screen chamber. At that point further delay was caused by stone not coming as fast as desired, and the work was greatly retarded, so that on December 31 the building was still unfinished. The work remaining to be done, however, was mainly interior finishing, the outside walls having been completed and the roof boarded over before the end of the year. The amount of this contract is $12,475. The number of men employed in erection varied from 5 to 8.

Terminal Chamber. — The contract for this building was made with Connery & Wentworth, on January 7. The work was let early in the year, to enable the contractor to procure his stone and to be otherwise prepared for a vigorous start in the spring. The actual work of erection began April 28, and the contract was satisfactorily completed on October 15. The amount of this contract was $19,743. The average number of men employed during the time of active construction was 9.

Force employed and Materials used.

The largest force employed by the contractors in 1903, on the construction of the aqueduct, reservoir and buildings, was during the week ending May 23, when 1,452 men and 253 horses were at work. The largest force employed during any week in 1902 was 1,421 men and 367 horses.

For the aqueduct in open trench, the tunnel lining and the masonry structures for the reservoir, 113,100 barrels of American natural cement and 107,000 barrels of Portland cement, or a total of 220,100 barrels of cement, were required. Of this total, 83,000 barrels were used in 1903.

The thin lining of brickwork for the interior of the aqueduct in open trench required the use of 7,303,000 bricks, which were furnished by the New England Brick Company from their yards at Epping, N. H., and at Cambridge.

Additional Work on Aqueduct and Reservoir.

During the first half of the year a variety of work not included in the contracts was done by a small day-labor force, under the direction of the engineers. This work included building fences on sections 2 and 3; cleaning aqueduct on sections 4 and 5, and applying two coats of cement wash to the brickwork; smoothing and seeding slopes of embankments at places where the soil dressing had been finished; thinning out the woods around the reservoir, in accordance with suggestions from the landscape architects; and mowing grass and weeds along the line of the aqueduct. After August 15 much attention was given to the finishing process each section was to receive after acceptance from the contractor. Although the contractors had been required to give the aqueduct a very thorough scraping, cleaning and washing, and to put the grounds in good condition before the work was regarded as acceptable, it was thought that the greater smoothness and water-tightness which might result from another scraping of the brickwork and the application of two coats of cement wash warranted the expense of doing this additional work. Considerable work was also done outside, in seeding of slopes, ditching, etc.

When the concrete lining of the tunnels was finished, the slight ridges and irregularities in the concrete where the panels of the forms had not fitted closely were so numerous that the walls of the tunnel were appreciably rough; and it was decided to chisel such places down, and then to skim-coat the roughest places with Portland cement in the same manner as the arch of the aqueduct had been finished. About 13,000 linear feet of sides and arch in tunnels were thus gone over in a very careful manner. The concrete had set so hard that the chipping process was slow and laborious, but it resulted in great improvement.

It was so late in the season when several of the sections were delivered by the contractor that the time for doing the additional work just described was very short, and a large force was necessary to complete it. At one time, while the cement washing of the aqueduct and trimming and skim-coating of tunnels were in progress, the day-labor gangs reached a maximum of 147 men and 7 horses.

Porcelain tiles bearing the station numbers have been set in the masonry, inside the aqueduct, at intervals of 100 feet; and similar tiles, with the proper names on them, designate where streets and culverts cross the aqueduct.

Some stone bounds have been set to mark the centre line of the aqueduct, but many more yet remain to be set.

Sanitary Inspection.

Dr. L. M. Palmer of South Framingham and Dr. H. B. Frost of Weston continued to make frequent visits to the contractors' camps in their districts, to see that they were kept in proper sanitary condition and were free from infectious diseases. There has been very little sickness among the workmen, and no alarming cases have been reported.

Engineering.

The time of the engineering assistants assigned to the several divisions of the work has been spent largely in the field, directing and supervising the work under construction. During the latter part of the season, as the outside work was completed, the engineering force was correspondingly diminished, and the remaining members were engaged entirely in office work, computing final estimates and completing records. In addition to the engineering work contingent upon aqueduct and reservoir construction, considerable work has been done setting stone bounds, building right-of-way fences, and supervising additional construction done by day-labor forces employed by the Board.

The office force at the department headquarters in Saxonville has furnished miscellaneous detailed plans required during construction, and has also attended to the testing of cement, preparation of record plans and routine administrative work. The testing of cement was continued throughout the year until November, and has required the services of two cement testers in the laboratory, one man collecting samples, and for a portion of the time a fourth man, who was stationed at the natural cement works in Binnewater, N. Y., to sample cement in advance of shipment. In addition to the regular acceptance tests of cement, various tests have been conducted in order to gain information as to the effect on the strength of briquettes of variations in the details of laboratory manipulations, etc. Numerous small concrete beams were also made, in various proportions, with several different cements, and broken under centre loading at periods varying from 1 week to several months. During the year 485 carloads of cement, containing 78,865 barrels, were received and tested, and about 18,000 briquettes were made for this purpose. Four brands of Portland and two of natural cement have been used during the year. A summary of tests made upon cement used in constructing the aqueduct from the commencement of operations to the end of 1903 is given in Appendix No. 2.

DISTRIBUTION DEPARTMENT.

(The statement of the work of this department has been prepared by Dexter Brackett, department engineer.)

The work comprises the construction, maintenance and operation of the pipes, reservoirs, pumping stations and all other works in the Metropolitan Water District, with the exception of the Sudbury, Cochituate and Weston aqueducts.

The engineering work of the department has been under the direct charge of the following assistants: —

William E. Foss, division engineer, has had charge of work connected with the laying of a supply pipe line through the city of Newton, and of investigations relating to the injury of water pipes by electrolytic action.

John L. Howard, division engineer, has had charge of surveys and investigations relating to the improvement of Spot Pond Brook, and of engineering work connected with the laying of 60-inch pipes in Medford, near Spot Pond. Early in August he was temporarily placed in charge of work at the Weston Reservoir and Aqueduct, and on October 5 resigned to accept a position with the Charles River Basin Commission.

Caleb M. Saville, division engineer, has had charge of engineering work connected with the installation of Venturi meters throughout the Metropolitan District, and of the investigations relating to the use and waste of water.

Alfred O. Doane, division engineer, has continued in charge of engineering work connected with the maintenance and operation of the pumping stations and pipe lines.

John W. Lynch, engineer of pumping stations, has continued in direct charge of the pumping stations at Chestnut Hill, and has had general supervision of the mechanical work at the other stations.

George E. Wilde, assistant superintendent, has had charge of the maintenance and operation of the pipe lines, reservoirs and other works in charge of the Distribution Department, with the exception of the pumping stations.

At the beginning of the year the engineering force, including inspectors, numbered 30, and this was the maximum number during the year. With the completion of the construction work the force has been gradually decreased, and at the close of the year the number employed was 17.

During the year 507 feet of 60-inch, 10,194 feet of 48-inch and 79 feet of 36-inch pipes have been laid, completing the pipe line 7 miles in length connecting the terminus of the Weston Aqueduct with the 48-inch pipes just easterly from Chestnut Hill Reservoir. Twenty-three Venturi meters have been set on connections through which water is supplied to the several cities and towns in the District. The superstructure of the gate-chamber has been built at the Bear Hill Reservoir.

Pipes and Pipe Yards.

No pipes have been purchased during the year. The temporary pipe yard at Forest Hills was abandoned June 4, some of the pipes which had been stored there for several years having been sold to the city of Holyoke, and the remainder transferred to the yards at Chestnut Hill and Glenwood. As soon as the delivery of pipes for the supply pipe line was completed, the pipes and other castings remaining in the yard in Newton, near the Woodland Station on the Boston & Albany Railroad, were removed to the Chestnut Hill yard, and the Woodland yard was abandoned on July 29.

Pipe Laying.

During the year 2.1 miles of pipes have been laid, making 84.19 miles now owned and operated by the Board in connection with the Distribution System.

Section 1, Supply Pipe Line.

Contractor, Ward & Cummings; date of contract, July 26, 1902; amount of contract, $36,838.94; laying 1,570 feet of 60-inch pipes between the terminal chamber of the Weston Aqueduct and Charles River, and three lines of 60-inch pipes, each 350 feet long, crossing under the Charles River.

At the close of the year 1902 the pipes between the terminal chamber and Charles River were all laid, and the work of laying the three lines of pipes under the bed of the river was completed for about one-half the distance. A description of the construction of the coffer-dam and of the method of laying the pipes was given in the report for the year 1902. The contractor resumed work on the coffer-dam on the easterly side of the river on May 11. On June 2 water was pumped from the inside of the dam, and the work of excavating the trench commenced. Pipe laying was resumed on July 3 and completed on July 31. The coffer-dam was entirely removed on August 15, and the dredging of material deposited in the river by the pumps and from the coffer-dam was completed on August 26.

Section 2, Supply Pipe Line.

Contractor, D. F. O'Connell; date of contract, April 7, 1902; amount of contract, $71,287.87; laying 17,100 feet of 48-inch pipe.

Work under this contract was completed in 1902, with the exception of laying a short length of pipe for a blow-off, building a few catch-basins and surface water-drains, and resurfacing the grass spaces along the line of the trench. This work was resumed early in April, and completed on April 21. The work of resurfacing the roadways, which was done by the street department of the city of Newton, was begun April 4 and completed about June 1. The amount paid the city of Newton for resurfacing roadways and repairing concrete gutters, including work done in 1902, was $15,466.84.

Section 3, Supply Pipe Line.

Contractor, D. F. O'Connell; date of contract, April 14, 1903; amount of contract, $32,271.11; laying 9,952 feet of 48-inch pipe.

From the end of Section 2 on Commonwealth Avenue, near Walnut Street, the pipe line crosses Walnut Street, passes under the end of a large culvert, and, following along the shore of Bullough's Pond, enters the Bullough Park driveway, through which it extends to Mill Street. It then runs easterly on Mill Street for 800 feet, thence through private land, Blake, Colby, Centre, Sargent and Kendrick streets to a point about 300 feet east of Waverly Avenue, where it connects with the pipes of Section 4.

The contractor began the delivery of pipes on Colby Street on May 1, and trench excavation on May 13. Pipe laying was completed on August 12, and the contract was finished on August 18. The final cleaning up and seeding of the grass land on this section was done by the maintenance force between August 10 and 21. The resurfacing of streets and repairing the tar concrete gutters and walks was done by the street department of the city of Newton between July 6 and September 26, at a cost of $5,841.58.

Section 4, Supply Pipe Line.

Contractor, Thomas F. Moore; date of contract, April 18, 1902; amount of contract, $27,468.48; laying 9,589 feet of 48-inch pipe.

Pipe laying on this section was nearly finished at the close of the year 1902. Between January 1 and 17, 1903, 97 linear feet of

48-inch pipes were laid, completing this part of the work. All work was then suspended for the season, and was resumed on April 14. The refilling and resurfacing of the pipe trench and the removal of the surplus material was continued until the final completion of the contract on May 26. The seeding of the grass land was done by the maintenance force between April 23 and May 20. The work of connecting the supply pipe line with the two existing 48-inch mains near the effluent gate-house at the Chestnut Hill Reservoir, setting two 36-inch valves, and setting a 48-inch Venturi meter on the pipe line near the same point, was done by the maintenance force between July 13 and August 8.

Section 12, Low-service Pipe Line.

Contractor, Coleman Bros.; date of contract, May 2, 1902; amount of contract, $60,727.03; laying 6,151 feet of 60-inch pipe.

Pipe laying on this section was completed January 4. The contractor continued work until January 17, and completed the embankment over the pipes through Wright's Pond, in order that the pond might be refilled during the winter. Work was then suspended, and resumed March 30. The sides of the deep cuts between Wright's Pond and Spot Pond were then sloped and covered with soil, and the surplus material which had been left alongside the trench was removed and used in grading near the south gate-house at Spot Pond. This work was completed May 19, after which the surface of the trench and slopes was seeded by the maintenance force.

Installation of Venturi Meters.

The work of placing Venturi meters on the connections supplying water to each city and town supplied from the Metropolitan Works was begun late in the year 1902, and when the work was stopped by cold weather twenty-four of the meter tubes had been set, but none of the registering apparatus had been received from the manufacturer. During the winter several of the registers were received and connected with the meter tubes, thus enabling measurements to be made of the quantity of water used in several cities and towns. In March the setting of meter tubes was resumed, and was continued until June 27, when the number required for measuring the water used in the eighteen cities and towns supplied from the Metropolitan Works had been set. One meter has since been set on the 48-inch supply

Bear Hill Reservoir in Stoneham — Spot Pond in the Distance.

pipe line near Chestnut Hill, and a 10-inch meter has been placed on a by-pass connected with the 30-inch main crossing Chelsea bridge between Chelsea and Charlestown. A meter tube has also been set on a connection with the pipes of the city of Cambridge, to be used in cases of emergency. The cost of meters and setting same, to January 1, has been $74,088.54.

Miscellaneous.

A contract for building the superstructure of the gate-chamber at the Bear Hill Reservoir was made with Woodbury & Leighton of Boston, on April 22, 1903. The work of erecting the building was begun July 1 and finished about September 1. The building has walls of seam-faced granite with red granite trimmings, and a roof covered with red tile. The interior walls are of red brick. The cost of the building was $2,750.

A woven-wire fence, 30 inches high and 739 feet in length, has been set around the Bear Hill Reservoir, for the purpose of preventing children from falling into the water. The wire fence was attached to posts of 1¼-inch diameter galvanized-iron pipe, set in concrete bases. This fence was erected by the maintenance force.

In December a connection was made between the 48-inch Metropolitan Water Works pipe and the pipes of the city of Cambridge on Massachusetts Avenue opposite Cambridge Common. A 24-inch Venturi meter was placed on this connection, and this, with a 30-inch valve, was set by the maintenance force. All other material and labor connected with making the connection were furnished by the city of Cambridge.

Engineering.

The engineering force has superintended the work of laying 60-inch pipes under the Charles River between Weston and Newton, laying 48-inch pipes in Newton, installing Venturi meters, and building the gate-house at the Bear Hill Reservoir. It has also prepared plans for steam piping and for boiler foundations at the Chestnut Hill pumping station, and made record plans showing the location of pipes and Venturi meters. In connection with the maintenance of the works, much time has been devoted to investigations relating to the use and waste of water and to the effect of electrolysis upon the pipes throughout the District. Tests have been made of oil and coal used at the several pumping stations, records kept of pressure in water mains, quantity of water pumped and consumed, amount of rainfall, and of the elevation of the water in the several reservoirs.

OFFICE FORCE.

Frank T. Daniels, *Principal Office Assistant;* John N. Ferguson, *Office Assistant to September 8;* Samuel E. Killam, *Office Assistant after September 8.*

The following is a statement of the more important matters upon which the drafting department has been engaged during the year.

In connection with the work at the Wachusett Reservoir, there were made construction plans for masonry arch highway bridges over the Quinapoxet, Stillwater and Nashua rivers; most of the contract plans for the South Dike; and a plan of grading near the northerly end of Worcester Street relocation.

Many working plans have been made for the Wachusett Dam, among which are those for stonework of the pools, waste-weir and main dam; details of equalizer and diffuser pipes, composition stop-plank grooves, cast-iron standards for flash-boards at the waste-weir, and wall castings for sluice gates. Studies were made in preparation for the final contract plans of the superstructure of the lower gate-chamber, which have been drawn by Shepley, Rutan & Coolidge, architects.

Several land plans have been made in connection with the relocation of the Central Massachusetts Railroad, and a set of twelve plans, showing details of location and alignment, has been nearly finished.

Among the drawings made for the Weston Aqueduct are detail plans for a weir at the head-chamber, gates and hoists for the siphon chambers, and gates and stop-planks for various chambers.

The department has also made many minor plans and a number of record drawings. Among these are record drawings of Sudbury Dam and of improvements at Lake Cochituate, plans for changes in steam piping at Chestnut Hill pumping stations, and drawings and tables giving details of standard water pipe castings.

The whole number of finished drawings made is 166, besides numerous sketches and studies.

The number employed in the drafting department was 10 at the beginning of the year. This number was reduced by resignations early in the year to 7, which is the number now employed.

John N. Ferguson, who had charge of the miscellaneous work of the office, such as receiving applications for employment, procuring supplies, making blue prints and miscellaneous investigations and computations, resigned on September 8 to accept a position with the Charles River Basin Commission. His position has been filled by Samuel E. Killam. The average force in this department has numbered 7.

Accidents.

Six fatal accidents have occurred during the year, one at the sand pit and two at the quarry connected with the Wachusett Dam, one at the viaduct over the Nashua River, and one each on the Weston Aqueduct and Reservoir.

Those at the sand pit, quarry and viaduct occurred in connection with the work of the McArthur Brothers Company. At the sand pit a laborer was killed by being caught in the machinery of the sand screen; at the quarry one laborer was killed by the falling of a large stone from a "skip," and another by a stone thrown from a blast; and at the viaduct a man was killed by falling with the travelling derrick. On Section 13 of the Weston Aqueduct a laborer was killed by the falling of a heavy stone, and on Section 1 of the Reservoir a laborer was killed by being struck by the dipper of one of the steam shovels which had been caught in the side of a car.

MAINTENANCE.

NOTE. — This report upon maintenance has been compiled from reports prepared by the engineers in charge of the various departments of the works.

The additional works maintained and operated in 1903 are about 3 miles of 48-inch and 60-inch pipe from Medford to Spot Pond, placed in service in January, and the Weston Aqueduct, Weston Reservoir and supply pipe line, placed in service on December 29.

Organization of Maintenance Force.

At the beginning of 1903 the total force employed directly by the Board was 174, exclusive of such of the engineers as devoted only a part of their time to maintenance. At the end of the year the force had decreased to 157. From time to time during the year there has been an additional temporary force engaged on special work, making the maximum number, including both the permanent and temporary force, 246.

Rainfall and Yield.

The total rainfall for the year has been a little less than the average, while the yield of the watersheds for the whole year has been very nearly the same as the average. The distribution of rainfall and run-off throughout the year has, however, been somewhat erratic. The month of May was very dry, but extremely heavy rains in June resulted in a freshet of some magnitude, — a very rare occurrence for the summer months. During the remainder of the year the rainfall and yield have in general been somewhat less than the average. Statistics relating to rainfall and yield of watersheds may be found in Appendix No. 3, tables Nos. 1 to 11.

Storage Reservoirs.

At the beginning of the year the reservoirs of the Sudbury watershed were nearly as full as it is desirable to keep them during the winter months, but the water was low in Lake Cochituate. At the beginning of April, however, they, as well as Lake Cochituate, had been entirely filled, and remained so until May 17, when they contained 16,066,900,000 gallons of water. The quantity of water stored then gradually decreased until June 10, after which the heavy rains filled all these reservoirs once more. They remained generally full until August 12, when they contained 16,019,500,000 gallons of water; after which the quantity of water stored gradually decreased, with some fluctuations, until the end of the year, when there were 11,376,800,000 gallons in store in these reservoirs.

A considerable quantity of water was stored in Wachusett Reservoir at the time of the June freshet; part of this was at once wasted into the river, to avoid damage to the works at the dam in case of further rains, and the remainder was gradually drawn into Sudbury Reservoir during the months of July and August. The maximum quantity retained by the dam amounted to 2,397,000,000 gallons on June 22. During November and December water was again stored in Wachusett Reservoir in considerable quantity. At the end of the year the quantity stored amounted to 1,760,100,000 gallons, making, with the quantities stored in the reservoirs of the Sudbury and Cochituate systems, a total of 13,136,900,000 gallons.

The following table gives the quantity of water stored in the storage reservoirs at the beginning of each month: —

Quantity of Water stored in Wachusett Reservoir, and in Reservoirs on Sudbury and Cochituate Watersheds, at the Beginning of Each Month.

Date.	In Wachusett Reservoir (Gallons).	In Sudbury Reservoir and Framingham Reservoir No. 3 (Gallons).	In All Other Storage Reservoirs (Gallons).	Total (Gallons).
1903.				
January 1,	141,000,000	6,236,600,000	5,479,500,000	11,857,100,000
February 1,	193,100,000	7,362,700,000	5,931,700,000	13,487,500,000
March 1,	141,400,000	7,488,700,000	6,213,400,000	13,843,500,000
April 1,	149,500,000	8,439,000,000	7,526,800,000	16,115,300,000
May 1,	263,100,000	8,374,100,000	7,674,700,000	16,311,900,000
June 1,	460,300,000	8,096,100,000	7,409,500,000	15,965,900,000
July 1,	1,615,800,000	8,475,800,000	7,658,300,000	17,749,900,000
August 1,	1,086,300,000	8,416,500,000	7,629,800,000	17,132,600,000
September 1,	296,400,000	7,531,000,000	7,539,600,000	15,367,000,000
October 1,	295,800,000	6,226,200,000	7,164,200,000	13,686,200,000
November 1,	304,300,000	6,529,300,000	6,841,000,000	13,674,600,000
December 1,	384,400,000	5,965,200,000	6,697,300,000	13,046,900,000
1904.				
January 1,	1,760,100,000	5,226,600,000	6,150,200,000	13,136,900,000

Wachusett Reservoir. — For several years the temporary dam at which the water of the Nashua River was diverted into the Wachusett Aqueduct has retained a limited amount of water. On April 19 the regulation of the water at the Wachusett Dam was begun. In the evening of June 22 the water reached the highest point to which it has yet been raised, elevation 309.44, or 25.44 feet above the bottom of the 48-inch cast-iron pipes through the dam. At the end of the year the water was 21.90 feet above the bottom of the pipes.

Sudbury Reservoir. — At the beginning of the year the water was 3.95 feet below the stone crest of the dam, which is at elevation 259.00. The reservoir was full on March 23, and was kept substantially full until August 16, when, the storage in the Wachusett Reservoir being exhausted and the supply to the Sudbury Reservoir being much reduced, it receded gradually, with some fluctuations, about 9 feet, reaching elevation 251.10 on December 20. At the end of the year the water was 6.37 feet below the crest.

The *Marlborough Brook filter-beds*, at the head of one branch of the Sudbury Reservoir, have been in service throughout the year.

They filtered all the water of the brook excepting for short periods of a small part of a day each on two occasions during freshets.

Analyses have been made monthly by the State Board of Health of the water before and after passing through the filter-beds, which show that the water was purified by the filters to a fairly satisfactory extent.

A large number of white pine, white spruce and hemlock trees have been set out at various places around the Sudbury Reservoir, and a few maples near the dam.

Some filled land near the head of the Southborough branch of the reservoir proved to be inadequately underdrained. To perfect the drainage, a new marginal drain has been constructed, discharging into the old drain pipes.

A considerable amount of work was done in locating corners and setting 150 stone bounds around the Sudbury Reservoir.

In the last annual report mention was made of the erosion of the granite in the pipe-chambers and of the cast-iron bellmouths connecting with the pipes through the dam at the Sudbury gate-house. Repairs to two of the chambers and bellmouths had been made at the time of that report by bolting steel plates over the eroded places. The third bellmouth has been protected by bolting steel plates over the eroded places, and the pipe-chamber by bolting on heavy cast-iron plates. A cast-iron plate has also been substituted for the steel plate on the bottom of one of the other chambers, as the fastenings of the steel plate had proved too light to withstand the force of the water.

Framingham Reservoir No. 3 was kept nearly full throughout the year, with an extreme range in elevation of about 3.5 feet. While the Sudbury Reservoir was full, or from late in March until the middle of August, the flash-boards were in position on the dam and the water kept as high as possible; but during the remainder of the year it was in general kept about 1 foot below the crest, to avoid wasting water from the effect of the wind.

Framingham Reservoir No. 2 has been kept practically full throughout the year. Water was drawn in varying quantities from this reservoir for the supply of the Metropolitan District between May 1 and 12, June 2 and 16, August 29 and September 12, September 17 and 18, October 1 and 17, and December 8 and 21. While water was being drawn from this reservoir, the surface was kept at the desired elevation by drawing water when needed from Ashland, Hopkinton and Whitehall reservoirs.

Framingham Reservoir No. 1 has been kept practically full throughout the year, except for a short time in May and June. Water was drawn in small quantities from this source for the supply of the District from May 7 to June 2.

A tool house and horse shed, about 18 by 20 feet in size, has been built near Framingham Dam No. 1, and a hay barn has been built near the foreman's house on Salem Street.

Ashland Reservoir. — At the beginning of the year the water in this reservoir was 3.89 feet below the elevation of high water. The reservoir was filled by the middle of January, and, except as drawn down in anticipation of freshets, it remained substantially full until the first of December. After December 1, however, when water was drawn first to displace the poorer water and later to maintain the supply in Framingham Reservoir No. 2, the surface receded, reaching elevation 220.12, 5.09 feet below high water, on December 20; the water then began to rise, and at the end of the year was 4.31 feet below high-water mark. Water was drawn from this reservoir in connection with the supply of the District for about three weeks in December.

The gate-keeper's house and outbuildings at the dam have been painted during the year.

Hopkinton Reservoir. — At the beginning of the year water in this reservoir was 2.12 feet below high water. Except when the reservoir was drawn down in anticipation of freshets, it was substantially full from January 10 to December 1, after which the quantity of water drawn was so great that the surface receded, reaching elevation 299.16, 5.84 feet below high water, on December 21. After this date the water gradually rose, and at the end of the year was 5.16 feet below high-water level. Water was drawn from this reservoir in connection with the supply of the District for about two weeks in October and three weeks in December. About half of the water drawn from this source for the maintenance of the supply to Framingham Reservoir No. 2 was filtered.

The gate-keeper's house and barn at the dam were painted during the year, the grounds at the rear of the house were graded, and about 200 pine trees were set out.

Whitehall Reservoir has been kept nearly full throughout the year, except as lowered in readiness for freshets, the extreme range in elevation being about 2.5 feet. In anticipation of a possible necessity for its use if the year should prove very dry, water was stored in this reservoir at a higher elevation than ever before, the highest point reached being elevation 339.80, 1.89 feet above the old high-water mark. Little water was drawn from this reservoir for the maintenance of the supply to Framingham Reservoir No. 2, and that during the first two weeks of June.

Farm Pond has been substantially full during the year. The lowest point reached was 0.84 of a foot below high water, on December 2, and at the end of the year the water had risen to 0.66 of a foot below high-water mark. No water has been drawn from this pond for the supply of the Metropolitan District, and the water collected by the pond has proved sufficient for the needs of the Framingham Water Company, so that it has not been necessary to furnish any water from the Sudbury Aqueduct to maintain the supply. It was necessary to waste water from the pond into the Sudbury River but once during the year.

Lake Cochituate at the beginning of the year was 6.08 feet below high water. It was full by the middle of March, and, although drawn down about a foot in the latter part of May, the heavy rains of June soon filled it again, and the lake was substantially full until September 20. After this date the draft was sufficient to lower the lake until October 17, when it reached elevation 142.37, 1.99 feet below high water; the surface remained within a few hundredths of a foot of this elevation for about a month, after which it rose slightly, and then receded again. At the end of the year the water was 1.94 feet below high-water mark.

Water was wasted at the outlet dam in considerable quantities in March and April, and in varying smaller quantities in June, July, August and September. No water was discharged from the Sudbury Aqueduct into the lake during the year.

Water was drawn from Lake Cochituate for the supply of the Metropolitan District from January 1 to April 28, May 3 to June 13, June 29 to July 1, July 6 to 21, and from September 20 to the end of the year.

The roof of the gate-house at Lake Cochituate has been strengthened by putting in new steel tie rods and by clamping together the wooden and iron rafters, and a new ceiling of hard pine has been built. The roof of the carriage house has been shingled.

There were 45,100,000 gallons of water drawn from Dudley Pond into Lake Cochituate between June 5 and 15. At the beginning of the year the pond was 3.69 feet below high water, and at the end of the year 3.41 feet below high water. The highest point was reached on April 20 and May 18, when the surface was 1.26 feet below high water.

The town of Natick has during the year ceased to take its water supply from Dug Pond, and, under authority of chapter 392 of the Acts of 1902, it is now pumping water from a large well on the borders of Lake Cochituate, just south of the Worcester turnpike. This well intercepts water which would otherwise find its way into Lake Cochituate. A pipe has also been laid into the lake, by which the supply could be taken directly in case the well should at any time prove insufficient. The waters of Dug Pond, which have always overflowed into Lake Cochituate when the pond was high, will now all find their way into the lake.

The surfaces of the embankments at Pegan Brook Meadow have been graded and seeded to grass, and a new bridge has been built over the waste-weir to the Pegan Brook settling reservoir.

The Pegan Brook filter-beds have been in use throughout the year whenever there was water to filter. All of the brook water was filtered, and since August 24 the water collected by the intercepting ditch from the brooks formerly draining into Pegan Brook Meadow has also been discharged upon the filters.

The total quantity of water pumped during the year was 299,-588,000 gallons, of which 278,280,000 gallons were from Pegan Brook and 21,308,000 gallons from the intercepting ditch. The total quantity of coal consumed was 302,300 pounds, so that 991 gallons of water were pumped per pound of coal.

The last annual report called attention to the unsatisfactory condition of the old pumping plant, and stated that plans had been made for a new pumping station, foundations for which were then in process of construction. These foundations, as well as concrete pipe galleries below the floor of the pumping station, were completed by a day-labor force on January 24, and a 20-inch and 16-inch force main from the pumping station to the filter-beds was completed on February 14. Four bids for the erection of the superstructure of the pumping station were received on March 12, and the contract was awarded to the lowest bidder, John J. Prindiville of South Framingham, for $4,200. The erection of the station began on April 23 and was completed on August 15, after considerable delay caused by non-arrival of the boilers, which had to be put in before the building could be completed. A small amount of extra work done by the contractor raised the amount paid him on the final estimate to $4,390.53.

This pumping station is built of brick, with a slate roof, except over the coal shed, where there is a gravel roof. It contains an engine room 18 by 20 feet, a boiler room 14 feet 3 inches by 15 feet, a shop 12 feet by 15 feet, and a coal room 13 feet 6 inches by 22 feet in interior dimensions. There is a brick chimney 53 feet in height and 2 feet square inside.

In the new pumping station the following machinery has been installed: two Lawrence centrifugal pumps (one 8-inch and one 10-inch), directly connected to 5 by 10 by 7 inch vertical, cross-compound engines of the marine type, which were built by the Fore River Ship and Engine Company of Quincy; a Blake air pump and jet condenser; and a Stillwell-Bierce and Smith-Vaile duplex feed pump. There are two 48-inch vertical tubular boilers, built by the James Russell Boiler Works in 1895, which were originally used in the Metropolitan sewerage pumping station at Alewife Brook. On August 20 the new pumping plant was started; since that date no pumping has been done at the old pumping station, which has been dismantled to a considerable extent.

Sources from which Water has been taken.

An average of 66,943,000 gallons per day was drawn from the South Branch of the Nashua River through the Wachusett Aqueduct into the Sudbury Reservoir, and an average of 92,675,000 gallons per day was drawn through the Sudbury Aqueduct from Framingham Reservoir No. 3, which obtains its supply mainly from the Sudbury Reservoir. An average of 5,346,000 gallons per day was drawn through the Sudbury Aqueduct from Framingham Reservoirs Nos. 1 and 2, which receive all of the water supplied from the main Sudbury River. A draft through the Weston Aqueduct from the Sudbury Reservoir was started on December 29, amounting to an average of 209,000 gallons per day for the year. An average of 10,619,000 gallons per day was drawn from Lake Cochituate through the Cochituate Aqueduct. The Spot Pond drainage area furnished 708,000 gallons per day, and 142,000 gallons per day were supplied from local sources in Medford and Lexington. The total quantity drawn from the several sources of supply is, according to the above figures, somewhat greater than the amount of water supplied to the Metropolitan District. This is due to leakage from the aqueducts, and to differences between the measurements of the quantity flowing in the aqueducts and that delivered by the pumps to the District.

The utmost care is taken to draw as little water as possible from the less satisfactory sources, and to draw the water only at such times as it is in good condition; but the maintenance of the supply, with the existing condition of the works and the large consumption of water, makes it necessary to draw some of the water from the less desirable sources.

Aqueducts.

The *Wachusett Aqueduct* has been in use for 302 days during the year. It was shut off for 28 days in the early part of the year, when the reservoir water was somewhat turbid, for 11 days while the aqueduct was being cleaned, and for 24 days on account of repairs in the aqueduct and work at the Wachusett Dam. The interior of the aqueduct was cleaned for its whole length on November 6 and 7 and between November 30 and December 8, and was found to be covered with an unusually thick coating of black slime. Nineteen months had elapsed since the previous cleaning of the aqueduct.

The arch of the cut and cover part of the Wachusett Aqueduct is built of concrete, while the sides and bottom are of concrete, lined with 4 inches of brickwork. Temperature changes causing contraction of the concrete resulted in a separation of sections of the arch built at different times, making minute cracks extending across the arch and occasionally through a few of the upper courses of the brick lining of the sides. These cracks have not appeared in the lower part of the aqueduct. It has not heretofore been possible to utilize the whole capacity of the aqueduct, and the surface of the water has been below the top of the brick lining; but with increased storage in Wachusett Reservoir, and a greater head on the pipes through the dam, it will be possible to utilize the full capacity of the aqueduct. In order to prevent leakage of water through the cracks in the arch, repairs became necessary which could only be made properly when the temperature was low. A force of about 20 men, consisting principally of masons and inspectors from the construction of Wachusett Dam, was put at work on these repairs on December 9, after work on the masonry of the dam was suspended, and the work of repairing the cracks was in progress at the end of the year.

These cracks were not wide enough for successful grouting or pointing with mortar. The concrete has consequently been cut away with chisels, widening the cracks to about ¼ of an inch for a depth of 2 inches, and the enlarged cracks were then pointed with mortar of neat Portland cement.

While the work of repairs was in progress in the masonry aqueduct the water was drawn out of the open channel, and considerable material, which had been washed into the channel by the brooks discharging into it, was removed.

The usual work of maintenance along the line of the aqueduct has been performed, and the aqueduct and its appurtenances are in excellent condition.

The *Sudbury Aqueduct* was in constant service during the year except on parts of 4 days, when it was necessary to empty it for cleaning. The flow for the whole year averaged 98,021,000 gallons per day (not including quantities wasted in cleaning the aqueduct), which is 2,615,000 gallons more than the daily amount of water carried by the aqueduct last year. The interior of the aqueduct from Framingham Dam No. 1 to the terminal chamber at Chestnut Hill Reservoir was cleaned once during the year, on April 2, 9, 16 and 23. The siphon pipes were also cleaned at the same time. The usual thick coating of black slime was found, but very little sponge except in the tunnels.

The Framingham low-level sewer in the valley of Beaver Dam Brook has been put in service by making connection with the pipe laid under Sudbury Aqueduct last year, and about two-thirds of the houses which can drain into the pipes already laid have been connected with the sewer. To complete the system, and to obtain all the benefits that should result from it, branch sewers should be laid in some other streets.

The interior of the arches at the Waban Bridge was heated with steam during the winter months, as usual, to prevent the formation of ice inside of the bridge. The weep-holes in the piers of Echo Bridge have also required considerable attention during the cold weather, to prevent the accumulation of ice in the interior of the arches.

The embankments near the east and west siphon chambers have been loamed, and the ironwork in all the buildings along the aqueduct has been painted during the year.

The *Cochituate Aqueduct* was in use 282 days. The interior of the aqueduct was cleaned from the influent gate-house at Lake Cochituate to Chestnut Hill Reservoir, with the exception of the siphon pipes, on April 30, May 1 and 2. The interior coating of black slime was very thick near the westerly end, but gradually diminished in thickness towards Chestnut Hill Reservoir. Sponge was found in considerable quantities, especially near the westerly end.

The city of Newton has built a 20 by 30 inch sewer, with a 10-inch subdrain, passing under the Cochituate Aqueduct in Newton Highlands, the top of the sewer being 14.6 feet below the bottom of the aqueduct. Cylindrical telescopic steel pipes were forced through under the aqueduct from a pit on one side 15 feet from the centre of the aqueduct, the earth being removed as the pipes were driven forward. It required 9 days, working with day and night shifts, to force the cylinders through to the pit on the opposite side of the aqueduct. After the steel pipes were in place the sewer and subdrain were built through them, and the space between them and the sewer was filled solid with concrete. The ground was very wet, and a large amount of pumping was required to enable the work to proceed. While the sewer was being built, all the holes, cracks and soft joints in the aqueduct were pointed, and the bottom plastered, for a distance of 115 feet on each side of the sewer.

The embankments near the siphon chambers and over the siphon pipes have been loamed, and the masonry of some of the culverts and waste-weirs pointed during the year. The ironwork in all the structures has been painted.

Surveys for locating the centre line of the aqueduct and land bounds have been made from Dedman's waste-weir to Charles River. As but few monuments were set on the surface of the ground when the aqueduct was built, this has required extensive surveys, partly within the interior of the aqueduct, as well as in the sinking of numerous test pits.

Pumping Stations.

Ninety-nine per cent. of all the water supplied to the Metropolitan Water District has been pumped at the two stations at Chestnut Hill Reservoir. Of the remainder, 65,040,000 gallons were supplied by gravity through the Weston Aqueduct, 258,410,000 gallons were drawn from Spot Pond, 44,530,000 gallons were supplied by the city of Medford from Wright's Pond, and 7,410,000 gallons were pumped by the town of Lexington from local sources.

The total quantity pumped at all of the stations during the year was 41,816,200,000 gallons, and the cost of operating the stations was $117,430.55, equivalent to $2.81 per million gallons pumped. The cost per million gallons is $0.31 more than the cost for the year 1902, the increase being due to the cost of installing two new boilers at the Chestnut Hill high-service station and a new line of steam pipe at the low-service station, and to the increase in the cost of fuel.

The cost of bituminous coal used at the high-service station at Chestnut Hill was $0.57 per ton, and at the low-service station $0.75 per ton, more than during the year 1902. A considerable saving has been made in the cost of fuel by mixing anthracite buckwheat coal and screenings with the bituminous coal.

The duty developed by the engines at the Chestnut Hill and Spot Pond stations was less than during the previous year. This result was due to the use of cheaper grades of fuel, which have been found to be more economical, although giving a smaller duty per pound of coal.

All lubricating oil used at the pumping stations has been tested, to see that its viscosity, specific gravity and burning point conformed with the contract requirements; and tests have been made to determine the calorific value and other properties of coal used at the several stations, as an aid in selecting coal best suited for use.

Coal for use at the several stations has been purchased as follows: —

	Gross Tons.					Price per Gross Ton.
	Chestnut Hill High-service Station.	Chestnut Hill Low-service Station.	Spot Pond Station.	West Roxbury Station.	Arlington Station.	
Loyal Hanna Coal and Coke Company, bituminous.	781.30	662.40	-	-	-	$7 61
Loyal Hanna Coal and Coke Company, bituminous.	698.77	605.80	-	-	-	5 86
Loyal Hanna Coal and Coke Company, bituminous.	1,103.88	986.54	-	-	-	4 94
E. B. Townsend, bituminous, . .	137.41	-	-	-	-	4 77
E. B. Townsend, bituminous, . .	-	65.31	-	-	-	4 75
E. B. Townsend, bituminous, . .	57.01	-	-	-	-	4 73
E. B. Townsend, bituminous, . .	63.71	317.86	-	-	-	4 50
Murrell Coal Company, bituminous, .	966.78	908.35	-	-	-	4 48
F. Walter & Son, buckwheat anthracite,	322.86	308.34	-	-	-	5 75
E. B. Townsend, buckwheat anthracite,	-	99.24	-	-	-	3 36
E. B. Townsend, buckwheat anthracite,	-	206.70	-	-	-	3 00
Gillespie & Pierce, screenings, . .	363.33	26.71	-	-	-	2 24
Locke Coal Company, bituminous, .	-	-	62.73	-	-	6 16
Locke Coal Company, bituminous, .	-	-	5.42	-	-	5 75
E. B. Townsend, bituminous, . .	-	-	109.64	-	-	5 07
E. B. Townsend, bituminous, . .	-	-	528.53	-	-	5 10
Locke Coal Company, buckwheat anthracite.	-	-	54.55	-	-	4 25
Locke Coal Company, buckwheat anthracite.	-	-	201.88	-	-	3 75
Locke Coal Company, screenings, . .	-	-	279.53	-	-	2 24
D. Doherty, bituminous, ...	-	-	-	22.32	-	11 48
D. J. Cutter & Co., bituminous, . .	-	-	-	34.18	-	$7 00 and 8 40
D. J. Cutter & Co., anthracite, . .	-	-	-	132.42	-	7 56 and 7 84
Marston Coal Company, anthracite, .	-	-	-	44.64	-	7 84
D. J. Cutter & Co , screenings, . .	-	-	-	5.40	-	2 24
Peirce & Winn Company, bituminous, .	-	-	-	-	314.88	4 89 to 11 20
Henry T. Woods, bituminous, . .	-	-	-	-	37.87	4 95
Peirce & Winn Company, screenings, .	-	-	-	-	161.14	2 24
Total gross tons, bituminous, . .	3,808.86	3,546.26	706.32	56.50	352.75	-
Total gross tons, anthracite, . .	322.86	614.28	256.43	177.06	-	-
Total gross tons, anthracite screenings.	363.33	26.71	279.53	5.40	161.14	-
Average price per gross ton, bituminous.	$5 53	$5 44	$5 19	$9 21	$6 12	-
Average price per gross ton, anthracite.	5 75	4 44	3 86	7 65	-	-
Average price per gross ton, anthracite screenings.	2 24	2 24	2 24	2 24	2 24	-

Chestnut Hill High-service Station.

The water used in the high-service district of Boston, in the city of Quincy and the towns of Watertown, Belmont and Milton, was pumped at this station.

The following are the statistics relating to the operations at this station: —

	Low Service, Engine No. 1.	High Service.			Totals.
		Engines Nos. 1 and 2	Engine No. 3.	Engine No. 4.	
Total quantity pumped (million gallons),	27.51	528.43	776.18	9,631.33	10,963.45
Total coal used (pounds),	22,253	850,524	750,153	8,177,358	9,800,288
Gallons pumped per pound of coal,	1,236.23	621.30	1,034.70	1,177.80	1,118.69
Average head pumped against (feet),	44.03	120.28	128.38	127.63	127.12
Cost of pumping: —					
Labor,	$102 17	$1,982 93	$1,263 24	$11,871 39	$15,219 73
Fuel,	55 79	2,024 64	1,777 32	19,522 94	23,380 69
Repairs,	139 61	2,709 53	3,657 43	5,571 84	12,078 41
Oil, waste and packing,	2 98	57 86	36 86	346 37	444 07
Small supplies,	8 56	166 12	105 83	994 52	1,275 03
Total for station,	$309 11	$6,941 08	$6,840 68	$38,307 06	$52,397 93
Cost per million gallons pumped to reservoir,	$11.236	$13.135	$8.813	$3.977	$4.779
Cost per million gallons raised 1 foot high,	.255	.109	.069	.031	.037

The cost per million gallons pumped to the reservoir was $0.715 more than in 1902, due to increased cost of fuel and repairs, and to the greater use of the less economical engines.

The two new vertical boilers, for which a contract was made in 1902, were delivered in April. The boilers were unloaded from the cars and erected in position on their foundations in the boiler room, and the old boiler removed from the building, by John Soley & Son, for the sum of $525.25. The wrought-iron flue was furnished and erected by the Hodge Boiler Works, for the sum of $524. The steam pipe was furnished by the Lumsden & Van Stone Company, for the sum of $235.30. The magnesia covering on the boilers, steam piping and smoke flue was furnished and applied by the C. W. Trainer Manufacturing Company, for the sum of $414.50. The construction of the boiler foundations and the erection of the boiler galleries, steam pipe, feed pipe and all small fittings were done by the regular maintenance force of the station. The foundations for the boilers are 19½ feet long, 10 feet wide and about 18 feet deep, made of Portland cement concrete. The depth of the foundations was required in order to reach solid ground, as the site of the boiler room was filled with stumps and other débris during the construction of Chestnut Hill Reservoir.

The boilers, designed by Dean & Main, mechanical engineers, are each 96 inches internal diameter, 24 feet 4⅜ inches high, and contain 392 tubes 2 inches in diameter and 15 feet long. The outer shell of the boiler is made of steel plates $^{27}/_{32}$ of an inch in thickness. Each boiler has a heating surface of 2,989 square feet, and is designed for use under 185 pounds steam pressure. They were built by the I. P. Morris Company of Philadelphia, at a cost of $12,555.67. The total cost of the boilers and fittings, including foundations, was about $16,000.

A heater for condensing the exhaust steam and utilizing waste heat from the blower, economizer and electric lighting engines and the feed pumps has been placed in the boiler room.

During July a new and longer expansion joint and a new separator casting were placed on the Allis engine (No. 4), for the purpose of preventing leakage of steam from the joints of the high-pressure cylinder. A ventilator about 8 feet in diameter has been built on the roof of the boiler house.

Chestnut Hill Low-service Station.

The daily average quantity of water for the year pumped by the three 35,000,000-gallon engines at this station was 76,091,000 gallons.

The following are the statistics relating to operations at this station: —

	Engines Nos. 5, 6 and 7.
Total quantity pumped (million gallons),	27,773.23
Total coal used (pounds),	8,561,549
Gallons pumped per pound of coal,	3,243.95
Average head pumped against (feet),	37.82
Cost of pumping: —	
Labor,	$16,254 32
Fuel,	20,974 79
Repairs,	2,651 52
Oil, waste and packing,	465 75
Small supplies,	1,174 92
Total for station,	$41,521 30
Cost per million gallons pumped to reservoir,	$1.495
Cost per million gallons raised 1 foot high,	.039

The cost per million gallons pumped to the reservoir was $0.141 more than for the year 1902. This is due to increased cost of fuel, and the increased cost of repairs caused by the installation of an additional line of steam pipe between the boilers and the engines.

Spot Pond Pumping Station.

At this station engine No. 8 was operated a few hours in February, and from April 26 to May 19 while repairs were being made on engine No. 9. During the remainder of the year all the water was pumped with engine No. 9, the 20,000,000-gallon Holly engine.

The following are the statistics relating to operations at this station : —

	Engine No. 8.	Engine No. 9.	Totals.
Total quantity pumped (million gallons),	178.82	2,570.01	2,748.83
Total coal used (pounds),	167,792	2,210,587	2,378,379
Gallons pumped per pound of coal,	1,065.72	1,162.59	1,155.76
Average head pumped against (feet),	119.43	128.00	127.45
Cost of pumping: —			
Labor,	$766 29	$6,075 58	$6,841 87
Fuel,	350 82	4,502 49	4,853 31
Repairs,	33 38	264 63	298 01
Oil, waste and packing,	13 69	108 50	122 19
Small supplies,	51 25	406 33	457 58
Total for station,	$1,215 43	$11,357 53	$12,572 96
Cost per million gallons pumped to reservoir,	$6.797	$4.419	$4.574
Cost per million gallons raised 1 foot high,	.057	.035	.036

The cost per million gallons pumped to the reservoir was $0.065 more than during the previous year, due entirely to the use of the less economical No. 8 engine. The quantity pumped was about 6 per cent. less than during the year 1902.

The repairs made to the No. 9 engine consisted of placing braces between the A frames directly under the high-pressure cylinder, for the purpose of preventing vibration; and also of putting a new bell crank on the inlet valve stem of the low-pressure cylinder. Material for these repairs was furnished by the Holly Manufacturing Company and was placed in position by our own employés.

West Roxbury Pumping Station.

At this station water was pumped for supplying the higher portions of West Roxbury and Milton.

The following are the statistics relating to operations at this station : —

Pumps operated 5,518 hours 30 minutes; average, 15 hours per day.

Daily average quantity of water pumped (gallons),	422,000
Daily average quantity of coal consumed (pounds),	1,439
Gallons pumped per pound of coal,	293
Average lift in feet,	132
Cost of pumping : —	
Labor,	$3,211 35
Fuel,	1,894 91
Repairs and small supplies,	181 81
Total for station,	$5,288 07
Cost per million gallons pumped to reservoir,	$34.354
Cost per million gallons raised 1 foot high,	.260

The quantity pumped was 70,000 gallons per day, or 20 per cent. greater than during the previous year, while the cost of operating the station was but very little more. This resulted in a reduction of $6.20 in the cost per million gallons pumped.

Arlington Pumping Station.

With the exception of 7,410,000 gallons, all water supplied to the town of Lexington and to the high-service district of Arlington was pumped at this station.

The following are the statistics relating to operations at this station : —

Pumps operated 7,378 hours 50 minutes; average, 20 hours per day.

Daily average quantity of water pumped (gallons),	484,000
Daily average quantity of coal consumed (pounds),	2,845
Gallons pumped per pound of coal,	170
Average lift in feet,	280
Cost of pumping : —	
Labor,	$2,824 89
Fuel,	2,359 27
Repairs and small supplies,	466 13
Total for station,	$5,650 29
Cost per million gallons pumped to standpipe,	$31.965
Cost per million gallons raised 1 foot high,	.114

The quantity pumped at this station was 169,000 gallons per day, or 53.6 per cent. greater than during the year 1902, caused by the addition of the town of Lexington to the district supplied. During the warm and dry weather in May the quantity pumped at the station for several consecutive days exceeded 900,000 gallons per day. Although the increase in the quantity pumped has made necessary the employment of an additional engineer for the greater part of the year, the cost per million gallons pumped to the standpipe was $8.804 less than in the previous year.

A Clayton air compressor has been installed at this station, for the purpose of supplying air to the air chambers on the suction and force mains.

Consumption of Water.

The daily average quantity of water consumed in the cities and towns supplied wholly or in part by the Metropolitan Works during the year 1903 was 107,148,000 gallons, equal to 119 gallons per inhabitant in the district supplied. Of the above quantity, 107,006,000 gallons per day were supplied by the Metropolitan Works and 142,000 gallons per day from local sources. Notwithstanding the addition of the town of Lexington to the territory supplied in 1902, there was a slight decrease from the consumption of the previous year. If the water used in Lexington in both years were included in making the comparison, then the decrease during the past year would be about 350,000 gallons per day.

The consumption in the several districts was as follows: —

	Gallons per Day.	Increase or Decrease (Gallons per Day).
Southern low-service district, embracing the low-service district of Boston, with the exception of Charlestown and East Boston,	43,728,000	Increase, 1,259,000
Northern low-service district, embracing the low-service districts of Somerville, Chelsea, Malden, Medford, Everett, Arlington, Charlestown and East Boston,	25,438,000	Decrease, 1,151,000
Southern high-service district, embracing the high-service districts of Boston, Quincy, Watertown, Belmont, and a portion of Milton,	29,527,000	Decrease, 16,000
Northern high-service district, embracing Melrose, Revere, Winthrop, Swampscott, Nahant and Stoneham, and the high-service districts of Somerville, Chelsea, Malden, Medford, Everett and East Boston,	7,529,000	Decrease, 470,000
Southern extra high-service district, embracing the highest portions of West Roxbury and Milton,	422,000	Increase, 58,000
Northern extra high-service district, embracing Lexington and the highest portions of Arlington,	504,000	Increase, 200,000
	107,148,000	

The slight decrease in the consumption during the past year may be considered a favorable showing, when compared with the increase of from 5,000,000 to 8,000,000 gallons per day which has occurred for several years past. A portion of the decrease is due to the reduction in waste during December of the present year as compared with the same month in 1902, there having been less extreme cold weather during this month of the past year. A considerable portion of the decrease is also undoubtedly due to the saving in waste effected in consequence of investigations which have been carried on during the past year. Although no well-organized effort has been made to prevent waste of water, many leaks which have been found during the investigations have been repaired. In the high-service district of the city of Boston, where the Deacon meters have been used to locate waste, the results have been especially noticeable. The daily average consumption of the southern high-service district shows this by a comparison of the quantities used during the first and last six months of the year. For the first period the daily average was 30,593,000 gallons, and for the last 28,475,000 gallons, while during several previous years the consumption of the district during the latter half of the year has always been the greater. The increase in the consumption of the northern extra high-service district was due to the admission of the town of Lexington.

Detailed statistics of the consumption of water may be found in Appendix No. 3, tables Nos. 19 to 23.

Quality of the Water.

Samples of water were collected every three months from eight points, every two months from two points, and monthly from ten points on the works, and sent to the State Board of Health for analysis and examination. Samples of water were also collected each week from many points upon the works, and examined microscopically and for color, odor, taste and turbidity by the biological force of the Metropolitan Water and Sewerage Board.

The quality of the water furnished was a little better than that of the previous year, chemically, microscopically and bacteriologically. The average color was slightly less according to the State Board of Health examinations, and slightly greater according to the Metropolitan Water Works examinations.

The following table gives a comparison of the average results of the examinations of Boston tap water, made for the years 1897 to

1903, inclusive. The additional supply from the South Branch of the Nashua River first reached the Metropolitan District about May 1, 1898.

	1897.	1898.	1899.	1900.	1901.	1902.	1903.
State Board of Health Examinations.							
Color (Nessler standard),	0.65	0.41	0.23	0.24	0.24	0.26	0.25
Total residue,	4.82	4.19	3.70	3.80	4.43	3.93	3.98
Loss on ignition,	1.84	1.60	1.30	1.20	1.64	1.56	1.50
Free ammonia,	0.0009	0.0008	0.0006	0.0012	0.0013	0.0016	0.0013
Albuminoid ammonia, total,	0.0193	0.0152	0.0136	0.0157	0.0158	0.0139	0.0125
Albuminoid ammonia, dissolved,	0.0177	0.0136	0.0122	0.0138	0.0143	0.0119	0.0110
Albuminoid ammonia, suspended,	0.0016	0.0016	0.0014	0.0019	0.0015	0.0020	0.0015
Chlorine,	0.40	0.29	0.24	0.25	0.30	0.29	0.30
Nitrogen as nitrates,	0.0137	0.0097	0.0137	0.0076	0.0173	0.0092	0.0142
Nitrogen as nitrites,	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Oxygen consumed,	0.64	0.44	0.35	0.38	0.42	0.40	0.39
Hardness,	1.6	1.4	1.1	1.3	1.7	1.3	1.5
Metropolitan Water and Sewerage Board Examinations.							
Color (platinum standard),	59	40	32	34	34	33	35
Turbidity,	-	-	-	-	2.0	2.3	2.2
Total organisms,	351	230	192	468	243	367	286
Amorphous matter,	177	131	201	97	38	34	36
Bacteria,	105	96	117	181	162	164	126

NOTE. — Chemical analyses are in parts per 100,000, organisms and amorphous matter in standard units per cubic centimeter, and bacteria in number per cubic centimeter. The standard unit has an area of 400 square microns, and by its use the number of diatomaceæ are decreased, and the number of chlorophyceæ and cyanophyceæ are very much increased, as compared with the number of organisms.

It should be noted that the above figures apply to tap water as furnished in the city of Boston. About 8 per cent. of the water supplied to the Metropolitan District is taken from Spot Pond, in which the color has been reduced by the bleaching action due to long storage to about one-half that of the water supplied to the remainder of the District. In other respects, however, the water from Spot Pond has been about the same as that supplied to other portions of the District.

Biological Laboratory.

On January 14 Edward P. Walters, biologist in charge of the laboratory, resigned. The vacancy was filled by the appointment on February 5 of Burton G. Philbrick, who has been in charge of the laboratory for the remainder of the year.

During the year 2,667 microscopical and 992 bacterial examinations of water were made at the laboratory of the Board, at No. 1 Ashburton Place, Boston. Of the microscopical examinations, 2,128 were of the regular weekly samples, while the remaining 539 were made in connection with special examinations. In addition to the bacterial examinations enumerated, a special study has been made of the relation of mill wastes, as found on the Wachusett watershed, to bacterial life. A slight change of method in recording color observations has been made. The results are now expressed in integers, instead of in decimals; that is, a color which would formerly have been recorded as 1.00 is now called 100. The color readings are also now made with water which has been filtered through filter paper, thus avoiding any effect which turbidity might have on color determinations.

The results of the color examinations are given in Appendix No. 3, Table No. 31, and the temperatures of the water and of the air in tables Nos. 32 and 33.

Sanitary Inspection.

The sanitary inspection of the Sudbury, Cochituate and Wachusett watersheds has been continued during the year, under the direction of William W. Locke, C.E., sanitary inspector.

Cases of contagious diseases upon the Wachusett watershed and within the site of the Wachusett Reservoir have been few, except for an epidemic of measles in Holden, from which no deaths resulted. There have been three cases of typhoid fever in Princeton, two in Holden and one in West Boylston, and none elsewhere upon the watershed of the reservoir. Within the site of the reservoir only one case of typhoid fever occurred. This was the case of a laborer who had just arrived on the works; he received prompt attention, and was immediately removed for treatment. Cases of contagious diseases upon the Sudbury and Cochituate watersheds have been somewhat numerous, especially in Marlborough. The total number of cases of typhoid fever within these watersheds during the year has been 23, divided as follows: Marlborough 10, Framingham 6, Westborough 3, Wayland 4.

A summary of the work of sanitary inspection for 1903 is given in the four following tables. The first table shows for the Wachusett watershed the number of premises inspected, the classification of cases inspected, and the condition of the premises at the end of the year; the second table gives the corresponding information for the Sudbury and Cochituate watersheds.

The headings of these tables explain themselves, except in a few instances; under the heading "Suspected" are included all cases where positive information could not be obtained, and where it is suspected that there may be some objectionable drainage; under the heading "Premises Vacant" are included all cases which at present furnish no objectionable drainage, but which might furnish such drainage if the premises were occupied; under the heading "Unsatisfactory" are included all cases where there may be, under the most unfavorable conditions, wash from privies or direct sink drainage, all suspected cases and all cases of manufacturing wastes entering feeders, even though there may be some attempt at previous purification.

The third table shows the improvements effected on the Wachusett watershed, and the fourth table the improvements effected on the Sudbury and Cochituate watersheds in 1903. No cases are entered as remedied unless complete sewer connections have been made or all probability of future contamination has been removed, and no cases are entered as partly remedied except where positive improvement in the sanitary condition has been effected.

Summary of Sanitary Inspections on the Wachusett Watershed in 1903.

District.	Number of Premises inspected.*	Classification of Cases inspected.									Condition at End of Year.	
		Cesspools dug before 1903.	Cesspools dug in 1903.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
French Brook,	88	35	1	-	-	2	6	34	-	7	79	9
Muddy Brook,	32	8	3	-	-	-	4	21	-	2	30	2
Gates Brook,	136	62	11	1	1	4	9	59	-	5	128	8
Malden Brook,	18	7	1	-	-	-	1	14	-	-	17	1
Chaffin Brook,	147	29	5	-	4	6	31	80	1	5	131	16
Asnebumskit Brook,	270	102	9	2	7	27	29	110	3	15	228	42
Musquapoag Brook,	101	18	4	-	4	-	18	58	1	11	89	12
South Wachusett Brook,	90	15	2	1	5	2	7	43	-	8	82	8
Trout Brook,	49	4	-	1	3	1	5	28	1	4	45	4
East Wachusett Brook,	213	43	4	1	9	6	26	113	-	16	196	17
Stillwater River,	172	54	10	-	4	5	17	75	-	8	165	7
Waushacum,	180	51	3	3	6	19	20	67	-	6	151	29
French Hill,	38	14	3	-	-	1	4	16	-	2	35	3
Totals,	1,534	342	56†	9	43	73	177	718	6	89	1,376	158

* On some premises there are two or more cases.

† In addition, ten cesspools and six privy vaults for temporary use were built at houses owned by the Board, which will be ultimately torn down.

Summary of Sanitary Inspections on the Sudbury and Cochituate Watersheds in 1903.

District.	Number of Premises inspected.*	Classification of Cases inspected.									Condition at End of Year.	
		Cesspools dug before 1903.	Cesspools dug in 1903.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
Sudbury Watershed.												
Farm Pond,	3	1	–	–	–	–	–	1	–	–	3	–
Framingham Reservoir No. 3,	7	4	–	–	–	–	2	1	–	–	5	2
Stony Brook,	55	36	2	1	–	3	3	10	–	4	49	6
Angle Brook,	325	172	7	–	3	10	63	35	5	25	260	65
Framingham reservoirs Nos. 1 and 2, and Cold Spring Brook.	27	16	1	–	–	–	6	2	–	2	23	4
Eastern Sudbury,	37	20	3	–	–	–	3	2	–	10	35	2
Indian Brook,	47	19	1	–	–	1	15	6	–	5	33	14
Western Sudbury,	23	6	1	–	1	–	5	4	1	6	16	7
Whitehall Reservoir,	5	4	–	–	–	–	1	2	–	–	4	1
Cedar Swamp,	54	30	–	–	–	1	7	–	2	2	47	7
Cochituate Watershed.												
Snake Brook,	36	19	4	–	2	–	9	4	–	3	28	8
Pegan Brook,	129	40	2	–	2	1	9	10	4	5	116	13
Course Brook,	6	3	–	–	–	–	1	1	–	1	5	1
Beaver Dam Brook,	137	49	2	–	2	1	15	12	4	7	118	19
Dug Pond,	36	5	–	–	–	3	7	–	–	1	26	10
Totals,	927	424	23	1	10	20	146	90	16	71	768	159

* Not including a large number of premises which were found on examination to be in a satisfactory sanitary condition, and likely to remain so. On some premises there are two or more cases.

Sanitary Improvements effected on the Wachusett Watershed in 1903.

District.	Remedied by Filter-bed.	Otherwise remedied.	Partly remedied.
French Brook,	–	–	2
Muddy Brook,	–	–	1
Gates Brook,	–	–	3
Malden Brook,	–	–	1
Chaffin Brook,	–	–	2
Asnebumskit Brook,	1	2	4
Musquapoag Brook,	–	–	–
South Wachusett Brook,	–	–	3
Trout Brook,	–	–	3
East Wachusett Brook,	–	–	–
Stillwater River,	2	–	8
Waushacum,	–	–	–
French Hill,	–	–	3
Totals,	3	2	30

Sanitary Improvements effected on the Sudbury and Cochituate Watersheds in 1903.

District.	Remedied by Sewer Connection.	Otherwise remedied.	Partly remedied.	Cesspools abandoned on Account of Sewer Connections.
Sudbury Watershed.				
Farm Pond,	-	-	-	-
Framingham Reservoir No. 3,	-	-	-	-
Stony Brook,	-	-	2	-
Angle Brook,	23	6	7	21
Framingham reservoirs Nos. 1 and 2, and Cold Spring Brook.	-	1	1	-
Eastern Sudbury,	-	-	3	-
Indian Brook,	-	-	1	-
Western Sudbury,	-	-	1	-
Whitehall Reservoir,	-	-	1	1
Cedar Swamp,	10	-	-	10
Cochituate Watershed.				
Snake Brook,	-	-	4	-
Pegan Brook,	59	2	2	57
Course Brook,	-	-	-	-
Beaver Dam Brook,	56	2	2	53
Dug Pond,	16	-	-	16
Totals,	164	11	24	158

The owner of the mill which last year discharged polluting matter directly into the stream has been enjoined by the Superior Court from continuing to do so. The pollution has been removed by the construction of tight vaults.

Among the important improvements made upon the Wachusett watershed, six sand filter-beds, with a total area of approximately 3,600 square feet, have been built to receive the drainage of the Mount Pleasant House in Holden. These received the sewage from a summer population of more than 200 after July 1, with very satisfactory results. Eight filter-beds, with a total area of 2,400 square feet, have also been constructed to dispose of the sewage from the Worcester County Truant School in Oakdale, and these have been in operation since November.

A special investigation of the private sanatoriums for consumptives in Rutland has been made, which showed that the methods of disposing of the wastes in some cases were unsatisfactory. The results were subsequently reported to the State Board of Health, which has ordered the owners of these premises to dispose of their drainage in a satisfactory manner. This order was given very late in the season, and as yet no work has been done in compliance with it.

The abandonment of Dug Pond as a source of water supply for Natick has resulted not only in the whole quantity of water collected in the pond being discharged into Lake Cochituate, but also in the town neglecting longer to prevent the contamination of the water and the use of the pond for bathing. An arrangement has accordingly been made with the town authorities, by which the Board is permitted to patrol the shores of the pond and prevent bathing, as well as to take such sanitary precautions along the brook draining into the pond as are taken in other parts of the watersheds.

The work of sewer connections in the various towns where there are sewers continues to be pushed, through the agency of the local boards of health, with satisfactory results in Natick and Framingham.

In Natick fixtures have been installed and sewer connections made with 75 houses, against 63 the previous year.

In South Framingham 56 houses have been connected, against 25 the previous year.

In Marlborough there have been 23 connections, against 35 the previous year.

In Westborough 10 connections have been made, against 13 the previous year.

Sanitary conditions in Hopkinton are not very satisfactory. The town is without a sewerage system, and the local board of health will do nothing to require owners of property to dispose of their drainage in a sanitary manner.

During the year the owner of the Reservoir House property in Woodville has constructed a filtration plant for the purification of the drainage from the hotel and livery stable, which formerly flowed directly into Whitehall Brook. The only suitable location for the filter-beds was on the site of a public way. With the consent of the Board the town of Hopkinton discontinued this way and laid out a new one over land of the Commonwealth.

Drainage of Swamps.

No additional ditches have been built during the year 1903, and no material repairs have been necessary to any of the ditches previously built. The ditches tributary to the open channel of the Wachusett Aqueduct, which have an aggregate length of 15.55 miles, have required most of the time of 2 men to maintain them in good condition; and, in addition, a foreman and 13 laborers worked 25 days cutting the grass on the banks of the ditches and the bushes for a width of 25 feet on each side. The ditches on the watersheds of Sudbury Reservoir and Framingham Reservoir No. 3, which have a total length of 9 miles, have required 129 days' labor to keep them in good condition. No repairs of any importance were necessary, but the ditches have been cleaned twice and the brush has been cut for a width of 10 feet on each side.

Observations of the color of water from Crane Swamp and from the swamp southwest of Marlborough Junction before and after draining have been given in previous reports. For the year 1903 the average colors were respectively 121 and 71, which are a little higher than during the two previous years. This increase in color was due entirely to the heavy rainfall during the month of June, which caused the swamps to become flooded with water.

Distributing Reservoirs.

The distributing reservoirs maintained by the Board are the Chestnut Hill Reservoir, Waban Hill Reservoir, and Forbes Hill Reservoir and Standpipe, of the southern high-service system; Spot Pond and the Mystic Reservoir near Tufts College, of the low-service system; the Fells Reservoir and Bear Hill Reservoir, of the northern high-service system; and the Arlington Standpipe, of the northern extra high-service system.

Chestnut Hill Reservoir.

The gate-houses and grounds connected with this reservoir have received the usual care, and are now in good order. The cost of policing the grounds during the summer season, in order to prevent injury to shrubbery and pollution of the water by the large number of visitors, is an important item of the total cost of maintaining this reservoir.

Waban Hill Reservoir.

On account of the growth of organisms which have given to the water objectionable tastes and odors, it was found necessary to shut the reservoir off from the supply from April 25 to June 6, and from October 25 to the end of the year. The grass slopes of the reservoir embankments have been somewhat improved in appearance during the year.

Forbes Hill Reservoir and Standpipe.

The reservoir has been kept full in readiness for use, but has not been drawn upon during the past year. The standpipe tower has been opened to the public during pleasant weather excepting on Sundays and holidays, and has been visited by large numbers of people. The general appearance of the ground has been somewhat improved.

Spot Pond.

On January 1, 1903, the surface of the water in the pond was 0.26 of a foot below high-water mark. Throughout the year the pond has been kept at or near high-water mark, the maximum height having been .63 of a foot above high water on February 17, and the minimum .74 of a foot below high water on December 31.

The grass and shrubbery at the pumping station and elsewhere around the pond have received the usual care, and more than usual attention has been given to protecting the trees from the ravages of the brown-tail and gypsy moths. In the vicinity of the southern gate-house and near the pumping station considerable injury was done to the foliage by these insects during the past summer, and much labor must be expended in order to prevent greater damage during the coming year. During the winter the maintenance force was employed in thinning out trees and underbrush on the land between Main Street and the west shore of the pond, for the purpose of lessening danger from fires and improving the general appearance of the woodland.

A concrete channel and measuring weir were built at the end of the 24-inch pipe which forms the outlet of the drain from Doleful Pond, replacing a small temporary wooden weir. Some repairs have been made to the riprap on the shores of the pond.

Mystic Reservoir.

This reservoir has been in constant use, and has received the ordinary care. The reservoir, gate-house and grounds are in good order.

Fells Reservoir.

This reservoir has been in constant use, has received regular attention and is now in good order.

Bear Hill Reservoir.

This reservoir was emptied and cleaned between August 12 and 14. With this exception, it has been in constant use during the year.

Arlington Standpipe.

This standpipe has been in service throughout the entire year. The grounds have been cared for by the Arlington Water Department.

Mystic Lake.

The bridge over the overflow at the dam has been rebuilt, at a cost of $401.90, and 840 linear feet of fence of the Massachusetts Highway Commission standard has been built on the line of Mystic Street, replacing the old fence which was decayed.

From the first of January until about the middle of April the surface of the water in the lake was kept about 4 feet above Boston City Base, or 3 feet below high-water mark. The maximum elevation during this time was 4.65. During the summer the water was kept between elevations 5.50 and 6 feet, and during the last three months of the year between elevations 4.50 and 5 feet, above Boston City Base.

Pipe Yards.

The buildings at both the Chestnut Hill and Glenwood pipe yards are in good condition. The roof of the office building at the Chestnut Hill yard has been covered with slate, in place of shingles. The fence of the Glenwood yard has been painted.

The number of horses in use in the department has been 12 throughout the year. Vehicles at both yards are in good order.

Pipe Lines.

The low-service pipe line between Boston Avenue in Medford and Spot Pond was placed in service on January 7, and the supply pipe line between the terminus of the Weston Aqueduct and the main pipes just easterly from Chestnut Hill Reservoir on December 29. With these exceptions, the pipes maintained by the department remain the same as on January 1, 1903.

No serious breaks occurred on the 84.19 miles of pipe lines owned and operated by the Board. A cracked 48-inch pipe was discovered when testing the supply pipe line before placing it in service, but leaks on pipes in use were all due to defective joints. The total number of these leaks was 18, of which 8 were on the pipes crossing the Charles, Mystic and Malden rivers. Leaks on these submerged pipe lines have occurred each year on the approach of cold weather, and, as the repairs must be made by a diver, the expense has been considerable.

Quite extensive repairs have been made during the past year at the two crossings of the Charles River, for the purpose of preventing leaks on these pipes in the future. The leaks have in nearly all cases occurred at the joints where one pipe with a smooth, taper end was joined to another having a lead-lined socket. The contraction of the iron pipes, due to the colder water in the winter season, pulled the pipes apart at these joints and caused leaks. The repairs consisted in preventing movement of the pipes at these taper joints by placing around the pipes heavy bands 1½ inches by 4 inches in section, made in halves and bolted together, and tying three lengths of pipe together by two 2½ inch diameter steel rods about 14 feet long, extending between the bands. Both bands and rods were thoroughly coated with asphaltum, applied while the iron was hot. Twenty-four sets of these bands and rods were used, securing all of the tapering joints on the four lines of 36-inch pipe crossing the Charles River, between Brighton and Cambridge.

The work was expensive, as the greater portion of it had to be done by divers, who worked at considerable disadvantage on account of the position of the pipe and the strength of the river current. The work was begun August 25. About a month was occupied in stopping leaks, after which the dredging and placing of the bands and rods occupied until December 19. The cost of the whole work was $8,126.97, of which $1,853.53 was paid for the bands and rods, $4,721 to the divers for labor and use of scows, and the balance for labor and materials furnished by the maintenance department.

Between April 23 and May 16 the temporary pipes which were laid to accommodate the work of laying the Metropolitan sewer on Adams Street in Milton and Quincy were taken up, and the 24-inch pipes replaced.

The tunnel at the Chelsea North Bridge, between Charlestown and Chelsea, was pumped out on September 15, for the purpose of examining both the tunnel and pipes. No leaks were found in the pipes, but one of the tie rods was found broken, and there was some leakage into the tunnel. The broken rod was replaced, but the tunnel leaks, which were not serious, were not repaired.

The ironwork of the pipe bridge over the Fitchburg Railroad on Massachusetts Avenue in Cambridge has been cleaned and painted with two coats of red lead where rusted. All the ironwork was given one coat of black and the wooden top a coat of gray paint. The woodwork of the bridge over the Boston & Maine Railroad on Walnut Street, Somerville, was repaired, and both iron and wood work painted. A new wooden top was placed on the bridge over the Boston & Maine Railroad at College Avenue in Medford. Three bridges over the Pines River and its branches, and the long bridge over the Saugus River between Saugus and Lynn, were each given one coat of paint. The fence on the pipe bridge over the Mystic River in Medford was cleaned, and the whole structure painted. All of the work on these bridges was done by the regular maintenance force.

Considerable work has been done on the pipe lines, on account of the injury done by electrolysis. The pipes have been uncovered and carefully cleaned and examined at several points in Cambridge, Chelsea and Lynn. In the latter city one length of pipe was taken up for the purpose of examination.

Three additional recording pressure gages have been established during the year, one in Lexington, one in Belmont and one at the Arlington pumping station, making 23 gages now in service, from which continuous records are obtained of the pressures in the mains at different points throughout the District. These, with similar gages maintained by the city of Boston, furnish information which is of much value in operating the works.

For the purpose of reducing and regulating the pressure in the pipe system of the town of Lexington, an 8-inch pressure-reducing valve was placed on a by-pass from the 10-inch pipe line on Massachusetts Avenue at the line between Arlington and Lexington. This valve, which was of a new design, made in this department, was built by the Waters Governor Company. It was placed in service on June 4, and has thus far worked very satisfactorily.

Venturi Meters and Prevention of Waste.

The operation of the Venturi meters for the purpose of determining the quantity of water used in each of the municipalities supplied from the Metropolitan Works was begun as soon as the meters were in readiness for use, the first being ready on January 24 and the last on June 26.

In general, the operation of the meters has been satisfactory. As was to be expected, in installing so many meters under conditions which were to a considerable extent untried, minor changes have been found necessary to meet the new conditions; but the results obtained by the use of the meters have been very satisfactory, and there appears to be no reason to doubt that the measurements are correct within a very small per cent. Allowing a reasonable amount for the leakage from the Metropolitan mains and reservoirs and for the quantity used at the pumping stations, the total quantity pumped at the pumping stations at Chestnut Hill each month agrees with the quantity measured by the meters within less than 2 per cent., which is probably as nearly correct as the total quantity pumped can be determined.

The operation of the meters requires the services of two men, who wind the clocks and read the meters twice each week and take off the registering charts weekly. They also make such minor repairs as are found necessary.

Much time has been spent in investigating causes of waste, and the results of these investigations, with suggestions as to methods of preventing waste, have been embodied in a special report by Dexter Brackett, Engineer of the Distribution Department, which forms a part of Appendix No. 8.

The inspection for detecting the violations of hand-hose regulations has been continued. The number of violations reported was less than during the previous year. This was partially due to the cool, wet weather during the summer, and partially to more strict observance of the regulations by the water takers. The number and character of the violations reported were as follows: —

	Rotary Sprinkler.	Fixed Sprinkler.	Hose on Fixed Support.	Hose held in Hand.	Totals.	Violations per 1,000 Inhabitants.
Boston, ...	15	20	34	35	104	.17
Arlington, ...	4	6	4	4	18	1.86
Chelsea, ...	-	-	7	3	10	.28
Everett, ...	-	-	5	6	11	.39
Lexington, ...	1	-	2	5	8	2.22
Medford, ...	50	41	52	52	195	9.29
Melrose, ...	3	4	37	24	68	4.89
Nahant, ...	14	1	3	2	20	.61
Quincy, ...	27	13	33	19	92	3.43
Revere, ...	-	-	-	-	-	-
Somerville, ...	15	32	25	72	144	2.13
Stoneham, ...	-	-	1	2	3	.47
Swampscott, . . .	61	19	17	21	118	16.57
Winthrop, ...	3	2	9	7	21	2.88
Totals, ...	193	138	229	252	812	-

Electrolysis.

An electrical survey of the Metropolitan District was made early in the year, to determine the difference of potential or electric pressure between the Metropolitan pipes and the electric railway tracks. A comparison of the results of this survey with surveys made in previous years shows very little change in the electrical conditions throughout the District. Several additional stations have been established where measurements can be made of the quantity of electricity flowing along the Metropolitan pipes, and there are now about 60 of these stations in use. By observations made from time to time at these points information has been obtained by which the limits of the danger districts and the points where the most serious damage is to be apprehended have been determined.

At several points in the city of Cambridge the pipes have been uncovered and examined. On 90 linear feet of 48-inch pipe on Boylston Street 525 pittings were located, varying from 1/16 to 5/8 of an inch in depth. Portions of two lines of 36-inch pipes crossing under the Charles River at Boylston Street were examined by the aid of a diver, and 11 pittings, from 2 inches to 6 inches in diameter and from 3/8 to 3/4 of an inch in depth, were found. A large quantity of electricity is leaving these pipes in the river, and they are being destroyed very rapidly.

The conditions on and surrounding the pipes crossing the Charles River between Brighton and Cambridge, near the foot of Magazine Street, the Mystic River between Somerville and Medford, the Malden River at Medford Street in Malden, and Chelsea Creek between Chelsea and East Boston, have in all cases been found to be favorable for electrolytic action, and at several points damage has been discovered.

In the city of Chelsea an examination of the 24-inch pipe on Broadway disclosed 250 pittings, from 1/16 to 9/16 of an inch in depth, on 280 square feet of pipe surface. In the city of Lynn the pipes were examined in December at several points and found to be very seriously damaged. At one point 387 pittings, from 1/32 to 7/16 of an inch in depth, were found on 175 square feet of surface of a 12-inch pipe, and at another point 200 pittings on an area of 44 square feet. The deepest pittings were .45 of an inch in depth, leaving but .24 of an inch of the original thickness of the pipe. It will be necessary to replace some of these pipes in the spring.

The Boston Elevated Railway Company covered 43 linear feet of 48-inch pipe on Boylston Street in Cambridge with burlap and asphaltum, for the purpose of insulating the pipes and preventing further electrolytic action. In order to prevent the flow of quite a large amount of electricity from the Metropolitan pipes to the pipes of the city of Cambridge, an insulated joint, made of a rubber gasket 1/2 inch in thickness, placed between two flanges, was inserted in a connection which was made between the Metropolitan 48-inch main and the pipe of the city of Cambridge on Massachusetts Avenue at Cambridge Common.

Clinton Sewerage.

The Clinton Sewage Disposal Works have been in daily operation during the whole year. The amount of sewage pumped and filtered has been about 3,000 gallons per day less than during the previous year, notwithstanding a number of additional house connections were made with the system. The extensive introduction of meters on house services by the Clinton Water Department has been an important factor in preventing an increase.

The regular force has been one engineer at the pumping station and two attendants at the filter-beds, one of the latter assisting the engineer at the pumping station a short time each morning. When additional help is required to clean out the ditches through which the effluent reaches the river, to furrow the beds, keep down the weeds in the summer time, or for other work, men employed on other parts of the work are transferred temporarily.

Following are statistics relating to the operation of the pumping station: —

Daily average quantity of sewage pumped (gallons),	783,000
Daily average quantity of coal consumed (pounds),	1,283
Gallons pumped per pound of coal,	610
Number of days pumping,	365
Cost of pumping: —	
Labor,	$1,133 63
Fuel,	1,352 03
Repairs and supplies,	192 69
Total for station,	$2,678 35
Cost per million gallons pumped,	$9 37
Cost per million gallons raised 1 foot high,	21

Filter-beds.

During the warmer part of the year sewage was applied in about the same quantity per bed to the 19 beds from which all soil had been removed and to the 6 beds from which soil had not been removed; but the latter beds were not used during the colder part of the year.

During the warmer portion of the year sewage was applied to the beds at a rate which averaged about 29,000 gallons per acre per day. For the first ½ hour after beginning pumping in the morning, when the sewage contains more sludge than at other times, it was turned upon a selected bed, which was frequently cleaned. The remainder of the beds were used in rotation; but after May 21 the sewage was allowed to run upon a single bed for only ½ hour, instead of 1½ hours, as in previous years, making the amount per application about 62,000 gallons, and causing each bed to be used about once in 2 days. The surface of the beds has been frequently loosened with a harrow. It was hoped that the smaller amount of sewage per application, together with the loosening of the surface of the beds, would improve the character of the effluent. It has had the effect of materially increasing the percentage of organic matter removed in comparison with the previous year, although the results are not as favorable in this respect as in the years 1900 and 1901; but there is a storage of nitrogen in the soil, as shown by the smaller percentage of free ammonia removed and the small amount of nitrates in the effluent.

The results obtained in the removal of organic matter, in the removal of free ammonia and in nitrification, are shown in the following tables. The results from July to December, inclusive, for the years 1900, 1901 and 1902, are also given in comparison.

[Parts per 100,000.]

	July to December, inclusive			January to June, 1903, inclusive.	July to December, 1903, inclusive.	Whole Year, 1903.
	1900.	1901.	1902.			
Albuminoid ammonia, sewage, .	1.51	1.0800	1.0917	.7650	1.0817	.9233
Albuminoid ammonia, effluent, .	.0763	.0454	.1009	.0846	.0718	.0782
Per cent. removed, ...	95	96	88	89	93	92
Oxygen consumed, sewage, . .	15.70	11.40	7.77	7.98	9.32	8.65
Oxygen consumed, effluent, . .	.93	.58	1.29	1.20	1.04	1.12
Per cent. removed, ...	94	95	80	85	89	87

[Parts per 100,000.]

	July to December, inclusive.			January to June, 1903, inclusive.	July to December, 1903, inclusive.	Whole Year, 1903.
	1900.	1901.	1902.			
Free ammonia, sewage, ...	4.5033	3.8667	5.0617	2.7983	4.8600	3.8292
Free ammonia, effluent, ...	.5722	.2525	.6709	.9802	1.0567	1.0185
Per cent. removed, ...	87	93	85	65	78	73
Nitrogen as nitrates, effluent, . .	1.2788	1.3213	1.2130	.4375	.3961	.4168

During the colder part of the year, when the temperature was below 15° above zero, all the sewage pumped in any day was run upon one of the 5 improved beds, which had been prepared with furrows 3 feet 6 inches apart. The average amount of sewage per application was 828,000 gallons, and each furrowed bed was used about once in 19 days. When the temperature was higher than 15° above zero, the sewage was applied to the improved beds which had not been furrowed, at the rate of 344,000 gallons per application, and each bed was used about once in 11 days.

The cost of maintaining the filter-beds has been as follows: —

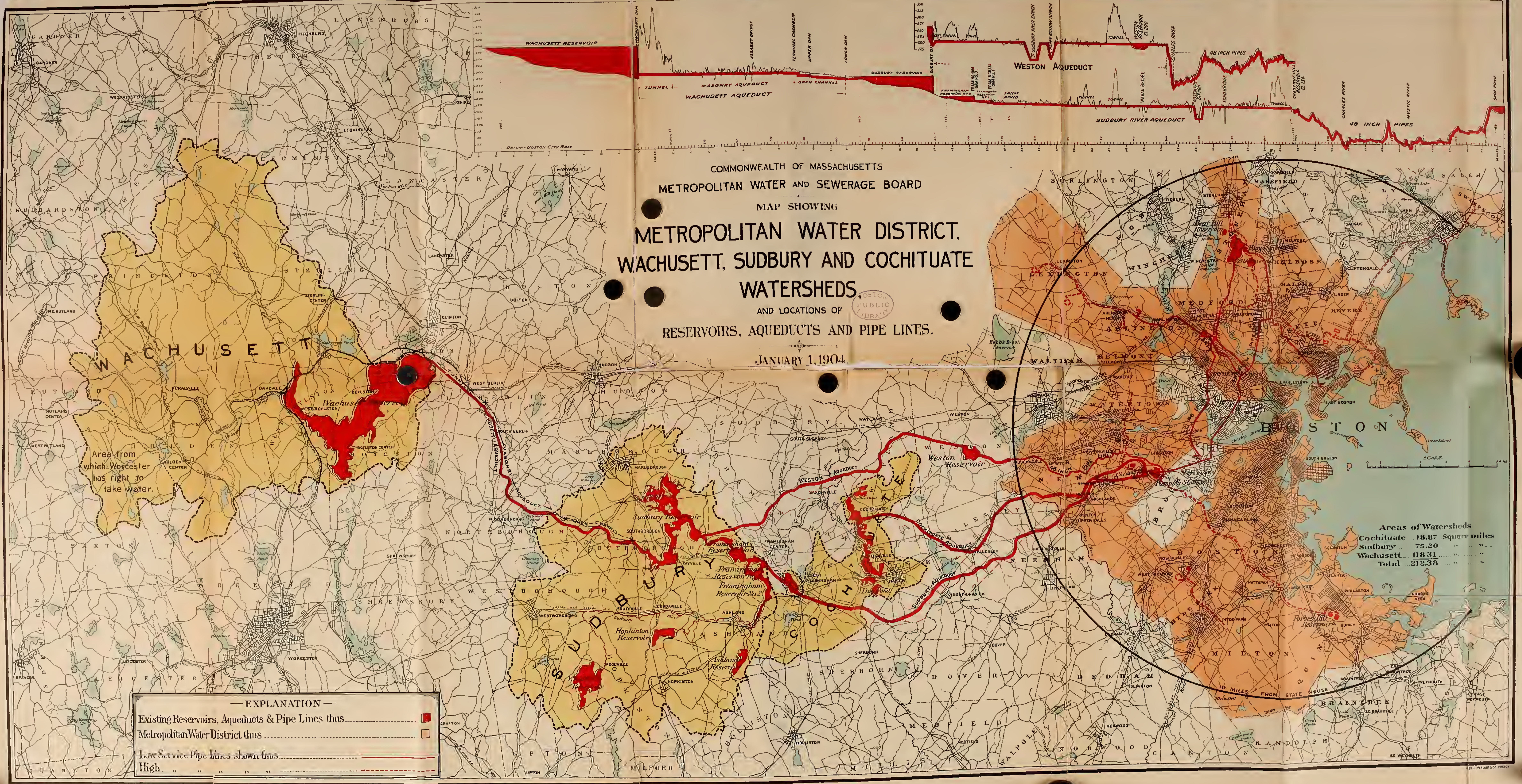
Labor,	$2,139 02
Repairs and supplies,	96 02
Total,	$2,235 04
Cost per million gallons filtered,	7 82

Appended to this report are tables of contracts giving the amount of work done and other information, a statement of the cement tests, a long series of tables relating to the maintenance of the Metropolitan Water Works, tables showing the length of main pipes and number of service pipes, meters and fire hydrants in the Metropolitan Water District, and a summary of statistics for 1903.

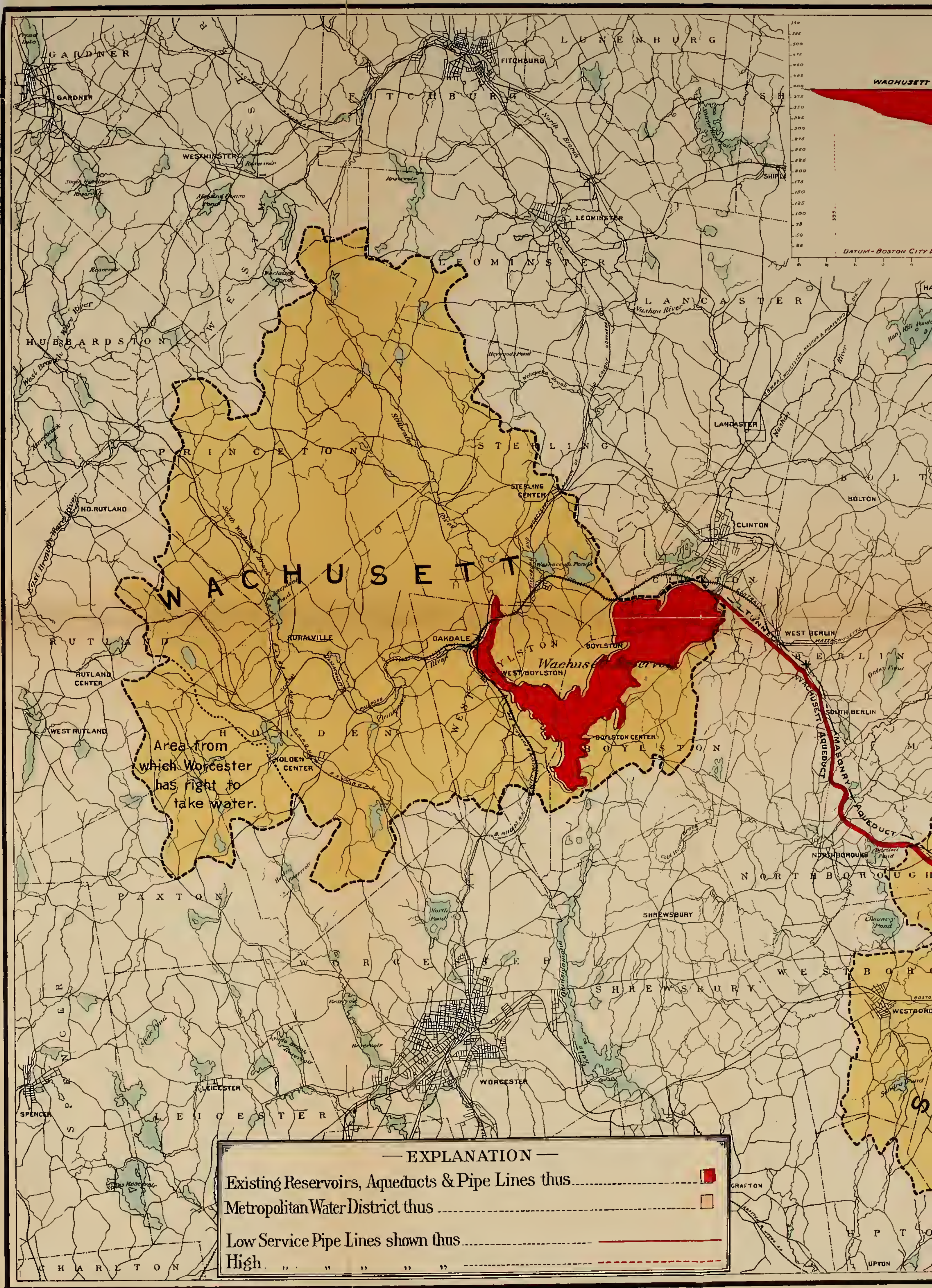
Respectfully submitted,

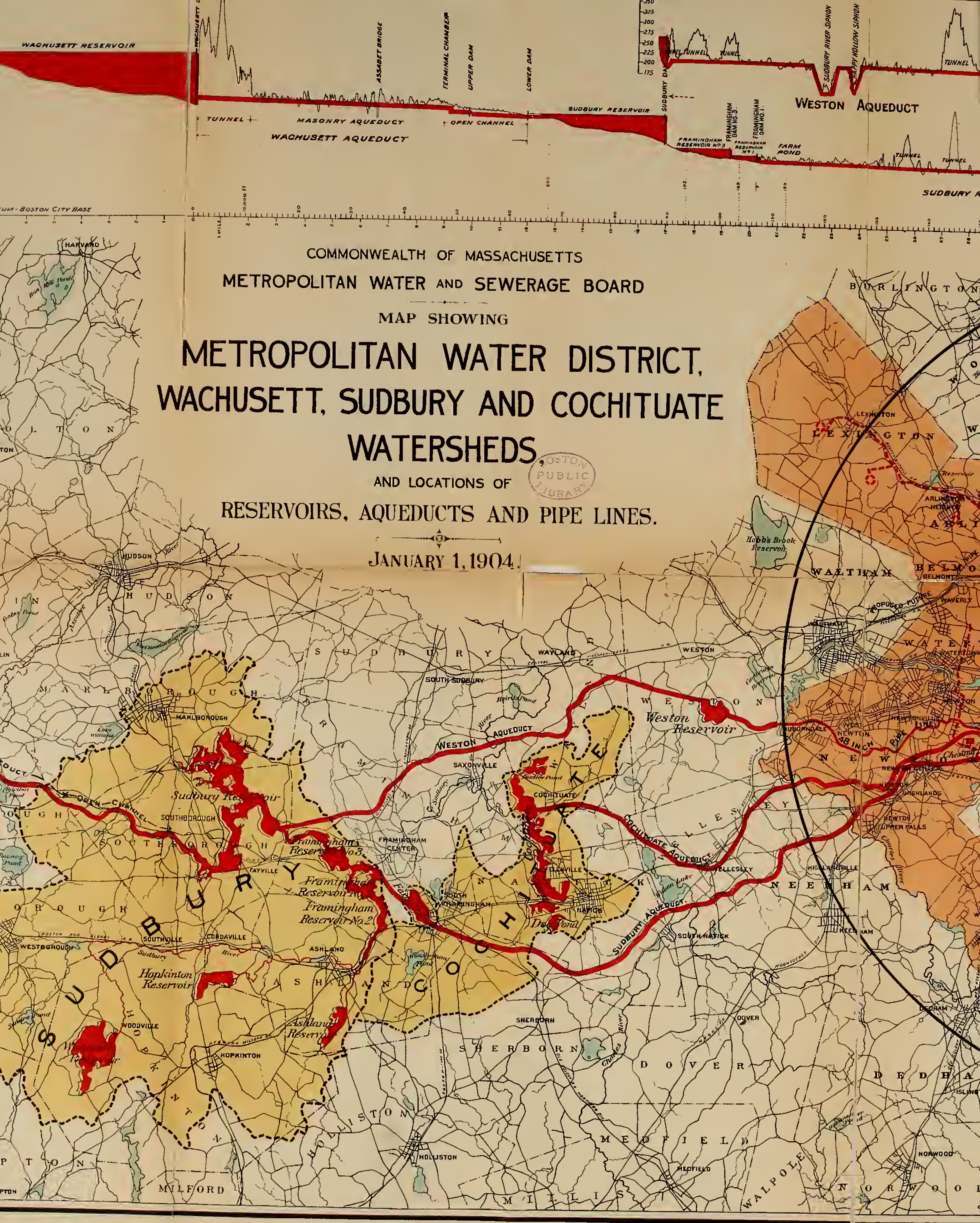
FREDERIC P. STEARNS,
Chief Engineer.

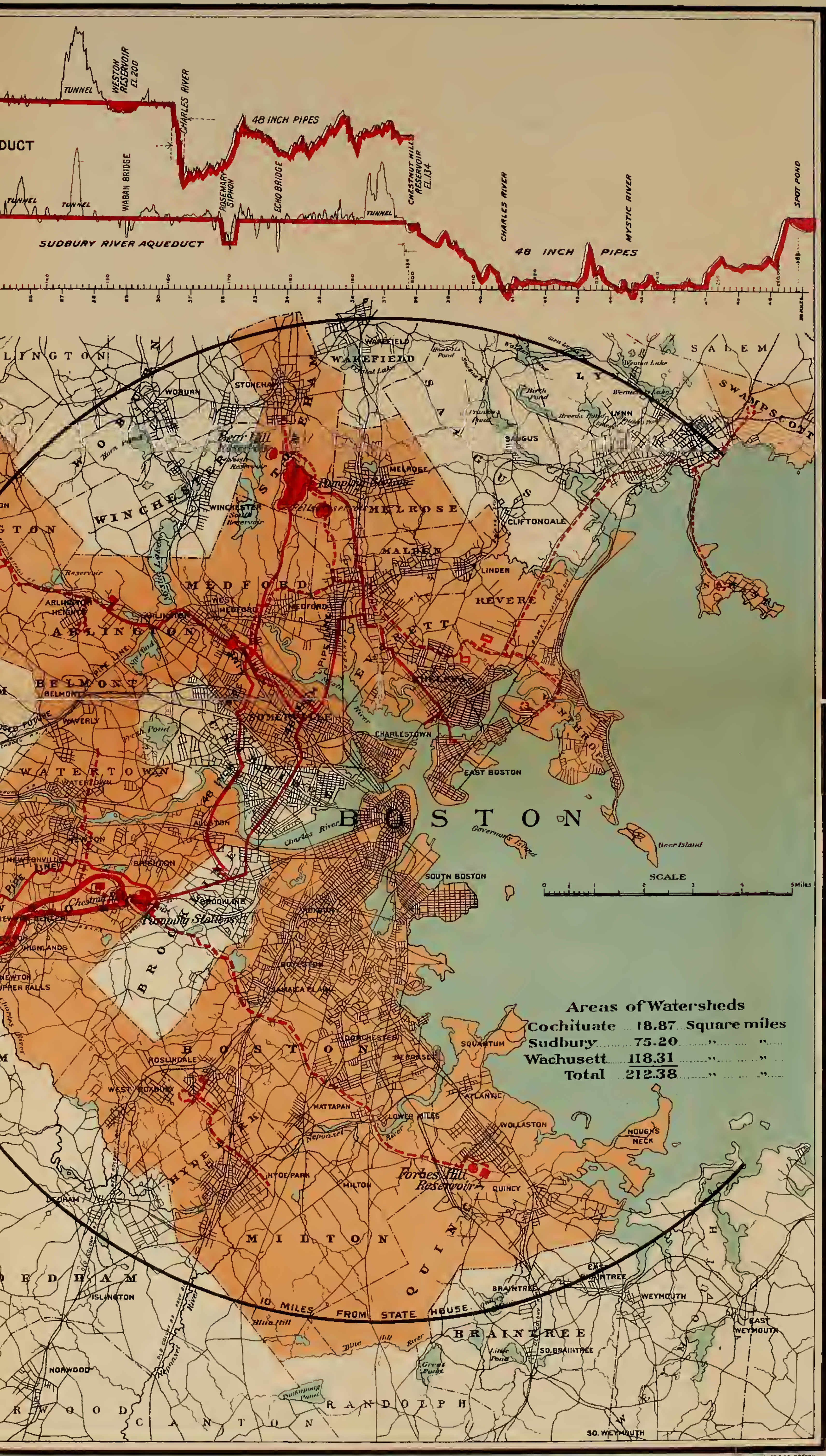
BOSTON, January 1, 1904.



COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN WATER AND SEWERAGE BOARD
MAP SHOWING
METROPOLITAN WATER DISTRICT,
WACHUSETT, SUDBURY AND COCHITUATE
WATERSHEDS,
AND LOCATIONS OF
RESERVOIRS, AQUEDUCTS AND PIPE LINES.
JANUARY 1, 1904.
— EXPLANATION —
Existing Reservoirs, Aqueducts & Pipe Lines thus
Metropolitan Water District thus
Low Service Pipe Lines shown thus
High " " " "
Areas of Watersheds
Cochituate 18.87 Square miles
Sudbury 75.20 " "
Wachusett 118.31 " "
Total 212.38 "
WACHUSETT
SUDBURY
COCHITUATE
BOSTON
Wachusett Reservoir
WACHUSETT AQUEDUCT
WESTON AQUEDUCT
SUDBURY RIVER AQUEDUCT
48 INCH PIPES
Weston Reservoir
Sudbury Reservoir
Hopkinton Reservoir
Ashland Reservoir
Framingham Reservoir No. 2
Area from which Worcester has right to take water.
10 MILES FROM STATE HOUSE
SCALE


WACHUSETT
Area from which Worcester has right to take water.
Wachusett Reservoir
GARDNER
FITCHBURG
LUNENBURG
WESTMINSTER
LEOMINSTER
LANCASTER
HUBBARDSTON
PRINCETON
STERLING
STERLING CENTER
NO. RUTLAND
CLINTON
BOLTON
RUTLAND
RUTLAND CENTER
WEST RUTLAND
RURALVILLE
OAKDALE
WEST BOYLSTON
BOYLSTON
BOYLSTON CENTER
HOLDEN
HOLDEN CENTER
WEST BERLIN
BERLIN
SOUTH BERLIN
WACHUSETT AQUEDUCT
MASONRY AQUEDUCT
TUNNEL
NORTHBOROUGH
PAXTON
SHREWSBURY
WORCESTER
LEICESTER
SPENCER
CHARLTON
WESTBOROUGH
GRAFTON
UPTON
DATUM – BOSTON CITY
— EXPLANATION —
Existing Reservoirs, Aqueducts & Pipe Lines thus
Metropolitan Water District thus
Low Service Pipe Lines shown thus
High " " " " "


COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN WATER AND SEWERAGE BOARD
MAP SHOWING
METROPOLITAN WATER DISTRICT,
WACHUSETT, SUDBURY AND COCHITUATE WATERSHEDS,
AND LOCATIONS OF
RESERVOIRS, AQUEDUCTS AND PIPE LINES.
JANUARY 1, 1904.
BOSTON PUBLIC LIBRARY
WACHUSETT RESERVOIR
ASSABET BRIDGE
TERMINAL CHAMBER
UPPER DAM
LOWER DAM
TUNNEL
MASONRY AQUEDUCT
OPEN CHANNEL
WACHUSETT AQUEDUCT
SUDBURY RESERVOIR
SUDBURY DAM
FRAMINGHAM RESERVOIR No 3
FRAMINGHAM DAM NO. 3.
FRAMINGHAM DAM NO. 1.
FARM POND
SUDBURY RIVER SIPHON
HAPPY HOLLOW SIPHON
WESTON AQUEDUCT
BOSTON CITY BASE
HARVARD
BOLTON
HUDSON
MARLBOROUGH
SUDBURY
SOUTH SUDBURY
WAYLAND
WESTON
Weston Reservoir
WESTON AQUEDUCT
SAXONVILLE
Sudbury Reservoir
SOUTHBOROUGH
FAYVILLE
Framingham Reservoir No. 3
FRAMINGHAM CENTER
Framingham Reservoir No. 2
SOUTH FRAMINGHAM
COCHITUATE
COCHITUATE AQUEDUCT
SUDBURY AQUEDUCT
WELLESLEY
NATICK
Dug Pond
SOUTHVILLE
CORDAVILLE
WESTBOROUGH
ASHLAND
Hopkinton Reservoir
Ashland Reservoir
WOODVILLE
HOPKINTON
HOLLISTON
SHERBORN
DOVER
MEDFIELD
MILFORD
MILLIS
WALPOLE
NORWOOD
DEDHAM
NEEDHAM
NEWTON
NEWTON UPPER FALLS
AUBURNDALE
WALTHAM
BELMONT
LEXINGTON
ARLINGTON HEIGHTS
Hobbs Brook Reservoir
BURLINGTON
SUDBURY



GEO. H. WALKER & CO. BOSTON.

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REPORT OF ENGINEER OF SEWERAGE WORKS.

To the Metropolitan Water and Sewerage Board.

GENTLEMEN : — The following is a report of the operations of the Engineering Department of the Metropolitan Sewerage Works for the year ending December 31, 1903.

ORGANIZATION.

The engineering organization at the end of the year is as follows : —

Division Engineers : —

FREDERICK D. SMITH, .	In charge of maintenance, South Metropolitan System, and construction of High-level Sewer, in Quincy.
FRANK I. CAPEN, . .	In charge of construction, High-level Sewer, in Roxbury, and of maintenance and construction, North Metropolitan System.
FRANK A. EMERY, . .	In charge of drafting rooms and records.

In addition to the above, there are employed 34 engineering and other assistants.

METROPOLITAN SEWERAGE DISTRICTS.

Areas and Populations.

During the year the areas comprising the Metropolitan sewerage districts have been extended, under the authority of chapter 242 of the Acts of 1903, to include the town of Revere. The North district now has an area of 91 square miles, and the South district 102 square miles, — a total, inclusive of water surfaces, of 193 square miles.

This area, developed from the original district of 114 square miles created by chapter 439 of the Acts of 1889, now includes the whole or parts of 25 cities and towns, as set forth in the following table : —

Table showing Areas and Estimated Populations within the Metropolitan Sewerage District, as of December 31, 1903.

	City or Town.	Area (Square Miles).		Estimated Population.	
North Metropolitan District.	Arlington,	5.20		10,000	
	Belmont,	4.66		4,900	
	Boston (portions of),	3.45		90,600	
	Cambridge,	6.11		99,900	
	Chelsea,	2.24		37,200	
	Everett,	3.34		28,800	
	Lexington,*	5.11		2,800	
	Malden,	5.07		40,200	
	Medford,	8.35		22,700	
	Melrose,	3.73		14,200	
	Revere,	5.86		13,100	
	Somerville,	3.96		69,200	
	Stoneham,	5.50		6,400	
	Wakefield,	7.65		10,300	
	Winchester,	5.95		8,300	
	Winthrop,	1.61		7,600	
	Woburn,	12.71		15,100	
			90.50		481,300
South Metropolitan District.	Boston (portions of),	20.92		147,700	
	Brookline,	6.81		24,000	
	Dedham,*	9.40		7,300	
	Hyde Park,	4.57		14,400	
	Milton,	12.59		7,600	
	Newton,	18.03		38,500	
	Quincy,	12.56		27,400	
	Waltham,	13.63		26,500	
	Watertown,	4.04		11,100	
			102.55		304,500
	Totals,		193.05		785,800

* Part of town.

METROPOLITAN SEWERS.

Sewers Purchased and Constructed and their Connections.

Within the Sewerage Districts there are now 93.86 miles of Metropolitan sewers. Of this total, 8.79 miles of sewer, with the Quincy pumping station, have been purchased from cities and towns of the districts, the remaining 85 miles of Metropolitan sewer having been constructed by Metropolitan boards.

The position, lengths and sizes of these sewers are given in the following tables, together with other data referring to the public and special connections with the system: —

North Metropolitan System.

City or Town.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1903.	Special Connections. Character or Location of Connection.	Special Connections. Number in Operation.
Boston: —					
Deer Island, .	6′ 3″ to 9′, ...	1.367	4	- -	-
East Boston, .	9′ to 1′, ...	5.467	17	- -	-
Charlestown, .	6′ 7″×7′ 5″ to 1′, . . .	3.292	12	Navy Yard, ... Almshouse, ...	8
Winthrop, . .	9′, ...	2.864	7	Club house, ...	1
Chelsea, . .	8′ 4″×9′ 2″ to 1′ 10″×2′ 4″,	4.232	7	Bakery, ... Rendering works, . . . Metropolitan Water Works blow-off, ...	3
Everett, . .	8′ 2″×8′ 10″ to 4′ 8″×5′ 1″, .	2.925	5	Metropolitan Water Works blow-off, ...	1
Malden, . .	3′ 9″×4′ 1″ to 1′ 3″, . .	3.931*	24	Metropolitan Water Works blow-off, ...	1
				Private houses, . . .	102
Melrose, . .	1′ 10″×2′ 9″ to 10″, . .	6.099†	29	Private houses, . . .	101
Cambridge, .	5′ 2″×5′ 9″ to 1′ 3″, . .	6.919	24	Slaughter-house, . . City Hospital, . . .	2
Somerville, . .	6′ 5″×7′ 2″ to 1′ 10″×2′ 3″, .	3.471	10	Tannery, ...	1
				Slaughter-houses (3), .	1
				Car-house, ...	1
Medford, . .	4′ 8″×5′ 1″ to 10″, . .	5.359	20	Armory building, . .	1
				Private houses, . . .	5
				Stable, ...	1
Winchester, .	2′ 11″×3′ 3″ to 1′ 3″, . .	6.403	12	Tannery, ...	2
				Private houses, . . .	2
				Gelatine factory, . .	1
Stoneham, . .	1′ 3″ to 10″, ...	.010	4	- -	-
Woburn, . .	1′ 10″×2′ 4″ to 1′ 3″, . .	.933	3	Glue factory, . . .	1
Arlington, . .	1′ 6″ to 10″, ...	3.520‡	33	Private houses, . . .	88
Belmont,§ . .	- -	-	1	- -	-
Wakefield,§ .	- -	-	1	- -	-
Revere, . .	- -	-	-	- -	-
		56.792‖	213		323

* Includes .988 of a mile of sewer purchased from the city of Malden.

† Includes .736 of a mile of sewer purchased from the town of Melrose.

‡ Includes 2.631 miles of sewer purchased from the town of Arlington.

§ The Metropolitan sewer extends but a few feet into the towns of Belmont and Wakefield.

‖ Includes 2.787 miles of Mystic River valley sewer in Medford, Winchester and Woburn, running parallel with the Metropolitan sewer.

South Metropolitan System.

City or Town.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1903.	Special Connections. Character or Location of Connection.	Special Connections. Number in Operation.
Boston (Back Bay),	6′ 6″ to 5′ 6″,	1.500*	8	Private house,	1
				Administration building, Boston Park Department,	1
				Simmons College buildings,	1
Boston (Brighton),	5′ 6″ to 12″,	3.714†	10	Abattoir,	3
Boston (Dorchester).	3′×4′ to 2′ 6″×2′ 7″,	2.870‡	6	- -	2
Boston (Roxbury),	6′ 6″×7′, 2′ 0″,	1.440	-	- -	-
Boston (West Roxbury).	9′ 3″×10′ 2″ to 12″,	7.011	3	Parental school,	1
				Lutheran Evangelical Church,	1
Brookline,	5′ 6″,	.127	2	- -	-
Dedham,	4′×4′ 1″ to 3′ 9″×3′ 10″,	2.350	4	- -	-
Hyde Park,	10′ 7″×11′ 7″ to 4′×4′ 1″,	4.511	12	Private buildings,	2
Milton,	11′×12′ to 8″,	3.598	4	- -	-
Newton,	4′ 2″×4′ 9″ to 1′ 3″,	2.910	6	Private houses,	2
Quincy,	11′ 3″×12′ 6″ to 60″ pipe,	6.287	-	- -	-
Waltham,	3′ 6″×4′,	.001	1	- -	-
Watertown,	4′ 2″×4′ 9″ to 12″,	.750§	5	Factory,	2
		37.069	61		16

* Includes .355 of a mile of sewer purchased from the city of Boston.
† Includes .026 of a mile of sewer purchased from the town of Watertown.
‡ Includes 1.24 miles of sewer purchased from the city of Boston.
§ Includes .025 of a mile of sewer purchased from the town of Watertown.

Cost of Construction.

The cost of the 93 miles of Metropolitan sewers enumerated above, including six pumping stations, siphons and appertaining structures, may be summarized as follows: *—

North Metropolitan System,	$5,901,914 09
South Metropolitan System,	6,934,976 37
	$12,836,890 46

Construction and Additions during the Year.

The last report indicated that 89.32 miles of Metropolitan sewers had been constructed to December 31, 1902. There has consequently been added, during the year under review, a length of 4.54 miles. This includes 3.14 miles of High-level Sewer, authorized by chapter 424 of the Acts of 1899; 0.44 miles of sewer, authorized by chapter 242 of the Acts of 1903, to provide sewerage facilities for the town of Revere; and 0.96 miles of sewer, authorized by chapter 336 of the Acts of 1903, to provide an additional outlet

* For detailed statement of cost, see report of Board, p. 56.

for the sewage of Belmont; all referred to in detail later in this report.

The following table gives details of areas, populations, local sewer mileage and other data for the whole Metropolitan Sewerage System: —

Area (Square Miles).	Estimated Total Population.	Miles of Local Sewer connected.	Estimated Population contributing Sewage.	Ratio of Contributing Population to Total Population (Per Cent.).	Connections made with Metropolitan Sewers.	
					Public.	Special.
North Metropolitan System.						
90.50	481,300	542.56	369,797	76.8	213	323
South Metropolitan System.						
102.55	304,500	391.56	140,501	46.1	61	16
Entire Metropolitan District.						
193.05	785,800	934.12	510,298	64.9	274	339

Of the estimated gross population of 785,800 on December 31, 1903, 510,298, representing 64.9 per cent., were on that date contributing sewage to the Metropolitan sewers, through a total length of 934 miles of local sewers owned by the individual municipalities. These sewers are connected with the Metropolitan system by 274 public and 339 special connections. It appears, also, that there has been during the year an increase of 64.24 miles of local sewers connected with Metropolitan systems, and that 16 public and 23 special connections have been added.

Pumping Stations and Pumpage.

The following table shows the average daily volume of sewage lifted at each of the five Metropolitan pumping stations during the year, as compared with corresponding volumes for the previous year: —

Pumping Station.	Average Daily Pumpage.			
	Jan. 1, 1902, to Dec. 31, 1902.	Jan. 1, 1903, to Dec. 31, 1903.	Increase during the Year.	
	Gallons	Gallons.	Gallons.	Per Cent.
Deer Island,	51,500,000	53,800,000	2,300,000	4.5
East Boston,	49,500,000	51,600,000	2,100,000	4.2
Charlestown,	29,800,000	29,900,000	100,000	0.3
Alewife Brook,	3,742,000	3,831,000	89,000	2.4
Quincy,	2,229,000	3,042,000	813,000	36.5

CONSTRUCTION ON THE NORTH METROPOLITAN SYSTEM.

This includes a branch sewer to the town of Revere, to provide an outlet for the sewage of the whole of the town ; and an extension of the existing Cambridge branch to Belmont, to provide an outlet for an area of 330 acres in the southeasterly portion of the town.

These extensions were authorized respectively by chapters 242 and 336 of the Acts of 1903. They comprise a total length of 2.6 miles of brick sewer, and for convenience in construction this length has been divided into three contract sections. Details of these sections are given in the succeeding report.

Extension to Revere.

Section 61, Chelsea (Construction by Day Labor).

Division Engineer in Charge. — Frank I. Capen.
Superintendent of Construction by Day Labor. — Henry J. Wright.

This section is about 4,136 feet in length, and comprises about 3,140 linear feet of 54-inch brick sewer and about 996 linear feet of 48-inch brick sewer.

It commences at Section 10 of the North Metropolitan trunk sewer, near the junction of Eastern Avenue and Marginal Street, Chelsea, and extends northerly along Eastern Avenue and across land of the Boston & Maine Railroad to Crescent Avenue, crossing under the tracks of the Grand Junction branch of the Boston & Albany Railroad, the tidal inlet known as Bass Creek, the Willoughby Street main sewer of the city of Chelsea, and the tracks of the Eastern Division of the Boston & Maine Railroad.

The sewer will all be built in open cut of an average depth of 22 feet. For about 1,000 feet southerly from Bass Creek the excavation is in hard, gravelly clay. The remainder of the section is located in tidal marshes on the westerly side of Eastern Avenue, where the excavation is in peat and silt. For this length the sewer will be constructed upon a platform supported by piles driven to an average depth of 30 feet below the sewer. Bucket excavators are employed to handle the excavation.

But little water has been found in the excavation, except passing under Bass Creek and the Willoughby Street main sewer; at these points tide water entered the trenches so freely that work could be carried on for a few hours only, near the time of low tide.

The sewer has a circular cross-section, with an 8-inch brick arch and a 4-inch brick invert, reinforced with concrete.

Work was begun on the section early in September; to date, a length of about 945 linear feet has been completed.

Section 62, Chelsea (Construction in Part by Day Labor, in Part by Contract).

Division Engineer in Charge. — Frank I. Capen.
Superintendent of Construction by Day Labor. — Henry J. Wright.
Contractor for Portion of Work in Tunnel. — Charles A. Haskin, Boston, Mass.

This section comprises about 2,790 linear feet of 48-inch brick sewer, beginning on Crescent Avenue, at Eastern Avenue, and running northeasterly across marsh land on line of Crescent Avenue extended, and through Crescent Avenue and its extension, to near the tidal inlet, known as Mill Creek, separating Chelsea and Revere.

For a length of 1,329 linear feet east of Louis Street, the work will be built in tunnel, at an average depth of 30 feet below the surface. The excavation for this length is generally in compact hard-pan and clay, where it has been found desirable to carry out the construction under air pressure.

The tunnel is being constructed under contract by Charles A. Haskin, an expert in pneumatic work. Headings are being driven north and south from a central shaft near Hooper Street, under an air pressure of 10 pounds per square inch in excess of that of the atmosphere, which is found sufficient to maintain the headings for short lengths without sheathing or bracing. The material is excavated so carefully that a lining of approximately 8 inches of Portland brickwork yields the requisite 48-inch bore for the sewer.

Work on this portion of the section was begun on October 29. To date, 540 linear feet of tunnel have been completed, at an average rate of 60 feet per week and a maximum of 100 feet.

The remaining 1,461 feet of this section consists of a length of 1,172 feet, extending from Eastern Avenue to Louis Street; and another of 289 feet, extending from the end of the tunnel portion to near the shore of Mill Creek. This 1,461 feet is being constructed by day labor. It is located mainly in tidal marsh, and the excavation, which is entirely open cut, is largely in peat and silt. A short length of pile foundation was found to be necessary on the shore of Mill Creek, and piles of an average length of 30 feet have been driven in advance of the excavation for the entire distance west of Louis Street. A bucket excavator is in use on this portion of the work.

The sewer is circular in cross-section, with an 8-inch brick arch and a 4-inch brick invert, reinforced by concrete. The day labor construction was commenced about the middle of September, and about 639 feet have been completed to date, showing an average rate of progress of 40 feet a week, with a maximum of 100 feet. Very little water has been encountered in the excavation.

Mill Creek Crossing, Chelsea and Revere (Construction by Day Labor).

Division Engineer in Charge.— Frank I. Capen.
Superintendent of Construction by Day Labor.— Henry J. Wright.

Mill Creek, the tidal inlet separating Chelsea from Revere, will be crossed by two parallel lines of 36-inch cast-iron pipe, each 240 feet in length, and laid 4 feet apart on centres, without depression below the continuous grade of the connecting brick sewer. This will bring the roof of the pipes about 2 feet below the bed of the inlet.

The work covers a total length of about 380 linear feet, and extends from a pipe chamber at the northerly end of Section 62, in Chelsea, across the creek, by means of the pipes mentioned above, to a pipe chamber on the Revere shore, and thence by 140 linear feet of 48-inch brick sewer, across the marsh, to a point near the boundary of the upland.

The pipes will be surrounded by clay and concrete filling, and will be laid in a coffer so arranged as to obstruct at one time but one-third of the effective water-way of the creek.

For a length of 180 feet on the Chelsea side the pipes will be laid upon a pile foundation. On the Revere side the excavation reaches a firm clay, upon which the pipes will be laid without additional support.

Construction was begun on November 9. Piling for the coffer has been driven entirely across the creek. About 90 linear feet of the coffer is in place and 80 linear feet of trench excavated. Four 12-foot lengths of pipe are in position.

Extension to Belmont.

Section 63, Cambridge.

Division Engineer in Charge. — Frank I. Capen.
Contractor. — Gow & Palmer, Boston, Mass.

This section comprises about 4,780 linear feet of 24-inch by 28-inch brick sewer, and 1,587 linear feet of 22-inch by 28-inch brick sewer.

The section begins on Mt. Auburn Street at Lowell Street, at the end of Section 30 of the Cambridge Branch of the Metropolitan sewer, constructed in 1893, and extends westerly along Mt. Auburn Street to Aberdeen Avenue; thence in Aberdeen Avenue and private land, across Homer Avenue, through private land, and across the Watertown branch of the Boston & Maine Railroad to Holworthy Place; through Holworthy Place, Holworthy Street and private land, across Cushing Street and through Cushing Avenue to the Belmont town line, — a total distance of 6,367 feet.

Work was commenced at Lowell Street, at the lower end of the section, on September 17. The excavation has been in sand and gravel, with a small amount of clay at the bottom. Water has been found in sufficient quantity to require the use of a small steam pump. About 2,500 linear feet of sewer have been completed at this opening, to date.

On October 3 a second opening was made in private land between Aberdeen and Homer avenues, from which point work was carried on in both directions; backward to the corner of Aberdeen Avenue and Mt. Auburn Street, and forward to Holworthy Street, — a total distance of 1,608 linear feet.

For a length of about 100 feet in Aberdeen Avenue the excavation was in soft earth, requiring a pile foundation. The remainder of the excavation was generally in good ground, without water.

A third opening was made on November 7, in Mt. Auburn Street, near the entrance to Mt. Auburn Cemetery. The work extended to Aberdeen Avenue, a distance of about 400 linear feet, and is practically completed. The excavation was in wet sand and gravel.

On November 16 a fourth opening was started in Cushing Avenue, about 600 feet from the Belmont line. The excavation from this point to the end of the section was in hard gravel, with but little water, and the sewer for this length is completed at this date.

From Holworthy Street through private land and across Cushing Street, and for about 200 feet along Cushing Avenue, the contractors were permitted by the Board to build the sewer in tunnel instead of in open trench. Work was started early in December; westerly from a heading at Holworthy Street, and both easterly and westerly from a shaft in Cushing Street. To date, about 270 linear feet of tunnel have been excavated, but no masonry has been built in the tunnel headings.

The sewer has a cross-section of a gothic arch with a semi-circular invert, built of 4-inch Portland brickwork. Both arch and invert are reinforced with Portland concrete where the surrounding earth is not firm, or water is found in the excavation.

Chapter 336 of the Acts of 1903, which authorizes this construction, directs that the city of Cambridge shall be allowed to make house connections with this sewer. Provision for these connections has been made by the introduction of 6-inch branches and chimneys into the side and arch of the sewer, at intervals of about 25 feet. Additional branches for the connection of the local sewers of the city of Cambridge have also been provided.

At the present rate of progress, this section will be completed by the latter part of February, 1904.

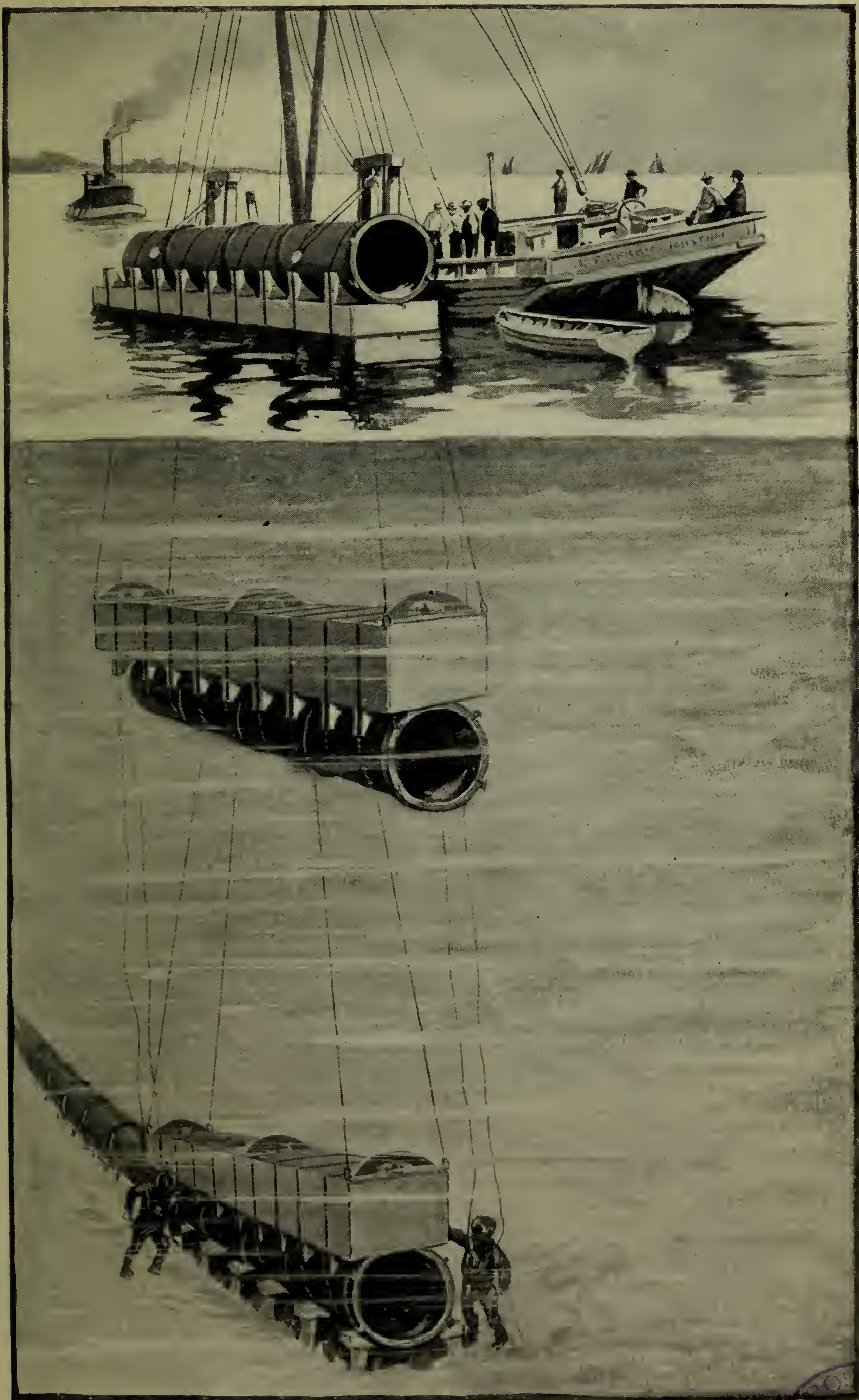
CONSTRUCTION ON THE SOUTH METROPOLITAN SYSTEM.

This consists of the near completion of the High-level Sewer, authorized by chapter 424 of the Acts of 1899, and which has been under construction since November of that year.

High-level Sewer.

This has been the important constructional work of the department during the year. Of the 47 contracts embraced in the 36 sections into which, for convenience in construction, the High-level Sewer has been divided, 38 have been completed, 8 are now under construction, and 1 is yet to be undertaken, consisting of the laying of a 24-inch force main from the Quincy sewerage pumping station to the High-level Sewer.

Exclusive of the 24-inch Quincy force main, the High-level Sewer will have, when completed, a length of 16.83 miles, all of



HIGH-LEVEL SEWER—METHOD OF PLACING OUTFALL PIPES.

which has been placed under contract. With the exception of a portion of the easterly outfall pipe line, practically the entire length has been completed.

During the year, approximately 1,000 cubic yards of rock have been excavated for sewer construction in tunnel and in open cut; and about 16,000 cubic yards were quarried at Rock Island, in Quincy, for use as riprap, re-enforcement of embankments, and in concrete masonry, on the adjacent sections 48 and 49. The above work, together with the loosening of compact earth on some sections, has involved the use of about 6½ tons of dynamite, powder or other explosives.

A more detailed description of the work, as divided into sections, follows: —

Section 43, Quincy and Hull.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Hiram W. Phillips, Quincy, Mass. (Two contracts.)

This comprises two lines of 60-inch cast-iron pipe, extending from Nut Island to a point about one mile beyond low-water mark in Boston harbor. Two separate contracts with the same contractor have been arranged for placing this pipe below the bed of the harbor.

The first contract, for the westerly line, was awarded last year, and the work under this contract, with the method of operation, was fully described in the last report.

The work during the past year has included the completion of the westerly line and a portion of the easterly line.

The westerly line, involving a total length of about 5,300 feet, has occupied ten months of actual labor. The working season includes the months from May to December, and the average rate of placing the pipe has been about 500 feet a month. The maximum rate during any week was 300 feet, and this was maintained during a number of weeks.

During the back-filling of the westerly line, two sections of the pipe, each 48 feet in length, about 2,000 feet from shore, were crowded off the pile caps, where the back-filling was not carefully placed, and the contractor is now replacing the lengths of pipe thus affected. This is the only unfavorable incident which has occurred during the placing of this line.

On the second contract, for the easterly line, about 1,000 feet have been laid, including the quarter-turn outlet pipe; the trench has been dredged for a further distance of about 1,800 feet; and the pile foundation upon which the pipes rest has been completed for a distance of 700 feet beyond the pipe laid.

The average rate of progress on the easterly line has been 480 feet a month. The maximum rate during any week was 300 feet.

All the pipe which the Board has purchased to date for use on these contracts has been placed in the harbor. On December 21 a contract was arranged with the Camden Iron Works, of Camden, N. J., for sufficient pipe to complete the work during the coming season.

The back-filling of the pipe trenches on these lines is not yet completed, but enough material has been deposited to secure the pipe against movement.

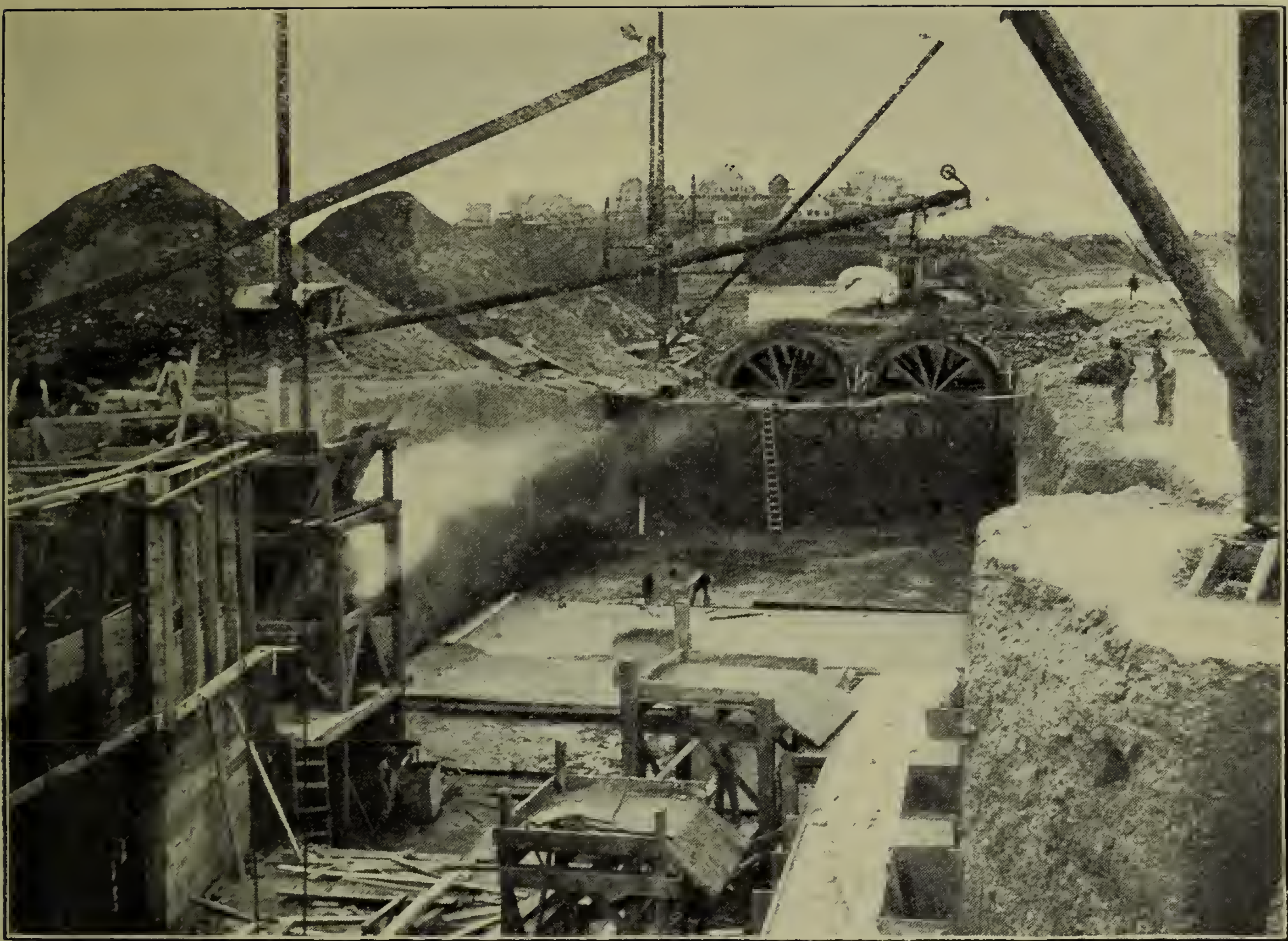
Section 44, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor for sewer, sand-catcher, and screen chamber and building foundations. — W. H. Ellis, Boston, Mass.
Contractor for screen house superstructure and chimney. — Woodbury & Leighton Company, Boston, Mass.

Section 44 consists of the placing of the shore ends of two lines of 60-inch cast-iron outfall pipe from the end of Section 43 to the screen chamber and controlling valves on Nut Island, involving a length of 270 feet on each line; together with the screen chamber and superstructure, the masonry sand-catcher, and about 918 linear feet of 11-foot 3-inch by 12-foot 6-inch sewer in trench and embankment. This corresponds to a total length of 1,539 feet of the High-level Sewer, and extends from near low water on the northerly shore of Nut Island, through the island and embankment on Nut Island bar, to a point on the northerly shore of Quincy Great Hill.

During the year, two contracts have been awarded on this section. The first, W. H. Ellis, contractor, comprises the placing of the 60-inch cast-iron outfall pipes, the construction of the screen chamber, sand-catcher, and sewer in embankment, and foundations for the screen house superstructure and chimney. Work on this contract began June 23, and is nearly completed at the present date.

Under a former contract, fully described in last year's report, an embankment with riprap slopes was built on Nut Island bar, in which



HIGH-LEVEL SEWER—SCREEN CHAMBER AND SAND CATCHER ON NUT ISLAND IN CONSTRUCTION—VIEWS FROM OPPOSITE ENDS.

was laid a boulder-concrete masonry foundation to support the connecting sewer from Nut Island to Quincy Great Hill. This foundation and embankment were superloaded during the winter of 1902–1903, and settlements were recorded. It was found that appreciable settlements in the subfoundation extended over a length of 675 feet, between Station 4+0 and Station 10+75, the maximum being about 2 feet. These had practically ceased before the work of building the connecting sewer in the embankment was attempted during the present year, and in the construction of the sewer, sufficient additional boulder-concrete was placed on the subfoundation to restore it to its original elevation.

The sewer is of the horseshoe type, having a concrete invert lined with 8 inches of brickwork, and a brick arch of a minimum thickness of 12 inches.

Extending northerly from the sewer for a distance of 270 feet is the structure known as the sand-catcher. This consists of double channels, each 20 feet wide by 18½ feet high, built with concrete inverts lined with 8 inches of brickwork, and brick arches of a minimum thickness of 16 inches, re-enforced by concrete spandrel walls. The purpose of the enlarged section is to check the velocity of the sewage, so that the sand and other heavy sludge, whose entrance into the outfall pipes might be objectionable, will be deposited in these channels. A line of manholes in the arches of the channels affords access for inspection and cleaning. A system of gates at both ends is so arranged that the sewage may be excluded from either channel while it is being cleaned.

The sand-catcher delivers into the screen chamber, which is a double channel 12 feet in width and 21 feet high, with a length of about 40 feet, having a dividing pier of granite. Here the sewage is conducted through movable screens, in duplicate, which are operated by machinery above, and are designed to intercept rags, paper and other floating matter, whose presence in the harbor would be offensive.

At the northerly end of the screen chamber are five 60-inch cast-iron outfall pipes, extending through the masonry. In the early years of operation but two of these will be used, the remaining three being bulkheaded and kept for future extensions. The flow of sewage through these pipes will be controlled by penstock valves operated by hydraulic pressure.

A portion of the screen chamber walls is used as foundation for the superstructure.

A second contract on this section has been arranged for building a house to cover screening machinery and appurtenances, about 80 feet long by 60 feet wide and about 40 feet high. This will contain a large room, about 50 feet square, in which will be located machinery for operating screens ; a boiler room, about 25 feet by 30 feet ; and a coal storage room, about 25 feet square, with a storeroom for tools above. In addition, there will be a vestibule, office and toilet room. The chimney will be about 100 feet high, placed at the easterly end of the building.

The building will be of dark-red brick, with Quincy granite trimmings.

The house was designed by Shepley, Rutan & Coolidge, architects. The contract was awarded on September 11 to the Woodbury & Leighton Company, of Boston, but on account of the delay in completing the foundations for the house, the erection of the building will be deferred until the coming spring.

Section 45, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Latta & Terry Company, Philadelphia, Pa.

Work under this contract was in progress at the date of the last report, consisting of excavation for and masonry filling in a tunnel of an inside finished bore of 11 feet 3 inches by 12 feet 6 inches, extending from near the northerly end of Quincy Great Hill, southeasterly along Island Avenue for a distance of 972 feet, to a point 780 feet from the corner of Island Avenue and Sea Avenue. At the date of the last report, 450 feet of the tunnel headings had been driven.

The excavation of the tunnel bore was completed on March 19, 1903. It was in compact hard-pan, in which it was found convenient to use explosives. The headings were practically dry. The excavation extended over a period from November, 1902, to March, 1903. The average rate of progress in the headings was approximately 200 feet a month, and the maximum rate 85 feet in one week from two headings.

The masonry section of the sewer comprises a concrete invert, with an 8-inch brick lining. The arch is of concrete, having a thickness of 14 inches, and completely fills the roof of the tunnel. Work on the section was completed May 28, 1903.

Section 46, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — W. H. Ellis, Boston, Mass.

This section comprises the construction of a masonry sewer 11 feet 3 inches wide by 12 feet 6 inches high, in an embankment extending from a point on Island Avenue about 780 feet southerly from Sea Street, across private lands and tidal flats, to Prospect Avenue, a distance of approximately 800 feet. The sewer is of horseshoe type, with Portland concrete invert lined with 4-inch brickwork, and brick arch of a minimum thickness of 12 inches. For about 160 feet the sewer rests on a pile and boulder-concrete foundation.

The embankment in which this sewer is constructed and the pile and boulder-concrete foundation were built during the previous year under an earlier contract. As originally constructed, the embankment was approximately 9 feet below the finished grade. Sufficient material was secured from the excavation for the sewer in this embankment to complete it to a height of approximately 3 feet above the roof of the sewer.

Work on this contract was begun July 15, 1903. The excavation was handled by an orange-peel excavator. The trench was completed November 26, and the masonry December 10. A small amount of grading yet remains to complete the slopes of the embankment.

Section 47, and Culverts and Embankments, Sections 48–49, Quincy.

These contracts were entirely completed prior to December 31, 1902.

Section 48, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Charles G. Belden & Co., Quincy, Mass.

The contract for the masonry sewer in this section was awarded in December of 1902. At the date of the last report, no work under this contract had been accomplished. The sewer is 11 feet 3 inches wide by 12 feet 6 inches high, of the horseshoe type, with concrete invert lined with 4 inches of brick, and a brick arch of a minimum thickness of 12 inches.

The section has a total length of 5,890 feet. It extends from the intersection of Sea and Darrow streets across private and marsh lands in a westerly direction, parallel to Sea Street. Four thousand three hundred feet have been constructed in embankment completed last year, 1,236 feet of which are on pile foundation. To prevent the decay of the piles, they have been cut off 7 feet above mean low water, and from this elevation the piling extends to an average depth of approximately 30 feet. The piles are driven 2½ feet on centres.

From 1 foot below the top of the piles to the subgrade of the sewer a subfoundation of boulder-concrete has been constructed. The excavation was handled by bucket excavators. Piles were generally driven in advance of the excavation to subgrade by the use of followers.

Work on the section was begun March 10 and completed November 20, the average rate of progress being 168 feet a week, and the maximum rate 272 feet.

It was anticipated that the excavated material from the trench in the embankment would be sufficient to complete it to a width of 25 feet at the top, and to an elevation 3 feet above the masonry arch of the sewer. Because of the unexpected penetration of the embankment filling into the meadows, this has not been fully realized. About 7,000 cubic yards of earth filling remain to be placed during the coming year.

Section 49, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Charles G. Belden & Co., Quincy, Mass.

This contract was awarded in May, 1901, and was in progress at the date of the last report. At that date 650 feet of a total length of 3,500 feet had been completed.

Of the total length of 3,500 feet, 650 feet were supported on piles cut off at elevation 7 feet above low water, and covered with a subfoundation of boulder-concrete extending from 1 foot below the top of the piles to the grade of the sewer. The sewer has the same cross-sectional dimensions and construction as that alluded to under Section 48 above. The excavation was handled by a bucket excavator.

The work on this section was completed July 15, 1903. The average rate of progress from the beginning was 28 feet a week, and the maximum 120 feet in one week. The embankments over the section have been fully completed, and dressed with loam and peat.

HIGH-LEVEL SEWER—CONSTRUCTION IN EMBANKMENT ACROSS MARSH IN QUINCY.

Sections 50, 51, 52, 53 and 54, Quincy; Section 55, Quincy and Milton; and Sections 56, 57, 58, 59 and 60, Milton.

These sections were completed prior to December 31, 1902, and have been fully described in preceding reports.

Section 61, Milton.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Charles G. Belden & Co., Quincy, Mass.

This contract was in progress at the date of the last report. The section comprises a 10-foot 7-inch by 11-foot 7-inch sewer, of the horseshoe type, extending along Brook Road from Canton Avenue in its widened location to beyond Pine Tree Brook, a total distance of 2,829 feet. At the beginning of the year a length of 316 feet of excavation and part of the masonry construction remained to be completed.

The excavation was completed April 2, 1903, being handled by the common type of bucket excavator. The masonry was completed on April 16. A large quantity of water was found in the excavation.

Several branches were introduced in the section, for convenience in connecting local sewers.

The construction under Pine Tree Brook involved a modified masonry cross-section, reinforced with concrete, in which the arch was depressed 1 foot.

Sections 62 and 63, Milton; Section 64, Milton and Hyde Park (Day Work); and Section 65, Hyde Park.

These sections were all completed prior to December 31, 1902, and have been described in earlier reports.

Section 66, Hyde Park.

Division Engineer in Charge. — C. Barton Pratt.
Contractor. — Ed. W. and John J. Everson, Providence, R. I.

This section consisted of a length of 5,300 feet of a 9-foot 3-inch by 10-foot 2-inch sewer, largely in rock tunnel, piercing the divide between the Stony Brook and Neponset River basins. The details of the work have been fully described in earlier reports. The construction was commenced on December 22, 1899, and at the date of the last report was practically completed, a manhole 65 feet in depth remaining to be built in the central shaft. This was completed on February 17, 1903.

Section 67, Hyde Park (Day Work); Section 68, Hyde Park and West Roxbury; and Sections 69 and 70, West Roxbury.

These sections were completed prior to December 31, 1902.

Part of Section 70, West Roxbury. (Constructed by Day Labor.)

Division Engineer in Charge. — Frank I. Capen.
Superintendent of Construction by Day Labor. — George F. Greenlaw.

During the contract construction of the 8-foot 9-inch by 9-foot 3-inch main sewer on this section, described in earlier reports, a length of about 189 feet was omitted in passing the Roslindale branch of Stony Brook, and another length of about 89 feet in passing Washington Street, Roslindale. Both gaps have been closed by day-labor construction during the past year.

At the brook crossing, lines of 48-inch cast-iron pipe have been laid in duplicate. For a length of about 10 feet directly under the brook channel, these lines of 48-inch pipe are reduced to 36 inches. It is anticipated that the pipes will serve until such time as the city of Boston shall have constructed the proposed masonry channels for the brook, when they will be replaced by a masonry sewer of the normal cross-section.

At Washington Street, a local sewer of the city of Boston, 36 inches by 48 inches in size, which lies at approximately the elevation of the springing line of the High-level Sewer, has been temporarily passed across the Metropolitan sewer by building into its arch a length of 48-inch cast-iron water pipe, which will serve until such time as the local sewer shall be diverted. Fifteen-inch and 24-inch masonry siphons have also been constructed under the High-level Sewer at this point to provide for possible future needs of the local sewer.

This day work was started March 19, and completed July 30, 1903.

Sections 71 and 72, West Roxbury.

These sections were completed prior to December 31, 1902.

Section 73, West Roxbury.

Division Engineer in Charge. — C. Barton Pratt (part of year); Frank I. Capen (part of year).
Contractor. — National Contracting Company, New York, N. Y.
Contractor for Portion of Work. — H. P. Nawn, Boston, Mass.
Superintendent of Construction by Day Labor. — Charles A. Haskin.

This section consists of a length of 4,795 feet of 9-foot circular sewer wholly in tunnel, at an average depth of 50 feet below the surface, extending along South and Centre streets from near St. Joseph Street to near Boylston Street, Jamaica Plain.

The contract for this work was awarded on November 3, 1900, to the National Contracting Company of New York City. Operations were begun by these contractors on December 1, 1900, and they proceeded with the work until February, 1902, at which date the Board took possession of it.

Two shafts had then been excavated to grade: one near Lakeville Place, in rock; the other at Pond Street, in sand. From the former, 1,300 feet of tunnel heading, in rock, had been partly excavated, and a little of the concrete invert of the sewer had been built. At the Pond Street shaft, an attempt had been made to drive a southerly heading by the pneumatic process, but substantially no progress had resulted.

After the work had been taken by the Board, that portion of the section south of Pond Street, comprising a length of 2,800 feet, was completed under the direction of the engineer by day labor. This work was in charge of Mr. Charles A. Haskin, an expert in pneumatic construction.

The day-work operations began March 26, 1902, and were carried out by the pneumatic process originally contemplated, under an air pressure of from 15 to 17 pounds per square inch. At the beginning of the past year, about 1,300 linear feet of tunnel had been completed. A full description of the details of the process of carrying out the work appeared in the last report. On September 4, 1903, this length of 2,800 feet had been fully completed, at an average rate of 50 linear feet and a maximum of 74 linear feet of completed tunnel a week.

On April 21, 1902, a contract for the completion of 1,300 linear feet of sewer in the rock tunnel partially excavated by the National Contracting Company, mentioned above, and for the construction of about 675 linear feet of sewer, mainly in sand tunnel, extending from the partially completed rock tunnel to the end of the section, was awarded to H. P. Nawn of Boston. The work of lining the rock tunnel was commenced on May 12, 1902, and completed on August 23, 1903. The 675 linear feet of sewer in sand and rock tunnel, under this contract, was begun August 25, 1902. It was carried out mainly by pneumatic process, by methods described in the last report for sand tunnel construction by day labor. At the beginning of the year about 56 linear feet had been completed. This length of 675 feet was completed on July 26, 1903, at an average rate of 22 linear feet a week for pneumatic tunnel, and a maximum of 40 linear feet.

An effort was made to drive the tunnel with sufficient accuracy to require a brick lining only 12 inches in thickness; but, owing to changing conditions of sand and water, and other difficulties, the thickness of the brickwork varied considerably, averaging about 15 inches.

Section 74, West Roxbury and Roxbury.

This section was completed prior to December 31, 1902.

Section 75, Roxbury.

Division Engineer in Charge. — C. Barton Pratt.
Contractor for Parts of Section. — E. W. Everson & Co., Providence, R. I.

This section involves a length of 3,052 feet of 6-foot 6-inch by 7-foot sewer in rock tunnel, at a maximum depth of 175 feet, under Parker Hill, Roxbury. It extends from the junction of Day and Heath streets, largely under private lands, to Calumet Street, and continues thence along St. Alphonsus Street to a point about midway between Tremont and Smith streets, as fully described in earlier reports. The construction was commenced on May 17, 1900, and at the date of the last report was completed except for the masonry lining of a length of 300 feet near Tremont Street. The work was completed on February 17, 1903.

Section 76, Roxbury.

Division Engineer in Charge. — Frank I. Capen.
Contractor. — H. P. Nawn, Boston, Mass.

This section includes duplicate lines of 48-inch cast-iron force-mains and appurtenances, extending from near the Ward Street pumping station to the end of Section 75 tunnel through Parker Hill, at St. Alphonsus Street near Tremont Street, Roxbury.

The difficulty of securing locations for double lines of 48-inch pipe in the streets of this section of the city rendered it desirable to lay the lines over different routes. The easterly line extends from the north side of Ward Street, near the pumping station, through Phillips, Conant, Oregon, Smith, and St. Alphonsus streets, a distance of 1,639 feet. The westerly line extends from the north side of Ward Street, at Vancouver Street, through Ward and St. Alphonsus streets, a distance of 1,402 feet. The pipes join the masonry gravity sewer by converging masonry channels terminating in a masonry bellmouth at the Section 75 tunnel. At the upper end of each force-main is a manhole for convenience of inspection, which also contains automatic flap valves to prevent the backward flow of sewage in the pipes when the pumps are not in operation. The pipes are laid at such elevations as to avoid unnecessary interference with existing pipes and sewers, at an average depth of 15 feet below the street surfaces.

The excavation was generally in sand and gravel. For about 100 feet near the upper end of the section disintegrated conglomerate was found.

The connections of these pipe lines with the pumping station will be laid after the installation of the pumping machinery, during the coming season.

Work commenced upon the easterly force-main June 30, 1903, and upon the other September 22, 1903. The pipes were laid at an average rate of 120 linear feet a week. To date, both pipe lines have been completed, and only a small amount of work remains at the masonry chamber. It is anticipated that the section will be finished as early as February 1, 1904.

Section 77, Roxbury.

Division Engineer in Charge. — Frank I. Capen.
Contractor for Pumping Station and Connections. — L. P. Soule & Son, Boston, Mass.
Contractor for Pumping Plant. — Allis-Chalmers Company, Milwaukee, Wis.

This section includes the pumping station situated on Ward Street, Roxbury, and its connections with the force-mains previously described as Section 76, and with the suction sewer hereinafter mentioned as Section 78.

The pumping station buildings are of hard brick, with granite trimmings and foundations of Portland concrete. They cover an area of about 16,500 square feet, and provide for an engine house about 65 by 120 feet, for three 50,000,000 gallon pumping engines, two of which are to be installed immediately; a boiler room and accessories, 38 by 105 feet, to accommodate four vertical boilers; an underground coal-pocket, 39 by 52 feet, with a storage capacity of 400 tons; a screen chamber, 42 by 47 feet, where incoming sewage will be passed through movable screens to intercept rags and other floating matter which it is desirable to remove before the sewage reaches the pumps; and a chimney 150 feet high, having a central flue 6 feet in diameter. The contract was awarded October 8, 1902, to L. P. Soule & Son of Boston.

At the beginning of the year the excavation for the foundations was partially completed, and the chimney foundation substantially finished. During the year the foundations, buildings and connections have been largely completed; but some work on the roof remains to be done, and the interior finish and flooring are yet to be put in. By the contract the buildings were to be finished by December 1, but a masons' strike during the summer delayed the work for two months, and prolonged the construction well into the winter. The grading of the lot will be completed and the connections with the force-mains will be made during the coming summer.

On January 17, 1902, a contract for the steam and pumping plants was awarded to the Allis-Chalmers Company of Milwaukee. This contract involves the furnishing and erecting of two 50,000,000 gallon vertical triple-expansion 60-inch stroke pumping engines, and of four 93-inch diameter internally-fired vertical tubular boilers and appurtenances.

The engines, boilers and other machinery are now being delivered, and it is anticipated that the plant may be in operation early in the coming summer. The construction and installation of the screening machinery alone remain to be provided for at this date.

Section 78, Roxbury.

Division Engineer in Charge. — Frank I. Capen.
Contractor. — Patrick McGovern, Boston, Mass.

This section, known as a suction sewer, extends from the boundary of the pumping station lot on Vancouver Street, northerly along

Vancouver Street to Ruggles Street, near Huntington Avenue, where it will connect with the existing Charles River Metropolitan main sewer. The sewer is 6 feet 6 inches by 7 feet in diameter, of the horseshoe type, with concrete invert lined with brick and 12-inch brick arch. It is about 23 feet below the surface of the street.

From Ruggles Street, for a length of 556 feet south, the excavation was largely in peat and silt. For this length the sewer is built on a timber platform supported on piles driven to an average depth of 40 feet. The remainder of the excavation on the section was largely in clay.

Great difficulty was encountered by the contractor in dealing with the obstructions found in Huntington Avenue, embracing local city sewers, conduits, gas and water pipes, and lines of electric railway.

Work on the section was begun October 20, 1902. The section was about one-half completed at the beginning of the present year. The whole section was finished May 15, 1903, giving an average rate of progress for the whole section of 25 feet a week.

MAINTENANCE.

Scope of Work and Force Employed.

The maintenance of Metropolitan Sewerage Systems includes the operation of five pumping stations and 94 miles of Metropolitan sewers, receiving the discharge from 934.12 miles of town and city sewers at 274 points, together with the care and study of inverted siphons under streams and in the harbor.

The present maintenance force of 84 men includes 47 engineers and other employés at the pumping stations, and 37 men employed on actual sewer maintenance and care of pumping station grounds. In the three following tables the use of the completed systems and other data are shown : —

North Metropolitan System.

Table showing Cities and Towns delivering Sewage in this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of December 31, 1903.]

Cities and Towns.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.*	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
Boston (Deer Island), .	0.70	Separate, . . .	-	-	1,500†	1,500†	-	-	100.0	-
Winthrop, . . .	26.16	Separate, . . .	1,650	4.5	7,425	7,600	1.21	1.61	97.7	75.2
Boston (East Boston), .	20.02	Separate and combined,	5,059	8.7	44,013	48,100	0.71	2.18	91.5	32.6
Chelsea, ...	12.88‡	Combined, . . .	1,350	7.0	9,450	37,200	0.65	2.24	25.4	29.0
Everett, ...	40.23	Separate and combined,	3,588	6.1	21,887	28,800	1.75	3.34	76.0	52.4
Malden, ...	47.07	Separate, . . .	4,053	6.0	24,318	40,200	2.53	5.07	60.5	49.9
Melrose, ...	32.44	Separate, . . .	2,194	4.3	9,434	14,200	1.60	3.73	66.4	42.9
Boston (Charlestown), .	20.75	Separate and combined,	5,062	7.9	39,990§	41,000	0.66	1.27	97.5	52.0
Cambridge, . . .	112.14	Separate and combined,	14,219	6.9	98,110	99,900	4.92	6.11	98.2	80.5
Somerville, . . .	83.41	Separate and combined,	12,118	5.5	66,650	69,200	3.27	3.96	96.3	82.6
Medford, ...	47.52	Separate, . . .	2,939	6.5	19,104	22,700	2.44	8.35	84.2	29.2
Winchester, . . .	20.12	Separate, . . .	765	5.5	4,208	8,300	1.01	5.95	50.7	17.0
Woburn, ...	12.30‖	Separate, . . .	858	5.8	4,976	15,100	0.89	12.71	33.0	7.0
Stoneham, . . .	10.94	Separate, . . .	455	4.4	2,002	6,400	0.59	5.50	31.3	10.7
Arlington, . . .	19.13	Separate, . . .	820	6.6	5,412	10,000	1.63	5.20	54.1	31.3
Belmont, ...	8.11	Separate, . . .	213	7.3	1,970¶	4,900	0.85	4.66	40.2	18.2
Wakefield, . . .	10.50	Separate, . . .	196	5.6	1,098	10,300	0.39	7.65	10.7	5.1
Lexington,** . . .	-	- -	-	-	-	2,800	-	5.11	-	-
Revere,†† . . .	18.14	Separate, . . .	1,500	5.5	8,250	13,100	1.16	5.86	63.0	19.8
Totals, . . .	542.56	- -	57,039	6.5	369,797	481,300	26.26	90.50	76.8	29.0

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1903.
† Estimated by Superintendent J. R. Gerrish of the Institution on Deer Island.
‡ The Pearl Street district of Chelsea temporarily excluded, owing to connection not being properly maintained.
§ Including 30 persons at navy yard.
‖ Exclusive of Mystic River valley sewer and tanneries.
** Lexington not connected.
¶ Including 2 connections with McLean Hospital, having an estimated population of 430.
†† Admitted by act of Legislature in 1903, but not yet connected.

South Metropolitan System.

Table showing Cities and Towns delivering Sewage to this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of December 31, 1903.]

Cities and Towns.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.*	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles	Square Miles.	Per Cent.	Per Cent.
Boston (Back Bay), .	21.97	Separate and combined.	1,433	15.8	22,641	23,400	1.20	1.61	96.8	74.5
Boston (Brighton), .	51.36	Separate and combined.	2,469	5.8	14,320	23,100	3.13	4.27	62.0	73.3
Brookline, . . .	55.32	Separate and combined.	2,870	6.9	19,803	24,000	3.20	6.81	82.5	47.0
Newton, ...	96.49	Separate, .	4,730	6.1	28,853	38,500	6.39	18.03	74.9	35.4
Watertown, . . .	30.93	Separate, .	1,519	5.4	8,202	11,100	1.76	4.04	73.9	43.6
Waltham, . . .	38.48	Separate, .	2,653	8.9†	23,612	26,500	2.40	13.63	89.1	17.6
Boston (Dorchester), .	14.95	Separate and combined.	1,087	6.8	7,392	43,000	0.86	4.89	17.2	17.6
Milton, ...	5.06	Separate and combined.	83	5.7	473	7,600	0.26	12.59	6.2	2.1
Hyde Park, . . .	17.93	Separate, .	713	8.8	6,274	14,400	0.97	4.57	43.6	21.2
Dedham, ...	13.96	-	172	5.0	860	7,300	0.70	9.40	11.8	7.4
Boston (Roxbury), .	-	-	-	-	-	30,200	-	1.23	-	-
Boston (West Roxbury),	4.63	Separate, .	156	7.2	1,123	28,000	0.28	8.92	4.0	3.1
Quincy, ...	40.48	-	1,219	5.7	6,948	27,400	2.01	12.56	25.4	16.0
Totals, . . .	391.56	-	19,104	7.4	140,501	304,500	23.16	102.55	46.1	22.6

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1903.

† Estimated by City Engineer.

Whole Metropolitan System.

Table showing Areas delivering Sewage to the Entire System, inclusive of added High-level Area; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations of December 31, 1903.]

System.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by Each House-connection.	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
							Square Miles.	Square Miles.	Per Cent.	Per Cent.
North Metropolitan, .	542.56	Separate and combined.	57,039	6.5	369,797	481,300	26.26	90.50	76.8	29.0
South Metropolitan, .	391.56	Separate and combined.	19,104	7.4	140,501	304,500	23.16	102.55	46.1	22.6
Totals, . . .	934.12	-	76,143	6.7	510,298	785,800	49.42	193.05	64.9	25.6

CAPACITY AND RESULTS.

The following tables summarize the pumping records for the year for the North Metropolitan and Quincy stations: —

Deer Island Pumping Station.

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.
Average duty for the year: 46,900,000 foot-pounds.
Average quantity raised each day: 53,800,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.79 to $5.50 per ton.

Table of Approximate Quantities, Lifts and Duties at the Deer Island Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1903.						
January,	1,956,900,000	63,100,000	47,000,000	85,600,000	10.93	47,200,000
February,	1,700,600,000	60,700,000	51,000,000	99,900,000	10.68	46,200,000
March,	2,283,800,000	73,700,000	55,900,000	103,800,000	11.09	49,200,000
April,	2,331,000,000	77,700,000	61,100,000	109,900,000	11.67	55,100,000
May,	1,422,200,000	45,900,000	32,000,000	60,600,000	10.36	44,700,000
June,	1,633,300,000	54,400,000	37,800,000	91,500,000	11.19	49,700,000
July,	1,506,000,000	48,600,000	40,600,000	70,700,000	10.59	48,600,000
August,	1,417,300,000	45,700,000	37,100,000	71,000,000	10.29	48,700,000
September,	1,282,800,000	42,800,000	36,000,000	53,400,000	10.26	44,800,000
October,	1,495,500,000	48,200,000	37,900,000	78,400,000	10.66	47,100,000
November,	1,237,700,000	41,300,000	34,100,000	63,900,000	10.41	41,200,000
December,	1,332,100,000	43,000,000	31,800,000	54,600,000	10.42	40,500,000
Total,	19,599,200,000	-	-	-	-	-
Average,	-	53,800,000	41,900,000	78,600,000	10.71	46,900,000

East Boston Pumping Station.

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.
Average duty for the year: 53,800,000 foot-pounds.
Average quantity raised each day: 51,600,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.98 to $4.09 per ton.

Table of Approximate Quantities, Lifts and Duties at the East Boston Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1903.						
January,	1,894,900,000	61,100,000	45,000,000	83,600,000	15.05	53,500,000
February,	1,644,500,000	58,700,000	49,000,000	97,900,000	14.82	54,100,000
March,	2,221,800,000	71,700,000	53,900,000	101,800,000	15.36	58,000,000
April,	2,271,000,000	75,700,000	59,100,000	107,900,000	15.44	58,700,000
May,	1,360,200,000	43,900,000	30,000,000	58,600,000	14.25	51,900,000
June,	1,573,300,000	52,400,000	35,800,000	89,500,000	14.60	54,200,000
July,	1,444,000,000	46,600,000	38,600,000	68,700,000	14.37	54,600,000
August,	1,345,600,000	43,400,000	35,100,000	69,000,000	14.37	56,200,000
September,	1,198,400,000	39,900,000	33,000,000	50,400,000	14.20	52,000,000
October,	1,402,500,000	45,200,000	34,900,000	75,400,000	14.36	55,400,000
November,	1,177,700,000	39,300,000	32,100,000	61,900,000	15.01	49,200,000
December,	1,270,100,000	41,000,000	29,800,000	52,600,000	15.13	47,400,000
Total,	18,804,000,000	-	-	-	-	-
Average,	-	51,600,000	39,700,000	76,400,000	14.75	53,800,000

Charlestown Pumping Station.

At this station are three submerged centrifugal pumps, two of them having impellers or wheels 7.5 feet in diameter, the other 8.25 feet in diameter. They are driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: two, 22,000,000 gallons each, with 11-foot lift; one, 60,000,000 gallons, with 8-foot lift.
Average duty for the year: 38,500,000 foot-pounds.
Average quantity raised each day: 29,900,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.98 to $4.09 per ton.

Table of Approximate Quantities, Lifts and Duties at the Charlestown Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1903.						
January,	1,064,700,000	34,300,000	27,500,000	44,700,000	8.11	41,300,000
February,	932,500,000	33,300,000	26,500,000	51,000,000	8.01	39,800,000
March,	1,102,400,000	35,600,000	28,400,000	49,600,000	8.14	40,600,000
April,	1,067,000,000	35,600,000	27,200,000	45,500,000	8.21	41,500,000
May,	784,400,000	25,300,000	21,100,000	28,100,000	7.58	33,700,000
June,	929,700,000	31,000,000	22,600,000	53,300,000	8.15	40,700,000
July,	894,100,000	28,800,000	23,800,000	41,200,000	7.85	36,600,000
August,	859,200,000	27,700,000	22,600,000	40,700,000	7.76	39,200,000
September,	790,800,000	26,400,000	21,800,000	32,500,000	7.65	37,600,000
October,	864,800,000	27,900,000	22,000,000	46,400,000	7.68	37,300,000
November,	786,100,000	26,200,000	21,300,000	40,400,000	7.66	36,600,000
December,	827,400,000	26,700,000	21,700,000	33,900,000	7.70	36,900,000
Total,	10,903,100,000	-	-	-	-	-
Average,	-	29,900,000	23,900,000	42,300,000	7.88	38,500,000

Alewife Brook Pumping Station.

The plant at this station consists of the original installation of small commercial pumps and engines, *i.e.*, two 9-inch Andrews vertical centrifugal pumps, with direct-connected compound marine engines, together with the recent additions. The latter consist of a specially designed engine of the vertical cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis.

Contract capacity of the two original pumps: 4,500,000 gallons each, with 13-foot lift.
Contract capacity of new pump: 13,000,000 gallons, with 13-foot lift.
Average duty for the year: 20,400,000 foot-pounds.
Average quantity raised each day: 3,831,000 gallons.
Force employed: 3 engineers.
Coal used: first-quality Cumberland, costing from $4.23 to $6.95 per ton.

Table of Approximate Quantities, Lifts and Duties at the Alewife Brook Pumping Station of the North Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1903.						
January,	159,783,000	5,154,000	3,622,000	6,931,000	12.93	24,400,000
February,	131,317,000	4,690,000	3,279,000	7,639,000	13.22	24,300,000
March,	183,689,000	5,925,000	3,622,000	7,934,000	12.87	27,800,000
April,	172,105,000	5,737,000	3,526,000	7,698,000	12.82	27,400,000
May,	105,589,000	3,406,000	2,786,000	4,085,000	13.28	20,000,000
June,	125,918,000	4,197,000	2,456,000	7,344,000	13.17	23,200,000
July,	103,663,000	3,344,000	2,550,000	5,044,000	13.30	19,200,000
August,	89,400,000	2,884,000	1,952,000	4,922,000	13.43	15,200,000
September,	73,577,000	2,453,000	1,868,000	3,380,000	13.38	16,400,000
October,	90,057,000	2,905,000	1,868,000	5,364,000	13.16	16,800,000
November,	72,488,000	2,416,000	1,868,000	3,669,000	13.17	14,300,000
December,	88,542,000	2,856,000	2,162,000	4,493,000	13.01	15,900,000
Total,	1,396,128,000	-	-	-	-	-
Average,	-	3,831,000	2,630,000	5,709,000	13.15	20,400,000

Quincy Pumping Station.

At this station are two compound condensing Deane pumping engines.

Contract capacity of pumps: one, 3,000,000 gallons, the other, 5,000,000 gallons, with 36-foot lift.
Average duty for the year: 31,300,000 foot-pounds.
Average quantity raised each day: 3,042,000 gallons.
Force employed: 3 engineers.
Coal used: first-quality Cumberland, costing from $4.75 to $5.25 per ton.

Table of Approximate Quantities, Lifts and Duties at the Quincy Pumping Station of the South Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
1903.						
January,	99,610,000	3,213,000	2,678,000	3,697,000	36.60	29,400,000
February,	89,720,000	3,205,000	2,302,000	4,360,000	37.14	27,600,000
March,	137,453,000	4,434,000	3,135,000	5,738,000	37.63	35,800,000
April,	141,959,000	4,732,000	4,088,000	5,690,000	44.81	41,400,000
May,	101,484,000	3,274,000	2,457,000	3,946,000	35.64	33,400,000
June,	87,996,000	2,933,000	2,322,000	3,824,000	35.24	33,100,000
July,	87,541,000	2,824,000	2,479,000	3,771,000	36.21	32,100,000
August,	74,932,000	2,417,000	2,242,000	2,574,000	33.72	27,300,000
September,	69,452,000	2,315,000	2,021,000	3,089,000	32.42	26,700,000
October,	74,406,000	2,400,000	2,058,000	2,779,000	34.72	29,900,000
November,	71,194,000	2,373,000	2,208,000	2,555,000	34.45	30,200,000
December,	74,064,000	2,389,000	2,225,000	3,033,000	33.33	28,600,000
Total,	1,109,811,000	-	-	-	-	-
Average,	-	3,042,000	2,518,000	3,755,000	35.99	31,300,000

In the following tables the total cost of pumping and the rate per million foot-gallons at each of the five pumping stations are shown in detail: —

Average Cost per Million Foot-gallons for Pumping at the Deer Island Station.

Volume (19,599.2 Million Gallons) × Lift (10.71 Feet) = 209,907 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$11,205 02	$0.05338
Coal,	9,972 86	.04751
Oil,	141 80	.00068
Waste,	77 44	.00037
Water,	1,258 80	.00599
Packing,	203 12	.00097
Miscellaneous supplies and renewals,	1,256 48	.00598
Totals,	$24,115 52	$0.11488

Average Cost per Million Foot-gallons for Pumping at the East Boston Station.

Volume (18,804 Million Gallons) × Lift (14.75 Feet) = 277,359 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$10,477 57	$0.03777
Coal,	11,514 37	.04151
Oil,	238 86	.00086
Waste,	42 94	.00015
Water,	856 80	.00308
Packing,	63 65	.00023
Miscellaneous supplies and renewals,	761 49	.00274
Totals,	$23,955 68	$0.08634

Average Cost per Million Foot-gallons for Pumping at the Charlestown Station.

Volume (10,903.1 Million Gallons) × Lift (7.88 Feet) = 85,916 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$10,319 61	$0.12011
Coal,	5,227 29	.06084
Oil,	203 52	.00237
Waste,	70 61	.00082
Water,	399 60	.00465
Packing,	89 29	.00104
Miscellaneous supplies and renewals,	1,454 71	.01693
Totals,	$17,764 63	$0.20676

Average Cost per Million Foot-gallons for Pumping at the Alewife Brook Station.

Volume (1,396.13 Million Gallons) × Lift (13.15 Feet) = 18,359 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$3,221 47	$0.17548
Coal,	2,239 11	.12196
Oil,	162 70	.00886
Waste,	36 02	.00196
Water,	225 06	.01225
Packing,	56 51	.00307
Miscellaneous supplies and renewals,	406 56	.02214
Totals,	$6,347 43	$0.34572

Average Cost per Million Foot-gallons for Pumping at the Quincy Station.

Volume (1,109.8 Million Gallons) × Lift (35.99 Feet) = 39,942 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$3,814 88	$0.09551
Coal,	3,155 83	.07901
Oil,	36 99	.00096
Waste,	14 19	.00035
Water,	170 94	.00428
Packing,	22 10	.00055
Miscellaneous supplies and renewals,	683 66	.01712
Totals,	$7,898 59	$0.19778

Material Intercepted at the Screens.

The sewage of the North Metropolitan District, on entering the three main line pumping stations and before reaching the pumps, is screened through cages, provided in duplicate, and raised or lowered by steam power. This intercepted material consists of rags, paper and other floating matter, and amounted to a total of about 2,840 cubic yards during the year. This is equivalent to about 2.5 cubic feet for each million gallons of sewage pumped at Deer Island.

Care of Special Structures.

At the Alewife Brook pumping station two small vertical boilers, installed at the time this plant was erected, have been taken out during the year and transferred to the Water Department. It was found more convenient and economical to introduce a single boiler of the capacity of the two. The boiler introduced is of the vertical fire-tube type, 56 inches in diameter, with 156 tubes about 96 inches in length. The boiler was built under contract with the Hodge Boiler Works of East Boston.

The exterior brick walls of the three large North Metropolitan pumping stations have been pointed and oiled during the year; at the Alewife Brook and East Boston pumping stations additional electric lighting plant has been introduced.

About 600 tons of riprap have been deposited on Deer Island Spit over the line of the outfall sewer, where the roof of the sewer had become partially denuded by changes in the surface. This riprap now forms a permanent protection of about 3 feet in thickness over the exposed parts of the discharge sewer, and restores the surface to substantially the condition found in 1893, at the date when the construction of this sewer was approved and permitted by the Massachusetts Harbor and Land Commissioners and the United States government.

Studies of sewage flow in the Metropolitan sewers, siphons and outfall pipes continue to indicate freedom from deposits and satisfactory conditions in general.

Respectfully submitted,

WILLIAM M. BROWN,
Engineer Metropolitan Sewerage Works.

BOSTON, January 1, 1904.

APPENDIX.

APPENDIX NO. 1.

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

[NOTE. — The details of contracts made before

	1. Number of Contract.	2. WORK.	3. Number of Bids.	Amount of Bid. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	166†	Excavating soil, . . .	6	$1,248,400 00	$1,096,300 00*	Nawn & Brock, . .
2	210	Excavating soil, . . .	3	377,830 00	360,870 00*	Newell & Snowling Construction Company.
3	246†	Section 3 of relocation of Central Massachusetts Railroad.	-‡	-‡	-‡	Nawn & Brock, . .
4	247†	Section 4 of relocation of Central Massachusetts Railroad.	7	51,561 00	50,772 25*	George M. Atkins & Co.,
5	257	Excavating soil, . . .	6	449,300 00	414,987 50*	Bruno, Salomone & Petitti.
6	264	Arch bridges and abutments at Oakdale, West Boylston, Mass.	8	42,470 00	37,335 00*	The George M. Atkins Company, Palmer, Mass.
7	268	Placing riprap on the westerly portion of the North Dike, Clinton and Sterling, Mass.	-‡	-‡	-‡	The McArthur Brothers Company, Chicago, Ill.
8	269†	Excavating soil and building road, West Boylston, Mass.	12	11,036 00	9,059 75*	Auguste Saucier, South Framingham, Mass.
9	270†	Steel highway bridges at Oakdale, West Boylston, Mass.	3	4,295 00	4,198 00*	Eastern Bridge and Structural Company, Boston, Mass.
10	273†	Excavating soil from Section 12 of Wachusett Reservoir, Boylston, Mass.	6	4,950 00	4,140 00*	Newell & Snowling Construction Company, Uxbridge, Mass.
		Total, ...	. .	. . .	. . .	. . . . . .

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

Appendix No. 1.

THE YEAR 1903 — WATER WORKS.

Reservoir Department.

1903 have been given in previous reports.]

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903	
June 13, '99,	Dec. 1, '02,	Dec. 2, '03,	- -	$1,014,712 74	$1,014,712 74	1
Aug. 1, '01,	Nov. 1, '04,	-	- -	360,870 00	292,787 39	2
May 6, '02,	Jan. 1, '03,	Nov. 14, '03,	- -	41,983 14	41,983 14	3
June 5, '02,	April 20, '03,	Oct. 26, '03,	- -	48,112 82	48,112 82	4
Dec. 27, '02,	Nov. 1, '05,	-	- -	414,987 50	184,269 17	5
April 16, '03,	Oct. 20, '03,	-	For earth excavation, $0.50 per cu. yd.; rock excavation, $2 per cu. yd.; Portland cement concrete, $7 and $6 per cu. yd.; stone masonry in abutments, $8 per cu. yd.; ashlar masonry, $16 per cu. yd.; dimension stone masonry, $20 per cu. yd.	38,578 22	38,528 22	6
May 16, '03,	Nov. 1, '04,	-	For riprap, $1.25 per cu. yd. of solid rock.	49,642 50	19,688 75	7
June 11, '03,	Nov. 1, '03,	Dec. 9, '03,	For earth excavation, $0.20 per cu. yd.; rock excavation, $1.75 per cu. yd.	12,384 35	12,384 35	8
June 16, '03,	Oct. 1, '03,	Dec. 22, '03,	For whole work, $4,198, .	4,198 00	4,198 00	9
Sept. 3, '03,	Dec. 1, '03,	Nov. 17, '03,	For earth excavation, $0.23 per cu. yd.	5,649 56	5,649 56	10
. . .	. . .	. . .	. . . .	$1,991,118 83	$1,662,314 14	

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	195	Wachusett Dam, . .	11	$1,680,870 00	$1,603,635 00*	McArthur Brothers Company.
2	244†	Section 1 of relocation of Central Massachusetts Railroad, ...	12	37,691 25	36,767 50*	Crary Construction Company.
3	245	Section 2 of relocation of Central Massachusetts Railroad (extension of Contract No. 195).	-‡	-‡	-‡	McArthur Brothers Company.
4	252†	Steel bridges, . . .	3	94,500 00	91,450 00*	American Bridge Company of New York.
5	263	Sluice valves for Wachusett Dam.	-‡	-‡	7,887 00	Coffin Valve Company, Boston, Mass.
6	272†	Stop-plank grooves and sills for Wachusett Dam.	3	11,275 00	9,997 00*	Coffin Valve Company, Boston, Mass.
7	274†	Rebuilding Lancaster Mills Dam, Clinton, Mass.	3	5,600 00	4,986 50*	Wm. H. Ward, Lowell, Mass.
8	275	South Dike of Wachusett Reservoir.	4	124,285 00	118,570 00*	John F. Magee & Co., Taunton, Mass.
		Total, ...	. .	. . .	. . .	. . . .

Contracts relating to the

9	238†	Excavating from Pegan Brook Meadow.	4	$42,790 00	$35,810 00*	Auguste Saucier, South Framingham, Mass.
10	6-M†	Superstructure of pumping station, Pegan filters, Natick, Mass.	4	4,460 00	4,200 00	J. J. Prindiville, South Framingham, Mass.
		Total, ...	. .	. . .	. . .	. . . .

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

YEAR 1903 — WATER WORKS — *Continued.*

Dam and Aqueduct Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
Oct. 1, '00,	Nov. 15, '04,	-	- -	$1,603,635 00	$987,308 24	1
May 26, '02,	Dec. 15, '02,	July 21, '03,	- -	40,908 81	40,908 81	2
April 18, '02,	April 18, '03,	-	- -	270,000 00	256,439 34	3
July 23, '02,	April 1, '03,	Aug. 20, '03,	- -	90,803 90	90,803 90	4
April 30, '03,	-	-	For whole work, $7,887, .	7,887 00	6,487 00	5
June 18, '03,	July 21, '03,	Oct. 1, '03,	For whole work, $9,997, .	10,012 00	10,012 00	6
Oct. 3, '03,	-	Nov. 20, '03,	For stone masonry, $6.07 per cu. yd.; earth filling above dam, $0.31 per cu. yd.	5,321 47	5,321 47	7
Dec. 26, '03,	Dec. 1, '04,	-	For grubbing, $75 per acre; soil excavation, $0.37 and $0.27 per cu. yd.; earth excavation, $0.35 and $0.25 per cu. yd.; rock excavation, $1.50 per cu. yd.; riprap, $0.85 per cu. yd.	118,570 00	-	8
. . .	. . .	. . .	. . . .	$2,147,138 18	$1,397,280 76	

Sudbury Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
May 8, '02,	Dec. 1, '02,	Jan. 10, '03,	- -	$46,460 96	$46,460 96	9
Mar. 17, '03,	June 15, '03,	Nov. 3, '03,	For whole work, $4,200, .	4,390 53	4,390 53	10
. . .	. . .	. . .	. . . .	$50,851 49	$50,851 49	

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	Amount of Bid. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	199	Section 2, Weston Aqueduct.	8	$234,581 50	$200,477 00*	Shanahan, Casparis & Co.
2	200	Section 3, Weston Aqueduct.	9	131,226 10	127,507 50*	Shanahan, Casparis & Co.
3	202†	Section 5, Weston Aqueduct.	16	139,023 00	137,526 50*	Bruno, Salomone & Petitti.
4	203	Section 6, Weston Aqueduct.	14	121,497 00	120,646 50*	Shanahan, Casparis & Co.
5	204	Section 12, Weston Aqueduct.	16	139,197 50	134,096 50*	Shanahan, Casparis & Co.
6	205	Section 13, Weston Aqueduct.	9	364,884 00	346,290 00*	Michael H. Keefe, assigned on Oct. 12, 1901, to Columbus Construction Company.
7	211	Sections 8 and 10, Weston Aqueduct.	11	155,508 50	146,139 00*	Winston & Co., . .
8	212	Section 11, Weston Aqueduct.	10	157,270 00	148,635 00*	Winston & Co., . .
9	213	Section 15, Weston Aqueduct.	5	197,556 00	171,645 00*	Winston & Co., . .
10	218	Section 14, Weston Aqueduct.	10	68,364 00	58,490 00*	Nawn & Brock, . .
11	219	Section 1 of the Weston Reservoir.	11	64,971 25	59,587 50*	Nawn & Brock, . .
12	220	Section 2 of the Weston Reservoir.	9	90,152 50	88,292 50*	Nawn & Brock, . .
13	224†	2 60-inch Venturi meters, .	-‡	-‡	-‡	Builders Iron Foundry,
14	228†	Sections 7 and 9, Weston Aqueduct.	4	147,788 00	134,990 00*	Edward Kendall & Sons,
15	250†	Section 1, Weston Aqueduct.	10	32,110 00	29,030 00*	T. H. Gill & Co., . .
16	258†	Superstructures on Weston Aqueduct.	7	29,315 00	27,352 00*	The Norcross Bros. Company.
17	259†	Superstructure of terminal chamber of the Weston Aqueduct, Weston, Mass.	5	19,922 00	19,743 00*	Connery & Wentworth, Boston, Mass.
18	267	Superstructures of channel and screen chambers of the Weston Aqueduct, Weston, Mass.	7	12,475 00*	9,150 00	Woodbury & Leighton Company, Boston, Mass.
19	271	Superstructures of head and meter chambers of the Weston Aqueduct, Southborough, Mass.	5	12,325 00	10,804 00*	C. A. Dodge & Company, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . . . .

* Contract based upon this bid. † Contract completed.
‡ Competitive bids were not received on this contract.

YEAR 1903 — WATER WORKS — *Continued.*

Weston Aqueduct Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
May 9, '01,	Aug. 1, '03,	-	- -	$201,904 54	$201,904 54	1
May 9, '01,	Aug. 1, '03,	-	- -	127,791 48	127,791 48	2
May 8, '01,	Aug. 1, '03,	Aug. 17, '03,	- -	128,226 63	128,226 63	3
May 9, '01,	Aug. 1, '03,	-	- -	116,641 31	116,641 31	4
May 9, '01,	Aug. 1, '03,	-	- -	142,021 55	142,021 55	5
May 20, '01,	Aug. 1, '03,	-	- -	417,252 64	417,252 64	6
Aug. 28, '01,	Aug. 1, '03,	-	- -	150,101 77	150,101 77	7
Aug. 28, '01,	Aug. 1, '03,	-	- -	159,892 59	159,892 59	8
Aug. 28, '01,	Aug. 1, '03,	-	- -	182,374 58	182,374 58	9
Nov. 26, '01,	Aug. 1, '03,	-	- -	58,490 00	56,600 00	10
Nov. 26, '01,	Aug. 1, '03,	-	- -	59,587 50	58,600 00	11
Nov. 26, '01,	Aug. 1, '03,	-	- -	100,000 00	93,500 00	12
Jan. 11, '02,	April 26, '02,	Oct. 30, '03,	- -	7,200 00	7,200 00	13
Mar. 8, '02,	July 1, '03,	Dec. 11, '03,	- -	135,752 56	135,752 56	14
June 19, '02,	July 1, '03,	Sept. 25, '03,	- -	34,483 39	34,483 39	15
Dec. 18, '02,	Aug. 1, '03,	Nov. 5, '03,	- -	27,352 00	27,352 00	16
Jan. 7, '03,	Sept. 1, '03,	Nov. 13, '03,	For whole work, $19,743, .	19,743 00	19,743 00	17
June 4, '03,	Oct. 1, '03,	-	For the channel chamber, $4,930; screen chamber, $7,545.	12,475 00	9,630 00	18
July 6, '03,	Oct. 1, '03,	-	For whole work, $10,804, .	10,804 00	7,580 00	19
. . .	. . .	. . .	. . . .	$2,092,094 54	$2,076,648 04	

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	216†	9,120 tons cast-iron water pipes (7,800 tons 48-inch, 1,320 tons 60-inch), 100 tons special castings.	2	48-inch pipes, $25.80 per ton; special castings, $60 per ton.	48-inch pipes, $22.87 per ton; special castings, $59 per ton.*	United States Cast Iron Pipe and Foundry Company.
2	222†	284 tons special castings,§	2	23,727 64	22,894 25*	Geo. F. Blake Manufacturing Company.
3	227†	Drain valves, sluice gates, steel work and Coffin ball-bearing gate stands,	Lot 1-2, Lot 2-3, Lot 3,‡	3,380 00 253 00 -‡	2,061 00* 220 00* -‡	Coffin Valve Company,
4	230†	250 tons special castings, .	3	19,370 00	15,500 00*	Camden Iron Works, .
5	235	Laying water pipes in Newton.	6	53,121 75	50,976 00*	D. F. O'Connell, . .
6	237†	Laying water pipes in Brighton and Newton.	7	34,430 00	28,363 00*	Thomas F. Moore, .
7	240†	Laying water pipes in Medford.	7	60,255 00	52,925 00*	Coleman Brothers, .
8	251†	Laying water pipes in Newton and Weston.	6	34,155 00	33,564 00*	Ward & Cummings, .
9	253†	42 Venturi meter tubes with registers and chart recorders.	-‡	-‡	-‡	Builders Iron Foundry,
10	262†	2 20-inch and 3 24-inch water valves.	2	1,800 00	1,620 00*	Coffin Valve Company, Boston, Mass.
11	265†	Laying water pipes in Newton.	11	27,586 75	25,513 75*	D. F. O'Connell, Boston, Mass.
12	266†	Superstructure of Bear Hill Reservoir gate-house, Stoneham, Mass.	3	3,778 00	2,750 00*	Woodbury & Leighton, Boston, Mass.
13	4-M†	2 vertical fire-tube boilers,	4	12,880 00	12,500 00*	The I. P. Morris Company.
14	5-M†	Excavating and building a trestle and coffer-dam.	-‡	-‡	-‡	Lawler Brothers, . .
15	7-M†	Steam piping at the Chestnut Hill pumping stations.	1	-	995 00*	The Lumsden & Van Stone Company, Boston, Mass.
16	Special Order.†	3 Venturi meter tubes with registers and chart recorders.	-‡	-‡	-‡	Builders Iron Foundry, Providence, R. I.

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

§ Includes pipes and castings supplied to other departments.

Year 1903 — Water Works — *Continued.*

Distribution Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
Nov. 21, '01,	Dec. 1, '02,	Feb. 20, '03,	- -	$225,495 11	$225,495 11	1
Nov. 25, '01,	Sept. 1, '02,	Feb. 3, '03,	- -	23,675 40	23,675 40	2
Jan. 24, '02,	-	Nov. 3, '03,	- -	3,841 00	3,841 00	3
Mar. 6, '02,	Dec. 1, '02,	June 11, '03,	- -	16,826 61	16,826 61	4
April 7, '02,	Dec. 1, '02,	-	- -	71,287 87	71,287 87	5
April 18, '02,	Nov. 1, '02,	July 21, '03,	- -	27,468 48	27,468 48	6
May 2, '02,	Dec. 15, '02,	June 4, '03,	- -	60,727 03	60,727 03	7
July 26, '02,	June 15, '03,	Sept. 4, '03,	- -	36,838 94	36,838 94	8
June 20, '02,	-	June 27, '03,	- -	31,120 08	31,120 08	9
Jan. 19, '03,	May 1, '03,	May 23, '03,	For 20-inch valves, $297; 24-inch valves, $342.	1,620 00	1,620 00	10
April 14, '03,	Sept. 1, '03,	Sept. 2, '03,	For laying cast-iron pipes: 48-inch, 36-inch and 20-inch, $2.25; 12-in., $1 per lin. ft.; rock excavation, $3.50 and $5 per cu. yd.; earth excavation, $1.25 per cu. yd.; setting air valves, $10; chambers for valves and blow-offs, $70 and $50; concrete masonry, $5 per cu. yd.	32,271 11	32,271 11	11
April 22, '03,	Aug. 1, '03,	Oct. 2, '03,	For whole work, $2,750, .	2,750 00	2,750 00	12
Feb. 24, '02,	June 30, '02,	Sept. 16, '03,	- -	12,470 40	12,470 40	13
Sept. 26, '02,	Dec. 1, '02,	Jan. 14, '03,	- -	3,694 39	3,694 39	14
Feb. 21, '03,	-	July 8, '03,	For whole work, $995, .	995 00	995 00	15
Feb. 14, '03,	-	June 30, '03,	For 10-inch, $648; 12-inch, $684; 30-inch, $1,251 each.	2,583 00	2,583 00	16

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	Special Order.†	4 chambers for Venturi meter registers.	-‡	-‡	-‡	Daniel Russell Boiler Works, Boston, Mass.
2	Special Order.†	26 tons special castings, .	4	1,498 80	1,319 43*	Camden Iron Works, Camden, N. J.
3	Special Order.†	Steel smoke flue at Chestnut Hill pumping station.	4	550 00	524 00*	The Hodge Boiler Works, Boston, Mass.
4	Special Order.†	Gleaner heater, . . .	-‡	-‡	-‡	I. B. Davis & Son, Boston, Mass.
5	Special Order.†	24 sets iron bands and bolts.	5	1,930 00	1,853 53*	New England Bolt and Nut Company, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . . . .

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

YEAR 1903 — WATER WORKS — *Continued.*

Distribution Department — Concluded.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
Mar. 23, '03,	-	May 29, '03,	For round chambers, $185 each; oval chambers, $230 each.	$785 00	$785 00	1
April 2, '03,	July 1, '03,	Aug. 19, '03,	For all castings, $61 per ton of 2,000 lbs.	1,636 66	1,636 66	2
April 30, '03,	May 20, '03,	June 2, '03,	For whole work, $524, . .	524 00	524 00	3
June 6, '03,	-	July 31, '03,	For heater, $523, . . .	523 00	523 00	4
Sept. 17, '03,	-	Oct. 21, '03,	For whole work, $1,853.53, .	1,853 53	1,853 53	5
. . .	. . .	. . .	. . . . . .	$558,986 61	$558,986 61	

Contracts made and pending during the Year 1903 — Water Works — *Concluded.*

Summary of Contracts.*

	Approximate Amount of Contracts.	Value of Work done December 31, 1903.
Wachusett Reservoir, 8 contracts,	$2,015,394 87	$1,568,020 18
Relocation of Central Massachusetts Railroad, 6 contracts,	496,006 67	482,446 01
Wachusett Dam, 4 contracts,	1,626,855 47	1,009,128 71
Sudbury Department, 1 contract,	46,460 96	46,460 96
Weston Aqueduct and Reservoir, 19 contracts,	2,092,094 54	2,076,648 04
Distribution Department, 12 contracts,	533,921 63	533,921 63
Total of 50 contracts made and pending during the year 1903,	$6,810,734 14	$5,716,625 53
231 contracts completed from 1896 to 1902, inclusive,	8,389,783 55	8,389,783 55
	$15,200,517 69	$14,106,409 08
Deduct for work done on 11 Sudbury Reservoir contracts by the city of Boston,	512,000 00	512,000 00
Total of 281 contracts,	$14,688,517 69	$13,594,409 08

* In this summary, contracts charged to maintenance are excluded.

Appendix No. 2.

Cement Tests — Water Works.

The following tables contain: —

1. Long-time tests of Portland cements used by the Dam and Aqueduct and Reservoir departments during the years 1896 to 1900, inclusive.

2. Tests of cements used in the construction of the Wachusett Dam and other works at the Wachusett Reservoir during the years 1901 to 1903, inclusive.

3. Tests of cements used in the construction of the Weston Aqueduct during the years 1901 to 1903, inclusive.

The methods of testing were the same as described in Appendix No. 3 of the annual report for the year 1897.

Summary of Tests of All Brands of Portland Cement, of which Nine Hundred Barrels or More were used on Construction Work by the Dam and Aqueduct and Reservoir Departments from 1896 to 1900, Inclusive.

BRAND.	Number of Barrels used.	Composition of Briquette.	Tensile Strength. Eighteen Months. Number of Briquettes.	Eighteen Months. Pounds per Square Inch.	Two Years. Number of Briquettes.	Two Years. Pounds per Square Inch.	Three Years. Number of Briquettes.	Three Years. Pounds per Square Inch.	Five Years. Number of Briquettes	Five Years. Pounds per Square Inch.
Atlas,	18,509	Neat,	65	848	80	813	64	814	32	777
		2 to 1,	65	324	80	325	64	336	32	302
Brooks-Shoobridge,	5,706	Neat,	5	674	55	702	53	696	27	679
		2 to 1,	5	521	55	447	53	449	27	453
Giant,	15,394	Neat,	55	598	55	622	45	618	24	633
		2 to 1,	55	426	55	422	45	414	24	401
Iron Clad,	7,778	Neat,	34	769	34	800	26	826	6	736
		2 to 1,	34	396	34	394	26	378	6	394
Stettin-Girstow,	979	Neat,	8	665	51	714	42	709	22	695
		2 to 1,	8	370	53	340	42	332	21	300
West Kent,	3,394	Neat,	19	586	59	589	51	570	29	562
		2 to 1,	19	522	59	434	51	424	26	391
Total,	51,760	Neat,	186	721	334	707	281	701	140	674
		2 to 1,	186	395	336	389	281	389	136	370

Summary of Tests of Cements used in the Construction of the Wachusett Dam

	Brand.	Number of Barrels used. Dam.	Railroad.	Arch Bridges and Abutments.	Totals.	Composition of Briquette.	Fineness. Per Cent. Residue on No. 50 Sieve, 2,500 Meshes to Square Inch.	Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Square Inch.	Per Cent. Residue on No. 180 Sieve, 32,400 Meshes to Square Inch.	Wire Tests. Minutes to Bear Light Wire.	Minutes to Bear Heavy Wire.
	Portland cement: —										
1	Alpha, . . .	150	341	-	491	Neat, .	.4	10.9	28.6	158	347
						2 to 1, .	-	-	-	-	316
2	Alsen, . . .	225	130	-	355	Neat, .	.4	11.2	26.4	116	291
						2 to 1, .	-	-	-	-	306
3	Atlas, . . .	3,064	699	-	3,763	Neat, .	.2	9.0	22.5	112	349
						2 to 1, .	-	-	-	-	279
4	Giant, . . .	50,581	1,932	-	52,513	Neat, .	.5	9.4	23.2	137	381
						2 to 1, .	-	-	-	-	380
5	Helderberg, . .	200	12	-	212	Neat, .	.2	5.0	19.9	173	480
						2 to 1, .	-	-	-	-	450
6	Iron Clad, . .	4,260	280	-	4,540	Neat, .	.1	4.2	17.1	86	304
						2 to 1, .	-	-	-	-	293
7	Lehigh, . .	-	984	4,368	5,352	Neat, .	.3	9.2	23.5	157	426
						2 to 1, .	-	-	-	-	414
8	Stettin-Girstow, .	-	2,200	-	2,200	Neat, .	.7	8.3	21.3	62	178
						2 to 1, .	-	-	-	-	351
9	Whitehall, . .	150	-	-	150	Neat, .	.3	8.3	27.5	180	360
						2 to 1, .	-	-	-	-	450
	Total, . .	58,630	6,578	4,368	69,576	Neat, .	.5	9.0	22.8	131	370
						2 to 1, .	-	-	-	-	370
	Natural cement: —										
10	Union, . . .	113,523	-	-	113,523	Neat, .	1.1	6.2	13.8	75	153
						1 to 1, .	-	-	-	63	125
						2 to 1, .	-	-	-	-	-

Summary of Tests of Cements used in Construction

	Brand.	Dam.	Railroad.	Arch Bridges and Abutments.	Totals.	Composition of Briquette.	No. 50 Sieve.	No. 100 Sieve.	No. 180 Sieve.	Light Wire.	Heavy Wire.
	Portland cement: —										
11	Atlas, . . .	-	-	-	91,875	Neat, .	.2	9.4	20.0	58	331
						2 to 1, .	-	-	-	-	417
12	Giant, . . .	-	-	-	7,653	Neat, .	.3	9.5	20.7	69	303
						2 to 1, .	-	-	-	-	366
13	Saylor's, . .	-	-	-	2,200	Neat, .	.2	6.2	18.0	161	479
						2 to 1, .	-	-	-	-	544
14	Lehigh, . .	-	-	-	5,160	Neat, .	.1	9.7	20.8	134	344
						2 to 1, .	-	-	-	-	515
	Total, . .	-	-	-	106,888	Neat, .	.2	9.4	20.0	65	333
						2 to 1, .	-	-	-	-	420
	Natural cement: —										
15	Hoffman, . .	-	-	-	98,347	Neat, .	1.1	6.8	-	27	61
						1 to 1, .	-	-	-	26	63
16	Union, . . .	-	-	-	14,738	Neat, .	1.0	6.8	13.1	40	90
						1 to 1, .	-	-	-	27	73
	Total, . .	-	-	-	113,085	Neat, .	1.1	6.8	-	29	65
						1 to 1, .	-	-	-	26	64

and Other Works at the Wachusett Reservoir, 1901 to 1903, Inclusive.

Tensile Strength.																		
One Day.		Seven Days.		Twenty-eight Days.		Three Months.		Six Months.		Nine Months.		One Year.		Eighteen Months.		Two Years.		
Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	
47	694	47	1,021	5	1,026	5	1,029	5	1,091	5	1,063	5	1,015	-	-	-	-	1
-	-	47	474	5	428	5	445	5	405	5	452	5	406	-	-	-	-	
31	625	32	776	15	753	5	761	5	834	5	723	5	813	-	-	-	-	2
-	-	32	373	15	433	5	413	5	447	5	380	5	393	-	-	-	-	
197	574	196	837	157	851	20	801	20	848	20	823	15	884	-	-	-	-	3
-	-	197	383	157	447	20	444	20	445	20	459	15	433	-	-	-	-	
3,286	605	3,226	876	3,009	911	210	863	190	904	170	883	145	883	110	911	100	872	4
-	-	3,290	406	3,012	446	210	456	190	452	170	439	140	439	110	392	100	400	
23	383	23	843	23	933	5	906	5	881	5	872	5	897	-	-	-	-	5
-	-	23	301	23	409	5	377	5	380	5	402	5	386	-	-	-	-	
222	652	218	700	221	712	25	714	25	788	25	769	25	807	10	894	-	-	6
-	-	218	403	222	451	25	474	25	486	25	497	25	488	10	542	-	-	
359	577	358	894	90	961	15	875	5	906	5	960	5	899	-	-	-	-	7
-	-	358	385	90	418	15	443	5	435	5	441	5	420	-	-	-	-	
252	377	251	475	251	538	15	597	15	664	15	692	-	-	-	-	-	-	8
-	-	250	281	252	378	15	448	15	496	15	486	-	-	-	-	-	-	
20	736	20	946	13	970	-	-	-	-	-	-	-	-	-	-	-	-	9
-	-	20	434	13	478	-	-	-	-	-	-	-	-	-	-	-	-	
4,437	591	4,371	845	3,784	873	300	835	270	877	250	857	205	876	120	909	100	872	
-	-	4,435	396	3,789	441	300	453	270	454	250	447	200	441	120	405	100	400	
4,534	171	4,529	223	2,073	297	250	360	225	406	-	-	160	438	-	-	65	483	10
-	-	4,529	181	2,065	275	250	419	225	496	-	-	160	553	-	-	65	645	
-	-	846	107	813	185	190	262	145	370	-	-	100	414	-	-	-	-	

of the Weston Aqueduct, 1901 to 1903, Inclusive.

4,356	423	4,346	664	2,266	718	490	745	275	757	-	-	160	751	83	748	26	835	11
-	-	4,169	284	3,141	401	523	470	288	445	-	-	172	397	85	402	43	399	
430	420	431	659	228	707	98	762	82	764	-	-	66	759	15	834	7	888	12
-	-	405	323	268	402	102	482	89	476	-	-	91	449	15	401	10	405	
127	214	130	719	104	792	73	780	85	830	-	-	65	822	5	933	-	-	13
-	-	127	269	103	398	67	410	78	397	-	-	61	350	-	-	-	-	
207	374	210	639	169	730	64	744	49	765	-	-	39	771	5	833	-	-	14
-	-	208	314	166	455	68	491	49	490	-	-	40	436	5	435	-	-	
5,120	415	5,117	664	2,767	721	725	750	491	772	-	-	330	769	108	773	33	847	
-	-	4,909	288	3,678	403	760	468	504	448	-	-	364	406	105	403	53	400	
4,485	138	4,474	164	2,569	253	220	320	159	355	-	-	170	353	69	380	39	361	15
-	-	4,415	128	2,586	242	217	335	168	383	-	-	131	347	75	338	38	325	
832	157	833	205	409	269	63	312	52	356	-	-	32	394	25	402	15	404	16
-	-	833	174	431	246	69	345	51	395	-	-	30	467	20	501	15	541	
5,317	141	5,307	170	2,978	255	283	318	211	355	-	-	202	360	94	386	54	373	
-	-	5,248	136	3,017	242	286	338	219	386	-	-	161	369	95	371	53	386	

Appendix No. 3.

Table No. 1. — *Monthly Rainfall in Inches at Various Places on the Metropolitan Water Works, in 1903.*

	Place.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Wachusett Watershed.	Princeton,	2.63	4.41	6.52	3.09	1.74	10.08	3.95	4.30	3.20	4.78	2.60	3.71	51.01
	Jefferson,	2.84	4.20	6.85	2.95	1.27	9.01	3.07	3.89	3.24	3.83	2.52	4.27	47.94
	Sterling,	2.66	4.39	6.37	3.05	0.97	10.56	3.27	3.34	2.62	4.38	2.16	3.84	47.61
	Boylston,	3.27	4.67	6.58	3.29	0.99	11.83	3.43	4.00	2.66	4.72	2.17	4.13	51.74
Sudbury Watershed.	Sudbury Dam,	3.65	3.85	6.37	2.87	0.95	10.41	2.69	3.44	1.89	4.84	1.50	2.84	45.30
	Framingham,	3.77	3.91	6.34	2.94	1.15	8.55	2.55	3.60	1.49	4.42	1.48	3.05	43.25
	Ashland Dam,	3.83	4.02	6.58	2.91	0.67	8.05	2.86	3.69	1.46	4.78	1.62	3.19	43.66
	Cordaville,	3.96	4.02	7.25	3.24	0.94	9.98	2.96	3.96	2.17	4.85	1.63	3.46	48.42
	Lake Cochituate,	3.81	3.88	6.30	3.17	1.56	7.61	3.00	4.20	1.31	4.27	1.53	3.18	43.82
	Chestnut Hill Reservoir,	3.95	4.60	6.62	4.33	0.79	8.14	3.54	4.01	2.96	4.87	1.53	3.01	48.35
	Spot Pond,	3.78	4.58	6.38	4.67	0.33	9.16	3.32	3.44	1.44	3.84	1.40	3.18	45.52
	Average of all,	3.47	4.23	6.56	3.32	1.03	9.40	3.15	3.80	2.22	4.51	1.83	3.44	46.96
	Average, Wachusett watershed,	2.85	4.42	6.58	3.10	1.24	10.37	3.43	3.88	2.93	4.43	2.36	3.99	49.58
	Average, Sudbury watershed,	3.80	3.95	6.63	2.99	0.93	9.25	2.77	3.67	1.75	4.72	1.56	3.14	45.16

Table No. 2. — *Rainfall in Inches at Jefferson, Mass., in 1903.*

Day of Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	-	-	-	-	-	-	-	-	-	-	-	-
2,	*	0.18†	-	*	-	-	-	-	-	0.08†	-	*
3,	0.50†	-	-	0.34†	-	-	-	-	-	-	-	0.67‡
4,	-	0.93†	-	0.15‖	0.09†	-	-	*	-	-	-	-
5,	-	-	0.19†	-	0.03†	-	*	*	0.16†	0.17†	0.42†	-
6,	0.15‡	-	-	-	-	-	0.23†	*	-	-	0.09‡	-
7,	0.10‡	-	*	*	0.40†	*	-	1.80†	-	*	-	-
8,	-	0.45‖	*	*	-	*	-	-	-	*	-	-
9,	-	-	*	1.58†	-	0.38†	-	-	-	*	-	0.70§
10,	-	-	2.07†	0.06†	-	0.07†	-	-	-	*	-	-
11,	0.45‖	*	0.75†	-	-	*	-	-	-	*	-	-
12,	-	0.42†	-	-	-	*	0.21†	-	-	2.50†	-	-
13,	-	-	-	-	-	2.75†	-	-	-	-	-	0.82§
14,	-	-	-	*	0.35†	*	0.04†	0.04†	-	-	-	-
15,	-	*	-	*	-	*	-	-	-	-	-	-
16,	-	0.52‡	-	*	-	2.34†	-	0.03†	2.12†	-	*	-
17,	-	1.00‡	-	0.82†	-	-	-	-	0.42†	*	1.84§	-
18,	-	-	-	-	-	0.14†	*	-	-	0.83†	-	-
19,	-	-	-	-	-	-	1.21†	-	-	-	-	-
20,	-	-	-	-	-	*	0.41†	0.22†	-	-	-	1.45†
21,	0.95§	-	*	-	-	*	-	-	-	-	-	*
22,	-	-	*	-	-	3.01†	0.22†	-	-	-	-	0.15‡
23,	-	-	*	-	-	-	-	-	-	0.25†	0.17†	-
24,	-	-	2.44†	-	-	-	-	-	-	-	-	0.06†
25,	0.14‡	-	-	-	-	0.08†	-	*	-	-	-	-
26,	-	-	-	-	-	-	-	0.95†	-	-	-	0.25‡
27,	-	-	-	-	-	-	-	-	0.54†	-	-	-
28,	0.05†	0.70†	0.20‖	-	0.38†	-	-	-	-	-	-	-
29,	-	-	-	-	-	0.20†	0.72†	*	-	-	-	0.17‡
30,	0.50†	-	*	-	0.02†	0.04†	0.03†	0.85†	-	-	-	-
31,	-	-	1.20†	-	-	-	-	-	-	-	-	-
Total,	2.84	4.20	6.85	2.95	1.27	9.01	3.07	3.89	3.24	3.83	2.52	4.27

Total for the year, 47.94 inches.

* Rainfall included in that of following day. † Rain. ‡ Snow.
§ Rain and snow. ‖ Rain, snow and hail.

Table No. 3. — *Rainfall in Inches at Framingham, Mass., in 1903.*

Day of Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	–	–	–	–	–	–	0.02†	–	–	0.16†	–	–
2,	*	0.15†	–	*	–	–	–	–	–	0.09†	–	*
3,	0.87†	–	–	0.16†	–	–	–	–	–	–	–	0.34‡
4,	–	0.89†	–	0.31†	0.02†	–	–	*	–	–	–	–
5,	–	–	0.14†	–	*	–	*	*	0.76†	0.11†	0.20†	–
6,	0.26‡	–	–	*	0.19†	–	0.25†	*	–	–	0.07‡	–
7,	0.09‡	–	–	*	0.13†	*	–	1.80†	–	*	–	–
8,	–	0.35§	*	1.59†	–	0.05†	–	–	–	0.18†	–	–
9,	–	–	*	*	–	0.54†	–	0.01†	–	*	–	0.78†
10,	–	–	1.49†	0.11†	–	0.64†	–	–	–	0.37†	–	–
11,	0.64§	0.41†	0.43†	–	–	*	–	0.01†	–	*	0.02†	–
12,	–	–	–	–	–	*	*	–	–	1.67	–	*
13,	–	–	–	–	–	1.60†	0.19†	–	–	–	–	0.39†
14,	–	–	–	–	*	–	0.07†	–	–	–	–	–
15,	–	*	–	*	0.44†	*	0.12†	–	–	–	–	–
16,	–	0.54‡	0.03§	0.75†	–	2.02†	–	0.09†	0.20†	–	*	–
17,	–	1.13‡	–	0.02†	–	0.02†	–	0.02†	0.15†	*	1.11§	–
18,	–	–	–	–	–	–	*	–	–	1.70†	–	–
19,	–	–	–	–	0.08†	–	0.96†	*	–	–	–	–
20,	*	–	–	–	–	*	*	0.37†	–	–	–	0.95†
21,	1.27†	–	*	–	–	*	0.61†	–	–	–	–	0.06§
22,	–	–	0.58†	–	–	2.90†	–	–	–	–	–	–
23,	–	–	*	–	–	*	0.02†	–	–	0.14†	0.08†	–
24,	–	–	2.29†	–	–	0.36†	–	–	–	–	–	–
25,	0.13‡	–	–	–	–	–	–	*	–	–	–	–
26,	–	–	–	–	–	–	0.01†	0.79†	–	–	–	0.43‡
27,	–	*	*	–	–	–	–	–	0.38†	–	–	–
28,	0.04†	0.44†	0.13†	–	0.27†	–	–	*	–	–	–	–
29,	*	–	–	–	–	0.36†	0.26†	0.19†	–	–	–	0.10‡
30,	0.47†	–	*	–	0.02†	0.06†	0.04†	*	–	–	–	–
31,	–	–	1.25†	–	–	–	–	0.32†	–	–	–	–
Total,	3.77	3.91	6.34	2.94	1.15	8.55	2.55	3.60	1.49	4.42	1.48	3.05

Total for the year, 43.25 inches.

* Rainfall included in that of following day. † Rain. ‡ Snow.
§ Rain and snow.

TABLE No. 4. — *Rainfall in Inches at Chestnut Hill Reservoir in 1903.*

DATE.	Amount.	Snow or Rain.	Duration.
Jan. 2,	0.94	Rain.	11.00 P.M. to
Jan. 3,			10.30 A.M.
Jan. 6,	0.39	Rain and snow.	7.00 A.M. to 8.30 P.M.
Jan. 7,	0.08	Snow.	1.30 P.M. to 8.30 P.M.
Jan. 11,	0.61	Snow and rain.	2.00 P.M. to 9.45 P.M.
Jan. 21,	1.11	Rain.	1.00 A.M. to 2.30 P.M.
Jan. 25,	0.25	Snow.	12.30 A.M. to 5.30 P.M.
Jan. 28,	0.08	Rain.	6.30 A.M. to 2.30 P.M.
Jan. 30,	0.49	Rain.	6.00 A.M. to 1.45 P.M.
Total,	3.95		
Feb. 2,	0.21	Rain.	3.00 P.M. to 8.00 P.M.
Feb. 4,	0.80	Rain.	5.30 A.M. to
Feb. 5,			4.15 A.M.
Feb. 8,	0.38	Snow and rain.	11.00 A.M. to 8.15 P.M.
Feb. 11,	0.43	Rain.	3.00 P.M. to 11.45 P.M.
Feb. 15,			11.30 P.M.
Feb. 16,	2.37	Snow.	to
Feb. 17,			3.00 P.M.
Feb. 28,	0.41	Rain.	2.00 A.M. to 4.30 P.M.
Total,	4.60		
Mar. 5,	0.20	Rain.	11.45 A.M. to 6.30 P.M.
Mar. 7,			9.30 P.M.
Mar. 8,	1.79	Rain.	to
Mar. 9,			
Mar. 10,			7.00 A.M.
Mar. 10,	0.52	Rain.	10.30 P.M. to
Mar. 11,			2.00 P.M.
Mar. 21,			1.00 A.M.
Mar. 22,	2.52	Rain.	to
Mar. 23,			
Mar. 24,			7.00 A.M.
Mar. 28,	0.09	Snow.	8.45 P.M. to
Mar. 29,			2.30 A.M.
Mar. 30,	1.50	Rain.	7.15 P.M. to
Mar. 31,			7.30 A.M.
Total,	6.62		
Apr. 2,	0.15	Rain.	9.15 P.M. to
Apr. 3,			7.30 A.M.
Apr. 4,	0.33	Rain.	11.50 A.M. to 6.30 P.M.
Apr. 6,			11.40 A.M.
Apr. 7,	1.77	Rain.	to
Apr. 8,			11.30 P.M.
Apr. 9,	0.22	Rain.	9.45 P.M. to
Apr. 10,			7.00 A.M.
Apr. 15,			3.00 A.M.
Apr. 16,	1.86	Rain.	to
Apr. 17,			7.00 A.M.
Total,	4.33		
May 4,	0.08	Rain.	6.00 A.M. to 8.30 A.M.
May 5,	0.17	Rain.	Showers during day.
May 14,	0.11	Rain.	8.15 P.M. to
May 15,			5.50 A.M.
May 19,	0.31	Rain.	3.30 P.M. to 4.30 P.M.
May 28,	0.12	Rain.	11.30 A.M. to 12.45 P.M.
Total,	0.79		

DATE.	Amount.	Snow or Rain.	Duration.
June 8,	0.55	Rain.	Showers during day.
June 11,			8.45 A.M.
June 12,	1.21	Rain.	to
June 13,			7.00 A.M.
June 15,	2.78	Rain.	6.10 A.M. to
June 16,			7.00 A.M.
June 20,			6.00 P.M.
June 21,	2.83	Rain.	to
June 22,			7.00 A.M.
June 24,	0.58	Rain.	4.00 A.M. to
June 25,			7.00 A.M.
June 29,	0.19	Rain.	6.20 P.M. to 9.30 P.M.
Total,	8.14		
July 1,	0.44	Rain.*	2.30 P.M. to 3.00 P.M.
July 6,	0.42	Rain.	10.30 A.M. to 11.45 A.M.
July 12,	0.04	Rain.	7.15 P.M. to
July 13,			7.00 A.M.
July 18,	1.41	Rain.	5.45 P.M. to
July 19,			6.30 P.M.
July 21,	0.32	Rain.	7.30 A.M. to 3.00 P.M.
July 22,	0.30	Rain.	6.15 P.M. to 8.00 P.M.
July 23,	0.29	Rain.	1.30 P.M. to 2.20 P.M.
July 26,	0.03	Rain.	Showers.
July 29,	0.20	Rain.	8.45 P.M. to 10.30 P.M.
July 30,	0.09	Rain.	7.30 P.M. to 10.30 P.M.
Total,	3.54		
Aug. 4,			2.30 P.M.
Aug. 5,	1.61	Rain.	to
Aug. 6,			7.00 A.M.
Aug. 6,	0.29	Rain.	6.00 P.M. to
Aug. 7,			9.30 A.M.
Aug. 16,	0.20	Rain.	6.30 P.M. to 10.30 P.M.
Aug. 20,	0.05	Rain.	4.00 A.M. to 7.00 A.M.
Aug. 20,	0.07	Rain.	2.00 P.M. to 3.00 P.M.
Aug. 25,	0.50	Rain.	8.00 A.M. to 12.30 P.M.
Aug. 25,	0.20	Rain.	5.30 P.M. to 9.00 P.M.
Aug. 28,	0.24	Rain.	11.50 P.M. to
Aug. 29,			10.30 A.M.
Aug. 30,	0.85	Rain.	9.00 A.M. to
Aug. 31,			7.00 A.M.
Total,	4.01		
Sept. 5,	1.25	Rain.	3.00 P.M. to 11.00 P.M.
Sept. 16,	0.31	Rain.	8.00 P.M. to 11.30 P.M.
Sept. 17,	0.35	Rain.	5.00 P.M. to 10.00 P.M.
Sept. 27,	1.05	Rain.	7.45 P.M. to 11.30 P.M.
Total,	2.96		
Oct. 2,	0.16	Rain.	1.30 A.M. to 4.30 A.M.
Oct. 5,	0.26	Rain.	2.30 P.M. to 5.10 P.M.
Oct. 7,	0.25	Rain.	8.00 P.M. to
Oct. 8,			5.30 A.M.
Oct. 8,	0.33	Rain.	9.55 P.M. to
Oct. 9,			5.15 A.M.
Oct. 10,	0.01	Rain.	Showers during day.
Oct. 11,	0.59	Rain.	9.00 A.M. to
Oct. 12,			7.00 A.M.
Oct. 13,	1.87	Rain.	9.00 A.M. to 11.30 P.M.
Oct. 17,	1.32	Rain.	1.10 P.M. to
Oct. 18,			5.30 A.M.
Oct. 18,	0.08	Rain.	11.50 A.M. to 1.30 P.M.
Total,	4.87		

* Thunder shower.

TABLE NO. 4. — *Rainfall in Inches at Chestnut Hill Reservoir in 1903* — Concluded.

DATE.	Amount.	Snow or Rain.	Duration.	DATE.	Amount.	Snow or Rain.	Duration.
Nov. 5,	0.28	Rain.	7.45 A.M. to 6.00 P.M.	Dec. 2,	0.15	Snow.	7.45 A.M. to
Nov. 6,	0.08	Snow.	6.45 A.M. to 10.00 P.M.	Dec. 3,			3.30 P.M.
Nov. 11,	0.02	Rain.	10.30 P.M. to	Dec. 9,	1.00	Rain.	4.25 P.M. to
Nov. 12,			4.45 A.M.	Dec. 10,			4.05 A.M.
Nov. 16,	1.03	Snow and rain.	9.30 A.M. to	Dec. 13,	0.59	Rain.	3.50 A.M. to 1.45 P.M.
Nov. 17,			11.00 P.M.	Dec. 20,	0.78	Rain.	5.00 A.M. to 9.00 P.M.
Nov. 22,	0.03	Snow.	11.30 A.M. to 3.30 P.M.	Dec. 22,	0.06	Rain and snow.	1.55 A.M. to 6.30 A.M.
Nov. 23,	0.09	Rain.	4.15 P.M. to 9.30 P.M.				
				Dec. 26,	0.31	Snow.	6.50 A.M. to 3.30 P.M.
				Dec. 29,	0.12	Snow.	12.45 P.M. to 7.45 P.M.
Total,	1.53			Total,	3.01		

Total for the year, 48.35 inches.

TABLE NO. 5. — *Rainfall in Inches on the Wachusett Watershed,* 1897 to 1903.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1897, ...	3.46	2.86	4.01	2.32	5.06	5.11	8.65	3.47	1.93	0.94	7.62	6.41	51.84
1898, ...	6.65	3.30	2.27	4.43	3.38	3.11	3.01	10.61	3.15	7.21	6.81	3.99	57.92
1899, ...	2.93	5.12	6.75	1.94	1.33	5.51	3.82	3.20	4.11	2.72	1.94	2.03	41.40
1900, ...	4.56	8.69	6.19	2.76	4.34	3.59	3.20	3.18	3.46	2.90	6.44	3.15	52.46
1901, ...	1.75	1.13	5.82	9.64	7.02	1.51	5.66	4.58	3.10	3.70	2.43	9.36	55.70
1902, ...	2.72	4.91	5.27	4.36	2.24	2.51	3.87	3.95	4.26	6.36	0.93	7.20	48.58
1903, ...	2.85	4.42	6.58	3.10	1.24	10.37	3.43	3.88	2.93	4.43	2.36	3.99	49.58
Total, ...	24.92	30.43	36.89	28.55	24.61	31.71	31.64	32.87	22.94	28.26	28.53	36.13	357.48
Average, ...	3.56	4.35	5.27	4.08	3.51	4.53	4.52	4.70	3.28	4.04	4.07	5.16	51.07

* Called in previous reports Nashua watershed (South Branch). The figures tabulated are means of observations at four places, as follows: January, 1897, to December, 1900, Princeton, Jefferson, Sterling and South Clinton; January, 1901, to December, 1903, Princeton, Jefferson, Sterling and Boylston.

TABLE NO. 6. — *Rainfall in Inches on the Sudbury Watershed,* 1875 to 1903.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1875,	2.42	3.15	3.74	3.23	3.56	6.24	3.57	5.53	3.43	4.85	4.83	0.94	45.49
1876,	1.83	4.21	7.43	4.20	2.76	2.04	9.13	1.72	4.62	2.24	5.76	3.62	49.56
1877,	3.22	0.74	8.36	3.43	3.70	2.43	2.95	3.68	0.32	8.52	5.80	0.87	44.02
1878,	5.63	5.97	4.69	5.79	0.96	3.88	2.97	6.94	1.29	6.42	7.02	6.37	57.93
1879,	2.48	3.56	5.14	4.72	1.58	3.79	3.93	6.51	1.88	0.81	2.68	4.34	41.42
1880,	3.57	3.98	3.31	3.11	1.84	2.14	6.27	4.01	1.60	3.74	1.78	2.83	38.18
1881,	5.56	4.65	5.73	2.00	3.51	5.39	2.35	1.36	2.62	2.95	4.09	3.96	44.17
1882,	5.95	4.55	2.65	1.82	5.07	1.66	1.77	1.67	8.74	2.07	1.15	2.30	39.40
1883,	2.81	3.87	1.78	1.84	4.19	2.40	2.68	0.73	1.52	5.60	1.81	3.55	32.78
1884,	5.09	6.54	4.72	4.41	3.47	3.44	3.67	4.65	0.85	2.48	2.65	5.17	47.14
1885,	4.71	3.87	1.07	3.60	3.48	2.87	1.43	7.18	1.43	5.09	6.09	2.72	43.54
1886,	6.36	6.28	3.61	2.22	3.00	1.47	3.27	4.10	2.90	3.24	4.64	4.97	46.06
1887,	5.20	4.78	4.90	4.27	1.16	2.65	3.76	5.28	1.32	2.83	2.67	3.88	42.70
1888,	4.15	3.68	6.02	2.43	4.82	2.54	1.41	6.22	8.59	4.99	7.22	5.40	57.47
1889,	5.37	1.65	2.37	3.41	2.95	2.80	8.94	4.18	4.60	4.25	6.29	3.14	49.95
1890,	2.53	3.51	7.73	2.64	5.21	2.03	2.46	3.87	6.00	10.51	1.20	5.31	53.00
1891,	7.02	5.23	6.48	3.91	2.01	3.77	3.39	4.73	2.38	3.83	3.09	3.68	49.52
1892,	5.85	3.14	4.06	0.83	5.58	2.76	4.23	4.44	2.84	1.17	5.80	1.13	41.83
1893,	2.92	8.20	3.67	3.60	6.61	2.38	2.57	5.41	1.74	4.07	2.20	4.86	48.23
1894,	4.09	3.91	1.43	3.42	4.24	1.15	3.26	2.03	2.63	5.34	3.43	4.81	39.74
1895,	4.06	1.39	2.98	5.25	2.02	2.77	5.04	4.15	2.30	10.68	6.63	3.35	50.62
1896,	2.39	7.18	5.24	1.57	2.57	3.22	2.51	2.40	7.72	3.76	3.02	2.12	43.70
1897,	4.00	2.91	3.66	2.82	4.37	4.46	5.44	3.51	2.94	0.47	6.40	5.21	46.19
1898,	6.83	4.49	2.40	4.66	3.22	2.48	4.09	8.17	2.62	6.71	6.93	3.28	55.88
1899,	4.18	4.91	7.01	1.90	1.45	2.51	3.22	1.43	3.95	2.69	2.18	1.78	37.21
1900,	4.96	9.14	6.35	2.58	4.32	2.99	2.42	2.26	3.36	3.83	5.70	2.74	50.65
1901,	1.82	1.52	6.57	8.60	7.23	1.38	5.71	4.57	3.30	2.82	2.90	9.69	56.11
1902,	2.52	6.18	5.34	4.13	1.86	2.89	2.94	3.40	4.54	4.44	1.45	6.38	46.07
1903,	3.80	3.95	6.63	2.99	0.93	9.25	2.77	3.67	1.75	4.72	1.56	3.14	45.16
Total,	121.32	127.14	135.07	99.38	97.67	89.78	108.15	117.80	93.78	125.12	116.97	111.54	1,343.72
Average,	4.18	4.39	4.66	3.43	3.37	3.10	3.73	4.06	3.23	4.31	4.03	3.85	46.34

* Means of observations at several places, as follows: January, 1875, to April, 1876, Lake Cochituate; April to June, 1876, Lake Cochituate, Westborough and Hopkinton; June to December, 1876, Lake Cochituate, Southborough, Marlborough, Westborough and Hopkinton; December, 1876, to January, 1883, Framingham, Southborough, Marlborough, Westborough and Hopkinton; January, 1883, to January, 1884, Framingham and Southborough; January, 1884, to January, 1890, Framingham and Westborough; January, 1890, to May, 1898, Framingham and Ashland Dam; June, 1898, to December, 1903, Framingham, Ashland Dam, Cordaville and Sudbury Dam.

TABLE NO. 7. — *Yield of the Wachusett Watershed* in Gallons per Day per Square Mile† from 1897 to 1903.*

MONTHS.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Mean for 7 Years, 1897-1903.
January,	796,000	1,563,000	2,092,000	796,000	519,000	1,676,000	1,265,000	1,244,000
February,	931,000	1,635,000	1,090,000	4,054,000	356,000	1,401,000	2,133,000	1,657,000
March,	2,760,000	3,088,000	2,776,000	3,722,000	2,718,000	3,992,000	3,423,000	3,212,000
April,	1,632,000	2,027,000	3,376,000	1,580,000	4,986,000	2,159,000	2,238,000	2,571,000
May,	1,163,000	1,390,000	862,000	1,382,000	2,729,000	1,031,000	569,000	1,304,000
June,	1,181,000	828,000	561,000	578,000	985,000	410,000	2,131,000	954,000
July,	1,442,000	333,000	354,000	217,000	477,000	292,000	624,000	534,000
August,	896,000	1,325,000	236,000	197,000	512,000	297,000	474,000	562,000
September,	380,000	676,000	250,000	127,000	320,000	241,000	375,000	338,000
October,	243,000	1,509,000	245,000	282,000	647,000	950,000	689,000	652,000
November,	1,283,000	2,170,000	430,000	875,000	517,000	635,000	634,000	935,000
December,	2,275,000	2,061,000	359,000	1,570,000	3,234,000	1,848,000	954,000	1,758,000
Average for year,	1,253,000	1,551,000	1,051,000	1,264,000	1,507,000	1,248,000	1,285,000	1,308,000
Average for driest 6 months,	886,000	1,013,000	312,000	377,000	576,000	471,000	626,000	661,000

* Called in previous reports Nashua watershed (South Branch).

† The area of the watershed used in making up these records included water surfaces amounting to 2.2 per cent. of the whole area from 1897 to 1902, inclusive, and to 2.4 per cent. in 1903.

Table No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1903.*

Months.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.
January,	103,000	643,000	658,000	1,810,000	700,000	1,120,000	415,000	1,241,000	335,000	995,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000	1,033,000	2,842,000
March,	1,604,000	4,435,000	4,814,000	3,507,000	2,330,000	1,374,000	4,004,000	2,839,000	1,611,000	3,785,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,169,000	1,546,000	867,000	1,350,000	2,853,000
May,	1,188,000	1,138,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000	937,000	1,030,000
June,	870,000	222,000	597,000	506,000	413,000	175,000	1,338,000	529,000	300,000	416,000
July,	321,000	183,000	202,000	128,000	157,000	176,000	276,000	86,000	115,000	224,000
August,	396,000	405,000	121,000	476,000	395,000	119,000	148,000	55,000	79,000	257,000
September,	207,000	184,000	60,000	161,000	141,000	80,000	197,000	307,000	91,000	44,000
October,	646,000	234,000	631,000	516,000	71,000	102,000	186,000	299,000	186,000	83,000
November,	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000	209,000	205,000	175,000
December,	584,000	453,000	1,290,000	3,177,000	463,000	175,000	775,000	315,000	194,000	925,000
Average for year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000	862,000	533,000	1,129,000
Average for driest 6 months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000	145,000	200,000

* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1903* — Continued.

MONTHS.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
January,	1,235,000	1,461,000	2,589,000	1,053,000	2,782,000	1,254,000	3,018,000	1,870,000	434,000	693,000
February,	1,354,000	4,801,000	2,829,000	1,950,000	1,196,000	1,529,000	3,486,000	943,000	1,542,000	991,000
March,	1,572,000	2,059,000	2,868,000	3,238,000	1,338,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000
April,	1,815,000	1,947,000	2,620,000	2,645,000	1,410,000	1,875,000	2,397,000	871,000	2,125,000	1,640,000
May,	1,336,000	720,000	1,009,000	1,632,000	880,000	1,366,000	583,000	1,259,000	2,883,000	840,000
June,	426,000	203,000	413,000	421,000	653,000	568,000	413,000	428,000	440,000	419,000
July,	62,000	116,000	115,000	117,000	634,000	107,000	149,000	214,000	158,000	161,000
August,	240,000	94,000	214,000	379,000	1,432,000	132,000	163,000	280,000	181,000	209,000
September,	121,000	117,000	111,000	1,155,000	823,000	457,000	203,000	229,000	108,000	150,000
October,	336,000	146,000	190,000	1,999,000	1,230,000	2,272,000	210,000	126,000	222,000	374,000
November,	1,177,000	673,000	369,000	2,758,000	1,941,000	1,215,000	305,000	697,000	319,000	836,000
December,	1,174,000	1,020,000	643,000	3,043,000	2,241,000	996,000	544,000	485,000	796,000	716,000
Average for year,	901,000	1,087,000	1,154,000	1,697,000	1,383,000	1,285,000	1,315,000	781,000	1,037,000	770,000
Average for driest 6 months,	391,000	223,000	234,000	953,000	944,000	747,000	239,000	327,000	237,000	356,000

* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE NO. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1903* — Concluded.

MONTHS.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Mean for 29 Years, 1875-1903.
January,	1,034,000	1,084,000	845,000	1,638,000	2,288,000	794,000	437,000	1,763,000	1,736,000	1,242,000
February,	541,000	2,676,000	1,067,000	3,022,000	1,381,000	3,800,000	300,000	1,674,000	2,279,000	1,896,000
March,	2,410,000	3,835,000	2,565,000	2,604,000	4,205,000	3,654,000	2,755,000	4,199,000	3,454,000	2,987,000
April,	2,515,000	1,494,000	1,515,000	1,829,000	2,521,000	1,350,000	4,204,000	1,885,000	2,261,000	2,076,000
May,	636,000	360,000	915,000	1,246,000	511,000	1,312,000	2,954,000	743,000	351,000	1,121,000
June,	174,000	399,000	962,000	530,000	66,000	316,000	753,000	303,000	1,987,000	526,000
July,	231,000	95,000	658,000	231,000	19,000	—18,000	306,000	66,000	445,000	198,000
August,	229,000	57,000	591,000	1,107,000	—35,000	—34,000	424,000	135,000	307,000	295,000
September,	89,000	388,000	182,000	369,000	94,000	65,000	305,000	178,000	130,000	233,000
October,	1,379,000	592,000	94,000	1,160,000	115,000	186,000	412,000	506,000	492,000	517,000
November,	2,777,000	659,000	909,000	1,986,000	304,000	663,000	474,000	444,000	363,000	889,000
December,	1,782,000	657,000	1,584,000	1,799,000	220,000	1,096,000	2,695,000	1,779,000	582,000	1,111,000
Average for year,	1,152,000	1,019,000	991,000	1,450,000	973,000	1,082,000	1,342,000	1,140,000	1,190,000	1,086,000
Average for driest 6 months,	460,000	314,000	564,000	777,000	93,000	194,000	445,000	271,000	388,000	441,000

* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE NO. 9. — *Wachusett System.* — Statistics of Flow of Water, Storage and Rainfall in 1903.*

[Watershed = 119.00 square miles.]

MONTHS.	Quantity of Water discharged through Wachusett Aqueduct (Gallons per Day).†	Quantity of Water wasted into River below Dam (Gallons per Day).	STORAGE.‡ Gain (Gallons per Day).	STORAGE.‡ Loss (Gallons per Day).	Total Yield of Watershed (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
January,	98,819,000	50,332,000	1,394,000	-	150,545,000	2.85	2.256	79.2
February,	73,979,000	181,650,000	-	1,829,000	253,800,000	4.42	3.436	77.8
March,	53,242,000	351,461,000	2,681,000	-	407,384,000	6.58	6.107	92.8
April,	38,983,000	225,837,000	1,560,000	-	266,380,000	3.10	3.864	124.8
May,	66,422,000	2,894,000	-	1,600,000	67,716,000	1.24	1.015	81.7
June,	53,487,000	151,280,000	48,786,000	-	253,553,000	10.37	3.678	35.5
July,	95,477,000	2,981,000	-	24,174,000	74,284,000	3.43	1.114	32.5
August,	70,093,000	20,513,000	-	34,171,000	56,435,000	3.88	0.846	21.8
September,	46,970,000	2,050,000	-	4,417,000	44,603,000	2.93	0.647	22.1
October,	75,071,000	2,635,000	4,229,000	-	81,935,000	4.43	1.228	27.7
November,	72,217,000	3,563,000	-	313,000	75,467,000	2.36	1.095	46.4
December,	58,919,000	3,971,000	50,665,000	-	113,555,000	3.99	1.702	42.7
Total,	-	-	-	-	-	49.58	26.988	-
Average for year,	67,070,000	82,319,000	3,526,000	-	152,915,000	-	-	54.4

* The corresponding data for previous years have been tabulated in former reports under the head of *Nashua River*.

† Including small quantities wasted in cleaning aqueduct.

‡ Aggregate storage in Wachusett Reservoir and in ponds and mill reservoirs.

TABLE NO. 10. — *Sudbury System. — Statistics of Flow of Water, Storage and Rainfall in 1903.*

[Watershed from 1875 to 1878 inclusive = 77.764 square miles; in 1879 and 1880 = 78.238 square miles; and from 1881 to 1903 inclusive = 75.2 square miles.]

MONTHS.	Quantity of Water received through Wachusett Aqueduct (Gallons per Day).*	Quantity of Water discharged through Sudbury Aqueduct (Gallons per Day).†	Quantity of Water discharged through Weston Aqueduct (Gallons per Day).‡	Quantity of Water used by Framingham Water Company (Gallons per Day).	Quantity of Water diverted from Watershed by Sewers, etc. (Gallons per Day).	Quantity of Water wasted into River below Lowest Dam (Gallons per Day).	STORAGE. Gain (Gallons per Day).	STORAGE. Loss (Gallons per Day).	Total Yield of Watershed (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
January, . .	98,819,000	105,639,000	-	464,000	1,616,000	80,032,000	41,584,000	-	130,516,000	3.80	3.096	81.4
February, . .	73,979,000	103,904,000	-	461,000	1,621,000	140,961,000	-	1,589,000	171,379,000	3.95	3.672	93.0
March, . .	53,242,000	96,052,000	-	461,000	2,442,000	163,310,000	50,703,000	-	259,726,000	6.63	6.161	92.9
April, . . .	38,983,000	85,907,000	-	453,000	2,110,000	117,790,000	2,720,000	-	169,997,000	2.99	3.903	130.5
May, . . .	66,422,000	103,361,000	-	555,000	822,000	1,410,000	-	13,368,000	26,358,000	0.93	0.625	67.4
June, . . .	53,487,000	93,780,000	-	547,000	1,680,000	88,173,000	18,760,000	-	149,453,000	9.25	3.431	37.1
July, . . .	95,477,000	101,274,000	-	603,000	955,000	28,910,000	-	2,979,000	33,468,000	2.77	0.794	28.7
August, . .	70,093,000	102,858,000	-	568,000	490,000	20,006,000	-	30,752,000	23,077,000	3.67	0.547	14.9
September, .	46,970,000	97,450,000	303,000	597,000	443,000	5,923,000	-	47,953,000	9,793,000	1.75	0.225	12.8
October, . .	75,071,000	86,861,000	307,000	581,000	677,000	16,545,000	7,074,000	-	36,974,000	4.72	0.877	18.6
November, . .	71,940,000	100,750,000	-	520,000	600,000	22,023,000	-	24,673,000	27,280,000	1.56	0.626	40.2
December, . .	57,687,000	99,878,000	14,448,000	474,000	694,000	26,619,000	-	40,639,000	43,787,000	3.14	1.038	33.1
Total, . .	-	-	-	-	-	-	-	-	-	45.16	24.995	-
Av. for year,	66,943,000	98,136,000	1,278,000	524,000	1,175,000	58,647,000	-	3,323,000	89,494,000	-	-	55.4

* Not including quantities of water wasted in cleaning aqueduct, which were not discharged into Sudbury Reservoir.

† Including quantities of water wasted in cleaning aqueduct.

‡ Including quantities of water wasted in cleaning aqueduct, and in flushing and filling Weston Reservoir.

TABLE No. 11. — *Cochituate System. — Statistics of Flow of Water, Storage and Rainfall in 1903.*

[Watershed of lake = 18.87 square miles.*]

MONTH.	Quantity of Water received from External Sources (Gallons per Day)	Quantity of Water discharged through Cochituate Aqueduct (Gallons per Day).	Quantity of Water diverted from Watershed by Sewers, etc. (Gallons per Day).	Quantity of Water wasted at Outlet (Gallons per Day).	STORAGE. Gain (Gallons per Day).	STORAGE. Loss (Gallons per Day).	Total Yield of Watershed (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
January,	-	16,813,000	978,000	-	8,848,000	-	26,639,000	3.81	2.52	66.1
February,	-	16,939,000	818,000	-	15,589,000	-	33,346,000	3.88	2.85	73.4
March,	-	10,984,000	1,413,000	18,642,000	21,532,000	-	52,571,000	6.30	4.97	78.9
April,	-	16,570,000	1,483,000	20,170,000	-	346,000	37,877,000	3.17	3.46	109.3
May,	-	11,703,000	532,000	-	-	3,832,000	8,403,000	1.56	0.79	50.9
June,	1,503,000†	8,386,000	610,000	15,243,000	3,267,000	-	26,003,000	7.61	2.38	31.3
July,	-	5,158,000	480,000	1,110,000	-	-	6,748,000	3.00	0.64	21.3
August,	-	-	274,000	5,287,000	-	587,000	4,974,000	4.20	0.47	11.2
September,	-	8,283,000	213,000	803,000	-	7,716,000	1,583,000	1.31	0.14	11.1
October,	-	18,145,000	339,000	-	-	7,678,000	10,806,000	4.27	1.02	23.9
November,	-	4,960,000	353,000	-	1,204,000	-	6,517,000	1.53	0.60	39.0
December,	-	10,477,000	410,000	-	-	948,000	9,939,000	3.18	0.94	29.6
Total,	-	-	-	-	-	-	-	43.82	20.78	-
Average for year,	123,000†	10,663,000	657,000	5,103,000	2,373,000	-	18,673,000	-	-	47.4

* Not including the watershed of Dudley Pond.

† From Dudley Pond.

Table No. 12. — *Elevations of Water Surfaces of Reservoirs above Boston City Base at the Beginning of Each Month.*

Date.	Chestnut Hill Reservoir. Ordinary High Water=134.00.		Lake Cochituate. High Water =144.36.	Dudley Pond. High Water =156.46.	Farm Pond. High Water =159.25.	Spot Pond. High Water =163.00.	Framingham Reservoir			Ashland Reservoir. Flash Boards 225.23.	Sudbury Reservoir. Flash Boards 259.97.	Hopkinton Reservoir. Flash Boards 305.00.	Whitehall Reservoir. Ordinary High Water =337.91.	Wachusett Reservoir.
	Bradlee Basin.	Lawrence Basin.					No. 1. Flash Boards 169.27.	No 2. Flash Boards 177.12.	No. 3. Flash Boards 186.50.					
Jan. 1, 1903,	133.23	133.31	138.28	152.77	158.72	162.74	167.93	176.17	184.28	221.32	255.05	301.88	338.07	290.11
Feb. 1, 1903,	132.97	133.07	139.67	153.33	159.02	162.63	168.13	176.30	185.53	223.94	257.60	303.78	337.44	291.30
March 1, 1903,	132.93	133.00	141.72	153.90	158.90	163.27	168.58	176.67	185.72	222.75	257.87	302.19	337.24	290.12
April 1, 1903,	134.34	134.52	144.52	154.77	159.39	163.01	168.57	176.47	186.11	224.77	260.08	304.26	339.11	290.32
May 1, 1903,	133.85	134.05	144.48	155.18	159.48	162.87	168.10	177.66	184.94	225.26	260.15	304.97	339.31	292.56
June 1, 1903,	133.96	134.33	144.02	154.83	159.05	163.22	165.09	177.28	184.30	225.54	259.61	305.21	339.25	295.30
July 1, 1903,	134.19	134.57	144.40	153.68	159.39	162.96	169.53	177.00	186.20	225.24	260.15	305.01	339.37	305.03
Aug. 1, 1903,	133.70	134.13	144.40	153.64	158.98	163.19	169.39	177.11	186.04	225.43	260.04	305.08	339.28	301.20
Sept. 1, 1903,	133.55	133.66	144.33	153.49	158.85	163.03	169.34	176.98	184.30	225.08	258.25	304.80	339.20	293.10
Oct. 1, 1903,	132.41	132.69	143.41	153.11	158.51	162.82	169.29	177.12	184.20	224.99	255.04	304.72	338.65	293.09
Nov. 1, 1903,	132.67	132.75	142.39	153.06	158.51	162.90	167.71	177.19	184.06	224.78	255.83	304.51	338.70	293.22
Dec. 1, 1903,	133.86	133.88	142.55	152.92	158.42	162.82	167.70	175.96	183.69	224.64	254.48	304.73	338.07	294.35
Jan. 1, 1904,	133.17	133.21	142.42	153.05	158.59	162.26	167.70	175.97	183.37	220.90	252.63	299.84	337.89	305.90

TABLE No. 13. — *Average Daily Quantity of Water flowing through Aqueducts in 1903, by Months.**

MONTH.	Wachusett Aqueduct (Gallons).	Weston Aqueduct (Gallons).	SUDBURY AQUEDUCT. From Framingham Reservoir No. 3 (Gallons).	SUDBURY AQUEDUCT. From Framingham Reservoirs Nos. 1 and 2 (Gallons).	SUDBURY AQUEDUCT. Total (Gallons).	Cochituate Aqueduct (Gallons).
January,	98,819,000	-	105,639,000	-	105,639,000	16,813,000
February,	73,979,000	-	103,904,000	-	103,904,000	16,939,000
March,	53,242,000	-	96,052,000	-	96,052,000	10,984,000
April,	38,983,000	-	84,517,000	-	84,517,000	16,177,000
May,	66,422,000	-	82,210,000	21,151,000	103,361,000	11,571,000
June,	53,487,000	-	82,783,000	10,997,000	93,780,000	8,386,000
July,	95,477,000	-	101,274,000	-	101,274,000	5,158,000
August,	70,093,000	-	101,890,000	968,000	102,858,000	-
September,	46,970,000	-	93,163,000	4,287,000	97,450,000	8,283,000
October,	75,071,000	-	78,735,000	8,126,000	86,861,000	18,145,000
November,	71,940,000	-	100,750,000	-	100,750,000	4,960,000
December,	57,687,000	2,461,000	81,968,000	17,910,000	99,878,000	10,477,000
Average,	66,943,000	209,000	92,675,000	5,346,000	98,021,000	10,619,000

* Not including quantities wasted in cleaning and flushing aqueducts, etc.

TABLE No. 14. — *Statement of Operations of Engines Nos. 1 and 2 at Chestnut Hill High-service Pumping Station for the Year 1903.*

Allowed for slip: { Engine No. 1, High service, 13.36 per cent. Engine No 1, Low service, 6.66 per cent. Engine No. 2, High service, 3.81 per cent. }

MONTH.	Engine No. 1. Total Pumping Time. Hrs.	Min.	Engine No. 1. Amount pumped, corrected for Slip (Million Gallons).	Engine No. 2. Total Pumping Time. Hrs.	Min.	Engine No. 2. Amount pumped, corrected for Slip (Million Gallons).	Total Amount pumped (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting; corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	171	15	72.78	-	-	-	72.78	111,138	13,567	12.2	654.86	120.12	65,530,000	75,730,000
February,	105	25	45.18	-	-	-	45.18	71,083	8,728	12.3	635.60	120.47	63,780,000	73,710,000
March,	268	45	115.47	-	-	-	115.47	183,968	22,278	12.1	627.66	120.12	62,800,000	72,580,000
April,	18	25	7.44	-	-	-	7.44	11,842	1,245	10.5	628.27	119.80	62,700,000	72,460,000
May,	105	35	42.10	-	-	-	42.10	65,133	7,655	11.8	646.37	120.75	65,010,000	75,130,000
June,	61	35	25.40	-	-	-	25.40	40,186	4,737	11.8	632.06	120.78	63,590,000	73,490,000
July,	538	25	196.53	2	20	.81	197.34	329,584	40,765	12.4	601.29	120.24	60,230,000	69,610,000
August,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
September,	17	05	6.47	-	-	-	6.47	10,673	1,110	10.4	606.20	120.96	61,080,000	70,590,000
September (low service),	62	55	27.51	-	-	-	27.51	22,253	2,390	10.7	1,236.23	44.03	45,340,000	48,510,000
October,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
November,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
December,	45	15	16.25	-	-	-	16.25	26,917	2,634	9.8	603.71	119.76	60,230,000	69,610,000
Total and average, high service,	1,331	45	527.62	2	20	.81	528.43	850,524	102,719	12.1	621.30	120.28	62,250,000	71,940,000
Total and average, low service,	62	55	27.51	-	-	-	27.51	22,253	2,390	10.7	1,236.23	44.03	45,340,000	48,510,000

During July, the water pumped by Engine No. 2 and 720,000 gallons of the water pumped by Engine No. 1 were diverted to low service during test for slip. The work of Engine No. 2 does not enter into the other calculations for the month.

TABLE No. 15. — *Statement of Operations of Engine No. 3 at Chestnut Hill High-service Pumping Station for the Year 1903.*

[7.5 per cent. allowed for slip.]

Month.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, corrected for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting; corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	-	-	-	-	-	-	-	-	-	-
February,	-	-	-	-	-	-	-	-	-	-
March,	267	40	252.63	250,183	31,407	12.6	1,009.78	127.34	107,110,000	115,730,000
April,	10	15	9.68	9,402	1,010	10.7	1,029.57	124.67	106,920,000	115,530,000
May,	-	-	-	-	-	-	-	-	-	-
June,	-	-	-	-	-	-	-	-	-	-
July,	551	40	505.67	483,072	69,476	14.4	1,046.77	129.04	112,520,000	121,580,000
August,	-	-	-	-	-	-	-	-	-	-
September,	4	10	3.96	3,812	400	10.5	1,038.82	126.55	109,510,000	118,330,000
October,	-	-	-	-	-	-	-	-	-	-
November,	-	-	-	-	-	-	-	-	-	-
December,	4	40	4.24	3,684	375	10.2	1,149.58	121.19	116,050,000	125,390,000
Total and average,	838	25	776.18	750,153	102,668	13.7	1,034.70	128.38	110,650,000	119,560,000

Table No. 16. — *Statement of Operations of Engine No. 4 at Chestnut Hill High-service Pumping Station for the Year 1903.*

[2 per cent. allowed for slip.]

Month.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, corrected for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per. Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting; corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.	Summary for Engines Nos. 1, 2, 3 and 4. Total Amount pumped, corrected for Slip (Million Gallons).	Summary for Engines Nos. 1, 2, 3 and 4. Daily Average Amount pumped (Million Gallons).
January,	744	00	944.30	792,652	95,102	12.0	1,191.32	128.14	127,160,000	129,730,000	1,017.08	32.809
February,	668	50	844.15	761,331	111,459	14.6	1,108.78	128.79	118,950,000	121,350,000	889.33	31.762
March,	476	55	583.21	513,924	70,008	13.6	1,134.82	128.72	121,680,000	124,140,000	951.31	30.687
April,	709	35	858.01	724,987	91,061	12.6	1,183.48	128.04	126,230,000	128,780,000	875.13	29.171
May,	744	00	934.37	793,993	94,713	11.9	1,176.80	125.25	122,780,000	125,260,000	976.47	31.499
June,	720	00	882.96	771,534	105,589	13.7	1,144.42	128.33	122,340,000	124,810,000	908.36	30.279
July,	191	15	223.65	185,309	22,901	12.4	1,206.90	128.85	129,540,000	132,160,000	926.66	29.893
August,	741	10	867.31	711,889	82,504	11.6	1,218.32	127.39	129,280,000	131,890,000	867.31	27.978
September,	715	50	869.81	735,949	90,255	12.3	1,181.89	129.09	127,090,000	129,660,000	907.75	30.258
October,	744	00	887.11	769,618	116,840	15.2	1,152.66	129.09	123,950,000	126,450,000	887.11	28.616
November,	720	00	839.65	649,049	64,479	9.9	1,293.66	125.23	134,950,000	137,680,000	839.65	27.988
December,	740	00	896.80	767,123	75,155	9.8	1,169.04	125.98	122,680,000	125,160,000	917.29	29.590
Total and average,	7,915	35	9,631.33	8,177,358	1,020,066	12.5	1,177.80	127.63	125,220,000	127,750,000	10,963.45	30.037

TABLE NO. 17. — *Statement of Operations of Engines Nos. 5, 6 and 7 at Chestnut Hill Low-service Pumping Station for the Year 1903.*

Allowed for slip: 6 per cent., January to April, inclusive; 8 per cent., May to August, inclusive (Defective valves.); 3 per cent., remainder of year.

MONTH.	Engine No. 5. Total Pumping Time. Hrs.	Engine No. 5. Total Pumping Time. Min.	Engine No. 5. Amount pumped, corrected for Slip (Million Gallons).	Engine No. 6. Total Pumping Time. Hrs.	Engine No. 6. Total Pumping Time. Min.	Engine No. 6. Amount pumped, corrected for Slip (Million Gallons).	Engine No. 7. Total Pumping Time. Hrs.	Engine No. 7. Total Pumping Time. Min.	Engine No. 7. Amount pumped, corrected for Slip (Million Gallons).	Total Amount pumped (Million Gallons).	Daily Average Amount pumped (Million Gallons).	Total Amount of Coal consumed (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet). Engine No. 5.	Average Lift (Feet). Engine No. 6.	Average Lift (Feet). Engine No. 7.	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting; corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	743	00	869.27	744	00	871.23	737	55	976.48	2,716.98	87.645	842,166	10.1	3,226.18	49.53	49.08	23.37	107,450,000	114,240,000
February,	665	10	789.01	670	45	797.79	672	00	884.96	2,471.76	88.277	826,565	11.9	2,990.40	49.47	48.78	23.49	99,510,000	105,800,000
March,	599	50	672.47	634	15	715.13	739	00	921.54	2,309.14	74.488	684,250	11.3	3,374.70	42.32	41.15	23.82	97,190,000	103,330,000
April,	555	10	643.44	540	20	619.29	709	10	897.62	2,160.35	72.012	619,543	10.0	3,487.01	42.88	42.93	23.00	100,600,000	106,960,000
May,	626	30	754.48	614	30	735.02	736	35	947.10	2,436.60	78.600	809,465	10.7	3,010.14	50.50	50.40	22.97	99,720,000	108,360,000
June,	532	20	619.39	535	55	617.58	707	30	845.86	2,082.83	69.428	643,195	14.2	3,238.26	44.91	44.30	22.94	96,590,000	104,950,000
July,	605	25	717.98	605	20	723.09	734	20	901.18	2,342.25	75.556	721,358	12.1	3,247.00	48.78	48.52	23.39	105,300,000	114,420,000
August,	590	45	715.01	555	50	650.62	707	00	882.95	2,248.58	72.535	665,295	10.0	3,379.82	47.26	44.85	23.61	104,950,000	114,040,000
September,	554	25	705.26	486	50	595.71	683	25	897.86	2,198.83	73.294	652,133	10.8	3,371.75	46.64	45.55	24.20	104,430,000	107,620,000
October,	571	10	690.27	514	20	611.39	724	25	925.50	2,227.16	71.844	690,133	11.5	3,227.15	46.20	46.69	24.67	100,510,000	103,580,000
November,	523	55	634.36	526	35	633.90	720	00	904.39	2,172.65	72.422	636,890	9.5	3,411.34	47.30	47.23	22.99	105,600,000	108,820,000
December,	600	00	748.55	615	50	763.19	687	05	894.36	2,406.10	77.616	770,556	12.1	3,122.55	49.83	49.44	23.71	104,040,000	107,210,000
Total and average,	7,167	40	8,559.49	7,044	30	8,333.94	8,558	25	10,879.80	27,773.23	76.091	8,561,549	11.2	3,243.95	47.31	46.76	23.52	102,210,000	108,380,000

TABLE NO. 18. — *Statement of Operations of Engines Nos. 8 and 9 at Spot Pond Pumping Station for the Year 1903.*

[Engine No. 8, 2.02 per cent. allowed for slip.]

Month.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, corrected for Slip. (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
February,	3	30	1.56	1,245	-	-	1,253.01	128.37	133,990,000	136,750,000
April,	90	00	39.16	37,854	4,978	13.2	1,034.50	118.88	102,440,000	104,550,000
May,	314	00	138.10	128,693	12,965	10.1	1,073.10	119.48	106,800,000	109,000,000
Total and average,	407	30	178.82	167,792	17,943	10.7	1,065.72	119.43	106,020,000	108,200,000

[Engine No. 9, 1.63 per cent. allowed for slip.]

Month.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, corrected for Slip. (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
January,	295	15	242.71	220,635	29,331	13.3	1,100.05	127.86	117,160,000	119,100,000
February,	256	50	208.96	182,561	23,495	12.9	1,144.60	127.47	121,540,000	123,560,000
March,	274	10	208.94	177,562	24,463	13.8	1,176.72	126.26	123,760,000	125,810,000
April,	243	00	173.13	140,267	18,114	12.9	1,234.29	124.60	128,110,000	130,240,000
May,	167	50	130.90	94,017	8,796	9.4	1,392.30	126.22	146,390,000	148,820,000
June,	307	10	239.71	191,671	35,365	18.5	1,250.63	126.95	132,250,000	134,450,000
July,	334	05	259.48	212,053	35,256	16.6	1,223.66	127.06	129,510,000	131,660,000
August,	300	35	247.10	214,718	38,659	18.0	1,150.81	129.86	124,490,000	126,560,000
September,	283	10	231.90	200,149	36,052	18.0	1,158.64	129.29	124,780,000	126,850,000
October,	260	30	213.79	188,935	32,142	17.0	1,131.55	129.55	122,110,000	124,140,000
November,	241	35	197.80	185,406	27,748	15.0	1,066.85	129.85	115,400,000	117,320,000
December,	263	10	215.59	202,613	29,218	14.4	1,064.05	129.75	115,000,000	116,910,000
Total and average,	3,227	20	2,570.01	2,210,587	338,639	15.3	1,162.59	128.00	123,960,000	126,020,000

TABLE No. 19. — *Average Daily Consumption of Water during the Year 1903, in the Cities and Towns supplied wholly or in Part by the Metropolitan Water Works, including Boston, Somerville, Chelsea, Malden, Everett, Quincy, Medford, Melrose, Revere, Watertown, Arlington, Lexington, Milton, Stoneham, Winthrop, Swampscott, Belmont, Nahant and a Small Portion of Saugus. (For Consumption of Water in Whole Metropolitan Water District see Table No. 23.)*

MONTH.	Supplied by Metropolitan Works (Million Gallons).	Supplied from Local Sources (Million Gallons).*	Total (Million Gallons).	Estimated Population.	Consumption per Inhabitant (Gallons).
January,	122.086	.164	122.250	890,300	137
February,	119.623	.099	119.722	892,200	134
March,	108.307	.662	108.969	894,100	122
April,	103.366	.764	104.130	895,900	116
May,	107.958	.013	107.971	897,800	120
June,	102.197	.008	102.205	899,600	114
July,	104.209	–	104.209	901,500	116
August,	100.510	–	100.510	903,300	111
September,	103.543	–	103.543	905,100	114
October,	100.555	–	100.555	907,000	111
November,	100.571	–	100.571	908,800	111
December,	111.774	–	111.774	910,600	123
For the year,	107.006	.142	107.148	900,500	119

* The city of Medford used 44,530,000 gallons from Wright's Pond from February 25 to April 28, and the town of Lexington pumped 7,410,000 gallons from local sources from January 1 to June 9.

TABLE No. 20. — *Average Daily Consumption of Water from the Low Service (1903).*

MONTH.	Southern Low Service of Boston excluding East Boston and Charlestown (Million Gallons).	Somerville, Chelsea, Everett, Malden, Medford, Charlestown, East Boston and Arlington.			Total Low-service Consumption (Million Gallons).
		Supplied from Metropolitan Sources (Million Gallons).	Gravity Supply to Medford from Wright's Pond (Million Gallons).	Total Northern Low-service Consumption (Million Gallons).	
January,	50.912	30.242	–	30.242	81.154
February,	49.040	30.851	.075	30.926	79.966
March,	44.610	25.953	.651	26.604	71.214
April,	42.512	24.201	.742	24.943	67.455
May,	42.355	24.752	–	24.752	67.107
June,	40.628	22.675	–	22.675	63.303
July,	40.881	24.530	–	24.530	65.411
August,	40.603	23.516	–	23.516	64.119
September,	41.759	24.156	–	24.156	65.915
October,	41.746	22.827	–	22.827	64.573
November,	42.374	23.188	–	23.188	65.562
December,	47.586	27.209	–	27.209	74.795
For the year,	43.728	25.316	.122	25.438	69.166

Table No. 21. — *Average Daily Consumption of Water, in Million Gallons, from the Southern High-service and the Southern Extra High-service Works, supplying Quincy, Watertown, Belmont, Milton and the Higher Portions of Boston (1903).*

Month.	Southern High Service. Pumped at Chestnut Hill High-service Station.	Southern Extra High Service. Pumped at Chestnut Hill High-service Station and again at West Roxbury.
January,	32.400	.389
February,	31.408	.388
March,	30.254	.377
April,	28.810	.381
May,	30.972	.527
June,	29.714	.475
July,	29.435	.434
August,	27.554	.404
September,	28.897	.456
October,	28.193	.418
November,	27.582	.406
December,	29.188	.402
For the year,	29.527	.422

Table No. 22. — *Average Daily Consumption of Water, in Million Gallons, from the Northern High Service, supplying Revere, Winthrop, Swampscott, Nahant, Stoneham, Melrose and a small portion of Saugus, and the Higher Portions of Breed's Island, Chelsea, Everett, Malden, Medford and Somerville, and from the Northern Extra High Service supplying Lexington and the Higher Portion of Arlington (1903).*

Month.	Northern High Service. Pumped at Spot Pond Station.	Northern Extra High Service.		
		Pumped at Arlington Station.	Pumped at Lexington.*	Total.
January,	7.859	.284	.164	.448
February,	7.501	.435	.024	.459
March,	6.701	.412	.011	.423
April,	7.054	.408	.022	.430
May,	8.692	.660	.013	.673
June,	8.054	.651	.008	.659
July,	8.334	.595	-	.595
August,	7.894	.539	-	.539
September,	7.715	.560	-	.560
October,	6.912	.459	-	.459
November,	6.616	.405	-	.405
December,	6.987	.402	-	.402
For the year,	7.529	.484	.020	.504

* A portion of the supply of the town of Lexington was pumped from local sources till June 9.

Table No. 23. — *Consumption of Water in the Metropolitan Water District, as constituted December 31, 1903, the Town of Swampscott and a Small Section of the Town of Saugus; 1893–1903.*

[Gallons per Day.]

Month.	1893.	1894.	1895.	1896.	1897.	1898.
January,	75,209,000	67,506,000	68,925,000	82,946,000	85,366,000	83,880,000
February,	71,900,000	68,944,000	80,375,000	87,021,000	83,967,000	87,475,000
March,	67,638,000	62,710,000	69,543,000	86,111,000	82,751,000	85,468,000
April,	62,309,000	57,715,000	62,909,000	77,529,000	79,914,000	76,574,000
May,	61,025,000	60,676,000	65,194,000	73,402,000	76,772,000	76,677,000
June,	63,374,000	68,329,000	69,905,000	77,639,000	77,952,000	83,463,000
July,	69,343,000	73,642,000	69,667,000	80,000,000	85,525,000	88,228,000
August,	66,983,000	67,995,000	72,233,000	78,537,000	84,103,000	87,558,000
September,	64,654,000	67,137,000	73,724,000	74,160,000	84,296,000	88,296,000
October,	63,770,000	62,735,000	67,028,000	71,762,000	79,551,000	81,770,000
November,	61,204,000	62,231,000	64,881,000	71,933,000	72,762,000	78,177,000
December,	66,700,000	65,108,000	70,443,000	79,449,000	76,594,000	86,355,000
Average for the year,	66,165,000	65,382,000	69,499,000	78,360,000	80,793,000	83,651,000
Population,	723,153	743,354	763,557	786,385	809,213	832,042
Consumption per inhabitant,	91.5	88.0	91.0	99.7	99.8	100.5

Month.	1899.	1900.	1901.	1902.	1903.
January,	96,442,000	100,055,000	111,275,000	118,435,000	125,176,000
February,	103,454,000	98,945,000	117,497,000	117,268,000	122,728,000
March,	90,200,000	97,753,000	105,509,000	108,461,000	111,977,000
April,	86,491,000	89,497,000	93,317,000	103,153,000	107,179,000
May,	89,448,000	87,780,000	95,567,000	106,692,000	111,589,000
June,	97,691,000	98,581,000	103,420,000	110,002,000	105,590,000
July,	96,821,000	107,786,000	106,905,000	108,340,000	107,562,000
August,	92,072,000	102,717,000	102,815,000	107,045,000	103,570,000
September,	91,478,000	103,612,000	102,103,000	107,752,000	106,772,000
October,	89,580,000	98,358,000	103,389,000	106,560,000	103,602,000
November,	86,719,000	93,648,000	101,324,000	105,175,000	103,477,000
December,	85,840,000	97,844,000	113,268,000	125,434,000	114,721,000
Average for the year,	92,111,000	98,059,000	104,645,000	110,345,000	110,277,000
Population,	854,870	877,698	903,000	928,300	953,600
Consumption per inhabitant,	107.8	111.7	115.9	118.9	115.6

This table includes the water consumed in the cities and towns enumerated in Table No. 19, together with the water consumed in Newton and Hyde Park, which are included in the Metropolitan Water District but have not been supplied from the Metropolitan Works.

Note relating to Chemical Examinations of Water, Tables Nos. 24–30.

The chemical examinations contained in the tables were made by the State Board of Health. Colors have been determined by the Nessler standard, but the corresponding values by the platinum standard are also given, for the purpose of comparison with colors determined in the laboratory of the Metropolitan Water and Sewerage Board, as given in subsequent tables. The odor recorded is taken in such a way that it is a much stronger odor than would be noticed in samples drawn directly from a tap or collected directly from a reservoir. The more important samples are collected and examined monthly; those of less significance, at intervals of two or three months.

TABLE NO. 24. — *Chemical Examinations of Water from the Wachusett Reservoir, Clinton.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
				Color.							Albuminoid.							
		Turbidity.	Sediment.	Nessler Standard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1903.																	
43675	Jan. 5	V. slight.	V. slight.	.36	37	Faintly vegetable.	Distinctly vegetable.	3.00	1.10	.0014	.0144	.0118	.0026	.18	.0070	.0000	.48	0.8
44046	Feb. 2	V. slight.	V. slight.	.33	35	None.	None.	3.15	1.50	.0014	.0156	.0148	.0008	.18	.0100	.0000	.47	0.5
44382	March 2	Decided.	Cons.	.36	37	None.	Faintly unpleasant.	2.65	1.10	.0028	.0200	.0160	.0040	.15	.0040	.0000	.50	0.5
44779	March 30	V. slight.	V. slight.	.32	34	None.	Faintly vegetable.	2.75	1.10	.0020	.0124	.0094	.0030	.16	.0080	.0000	.40	0.8
45196	May 4	V. slight.	Slight.	.28	32	None.	Faintly vegetable.	3.35	1.40	.0022	.0156	.0136	.0020	.19	.0050	.0001	.34	1.0
45618	June 1	V. slight.	Cons.	.24	29	Faintly vegetable.	Faintly vegetable.	3.40	1.25	.0010	.0140	.0102	.0038	.21	.0020	.0001	.40	1.0
46124	July 6	V. slight.	Slight.	.43	41	V. faintly unpleasant.	V. faintly unpleasant.	3.25	1.60	.0022	.0204	.0166	.0038	.16	.0000	.0002	.56	0.6
46591	Aug. 3	Decided.	Cons.	.31	34	Faintly vegetable.	Faintly vegetable.	3.50	1.25	.0016	.0172	.0152	.0020	.19	.0030	.0001	.46	1.0
47022	Aug. 31	Decided.	Cons.	.23	28	None.	None.	3.70	1.10	.0028	.0150	.0128	.0022	.23	.0050	.0000	.41	0.8
47458	Oct. 5	Slight.	Slight.	.34	35	Faintly unpleasant.	Faintly unpleasant.	4.00	1.70	.0028	.0138	.0112	.0026	.28	.0050	.0000	.42	1.0
47934	Nov. 2	Slight.	Slight.	.42	40	V. faintly unpleasant.	Faintly unpleasant.	3.75	1.40	.0026	.0154	.0140	.0014	.32	.0050	.0002	.44	0.8
48302	Nov. 30	V. slight.	V. slight.	.37	37	Faintly vegetable.	Distinctly vegetable.	4.05	1.75	.0018	.0156	.0138	.0018	.33	.0080	.0001	.50	1.3
Av.	....	....	....	.33	35	....	....	3.38	1.35	.0020	.0158	.0133	.0025	.21	.0052	.0001	.45	0.8

TABLE NO. 25. — *Chemical Examinations of Water from Framingham Reservoir No. 3.*

[Parts per 100,000]

Number.	Date of Collection.	Appearance.		Appearance: Color.		Odor.		Residue on Evaporation.		Ammonia.	Ammonia: Albuminoid.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Nessler Standard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1903.																	
43660	Jan. 5	V. slight.	V. slight.	.30	33	Distinctly vegetable.	Distinctly vegetable.	4.65	1.85	.0054	.0144	.0126	.0018	.32	.0100	.0000	.46	1.7
44012	Feb. 2	Slight.	Cons.	.35	36	V. faintly unpleasant.	V. faintly unpleasant.	4.35	1.45	.0052	.0132	.0128	.0004	.31	.0180	.0001	.50	1.1
44377	March 2	V. slight.	Slight.	.30	33	None.	None.	3.90	1.45	.0038	.0110	.0094	.0016	.27	.0240	.0001	.46	1.1
44771	March 30	V. slight.	Slight.	.27	31	None.	V. faintly vegetable.	3.35	1.10	.0020	.0140	.0106	.0034	.23	.0160	.0000	.35	1.3
45186	May 4	V. slight.	Slight.	.21	27	None.	Faintly vegetable.	3.55	1.05	.0018	.0156	.0114	.0042	.22	.0190	.0002	.34	1.1
45612	June 1	V. slight.	Slight.	.21	27	None.	Faintly vegetable.	4.15	1.25	.0018	.0122	.0104	.0018	.25	.0140	.0002	.38	1.4
46112	July 6	Slight.	Slight.	.23	28	Faintly vegetable.	Faintly vegetable.	3.90	1.55	.0020	.0120	.0104	.0016	.26	.0080	.0002	.42	1.1
46594	Aug. 3	V. slight.	Slight.	.24	29	Faintly vegetable.	Distinctly unpleasant	3.95	1.30	.0016	.0152	.0134	.0018	.25	.0070	.0002	.43	1.6
46989	Aug. 31	V. slight.	Slight.	.22	27	None.	None.	3.40	1.15	.0030	.0142	.0126	.0016	.23	.0040	.0000	.32	1.1
47433	Oct. 5	V. slight.	Slight.	.19	26	Faintly vegetable.	Distinctly vegetable and faintly unpleas.	3.20	1.30	.0006	.0150	.0124	.0026	.24	.0020	.0000	.34	1.3
47905	Nov. 2	V. slight.	Slight.	.21	27	V. faintly vegetable.	Faintly vegetable.	3.75	1.35	.0018	.0158	.0130	.0028	.28	.0030	.0000	.31	1.4
48290	Nov. 30	Slight.	Cons.	.26	30	V. faintly vegetable.	Faintly vegetable.	4.05	1.35	.0032	.0130	.0110	.0020	.30	.0050	.0000	.37	1.7
Av.	…	…	…	.25	29	…	…	3.85	1.35	.0027	.0138	.0117	.0021	.26	.0108	.0001	.39	1.3

TABLE NO. 26. — *Chemical Examinations of Water from Lake Cochituate.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.		Color.		Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
											Albuminoid.							
		Turbidity.	Sediment.	Nessler Standard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1903.																	
43668	Jan. 5	V. slight.	V. slight.	.29	32	Faintly vegetable.	Decidedly unpleasant.	5.00	2.00	.0046	.0144	.0134	.0010	.51	.0060	.0001	.44	2.2
44013	Feb. 2	V. slight.	V. slight.	.29	32	None.	Faintly vegetable.	5.10	2.05	.0010	.0218	.0204	.0014	.48	.0100	.0001	.49	2.1
44407	March 4	V. slight.	V. slight.	.30	33	V. faintly vegetable.	Faintly vegetable.	5.65	2.95	.0012	.0146	.0132	.0014	.46	.0140	.0002	.50	2.0
44772	March 30	V. slight.	Slight.	.25	29	None.	V. faintly vegetable.	4.75	1.85	.0008	.0168	.0136	.0032	.45	.0120	.0002	.38	1.8
45187	May 4	V. slight	Cons.	.23	28	None.	None.	4.65	1.65	.0022	.0176	.0154	.0022	.44	.0120	.0002	.43	2.0
45611	June 1	V. slight.	Slight.	.23	28	None.	Faintly vegetable.	4.80	1.70	.0026	.0176	.0146	.0030	.46	.0110	.0003	.45	2.0
46113	July 6	V. slight	Slight.	.22	27	Faintly vegetable.	Distinctly vegetable, sweetish.	4.60	1.45	.0014	.0200	.0188	.0012	.44	.0060	.0003	.50	1.8
46595	Aug. 3	V. slight.	V. slight.	.21	27	Faintly vegetable.	Faintly vegetable.	5.00	1.90	.0016	.0216	.0170	.0046	.44	.0030	.0002	.44	2.0
46990	Aug. 31	V. slight.	Slight.	.18	24	Faintly vegetable.	Faintly vegetable.	5.00	2.10	.0012	.0218	.0170	.0048	.46	.0020	.0001	.38	1.8
47432	Oct. 5	Slight.	Slight.	.15	22	Faintly vegetable.	Faintly vegetable, distinctly sweetish.	4.75	2.00	.0020	.0234	.0174	.0060	.47	.0040	.0000	.39	1.8
47912	Nov. 2	V. slight.	Cons.	.19	26	Faintly vegetable.	Distinct cucumber.	4.55	1.60	.0016	.0174	.0144	.0030	.48	.0060	.0001	.44	2.1
48291	Nov. 30	Slight.	Cons.	.22	27	Faintly unpleasant.	Distinct cucumber.	5.10	2.00	.0044	.0190	.0156	.0034	.43	.0060	.0003	.41	2.7
Av...	....	....	....	.23	28	....	....	4.91	1.94	.0020	.0188	.0159	.0029	.46	.0077	.0002	.44	2.0

TABLE No. 27. — *Chemical Examinations of Water from Spot Pond, Stoneham.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.		Color.		Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
											Albuminoid.							
		Turbidity.	Sediment.	Nessler Standard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1903.																	
43696	Jan. 7	None.	V. slight.	.05	9	Faintly vegetable.	Distinctly vegetable.	4.25	1.65	.0028	.0180	.0160	.0020	.33	.0020	.0000	.36	1.6
44009	Feb. 2	None.	V. slight.	.08	15	None.	Faintly unpleasant.	4.00	1.40	.0026	.0152	.0124	.0028	.35	.0050	.0000	.33	1.3
44463	March 9	V. slight.	Slight.	.10	18	None.	None.	4.35	1.90	.0020	.0124	.0122	.0002	.33	.0050	.0000	.27	1.7
44762	March 30	V. slight.	V. slight.	.11	19	None.	None.	3.60	1.20	.0012	.0144	.0128	.0016	.30	.0080	.0000	.29	1.6
45178	May 4	None.	Slight.	.09	17	None.	None.	3.75	1.35	.0032	.0136	.0114	.0022	.28	.0070	.0000	.24	1.4
45735	June 8	None.	V. slight.	.09	17	V. faintly vegetable.	V. faintly vegetable.	4.00	1.30	.0012	.0158	.0130	.0028	.29	.0020	.0001	.23	1.6
46222	July 13	V. slight.	Slight.	.05	9	None.	V. faintly vegetable.	3.20	0.80	.0022	.0122	.0112	.0010	.29	.0010	.0000	.22	1.6
46576	Aug. 3	V. slight.	Slight.	.06	11	None.	None.	3.30	1.15	.0008	.0134	.0112	.0022	.33	.0020	.0000	.25	1.6
46985	Aug. 31	V. slight.	V. slight.	.08	15	Faintly unpleasant.	Distinctly unpleasant.	3.50	1.10	.0012	.0156	.0112	.0044	.29	.0000	.0000	.24	1.1
47427	Oct. 5	Slight.	Slight.	.09	17	V. faintly vegetable.	Distinctly vegetable.	3.55	1.50	.0018	.0164	.0128	.0036	.29	.0060	:0001	.19	1.4
47901	Nov. 2	V. slight.	Cons.	.08	15	V. faintly vegetable.	Distinctly vegetable.	3.65	1.15	.0008	.0160	.0132	.0028	.29	.0010	.0000	.25	1.6
48284	Nov. 30	V. slight.	Slight.	.06	11	Faintly vegetable.	Faintly vegetable.	3.55	1.25	.0022	.0152	.0134	.0018	.28	.0010	.0000	.25	1.6
Av..	....	....	....	.08	15	....	....	3.72	1.31	.0018	.0149	.0126	.0023	.30	.0033	.0000	.26	1.5

TABLE NO. 28. — *Chemical Examinations of Water from a Faucet at the State House, Boston.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.				Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
				Nessler Standard.	Transformed to Platinum Standard.						Total.	Dissolved.	Suspended.					
	1903.																	
43654	Jan. 5	V. slight.	V. slight.	.30	33	Faintly vegetable.	Distinctly vegetable.	4.50	1.80	.0020	.0126	.0110	.0016	.34	.0070	.0001	.44	1.4
44005	Feb. 2	V. slight.	V. slight.	.34	35	None.	Faintly vegetable.	4.70	1.75	.0022	.0130	.0102	.0028	.36	.0200	.0001	.50	1.6
44363	March 2	V. slight.	V. slight.	.32	34	None.	Faintly vegetable.	4.20	1.50	.0014	.0096	.0096	.0000	.32	.0230	.0002	.47	1.7
44757	March 30	V. slight.	V. slight.	.27	31	Faintly vegetable.	Faintly vegetable.	4.50	1.75	.0016	.0132	.0114	.0018	.38	.0300	.0002	.34	1.8
45176	May 4	None.	V. slight.	.24	29	Faintly vegetable.	Faintly vegetable.	3.65	1.50	.0012	.0110	.0098	.0012	.23	.0200	.0002	.35	1.4
45594	June 1	V. slight.	Slight.	.22	27	Faintly vegetable.	Faintly vegetable.	3.90	1.15	.0010	.0122	.0108	.0014	.34	.0190	.0000	.38	1.4
46107	July 6	Slight.	Cons.	.22	27	Faintly vegetable.	Faintly vegetable.	3.80	1.40	.0008	.0108	.0080	.0028	.28	.0120	.0001	.36	1.3
46577	Aug. 3	V. slight.	Slight.	.21	27	None.	None.	4.00	1.50	.0004	.0128	.0112	.0016	.30	.0170	.0002	.37	1.6
46983	Aug 31	V. slight.	Cons.	.24	29	Faintly vegetable.	Faintly vegetable and unpleasant.	3.50	1.25	.0006	.0130	.0122	.0008	.22	.0060	.0000	.38	1.1
47449	Oct. 6	Slight.	V. slight.	.23	28	Faintly vegetable.	Faintly vegetable.	3.40	1.50	.0006	.0132	.0114	.0018	.24	.0050	.0001	.39	1.4
47897	Nov. 2	V. slight.	Slight.	.18	24	Faintly vegetable.	Faintly vegetable.	3.80	1.50	.0014	.0152	.0136	.0016	.27	.0050	.0000	.33	1.6
48280	Nov. 30	Slight.	V. slight.	.23	28	Faintly vegetable.	Faintly vegetable.	3.75	1.35	.0024	.0130	.0124	.0006	.30	.0070	.0004	.34	1.4
Av...	....	....	....	.25	29	....	....	3.98	1.50	.0013	.0125	.0110	.0015	.30	.0142	.0001	.39	1.5

TABLE NO. 29. — *Averages of Examinations of Water from Various Parts of the Metropolitan Water Works.* — *1903.*

[Parts per 100,000.]

LOCALITY.	Samples Collected.	Color.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed	Hardness.
		Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
							Total.	Dis-solved.	Sus-pended.					
Quinepoxet River, Holden,	Bi-monthly,	.36	37	3.37	1.32	.0044	.0183	.0152	.0031	.36	.0052	.0001	.49	0.5
Stillwater River, Sterling,	Bi-monthly,	.35	36	3.07	1.37	.0024	.0168	.0153	.0015	.18	.0017	.0001	.51	0.5
Wachusett Reservoir, Clinton,	Monthly,	.33	35	3.38	1.35	.0020	.0158	.0133	.0025	.21	.0052	.0001	.45	0.8
Marlborough (Walker's) Brook,	Monthly,	.47	44	16.88	5.50	.1572	.0491	.0281	.0210	3.03	.1502	.0049	.59	6.0
Marlborough Brook filter-beds, effluent,	Monthly,	.19	26	12.57	-	.0431	.0148	-	-	1.86	.1575	.0005	.31	4.5
Sudbury Reservoir, surface,	Monthly,	.26	30	3.71	1.41	.0025	.0139	.0119	.0020	.25	.0100	.0001	.40	1.3
Sudbury Reservoir, bottom,	Monthly,	.27	31	3.81	1.35	.0033	.0133	.0115	.0018	.26	.0112	.0001	.40	1.3
Framingham Reservoir No. 3, near dam,	Monthly,	.25	29	3.85	1.35	.0027	.0138	.0117	.0021	.26	.0108	.0001	.39	1.3
Hopkinton Reservoir, influent,	Quarterly,	1.46	113	5.85	3.34	.0027	.0315	.0297	.0018	.45	.0025	.0000	1.51	1.3
Hopkinton Reservoir, surface,	Quarterly,	.55	49	3.74	1.76	.0024	.0176	.0152	.0024	.30	.0035	.0000	.70	0.6
Hopkinton Reservoir, bottom,	Quarterly,	.51	47	3.50	1.55	.0027	.0145	.0132	.0013	.29	.0045	.0000	.63	0.6
Ashland Reservoir, influent,	Quarterly,	1.46	113	5.61	3.04	.0021	.0334	.0307	.0027	.32	.0032	.0000	1.37	1.3
Ashland Reservoir, surface,	Quarterly,	.62	53	3.66	1.69	.0022	.0188	.0168	.0020	.25	.0020	.0000	.75	0.7
Ashland Reservoir, bottom,	Quarterly,	.56	50	3.40	1.54	.0031	.0169	.0150	.0019	.24	.0037	.0000	.68	0.6
Framingham Reservoir No 2, influent,	Quarterly,	.86	67	4.57	2.15	.0020	.0235	.0217	.0018	.36	.0042	.0000	.92	0.9
Framingham Reservoir No. 2, near dam,	Quarterly,	.70	58	4.14	2.08	.0035	.0208	.0185	.0023	.31	.0047	.0000	.78	0.9
Lake Cochituate,	Monthly,	.23	28	4.91	1.94	.0020	.0188	.0159	.0029	.46	.0077	.0002	.44	2.0
Terminal chamber, Sudbury Aqueduct,	Monthly,	.27	31	3.88	1.41	.0022	.0142	.0123	.0019	.27	.0113	.0001	.41	1.3
Spot Pond,	Monthly,	.08	15	3.72	1.31	.0018	.0149	.0126	.0023	.30	.0033	.0000	.26	1.5
Tap in Revere,	Monthly,	.08	15	3.83	1.25	.0015	.0141	.0114	.0027	.30	.0043	.0001	.26	1.6
Tap at State House,	Monthly,	.25	29	3.98	1.50	.0013	.0125	.0110	.0015	.30	.0142	.0001	.39	1.5
Tap in Quincy,	Monthly,	.24	29	4.12	1.51	.0010	.0122	.0110	.0012	.32	.0162	.0000	.37	1.6

TABLE No. 30. — *Chemical Examinations of Water from a Faucet in Boston, from 1888 to 1903.*

[Parts per 100,000.]

YEAR.	COLOR.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
	Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	ALBUMINOID. Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
1888, . .	.38	38	4.94	1.53	.0012	.0215	-	-	.40	.0183	.0002	-	-
1889, . .	.51	46	4.71	1.43	.0005	.0199	.0176	.0023	.42	.0272	.0002	-	-
1890, . .	.35	36	4.70	1.25	.0003	.0169	.0148	.0021	.42	.0241	.0001	-	2.2
1891, . .	.37	38	4.39	1.63	.0005	.0161	.0136	.0025	.37	.0227	.0001	-	1.7
1892, . .	.37	37	4.70	1.67	.0007	.0168	.0138	.0030	.41	.0210	.0001	-	1.9
1893, . .	.61	53	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.60	1.8
1894, . .	.69	58	4.64	1.83	.0006	.0169	.0150	.0019	.41	.0106	.0001	.63	1.7
1895, . .	.72	59	4.90	2.02	.0006	.0197	.0175	.0022	.40	.0171	.0001	.69	0.7
1896, . .	.49	45	4.29	1.67	.0005	.0165	.0142	.0023	.37	.0155	.0001	.56	1.4
1897, . .	.65	55	4.82	1.84	.0009	.0193	.0177	.0016	.40	.0137	.0001	.64	1.6
1898, . .	.41	40	4.19	1.60	.0008	.0152	.0136	.0016	.29	.0097	.0001	.44	1.4
1899, . .	.23	28	3.70	1.30	.0006	.0136	.0122	.0014	.24	.0137	.0001	.35	1.1
1900, . .	.24	29	3.80	1.20	.0012	.0157	.0139	.0018	.25	.0076	.0001	.38	1.3
1901, . .	.24	29	4.43	1.64	.0013	.0158	.0142	.0016	.30	.0173	.0001	.42	1.7
1902, . .	.26	30	3.93	1.56	.0016	.0139	.0119	.0020	.29	.0092	.0000	.40	1.3
1903, . .	.25	29	3.98	1.50	.0013	.0125	.0110	.0015	.30	.0142	.0001	.39	1.5

TABLE No. 31. — *Colors of Water from Various Parts of the Metropolitan Water Works, 1903. (Means of Weekly Determinations.)*

[Platinum Standard.]

MONTH.	WACHUSETT RESERVOIR.	SUDBURY RESERVOIR.				FRAMINGHAM RESERVOIR No. 3.			WHITEHALL RESERVOIR.
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.
January, ...	40	48	44	43	43	40	40	41	45
February, ...	35	37	39	40	38	40	41	41	46
March, ...	42	36	36	37	65	35	35	36	40
April, ...	43	32	32	32	58	34	34	34	40
May, ...	40	34	34	34	41	31	31	31	45
June, ...	50	30	30	30	64	33	34	33	50
July, ...	47	33	36	34	46	31	31	31	49
August, ...	48	36	36	36	47	36	36	36	47
September, ...	44	30	30	30	45	30	30	31	46
October, ...	61	29	30	29	61	32	32	32	53
November, ...	51	34	35	36	53	35	35	35	51
December, ...	53	41	39	40	59	38	38	38	44
Mean, ...	46	35	35	35	52	35	35	35	46

TABLE NO. 31 — *Continued.*

[Platinum Standard.]

MONTH.	Hopkinton Reservoir.				Ashland Reservoir.				Framingham Reservoir No. 2.			
	Surface.	Mid-depth.	Bottom.	Influent.	Surface.	Mid-depth.	Bottom.	Influent.	Surface.	Mid-depth.	Bottom.	Influent.
January, ...	54	46	51	113	72	62	56	99	65	67	74	56
February, ...	53	51	48	95	63	57	55	87	56	57	58	57
March, ...	54	54	56	90	61	61	63	82	60	61	61	66
April, ...	63	63	63	106	70	70	70	102	68	68	68	72
May, ...	64	64	64	142	69	69	69	142	66	67	67	81
June, ...	62	61	61	162	69	70	69	138	89	95	90	98
July, ...	70	70	65	209	78	80	70	180	113	113	113	126
August, ...	71	71	67	179	74	78	70	151	98	98	98	94
September, ...	66	67	66	149	66	68	67	95	77	77	77	86
October, ...	59	59	65	163	65	65	65	111	71	71	72	84
November, ...	57	57	57	148	61	61	61	169	82	84	82	89
December, ...	56	56	56	125	60	60	61	128	70	70	72	77
Mean, ...	61	60	60	140	67	67	65	124	76	77	78	82

TABLE NO. 31 — *Continued.*

[Platinum Standard.]

MONTH.	Framingham Reservoir No. 1.	Lake Cochituate.				Spot Pond.			Fells Reservoir.	Bear Hill Reservoir.
	Surface.	Surface.	Mid depth.	Bottom.	Influent Streams.*	Surface.	Mid-depth.	Bottom.	Effluent Gate-house.	Gate-house.
January, .	63	32	31	36	67	16	19	18	17	18
February, .	53	33	29	33	68	17	18	18	15	17
March, . .	57	35	34	37	77	15	16	16	16	16
April, . .	66	35	36	36	80	16	16	16	13	14
May, . .	56	34	34	40	72	14	14	14	13	13
June, . .	78	30	30	54	89	16	15	16	14	14
July, . .	85	30	31	67	97	16	17	17	14	15
August, . .	83	29	32	78	77	17	17	20	17	18
September, .	61	27	31	105	56	19	19	19	17	18
October, .	61	29	34	124	56	24	25	25	22	21
November, .	74	34	34	57	66	22	22	22	21	20
December, .	73	31	33	34	57	20	21	21	18	19
Mean, .	68	32	32	58	72	18	18	19	16	17

* The colors given in this column represent the combined colors of the waters of the four principal feeders. The color of each is determined monthly, and due weight is given, in combining the results, to the sizes of the streams.

TABLE No. 31 — *Concluded.*

[Platinum Standard.]

MONTH.	Chestnut Hill Reservoir. Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gatehouse No. 2.	Tap at 244 Boylston Street, Boston (Low Service).	Tap at 1 Ashburton Place, Boston (High Service).
January,	–	–	–	39	34	37	38	38
February,	–	–	–	40	34	38	39	39
March,	33	33	31	36	29	35	36	36
April,	32	33	33	33	33	32	33	33
May,	34	–	–	39	28	34	35	33
June,	35	–	–	42	30	35	38	37
July,	30	31	34	31	–	30	31	31
August,	33	33	47	36	–	33	35	35
September,	31	32	82	35	26	31	33	35
October,	32	32	32	34	28	32	34	35
November,	31	31	31	33	30	32	33	33
December,	–	–	–	40	29	38	39	38
Mean,	32	32	41	37	30	34	35	35

TABLE No. 32. — *Temperatures of Water from Various Parts of the Metropolitan Water Works, 1903. (Means of Weekly Determinations.)*

[The temperatures are taken at the same places and times as the samples for microscopical examination; the depth given for each reservoir is the depth from high-water mark where the temperatures are taken.]

[Degrees Fahrenheit.]

MONTH.	Wachusett Reservoir.	Sudbury Reservoir (Depth at Place of Observation 54.5 Feet).				Framingham Reservoir No. 3 (Depth at Place of Observation 20.5 Feet).			Hopkinton Reservoir (Depth at Place of Observation 54.3 Feet).			
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Influent.
January,	33.3	32.5	34.3	35.8	32.9	35.0	35.7	36.1	39.8	41.0	39.6	32.5
February,	32.6	33.5	34.6	35.6	33.2	35.0	36.0	36.8	39.3	40.3	39.8	32.9
March,	41.0	37.2	37.4	37.5	41.0	41.1	41.6	42.0	43.2	42.8	42.7	42.1
April,	49.5	47.4	47.3	46.8	48.8	49.3	49.4	49.0	47.8	47.2	47.5	53.3
May,	64.1	61.1	58.8	57.7	62.8	61.5	58.3	55.7	60.1	52.1	49.5	60.5
June,	65.8	64.4	63.8	62.8	62.4	65.0	62.8	61.0	64.6	53.8	52.1	64.1
July,	72.9	72.9	68.6	66.6	71.1	71.0	69.6	67.9	72.9	57.1	52.8	71.7
August,	72.5	72.2	70.8	69.5	70.1	70.2	69.7	69.3	71.2	56.3	53.6	69.6
September,	67.7	68.9	67.5	67.0	67.2	67.7	67.4	66.6	67.8	57.9	54.8	63.9
October,	57.0	58.1	57.9	57.3	54.1	55.5	54.9	54.2	59.2	56.6	53.6	53.9
November,	47.1	45.8	45.7	45.3	42.6	44.6	44.3	44.3	47.9	47.8	47.6	41.0
December,	33.0	34.4	35.8	36.7	33.7	35.8	36.3	36.5	36.1	36.1	36.2	32.6
Mean,	53.0	52.4	51.9	51.6	51.7	52.6	52.2	51.6	54.2	49.1	47.5	51.5

TABLE No. 32 — *Continued.*

[Degrees Fahrenheit.]

MONTH.	Ashland Reservoir (Depth at Place of Observation 40.7 Feet).				Framingham Reservoir No. 2 (Depth at Place of Observation 20.5 Feet).				Lake Cochituate (Depth at Place of Observation 62.0 Feet).		
	Surface.	Mid-depth.	Bottom.	Influent.	Surface.	Mid-depth	Bottom.	Influent.	Surface.	Mid-depth.	Bottom.
January,	36.6	38.8	40.0	32.5	33.4	33.9	35.5	33.3	34.1	35.0	35.7
February,	36.3	38.0	39.8	32.7	34.3	35.2	36.6	33.9	36.5	37.3	38.5
March,	41.4	41.3	41.2	45.4	42.2	42.4	42.6	42.1	42.5	41.8	41.7
April,	47.8	47.1	46.6	52.5	49.4	49.0	48.5	51.9	49.5	46.5	46.1
May,	61.0	52.8	49.1	55.9	64.2	61.7	57.8	64.3	60.6	50.7	49.1
June,	64.8	55.7	50.4	61.1	65.8	64.3	62.4	62.7	63.9	51.3	49.4
July,	73.8	58.0	51.7	68.4	73.6	72.4	69.8	71.4	73.0	51.3	50.5
August,	70.6	59.1	52.0	68.1	71.3	69.5	68.3	68.1	70.5	51.8	49.6
September,	67.2	61.6	52.1	59.8	68.5	67.0	65.9	67.4	67.5	50.3	47.7
October,	57.3	57.3	51.5	51.9	55.5	55.0	54.8	52.2	57.5	52.0	46.9
November,	47.0	47.0	47.0	43.0	44.4	42.3	44.1	43.0	47.8	47.6	46.3
December,	37.8	37.9	38.5	32.7	33.9	35.1	36.2	33.5	36.0	36.8	37.2
Mean,	53.5	49.7	46.7	50.3	53.0	52.3	51.9	52.0	53.3	46.0	44.9

TABLE No. 32 — *Continued.*

[Degrees Fahrenheit]

MONTH.	Whitehall Reservoir.	Spot Pond (Depth at Place of Observation 28.0 Feet).			Fells Reservoir.	Bear Hill Reservoir.
	Surface.	Surface.	Mid-depth.	Bottom.	Effluent Chamber.	Gate house.
January,	36.9	34.1	35.2	35.8	36.6	36.4
February,	38.6	35.4	36.9	38.1	37.5	37.1
March,	41.3	40.3	41.2	41.6	41.9	42.7
April,	50.8	47.6	47.6	47.6	47.7	48.3
May,	64.6	58.9	58.1	53.8	58.9	59.0
June,	66.2	63.3	62.7	58.7	63.0	62.7
July,	76.0	71.7	68.0	60.6	71.4	71.6
August,	73.5	70.5	70.2	63.8	70.5	70.5
September,	63.5	67.4	66.8	66.5	67.4	66.9
October,	58.0	58.0	58.0	58.0	57.7	57.5
November,	41.8	46.2	46.1	46.0	45.6	45.0
December,	35.8	34.7	34.8	35.1	36.8	36.6
Mean,	53.9	52.3	52.1	50.5	52.9	52.9

TABLE No. 32 — *Concluded.*

[Degrees Fahrenheit.]

MONTH.	Chestnut Hill Reservoir (Depth at Place of Observation 26.0 Feet).						Low-service Tap, 244 Boylston Street, Boston.	High-service Tap, 1 Ashburton Place, Boston.
	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gatehouse No. 2.		
January,	-	-	-	36.6	36.8	35.1	36.9	38.0
February,	-	-	-	36.1	37.4	35.4	37.1	38.0
March,	46.0	45.8	45.8	41.6	41.3	41.5	42.8	43.7
April,	49.3	47.5	47.5	48.0	47.9	48.2	48.8	49.1
May,	60.4	-	-	57.7	56.1	58.8	58.2	58.6
June,	63.1	-	-	61.9	63.5	62.5	62.8	63.6
July,	71.0	68.6	60.5	66.5	-	68.7	68.9	68.8
August,	71.6	70.3	61.9	69.6	-	71.5	70.1	69.6
September,	67.4	66.8	62.8	67.1	65.5	66.9	67.3	67.6
October,	58.4	58.2	57.9	57.5	58.2	58.1	59.4	59.4
November,	48.5	48.5	48.5	43.8	48.8	45.5	48.4	47.7
December,	-	-	-	37.2	40.1	36.0	38.9	38.7
Mean,	59.5	58.0	55.0	52.0	49.6	52.4	53.3	53.6

TABLE No. 33. — *Temperatures of the Air at Three Stations on the Metropolitan Water Works, 1903.*

[Degrees Fahrenheit]

MONTH.	Chestnut Hill Reservoir.			Framingham.			Clinton.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
January,	47.0	—3.0	28.1	50.0	—7.0	27.0	45.5	—7.5	24.3
February,	60.0	—4.0	30.2	60.0	—11.0	29.1	53.5	—4.0	27.0
March,	76.0	18.5	44.8	75.0	16.0	43.9	73.0	19.0	42.2
April,	84.0	23.0	47.5	83.0	19.0	47.0	82.0	22.5	45.8
May,	91.0	30.0	59.4	91.0	28.0	59.2	88.0	27.5	58.9
June,	85.0	40.0	60.8	86.0	37.0	60.1	84.0	39.5	59.8
July,	95.0	51.0	72.0	94.0	45.0	69.9	93.5	50.0	70.6
August,	86.0	46.0	64.4	85.0	44.0	63.0	83.0	45.5	62.9
September,	90.0	35.0	63.8	89.0	35.0	62.9	87.0	36.5	62.0
October,	77.0	25.0	52.9	75.0	22.0	52.2	73.0	24.5	50.3
November,	71.0	9.0	39.0	72.0	9.0	37.9	70.5	6.5	36.6
December,	53.0	—6.0	27.0	54.0	—12.0	25.3	51.5	—4.0	24.3
Average,	-	-	49.2	-	-	48.1	-	-	47.1

TABLE NO. 34. — *Table showing Length of Main Lines of Water Pipes and Connections owned and operated by Metropolitan Water and Sewerage Board, and Number of Valves set in Same.*

	Diameter of Pipes in Inches.													Total.
	60	48	42	36	30	24	20	16	14	12	10	8	6	
Total length owned and operated January 1, 1903 (feet),	8,562	160,957	8,075	46,531	26,910	46,552	57,091	54,207	26	21,527	640	1,585	798	433,461
Gate valves in same,	-	40	-	37	27	33	37	55	1	60	13	12	13	328
Air valves in same,	3	92	3	35	4	19	34	29	-	9	-	-	-	228
Length laid or relaid during 1903 (feet),	507	10,212	-	101	12	567	38	267	-	136	46	-	-	11,886
Gate valves in same,	-	2	-	2	1	3	1	7	-	8	2	-	-	26
Air valves in same,	2	10	-	-	-	-	-	-	-	-	-	-	-	12
Length abandoned during 1903 (feet),	-	69	-	6	-	468	41	80	-	95	42	-	-	801
Gate valves in same,	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Air valves in same,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Length owned and operated January 1, 1904 (feet),	9,069	171,100	8,075	46,626	26,922	46,651	57,088	54,394	26	21,568	644	1,585	798	444,546*
Gate valves in same,	-	42	-	39	28	36	38	62	1	67	15	12	13	353
Air valves in same,	5	102	3	35	4	19	34	29	-	9	-	-	-	240

* 84.19 miles.

TABLE NO. 35. — *Statement of Cast-iron Hydrant, Blow-off and Drain Pipes laid to January 1, 1904, owned and operated by Metropolitan Water and Sewerage Board.*

	Diameter of Pipes in Inches.								Total.
	24	20	16	12	10	8	6	4	
Length laid to January 1, 1903 (feet),	352	258	2,198	4,193	173	155	2,644	1,150	11,123
Length laid during 1903 (feet),	-	35	16	225	-	160	5	-	441
Length abandoned during 1903 (feet),	-	-	-	-	-	-	-	-	-
Total length in use January 1, 1904 (feet),	352	293	2,214	4,418	173	315	2,649	1,150	11,564
Valves set to January 1, 1903,	-	-	17	70	1	-	53	39	180
Valves set during 1903,	-	-	1	5	-	1	1	-	8
Valves abandoned during 1903,	-	-	-	-	-	-	-	-	-
Total valves in use January 1, 1904,	-	-	18	75	1	1	54	39	188

TABLE NO. 36. — *Length of Water Pipes, Four Inches in Diameter and Larger, in the Several Cities and Towns supplied by the Metropolitan Water Works.*

BY WHOM OWNED.	Inches.																			Total.	
	60	48	42	40	36	30	28	24	20	18	16	14	12	10	8	7	6	5	4	Feet.	Miles.
Metropolitan Water Works.	9,069	171,100	8,075	-	46,626	26,922	-	46,651	57,088	-	54,394	26	21,568	644	1,585	-	798	-	-	444,546	84.19
Boston, . . .	-	33,671	16,813	23,104	39,984	87,505	244	79,751	93,896	-	190,249	-	1,149,844	124,575	579,695	-	1,345,330	-	87,903	3,852,564	729.64
Somerville, . .	-	-	-	-	-	-	-	-	3,596	387	2,071	8,037	77,843	46,290	89,353	-	191,255	-	20,064	438,896	83.12
Malden, . . .	-	-	-	-	-	-	-	-	-	-	-	12,174	67,540	21,699	69,132	-	192,663	-	69,957	433,165	82.04
Chelsea, . . .	-	-	-	-	-	-	-	-	-	-	2,380	-	-	39,448	25,570	-	125,756	-	10,004	203,158	38.48
Quincy, . . .	-	-	-	-	-	-	-	-	2,679	-	19,813	-	21,254	32,438	85,030	994	201,712	948	97,221	462,089	87.52
Everett, . . .	-	-	-	-	-	-	-	2,484	2,900	-	2,233	206	5,570	35,403	18,275	-	125,488	-	32,208	224,767	42.57
Medford, . .	-	-	-	-	-	-	-	-	673	-	6,775	9,585	24,705	30,394	65,041	-	84,540	-	48,596	270,309	51.20
Melrose, . . .	-	-	-	-	-	-	-	-	-	-	5,178	2,920	23,075	7,553	23,464	-	106,686	-	71,345	240,221	45.50
Revere,* . . .	-	-	-	-	-	-	-	-	-	-	22,650	5,700	7,380	8,550	16,435	-	64,237	-	67,833	192,785	36.51
Watertown, . .	-	-	-	-	-	-	-	-	-	-	400	12,127	5,959	4,169	19,261	-	106,510	-	13,239	161,665	30.62
Winthrop,* . .	-	-	-	-	-	-	-	-	-	-	-	-	4,000	4,800	19,320	-	23,931	-	70,000	122,051	23.12
Belmont, . .	-	-	-	-	-	-	-	-	-	-	-	-	2,161	13,102	12,896	-	69,386	-	283	97,828	18.53
Nahant, . . .	-	-	-	-	-	-	-	-	-	-	-	-	150	11,550	4,850	-	32,740	-	34,925	84,215	15.95
Arlington, . .	-	-	-	-	-	-	-	-	-	-	-	-	31,804	19,806	21,359	-	78,089	-	33,465	184,523	34.95
Swampscott, . .	-	-	-	-	-	-	-	-	-	-	-	-	12,072	13,634	13,217	-	46,130	-	9,110	94,163	17.83
Stoneham, . .	-	-	-	-	-	-	-	-	-	-	-	-	4,525	4,725	2,970	-	81,392	-	12,829	106,441	20.16
Milton, . . .	-	-	-	-	-	-	-	-	-	-	103	44	22,331	16,630	29,373	-	102,875	-	12,521	183,877	34.83
Lexington, . .	-	-	-	-	-	-	-	-	-	-	-	-	9,000	2,664	6,010	-	41,500	-	32,400	91,574	17.34
Total feet, .	9,069	204,771	24,888	23,104	86,610	114,427	244	128,886	160,832	387	306,246	50,819	1,490,781	438,074	1,102,836	994	3,021,018	948	723,903	788,837	-
Total miles, .	1.72	38.78	4.71	4.38	16.40	21.67	.05	24.41	30.46	.07	58.00	9.63	282.34	82.97	208.87	.19	572.16	.18	137.11	-	1,494.10

* Pipes owned by Revere Water Company.

TABLE NO. 37. — *Number of Service Pipes, Meters and Fire Hydrants in the Several Cities and Towns supplied by the Metropolitan Water Works.*

City or Town.	Services.	Meters.	Fire Hydrants.
Boston,	90,028	4,745	7,850
Somerville,	10,854	635	973
Malden,	6,742	4,670	401
Chelsea,	6,314	134	298
Quincy,	5,326	165	639
Everett,	4,766	59	494
Medford,	4,083	177	479
Melrose,	3,270	100	280
Revere,	2,510	47	126
Watertown,	1,730	1,619	318
Winthrop,	1,850	17	113
Belmont,	643	643	148
Nahant,	467	47	59
Arlington,	1,756	105	351
Swampscott,	1,114	-	121
Stoneham,	1,246	20	95
Milton,	1,173	1,173	273
Lexington,	646	8	93
Total,	144,518	14,364	13,111

Appendix No. 4.

Summary of Statistics for the Year 1903.

The Metropolitan Water Works supply the Metropolitan Water District, which includes the following cities and towns: —

City or Town.	Population, Census of 1900.	Estimated Population, May 1, 1903.
Boston,	560,892	597,900
Somerville,	61,643	68,000
Chelsea,	34,072	36,900
Malden,	33,664	39,000
Newton,*	33,587	37,600
Everett,	24,336	27,900
Quincy,	23,899	26,700
Medford,	18,244	21,000
Hyde Park,*	13,244	14,200
Melrose,	12,962	14,000
Revere,	10,395	12,600
Watertown,	9,706	10,800
Arlington,	8,603	9,700
Milton,	6,578	7,400
Stoneham,	6,197	6,400
Winthrop,	6,058	7,300
Belmont,	3,929	4,700
Lexington,	3,831	4,100
Nahant,	1,152	1,300
Total population of Metropolitan Water District,	872,992	947,500
Swampscott,†	4,548	5,000
Saugus,‡	158	200

* No water supplied to these places during the year from Metropolitan Water Works.

† Not in the Metropolitan Water District, but has been supplied with water from the Metropolitan Water Works.

‡ Only a small portion of Saugus is supplied with water.

Sources of Supply.

Source.	Area of Watershed (Square Miles).	Remarks.
Lake Cochituate, ...	18.87	Works built by city of Boston in 1848.
Sudbury River, ...	75.20	Works built by city of Boston in 1872 78.
Nashua River (South Branch), . . .	118.31	Works begun in 1895; not finished.

Mode of Supply.

1 per cent. from gravity.

99 per cent. from pumping.

Pumping.

Chestnut Hill High-service Station:—

Builders of pumping machinery, Holly Manufacturing Company, Quintard Iron Works and E. P. Allis Company.

Description of coal used: — Bituminous: Loyal Hanna, Ocean and Quemahoning; anthracite: buckwheat and coal screenings. Price per gross ton in bins: bituminous $4.48 to $7.61, buckwheat $5.75, screenings $2.24. Average price per gross ton $5.34. Per cent ashes 12.5.

Chestnut Hill Low-service Station:—

Builders of pumping machinery, Holly Manufacturing Company.

Description of coal used: — Bituminous: Loyal Hanna, Ocean and Quemahoning; anthracite: buckwheat and coal screenings. Price per gross ton in bins: bituminous $4.48 to $7.61, buckwheat $3.36 and $5.75, screenings $2.24. Average price per gross ton $5.49. Per cent. ashes 11.2.

Spot Pond Station:—

Builders of pumping machinery, Geo. F. Blake Manufacturing Company and Holly Manufacturing Company.

Description of coal used: — Bituminous: Georges Creek, Cumberland and Ocean; anthracite: buckwheat and coal screenings. Price per gross ton in bins: bituminous $5.07 to $6.16, buckwheat $3.75 and $4.25, screenings $2.24. Average price per gross ton $4.57. Per cent. ashes, 15.0.

	Chestnut Hill High-service Station.			
	Engine No. 1 (Low Service).	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 4.
Daily pumping capacity (gallons), ...	8,000,000	16,000,000	20,000,000	30,000,000
Coal consumed for year (pounds), ...	22,253	850,524	750,153	8,177,358
Cost of pumping, figured on pumping station expenses,	$309.11	$6,941.08	$6,840.68	$38,307.06
Total pumpage for year, corrected for slip (million gallons), ...	27.51	528.43	776.18	9,631.33
Average dynamic head (feet), ...	44.03	120.28	128.38	127.63
Gallons pumped per pound of coal, ...	1,236.23	621.30	1,034.70	1,177.80
Duty on basis of plunger displacement, ...	48,510,000	71,940,000	119,560,000	127,750,000
Cost per million gallons raised to reservoir, . . .	$11.236	$13.135	$8.813	$3.977
Cost per million gallons raised one foot, ...	.255	.109	.069	.031

	Chestnut Hill Low-service Station.	Spot Pond Station.	
	Engines Nos. 5, 6 and 7.	Engine No. 8.	Engine No. 9.
Daily pumping capacity (gallons),	105,000,000	10,000,000	20,000,000
Coal consumed for year (pounds),	8,561,549	167,792	2,210,587
Cost of pumping, figured on pumping station expenses,	$41,521.30	$1,215.43	$11,357.53
Total pumpage for year, corrected for slip (million gallons),	27,773.23	178.82	2,570.01
Average dynamic head (feet),	37.82	119.43	128.00
Gallons pumped per pound of coal,	3,243.95	1,065.72	1,162.59
Duty on basis of plunger displacement,	108,380,000	108,200,000	126,020,000
Cost per million gallons raised to reservoir,	$1.495	$6.797	$4.419
Cost per million gallons raised one foot,	.039	.057	.035

Consumption.

Estimated total population of the nineteen cities and towns supplied wholly or partially during the year 1903,	900,500
Total consumption, gallons,	39,109,120,000
Furnished from Metropolitan Water Works sources, gallons,	39,057,180,000
Furnished from local sources, gallons,	51,940,000
Average daily consumption, gallons,	107,148,000
Gallons per day to each inhabitant,	119.0

Distribution.

	Owned and operated by Metropolitan Water and Sewerage Board.	Total in District supplied by Metropolitan Water Works.
Kinds of pipe used,	-*	-†
Sizes,	60 to 6 inch.	60 to 4 inch.
Extensions less length abandoned, miles,	2.1	37.02
Length in use, miles,	84.19	1,494.10
Stop gates added,	25	-
Stop gates now in use,	353	-
Service pipes added,	-	2,914
Service pipes now in use,	-	144,518
Meters added,	-	1,291
Meters now in use,	-	14,364
Fire hydrants added,	-	178
Fire hydrants now in use,	-	13,111

* Cast-iron and cement-lined wrought iron. † Cast-iron, cement-lined wrought iron and kalamine.

APPENDIX No. 5.

CONTRACTS MADE AND PENDING DURING

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	34†	56-inch vertical boiler and connections, Alewife Brook pumping station, Somerville.	4	$1,135 00	$1,098 00*	The Hodge Boiler Works, Boston, Mass.
2	44	Section 63, Belmont Extension, Cambridge, 6,367 linear feet of brick sewer, 22 in. by 28 in. and 24 in. by 28 in. in open cut and tunnel.	7	49,691 50	45,288 00*	Gow & Palmer, Boston, Mass.
3	45	Pile driving in advance of excavation on sections 61 and 62, Revere Extension, Chelsea.	-‡	-‡	-‡	Mayo Contracting Company, Boston, Mass.
4	46	Part of Section 62, Revere Extension, Chelsea, 1,329 linear feet of 48 in. brick sewer in tunnel.	-‡	-‡	-‡	Chas. A. Haskin, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . .

Contracts relating to the

5	-†	Section 66, High-level Sewer, Hyde Park.	10	$240,150 00	$215,600 00*	Ed. W. & John J. Everson, Providence, R. I.
6	14†	Part of Section 75, High-level Sewer, Roxbury.	4	91,050 00	86,700 00*	E. W. Everson & Co., Providence, R. I.
7	16	Section 77, High-level Sewer, Roxbury, pumping plant for Ward Street pumping station.	3	207,000 00	204,000 00*	Allis-Chalmers Company, Milwaukee, Wis.

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

Appendix No. 5.

THE YEAR 1903 — SEWERAGE WORKS.

North Metropolitan System.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
Mar. 12, '03,	May 25, '03,	June 23, '03,	For whole work, $1,098, .	$1,098 00	$1,098 00	1
Sept. 14, '03,	June 1, '04,	-	For earth excavation and refilling for 24-inch by 28-inch sewer, $4.50 per lin. ft. trench; for 22-inch by 28-inch, $4 per lin. ft.; American cement brickwork, $12.50 per cu. yd.; Portland cement brickwork, $14.75 per cu. yd.; American cement concrete, $5 per cu. yd.; Portland cement concrete, $6 per cu. yd.; spruce lumber in place, $40 per M. feet B. M.; spruce piles, $0.25 per lin. ft. driven.	45,288 00	36,109 72	2
Oct. 9, '03,	-	-	For spruce piles driven, $0.22 per lin. ft.	20,500 00§	6,510 68	3
Oct. 23, '03,	May 1, '04,	-	For rock or earth excavation and refilling for 48-inch sewer, $12 per lin. ft. tunnel; Portland cement brick masonry, in tunnel, $18 per cu. yd.	31,200 00	11,244 00	4
. . .	. . .	. . .	. . . . . .	$98,086 00	$54,962 40	

South Metropolitan System.

Oct. 13, '99,	Oct. 1, '01,	Feb. 17, '03,	- -	$232,051 94	$232,051 94	5
Oct. 11, '01,	Nov. 1, '02,	Feb. 17, '03,	- -	92,977 67	92,977 67	6
Jan. 17, '02,	Jan. 17, '04,	-	- -	204,000 00	-	7

§ Approximate.

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	21†	Part of Section 73, High-level Sewer, West Roxbury.	-‡	-‡	-‡	H. P. Nawn, Boston, Mass.
2	23†	Section 61, High-level Sewer, Milton.	4	$122,597 50	$119,095 00*	Chas. G. Belden & Co., Quincy, Mass.
3	22	Part of Section 43, Quincy and Hull, westerly line of 60-inch cast-iron pipe harbor outfalls.	2	109,273 50	94,492 45*	Hiram W. Phillips, Quincy, Mass.
4	24†	Parts of Section 49, High-level Sewer, Quincy.	2	95,385 60	89,374 00*	Chas. G. Belden & Co., Quincy, Mass.
5	26†	Curved plates for tunnel, Section 73, High-level Sewer, West Roxbury.	5	31,550 00	29,487 50*	James Russell Boiler Works Company, Boston, Mass.
6	30†	Part of Section 78, High-level Sewer, Roxbury.	8	18,360 00*	17,820 00	Patrick McGovern, Boston, Mass.
7	27	Section 77, High-level Sewer, Roxbury, Ward Street pumping station and connections.	6	235,719 50	224,505 00*	L. P. Soule & Son, Boston, Mass.
8	29†	Section 45, High-level Sewer, Quincy.	5	71,620 00	68,372 00*	Latta & Terry Company, Philadelphia, Pa.
9	28†	Section 48, High-level Sewer, Quincy.	11	241,330 00*	231,504 80	Chas. G. Belden & Co., Quincy, Mass.
10	32†	Section 76, High-level Sewer, Roxbury, 1,265 tons 48-inch cast-iron pipe and special castings.	3	36,845 00	35,955 00*	Warren Foundry and Machine Company, Phillipsburg, N. J.
11	36	Section 76, High-level Sewer, Roxbury, laying 48-inch force-mains and building connecting sewer.	4	29,150 00	26,230 00*	H. P. Nawn, Boston, Mass.
12	33	Section 46, High-level Sewer, Quincy.	3	40,328 00	37,044 00*	W. H. Ellis, Boston, Mass.

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

YEAR 1903 — SEWERAGE WORKS — *Continued.*

South Metropolitan System — Continued.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
April 21, '02,	April 1, '03,	Sept. 28, '03,	- -	$122,082 52	$122,082 52	1
May 20, '02,	May 1, '03,	April 18, '03,	- -	117,099 88	117,099 88	2
May 28, '02,	July 1, '03,	-	- -	94,492 45	86,728 61	3
June 18, '02,	Jan. 1, '03,	July 15, '03,	- -	86,251 42	86,251 42	4
June 24, '02,	-	April 8, '03,	- -	29,500 14	29,500 14	5
Oct. 7, '02,	April 1, '03,	May 15, '03,	- -	27,460 39	27,460 39	6
Oct. 8, '02,	Dec. 1, '03,	-	- -	224,505 00	199,724 42	7
Oct. 14, '02,	April 1, '03,	June 6, '03,	- -	66,944 19	66,944 19	8
Dec. 19, '02,	Sept. 1, '03,	Nov. 20, '03,	- -	264,992 10	264,992 10	9
Dec. 26, '02,	July 1, '03,	July 7, '03,	- -	36,355 27	36,355 27	10
June 9, '03,	Dec. 1, '03,	-	For laying 48-inch pipe, $6.50 per lin. ft.; Portland cement brick masonry, $18 per cu. yd.; Portland cement concrete masonry, $7.50 per cu. yd.; rock excavation in trench, $4 per cu. yd.	29,366 06	27,216 85	11
June 11, '03,	Sept. 1, '03,	-	For earth excavation and refilling in trench and embankment for 135 in. by 150 in. sewer, $7 per lin. ft.; American cement brick masonry, $12.10 per cu. yd.; Portland cement brick masonry, $13.20 per cu. yd.; Portland cement concrete masonry, $5.30 per cu. yd.; spruce lumber in trench in place, $30 per M. ft. B. M.	37,044 00	28,802 04	12

CONTRACTS MADE AND PENDING DURING THE

Contracts relating to the

	1. Number of Contract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID. 4. Next to Lowest.	5. Lowest.	6. Contractor.
1	35	Parts of Section 44, High-level Sewer, Quincy.	4	$133,845 00	$125,554 60*	W. H. Ellis, Boston, Mass.
2	43	Part of Section 43, High-level Sewer, Quincy and Hull, easterly line of 60-inch cast-iron pipe, harbor outfalls.	-‡	-‡	-‡	Hiram W. Phillips, Quincy, Mass.
3	37†	Easterly line of Section 43, High-level Sewer, Quincy and Hull, 360 tons 60-inch cast-iron pipe, 120 tons 60-inch cast-iron pipe with turned spigots, 3.2 tons special castings.	2	16,618 83*	16,398 25§	United States Cast-iron Pipe and Foundry Company, New York, N. Y.
4	42	Two vertical fire-tube boilers and fittings for the Nut Island screen house, Quincy.	5	6,430 00	6,315 00*	Edward Kendall & Sons, Cambridge, Mass.
5	39	Part of Section 44, High-level Sewer, Quincy, screen house on Nut Island.	6	29,971 00	29,940 00*	Woodbury & Leighton Company, Boston, Mass.
6	40	Quincy pumping station, force-main line, 291 tons 24-inch cast-iron pipe and 8 tons special castings.	3	7,857 60	7,238 50*	Camden Iron Works, Camden, N. J.
7	47	Easterly line of Section 43, High-level Sewer, Quincy and Hull, 1,726 tons 60-inch cast-iron pipe; 536 tons 60-inch cast-iron pipe with turned spigots; 2.8 tons special castings.	2	64,617 80	56,966 70*	Camden Iron Works, Camden, N. J.
		Total, ...	. .	. . .	. . .	. . . . . .

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

§ This did not conform to time of delivery specified.

YEAR 1903 — SEWERAGE WORKS — *Continued.*

South Metropolitan System — Concluded.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1903.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1903.	
June 11, '03,	Sept. 1, '03,	-	For earth excavation, $0.80 per cu. yd.; American cement brick masonry, $12 per cu. yd.; Portland cement brick masonry, $13.20 per cu. yd.; American cement concrete masonry, $4.20 per cu. yd.; Portland cement concrete masonry, $5.30 per cu. yd.; Portland cement boulder concrete masonry, $4 per cu. yd.; cut granite stone masonry, $65 per cu. yd.; laying 60-inch cast-iron pipe in trench, $4 per lin. ft.; spruce lumber in trench in place, $30 per M. ft. B. M.; loam excavation and surfacing, $0.40 per cu. yd.	$125,554 60	$100,035 45	1
June 30, '03,	July 1, '04,	-	For laying 60-inch pipe below the bed of the harbor, $17.33 per lin. ft.; for reinforcement of outlet, $3,250.	99,570 14	18,779 42	2
July 10, '03,	Oct. 15, '03,	Oct. 13, '03,	For 60-inch pipe, $33.35 per ton; 60-inch pipe with turned spigots, $36.35 per ton; special castings, $79 per ton.	16,875 24	16,875 24	3
Aug. 14, '03,	Dec. 1, '03,	-	- -	6,315 00	6,315 00	4
Sept. 11, '03,	-	-	- -	29,940 00	-	5
Dec. 21, '03,	May 1, '04,	-	For 24-inch cast-iron pipe, $23.50 per ton; special castings, $50 per ton.	7,238 50	-	6
Dec. 21, '03,	June 1, '04,	-	For pipe and special castings, $24.27 per ton.	56,966 70	-	7
. . .	. . . .	. . .	. . . .	$2,007,583 21	$1,560,192 55	

CONTRACTS MADE AND PENDING DURING THE YEAR 1903 — SEWERAGE WORKS — *Concluded.*

Summary of Contracts.*

	Approximate Amount of Contracts.	Value of Work done December 31, 1903.
North Metropolitan System, 4 contracts,	$98,086 00	$54,962 40
South Metropolitan System, 22 contracts,	2,007,583 21	1,560,192 55
Total of 26 contracts made and pending during the year 1903,	$2,105,669 21	$1,615,154 95

* In this summary the cost of day work and contracts charged to maintenance are excluded.

Appendix No. 6.

Cement Tests — Sewerage Works.

During the year a total of about 74,000 barrels of Portland and 12,000 barrels of Rosendale cement have been used. The cement was subjected to the usual tests to determine its fineness, tensile strength, specific gravity and freedom from checking, cracking and other imperfections. In the following table the results under the first two heads are summarized for three and one-fourth years: —

Summary of Cement Tests made by Metropolitan Sewerage

	BRAND.	Number of Barrels used.	Composition of Briquettes.	Fineness. Per Cent. Residue, No. 50 Sieve.	Fineness. Per Cent. Residue, No. 100 Sieve.	Fineness. Per Cent. Residue, No. 120 Sieve.	Tensile Strength. Twenty-four Hours. Briquettes.	Tensile Strength. Twenty-four Hours. Pounds per Square Inch.	Tensile Strength. Seven Days. Briquettes.	Tensile Strength. Seven Days. Pounds per Square Inch.
	Portland: —									
1	Alpha,	4,481	Neat, 2 to 1,	0 –	9.8 –	12.8 –	190 –	359 –	209 205	831 358
2	Alsen,	2,599	Neat, 2 to 1,	0 –	10.0 –	12.6 –	60 –	467 –	60 45	681 344
3	Atlas,	109,479	Neat, 2 to 1,	0 –	9.6 –	11.9 –	2,170 –	397 –	2,497 2,195	701 360
4	Brooks-Shoobridge,	150	Neat, 2 to 1,	0 –	10.0 –	13.2 –	35 –	367 –	45 35	568 245
5	Catskill,	3,989	Neat, 2 to 1,	0 –	9.2 –	12.0 –	160 –	338 –	195 180	750 325
6	Dexter,	570	Neat, 2 to 1,	0 –	8.2 –	11.1 –	45 –	400 –	50 30	845 415
7	Lehigh,	84,125	Neat, 2 to 1,	0 –	9.8 –	12.8 –	2,098 –	372 –	2,230 1,840	749 358
8	Star,	13,311	Neat, 2 to 1,	0 –	9.6 –	12.0 –	465 –	380 –	445 382	769 347
9	Vulcanite,	22,373	Neat, 2 to 1,	0 –	9.4 –	11.6 –	495 –	376 –	525 485	831 481
	Total,	241,077	Neat, 2 to 1,	0 –	9.5 –	12.3 –	5,718 –	384 –	6,256 5,397	747 359
	Rosendale: —									
10	Beach's,	5,399	Neat, 1½ to 1,	4.0 –	16.0 –	19.0 –	90 –	143 –	25 85	144 63
11	Crescent,	408	Neat, 1½ to 1,	3.0 –	15.0 –	20.0 –	10 –	187 –	10 10	180 76
12	Hoffman,	14,713	Neat, 1½ to 1,	3.6 –	15.6 –	17.7 –	360 –	143 –	370 265	154 66
13	Newark and Rosendale,	17,171	Neat, 1½ to 1,	3.8 –	15.7 –	18.1 –	450 –	140 –	556 500	150 69
14	Norton,	3,206	Neat, 1½ to 1,	3.3 –	14.2 –	16.3 –	225 –	145 –	290 280	158 72
15	Olympia,	5,495	Neat, 1½ to 1,	3.8 –	16.2 –	18.7 –	160 –	168 –	139 158	176 63
16	Union,	6,663	Neat, 1½ to 1,	1.1 –	8.2 –	10.2 –	135 –	172 –	135 145	187 92
	Total,	53,055	Neat, 1½ to 1,	3.2 –	14.4 –	17.1 –	1,430 –	157 –	1,525 1,443	164 72

Works, October 1, 1900, to December 31, 1903.

Tensile Strength — Concluded.														
Twenty-eight Days.		Three Months.		Six Months.		Nine Months.		One Year.		Eighteen Months.		Two Years.		
Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	Briquettes.	Pounds per Square Inch.	
15	911	5	893	5	721	10	894	25	881	–	–	10	757	1
55	495	50	514	40	459	20	510	35	468	5	321	45	562	
–	–	–	–	–	–	–	–	10	817	–	–	–	–	2
5	495	30	528	20	562	5	481	35	567	10	574	–	–	
190	790	35	805	30	861	25	795	65	770	15	919	35	872	3
515	457	365	545	285	583	110	593	215	577	60	710	20	675	
–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
–	–	25	451	–	–	5	481	10	535	–	–	–	–	
29	812	15	870	–	–	5	884	5	818	–	–	10	760	5
70	466	40	478	10	543	10	441	25	545	–	–	–	–	
15	882	–	–	10	974	–	–	5	946	–	–	–	–	6
20	475	25	527	5	553	5	599	15	584	5	637	–	–	
90	852	25	840	30	895	5	874	30	902	5	898	10	965	7
395	472	230	533	135	557	105	560	160	553	10	570	15	618	
55	852	5	814	–	–	10	895	34	889	5	702	15	915	8
115	433	85	436	40	480	29	464	45	541	10	532	70	568	
70	845	10	785	20	847	5	847	30	950	10	832	10	794	9
170	534	120	586	80	623	20	593	30	594	5	597	10	557	
464	849	95	835	95	860	60	865	204	872	35	838	90	844	
1,345	478	970	511	615	545	309	525	570	552	105	563	160	596	
5	230	–	–	5	316	5	410	5	393	–	–	–	–	10
5	178	15	252	20	258	5	267	25	281	20	267	–	–	
–	–	–	–	–	–	–	–	–	–	–	–	–	–	11
–	–	5	274	–	–	5	327	–	–	–	–	–	–	
45	261	10	322	5	304	5	402	15	407	–	–	30	418	12
85	175	60	272	35	280	40	298	30	349	–	–	45	312	
90	215	10	301	5	404	5	412	35	362	–	–	35	385	13
115	154	45	244	40	269	30	258	40	268	5	267	25	253	
49	190	15	303	–	–	–	–	5	363	–	–	10	451	14
80	168	10	244	5	272	–	–	5	247	–	–	15	273	
20	228	–	–	5	364	10	322	30	386	–	–	10	412	15
25	164	30	292	15	323	15	301	30	275	–	–	15	244	
–	–	–	–	–	–	–	–	–	–	–	–	–	–	16
70	149	30	226	–	–	–	–	5	351	–	–	5	362	
209	225	35	309	20	347	25	387	90	382	–	–	85	417	
380	165	195	258	115	280	95	290	135	295	25	267	105	289	

Appendix No. 7.

LEGISLATION OF THE YEAR 1903 AFFECTING THE METROPOLITAN WATER AND SEWERAGE BOARD.

ACTS.

[Chapter 161.]

An Act relative to lands taken for the purposes of water supply.

Be it enacted, etc., as follows:

R. L. 12, § 12, amended.

Section 1. Section twelve of chapter twelve of the Revised Laws is hereby amended by adding at the end thereof the following: — If land within any city or town shall have been taken from such city or town for said purposes, and for any one of the three years prior to the taking shall have been used for any public purpose, and for that reason no taxes shall have been collected thereon, the city or town and the board or officer having charge of the water supply may within six years after the taking agree as to the value of the land upon which the annual payment is to be made as aforesaid from the time of the taking, and if they cannot agree the board or officer shall notify the city or town thereof; and thereupon the value shall be determined by the superior court under the provisions of said sections seventy-eight and seventy-nine, and said notice shall be deemed to be the notice referred to in said section seventy-eight. The provisions of this section and of the two preceding sections shall apply to property acquired for the purposes of the metropolitan water supply, — so as to read as follows: — *Section 12.*

Valuation of land held by a city or town in another city or town for a water supply.

The assessors of a city or town in which land is acquired by another city or town for the purpose of a water supply shall, within one year after such acquisition, determine the said average valuation of such land, and certify the amount so determined to such other city or town. The mayor of a city or the selectmen of a town, within six months after receipt of said certificate, may appeal from such determination to the superior court for the county where the land lies; and said court shall determine such valuation in the manner provided in the two preceding sections, and the provisions of sections seventy-eight and seventy-nine, so far as applicable, shall govern such appeal.

Valuation of certain land, how determined.

If land within any city or town shall have been taken from such city or town for said purposes, and for any one of the three years prior to the taking shall have been used for any public purpose, and for that reason no taxes shall have been collected thereon, the city or town and the board or officer having charge of the water supply may within six years after the taking agree as to the value of the land upon which the annual payment is to be made as aforesaid from the time of the taking, and if they cannot agree the board or officer shall notify the city or town thereof; and thereupon the value shall be determined by the superior court under the provisions of said sections seventy-eight and seventy-nine, and said notice shall be deemed to be the notice referred to in said section seventy-eight. The provisions of this section and of the two preceding sections shall apply to property acquired for the purposes of the metropolitan water supply.

Section 2. This act shall take effect upon its passage. [*Approved March 18, 1903.*

[Chapter 242.]

An Act to provide for the addition of the town of Revere to the north metropolitan sewerage system.

Be it enacted, etc., as follows:

Town of Revere added to the north metropolitan sewerage district, etc.

Section 1. The territory comprising the town of Revere is hereby added to the north metropolitan sewerage district, created by chapter four hundred and thirty-nine of the acts of the year eighteen hundred and eighty-nine. In becoming a part of the metropolitan system said addition shall be subject to the provisions and shall conform to the requirements of the aforesaid act and of acts in amendment thereof and in addition thereto, except as otherwise provided herein, and the proportionate liability incurred by said addition shall be assumed by the town of Revere. Any authority granted to other municipalities by said act or acts in amendment thereof and in addition thereto is also vested in the town of Revere, in common with said other municipalities.

Outlet to be provided for sewage, etc.

Section 2. The metropolitan water and sewerage board shall provide one or more outlets at the Revere town line for the sewage of said town, and, acting on behalf of the Commonwealth, shall construct a main trunk sewer or sewers through such parts of the city of Chelsea as may be necessary, to such point in the north metropolitan system at the corner of Eastern avenue and Marginal street in Chelsea, as said board may determine. The sewer or sewers so to be constructed to enter the town of Revere shall be built at a sufficiently low grade to drain by gravity the sewage from the whole town of Revere.

Metropolitan water and sewerage board to exercise certain authority, etc.

SECTION 3. In providing such outlets and in receiving sewage from the town of Revere, and in any action relating thereto, and for the purpose of taking, constructing and maintaining such additional main lines of sewer, the said metropolitan water and sewerage board, acting on behalf of the Commonwealth, shall have and exercise all the authority conferred upon them by chapter four hundred and thirty-nine of the acts of the year eighteen hundred and eighty-nine and acts in amendment thereof and in addition thereto, and by chapter one hundred and sixty-eight of the acts of the year nineteen hundred and one; and all the provisions of said acts are hereby made applicable to this additional construction, except as otherwise provided herein.

Metropolitan Sewerage Loan.

SECTION 4. To meet the expenses incurred under the provisions of this act the treasurer and receiver general shall, with the approval of the governor and council, issue scrip or certificates of debt, in the name and behalf of the Commonwealth and under its seal, to an amount not exceeding two hundred thousand dollars, for a term not exceeding thirty years. Such scrip or certificates of debt shall be issued as registered bonds or with interest coupons attached, and shall bear interest at a rate not exceeding four per cent per annum, payable semi-annually on the first days of March and September in each year. Said interest and the scrip or certificates shall be payable and when due shall be paid in gold coin or its equivalent. Such scrip or certificates of debt shall be designated on the face thereof, Metropolitan Sewerage Loan, shall be countersigned by the governor, and shall be deemed a pledge of the faith and credit of the Commonwealth, redeemable at the time specified therein in gold coin or its equivalent, and shall be sold and disposed of at public auction or in such other mode and at such times and prices and in such amounts and at such rate of interest, not exceeding four per cent per annum, as the treasurer and receiver general with the approval of the governor and council shall deem for the best interests of the Commonwealth. Any scrip or certificates of debt issued under the provisions of this act shall be considered as an addition to and shall become a part of the loan authorized by chapter four hundred and thirty-nine of the acts of the year eighteen hundred and eighty-nine, as amended by chapter three hundred and seven of the acts of the year eighteen hundred and ninety-four, and by chapter two hundred and ninety-four of the acts of the year eighteen hundred and ninety-five.

Payment of loan, etc.

SECTION 5. The interest and sinking fund requirements of the moneys expended in constructing that part of the sewerage system provided for in this act, and the cost of maintenance and operation thereof, shall be deemed and paid as a part of the interest, sinking fund requirements and costs specified in section fifteen of said chapter four hundred and thirty-nine, and the sinking fund established under the provisions of said chapters shall be a sinking fund for the extinguishment of the debt authorized by this act, said funds to be increased in the following manner: — The treasurer and receiver general shall from year to year, beginning with the year nineteen hundred and three, apportion to said sinking fund an amount sufficient with its accumulations to extinguish the debt at maturity; and in making the assessment for the increase of said sinking fund upon the several cities and towns liable thereto seven two hundred and fortieths of the whole amount shall be assessed in each of the first seven years, beginning with the year nineteen hundred and three, one thirtieth in each of the next ten years, beginning with the year nineteen hundred and ten, and the remainder shall be distributed equally in the next ten years, beginning with the year nineteen hundred and twenty. Any premium realized from the sale of said scrip or certificates of debt shall be applied to the payment of the interest on said loan as it accrues.

Town of Revere to be included in determining proportions to be assessed.

SECTION 6. The commissioners to be appointed by the supreme judicial court under the provisions of section fourteen of chapter four hundred and thirty-nine of the acts of the year eighteen hundred and eighty-nine, for the purposes specified in said section, and any other commissioners thereafter appointed for said purposes, shall include the town of Revere among the cities and towns whose proportions are to be determined as provided in said section.

Determination of amount to be paid by town, until included in a finding of commissioners.

SECTION 7. The metropolitan water and sewerage board, until the town of Revere has been included in a finding of commissioners appointed by the supreme judicial court, shall each year determine the amount to be paid by said town in that year as its fair share of the interest, sinking fund requirements and cost of maintenance and operation of said north metropolitan sewerage system, and the same shall be certified by the treasurer and receiver general and paid by said town as provided for payments of proportional parts of such interest, sinking fund requirements and costs by the other cities and towns in said district: *provided*, *however*, that no part of the cost of maintenance shall be assessed upon said town until its sewers are connected with the north metropolitan system as provided herein.

Proviso.

SECTION 8. This act shall take effect upon its passage. [*Approved April 16, 1903.*

[CHAPTER 315.]

AN ACT TO PROVIDE FOR EXPENSES INCURRED IN THE CONSTRUCTION BY THE METROPOLITAN WATER AND SEWERAGE BOARD OF THE SEWER FOR THE NEPONSET RIVER VALLEY.

Be it enacted, etc., as follows:

Treasurer and receiver general to issue scrip or certificates of debt, etc.

SECTION 1. The treasurer and receiver general, in order to meet additional expenses incurred under the provisions of chapter four hundred and six of the acts of the year eighteen hundred and ninety-five, and of acts in amendment thereof and in addition thereto, shall, with the approval of the governor and council, issue from time to time scrip or certificates of debt in the name and behalf of the Commonwealth and under its seal, to an amount not exceeding four thousand dollars, in addition to the amounts hitherto authorized to be issued under the provisions of said chapter and acts, and the said provisions shall apply to this additional loan.

SECTION 2. This act shall take effect upon its passage. [*Approved May 5, 1903.*

[CHAPTER 327.]

AN ACT TO AUTHORIZE THE CITIES OF CAMBRIDGE AND SOMERVILLE AND THE TOWNS OF ARLINGTON AND BELMONT TO IMPROVE THE CONDITION OF ALEWIFE BROOK, LITTLE RIVER AND WELLINGTON BROOK.

Be it enacted, etc., as follows:

Alewife brook, etc., may be improved for drainage purposes.

SECTION 1. At any time or times within five years after the passage of this act the cities of Cambridge and Somerville and the towns of Arlington and Belmont, acting by the special commission hereinafter constituted may, at their joint expense, for the purpose of surface drainage, widen, fill, clear, grade, deepen, alter the channel of, wall up, cover and otherwise improve, in whole or in part, Alewife brook from its junction with Mystic river to its junction with Little river, and Little river from its junction with Alewife brook to the Arlington line, and Wellington brook from Little river to Wellington street.

. . . .

SECTION 5. For the purpose of regulating the flow of water in the channels of said brooks and Little river, and of preventing the inflow of tide water from Mystic river into Alewife brook and upon the marshes and meadows along and in the vicinity of said brooks and Little river, said special commission shall, upon such terms and conditions as may mutually be agreed upon by said special commission and the metropolitan water and sewerage board and the metropolitan park commission, construct suitable tide-gates located near Mystic river upon land now owned by the Commonwealth of Massachusetts, and under the care and control of the metropolitan water and sewerage board and metropolitan park commission. If said special commission cannot agree with said board and said metropolitan park commission upon the terms and conditions aforesaid, the same shall be determined by the state board of health.

Tide-gates may be constructed, etc.

. . . .

SECTION 12. This act shall take effect upon its passage. [*Approved May 7, 1903.*

[CHAPTER 336.]

AN ACT TO PROVIDE AN ADDITIONAL OUTLET FOR THE SEWAGE OF THE TOWN OF BELMONT.

Be it enacted, etc., as follows:

SECTION 1. The metropolitan water and sewerage board is hereby authorized and directed to provide an outlet for the sewage of that part of the town of Belmont, approximately three hundred and thirty acres in area, situated north of Belmont street and adjoining the city of Cambridge on the westerly side of that city, and to construct for that purpose a sewer extending westerly from the existing metropolitan sewer in Mount Auburn street, at Lowell street, through Mount Auburn street to Aberdeen avenue, thence northerly through Aberdeen avenue, and westerly through Dundee street and private lands and under the Watertown branch railroad; thence westerly through Holworthy place and Holworthy street and private lands to Cushing street near Cushing avenue; and thence westerly in Cushing avenue to the Belmont line at Ericson street. The city of Cambridge shall have the right to make and maintain house connections with said additional metropolitan sewer and to connect lateral sewers therewith, in the same manner in which con-

Outlet to be provided for sewage of part of town of Belmont, etc.

City of Cambridge may make house connections with sewer, etc.

nections are made with the present sewers of that city, under the direction of the metropolitan water and sewerage board: *provided, however*, that no drain or sewer used for the conveyance of any rain water shall be connected with said sewer.

Proviso.

Metropolitan water and sewerage board to exercise certain authority, etc.

SECTION 2. In providing an outlet for the sewage of the aforesaid part of the town of Belmont and in receiving sewage from said area, and in all action relating thereto, and for the purpose of constructing and maintaining the additional metropolitan sewer, the metropolitan water and sewerage board, acting on behalf of the Commonwealth, shall have and exercise all the authority conferred upon said board by chapter four hundred and thirty-nine of the acts of the year eighteen hundred and eighty-nine, and by acts in amendment thereof and in addition thereto, regarding the original system or anything relating thereto; and all the provisions of said chapter and acts are hereby made applicable to this additional taking and construction, except as otherwise provided herein.

Treasurer and receiver general to issue scrip or certificates of debt, etc.

SECTION 3. The treasurer and receiver general, in order to meet the expenses incurred under this act, shall, with the approval of the governor and council, issue from time to time scrip or certificates of debt in the name and behalf of the Commonwealth and under its seal, to an amount not exceeding fifty thousand dollars, and any scrip or certificates of debt so issued shall be considered as in addition to the amounts authorized under said chapter four hundred and thirty-nine and acts in amendment thereof and in addition thereto, and the provisions of said chapter and acts in relation to the loan so authorized shall apply to this additional loan.

SECTION 4. This act shall take effect upon its passage. [*Approved May 9, 1903.*

[CHAPTER 356.]

AN ACT TO PROVIDE FOR EXPENSES INCURRED IN THE CONSTRUCTION BY THE METROPOLITAN WATER AND SEWERAGE BOARD OF THE HIGH-LEVEL GRAVITY SEWER FOR THE RELIEF OF THE CHARLES AND NEPONSET RIVER VALLEYS.

Be it enacted, etc., as follows:

Treasurer and receiver general to issue scrip or certificates of debt, etc.

SECTION 1. The treasurer and receiver general of the Commonwealth, in order to meet additional expenses incurred under the provisions of chapter four hundred and twenty-four of the acts of the year eighteen hundred and ninety-nine, shall, with the approval of the governor and council, issue from time to time scrip or certificates of debt in the name and behalf of the Commonwealth and under its seal, to an amount not exceeding nine hundred and ninety-six thousand dollars, in addition to the amount authorized to be issued under the provisions of said chapter; and the provisions of said chapter and of acts in amendment thereof and in addition thereto shall apply to this additional loan.

SECTION 2. This act shall take effect upon its passage. [*Approved May 15, 1903.*

[CHAPTER 383.]

AN ACT RELATIVE TO SEPARATE SYSTEMS OF DRAINAGE.

Be it enacted, etc., as follows:

Surface or storm water, etc., to be kept separate from sewage in certain cases.

SECTION 1. The owner of every estate abutting on a public way in which a drain, namely, a conduit for surface or storm water and such waters as shall be specified by the state board of health; and a sewer, namely, a conduit for all other waters and for sewage, all such other waters to be considered sewage, shall have been provided by a city or town, and the owner of any other estate, using any such drain or sewer, shall make or change the plumbing of his estate so that the waters shall be kept separate from the sewage; and shall, as directed by the officer having charge of the maintenance of sewers in such city or town, make connections for, and conduct, the waters into the drain and the sewage into the sewer.

Plumbing of certain estates to be so arranged as to keep waters separate from sewage, etc.

SECTION 2. The owner of every estate whose sewage is to be taken into any metropolitan sewer shall hereafter, in plumbing his estate, so arrange the plumbing as to keep the waters separate from the sewage, and shall, as directed by said officer, make connections for, and conduct, the waters into the drain and the sewage into the sewer; but where only one conduit shall have been provided in the street by the city or town, such owner shall, as directed by said officer, construct said connections into the street and connect them with the conduit so provided, and the city or town shall provide the other conduit and all necessary connections with either conduit.

Branch intercepting sewers, etc., to be constructed in certain cities and towns.

SECTION 3. Any city or town using any metropolitan sewer may, in any year, and shall in any year specified by the officer or board having charge of said sewers, expend one twentieth of one per cent of its taxable valuation, to be met by loan outside the debt limit, in the construction, in connection with said sewers, of branch intercepting sewers, connections of existing sewers with intercepting sewers, branch drains, sewers or drains in any street where one thereof only shall have been built, and the necessary connections aforesaid.

Enforcement of provisions.

SECTION 4. The supreme judicial court and the superior court shall have jurisdiction in equity to enforce the provisions of this act.

SECTION 5. This act shall take effect upon its passage. [*Approved May 26, 1903.*

[CHAPTER 399.]

AN ACT TO PROVIDE FOR EXPENSES INCURRED IN THE CONSTRUCTION BY THE METROPOLITAN WATER AND SEWERAGE BOARD OF THE NORTH METROPOLITAN SEWERAGE SYSTEM.

Be it enacted, etc., as follows:

Treasurer and receiver general to issue scrip or certificates of debt, etc.

SECTION 1. The treasurer and receiver general of the Commonwealth, in order to meet additional expenses incurred under the provisions of chapter four hundred and thirty-nine of the acts of the year eighteen hundred and eighty-nine, and of acts in amendment thereof and in addition thereto, shall, with the approval of the governor and council, issue from time to time scrip or certificates of debt in the name and behalf of the Commonwealth and under its seal, to an amount not exceeding two hundred and fifty thousand dollars, in addition to the amounts hitherto authorized to be issued under the provisions of said chapter and of acts in amendment thereof and in addition thereto, and the provisions of said chapter and of said acts shall apply to this additional loan.

SECTION 2. This act shall take effect upon its passage. [*Approved May 27, 1903.*

[CHAPTER 443.]

AN ACT TO AUTHORIZE THE CITY OF MARLBOROUGH TO INCUR INDEBTEDNESS FOR SEWERAGE PURPOSES.

Be it enacted, etc., as follows:

City of Marlborough may issue bonds, notes or scrip, etc.

SECTION 1. The city of Marlborough, for the purpose of constructing sewers and of extending and improving its system of sewerage and sewage disposal, may incur indebtedness to the amount of twenty-five thousand dollars beyond its debt limit as fixed by law, and in addition to the amount heretofore authorized by law for sewerage purposes; and may issue bonds, notes or scrip therefor. Such bonds, notes or scrip shall be payable within such periods, not exceeding thirty years from the dates thereof, and shall bear such rate of interest not exceeding four per cent per annum, as the city council shall determine. Except as otherwise provided herein the provisions of chapter twenty-seven of the Revised Laws and of acts in amendment thereof and in addition thereto shall, so far as they may be applicable, apply to the indebtedness hereby authorized, and to the securities issued therefor.

R. L. 27, etc., to apply.

SECTION 2. The city of Marlborough for the better protection from pollution of the metropolitan water supply, shall, within six months after the passage of this act, construct an additional main sewer in accordance with plans satisfactory to the metropolitan water and sewerage board, from a point near the junction of Maple street and Mill street in said city, to the sewerage disposal area of the city. The Commonwealth shall repay to the said city the reasonable cost of constructing such additional main sewer, and for that purpose the treasurer of the Commonwealth shall, within sixty days after the date of the completion of said sewer, upon the certificate of the metropolitan water and sewerage board, pay to the city of Marlborough said cost of construction from the funds of the Metropolitan Water Loan.

Additional main sewer to be constructed, etc.

Metropolitan water and sewerage board to approve plans.

Payment of cost.

SECTION 3. This act shall take effect upon its passage. [*Approved June 19, 1903.*

RESOLVES.

[CHAPTER 41.]

RESOLVE TO EXTEND THE TIME WITHIN WHICH THE METROPOLITAN WATER AND SEWERAGE BOARD MAY REPORT CONCERNING THE QUANTITY OF WATER SUPPLIED IN THE METROPOLITAN DISTRICT.

Resolved, That the time within which the metropolitan water and sewerage board is required by chapter three hundred and ninety-one of the acts of the year nineteen hundred and two to report concerning the quantity of water supplied to cities and towns in the metropolitan water district is hereby extended to the first day of February in the year nineteen hundred and four. [*Approved April 8, 1903.*

Time for making a certain report extended.

[Chapter 105.]

Resolve relative to an investigation of the improvement of Spot Pond brook by the Metropolitan water and sewerage board.

Improvement of Spot Pond brook.

Resolved, That the metropolitan water and sewerage board is hereby authorized and requested, in conjunction with the cities of Malden and Melrose, to re-examine the subject of the condition of Spot Pond brook and report to the next general court, not later than the fifteenth day of January in the year nineteen hundred and four, what modifications, if any, can be made in the plan submitted by said board to the general court of the year nineteen hundred and three, with a view to lessening the expense of said improvement, and what limitations shall be made as to the amount of said expense to be assessed on said cities of Malden and Melrose. [*Approved June 24, 1903.*

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AFFECTING THE

METROPOLITAN WATER AND SEWERAGE BOARD.

Appendix No. 8.

REPORT ON THE MEASUREMENT, CONSUMPTION AND WASTE OF WATER SUPPLIED TO THE METROPOLITAN WATER DISTRICT.

Made under Chapter 391 of the Acts of the Year 1902.

To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.

The Metropolitan Water and Sewerage Board presents the following report, under the provisions of chapter 391 of the Acts of the year 1902.

This Act authorized the Board to construct such works as it might deem necessary for measuring the water supplied to each of the cities and towns in the Metropolitan Water District, and required the Board to measure and report the quantity of water so supplied to each of the cities and towns, to report whether it is used therein unnecessarily or improperly, to make recommendations for the prevention of waste, and also for the apportionment of the annual assessment with a view to making the consumption of water an element in the amount to be assessed. The full text of the Act is as follows: —

Section 1. The metropolitan water and sewerage board is hereby authorized to construct and maintain such works and to provide such other means as it may deem necessary for measuring the water supplied to each of the cities and towns in the metropolitan water district, and the expenses thereof shall be considered as a part of the expenditure required for the construction and maintenance, respectively, of the metropolitan water works.

Section 2. The said board shall report to the next general court the quantity of water supplied to each of the said cities and towns, and shall also report whether water is being used therein unnecessarily or improperly, and shall make recommendations as to the manner in which waste may be prevented and as to the manner in which the consumption of water may be considered in the apportionment among the cities and towns of the annual assessment required for the construction and maintenance of the metropolitan water works.

SECTION 3. This act shall take effect upon its passage. [*Approved May 13, 1902.*

The time within which the Board should report was extended for one year by chapter 41 of the Resolves of the year 1903.

Studies, in anticipation of the passage of the Act, had been made for determining the number and size of meters which would be required for measuring the water supplied to the several cities and towns, and directly after its passage contract was made for the furnishing of Venturi meters of the various sizes as called for. Considerable time was necessarily required for the manufacture of the meters, so that it was in August, 1902, when the meters were first obtained and the installation of them was begun. A considerable portion of them were set during the latter part of that year, and the remainder were installed in the first half of the year 1903. The measurement of water was begun on January 1, 1903, through the first of these meters to be installed, and others were put into operation from time to time, so that the last of the meters was completed on June 26, since which date during a period of about six months continuous measurements have been made.

The work of providing and installing the meters was entrusted to Dexter Brackett, engineer of the Distribution Department of the Water Works; and he, with his assistants, has also made the various investigations which were required by the Act. Mr. Brackett's entire report to the Board is presented herewith for the consideration of the General Court.

Water is supplied from the Metropolitan Water Works to 18 different municipalities, having an aggregate population, as is estimated, on May 1, 1903, of 897,600. The daily average number of gallons of water supplied in the year 1903 was 107,148,000, — an average of 119 gallons per day for the use of each inhabitant of the District supplied.

The tables accompanying the report show, for the period beginning on June 28, 1903, and ending on January 2, 1904, the number of gallons of water per day furnished to each of these municipalities, and also show the number of gallons furnished per inhabitant in each city and town during that period.

It will be seen that the consumption of water per capita varies greatly in the different municipalities, the average furnished each inhabitant in this period varying from 44 gallons in Milton to 130 gallons in Boston. The consumption also largely varies in each municipality according to the season of the year. The measurements for the other half of the year, including a larger portion of the colder weather, would show a somewhat greater consumption, and would also show a still greater variation in the different periods. In the cold weather early in January of the present year the consumption in the District rose in one day to 160,000,000 gallons, equivalent to 175 gallons per inhabitant. A corresponding but much smaller maximum consumption occurs in the driest periods of summer.

The differences in the rate of consumption of water in the various municipalities of the District are to some extent due to the different uses to which water is applied, a greater consumption being naturally required in those municipalities where water is more largely used for manufacturing, mechanical and trade purposes.

The water supplied by the Metropolitan Water Works is taken and used for: —

(1) Domestic purposes.

(2) Manufacturing, mechanical and trade purposes.

(3) Public purposes.

A careful and extended study has been made of the actual consumption of water as required for all these uses in the District, and the conclusion has been reached that the amount actually required and consumed for all necessary and legitimate uses does not exceed 60 gallons per inhabitant per day. Inasmuch as the daily amount actually supplied to the District was at the rate of 119 gallons per inhabitant, it would follow that about one-half of the entire supply was lost by waste or leakage, or was unnecessarily or improperly consumed. The investigations made conclusively indicate that there is, as a matter of fact, such loss and unnecessary use.

There are chiefly two causes of this loss and unnecessary use.

A large amount of water is lost by leaks from broken main and service pipes which form the supply system of each city and town, and by the existence of defective joints connecting the separate pipes. The pipes being underground, the defects often remain for a long period undiscovered, and large quantities of water flow into the ground.

A still larger loss of the water supplied is suffered on the premises of the individual water takers. Leakages arising from defective plumbing and improper fixtures are permitted to exist, by which there is a constant escape of water; continuous streams are purposely allowed to run during the winter, to prevent the pipes from freezing; and during the hot weather much water is allowed to run, in order to obtain water for drinking.

It is impossible to keep pipes and fixtures absolutely tight and in order, and to prevent all waste underground and in buildings, but by far the larger part of this loss is preventable, and in certain municipalities has been prevented.

The losses and misuse of water occur principally in the local systems of distribution, over which the Metropolitan Water and Sewerage Board has no control. To prevent such losses and misuse, constant and efficient inspection and enforcement of regulations are required on the part of all local authorities. It is doubtful whether such inspection and enforcement can be uniformly secured, unless both the municipality and the individual water taker are made to become pecuniarily interested in the result. The measurement of water supplied has been found not only the best means for the detection of waste, but also, when made an element in the fixing of water rates, an efficient means of prevention.

The experience of cities and towns outside of this District has invariably been that the introduction of the element of measurement to water takers has been attended by a decreased and more normal consumption. A like result has been demonstrated by the experience of four municipalities within the District. In the towns of Belmont and Milton all the services are metered, in the town of Watertown 89.5 per cent. of the services are metered, and in the city of Malden 63.4 per cent. are metered. In all the other municipalities of the District the metered services constitute only from .5 to 9.3 per cent. of the entire number. The rate of consumption in the above-named four municipalities was for the period observed not only low, being 47, 44, 49 and 47 gallons per inhabitant, as against an average per capita consumption of 116 gallons in the remainder of the District, but notably uniform.

The investigations demonstrate that it is within the power of the municipalities largely to check the unnecessary use and waste of water.

It is also shown that the payment of meter rates does not bear hard upon any class of water takers. The imposition of a minimum rate for metered water, somewhat lower than is now charged where rates are fixed according to the fixtures in use, as is usually done, would give the taker an amount of water found liberal for necessary domestic use. The larger takers are now generally supplied at meter rates.

The providing of inspectors and installation of meters involve considerable expenditures on the part of the municipalities providing them. Under the present system of assessments, by which the quantity of water received and consumed by a municipality has no special influence in fixing the amount which it has to pay, there is no direct financial encouragement to strive to stop waste and leakage. The city of Boston, which pays about 80 per cent. of the entire assessment, may be said to have a material return for the expenditures which it makes for this purpose; but the laudable efforts of the other municipalities in the District meet but a slight financial reward through the general saving effected by their separate action. It seems that, if any municipality energetically proceeds to reduce consumption within its limits to a reasonable amount, it should have the benefit of a corresponding decrease in the amount which it has to pay for water.

Under the Metropolitan Water Act an annual assessment is imposed upon the District, sufficient to meet the expenses of maintenance, the interest on the indebtedness for construction, and the sinking fund requirements. The city of Boston is required to pay such proportion of the entire assessment as its valuation bears to the total valuation of the District. The remainder of the assessment is apportioned to the other cities and towns, one-third in proportion to their respective valuations, and two-thirds in proportion to their respective populations.

The Act called for a larger proportional payment from Boston because its main works of supply were taken and paid for by the District; while, with some small exceptions, the similar works of other cities and towns were not taken, but were left of little value to them.

The Board has in its annual reports repeatedly called attention to the necessity of taking measures for reducing the unnecessary consumption of water, and the desirability of making the amount of consumption an element, not only in fixing the amount of assessment to be imposed upon each municipality, but also in fixing the water rates of each individual water taker, so that each municipality and each individual taker should have a direct pecuniary interest in checking waste and excessive use. In its report made on January 1, 1902, it suggested, as a step in this direction, that, in the cities and towns in which population was an element in determination of the assessment, consumption should be substituted for population, so that in the municipalities outside of Boston the assessment should be based, one-third in proportion to valuation and two-thirds in proportion to consumption.

The results of the investigations have confirmed the Board in the opinion which it had previously maintained. Inasmuch as municipalities are called upon to contribute in general to the cost of public works according to their respective valuations, it may be wise to continue, in accordance with the provisions of existing legislation, to make valuation, to a certain extent, an element in fixing the respective assessments of the municipalities. The Board is strongly of the opinion that, at least, the assessments of the cities and towns outside of Boston should be based two-thirds upon the basis of consumption, and that the consumption should be an element, though perhaps to a less degree, in the city of Boston. In order to assist in determining what basis of apportionment may properly be adopted, various tables are given, showing the respective assessments which would be made upon the municipalities upon various bases of apportionment.

The Board has hitherto urged that the great unnecessary consumption of water is not only causing larger annual expenditures for maintenance and operation, but is hastening the time when great expenditures must be incurred for new sources of supply, new pumping facilities, new aqueducts, new reservoirs, new mains and all other equipment. Such unnecessary consumption is also hastening the time when corresponding expenditures must be incurred for new works for the disposal of sewage.

It is estimated that, if the present rate of consumption is unchecked, the present sources of water supply will become inadequate within the period of ten years; so that, in a comparatively few years after the works now in progress are completed, construction of additional works will have to be provided for. If, on the other hand, unnecessary consumption is prevented, as is believed possible, such additional construction may be deferred for considerably more than twenty years.

It is believed that such early expenditures as may be required for inspection and for measurement of water will be within a reasonable period offset by the saving which will result. Not only efforts for the reduction of the consumption would seem demanded for the interests of the municipalities of the Metropolitan District and the individual water takers, but the Metropolitan District cannot properly ask other portions of the Commonwealth to submit to burdens and sacrifices in order to provide the cities and towns of the Metropolitan District with a supply of water, unless the District itself takes all reasonable efforts to make such burdens and sacrifices as light as possible.

The Board requests an especial and full consideration of the statements and results given by Mr. Brackett in his report, and a careful examination of the tables and diagrams which accompany it.

Respectfully submitted,

HENRY H. SPRAGUE,
HENRY P. WALCOTT,
JAMES A. BAILEY, Jr.,
Metropolitan Water and Sewerage Board.

February 11, 1904.

Report of the Engineer of the Distribution Department.

To the Metropolitan Water and Sewerage Board.

Gentlemen: — The following report contains the results of work done and investigations made under authority of chapter 391 of the Acts of the General Court for the year 1902, which authorized the construction of works for measuring the water used in each of the cities and towns in the Metropolitan Water District, and directed the Board to report the quantity supplied to each of the cities and towns, and also whether water is being unnecessarily or improperly used, and to make recommendations regarding the prevention of waste, and the manner of apportioning the annual assessment among the cities and towns.

The Metropolitan Water Works supply water to 18 cities and towns, having, on May 1, 1903, an estimated aggregate population of 897,600, and comprising a territory of 142.7 square miles in area, the greater portion of which lies within a radius of 10 miles from the State House. Topographically, the part of this territory where the greater portion of the water is used is less than 50 feet above sea level. The greater part of the area included in the several municipalities is, however, at a higher elevation, and at one point in the town of Milton it rises to elevation 640 above Boston city base. Other summits in the District are: Arlington Heights, elevation 377; Bellevue Hill, in West Roxbury, elevation 340; and Bear Hill, in Stoneham, elevation 315.

The area, population, number of service pipes, meters and mileage of pipe in use in the several cities and towns are shown by Table No. 1.

TABLE NO. 1.

City or Town.	Area (Square Miles).	Estimated Population, May 1, 1903.	Number of Services, January, 1903.	Number of Meters, January, 1903.	Per Cent. of Services metered.	Miles of Pipe.
Boston,	38.2	597,900	89,384	4,617	5.2	723.0
Somerville,	4.2	67,600	10,710	271	2.5	82.5
Malden,	4.9	36,900	6,700	4,245	63.4	82.0
Chelsea,	2.3	35,900	6,257	113	.2	38.7
Everett,	3.4	28,000	4,670	49	1.0	42.0
Quincy,	16.5	26,800	4,850	152	3.1	83.7
Medford,	7.1	21,000	4,039	124	3.1	50.4
Melrose,	5.1	13,900	3,221	95	3.0	44.5
Revere,	5.9	12,700	2,261	28	1.2	34.5
Watertown,	4.1	10,800	1,692	1,515	89.5	30.1
Arlington,	5.2	9,700	1,700	94	5.5	34.3
Milton,	12.9	7,400	1,078	1,078	100.0	35.0
Winthrop,	1.6	7,300	1,747	9	.5	22.7
Stoneham,	6.6	6,400	1,157	19	1.7	19.9
Belmont,	4.6	4,800	621	621	100.0	17.9
Lexington,	16.0	4,100	620	4	.6	11.7
Nahant,	1.0	1,300	462	43	9.3	15.9
Swampscott,	3.1	5,100	1,055	-	-	17.2
	142.7	897,600	142,224	13,077	9.2	1,386.0

Previous to the formation of the Metropolitan Water District nearly all of these cities and towns drew their supplies from different sources, and maintained separate reservoirs and pumping stations. Since the construction of the Metropolitan Works eleven sources of supply have been abandoned, and the pumping, which was formerly done at twenty stations, is now done at five stations. All water delivered by the Sudbury and Cochituate aqueducts is delivered by gravity into Chestnut Hill Reservoir, whence it is raised by pumping machinery to different elevations supplying separate districts. The water delivered by the Weston Aqueduct, which was completed and placed in service on December 29, 1903, is discharged directly into the low-service mains without any pumping.

For the southern low-service district, comprising the lower portion of the city of Boston, excepting in Charlestown and East Boston, the pressure at the pumping station at Chestnut Hill is maintained so as to deliver water in the city at an elevation of about 130 feet above Boston city base at all times during day and night.

For the northern low-service district, including the lower portion of the cities of Somerville, Medford, Malden, Everett, Chelsea, and for Charlestown and East Boston, water is pumped into Spot Pond at elevation 163 above Boston city base.

For the southern high-service district, comprising Quincy, Watertown and Belmont, and the higher portion of the city of Boston, water is pumped from Chestnut Hill to the Fisher Hill and Waban Hill reservoirs. High-water mark in the Fisher Hill Reservoir is at elevation 251, and in Waban Hill Reservoir 264.5 feet above Boston city base.

For the northern high-service district, comprising the city of Melrose, the towns of Revere, Winthrop, Nahant, Swampscott and Stoneham and the higher portions of the cities of Somerville, Medford, Malden, Everett and Chelsea, water is pumped from Spot Pond to the Fells Reservoir at elevation 271, and to Bear Hill Reservoir at elevation 300. The town of Stoneham alone is supplied from the Bear Hill Reservoir.

For the town of Lexington and the higher portion of the town of Arlington, water is pumped from the low-service mains in Arlington to a standpipe on Arlington Heights at elevation 443. For the higher portion of the town of Milton and of the West Roxbury district of Boston, water is pumped to a standpipe on Mt. Bellevue, in West Roxbury, at elevation 376.

For the year 1902 the percentage of the total consumption used in the several districts was as follows: —

Southern low-service district,	40.0
Northern low-service district,	25.0
Southern high-service district,	27.0
Northern high-service district,	7.4
Northern extra high-service district,	.3
Southern extra high-service district,	.3

Table No. 2 shows the revenue received from water rates for the year 1902 in the several cities and towns supplied by the Metropolitan Works.

TABLE No. 2.

CITY OR TOWN.	Revenue from Water Rates. Received from Private Consumers.	Received from Municipalities.	Total.	Revenue from Metered Water.	Per Cent. of Revenue from Metered Water.
Boston,	$2,306,191 98	*–	$2,306,191 98	$1,005,312 26	43.6
Somerville,	213,965 51	*–	213,965 51	50,733 53	23.7
Chelsea,	100,468 03	$6,821 00	107,289 03	23,629 86	22.0
Malden,	95,968 95	1,143 29	97,112 24	68,403 08	70.5
Everett,	80,827 74	674 40	81,502 14	23,284 50	28.6
Quincy,	78,093 48	*–	78,093 48	14,452 65	18.5
Medford,	53,549 53	6,148 72	59,698 25	6,667 48	11.2
Melrose,	49,990 22	*–	49,990 22	3,041 54	6.1
Revere,	† 32,382 93	5,117 07	† 37,500 00	1,511 95	4.0
Watertown,	31,196 88	*–	31,196 88	30,034 88	96.3
Arlington,	35,721 89	*–	35,721 89	4,065 98	11.4
Milton,	27,694 68	11,155 70	38,850 38	38,850 38	100.0
Winthrop,	† 27,818 08	4,681 92	† 32,500 00	293 71	.9
Stoneham,	19,246 35	2,400 00	21,646 35	2,123 95	9.8
Belmont,	11,840 51	452 51	12,293 02	12,293 02	100.0
Lexington,	9,729 87	4,630 99	14,360 86	736 42	5.1
Nahant,	6,382 47	800 00	7,182 47	791 96	11.0
Swampscott,	17,104 33	1,435 50	18,539 83	–	–
	$3,198,173 43	$45,461 10	$3,243,634 53	$1,286,227 15	39.7

* No revenue received for water used for municipal purposes. † Estimated.

MEASUREMENT OF WATER CONSUMED.

Before measurements and investigations could be made to determine the quantity of water used and wasted, it was necessary to provide means for measuring the water supplied to the several cities and towns. Previous to May 13, 1902, when the Act authorizing such measurement was approved, studies had been made to determine the best method of measuring the water used, and on June 20, 1902, a contract was made with the Builders Iron Foundry of Providence, R. I., for furnishing 42 Venturi meters, in sizes from 8 inches to 48 inches. These, with 3 meters previously purchased and set, and 4 meters which were subsequently ordered, make 49 meters which have been placed at the following points on the pipes supplying the several cities and towns: —

District supplied by Meter.	Location of Meter.	Size of Meter (Inches).
Arlington, . .	Medford Street, at Parallel Street, ...	20
Belmont, . .	Common Street, at Belmont Street, ...	12
Boston (2 meters),	Low-service pumping station, Chestnut Hill Reservoir, . . .	48
Boston, . . .	Boylston Street, Brookline, ...	48
Boston, . . .	Brookline Reservoir grounds, Brookline, ...	30
Boston, . . .	Chestnut Hill Reservoir, near effluent gate chamber, ...	48
East Boston, . .	Condor Street, at Brooks Street, ...	24
Brighton, . .	Chestnut Hill Avenue, at Beacon Street, ...	16
Charlestown, . .	Broadway, at Walnut Street, Somerville, ...	24
Charlestown, . .	Pearl Street, at Walnut Street, Somerville, ...	30
Charlestown, . .	Broadway, Chelsea, near North Bridge, ...	10
Dorchester, . .	Morton Street, at Blue Hill Avenue, ...	16
Dorchester, . .	River Street, at Morton Street, ...	12
West Roxbury, .	Arborway, at South Street, ...	20
Chelsea, . . .	Powder Horn Hill, at Chelsea Reservoir, ...	16
Chelsea, . . .	Second Street, at Broadway, ...	24
Chelsea, . . .	Second Street, Everett, at Locust Street, ...	12
Everett, . . .	Broadway, at Hancock Street, ...	16
Everett, . . .	Main Street, at Wyllis Avenue, ...	12
Everett, . . .	Broadway, at Corey Street, ...	20
Lexington, . .	Massachusetts Avenue, at Arlington-Lexington line, ...	12
Malden, . . .	Highland Avenue, at Clifton Street, ...	16
Malden, . . .	Hancock Street, at Cross Street, ...	12
Malden, . . .	Washington Street, at Winter Street, ...	16
Malden, . . .	Clifton Street, at Washington Street, ...	16
Malden, . . .	Medford Street, at Pearl Street, ...	12
Malden, . . .	Medford Street, at Green Street, ...	16
Medford, . .	Governors Avenue, at High Street, ...	10
Medford, . .	Boston Avenue, at College Avenue, ...	8
Medford, . .	Governors Avenue, at High Street, ...	20
Medford, . .	Jerome Street, at High Street, ...	10
Melrose, . . .	Ravine Road, right of way to Melrose Reservoir, ...	20
Milton, . . .	Adams Street, at Canton Avenue, ...	12
Nahant, . . .	Beach Road, at Nahant-Lynn line, ...	8
Quincy, . . .	Adams Street, at Beale Street, ...	24
Revere, . . .	Prospect Avenue, at Revere Reservoir, ...	12
Somerville, . .	Boston Avenue, at Professors Row, ...	12
Somerville, . .	Cedar Street, at Broadway, ...	16
Somerville, . .	Broadway, at Willow Avenue, ...	16

DISTRICT SUPPLIED BY METER.	Location of Meter.	Size of Meter (Inches).
Somerville, . .	Medford Street, at Central Street, ...	12
Somerville, . .	Pearl Street, at Walnut Street, ...	16
Somerville, . .	Broadway, at Marshall Street, ...	12
Somerville, . .	Webster Avenue, near Newton Street, ...	20
Somerville, . .	Willow Street, at Elm Street, ...	16
Swampscott, . .	Ocean Street, at Nahant Road, ...	12
Stoneham, . .	High-service pumping station, Spot Pond, ...	24
Watertown, . .	Mount Auburn Street, near Irving Street, ...	16
Winthrop, . .	Atlantic Avenue, at Crescent Avenue, ...	16

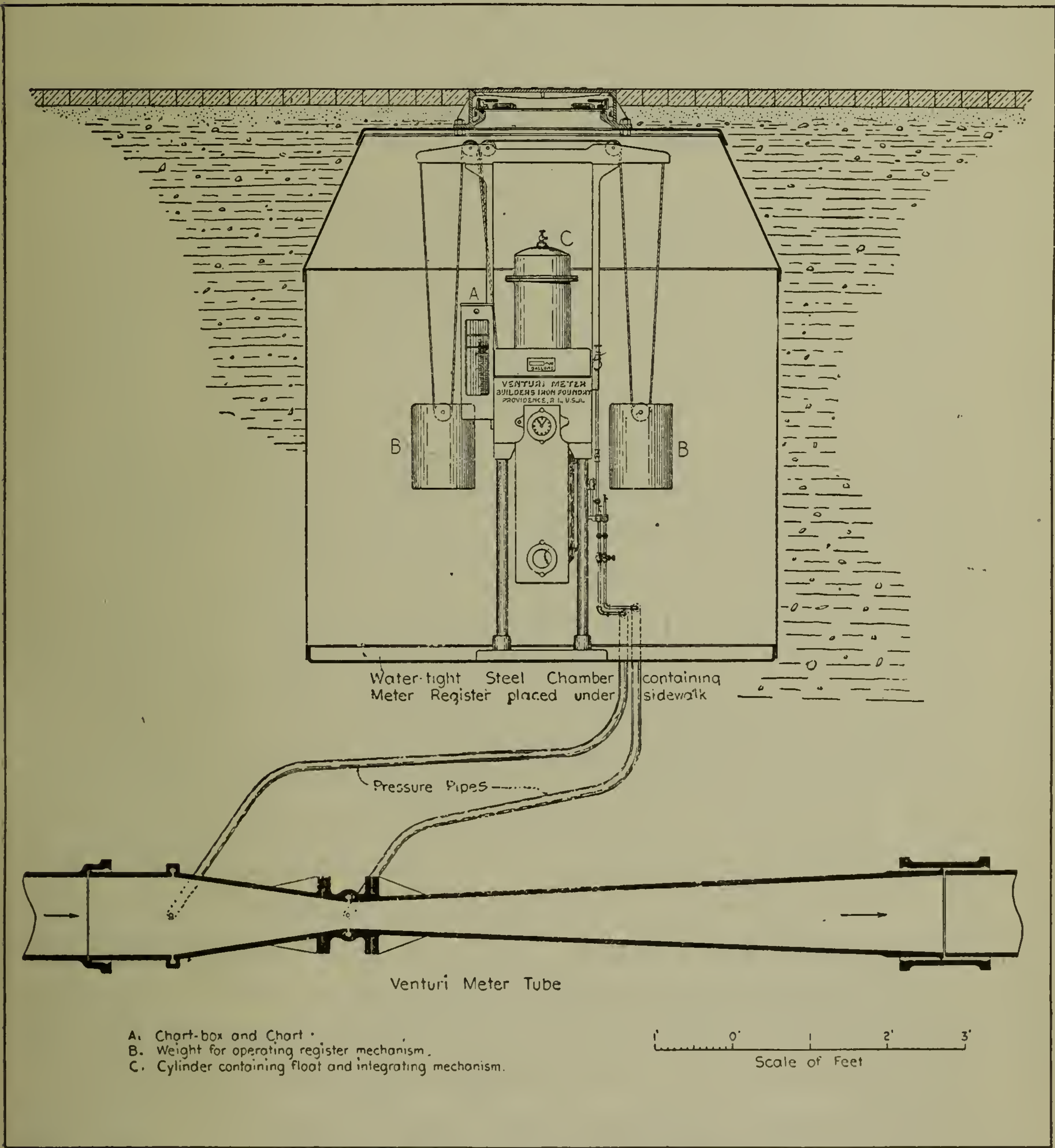
The work of setting the meters was begun in August, 1902, and continued as fast as the meters were received, until the middle of December, 1902, when the work was stopped by cold weather. It was resumed in March, 1903, and continued until June 27, when all meters required for measuring the water used in the 18 cities and towns supplied by the Metropolitan Works had been set. The cost of the work to date has been $74,088.54. This amount does not include the cost of 2 48-inch, 1 36-inch, 1 24-inch and 2 16-inch meters purchased and set previous to the passage of the Act.

Although 24 of the meter tubes were set during the year 1902, the manufacturers did not deliver any of the registering apparatus until early in 1903; and it was not until January 24 that any of the meters purchased in 1902 were placed in service.

Continuous measurements of the consumption in the several cities and towns have been made since the following dates: —

Stoneham, . . .	January 1	Milton, ...	February 28
Melrose, ...	January 24	Chelsea, ...	April 11
Medford, . . .	February 3	Quincy, ...	May 8
Everett, ...	February 6	Nahant, ...	June 18
Revere, ...	February 13	Swampscott, . . .	June 18
Malden, ...	February 16	Arlington, . . .	June 19
Watertown, . . .	February 16	Lexington, . . .	June 19
Belmont, ...	February 20	Somerville, . . .	June 24
Winthrop, . . .	February 26	Boston, ...	June 26

The Venturi meter is entirely different in principle, design and operation from the water meters in general use for measuring water used by water takers. The meter proper consists of two truncated



VENTURI METER AND REGISTER CHAMBER.

cones of cast iron, joined at the smallest diameter by a short throat piece of cast iron lined with brass, having a diameter varying in different meters from one-quarter to one-half of the diameter of the large ends of the cones, the three parts making what is known as the meter tube. At the up-stream end and at the throat small holes are drilled into the tube, from which pipes are carried to the register. The operation of the meter is due to the fact that when water is flowing through the tube the pressure at the throat is less than at the up-stream end, and that the difference in pressure is dependent upon the quantity of water flowing through the tube. The differing pressures at the up-stream end and throat of the meter tube are transmitted through small pipes to the register, which can be located at any convenient point within 300 or 400 feet of the tube. In the register the differences of pressure affect the level of a column of mercury which carries a float. The position of this float is thus made dependent upon the quantity of water passing through the meter; and by suitable mechanism the quantity is recorded by a counter, and the rate of flow at intervals of ten minutes is recorded upon a roll of paper, so that the fluctuations in the flow throughout each day can be observed. Although the pressure at the throat of the meter is often several pounds less than at the inlet or up-stream end, the lost pressure is nearly all regained by the time the water reaches the outlet end of the tube, so that the net loss of pressure caused by the meter is seldom more than one pound, under ordinary conditions of use.

This type of meter is well adapted for measuring large volumes of water through pipes in which the maximum rate of flow does not exceed eight or ten times the minimum rate. The smallest rate of flow recorded by the 8-inch meters is 50,000 gallons per day, and the 48-inch meters record flows at the rate of 60,000,000 gallons during the same time. Comparisons of the water used in the Metropolitan District, as determined by current meter measurements of the flow in the aqueducts, by displacement of the plungers on the pumping engines and by the Venturi meters, indicate that the meters probably give results which are accurate within 2 per cent. Facsimile copies of records made by the meters, showing the rate of consumption in some of the districts, are shown on diagram 9.

The daily average quantity of water used in each of the cities and towns during each month since June 30, 1903, is given in the following table (No. 3), and in a table appended to this report will be found the daily average for each week.

TABLE NO. 3. — *Daily Average Consumption of Water in Cities and Towns supplied from Metropolitan Works as measured by Venturi Meters.*

CITY OR TOWN.	July.		August.		September.		October.		November.		December.	
	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.	Gallons per Day.	Gallons per Capita.
Boston, . .	76,616,200	128	75,322,600	125	77,172,100	128	76,815,100	128	77,201,700	128	85,284,400	141
Somerville, . .	5,944,600	88	5,357,300	79	5,630,900	83	5,424,500	79	5,267,100	77	5,863,200	85
Malden, . .	1,883,800	51	1,764,800	48	1,913,600	51	1,742,700	47	1,620,500	43	1,653,300	44
Chelsea, . .	3,330,000	93	3,195,900	89	3,190,300	88	3,194,700	88	3,218,200	89	4,150,200	115
Everett, . .	2,169,800	77	2,188,200	77	2,260,100	80	2,209,200	78	2,350,800	82	2,636,700	92
Quincy, . .	2,670,900	99	2,397,000	89	2,392,400	88	2,273,300	84	2,252,400	83	2,475,800	91
Medford, . .	1,693,200	81	1,572,800	75	1,753,600	84	1,647,500	78	1,594,000	75	1,659,400	78
Melrose, . .	1,469,300	105	1,403,500	100	1,442,800	103	1,414,600	101	1,341,300	95	1,304,600	93
Revere, . .	868,500	67	859,400	66	813,100	62	704,800	53	691,700	52	824,500	62
Watertown, .	578,100	53	549,400	50	560,400	51	525,800	48	496,600	45	480,200	44
Arlington, . .	799,700	82	640,200	65	501,900	51	554,300	56	531,300	54	567,600	57
Milton, . .	338,500	46	335,700	45	365,500	49	319,900	43	327,900	44	272,100	36
Winthrop, . .	738,300	100	758,200	102	694,100	93	602,800	80	564,500	75	640,700	84
Stoneham, . .	483,600	76	505,600	79	458,700	72	441,700	69	445,200	70	475,600	74
Swampscott, .	713,100	94	715,100	94	592,500	83	457,100	74	347,500	67	338,600	65
Belmont, . .	208,800	43	229,000	47	252,100	52	243,000	50	226,100	46	215,200	44
Lexington, . .	267,800	74	278,800	78	309,000	86	233,900	65	181,200	50	185,500	52
Nahant, . .	317,600	83	237,300	62	194,600	58	86,100	37	41,600	31	52,900	39
	101,091,800	112	98,310,800	108	100,497,700	111	98,891,000	109	98,699,600	109	109,080,500	120

The total consumption of the District, as given in the preceding table, is about $2\frac{1}{2}$ per cent. less than the consumption as measured by the displacement of the pump plungers at the pumping stations. The difference includes the quantity used in all of the pumping stations and the leakage from the Metropolitan mains and reservoirs. This use and leakage is estimated to be not less than 500,000 gallons per day.

It will be noticed that there are great differences in the per capita use in the several municipalities. To some extent these differences can be explained by the difference in the class of takers supplied; but, excepting the five larger cities, where the manufacturing and trade use is considerable, it is safe to assume that where the consumption per capita is more than 50 gallons per day the excess is wasted.

Investigations have been made to determine the amount of water used in the several municipalities for domestic purposes, for manufacturing, mechanical and trade purposes, and for public purposes; also to ascertain the various ways in which water is unnecessarily used or wasted.

Use of Water for Domestic Purposes.

The term "domestic use" will, for the purposes of this report, be understood to include not only the strictly household use, but also the water used for private stables and watering lawns. The best information regarding the quantity used for these purposes is obtained from the records of the cities and towns where all or a large percentage of the water takers are supplied through meters. Within the Metropolitan District there are about 8,500 meters supplying water for domestic purposes. In the towns of Belmont and Milton every service pipe is metered; in Watertown, 89.5 per cent.; and in Malden, 63.4 per cent.

The average daily quantity of water used for domestic purposes as measured by meters in each of these municipalities during the years 1901 and 1902 was as follows: —

CITY OR TOWN.	Number of Consumers.		Gallons per Day.		Gallons per Day per Consumer.	
	1901.	1902.	1901.	1902.	1901.	1902.
Belmont,	3,600	3,900	63,760	66,630	17.7	17.1
Malden,	21,100	22,550	414,030	450,160	19.6	20.0
Milton,	6,850	7,450	115,000	143,500	16.8	19.3
Watertown,	9,650	10,250	147,200	152,900	15.3	14.8
	41,200	44,150	739,990	813,190	18.0	18.4

The above quantities include water used for stables supplied in connection with dwellings and that used for lawn sprinkling, as well as that used strictly for household purposes. In all these municipalities the meters have been in use but a comparatively few years, and it is not probable that they have become worn so as to cause a large percentage of error in registration. The experience in other cities and towns where meters are in general use on domestic services corroborates the results obtained in the Metropolitan District.

Table No. 4 gives the per capita metered consumption for the year 1902 in several places where all or a large percentage of the water used is metered.

Table No. 4.

CITY OR TOWN.	Estimated Number of Consumers.	Per Cent. of Services metered.	Total Daily Average Metered Consumption (Gallons).	Gallons per Consumer per Day.		
				Domestic.	Manufacturing.	Totals.
Brockton,	37,800	90.0	822,670	13.2	8.5	*21.8
Fall River,	107,650	96.0	2,607,100	15.5	5.2	*22.2
Newton,	35,400	86.0	1,202,740	23.1	4.6	*34.0
Ware,	7,690	100.0	203,430	25.4	1.1	26.5
Woonsocket, R. I.,	34,474	86.7	762,380	11.6	10.5	22.1
Wellesley,	5,147	100.0	132,540	25.6	.1	25.7
Worcester,	119,330	94.5	4,331,030	16.1	17.8	*36.3
Yonkers, N. Y.,	51,000	98.7	2,413,380	19.7	22.0	*42.7
	398,491	-	12,475,270	16.7	-	-

* Includes water used for public purposes.

The statement sometimes made that the greatest use or waste of water is to be found in the cheapest class of houses is not substantiated by the results obtained where water is supplied by meter. On the contrary, experience seems to indicate that the per capita use of water for domestic purposes increases with the value of the property supplied.

This is illustrated by the following tables (Nos. 5 and 6), the first of which gives the per capita consumption in tenement houses in the city of Boston during the year 1902, and the second the per capita consumption in houses of differing value in other cities: —

TABLE NO. 5. — *Use of Water in Tenement Houses in Boston during 1902.*

WARD.	Number of Houses.	Number of Families.	Number of Persons.	Gallons per Day. Per Family.	Gallons per Day. Per Capita.	Monthly Rental.
Ward 6,	21	263	1,226	115	24.8	$12 to $16
Ward 7,	8	75	365	71	14.5	12 to 16
Ward 7,	13	155	755	64	13.2	16 to 20
Ward 8,	15	131	625	113	23.7	16 to 20
Ward 9,	20	171	758	92	20.7	12 to 20
Ward 8,	12	116	553	141	29.6	20 to 25
Ward 8,	10	88	420	138	29.0	25 to 30
Ward 10,	21	209	949	150	33.1	25 to 30
Ward 10,	20	250	1,135	200	43.9	30 to 40
Ward 11,	10	111	545	190	38.7	25 to 45
Ward 11,	10	89	437	194	39.5	35 to 55
Ward 11,	9	81	398	218	44.4	50 upwards
	169	1,739	8,166	139	29.63	-

TABLE NO. 6. — *Domestic Consumption per Capita in Newton, Fall River, Worcester and London, Eng., as determined by Meter Measurement.*

CITY OR TOWN.	Number of Houses.	Number of Families.	Number of Persons.	Consumption (Gallons). Per Family.	Consumption (Gallons). Per Capita.	Remarks.
Newton,	490	490	2,450	132.5	26.5	All houses supplied with modern plumbing.
Newton,	-	619	3,005	-	6.6	These families have but one faucet each.
Newton,	-	278	1,390	34.5	6.9	These families have but one faucet each.
Fall River,	28	34	170	127.5	25.5	The most expensive houses in the city.
Fall River,	64	148	740	42.0	8.4	Average class of houses, generally having bath and water-closet.
Worcester,	-	81	327	80.2	19.9	Woodland Street, best class of houses.
Worcester,	-	37	187	118.1	23.4	Cedar Street, best class of houses.
Worcester,	-	93	447	95.0	19.8	Elm Street, houses of moderate cost.
Worcester,	-	245	1,104	55.1	12.2	Southbridge Street, cheaper houses.
Worcester,	-	229	809	55.0	15.6	Austin Street, cheaper houses.
London, Eng.,	1,169	-	8,183	-	25.5	Houses renting from $250 to $600; each have bath and two water-closets.
London, Eng.,	727	-	5,089	-	18.6	Middle class, average rental, $200.

During the past thirty years the number of water fixtures has increased much faster than the population. In Boston, for example, the average number of fixtures per capita increased from .523 in 1870 to 1.165 in 1900, so that the opportunities for the use and waste of water were greatly increased. It is probable that there is likely to be still further increase in the use of water for domestic purposes, even though it be supplied and paid for by meter measurement; but it does not seem probable that the quantity needed will exceed 25 gallons per capita for many years to come.

Use of Water for Manufacturing, Mechanical and Trade Purposes.

The use of water for manufacturing, mechanical and trade purposes varies to a wide degree in different municipalities, depending upon the extent of business and trade and upon the character of the purposes for which water is used. The manufacturing and trade use in the Metropolitan Water District is centered in Boston, although the per capita use for these purposes is quite large in several other cities and towns.

The greater portion of the water used for manufacturing and trade in the Metropolitan District is supplied through meters, and the metered use in the several municipalities for these purposes during the year 1902 was as follows: —

TABLE NO. 7. — *Water supplied through Meters for Manufacturing, Mechanical and Trade Purposes, during the Year 1902.*

[Gallons per capita per day.]

	Boston.	Somerville.	Chelsea.	Malden.	Everett.	Quincy.	Medford.	Melrose.	Revere.	Watertown.	Arlington.	Milton.	Winthrop.	Stoneham.	Belmont.	Lexington.	Nahant.	Swampscott.	Metropolitan District.
Bakeries,	.07	.06	.18	-	.04	-	-	.03	-	-	-	-	-	-	-	-	-	-	.06
Breweries and bottling,	.96	.10	-	-	.04	-	-	-	-	-	-	-	-	-	-	-	-	-	.65
Electric companies,	1.73	.62	-	1.40	-	.31	-	-	1.42	-	-	-	-	-	-	.58	-	-	1.29
Elevators and motors,	1.70	.09	.04	.08	.02	-	.08	.07	.01	-	-	.04	.03	-	.03	-	-	-	1.16
Factories and machine shops,	2.10	.73	6.15	.85	.37	2.03	.48	.19	-	1.91	.09	.11	-	1.74	-	-	-	-	1.86
Farms and greenhouses,	.04	.02	-	.04	-	.02	.02	.16	.10	1.06	4.12	.01	-	.23	4.76	-	-	-	.12
Gas works,	.31	-	.05	.11	13.46	-	-	-	-	-	.23	-	-	-	-	.28	-	-	.63
Hotels,	2.70	.07	.13	.08	-	.06	.08	.16	.16	-	.18	-	-	-	-	-	-	-	1.83
Iron works,	.29	.01	.35	-	1.22	-	-	-	-	-	-	-	-	-	-	-	-	-	.25
Laundries,	.41	-	.12	.01	.05	-	.29	.08	-	-	-	.02	-	-	-	-	-	-	.29
Offices and stores,	5.12	.39	.12	.70	.23	.28	.63	.19	-	.64	.41	.07	-	-	.03	-	-	-	3.53
Oil and chemicals,	.12	.16	.06	.06	2.61	-	.68	.04	-	-	.02	-	-	-	-	-	-	-	.19
Railways,	5.62	5.63	2.62	.04	.04	-	1.03	.17	-	.66	.67	.01	-	1.17	.19	1.67	-	-	4.35
Restaurants and saloons,	.85	-	-	-	.11	-	-	-	-	-	-	-	-	-	-	-	.10	-	.57
Shipping,	.77	.10	1.25	.06	-	.10	-	-	-	-	-	-	-	-	-	-	.27	-	.57
Slaughtering,	.09	5.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.46
Stables,	.59	.48	1.27	.15	.19	.01	.15	.45	-	-	-	.36	-	.18	.05	-	1.21	-	.51
Sugar refineries,	1.12	-	-	-	-	2.32	-	-	-	-	-	-	-	-	-	-	-	-	.82
Miscellaneous,	.30	.11	.01	.35	.22	1.58	.45	-	.19	-	.38	4.07	.14	-	-	-	-	-	.33
Totals,	24.90	13.98	12.38	3.93	18.61	6.72	3.89	1.54	1.88	4.27	6.11	4.69	.17	3.34	5.06	2.52	1.58	-	19.47

Careful estimates of the quantity of water used for these purposes, which is not metered, indicate that the amount is not more than 5 gallons per capita in Boston and from 2 to 3 gallons per capita in other cities and towns in the District, with an average of about 4 gallons for the whole District. This quantity, added to the quantity supplied through meters, gives about 23.5 gallons per capita per day required at the present time for manufacturing, mechanical and trade purposes in the Metropolitan Water District.

In other cities of the United States there exists a wide difference in the amount of water used from the public water supplies for manufacturing and mechanical purposes, depending upon the character of the manufacturing carried on or the rates charged for water, and upon other local conditions.

The following table (No. 8) gives the total metered consumption in 1902 in several of the largest cities of the United States, where very little or none of the water supplied for domestic use is metered: —

TABLE NO. 8.

CITIES.	Number of Meters.	Daily Average Metered Consumption (Gallons).	Per Cent. of Services metered.	Gallons per Capita.	Gallons per Metered Service per Day.
Boston,	5,381	17,521,400	6.03	29.90	3,393
St. Louis, Mo.,	4,635	15,149,000	6.41	23.30	3,495
Baltimore, Md ,	2,182	13,226,000	2.17	25.20	6,061
Buffalo, N. Y.,	1,375	16,501,800	2.04	46.00	12,000
Pittsburg, Pa.,	394	4,279,000	1.09	16.40	10,860
Detroit, Mich.,	5,847	14,970,800	9.24	42.70	2,543
Chicago, Ill.,	7,075	41,096,000	2.18	18.30	5,809
Philadelphia, Pa.,	1,510	16,430,400	.59	12.20	10,881

In the city of Buffalo the water rates are very low, and the use of water for manufacturing and mechanical purposes is very large. From 2.04 per cent., or about one-fiftieth of the service pipes in use, there are drawn daily 16,501,800 gallons, — an amount equivalent to 46 gallons per inhabitant for the whole city. This per capita quantity used by a comparatively few water takers is 8 gallons more than the per capita consumption in the city of Fall River for all purposes, domestic, manufacturing and public. In Fall River the use of water from the public water supply for manufacturing and trade purposes is only 5 gallons per capita, the factories obtaining their supply of water from a stream which flows through the city.

A comparison of the figures giving the percentage of services metered and the daily number of gallons used per meter and per capita indicates that but a small portion of the total manufacturing, mechanical and trade uses are metered in several of the cities, and that the total use for these purposes is much larger than in the Metropolitan District.

Use of Water for Public Purposes.

The principal uses included under this head are for public buildings, for public fountains, for sprinkling streets, for flushing water pipes and sewers, and for extinguishing fires.

While the quantity used for public purposes in most cities is a very small proportion of the total quantity used, there is a large difference in the quantity used in different cities, and in some instances the public use is quite a large proportion of the total. Where no charge is made for water used in public buildings and for other public uses, it often happens that little or no attention is given by the officials in charge to prevent the extravagant use or waste of water, and for this reason the quantity used is sometimes very large. In the several municipalities comprising the Metropolitan Water District the practice regarding payment for water used for public purposes is not at all uniform. In Boston, Somerville, Quincy, Melrose, Watertown, Arlington and Stoneham the water departments receive no income from water furnished to other departments of the municipality; but in Watertown, Quincy and Stoneham the income from water rents is insufficient to pay the maintenance, interest and sinking fund requirements, and a sum to meet the deficiency is raised by general taxation. In Chelsea, Revere, Milton, Winthrop, Lexington and Nahant the water departments receive an income for water used for all public purposes, including a payment for fire hydrants. In Malden, Everett and Belmont an income is received for water used in public buildings, but no charge is made for fire hydrants or for water used in sprinkling streets and flushing sewers. In Medford an income is received for water used in public buildings and for fire hydrants, but not for street sprinkling and flushing sewers.

Public Buildings.

Under the head of public buildings are included schools, fire engine houses, State House, city and town halls, hospitals, asylums and jails, churches and theatres, and all other national, State, county and municipal buildings.

The best measurement of the quantity required for public schools is that furnished by the records in several of the cities and towns where the water furnished to the schools has been metered. The results of these measurements are given in the following table (No. 9): —

TABLE No. 9. — *Use of Water in Schools.*

City or Town.	Year.	Number of Schools metered.	Teachers and Scholars in Schools metered.	Total Teachers and Scholars in City.	Gallons per Scholar per School Day.*	Gallons per Day per Inhabitant for Schools.	Remarks.
Boston, . .	1899	†–	72,190	72,190	6.22	.41	All metered except about 7 per cent.
Malden, . .	1901	17	5,446	5,446	2.21	.17	
Malden, . .	1902	18	5,640	5,640	2.26	.18	
Medford, . .	1901	13	2,734	3,214	4.02	.33	
Medford, . .	1902	13	2,874	3,354	4.11	.34	
Belmont, . .	1902	4	626	626	6.96	.48	
Milton, . .	1901	6	1,122	1,122	6.56	.53	One school of 70 scholars does not use city water, and is not metered.
Somerville, .	1899	22	9,004	9,228	6.29	.46	All except one school metered.

* This column is based on the assumption that there are 180 school days in the year.

† The quantity used was metered, except about 7 per cent., which was estimated from the amount received from annual rates at 14 cents per 100 cubic feet. The number of scholars in the unmetered schools could not be readily ascertained.

The use for public schools should not exceed .5 of a gallon per capita of the total population. The private schools and colleges in the Metropolitan District used by meter measurement, in the year 1902, a quantity equivalent to .2 of a gallon per capita of the entire population, which, added to the public school use, gives .7 of a gallon for the total use of schools.

During the year 1902 the water used through meters in the national, State and county buildings in the District, including the use at the Navy Yard and the Watertown Arsenal, was equivalent to .58 of a gallon per capita; and the quantity supplied through meters to the hospitals, asylums, jails and prisons was equivalent to .5 of a gallon per capita. In Boston the water supplied to the public institutions on Deer, Long, Rainsford and Gallops islands, the city hospital, the insane asylum, city hall, fire engine houses and other municipal buildings is not metered, neither is that supplied to public buildings in several other cities and towns. This unmetered quantity is estimated at 1.5 gallons per capita of the total population.

In churches, theatres, clubs and public halls the quantity used in 1902 by meter measurement was equivalent to .4 of a gallon per capita, and it is probable that at least .1 of a gallon was used which was not metered, making the use for these purposes .5 of a gallon per capita per day.

The total for public buildings is as follows: —

	Gallons.
Schools,	.70
National, State and county buildings, metered,	.58
Hospitals, asylums and jails, metered,	.50
Churches, theatres and clubs, metered,	.40
Public buildings, other than schools, unmetered,	1.60
Total for public buildings,	3.78

Public Fountains.

The estimated quantity of water used by 139 public drinking fountains, which are located in the several cities and towns supplied by the Metropolitan Works, averages 664,640 gallons per day, equivalent to .74 of a gallon per capita of the population supplied.

The following table (No. 10) shows the estimated quantities used in the several cities and towns: —

TABLE NO. 10.

CITY OR TOWN.	Number of Public Drinking Fountains.	Estimated Daily Average Quantity used (Gallons).	CITY OR TOWN.	Number of Public Drinking Fountains.	Estimated Daily Average Quantity used (Gallons).
Arlington,	4	10,120	Nahant,	3	9,030
Belmont,	2	11,230	Quincy,	9	34,060
Boston,	62	380,900	Revere,	4	16,040
Chelsea,	2	17,240	Somerville,	6	33,410
Everett,	3	16,670	Stoneham,	1	1,560
Lexington,	3	10,490	Swampscott,	4	11,810
Malden,	11	48,460	Watertown,	4	5,500
Medford,	10	32,280	Winthrop,	4	13,770
Melrose,	4	8,810			
Milton,	3	3,260	Total,	139	664,640

In the greater proportion of the drinking fountains the water runs continuously, and it follows that the greater part of the water is wasted. The average use in 18 fountains of this class in Boston, as determined by measurement, was 14,000 gallons per day each. Thirty-three of the drinking fountains for animals used in Boston are so arranged that during the six summer months the flow into the trough is controlled by an automatic valve, and no water is wasted; during the winter season the flow is continuous. Meters attached to two of these fountains showed that the use during the summer was at the rate of 1,250 gallons per day, and during the winter, when less water is needed, 6,250 gallons, or five times the summer use.

In the city of Boston there are 20 ornamental playing fountains, located on the Common, public gardens and public squares, nearly all of which are allowed to run continuously during six months of the year. The quantity discharged by these fountains has been measured where practicable, and the total quantity is estimated to be 237,000 gallons per day for six months, equivalent to .2 of a gallon per capita for the whole year. The combined use for drinking and ornamental fountains is about 1 gallon per capita per day.

Street Sprinkling.

For sprinkling streets throughout the Metropolitan District in the year 1901 the quantity used is estimated to have been nearly 700,000,000 gallons, equivalent to 2.13 gallons per capita per day for the year.

TABLE No. 11. — *Water used for sprinkling Streets in the Metropolitan District, 1901.*

CITY OR TOWN.	Total Gallons.	Gallons per Square Yard of watered Street, per Year.	Gallons per Capita per Day.	Average Width (Feet).	Length of Street watered (Miles).	Basis of Estimates.
Arlington, .	6,960,000	44.1	2.12	35.0	7.69	Estimated by town engineer and superintendent of streets.
Belmont, . .	2,250,000	18.8	1.47	30.0	6.82	Estimated by superintendent of streets.
Boston, . .	492,046,200	* 51.0	2.35	* 31.9	* 476.00	Record kept by cart-loads.
Chelsea, . .	14,198,600	42.9	1.12	27.0	18.14	Record kept by cart-loads.
Everett, . .	18,214,800	44.9	1.87	28.8	23.91	Estimated by superintendent of Board of Public Works.
Malden, . .	23,664,900	54.0	1.87	31.1	24.05	Record kept by cart-loads.
Medford, . .	23,795,900	51.5	3.41	28.2	27.96	Estimated from data furnished by street department.
Melrose, . .	10,000,000	38.8	2.06	27.0	16.22	Estimated by superintendent of Public Works.
Milton, . .	14,559,900	27.5	5.87	21.2	42.57	All metered at standpipes.
Nahant, . .	3,784,000	21.6	8.63	24.0	12.45	Estimated by superintendent of streets.
Quincy, . .	12,960,000	57.0	1.43	26.0	14.90	Estimated by commissioner of Public Works.
Revere, . .	3,942,500	19.7	.96	31.4	10.88	Record kept by cart-loads.
Somerville, .	45,780,300	60.5	1.97	24.3	53.02	Estimated by street department.
Stoneham, .	1,400,000	31.8	.60	37.5	2.00	Estimated by water department.
Swampscott, .	6,292,800	36.7	3.67	28.4	10.26	Estimated by superintendent of Water Works.
Watertown, .	13,450,000	51.6	3.67	39.3	11.33	Estimated by superintendent of streets.
Winthrop, .	5,900,600	19.2	2.48	25.8	20.28	Record kept by cart-loads.
	699,200,500	48.1	2.13	30.1	778.48	

Total square yards, 13,754,700.

* Length of sprinkled roadways in Boston park system not known, and so not included with these figures. The amount of water used for this purpose was 37,500,000 gallons, and this is included in the other two columns.

The quantity used in the several municipalities has been determined from the best data obtainable. In the town of Milton the water was measured by meter at each standpipe; in Boston, Chelsea, Malden, Revere and Winthrop a record was kept of the number of loads used and the capacity of the carts; in other municipalities the quantity used has been estimated by the department officials; and, while there are doubtless inaccuracies in some of the items, it is thought that the total is fairly correct.

Flushing Water Pipes and Sewers and extinguishing Fires.

Very little information is available from which to estimate the quantity used for flushing water pipes and sewers and extinguishing fires. Although large quantities of water are at times drawn from the pipes for extinguishing fires and for flushing water pipes, the use continues for but a short time, and the total use during the year is comparatively small; the per capita yearly use probably does not exceed .20 of a gallon.

The quantity required for public purposes may be summarized as follows: —

	Gallons per Capita.
Public buildings,	3.78
Drinking and ornamental fountains,	1.00
Street sprinkling,	2.13
Flushing water pipes and sewers and extinguishing fires,	.20
	7.11

Quantity actually needed for All Purposes.

From the preceding statements the total quantity actually required for legitimate use in the Metropolitan Water District at the present time is shown to be less than 60 gallons per inhabitant per day, divided as follows: —

	Gallons.
Domestic use,	25.0
Manufacturing, mechanical and trade use,	23.5
Public use,	7.0
	55.5

Quantity of Water wasted.

If, as has been stated, the actual requirements for domestic, manufacturing, trade and public purposes in the Metropolitan District do not exceed 60 gallons per inhabitant, while the total supplied to the District is nearly 120 gallons, it is evident that one-half of the water furnished must be wasted either from the street mains and service pipes, or from the water fixtures and piping on the premises of the water takers. A strong proof of the existence of waste is shown by measurements of the water used between 1 and 4 A.M., when the legitimate use of water is at its minimum.

The following table (No. 12) gives the results of continuous measurements of the water used in each of the cities and towns supplied by the Metropolitan Works for the period of six months, from June 28, 1903, to January 2, 1904, and shows not only the daily average quantity used, but also the rate of use between the hours of 1 and 4 A.M. : —

TABLE NO. 12. — *Daily Average (24 Hours) and Night Rate of Consumption from Metropolitan Works, June 28, 1903, to January 2, 1904.*

City or Town.	Service.	Estimated Population.	Average Daily Consumption (Gallons).	Average Daily per Capita (Gallons).	Average Night Rate 1 to 4 A.M. (Gallons per 24 Hours).	Night Rate per Capita (Gallons per 24 Hours).
Arlington,	High,	3,005	252,000	84	* 200,000	67
	Low,	6,840	367,000	54	* 225,000	33
	Total,	9,845	619,000	63	425,000	43
Belmont,	High,	4,875	228,000	47	111,000	23
Boston,	High,	199,750	24,763,000	124	17,259,000	86
	Low,	402,425	53,465,000	133	37,846,000	94
	Total,	602,175	78,228,000	130	55,105,000	92
Chelsea,	High,	7,480	537,000	72	352,000	47
	Low,	28,645	2,862,000	100	2,005,000	70
	Total,	36,125	3,399,000	94	2,357,000	65
Everett,	High,	7,255	370,000	51	220,000	30
	Low,	21,195	1,937,000	91	1,332,000	63
	Total,	28,450	2,307,000	81	1,552,000	55
Lexington,	High,	3,600	243,000	68	* 135,000	38
Malden,	High,	8,995	493,000	55	278,000	31
	Low,	28,320	1,271,000	45	647,000	23
	Total,	37,315	1,764,000	47	925,000	25
Medford,	High,	4,030	454,000	113	318,000	79
	Low,	17,005	1,200,000	71	680,000	40
	Total,	21,035	1,654,000	78	998,000	48
Melrose,	High,	14,015	1,395,000	100	1,000,000	71
Milton,	High,	7,475	325,000	44	115,000	15
Nahant,	High,	† 2,555	158,000	62	* 50,000	20
Quincy,	High,	27,135	2,415,000	89	1,554,000	57
Revere,	High,	13,165	796,000	60	494,000	38
Somerville,	High,	15,985	1,152,000	72	605,000	38
	Low,	52,325	4,448,000	85	2,811,000	54
	Total,	68,310	5,600,000	82	3,416,000	50
Stoneham,	High,	6,400	467,000	73	322,000	50
Swampscott,	High,	† 6,380	527,000	83	* 260,000	41
Watertown,	High,	10,950	532,000	49	217,000	20
Winthrop,	High,	7,485	668,000	89	414,000	55
District totals,	High,	350,535	35,775,000	102	23,904,000	68
	Low,	556,755	65,550,000	118	45,546,000	82
Totals,	. .	907,290	101,325,000	112	69,450,000	77

* Estimated. † Allowance made for transient population during summer months.

It will be noticed that both the daily per capita and night rates of consumption vary widely in different districts, even where the takers are of the same general class. Where the rate for twenty-four hours is large, the night rate is in almost every case excessive. It is also noticeable that the lowest rates of consumption are to be found in those districts where water meters are in general use. Take, for example, the rates of consumption during the night in Milton, Watertown, Belmont and Malden, as compared with those in Medford, Melrose, Winthrop and the high-service districts of Brighton and Chelsea. The population of each of these groups is about 60,000. They are districts in which the manufacturing use is very small, and there appears to be no good reason why the legitimate use of water between the hours of 1 and 4 A.M. should not be very small in every case. In the first group the rate varies from 13.4 to 25.5 gallons per capita, with an average of 18 gallons; while in the second group it varies from 43 to 71.4 gallons, with an average of 58.3 gallons. The difference between 18 and 58 gallons is unquestionably preventable waste.

In districts where the use for manufacturing, mechanical and trade purposes is large, the legitimate use during the night is in some instances also large. Water is used in considerable quantities during the night, as well as the day, in electric light and power stations, gas works, hotels and large institutions. For example, at the New England Gas and Coke Works in Everett water is used between the hours of 1 and 4 A.M. at the rate of 500,000 gallons per day, which is equivalent to 18.5 gallons per capita per day for the entire population of the city. This, however, is an exceptional case. Considering the whole Metropolitan District, the legitimate draft during the night is very small, when compared with 77 gallons per capita, which was the average minimum rate during the last six months of the year 1903. Nearly all of the water used for manufacturing, mechanical and trade purposes is metered, and the total is but 23.5 gallons per capita, of which the greater part must be used during the day. It is not probable that the legitimate use for all purposes during the hours of minimum consumption is more than 17 gallons per capita, in which case the difference between 77 gallons drawn from the pipes and 17 gallons used, or 60 gallons, must be wasted. This amount agrees very closely with the amount obtained by subtracting the total quantity estimated as actually required for all purposes in the Metropolitan District from the total quantity used.

Diagram No. 1 shows graphically the comparative volume of water used and wasted in the several municipalities, the cities and towns being arranged in order of per capita use. The unshaded areas at the top of the diagram show the estimated volume legitimately used, and the shaded areas at the bottom of the diagram the volume wasted. The dotted lines show the minimum rate of use, and the areas between the dotted lines and the shaded areas show the estimated use during the hours of minimum consumption.

Diagram No. 2 shows the rate of consumption in the whole district supplied by the Metropolitan Works for each hour during three weeks, as measured by Venturi meters. During the week ending July 11, 1903, the weather was hot and dry, especially during the latter part of the week; during the week ending August 8 the weather was comparatively cool, with showers and little sunshine; and during the week ending January 9, 1904, was extremely cold. On Monday, July 6, .42 of an inch of rain fell, making street sprinkling unnecessary until Tuesday afternoon. For this reason the use during Monday, July 6, was very nearly the same as on Monday, August 3. During the last four days of the week ending July 11 the maximum temperature was from 89 to 95 degrees, and a large amount of water was used for sprinkling streets and lawns. The consumption for these days was from 14,000,000 to 17,000,000 gallons per day more than during the corresponding days of the week ending August 8, when frequent showers and cool weather made both street and lawn sprinkling unnecessary. During both of these weeks the minimum rate of use was about 75 gallons per capita. The dotted upper line on the diagram shows the use during a week of very cold weather.

Causes of Waste.

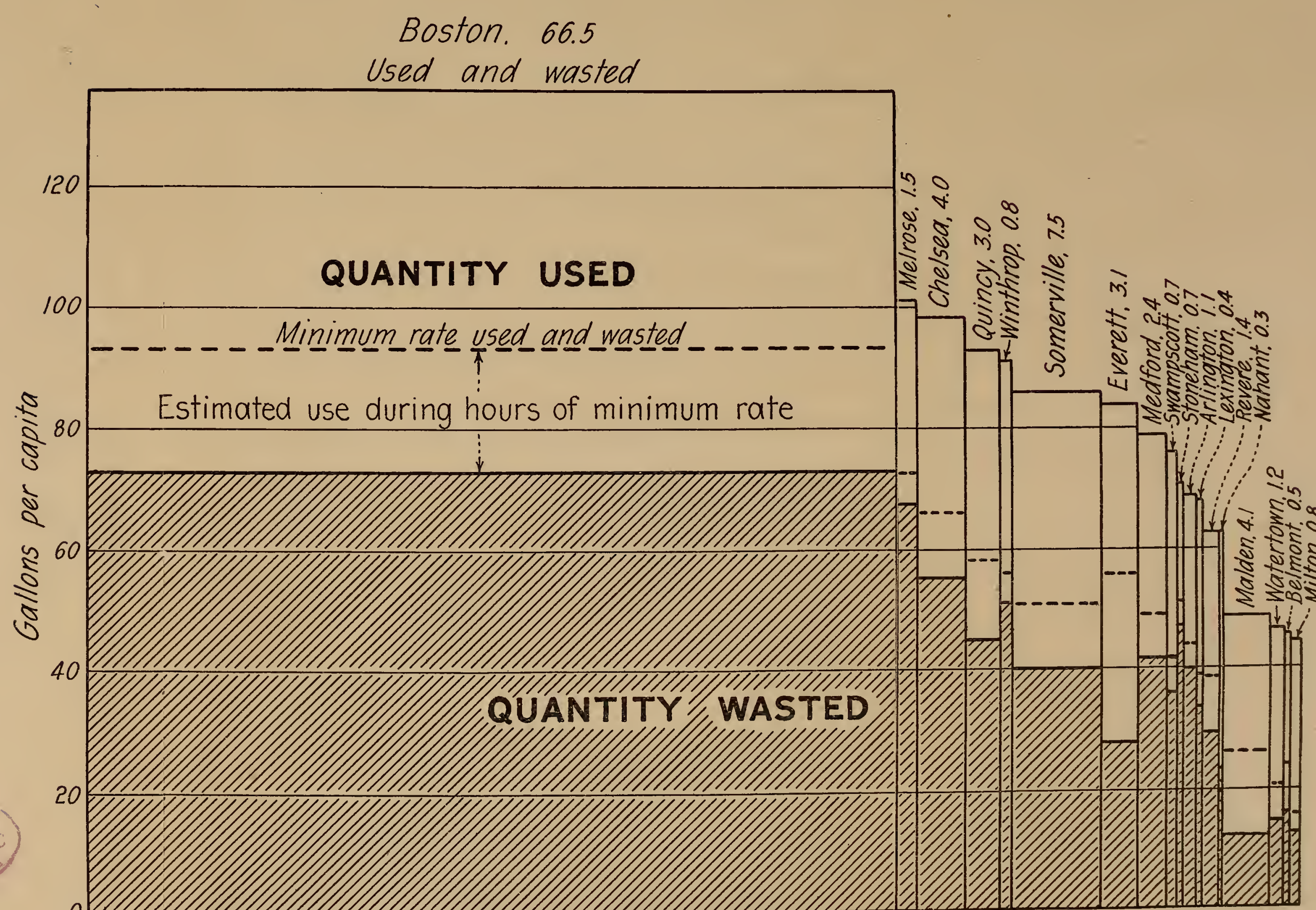
Water is wasted, either negligently or wilfully, from mains and service pipes in the public streets, or from pipes and fixtures on the premises of the water takers.

Waste from Street Mains and Services.

The amount wasted from the street mains and service pipes is a much larger percentage of the total consumption than has been generally estimated. This fact is proved by the results obtained

Diagram showing the per capita quantity of water used and wasted in the several cities and towns supplied by the Metropolitan Water Works.

Figures following names of cities and towns show percentage of total population of district



where water supplied to individual takers is measured, and can be compared with the total quantity supplied to the city or town. In the Metropolitan District in the town of Milton the water supplied to every taker is metered, including that used for street watering and other public purposes. In Belmont all supplies are metered, and a careful record is kept of the number of loads of water used for street watering. The total quantity of water delivered into the pipes of each town has been measured by means of Venturi meters, and, if the meters through which water is supplied to individual takers record accurately the water passing through them, the difference between the quantity recorded by the local meters and that delivered into the pipes of the town must represent the leakage from the street mains and service pipes.

The results of the observations made in these towns are as follows: —

TOWNS.	Gallons per Day.			Per Cent. unaccounted for.	Gallons per Day unaccounted for per Mile of Pipe.
	Delivered into Pipes of Town.	Metered to Consumer.	Unaccounted for.		
Milton, April, May, June,	325,100	216,300	108,800	33.5	3,110
Milton, July, August, September,	328,000	199,100	128,900	39.3	3,680
Belmont, March 15 to May 15,	171,500	135,300	36,200	21.1	2,130
Belmont, May 15 to September 15,	230,500	145,000	85,500	37.1	4,780

In both of these towns meters have been used but a few years, and it does not seem probable that the loss in registration of the meters can be more than 2 or 3 per cent.

Similar results have been obtained in every city and town where the water supply to individual takers has been metered. In the following cities and towns meters are in use on all or a very large percentage of the services, but in every case a large percentage of the water delivered into the mains from the reservoir or pumps is unaccounted for by the meters.

TABLE No. 13.

City or Town.	Delivered into Mains.			Metered to Consumers, or otherwise accounted for.		Per Cent. unaccounted for.	Gallons per Day unaccounted for per Mile of Pipe.
	Per Cent. of Taps metered.	Daily Average (Gallons).	Gallons per Consumer.	Gallons.	Gallons per Consumer.		
Brockton, . .	90.0	1,362,470	36.0	902,120	22.0	32.3	6,200
Ware, . .	100.0	338,160	44.0	203,430	26.5	39.8	11,200
Worcester, . .	94.5	8,094,840	68.0	4,331,030	39.0	46.5	20,800
Wellesley, . .	100.0	257,000	50.0	150,000	29.0	41.5	3,450
Yonkers, N. Y.,	100.0	4,540,900	89.0	2,463,490	42.7	45.7	23,340
Fall River, . .	96.0	4,365,060	40.5	3,430,300	32.0	21.5	10,000
Woonsocket, R.I.	86.7	989,420	28.6	762,380	22.0	23.0	4,370

In Belmont and Milton the quantity unaccounted for by the house meters varied from 2,130 to 4,780 gallons per mile of pipe per day, while in the cities and towns given in the above table the corresponding quantities vary from 3,450 to over 23,000 gallons. It is possible that in some instances the quantity delivered into the mains is overestimated, but there is no doubt that in the majority of cities there is a large leakage from mains and services. The opportunities for leakage from pipes buried underground are great, and the chances for their discovery are in most cases comparatively small. In the Metropolitan Water District there are 1,457 miles of pipes, on which there are 750,000 leaded joints from which leakage may occur. Leaks of considerable magnitude often remain undiscovered for months, the water escaping into the ground or into a brook or sewer. Several years ago, while Deacon waste-water meters were being used in Boston to detect leaks, several 4-inch and 6-inch cast-iron pipes were found broken, from which the water was escaping unseen into the sewers. In a number of instances this leakage was at the rate of 24,000 gallons per day, and in one instance 100,000 gallons per day were found to be running into a sewer from a 6-inch pipe which was broken entirely off.

A very forcible illustration of this source of waste has been furnished in the town of Stoneham. During the first six months of the year 1902 about 800,000 gallons per day were supplied to the town. As this quantity appeared larger than was needed for legitimate use, an investigation was instituted for the purpose of learning where the water was used, with the result that four leaks in the street mains were found, which gave no surface indications. After these were repaired the consumption of water fell to 330,000 gallons per day, indicating that 470,000 gallons per day had been wasting from a few unseen defective pipes.

On the Boston works several large leaks in mains and service pipes have been discovered during the past year by means of the Deacon waste-water meters. The aggregate waste from eight of these was about 27,000 gallons per hour, equivalent to 648,000 gallons per day. In Arlington, Chelsea and Medford leaks from defective joints in the street mains have been discovered from which water was wasting at rates of from 1,000 to 2,000 gallons per hour, without any indications being given on the surface.

Tests have been made in Melrose to determine the amount of water leaking from the mains and services, by measuring with a meter the rate of flow into the pipe supplying certain streets while all the stop cocks on the house services were closed. These tests were made during the night, when the legitimate use was very small. The result of these measurements was as follows: —

Table No. 14.

Length of Main.	Size (Inches).	Number of Service Pipes.	Leakage from Mains (Gallons per Hour).	Leakage and Use in Houses (Gallons per Hour).
1,000 feet,	6	20	1,035	180
600 feet,	6	13	250	290
1,000 feet,	6	22	225	70
400 feet,	6	10	675	45
500 feet,	6	9	-	25
1,150 feet,	4	21	1,080	270
350 feet,	-	8	-	90
700 feet,	6	14	-	180
1,550 feet,	6	21	180	520
1,000 feet,	-	22	-	270
600 feet,	8	12	-	180
1,250 feet,	14	33	45	270

The total leakage from less than 2 miles of pipes was 3,490 gallons per hour, or at the rate of 43,770 gallons per mile of pipe per day.

If, as has been shown by numerous examples, from 50,000 to 100,000 gallons of water per day can run into the ground continuously for months from a single leak in a main or service pipe, and give no indication on the surface of the ground, it is reasonable to conclude that there are, on the 750,000 joints in the street mains and the 150,000 service pipes, many smaller leaks, which, being smaller, are not easily discovered, but which in the aggregate waste a large quantity of water. Some water is wasted from street mains through carelessness in the manipulation of blow-off gates by department employés, and by the extravagant use of water for flushing sewers. Several years ago a blow-off valve was carelessly left open in Boston, and water ran for several days into a sewer at the rate of 3,000,000 gallons per day. In flushing water pipes and sewers much larger quantities are often used than are necessary for accomplishing the results desired, but it is not thought that the aggregate amount wasted in this way is large.

The tests which have been made in the several municipalities of the Metropolitan District tend to show that the leakage from the street mains and services is very large, and that from 10,000 to 15,000 gallons per mile of street main escape each day into the ground or into some underground channel. If this estimate is correct, the total leakage from the mains and services is from 15,000,000 to 22,500,000 gallons per day, — equivalent to from 16.5 to 25 gallons per inhabitant.

Waste from Pipes and Fixtures on Premises of Water Takers.

Waste from pipes or fixtures on premises of water takers is due either to defective plumbing or to permitting the water to run from open fixtures, either negligently or wilfully. Where the amount paid for water is not dependent upon the quantity of water used, the average water taker pays little attention to the condition of the plumbing on his premises; and, so long as the leaking fixtures cause no damage to his property, they are seldom repaired unless discovered by inspectors of the Water Department. For this reason the amount of waste from defective fixtures in cities where meters are not used depends largely upon the thoroughness with which the house-to-house inspection is done by the local authorities.

The greatest source of negligent waste from defective fixtures is undoubtedly the ball cock which controls the flow of water into tanks supplying water-closets and other fixtures. The ball cock seldom remains tight more than a few months, and when defective allows a constant stream of water, often of considerable size, to flow unseen, though not always unheard, to the sewer. Although the ball cock is more liable than any other plumbing fixture to be the cause of waste, its inspection is more difficult than that of other fixtures, the tanks being generally placed in inaccessible places in buildings. Unless the inspection is very thoroughly performed, the greatest source of this kind of waste is therefore apt to be overlooked. Nevertheless, more tank fixtures are reported defective than any other class.

The following figures, taken from the annual reports of the Boston Water Department, show the results of inspections made during the past seven years: —

	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Number of fixtures in use,	697,640	617,721	644,468	653,189	689,973	698,803	-
Tank fixtures leaking,	959	7,110	10,539	6,035	4,624	6,160	10,888
Faucets leaking,	521	4,655	7,995	2,634	1,963	3,282	5,086
Water-closets leaking,	-	1,080	4,887	1,091	199	223	294
Pipes leaking,	120	413	1,179	362	249	268	426
Wilful waste,	2	164	113	42	22	67	5

The differences between the number of leaks reported in different years are probably due to differences in the thoroughness of the inspection, rather than to the condition of the plumbing.

The results of inspections in several other cities and towns are given as follows: —

CITY OR TOWN.	Taps, Sinks, Bowls, Baths and Wash Trays.		Water-closets and Tanks.	
	Number in use.	Number found leaking.	Number in use.	Number found leaking.
Chelsea,	23,232	1,006	8,813	1,872
Everett,	22,680	548	6,368	1,138
Revere,	8,104	126	2,642	579
Somerville,	-	757	-	1,404
Winthrop,	6,803	69	2,296	101

To a greater degree than in the case of the street mains does the leakage from water fixtures take place from a very large number of small openings which permit of a constant flow. Few people realize that sufficient water will flow, in twenty-four hours, through an orifice of no greater diameter than an ordinary lead pencil, under the average pressure which exists in the pipes throughout the Metropolitan District, to furnish an ample domestic supply for 360 persons; and that in the same time more water will leak through an orifice the size of an ordinary pin than would be used by a fairly economical family of five persons. It is the continual running of thousands of little streams which causes the greater part of waste on the premises of the water takers.

Wilful Waste.

During the winter season large quantities of water are drawn from the pipes by water takers for the purpose of preventing the freezing of water in the house piping; and throughout the year faucets and water-closet fixtures are left or fastened open by water takers for the purpose of flushing water-closets and drain pipes, or in order that the water at the faucet may be constantly kept cool. The legitimate use of water is no larger during the winter season than during the months of November and April, but the actual use in the Metropolitan District is much larger during cold weather than during any other season of the year.

The average use for the months of November and April, compared with the use during intervening months for the past three years, was as follows: —

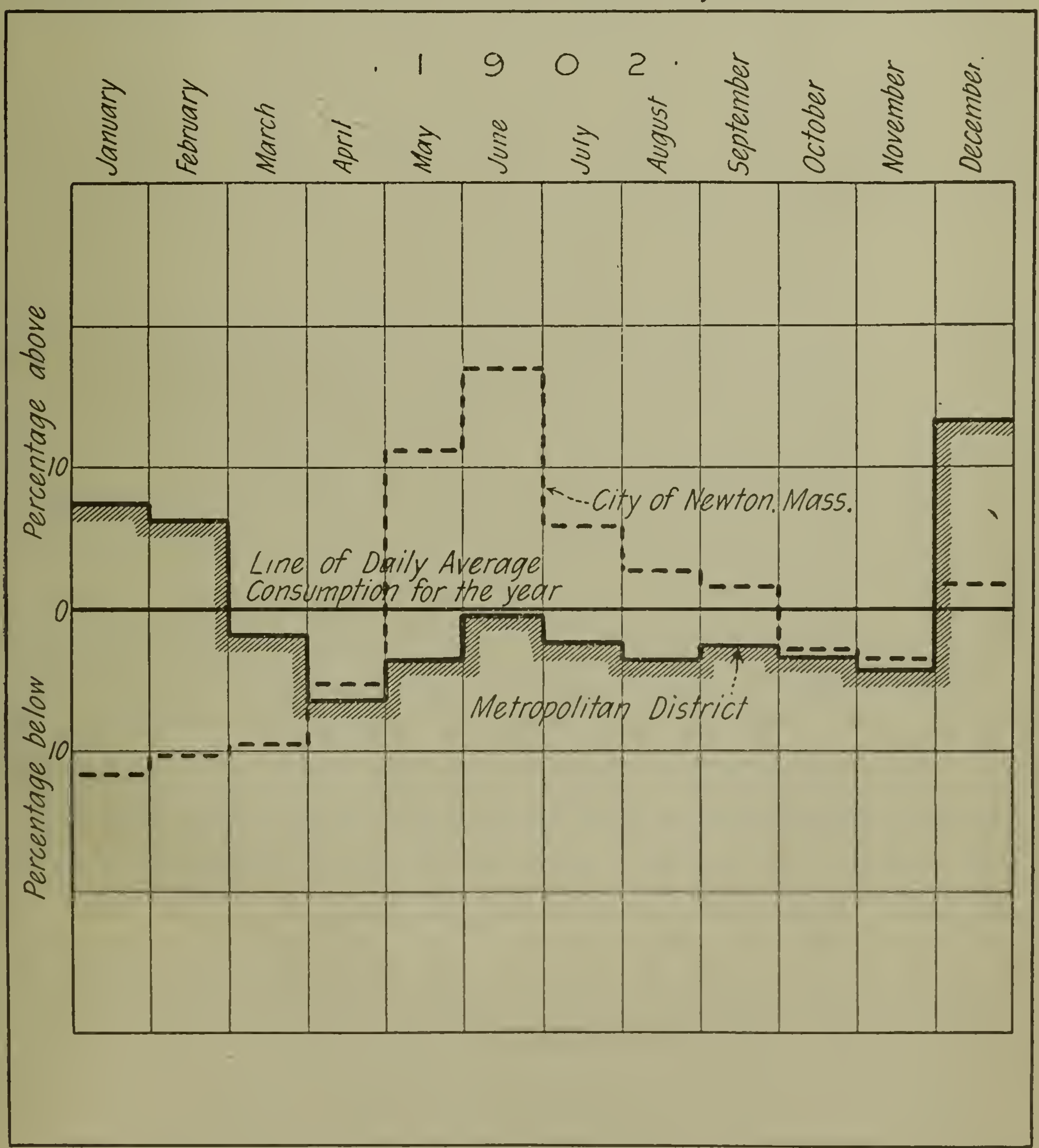
YEAR.	Daily Average (Gallons).		Difference wasted to prevent freezing of Water in Pipes (Gallons per Day).	Daily Number of Gallons per Capita wasted (Yearly Average).
	November and April.	December, January, February and March.		
1900-01, . . .	90,322,000	104,878,000	14,556,000	5.74
1901-02, . . .	99,317,000	111,417,000	12,100,000	4.61
1902-03, . . .	104,950,000	121,589,000	16,639,000	6.16

In the cities where meters are in general use, waste of this character does not occur to any great extent, as each property owner is pecuniarily interested so to arrange the plumbing in his buildings that it does not become necessary to allow water to run in order to prevent it from freezing.

In the district supplied by the Metropolitan Works the use of water during the winter months is much larger than at any other season of the year; while in the city of Newton, where meters are in general use, the minimum use occurs during the winter. This is illustrated by Diagram No. 3.

Diagram No. 3

Diagram showing percentage of variation from the daily average consumption of water for the several months of the year 1902 in the Metropolitan District and in the City of Newton, Mass



The effect of cold weather upon the use of water is illustrated very forcibly on Diagram No. 2, on which is shown the rate of consumption from the Metropolitan Works during each hour of the week ending January 9, 1904. On Tuesday and Wednesday, which were the coldest days of the week, the consumption was about 60,000,000 gallons per day greater than during corresponding days in the month of August; and the lowest rate at which water was drawn from the pipes during the night was 150 gallons per capita, — an amount greater than the maximum rate of use during the corresponding days in August.

The amount wasted during extremely cold weather, as well as the effect of meters in controlling waste, is very forcibly illustrated by diagrams Nos. 4, 5 and 6, which show graphically the use of water in Boston, Chelsea and Malden on January 5, 1904, compared with the use on a day in August, 1903. The cities of Malden and Chelsea have approximately the same population. Malden uses meters on 69 per cent. of its service pipes, Chelsea on 2 per cent. The per capita use in Malden on August 4 was 41 gallons, and in Chelsea 88 gallons. On January 5, 1904, when the average temperature for twenty-four hours was 2 degrees below zero, the per capita use in Malden increased to 57 gallons, and in Chelsea to 211 gallons. In Malden the increase caused by cold weather was about 16 gallons per capita, and in Chelsea 123 gallons. Between the hours of 2 and 4 A.M. on January 5, water was drawn from the pipes in Chelsea at the rate of 192 gallons per day for each inhabitant of the city, and in Boston the rate during the same hours was 178 gallons per capita.

The per capita waste caused by running water to prevent its freezing is largest in those districts where houses are of the cheaper class, but which are furnished with all modern conveniences for the use of water. The cold-weather waste during the week ending January 9, in Chelsea, Charlestown, East Boston and Somerville, was from 60 to 100 gallons per capita; while in Medford, Melrose, Arlington and Quincy it ranged from 15 to 20 gallons.

Hourly Variation in the Consumption of Water in the Metropolitan District. (From Venturi Meter Records, 1903-4.) *Diagram No. 2*

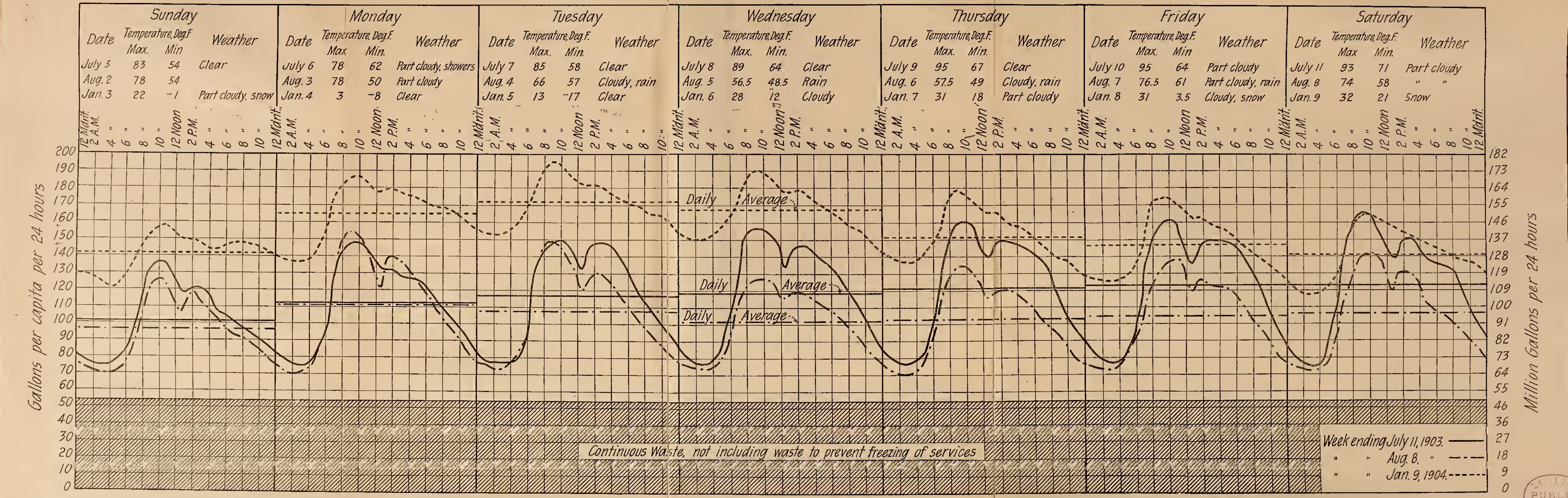
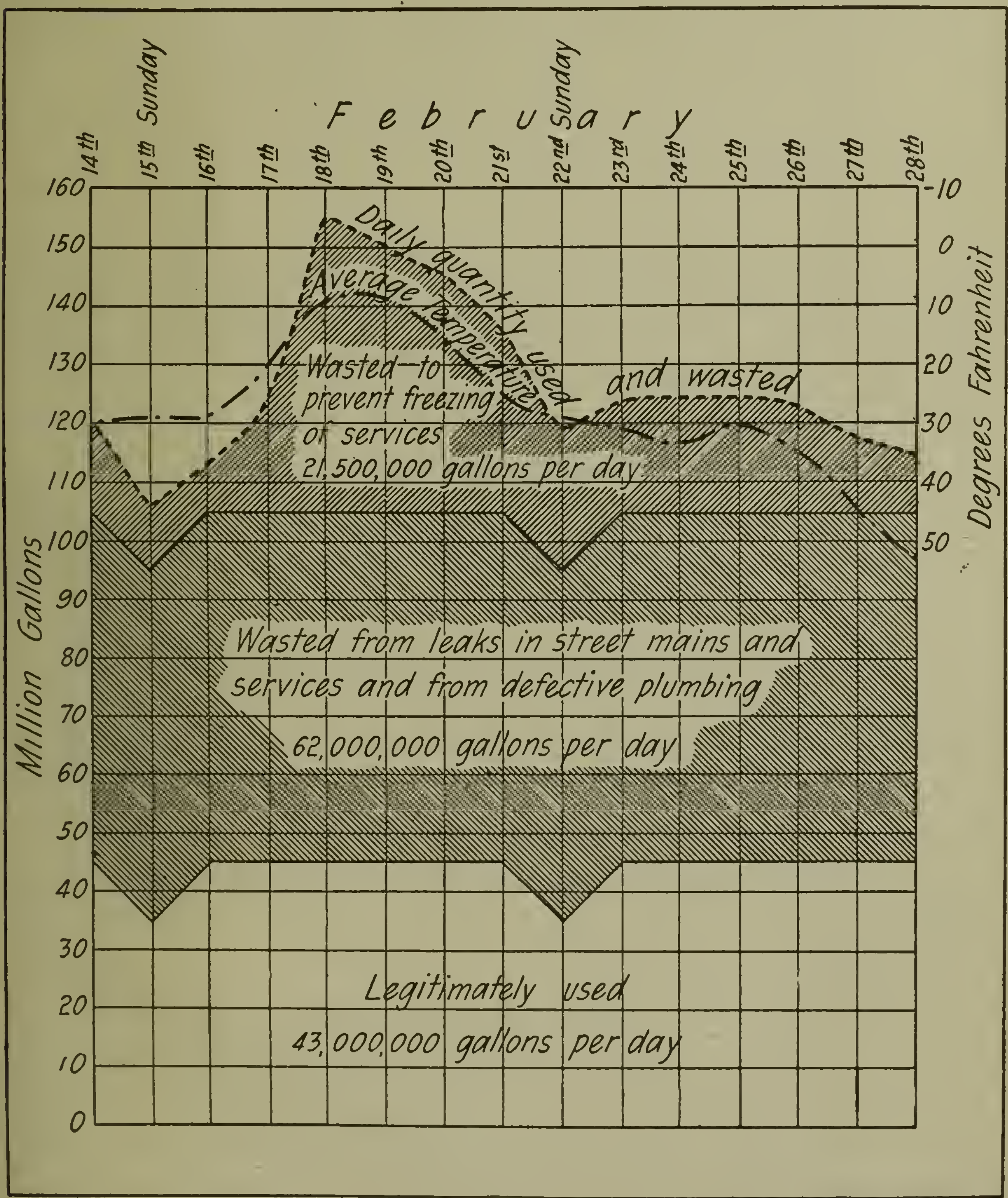


Diagram No. 7 shows the consumption of water in the city of Boston during a cold period in February, 1903.

Diagram No. 7

Diagram showing daily quantity of water used and wasted in Metropolitan Water District. Feb. 14 to 28. 1903.



The daily average consumption of water previous to the cold weather was about 105,000,000 gallons per day. On February 18, 155,500,000 gallons were used, of which 50,500,000 gallons, equivalent to 57 gallons per capita of the entire population of the District, were wasted for the purpose of preventing the freezing of service pipes and plumbing.

It is the practice of some water takers to allow water to run continuously from water-closets, for the purpose of cleansing house drains; others permit the water to run from the kitchen faucet, in order that the water may not become warm in the pipes, and some even use a constant stream of water, instead of ice, for the purpose of preserving food. Some water is wasted by each of these methods, but they are sources of waste which are not easily detected by house-to-house inspection, and no attempt has been made to determine the exact amount wasted from these causes.

Prevention of Waste.

Much waste of water may be prevented by the inspection of house plumbing, and this method, aided by the use of Deacon meters, accomplished good results for several years in the city of Boston. The use of these meters and the work of inspection were begun in 1883, and in 1884 the consumption had been reduced from 91.5 gallons to 68 gallons per capita. The inspection was continued about ten years, but with decreasing diligence; and for ten years previous to 1903 little attention was given to the prevention of waste. In order to obtain facts as to the present condition of affairs, measurements of the consumption during the night have been made by the Boston Water Department during the past year in some of the residential districts of the city by the use of the Deacon meters; and where the measurements indicated a large waste of water, efforts have been made to locate and prevent the same. The measurements were made between the hours of 1 and 4 A.M., when the legitimate use in residential districts is least.

The Deacon meters were first used in the Charlestown district in 1881, and in Table No. 15 the results of measurements made at that time are given, also other measurements made in 1893, about the time active inspection was stopped, as well as those made during the present year.

TABLE No. 15.

Population of District.			Night Rate or Waste (Gallons per Capita per Day).			
1881.	1893.	1903.	Before Inspection, 1881.	After Inspection, 1881.	1893.	1903.
3,675	4,700	4,725	39.0	13.7	24.8	52.8
2,170	2,925	2,975	33.1	13.2	23.8	52.2
1,875	2,325	2,425	44.6	15.1	21.2	63.3
2,030	3,125	3,250	43.2	20.2	40.0	88.0
1,880	1,800	1,800	42.2	22.3	26.7	70.6
1,790	2,150	2,400	53.3	17.8	27.9	53.0
2,540	3,300	3,450	31.9	19.2	26.2	55.7
15,960	20,325	21,025	41.8	17.0	27.3	61.5

There has been very little change in the character of the population or of the plumbing in these sections during the twenty-two years since the first tests were made. By thorough inspection the waste was reduced in 1881 from 41.8 to 17 gallons per capita. Between 1881 and 1893 the inspection was less thoroughly performed, and the waste increased to 27.3 gallons. Since 1895 very little attempt has been made to detect and prevent waste, with the result that the night rate has increased to 61.5 gallons per capita.

The increase in waste in other sections of the city of Boston during the past four years is shown in Table No. 16 : —

TABLE No. 16.

DISTRICT.	Section.	Population.		Rate of Use between 1 and 4 A.M. (Gallons per Capita per Day).		
		1899.	1903.	1899.	1903.	Increase.
Roxbury, . .	Walnut Avenue, Section 1, . .	2,100	2,150	42.2	81.5	39.3
Roxbury, . .	Walnut Avenue, Section 2, . .	2,200	2,200	31.7	73.1	41.4
Roxbury, . .	Walnut Avenue, Section 3, . .	2,600	2,700	38.4	48.0	9.6
Roxbury, . .	Walnut Avenue, Section 4, . .	1,400	1,500	58.3	116.8	58.5
Roxbury, . .	Warren Street, No. 1, Section 1,	2,150	2,150	88.8	84.8	—4.0
Roxbury, . .	Warren Street, No. 1, Section 2,	1,100	1,100	30.5	43.6	13.1
Roxbury, . .	Warren Street, No. 1, Section 3,	2,000	2,000	30.0	62.4	32.4
Roxbury, . .	Warren Street, No. 2, Section 1,	2,550	2,650	52.7	56.2	3.5
Roxbury, . .	Warren Street, No. 2, Section 2,	2,800	2,800	54.0	65.1	11.1

TABLE No. 16 — *Concluded.*

DISTRICT.	Section.	Population. 1899.	Population. 1903.	Rate of Use between 1 and 4 A.M. (Gallons per Capita per Day). 1899.	1903.	Increase.
Roxbury,	Warren Street, No. 2, Section 3,	1,650	1,400	31.3	82.3	51.0
Roxbury,	Cedar Street, Section 1,	2,100	2,150	40.0	82.6	42.6
Roxbury,	Cedar Street, Section 2,	2,250	2,400	37.8	79.0	41.2
Roxbury,	Cedar Street, Section 3,	2,400	2,450	51.5	58.8	7.3
Roxbury,	Cedar Street, Section 4,	2,500	2,250	32.6	66.1	33.5
Roxbury,	Lamartine Street, Section 1,	2,700	2,700	41.8	106.7	64.9
West Roxbury,	Spring Park Avenue, Section 1,	3,950	4,175	27.9	50.0	22.1
West Roxbury,	Spring Park Avenue, Section 2,	1,800	1,900	60.0	53.0	−7.0
West Roxbury,	Burroughs Street, Section 1,	1,200	1,450	55.0	72.7	17.7
West Roxbury,	Burroughs Street, Section 3,	650	750	59.0	54.4	−4.6
City proper,	Bowdoin Street, Section 1,	1,600	1,550	76.5	102.2	25.7
City proper,	Bowdoin Street, Section 2,	2,400	2,700	58.0	97.8	39.8
City proper,	Joy Street, Section 1,	2,500	2,850	28.3	26.0	−2.3
City proper,	Joy Street, Section 2,	2,000	5,000	58.8	69.6	10.8
South Boston,	Fifth Street, Sections 1 and 2,	5,600	5,700	41.7	61.0	19.3
		54,200	58,675	-	-	-

It is very evident, from an inspection of the above tables, that at the present time a very large quantity of water is being wasted, and that any system of house-to-house inspection must be continuous in order to be effective. House-to-house inspection is open to the objection that the constant visits of inspectors are annoying to the householders.

While these investigations were in progress, several large leaks were located from the street mains and services; and house-to-house inspection on streets where much waste was noted disclosed in some cases that the house plumbing was in very poor condition. On one street, where the night rate was 5,200 gallons per hour, the inspection disclosed ball cocks wide open, and every faucet in three houses running large streams, the washers being entirely gone. On another street, in fifteen out of sixteen houses examined, the ball cocks were defective, and wasting large streams of water.

In addition to the large leaks which were located in the street mains and service pipes, there are no doubt many smaller leaks still undiscovered; but the inspection proved that the house plumbing is very defective, and the greater part of the present enormous waste in Boston is probably due to waste on the premises of the water takers.

Effect of using Meters.

The most certain means of detecting waste, and the most effectual means of preventing the extravagant use and waste of water, is that of measuring the water supplied to each municipality, district or individual water taker, and obliging each municipality and individual to pay for water in proportion to the quantity used. Where meters are in use, each water taker finds it to be for his interest to see that the plumbing fixtures which he uses are of the best quality, and that they are kept in repair; that the pipes in his buildings are so located that they will not freeze during cold weather; and that his family or employés are not wasteful in the use of water. The introduction of meters upon all old works has always been followed by a reduction in the quantity of water used; and in cities and towns where they have been introduced when the works were built, the per capita consumption is universally very low. The effect of the use of meters is well illustrated by a comparison between the per capita consumption of water in cities and towns where meters are in general use with that in those where water is paid for at schedule rates. Differences in climate, in character of business and in location, as affecting the available supply of water, often have a marked effect upon the consumption in different cities; but in the following table an attempt has been made to eliminate these differences, as far as possible.

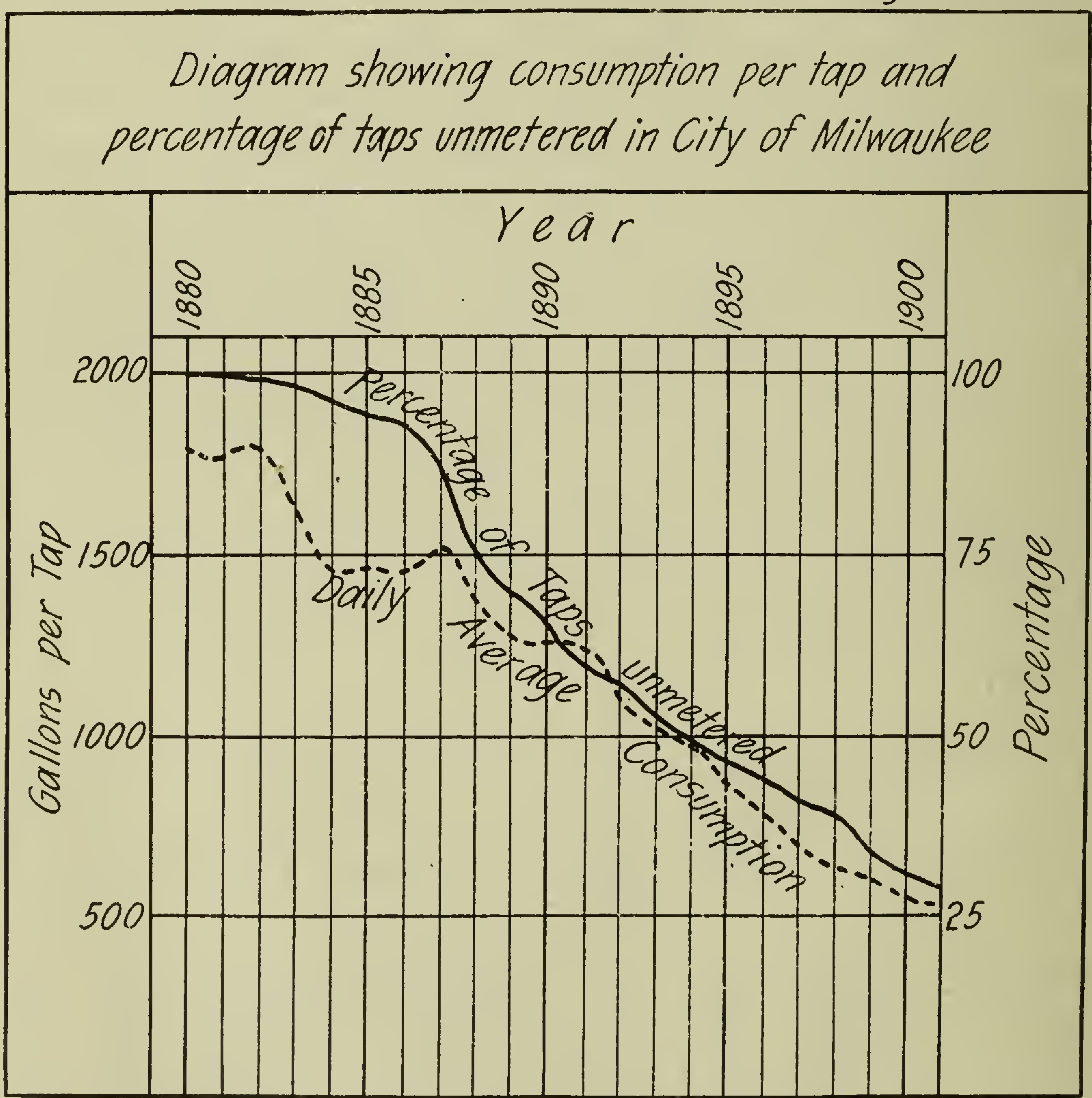
TABLE No. 17.

City or Town.	Number of Consumers.	Per Cent. of Services metered.	Consumption (Gallons per Day per Consumer).	City or Town.	Number of Consumers.	Per Cent. of Services metered.	Consumption (Gallons per Day per Consumer).
Milwaukee, Wis.,	308,000	80.0	81.0	Buffalo, N. Y., .	360,000	2.0	324.0
Providence, R. I.,	198,400	84.5	58.0	Indianapolis, Ind.,	169,100	6.0	79.0
Worcester, . .	119,330	94.5	68.0	New Haven, Ct.,	108,000	2.6	150.0
Fall River, . .	107,650	96.0	41.0	New Bedford, .	61,000	18.0	104.0
Lowell, . .	100,000	65.0	57.0	Cambridge, .	94,150	15.0	85.0
Lawrence, . .	65,000	83.0	53.0	Haverhill, . .	37,200	10.0	95.0
Brockton, . .	37,800	90.0	36.0	Lynn, . . .	74,000	25.0	63.0
Newton, . .	35,400	86.0	54.0	Waltham, . .	24,550	6.0	99.0
Woonsocket, R. I.,	34,474	96.0	29.0	Salem, . .	36,250	3.0	79.0
Ware, . . .	7,690	100.0	44.0	Montague, . .	6,150	2.0	73.0
Wellesley, . .	5,147	100.0	49.0	Dedham, . .	7,500	2.0	83.0
Reading, . .	4,385	100.0	33.0	Braintree, . .	5,980	1.0	91.0
	1,023,276	-	61.7		983,880	-	178.5

In the first four columns are given the statistics for twelve cities and towns where meters are in general use, and in the following columns corresponding data for an equal number of cities and towns of approximately equal size where few meters are used, but where the conditions as regards location and trade are generally similar. The average per capita consumption where meters are used is but little more than one-third of that in the unmetered cities.

The effect of the use of meters upon the consumption of water is very graphically illustrated by Diagram No. 8, which shows the daily number of gallons used per tap in the city of Milwaukee, and the percentage of unmetered taps for each of the past twenty-two years.

Diagram No. 8



It will be noticed that there has been a gradual reduction in the quantity of water used with the increase in the use of meters. In 1880, with no meters in use, 1,750 gallons were drawn from each tap; in 1890, with about one-third of the taps metered, the quantity drawn from each was only 1,250 gallons; and in 1902, with 72 per cent. metered, the quantity used per tap was only 550 gallons.

During the past two years the Water Department in the city of Cleveland has been engaged in placing meters upon service pipes. At the end of the year 1902, 11,099 meters were in use on 56,816 services; and the daily average consumption for the year was 69,964,740 gallons. At the close of the year 1903 the number of meters had been increased to 25,193; and the daily average consumption for the year was 62,012,000 gallons. As a result of this work, the daily average consumption for the year 1903 was about 8,000,000 gallons per day less than in 1902, and the greater part of this reduction was no doubt due to the meters set during the previous year.

Effect of Meters upon the Poor.

The fear has been sometimes expressed, by those who have not given the subject careful study, that the use of water meters will have the effect of reducing the use of water by the poorer class of takers below an amount necessary for health. The experience in the cities and towns using meters does not indicate that there need be any fear of such a result. It is the usual custom, where meters are used, to make a uniform minimum charge of from $10 to $12 to each water taker, for which sum the taker is entitled to use the quantity for which an equal charge would be made at meter rates. The yearly schedule rate paid by water takers in the different municipalities of the Metropolitan District for the use of one faucet and a water-closet is generally from $9 to $11, and the rate for a single faucet is $5. For $10 per annum per taker, every person in a family of average size, if supplied by meter at the rate of 14 cents per 100 cubic feet, which is the rate generally in force throughout the District, will have the privilege of using 30 gallons, or twelve pailfuls of water per day, which experience shows to be ample for domestic use. In many municipalities where water used for domestic purposes is metered, exception is made in cases where premises are supplied through a single faucet, and the schedule rate remains in force. There appears to be no reason, however, why a minimum rate of $5 per year should not be made for premises of this kind supplied by meter. Experience shows that the majority of the water takers using water for domestic purposes use less than the quantity to which they are entitled by the minimum charge.

In the city of Malden the minimum yearly charge is $12, for which sum each water taker is entitled to use 47,470 gallons, equivalent to 130 gallons per day, or 26 gallons per day for each member of a family of average size. In the year 1901 the total number of meters on domestic services was 3,490, and the daily average number of gallons used by each service was 112.8. The number using less than the minimum quantity was as follows: —

Cubic Feet per Year.	Number of Services.	Gallons per Day per Service.	Cubic Feet per Year.	Number of Services.	Gallons per Day per Service.
Less than 500, . . .	28	* 6.4	Between 3,000 and 4,000, .	566	72.0
Between 500 and 1,000, .	52	* 16.1	Between 4,000 and 5,000, .	560	92.0
Between 1,000 and 2,000, .	259	* 33.9	Between 5,000 and 6,300, .	621	114.0
Between 2,000 and 3,000, .	441	52.5		2,527	77.4

* Many of these were metered for but a portion of the year.

In the city of Providence the minimum charge is $10 per annum, for which each taker or service is entitled to use 91.32 gallons per day. In 1888 an analysis was made to show the number of takers using less than the quantity permitted by the minimum rate, with the following result: —

Cubic Feet Per Year.	Number of Services.	Gallons per Day per Service.	Cubic Feet per Year.	Number of Services.	Gallons per Day per Service.
Less than 1,500, . . .	167	30.74	Between 3,000 and 3,500, .	446	71.73
Between 1,500 and 2,000, .	237	40.99	Between 3,500 and 4,000, .	462	81.98
Between 2,000 and 2,500, .	361	51.23	Between 4,000 and 4,457, .	435	91.32
Between 2,500 and 3,000, .	445	61.48		2,553	66.70

The total number of meter accounts at this time, including those for trade, manufacturing and mechanical use, was 7,074, of which 5,110, or 72 per cent., paid less than $20 per year.

Use of Meters on Street Mains.

As has been already stated on previous pages, there is a large leakage from the pipes in the streets, and this cannot be detected except in the aggregate, and cannot be prevented by measuring the water supplied to each taker. Underground leaks in the streets can be best located by placing meters on the street mains, in such a manner that districts containing from 2,000 to 5,000 persons can be isolated from the remainder of the pipe system. The type of meter used for buildings is not well adapted to this service, but either the Venturi meter previously described, or the Deacon waste-water meter, which has been used in Boston for detecting waste, can be used to good advantage. Both of these meters record the rate at which water is drawn through them, and by closing valves on the pipes, the leaks, both in mains and service pipes, can be located within narrow limits. The Deacon meter gives a continuous record of the rate of flow; the Venturi meter records the rate of flow at intervals of ten minutes.

Samples of the records made by both of these types of meters are shown on the following pages.

The Venturi meter records, shown on Diagram No. 9, are full size facsimiles of original records, showing the increased draft caused by leaks in street mains. On Diagram No. 10 is shown, on a slightly reduced scale, the facsimile of a record made by a Deacon meter in July, 1881, before any attempt had been made to prevent waste, together with records made at later dates. It will be noticed that the record of November, 1881, shows a line approximately parallel with the record made in the preceding July, indicating that the reduction due to stopping waste was continuous throughout the twenty-four hours. It is also noticeable that the draft during the day was but very little larger in November, 1903, than it was in July, 1881, twenty-two years before, while the night rate or waste in 1903 was the largest recorded.

By the most thorough inspection it is not practicable to prevent all underground waste of water, and the best results can only be obtained by a force of well-trained, conscientious employés. This condition of affairs is more or less difficult of attainment, but it is perfectly feasible to reduce the underground waste to from 10 to 15 gallons per capita, and the total waste, including that in buildings, to from 15 to 20 gallons.

Method of Assessment.

By the present method of apportioning the amount required to pay the interest, sinking fund requirements, and expenses of maintenance and operation for the Metropolitan Water District, the city of Boston pays in the proportion that its valuation bears to the total valuation of the whole water district; and the remaining cities and towns pay the remainder of the required amount, one-third in proportion to their respective valuations and two-thirds in proportion to their respective populations, including, however, only one-sixth of the total valuation and one-sixth of the total population of any city and town which has not reached the safe capacity of its sources of supply, and has not made application for a supply of water. By this method of assessment the proportion paid by the several municipalities is not affected by the quantity used, and, although each municipality should be interested to keep the cost of constructing and maintaining works as small as possible, the inducement to prevent waste of water is general rather than special, especially in the smaller cities and towns. Under the present system, those cities and towns where the quantity of water used is kept within reasonable limits, either by the use of meters or by inspection, pay a higher rate for the water used than those where meters are not in use, and little or no attempt is made to prevent waste. This is shown by the following table (No. 18), giving the cost to each municipality of the water used during the year 1903. The quantity used has been determined from actual measurement during the last six months of the year, and estimated for the remaining time.

TABLE NO. 18.

CITY OR TOWN.	Amount of Assessment for 1903.	Estimated Quantity used (Million Gallons).	Cost per Million Gallons.
Boston,	$1,510,857 46	29,382.50	$51 42
Somerville,	77,288 43	2,120.65	36 45
Malden,	41,635 31	646.05	64 45
Chelsea,	39,877 54	1,277.50	31 21
Everett,	29,794 15	857.75	34 73
Quincy,	30,237 42	912.50	33 14
Medford,	24,654 86	602.25	40 05
Melrose,	17,815 34	511.00	34 86
Revere,	13,771 64	299.30	46 01
Watertown,	13,440 83	182.50	73 65
Arlington,	11,549 55	244.56	47 23
Milton,	14,813 20	120.45	122 79
Winthrop,	8,653 44	244.55	35 38
Stoneham,	7,523 04	164.25	45 80
Belmont,	5,701 23	80.30	71 00
Lexington,	5,733 77	87.60	64 47
Nahant,	3,211 08	51.10	62 84
	$1,856,558 29	37,784.80	$49 14

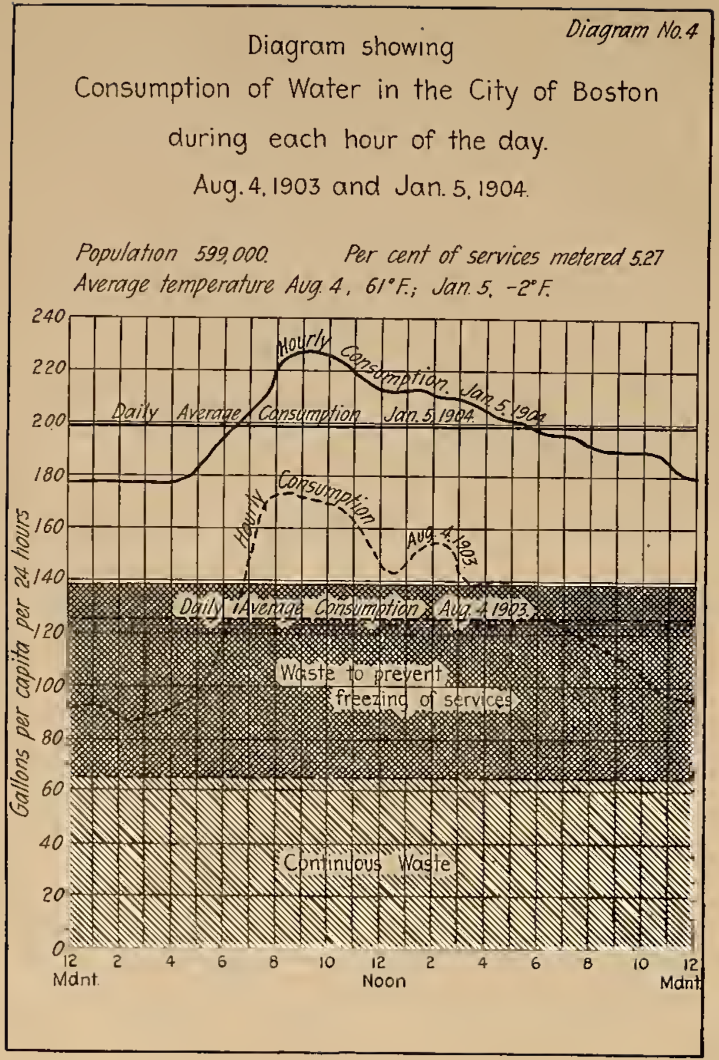


Diagram No. 4
Diagram showing
Consumption of Water in the City of Boston
during each hour of the day.
Aug. 4, 1903 and Jan. 5, 1904.
Population 599,000. Per cent of services metered 5.27
Average temperature Aug. 4, 61° F.; Jan. 5, -2° F.
Gallons per capita per 24 hours
240
220
200
180
160
140
120
100
80
60
40
20
0
Hourly Consumption Jan. 5, 1904
Daily Average Consumption Jan. 5, 1904
Hourly Consumption Aug. 4, 1903
Daily Average Consumption Aug. 4, 1903
Waste to prevent freezing of services
Continuous Waste
12 Mdnt.
2
4
6
8
10
12 Noon
2
4
6
8
10
12 Mdnt.

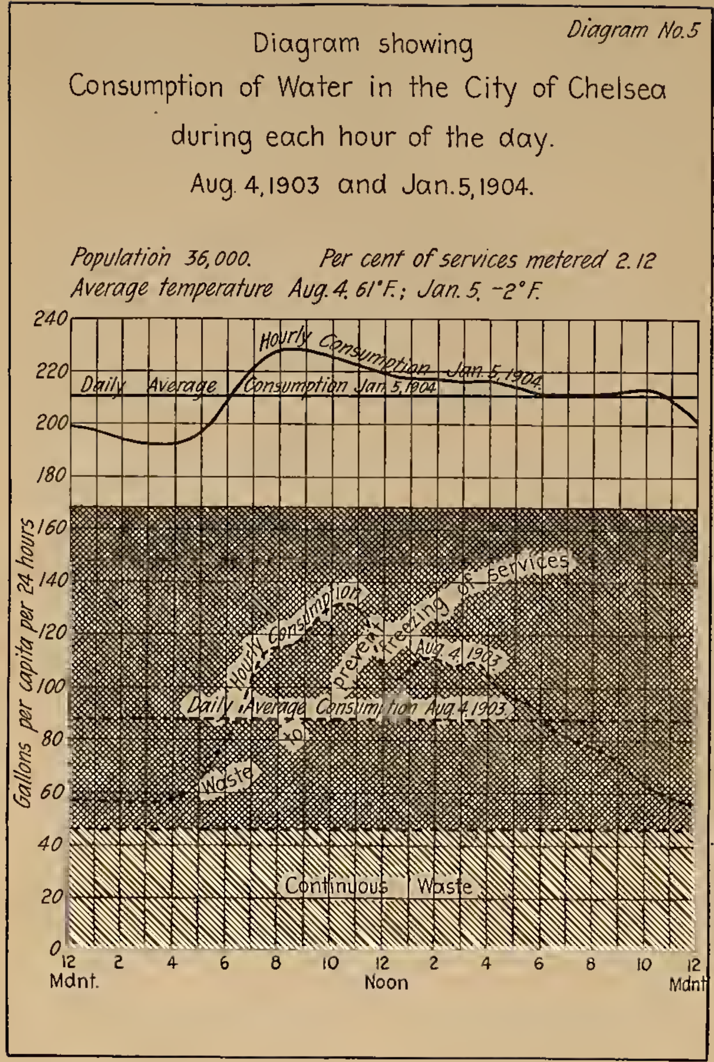


Diagram No. 5
Diagram showing
Consumption of Water in the City of Chelsea
during each hour of the day.
Aug. 4, 1903 and Jan. 5, 1904.
Population 36,000. Per cent of services metered 2.12
Average temperature Aug. 4, 61° F.; Jan. 5, -2° F.
Gallons per capita per 24 hours
240
220
200
180
160
140
120
100
80
60
40
20
0
Hourly Consumption Jan. 5, 1904
Daily Average Consumption Jan. 5, 1904
Hourly Consumption Aug. 4, 1903
Daily Average Consumption Aug. 4, 1903
Waste to prevent freezing of services
Continuous Waste
12 Mdnt.
2
4
6
8
10
12 Noon
2
4
6
8
10
12 Mdnt.

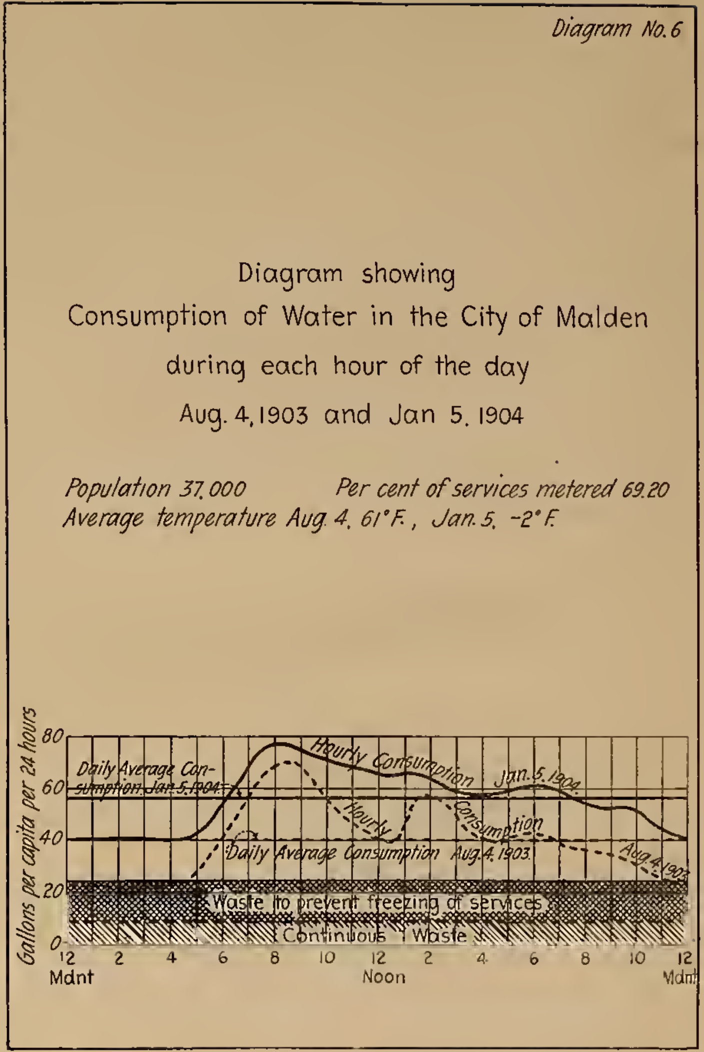


Diagram No. 6
Diagram showing
Consumption of Water in the City of Malden
during each hour of the day
Aug. 4, 1903 and Jan 5. 1904
Population 37,000 Per cent of services metered 69.20
Average temperature Aug. 4, 61° F., Jan. 5, -2° F.
Gallons per capita per 24 hours
80
60
40
20
0
Hourly Consumption Jan. 5, 1904
Daily Average Consumption Jan. 5, 1904
Hourly Consumption Aug. 4, 1903
Daily Average Consumption Aug. 4, 1903
Waste to prevent freezing of services
Continuous Waste
12 Mdnt
2
4
6
8
10
12 Noon
2
4
6
8
10
12 Mdnt

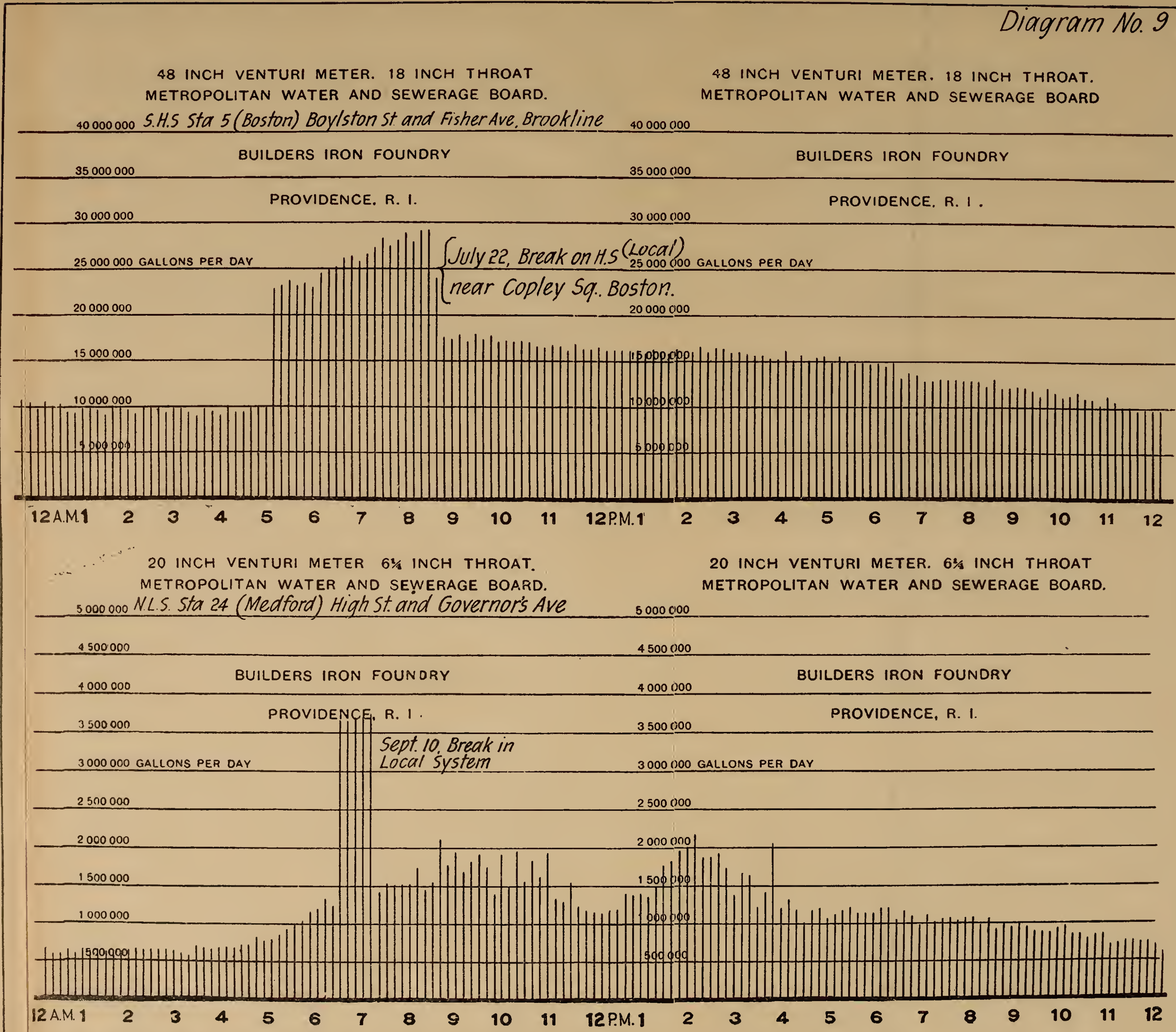


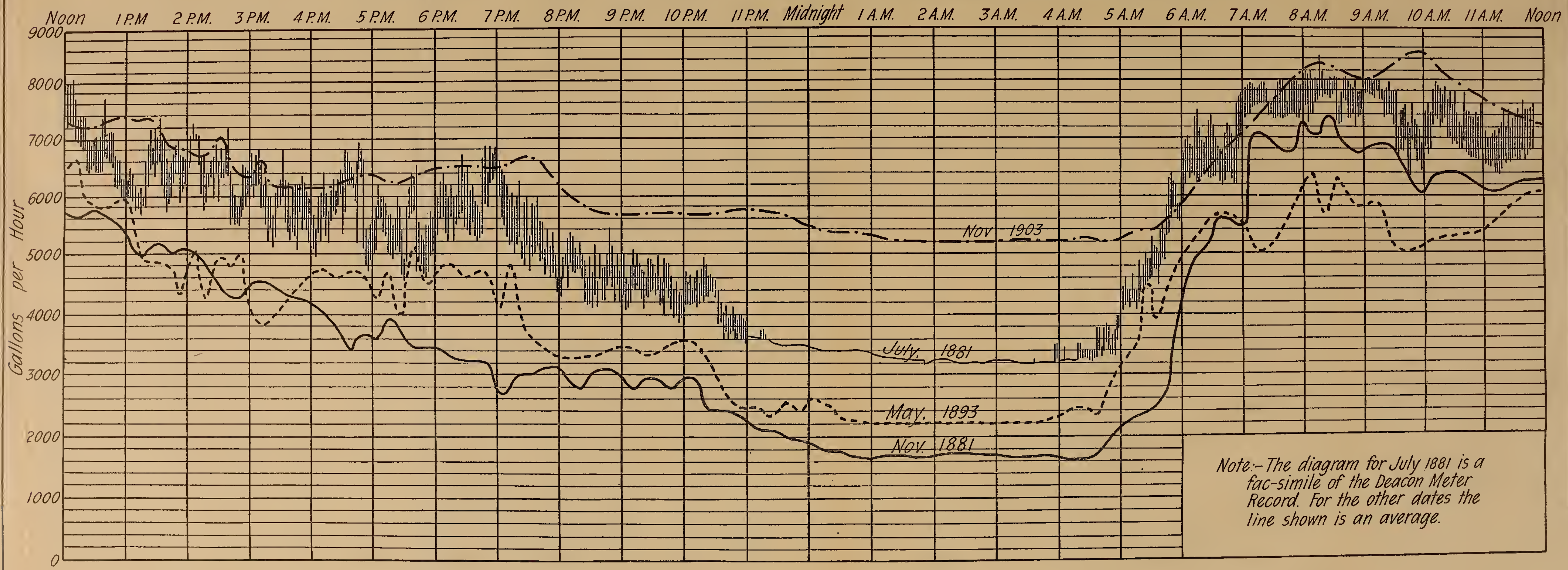
Diagram No. 9
48 INCH VENTURI METER. 18 INCH THROAT
METROPOLITAN WATER AND SEWERAGE BOARD.
S.H.S Sta 5 (Boston) Boylston St and Fisher Ave, Brookline
BUILDERS IRON FOUNDRY
PROVIDENCE, R. I.
40 000 000
35 000 000
30 000 000
25 000 000 GALLONS PER DAY
20 000 000
15 000 000
10 000 000
5 000 000
July 22, Break on H.S (Local) near Copley Sq. Boston.
48 INCH VENTURI METER. 18 INCH THROAT.
METROPOLITAN WATER AND SEWERAGE BOARD
BUILDERS IRON FOUNDRY
PROVIDENCE, R. I.
12 A.M. 1 2 3 4 5 6 7 8 9 10 11 12 P.M. 1 2 3 4 5 6 7 8 9 10 11 12
20 INCH VENTURI METER 6¼ INCH THROAT.
METROPOLITAN WATER AND SEWERAGE BOARD.
N.L.S. Sta 24 (Medford) High St. and Governor's Ave
BUILDERS IRON FOUNDRY
PROVIDENCE, R. I.
5 000 000
4 500 000
4 000 000
3 500 000
3 000 000 GALLONS PER DAY
2 500 000
2 000 000
1 500 000
1 000 000
500 000
Sept. 10, Break in Local System
20 INCH VENTURI METER. 6¼ INCH THROAT
METROPOLITAN WATER AND SEWERAGE BOARD.
BUILDERS IRON FOUNDRY
PROVIDENCE, R. I.
12 A.M. 1 2 3 4 5 6 7 8 9 10 11 12 P.M. 1 2 3 4 5 6 7 8 9 10 11 12

Diagram No. 10

Diagram showing Hourly Rate of Consumption in a Portion (Section, Winthrop 2) of Charlestown District, City of Boston.

Summary of Tests

Date	Population	Rate, Gallons per Hour		Gallons per capita per day		Remarks
		Average for 24 hrs.	Night Rate (waste)	Average for 24 hrs.	Night Rate (waste)	
July, 1881	1880	5350	3300	68.4	42.2	Before inspection
Nov. 1881	1880	3750	1740	47.8	22.3	After two or three inspections
May, 1893	1800	4100	2200	54.7	29.3	Inspection continued until July 1895
Nov. 1903	1825	6400	5200	84.0	68.4	No inspection for 8 years



In order to show the effect of using the quantity of water consumed as a factor in determining the amount to be paid by the several municipalities, the following statements have been prepared, showing the results under different conditions. The assessments of Newton and Hyde Park have been based upon one-sixth of the quantity of water consumed in 1903.

TABLE No. 19.

If each city and town had been assessed for the year 1903 in proportion to the quantity of water used, the amounts paid would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	$1,445,761 76	$65,095 70	-
Somerville,	104,340 45	-	$27,052 02
Newton,	6,315 74	2,937 13	-
Malden,	31,784 22	9,851 09	-
Chelsea,	62,858 40	-	22,980 86
Everett,	42,210 80	-	12,416 65
Quincy,	44,901 52	-	14,664 10
Medford,	29,635 38	-	4,980 52
Hyde Park,	3,045 76	-	295 84
Melrose,	25,150 83	-	7,335 49
Revere,	14,724 26	-	952 62
Watertown,	8,987 78	4,453 05	-
Arlington,	12,033 53	-	483 98
Milton,	5,923 34	8,889 86	-
Winthrop,	12,033 53	-	3,380 09
Stoneham,	8,072 18	-	549 14
Belmont,	3,942 66	1,758 57	-
Lexington,	4,316 38	1,417 39	-
Nahant,	2,522 56	688 52	-
	$1,868,561 08	$95,091 31	$95,091 31

TABLE NO. 20.

If the city of Boston had been assessed in proportion to its valuation, and the remainder of the amount divided among the remaining municipalities in proportion to the quantity of water used by each, the results would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston,	$1,510,857 46	-	-
Somerville,	88,281 25	-	$10,992 82
Newton,	5,340 52	$3,912 35	-
Malden,	26,895 73	14,739 58	-
Chelsea,	53,179 80	-	13,302 26
Everett,	35,705 97	-	5,911 82
Quincy,	37,988 12	-	7,750 70
Medford,	25,071 45	-	416 59
Hyde Park,	2,582 62	167 30	-
Melrose,	21,272 63	-	3,457 29
Revere,	12,458 82	1,312 82	-
Watertown,	7,597 63	5,843 20	-
Arlington,	10,180 24	1,369 31	-
Milton,	5,015 00	9,798 20	-
Winthrop,	10,180 25	-	1,526 81
Stoneham,	6,835 72	687 32	-
Belmont,	3,340 95	2,360 28	-
Lexington,	3,648 58	2,085 19	-
Nahant,	2,128 34	1,082 74	-
	$1,868,561 08	$43,358 29	$43,358 29

Table No. 21.

If the city of Boston had been assessed in proportion to its valuation, and the remainder of the amount divided among the remaining municipalities, one-third in proportion to valuation and two-thirds in proportion to the quantity of water used, the results would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	Difference, compared with Actual Assessment.	
		Less.	More.
Boston,	$1,510,857 46	-	-
Somerville,	82,311 18	-	$5,022 75
Newton,	7,923 14	$1,329 73	-
Malden,	30,168 72	11,466 59	-
Chelsea,	45,575 02	-	5,697 48
Everett,	32,347 14	-	2,552 99
Quincy,	34,693 67	-	4,456 25
Medford,	25,436 30	-	781 44
Hyde Park,	2,543 27	206 65	-
Melrose,	20,678 85	-	2,863 51
Revere,	12,998 95	772 69	-
Watertown,	10,030 01	3,410 82	-
Arlington,	10,824 11	725 44	-
Milton,	12,412 32	2,400 88	-
Winthrop,	10,151 63	-	1,498 19
Stoneham,	6,667 60	855 44	-
Belmont,	4,496 33	1,204 90	-
Lexington,	4,821 84	911 93	-
Nahant,	3,623 54	-	412 46
	$1,868,561 08	$23,285 07	$23,285 07

Table No. 22.

If the assessment for 1903 had been divided among all the municipalities, including Boston, one-third in proportion to valuation and two-thirds in proportion to quantity used, the results would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	Difference, compared with Actual Assessment.	
		Less.	More.
Boston,	$1,467,474 44	$43,383 02	-
Somerville,	93,016 97	-	$15,728 54
Newton,	8,576 70	676 17	-
Malden,	33,428 56	8,206 75	-
Chelsea,	52,020 74	-	12,143 20
Everett,	36,679 85	-	6,885 70
Quincy,	39,295 84	-	9,058 42
Medford,	28,476 87	-	3,822 01
Hyde Park,	2,858 90	-	108 98
Melrose,	23,263 58	-	5,448 24
Revere,	14,518 72	-	747 08
Watertown,	10,949 77	2,491 06	-
Arlington,	12,052 22	-	502 67
Milton,	13,023 87	1,789 33	-
Winthrop,	11,379 54	-	2,726 10
Stoneham,	7,492 93	30 11	-
Belmont,	4,895 63	805 60	-
Lexington,	5,269 34	464 43	-
Nahant,	3,886 61	-	675 53
	$1,868,561 08	$57,846 47	$57,846 47

TABLE NO. 23.

If the assessment for 1903 had been divided among all the cities and towns, one-half in proportion to valuation and one-half in proportion to quantity used, the results would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	DIFFERENCE, COMPARED WITH ACTUAL ASSESSMENT.	
		Less.	More.
Boston, ...	$1,478,312 10	$32,545 36	-
Somerville, ...	87,355 23	-	$10,066 80
Newton, ...	9,716 52	-	463 65
Malden, ...	34,250 73	7,384 58	-
Chelsea, ...	46,601 91	-	6,724 37
Everett, ...	33,914 38	-	4,120 23
Quincy, ...	36,511 68	-	6,274 26
Medford, ...	27,897 62	-	3,242 76
Hyde Park, ...	2,746 78	3 14	-
Melrose, ...	22,329 31	-	4,513 97
Revere, ...	14,406 61	-	634 97
Watertown, ...	11,940 10	1,500 73	-
Arlington, ...	12,070 91	-	521 36
Milton, ...	16,555 45	-	1,742 25
Winthrop, ...	11,061 88	-	2,408 44
Stoneham, ...	7,212 65	310 39	-
Belmont, ...	5,362 77	338 46	-
Lexington, ...	5,736 48	-	2 71
Nahant, ...	4,577 97	-	1,366 89
	$1,868,561 08	$42,082 66	$42,082 66

Table No. 24.

If the assessment for 1903 had been divided as follows: Boston, two-thirds in proportion to valuation, one-third in proportion to water used; and other municipalities, one-third in proportion to valuation, two-thirds in proportion to quantity used, the results would have been as follows: —

CITY OR TOWN.	Amount of Assessment, on Basis above given.	Difference, compared with Actual Assessment.	
		Less.	More.
Boston,	$1,489,162 83	$21,694 63	-
Somerville,	87,303 33	-	$10,014 90
Newton,	8,403 67	849 20	-
Chelsea,	48,339 13	-	8,461 59
Malden,	31,998 45	9,636 86	-
Everett,	34,308 98	-	4,514 83
Quincy,	36,797 84	-	6,560 42
Medford,	26,979 01	-	2,324 15
Hyde Park,	2,697 52	52 40	-
Melrose,	21,933 01	-	4,117 67
Revere,	13,787 33	-	15 69
Watertown,	10,638 33	2,802 50	-
Arlington,	11,480 59	68 96	-
Milton,	13,165 12	1,648 08	-
Winthrop,	10,767 32	-	2,113 88
Stoneham,	7,071 98	451 06	-
Belmont,	4,769 04	932 19	-
Lexington,	5,114 29	619 48	-
Nahant,	3,843 31	-	632 23
	$1,868,561 08	$38,755 36	$38,755 36

By the provisions of the Act constituting the Metropolitan Water District, the city of Boston was paid for all of its supply works, while those of the other cities and towns were not taken, with the exception of Spot Pond and pumping stations on its shores, which were the property of the cities of Malden, Medford and Melrose. The works of the cities of Quincy and Newton and of the towns of Arlington, Revere, Watertown, Lexington and Hyde Park, also portions of the works supplying water to Malden, Melrose and Medford, were not taken, and are now of little value, excepting those of Newton and Hyde Park, which still furnish those municipalities.

These facts were considered in fixing the proportion of the cost to be paid by Boston and the other municipalities, and the part to be paid by the city of Boston was based upon its valuation in proportion to the valuation of the whole District. The proportion of the valuation of the city of Boston to that of the whole District is larger than the corresponding percentage of its population or of the quantity of water used; for this reason, any change in the present method of assessment of the whole district, by substituting the quantity of water used for population, will decrease the assessment of the city of Boston.

For the year 1903 the percentages of valuation, population and water used in the several municipalities were as follows: —

TABLE NO. 25. — *Showing the Proportion of Valuation, Population and Quantity of Water used for the Year 1903; also, the Proportion of Metropolitan Water Assessment paid by the Several Cities and Towns.*

CITY OR TOWN.	Percentage of Valuation.	Percentage of Estimated Population.	Percentage of Water used.	Percentage paid on Present Basis of Estimate.
Boston,	80.857	66.284	77.373	80.857
Somerville,	3.767	7.505	5.584	4.136
Newton,*	.701	.700	.338	.495
Malden,	1.965	4.098	1.701	2.228
Chelsea,	1.625	3.980	3.364	2.134
Everett,	1.371	3.313	2.259	1.595
Quincy,	1.504	2.977	2.403	1.618
Medford,	1.400	2.303	1.586	1.320
Hyde Park,*	.132	.263	.163	.147
Melrose,	1.043	1.542	1.346	.953
Revere,	.754	1.436	.788	.737
Watertown,	.797	1.201	.481	.719
Arlington,	.648	1.079	.644	.618
Milton,	1.456	.820	.317	.793
Winthrop,	.540	.815	.644	.463
Stoneham,	.339	.706	.432	.403
Belmont,	.364	.533	.211	.305
Lexington,	.383	.398	.231	.307
Nahant,	.354	.247	.135	.172
	100.000	100.000	100.000	100.000

* Percentages for Newton and Hyde Park are based upon one-sixth of the valuation, population and water used.

In view of the conditions under which the present method of apportioning the assessment was established, it does not appear to be equitable to so radically modify the same as to eliminate entirely the factor of valuation. On the other hand, it is very desirable that the assessment shall be divided in such a manner that each city and town shall feel a pecuniary interest in preventing the waste of water. The city of Malden, and the towns of Belmont, Milton and Watertown, have, by the general use of meters, prevented to a great extent the waste of water within their limits; while in most of the other cities and towns in the District very little attention is given to any means of preventing unnecessary use and waste. From a business point of view, it seems proper that those municipalities which adopt measures to prevent waste of water, and thus reduce the expense of constructing and maintaining the Metropolitan Water Works, should receive a direct benefit, and that they should not be obliged to pay for the negligence of others. This can to some extent be accomplished by using both valuation and quantity of water as factors in determining the proportion to be paid; and if each of these factors is given equal value, the results will, as a whole, be an improvement upon the present method.

Reasons for checking Waste.

The quantity of water that will be required in the future to supply cities and towns now furnished with water from the Metropolitan Works is estimated as follows, the figures in the second and third columns being the quantities that will be needed if waste is not checked, and those in the fourth and fifth columns those required if water is sold to all consumers by measurement, and waste of water prevented as far as practicable, assuming, in both cases, an increasing consumption per capita.

YEAR.	Waste not checked.		Waste prevented.	
	Gallons per Capita.	Million Gallons per Day.	Gallons per Capita.	Million Gallons per Day.
1910,	134	152	80	90
1915,	144	181	85	107
1920,	154	219	90	128
1925,	164	262	95	150
1930,	174	310	100	175

The estimated safe capacity of the Cochituate, Sudbury and Nashua River works is 173,000,000 gallons per day; and, if present conditions are allowed to continue, additional sources of supply will be required by 1913, the construction of which will require several years, so that within five years from the time when the Nashua River works now being built will be finished the construction of new works will be called for.

The sources which were suggested in 1895 by the State Board of Health, in its report on additional water supply, as available for supplementing the supply from the Nashua River, are as follows: —

	Estimated Available Yield (Million Gallons per Day).	Total Available from all Sources (Million Gallons per Day).
Assabet River,	28	201
Upper Ware River,	71	272
Lower Ware and Swift rivers,	200	472

The addition of the Assabet River will be followed almost immediately by works from the Upper Ware River, and within eighteen years the construction of works from the Swift River will become necessary. In order to distribute the increasing quantity of water to the several municipalities, no less than ten lines of large pipes will be required, leading from the terminus of the Weston Aqueduct, and additional main pipes will also be required in different portions of the District. Additional pumping machinery will also be needed.

It is estimated that the cost of the new works required within the next twenty-five years to supply the probable demand for water, if waste is unchecked, will be at least $32,000,000, assuming that the District remains constituted as at present. If other cities and towns are added, as is probable, the time when the additional works will be needed will be shortened.

Not only is the cost of constructing and maintaining the works necessary for supplying water to the Metropolitan District increased by the waste of water, but the cost of the works required to dispose of the water after it has been delivered to the water takers is also increased. The greater part of the water that is wasted runs into the sewers, and is pumped one or more times before being discharged into the ocean. The North Metropolitan Sewerage Works, when built, about ten years ago, were expected to have a capacity sufficient to meet the demands of the District until 1930; but it has already been found necessary to duplicate some portions of the system, and within a comparatively few years the entire system must be duplicated, if the quantity of sewage to be provided for continues to increase at the present rate. The city of Boston has been obliged to construct new reservoirs and pumping machinery, and new and extensive works are now being constructed to relieve the Boston system of a portion of the sewage now cared for. The total cost of the Metropolitan and Boston main drainage systems has been about $19,000,000; and larger sewers and additional pumping machinery will be required, and increased cost of maintenance will result, if waste of water is allowed to continue to increase. All the available sources of water supply east of the Connecticut River will be required during the next twenty-five years, and an immense sum of money must be expended for the construction of works to bring to the District water which will serve no useful purpose, but will, on the other hand, cause inconvenience and expense to the Metropolitan District, through making necessary additional water mains and sewerage works.

In conclusion, I desire to express my appreciation of the assistance furnished, during the progress of the investigations and the preparation of this report, by the officials in charge of the water departments in the several municipalities of the District.

Table No. 26, appended to this report, gives the daily average number of gallons of water used during each week from June 28, 1903, to January 2, 1904, in the several cities and towns supplied from the Metropolitan Water Works; and Table No. 27 contains statistics relative to the consumption of water, number of services and meters in use, revenue from sale of water, etc., in twenty-one of the large cities of the United States.

Respectfully submitted,

DEXTER BRACKETT,

Engineer, Distribution Department.

TABLE NO. 26. — *Daily Average Number of Gallons of Water used in the Several Cities and Towns supplied from the Metropolitan Water Works during Each Week from June 28, 1903, to January 2, 1904, as measured by Venturi Meters.*

WEEK ENDING —	Boston.	Somerville.	Malden.	Chelsea.	Everett.	Quincy.	Medford.	Melrose.	Revere.
July 4,	76,482,700	6,086,800	1,853,100	3,326,900	2,206,700	2,612,200	1,592,400	1,396,400	782,100
July 11,	79,510,700	6,478,300	1,912,400	3,507,500	2,212,200	2,964,800	1,810,900	1,525,700	915,000
July 18,	77,770,900	6,208,400	2,002,000	3,394,700	2,290,000	2,992,900	1,946,100	1,570,100	929,100
July 25,	73,421,300	5,371,400	1,731,100	3,155,700	1,986,900	2,274,100	1,574,000	1,378,900	802,000
August 1,	75,708,300	5,588,000	1,910,900	3,252,700	2,168,700	2,454,400	1,467,100	1,440,100	878,700
August 8,	73,795,200	5,143,100	1,613,700	3,226,700	2,113,500	2,256,100	1,535,000	1,400,300	819,400
August 15,	75,639,200	5,548,000	1,735,000	3,173,000	2,115,100	2,437,100	1,485,000	1,413,400	853,600
August 22,	76,778,300	5,458,500	1,829,500	3,192,000	2,235,300	2,471,400	1,624,500	1,433,100	889,400
August 29,	75,117,800	5,284,400	1,868,000	3,213,100	2,283,700	2,434,900	1,667,100	1,386,100	891,600
September 5,	74,989,000	5,224,700	1,737,100	3,093,700	2,216,600	2,328,700	1,554,700	1,319,000	792,600
September 12,	76,318,000	5,551,200	1,884,000	3,078,100	2,243,700	2,361,400	1,719,300	1,408,400	834,900
September 19,	79,178,500	6,075,000	2,070,100	3,271,300	2,395,000	2,489,100	1,899,600	1,535,100	880,100
September 26,	77,764,900	5,522,000	1,954,000	3,240,800	2,204,400	2,410,900	1,777,500	1,448,900	783,000
October 3,	76,847,200	5,691,200	1,841,600	3,277,200	2,204,700	2,324,700	1,764,700	1,485,600	735,900
October 10,	76,597,700	5,668,900	1,751,400	3,235,400	2,130,700	2,260,600	1,680,300	1,440,400	706,700
October 17,	77,009,800	5,303,900	1,688,900	3,190,400	2,177,900	2,229,000	1,618,400	1,395,000	693,000
October 24,	76,949,600	5,312,400	1,800,800	3,196,100	2,244,800	2,267,300	1,618,500	1,407,400	698,700
October 31,	76,689,600	5,298,400	1,687,400	3,121,700	2,285,100	2,314,400	1,622,700	1,385,100	707,400
November 7,	77,502,200	5,320,800	1,692,500	3,095,000	2,333,400	2,300,300	1,620,100	1,400,000	700,000
November 14,	77,384,500	5,284,000	1,648,600	3,157,100	2,302,300	2,202,100	1,585,100	1,344,300	686,400
November 21,	75,903,100	5,283,700	1,620,600	3,141,400	2,330,000	2,233,100	1,575,500	1,315,900	673,400
November 28,	76,904,000	5,108,900	1,535,500	3,337,400	2,379,700	2,239,600	1,597,000	1,312,600	685,500
December 5,	81,096,600	5,515,600	1,567,700	3,714,800	2,553,600	2,373,700	1,588,400	1,314,900	767,700
December 12,	79,365,400	5,350,700	1,589,900	3,495,800	2,461,000	2,346,900	1,549,900	1,304,700	711,800
December 19,	86,711,200	5,942,300	1,593,500	4,054,900	2,641,600	2,455,400	1,651,900	1,325,300	851,200
December 26,	86,086,000	6,099,200	1,768,000	4,546,500	2,713,100	2,692,700	1,745,800	1,279,000	853,500
January 2,	94,639,400	6,487,300	1,750,800	5,080,300	2,852,000	2,483,400	1,773,200	1,301,000	961,000
Average gallons per day,	78,228,200	5,600,300	1,764,400	3,398,900	2,306,700	2,415,200	1,653,500	1,395,100	795,700

TABLE No. 26 — *Concluded.*

WEEK ENDING —	Watertown.	Arlington.	Milton.	Winthrop.	Stoneham.	Belmont.	Lexington.	Nahant.	Swampscott.	Total.
July 4,	528,700	722,700	302,900	683,000	377,100	165,200	292,000	335,000	604,900	100,350,800
July 11,	611,200	854,200	365,300	817,700	509,700	214,100	352,300	379,900	726,700	105,668,600
July 18,	636,700	941,200	375,500	814,000	493,600	262,900	253,000	399,600	786,100	104,066,800
July 25,	506,700	737,000	270,900	589,600	497,100	170,400	205,400	215,600	690,000	95,578,100
August 1,	587,300	695,400	366,700	767,700	496,600	213,300	243,000	256,600	710,900	99,206,400
August 8,	522,700	670,000	334,700	768,900	512,000	215,900	261,300	232,200	696,600	96,117,300
August 15,	581,100	630,000	354,700	750,000	508,000	244,300	269,000	213,200	708,900	98,658,600
August 22,	559,200	630,200	344,800	764,000	521,000	235,100	278,400	289,000	726,400	100,260,100
August 29,	544,200	651,900	317,000	775,600	499,000	228,800	312,600	234,300	745,000	98,455,100
September 5,	496,400	538,900	290,100	663,100	447,900	208,700	274,900	159,600	658,400	96,994,100
September 12,	554,300	582,700	377,000	690,400	441,900	188,100	321,900	180,900	659,400	99,395,600
September 19,	594,100	624,400	400,700	762,300	491,900	308,000	327,600	238,500	633,400	104,174,700
September 26,	579,700	634,700	378,000	683,100	461,700	274,600	309,100	204,700	485,900	101,117,900
October 3,	558,400	617,200	356,100	639,300	438,000	281,100	296,100	167,700	508,000	100,034,700
October 10,	577,700	553,200	312,500	597,300	428,600	254,700	259,600	103,100	425,900	98,984,700
October 17,	529,000	554,400	301,400	594,000	416,300	236,400	209,700	91,500	456,900	98,695,900
October 24,	504,100	556,700	320,400	603,900	446,700	243,900	223,900	51,900	450,100	98,897,200
October 31,	478,400	525,800	330,000	600,000	476,600	220,600	215,900	62,900	473,600	98,495,600
November 7,	522,400	543,300	349,400	580,300	449,400	229,400	188,600	40,000	426,400	99,293,500
November 14,	497,700	525,900	325,000	575,100	442,400	226,100	186,000	40,000	369,600	98,782,200
November 21,	490,600	539,400	324,400	536,300	449,900	226,700	169,300	44,600	302,600	97,160,500
November 28,	478,600	519,200	316,900	557,600	434,700	222,400	178,900	40,000	293,300	98,141,800
December 5,	486,900	522,700	313,800	594,300	460,900	225,700	187,700	48,100	340,700	103,673,800
December 12,	479,000	518,300	268,600	584,400	484,800	219,100	176,700	56,900	327,000	101,290,900
December 19,	493,400	542,900	263,400	641,300	481,600	207,700	189,700	42,500	313,100	110,402,900
December 26,	438,000	572,500	262,400	657,200	459,700	205,900	194,800	41,100	362,200	110,977,600
January 2,	515,600	709,400	261,200	741,800	491,600	222,700	176,800	83,300	355,500	120,886,300
Average gallons per day,	531,600	619,000	325,300	667,900	467,400	227,800	242,700	157,500	527,300	101,324,500

Table No. 27. — *Water Works Statistics of the Large Cities of the United States for the Year 1902.*

Cities.	Population.	Total Daily Average Consumption (Gallons).	Daily Average Metered Consumption (Gallons).	Number of Services.	Number of Meters.	Miles of Pipe.	Consumption per Capita (Gallons).	Metered Consumption per Capita (Gallons).	Per Cent. of Consumption metered.	Per Cent. of Services metered.	Total received for Water.	Receipts for Metered Water.	Per Cent. received for Metered Water.	Total received per Million Gallons.	Received for Metered Water per Million Gallons.
New York (Manhattan),	2,091,000	282,000,000	64,246,600	150,000	37,493	897.00	135.0	30.7	22.80	25.00	$5,592,894 00	$3,132,316 00	56.00	$54 34	$135 00
Chicago, Ill.,	2,250,000	358,101,700	41,096,000	324,200	7,075	1,918.80	159.0	18.3	11.50	2.18	3,164,910 53	1,329,684 69	42.00	24 21	86 00
Philadelphia, Pa.,	1,349,500	313,992,600	16,430,400	255,400	1,510	1,381.00	233.0	12.2	5.23	.59	3,459,095 67	226,684 10	6.56	30 20	38 00
Metropolitan Water District,	874,200	107,268,000	21,213,500	141,600	13,073	1,457.00	122.7	24.4	19.80	9.24	3,243,634 53	1,286,227 15	39.70	82 85	166 12
St. Louis, Mo.,	650,000	87,000,000	15,149,000	72,005	4,635	709.00	134.0	23.3	17.41	6.41	1,748,541 21	760,545 50	43.50	55 00	137 00
Boston,	-	-	17,521,400	89,337	5,164	727.00	-	29.9	-	6.03	2,306,191 98	1,005,312 26	43.60	-	157 19
Baltimore, Md.,	525,000	59,647,900	13,226,000	100,151	2,182	634.00	114.0	25.2	22.17	2.17	554,530 72	264,283 06	47.60	25 50	55 00
Cleveland, O.,	424,000	69,964,500	19,050,900	56,816	11,099	577.00	165.0	45.0	27.23	21.11	864,140 11	433,778 81	50.20	33 90	62 00
Buffalo, N. Y.,	360,000	116,810,400	16,501,800	67,531	1,375	500.45	324.0	46.0	14.12	2.04	682,920 21	135,520 75	19.80	16 00	23 00
Cincinnati, O.,	345,400	43,033,000	10,513,670	37,302	3,607	440.00	124.6	30.4	24.40	9.67	800,970 50	334,505 82	41.76	51 00	88 00
Pittsburg, Pa.,	260,000	63,800,000	4,279,000	36,112	394	362.50	246.0	16.4	6.71	1.09	774,042 64	177,223 00	22.90	33 20	114 00
Detroit, Mich.,	327,000	51,390,900	14,970,800	63,342	5,847	617.00	157.0	42.7	29.17	9.24	398,290 81	136,176 40	34.40	21 20	25 00
Milwaukee, Wis.,	308,000	25,010,800	-	45,480	32,721	370.00	81.0	-	-	71.94	531,853 28	305,112 59	57.50	58 20	-
Newark, N. J.,	260,000	26,000,000	-	36,278	13,275	263.00	100.0	-	-	36.60	695,161 05	381,932 88	54.00	73 20	-
Louisville, Ky.,	241,000	16,582,600	-	23,877	1,944	254.00	68.8	-	-	8.14	410,666 17	169,298 87	41.15	67 80	-
Indianapolis, Ind.,	200,000	15,653,100	-	11,459	650	225.90	78.0	-	-	5.67	282,231 31	-	-	49 40	-
Providence, R. I.,	198,400	11,563,400	-	22,758	19,216	-	58.0	-	-	84.50	605,307 35	512,051 95	84.60	143 50	-
Toledo, O.,	140,000	9,823,900	-	12,864	6,292	175.20	70.0	-	-	48.85	150,630 19	112,750 37	74.80	42 10	-
Worcester,	124,300	8,094,800	4,331,000	13,832	13,076	180.90	65.0	34.8	53.55	94.50	270,088 81	262,500 87	97.20	91 50	166 00
Paterson, N. J.,	109,000	9,900,000	1,390,400	11,669	3,000	113.90	91.0	12.8	14.00	25.70	-	-	-	-	-
Fall River,	108,700	4,365,100	-	7,282	6,973	92.70	40.1	-	-	-	175,856 95	171,677 36	-	110 20	-