METROPOLITAN WATER AND SEWERAGE BOARD

FOURTH ANNUAL REPORT

JANUARY 1, 1905

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.

WESTON RESERVOIR—View from Ash Street looking towards Screen Chamber at Outlet.

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FOURTH ANNUAL REPORT

OF THE

Metropolitan Water and Sewerage Board.

January 1, 1905.

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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, 1904, and now presents a detailed statement of the operations for the year, being its

FOURTH 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 the same as in the preceding year: 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, during the early part of the past year, consisted, in addition, of the same number of employés as in the preceding year; but during the year considerable reduction has been made, and the force now comprises a book-keeper, an assistant book-keeper, an assistant in auditing, a paymaster, one general clerk, four stenographers, a telephone operator, one messenger, and a janitor with two assistants, one of whom acts as watchman. It has been determined in the coming year to place the auditing department under the general supervision of the secretary, the present auditor acting as purchasing agent.

Alfred C. Vinton continued as conveyancer during the first half of the year, a position which he had filled efficiently since the organization of the Water Board. Owing to the diminution in the amount of conveyancing, he severed his connection with the Board on July 1, 1904, and since that date George D. Bigelow, who had acted as assistant conveyancer, has been in charge, assisted by Miss Alline E. Marcy, title examiner, and by one stenographer.

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.

The various departments of the Water Works have been, subject to the Chief Engineer, in charge of the following: Dexter Brackett, Engineer of the Distribution Department, and, since March 10, also in charge of the Sudbury Department; Thomas F. Richardson, Engineer of the Dam and Aqueduct Department; Charles E. Wells, Engineer of the Reservoir Department; Frank T. Daniels, Principal Office Assistant. Horace Ropes was Engineer of the Weston Aqueduct Department until May 25, when this department was abolished and the duties were transferred to the Distribution Department.

The engineering force employed on the Water Works, both in construction and maintenance, has, upon the average during the year, comprised, in addition, 10 division engineers, 16 assistant engineers, and others in various engineering capacities and as sanitary inspectors, clerks, stenographers and messengers, to the number of 101, — in all, 127. The maximum engineering force employed at any one time during the year on construction and maintenance was 148.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 11. 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 minor operations.

In addition, a maintenance force, numbering, upon the average during the year, 202, 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 216, and was distributed among the various departments as follows: Sudbury and Distribution Departments, 203; Dam and Aqueduct Department, 12; 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 11, when the number amounted to 1,627.

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

He was assisted during the larger part of the year by 2 division engineers who were in charge of the various sections of sewer construction, 1 division engineer in charge of drafting room and records, 6 assistant engineers, 6 inspectors, and 22 others, who were 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 37.

Day-labor forces, under the general supervision of the engineers and the immediate direction of foremen, have been employed on the High-level Sewer in grading the roads and grounds about the Ward Street pumping station, in connecting the Charles River valley sewer with the High-level Sewer, and in grading and filling on Nut Island, in Quincy. On the North Metropolitan System, day-labor forces have been employed in the construction of parts of sections 61 and 62 of the Revere extension in Chelsea and in minor work.

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 July 24, when the number amounted to 302.

Upon the completion of construction on both the North and South Metropolitan systems, the engineering force was reduced to 9, all of whom are now employed in maintenance of the works.

The regular maintenance force required for the operation of the pumping stations, the care and inspection of the sewers, and for other parts of the Sewerage Works, exclusive of engineers and day-labor construction forces before enumerated, has upon the average numbered 90. The opening of the High-level Sewer and putting into operation of the Ward Street pumping station and Nut Island screen-house late in the year necessitated an increase in the force, which at the end of the year numbered 125, of whom the engineer in charge and 9 assistants and draftsmen were engaged in general upon the works, and of the remainder, 72 were employed upon the North System and 43 upon the South System.

(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 and auditor and the conveyancer, and the main engineering offices of both the Water Works and the Sewerage Works.

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. A branch office of the Dam and Aqueduct Department has been maintained at the Wachusett Dam. The main office of the Weston Aqueduct Department in Saxonville was discontinued on June 30, and the branch office located in Wayland was discontinued on February 29, and that in Weston on July 16. 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. Branch 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; and the maintenance force for the southern part of the District has headquarters in buildings at the Chestnut Hill Reservoir.

Maintenance in connection with the Water Works has embraced the care and operation of 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 in active operation; the Wachusett Reservoir; Lake Cochituate; the Sudbury Reservoir and the various smaller reservoirs in the Sudbury watershed; Spot Pond, Chestnut Hill Reservoir and the smaller distributing reservoirs in different portions of the District; the Cochituate, Sudbury, Wachusett and Weston aqueducts; as well as the various gate-houses, siphon and terminal chambers and other structures connected with the several reservoirs and aqueducts, dwellings for attendants, and various other buildings for operating purposes.

There were maintained, in connection with the construction of the Sewerage Works, branch engineering offices at Hough's Neck and Roxbury; an office for a portion of the year at Chelsea; and, in addition, seven portable booths were in use along the line of the work. For the maintenance of the Sewerage Works there are operated the Deer Island, East Boston, Charlestown, Alewife Brook, Ward Street and Quincy pumping stations, the Nut Island screen-house, the North Metropolitan Sewer and its extensions, and the Charles River valley, Neponset valley and High-level sewers. Branch headquarters of the maintenance and repair forces of the Sewerage Works are maintained at the East Boston and Ward Street pumping stations and at the stockyard at Hough's Neck.

(3) Conveyancing.

During the earlier portion of the year many claims for damages to real estate were settled, so that a large amount of conveyancing work was required in the way of examining the records, bringing up to date the titles at the registry of deeds, and the preparation and drafting of deeds and other necessary instruments.

The total number of cases settled during the year was 73, of which 68 were on account of Water Works, and affected 734.345 acres of land, and 5 on account of Sewerage Works, affecting 1.121 acres.

In addition, examinations of titles and the preparation of papers were required on account of various questions affecting lands which had been acquired from the city of Boston, and of various other claims which arose with reference to lands of the Commonwealth. The number of titles, therefore, which have been actually examined, and the questions relating thereto which required the preparation of various instruments, were much greater than the number above indicated.

In addition, also, there have been drafted 3 instruments of takings, embracing 127.50 acres, 2 on account of the Water Works and 1 on account of the Sewerage Works; and 13 deeds of lands and releases of rights in lands have been called for, and many papers in the nature of leases, licenses and forms of contract have been drafted.

Besides the work that has been done especially for the Board, many reports on titles have been called for by the Attorney-General for use in the preparation of suits and for the information of the Attorney-General's Department.

The hearings which have been had in the suits of the cities of Malden, Medford and Melrose against the Commonwealth, on account of the taking of Spot Pond and the various lands adjoining and contiguous thereto, have involved protracted examinations of records and reports and opinions upon titles. Investigation of the titles and history of the lands covered by Spot Pond, and the adjacent lands used in connection therewith, has extended from the beginning of legislative grants and registry records down to the present date; and this examination has required not only investigations at the registry of deeds, but also in the Massachusetts Archives, the histories of the various cities and the genealogies of the early settlers.

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

II. WATER WORKS — CONSTRUCTION.

The amount expended for construction, including real estate acquired and payment of claims, on account of the Water Works during the year 1904, was $2,174,498.19. Of this amount, $1,-506,803.38 was expended on account of the Wachusett Dam and Reservoir; $216,740.74 on account of the Weston Aqueduct and Reservoir; $40,554.03 for the improvement of the Wachusett watershed; $39,481.28 for diversion of water; $327,527.62 on account of the taking of Spot Pond; and the remainder, $43,391.14, upon various other operations on the works. The total amount expended for construction since the beginning of the works in the year 1895 has been $38,388,255.76.

(1) Wachusett Dam and Reservoir.

(*a*) *Wachusett Dam.*

The work upon the Wachusett Dam during the past year has included not only the carrying up in height of the main structure, but also the continuation of the excavations and building into the banks at each end of the dam, so that the ends as well as the foundations shall be embedded in the rock. At the end of the preceding year the masonry had reached an average elevation of 345

Wachusett Dam and Power and Gate House at End of 1904.

feet, and during the year 1904 an average elevation has been reached of 396 feet, above the Boston City Base, — an elevation which is 130 feet above the original river bed, and 188 feet above the lowest point of the foundation. This average elevation is 1 foot above the full-reservoir level, and there consequently remain, upon an average, but 19 feet more in height to be added.

The length of the dam has been extended from 739 feet to 1,024 feet, exclusive of the waste-weir, which is 452 feet in length. During the year 59,900 cubic yards of earth and 36,810 cubic yards of rock have been excavated. The stone masonry has amounted to 82,333 cubic yards. There have been used in the work during the year 16,561 barrels of Portland cement and 61,739 barrels of natural cement.

The abutment, so called, at the easterly end of the dam near Boylston Street, has been in like manner carried up, and the bastion at the westerly end, which divides the dam from the waste-weir, has been built nearly to the proper height. The most of the masonry work upon the waste-weir has been completed, and all but a small portion of the waste channel, which extends along the ledge from the weir to the river below the dam, a distance of about 1,240 feet, has been excavated and made ready for use. A granite arch bridge about 131 feet long, and having a span of 35 feet 6 inches, has been constructed across the lower end of the channel, which will afford access to the dam on the westerly side of the river.

The substructure, containing the gates and valves for the lower gate-chamber, was built in the preceding year, but during the past year the superstructure has been erected. This is a building 104 feet 6 inches long, 74 feet wide, and having a height of about 59 feet above the ground. The greater part of the interior is made up of one large room, in which will be installed the necessary machinery for the production of power. There are in addition several smaller rooms, which will be used for the various purposes needed in connection with the operation of the works. The exterior walls are from the same stone quarry from which the ashlar stone for the dam has been obtained.

The upper gate-chamber is built within the main structure of the dam itself, the water being introduced at ports or openings in the walls, and conveyed through sluice-gates by 48-inch pipes through the structure of the dam.

Much work has been accomplished in the grading of the banks along the river below the dam, and in depositing soil both upon the banks and the grounds at the foot of the dam and around the pool. The foundations have also been laid for the various drives and paths leading to the dam.

The work upon the dam has so far advanced that there seems but little doubt that it may be completed during the coming year.

(*b*) *Wachusett Reservoir.*

The building of the Wachusett Reservoir has progressed favorably during the past year. A total of 1,115,341 cubic yards of soil was removed from the bed of the reservoir, and 621 acres of land were stripped. It was estimated that in all, the soil was to be removed from 4,200 acres to the extent of about 6,900,000 cubic yards, and there have been excavated since the beginning of the work to the present date 6,760,405 cubic yards of soil from 3,857 acres. Of the total amount of soil, about 98 per cent. has been removed, and there remain to be stripped about 343 acres.

A large amount of the soil which has been removed, as in previous years, has been carried and deposited in the embankment of the North Dike; but a larger portion has been deposited at different places on the margin of the reservoir, for the purpose of avoiding shallow flowage, and also considerable amounts of soil have been used for the building of the South Dike and for highway embankments. The larger amount of the stripping done has been performed near the upper end of the reservoir in West Boylston, but the soil has also been removed from considerable tracts in Boylston as well as in Clinton and Sterling.

As arrangements have been made by which it may be possible to flow the reservoir during the early part of the present year to elevation 375, the grass and weeds which have grown in the area already cleared have been removed and burned, and a final cleaning has been made of the reservoir bottom to the elevation named. The number of acres thus cleared and made ready for flowing is estimated to be about 3,681.

Additional soil for the completion of the North Dike has been deposited during the year, and the placing of riprap on the slopes toward the reservoir has been completed. The dike has an entire length of 11,100 feet. More than 5,700,000 cubic yards of material have been used in the construction of the dike, and 139,000 cubic yards of riprap have been laid upon the water slopes. The cost of the dike has been substantially $750,000.

The South Dike has been entirely constructed during the year, except a portion of the riprapping. This dike has a length of about 2,925 feet, and has been constructed in a manner similar to that in which the North Dike was built. The soil removed from the reservoir has been placed to form the dike, the cut-off trench has been excavated and refilled with compacted material, and the water slopes have been riprapped in part. The cut-off trench was excavated to a maximum depth of 28.5 feet. The material used in the construction of the South Dike has amounted to 418,904 cubic yards of earth, soil and rock, and 7,687 cubic yards of riprap.

The number of buildings in West Boylston removed from the reservoir site during the year was 12, which embraced 2 churches, 6 dwellings, 2 barns, a hall and a store. The total number of buildings removed prior to the year was 259. In the town of Boylston there were removed 8 dwelling houses, a barn and a schoolhouse, — a total of 10 buildings. A few more buildings are still to be removed, but the work of demolition has been nearly completed.

The two nurseries, one upon the north side and the other upon the south side of the reservoir, have been maintained. These nurseries contain upwards of 700,000 seedlings and plants. The larger number of these are white pines and arbor vitæ, but there are many sugar maples, spruces and Scotch pines and smaller numbers of hemlocks, tamaracks and larches. About 200 acres upon the margin of the reservoir have been planted with seedlings grown in the nurseries, and much improvement has been made by the planting along the interior roads about the reservoir and by the cutting out of dead and undesirable trees.

The bodies which had been buried in the old Beaman Cemetery in West Boylston have been removed to a new burial lot adjoining the West Boylston Cemetery. The 65 bodies found were removed, with the respective monuments, headstones and footstones, and properly deposited in the new burial ground. The ground occupied by the burial lot was purchased for the purpose. The lot was graded and seeded and a substantial wall built to enclose it, and a gravel drive leading to it was constructed.

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

An important feature of the work of the past year has been the building of the embankment across the upper end of the reservoir in West Boylston in continuation of Worcester Street. This embankment has in places a height of 64 feet, and a width of 43 feet at the top and 300 feet at the bottom. Instead of building a masonry bridge with its abutments at the original channel of the river, it was determined to divert the river to the northerly side of the reservoir and to excavate a channel through the rock ledge, and by this means the larger part of the work of building abutments was avoided. A granite bridge has been extended across this channel, having a span of 47.5 feet, the top of the span being at a height of 60 feet above the bed of the channel. The sides of the embankment have been covered with paving. This work has been completed, and the road across the reservoir has been opened to public travel.

The new road from West Boylston has been continued and constructed from Pleasant Street through the village of Oakdale and as far as the new location of Holden Street. A single-arch granite bridge was built at the crossing of the Stillwater River, and a three-arch granite bridge has been constructed where the crossing is made of the Quinepoxet River. Overhead bridges have been built at the two crossings over the Boston & Maine Railroad. Holden Street has also been relocated and substantially reconstructed so as to permit public travel. The new construction of roads at Oakdale has done away with all grade crossings.

There have been no new locations of highways.

During the year a portion of North Main Street extending northeasterly from a point near East Main Street to Pleasant Street has been discontinued, and also the southwesterly part of Pleasant Street between the new highway and North Main Street, all in Oakdale. A small portion also of the old location of the Central Massachusetts Division of the Boston & Maine Railroad in Oakdale has been discontinued.

The following is a list of the roads which have been discontinued during the year on account of the work of construction of the Wachusett Reservoir: —

WACHUSETT RESERVOIR — ARCH BRIDGE OVER THE NEW CHANNEL AT WEST BOYLSTON.

List of Roads discontinued during the Year 1904.

[Including a part of the Central Massachusetts Railroad location, being No. 24.]

No.	Location.	Description.	Date of Discontinuance.
24	West Boylston, Oakdale Village.	That part of the old location of the Central Massachusetts Division of the Boston & Maine Railroad which extends easterly from the new location of said railroad, near the new highway, to that part of the old location heretofore discontinued, near the Worcester, Nashua and Portland Division of the Boston & Maine Railroad.	Feb. 20, 1904.
25	West Boylston, Oakdale Village.	(1) That part of North Main Street which lies between portions of said street heretofore discontinued, extending northeasterly from a point near East Main Street to Pleasant Street. (2) The southwesterly part of Pleasant Street, extending southwesterly between the new highway and North Main Street.	Oct. 15, 1904.

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

A settlement has been effected with the Boston & Maine Railroad, by which the old track of the Central Massachusetts Railroad through the bed of the Wachusett Reservoir has been surrendered to the Commonwealth; the interchange of lands required for the purposes of the relocation and the adjustment of the account between the railroad and the Commonwealth have been made.

Although the substantial part of the work of relocation was accomplished in the year 1903, some final work has been required during the past year, and some other subsidiary work has been necessary in connection with the relocation of the railroad.

It was deemed necessary to reinforce to a considerable extent the two railroad bridges which cross the Stillwater and Quinepoxet rivers. The masonry generally was grouted; the places opened were filled with mortar, and portions of the wingwalls had to be relaid.

The relocation of the railroad and the operations in connection therewith have required an expenditure of $821,700.77.

(*e*) *Clinton Catholic Cemetery.*

A considerable balance remains due on account of the taking of the lands constituting the St. John's Catholic Cemetery Association in Clinton. In accordance with the tripartite agreement which was executed between the Board, the Roman Catholic Bishop of Springfield and the St. John's Catholic Cemetery Association, incorporated for the purpose of holding the new cemetery lands which were acquired in Lancaster, the grounds were properly improved and all the bodies were transferred and reburied.

The Board, at the completion of the work, notified the two parties that it stood ready to pay over the balance due in accordance with the agreement, and to convey the lands in Lancaster, to which it has held the title, to the St. John's Catholic Cemetery Association, upon the release to the Commonwealth of the old cemetery lot and of all claims for damages. No action, however, has been taken by either of the two parties toward effecting a final settlement.

(2) Weston Aqueduct and Reservoir.

The Weston Aqueduct and Reservoir were so far completed during the year 1903 that water was first introduced from the terminal chamber into the Metropolitan Water District on one of the last days of that year. During the past year it has been necessary to uncover and clean a portion of the rocky bed of the reservoir, as this work could not be accomplished in the colder weather; to grade and cover with loam a portion of the embankments; and also along the larger part of the aqueduct to grade and seed the embankments, to build the fences and to set the stone bounds. Final work also was done upon the screen-chamber at the reservoir.

Final payments upon contracts have been made, but some claims for allowances under the contracts have not yet been settled, and a few claims for land and other damages also remain to be adjusted.

One siphon pipe required for the crossing of the Sudbury River and Happy Hollow valley in Wayland has been laid, but ultimately three lines of these pipes will be required, as the demands of the District shall increase.

The cost of the aqueduct, extending from the dam at the Sudbury Reservoir to the terminal chamber overlooking the Charles River at Weston, exclusive of the reservoir, will be about $2,500,000, which is about $200,000 per mile of the aqueduct proper. The cost of the reservoir, having an area of 66.6 acres and a capacity exceeding 200,000,000 gallons, is about $350,000, or about $1,720 per million gallons. The cost of both aqueduct and reservoir will, therefore, be about $2,850,000.

The State Board of Health, in its report of 1895, estimated the cost of the aqueduct as then proposed at $3,226,000. This estimate, however, was for one having a capacity of 250,000,000 instead of

WESTON AQUEDUCT—SIPHON CHAMBERS ABOVE HAPPY HOLLOW IN WAYLAND.

300,000,000 gallons per day, and did not include an equalizing reservoir. Although the present aqueduct has a capacity exceeding by one-fifth that formerly proposed and includes in addition the Weston Reservoir, the work as now constructed has been largely within the estimates made by the State Board of Health.

(3) Clinton Sewerage and Filtration Works.

An improvement has been effected during the past year in the filtration works which are used for the purification of the Clinton sewage. In connection with the filter-beds, which are located in the town of Lancaster, 8 separate settling basins have been constructed, each about 320 feet long and 33 feet wide, and having a capacity of about 237,000 gallons.

The basins are in general constructed upon the surface of the ground, so that the bottom may be to a considerable extent impervious to the passage of water. Each basin has an inlet and outlet structure of Portland cement concrete, with gates for controlling the flow of sewage in and out; and they are so arranged that all or a part of the sewage can be passed through them, or that all can be delivered, as formerly, directly to the filter-beds.

By means of these basins the more solid matter of the sewage will settle at the bottom, and, when the basin is emptied, can be speedily disposed of.

(4) Pipe Laying and Venturi Meters.

No construction has been carried on by the Distribution Department during the year except the placing of one Venturi meter. The engineer and his assistants in this department have been called upon to make record plans of work done in past years, and also to spend much time upon the preparation of plans, statistics and estimates in connection with the suit brought by the cities of Malden, Medford and Melrose against the Commonwealth for damages on account of the taking of Spot Pond; and a large increase in the work of maintenance was placed upon the department.

(5) Improvement of Spot Pond Brook.

In response to the special report made in January of the year 1904, the Legislature of that year passed "An Act to provide for the improvement of Spot Pond Brook by the Metropolitan Water and Sewerage Board," which was approved on June 3, 1904, and constituted chapter 406 of the Acts of the year.

This act provided for improving or changing the channel of Spot Pond Brook between Spot Pond in the town of Stoneham and tide-water in the city of Malden, substantially in accordance with the plans and recommendations made in the report of the Board to the General Court in the preceding year. The act, however, provided that no work should be begun upon the improvement until commissioners, who might within three months after the passage of the act be appointed upon the petition either of the Board or of the city of Malden or the city of Melrose, had after hearing made award of the proportion in which the expenses of carrying out the improvement should be paid by the Metropolitan Water District and by the city of Malden and the city of Melrose. The city of Melrose has made petition for the appointment of commissioners as provided in the act, but no hearing has yet been had thereon.

(6) 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 18 officers: 8 (reduced to 3 in December) in the town of Clinton; 3, 1 of whom is mounted, (reduced to 1 in December) in the town of Boylston; 6 (reduced to 5 in November and placed on half time in December) in the town of West Boylston; and 1 mounted officer in Sterling.

The construction of the Weston Aqueduct having been entirely completed, the 2 officers in Weston were discharged on February 20, 1904.

(7) 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 two takings, however, in West Boylston, of land to be used on account of the Wachusett Reservoir, affecting an area of 125.82 acres.

List of Takings for Metropolitan Water Works for the Year 1904.

No.	Location and Description.	Former Owners.	Recorded.	Purpose of Taking.
			1904.	
106	West Boylston and Holden (on Quinepoxet River, both sides of and including a street called River Street in Holden and Holden Street in West Boylston, and a small parcel north of the Boston & Maine Railroad, Central Massachusetts Division). Area, 102.96 acres in fee.	Austin H. Warfield.	March 22.	Wachusett Reservoir.
107	West Boylston (southeast of Pleasant Street and north of land of the County of Worcester Truant School). Area, 22.86 acres in fee.	Heirs of Charles M. Harris *et al.*	April 23.	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, except for about 127.21 acres, aside from Spot Pond and the contiguous lands and the works of the cities of Malden, Medford and Melrose, payments for which, amounting to $317,820.68, have been made on account. The Spot Pond suits are now pending before a commission. In nearly all cases affecting private lands purchases have preceded the takings.

Settlements under purchases and takings of land, for all purposes of the Water Works, have been effected in the past year in 47 cases, and for an aggregate of 302.005 acres, with the buildings thereon. The sums paid in these settlements have amounted to $144,404.16. In only 9 of these cases have the settlements been results of suits at law, and the total amount paid in the court settlements has been $42,928.90.

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, exclusive of the works of water supply acquired from the city of Boston, on January 1, 1898, has amounted to 818; and under them the Board has acquired rights, in fee or in easements, in 12,011.744 acres, or 18.77 square miles, for which an aggregate of $3,927,852.07 has been paid. Only 41 of these cases have been settled by suits at law, and the total amount paid under judgments of the court has been $136,930.23, or less than 4 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, 1904.

LOCATION.	For the Year 1904.			From Beginning of Work.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
*Wachusett Reservoir.**						
Clinton,	6.594	23	$43,645 21	1,286.804	421	$2,825,977 88
Boylston,	26.090			3,926.430		
West Boylston,	9.978			1,637.648		
Sterling,	12.125			714.675		
Lancaster,	-			69.970		
Holden,	-			167.000		
Berlin,	10.120			11.610		
Total,	64.907	23	$43,645 21	7,814.137	421	$2,825,977 88
Improving Wachusett Watershed.						
Holden,	84.300	3	$38,000 00	84.300	3	$38,000 00
West Boylston,	64.430			64.430		
Total,	148.730	3	$38,000 00	148.730	3	$38,000 00
Wachusett Aqueduct.						
Berlin,	-	1	$1,875 00	46.510	65	$74,362 40
Boylston,	-			.380		
Northborough,	-			96.070		
Southborough,	7.270			89.580		
Marlborough,	.660			51.740		
Clinton,	-			13.510		
Total,	7.930	1	$1,875 00	297.790	65	$74,362 40
Sudbury Reservoir.†						
Southborough,	-	-	-	1,995.580	150	$658,318 75
Marlborough,	-			750.980		
Total,	-	-	-	2,746.560	150	$658,318 75

* Including payments on account of St. John's Catholic Cemetery.

† Including settlements made by city of Boston.

Summary of Land Settlements for Water Works to December 31, 1904 — Concluded.

LOCATION.	For the Year 1904.			From Beginning of Work.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
Improving Sudbury Watershed.						
Northborough, . . .	23.470			171.400		
Southborough, ...	2.166			4.826		
Westborough, ...	–	2	$3,023 06	202.480	37	$16,522 16
Ashland, ...	–			.630		
Marlborough, ...	–			.740		
Total, ...	25.636	2	$3,023 06	380.076	37	$16,522 16
Clinton Sewerage System.						
Clinton, ...	–	–	–	5.320	36	$37,794 40
Lancaster, ...	–			129.860		
Total, ...	–	–	–	135.180	36	$37,794 40
Weston Aqueduct.						
Newton, ...	.193			.321		
Weston, ...	17.240			283.942		
Framingham, ...	2.740	16	$56,851 69	100.885	76	$166,856 40
Wayland, ...	34.525			69.379		
Southborough, ...	–			.450		
Total, ...	54.698	16	$56,851 69	454.977	76	$166,856 40
Distribution System.						
Boston, ...	.104			.804		
Brookline, ...	–			.050		
Arlington, ...	–			1.800		
Malden, ...	–			.160		
Medford, ...	–	2	$1,009 20	2.390	29	$108,420 08
Newton, ...	–			.060		
Quincy, ...	–			5.230		
Stoneham, ...	–			20.850		
Total, ...	.104	2	$1,009 20	31.344	29	$108,420 08
Improving Lake Cochituate.						
Natick, ...	–	–	–	2.950	1	$1,600 00
Total, ...	–	–	–	2.950	1	$1,600 00
Aggregates, . . .	302.005	47	$144,404 16	12,011.744	818	$3,927,852 07

The settlements above enumerated do not take into account the lands acquired under the provisions of the Metropolitan Water Act, which required the Board to take the property held by the city of Boston for the purposes of water supply. The takings from the city under the Act, which were made on January 1, 1898, included the Cochituate works, all the Sudbury works except the then unfinished Sudbury Reservoir, the construction of which had been already assumed by the Board, the Chestnut Hill Reservoir and adjacent lands, and the Mystic works. The lands thus taken aggregated about 3,744 acres, and, in accordance with the agreement made with the city, a sum total of $12,531,000 was paid for the entire works then acquired.

Including the property thus taken from the city of Boston, the settlements have numbered 819; and under them the Board has acquired lands in fee or in easements amounting to about 15,756 acres, or about 24.6 square miles, at a total expenditure of $16,458,852.07. More than 99 per cent. of the total amount involved in all these settlements has thus been paid in accordance with agreements made without the determination of a court.

Under the similar provision of the Metropolitan Water Act, the Board was required to take, from the cities of Malden, Medford and Melrose, Spot Pond and the adjacent lands, settlement for which has not yet been effected.

(8) 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, 1904, to the number of 2. Settlements of such claims have been effected during the year in 18 cases, under which the sum of $20,265 has been paid. Two claims have been disallowed. All of these claims except 1 have been settled by the Board outside of the court. The number of claims of this class settled since the beginning of the Water Works has been 282, and the total sum paid on account of such claims has been $139,286.

(9) Claims and Settlements for Loss of Employment.

During the year ending December 31, 1904, 6 claims for loss of employment by residents of West Boylston have been filed. Settlements have been made in 3 cases, the amount paid being $200.49. During the year 6 claims have been disallowed. The whole number of settlements effected has been 474. The total amount paid on account of these claims has been $85,884.65.

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

Settlements in 24 cases of injury to real estate in the towns of Clinton, Sterling and West Boylston have been made during the year ending December 31, 1904, and the sum of $26,151.17 has been paid. Of these claims, 2 have been settled in the courts. The total number of claims of this class settled to December 31, 1904, has been 248, and the total amount paid thereon has been $244,395.77.

It was provided by chapter 436 of the Acts of the year 1904 that the owners of real estate situated in that part of the town of Boylston lying on the southerly and southeasterly sides of the reservoir and within the limits of the Nashua River watershed should have the right to recover for damages to real estate not taken, but directly or indirectly decreased in value by reason of the Metropolitan Water Act, in a manner similar to that before provided for owners of real estate in the town of West Boylston. No claims have been allowed by the Board under this act.

(11) 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 $37,463.80. The total sum paid under settlements and judgments for such claims since the beginning of the construction of the Water Works has been $1,135,708.91. 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.

Considerable addition has been made during the past year to the duties of the Engineer of the Distribution Department. On March 10 the Sudbury Department, including also Lake Cochituate and the Cochituate Aqueduct, and on May 25 the Weston Aqueduct, were placed in charge of the Engineer of the Distribution Department. The title of the head of the department was changed to that of Engineer of Sudbury and Distribution Departments. This engineer has now, therefore, charge of substantially all the work of maintenance and operation as far west as Southborough. He is assisted by Charles E. Haberstroh, who has the immediate supervision of the Sudbury and Cochituate works and the portion of the Weston Aqueduct above the Weston Reservoir; by George E. Wilde, who has the immediate supervision of the Weston Reservoir and the remainder of the Weston Aqueduct, and of all the reservoirs and pipe lines within the Metropolitan District; and by John W. Lynch who has charge of the several pumping stations.

(1) Operation of Works.

All the 19 cities and towns, included within the Metropolitan Water District, having an estimated population of 972,600, have been supplied with water during the year, except the city of Newton and the town of Hyde Park. These two municipalities, though belonging to the District, have as yet made no application for a supply of water; and, the Board being still of the opinion that they have not reached the safe capacity of their own sources of supply in a dry year, they have been charged with but one-sixth of the entire assessment and have not been supplied with water from the Metropolitan Water Works.

In addition, the town of Swampscott is supplied with water under a special arrangement made with the Board, and a small part of the town of Saugus is permitted to take water under a contract with the Revere Water Company, which supplies water to the town of Revere.

In April a request was made to the Board by the Cambridge Water Board for a temporary supply of water; and, inasmuch as it appeared that an emergency existed in that city, not only by reason of the scarcity of water but also of the danger to health which would arise from the drawing down of Fresh Pond to a lower level, the Board voted to furnish water to the city to meet this emergency, such water to be supplied to the city of Cambridge subject to the same limitations and restrictions as should apply to the cities and towns of the Metropolitan Water District. Under this agreement water was furnished to that city for a period of 39 days, to the amount of 331,540,000 gallons, for which the city paid to the Commonwealth the sum of $15,218.70. Subsequently, in November, a request was again made by the Cambridge Water Board for a temporary supply of water; and, inasmuch as it appeared that a like emergency had again arisen, the Board agreed to furnish water to the city of Cambridge to the extent of 300,000,000 gallons, subject to the same provisions as before. The 300,000,000 gallons were accordingly furnished, for which the Commonwealth is to receive $15,000.

It was understood that the Cambridge authorities should, upon the meeting of the Legislature, ask for legislation by which the furnishing temporarily of water should be authorized by statute in case a similar emergency should again arise.

Except the water supplied by the city of Newton and the town of Hyde Park from their own sources, the water supplied to the Metropolitan Water District came from the sources of the Metropolitan Water System, and amounted to a total of 41,929,740,000 gallons, or an average daily supply of 114,876,000 gallons.

(2) Storage Reservoirs.

Lake Cochituate, which is the storage reservoir of the Cochituate watershed, has a normal capacity of 2,242,400,000 gallons. In the Sudbury watershed the Sudbury Reservoir has a like capacity of 7,253,500,000 gallons, and the 7 smaller reservoirs have a combined capacity of 6,362,600,000 gallons. All the storage reservoirs, therefore, of the Cochituate and Sudbury watersheds, have a total capacity of 15,858,500,000 gallons. These reservoirs, however, hold at certain periods a somewhat larger amount of water than is estimated as their normal capacity.

These storage reservoirs contained on January 1, 1904, 11,376,800,000 gallons, but were gradually lowered until February 22, when they contained 10,550,000,000 gallons, the lowest amount reached. The largest quantity on storage in these reservoirs was on June 8, when they contained 16,011,500,000 gallons.

The amount of water in storage was largely increased by the additional quantity which was stored in the unfinished Wachusett Reservoir. The amount stored in the Wachusett Reservoir was increased from 1,760,100,000 gallons, at the beginning of the year, to a maximum of 10,117,500,000 gallons on June 8.

There was a maximum total quantity of water in storage for the uses of the Metropolitan Water District on June 8, when the amount of 26,129,000,000 gallons was reached.

The water in the Wachusett Reservoir was carried in June to the full height permitted by the condition of the dam and reservoir. Before this time, considerable water, estimated at 8,600,000,000 gallons, was wasted into the river, because the conditions made it impossible to raise the water to a higher level.

An average of 88,554,000 gallons per day was drawn from the Wachusett Reservoir and conveyed through the Wachusett Aqueduct into the Sudbury Reservoir. From the Framingham Reservoir No. 3, which received not only this supply but also the yield of a considerable portion of the Sudbury watershed, there was drawn and conveyed through the Sudbury Aqueduct an average of 64,827,000 gallons per day, and an average of 30,575,000 gallons per day was carried through the Weston Aqueduct into the District. An average of 9,004,000 gallons per day was also drawn through the Sudbury Aqueduct from Framingham Reservoir No. 2. An average of 14,984,000 gallons per day was drawn from Lake Cochituate through the Cochituate Aqueduct. Lake Cochituate was, however, somewhat reinforced by water received on several days in the year from the Framingham reservoirs. It is estimated that the Spot Pond watershed yielded an average of 497,000 gallons per day, which was in addition to the quantity pumped into the pond.

Water was drawn substantially during the entire year from the Wachusett Reservoir or Nashua River; from the Sudbury Reservoir and Framingham Reservoir No. 3; from Lake Cochituate for a period of 8½ months; from Framingham Reservoir No. 2, Ashland Reservoir and Hopkinton Reservoir for a continuous period of 4 months; and during 15 days from Whitehall Reservoir. No water was drawn from Framingham Reservoir No. 1 or from Farm Pond directly into the District.

A driveway leading to the Sudbury Reservoir and Dam, which had been badly worn during the construction of the Weston Aqueduct, received thorough repairs. A wooden building, arranged for workshop and storage purposes, has been erected in connection with the other buildings of the Commonwealth situated near the Dam. Some repairs were also required at Framingham Reservoir No. 1 and at Lake Cochituate.

(3) Distributing Reservoirs.

The distributing reservoirs, so called, comprising Spot Pond, Chestnut Hill, Fells, Mystic, Waban Hill, Forbes Hill and Bear Hill reservoirs, and the Arlington and Forbes Hill standpipes, which are situated within the Metropolitan District, and were built more especially for the purpose of facilitating the distribution of water in the District, also serve secondarily for the storage of a large quantity of water which can be drawn upon in case of emergency. The total capacity of the above-named reservoirs is 2,181,230,000 gallons. To this total may be added 200,000,000 gallons, the capacity of the Weston Reservoir, which was built especially as an equalizing reservoir for the waters coming through the Weston Aqueduct. During the past year, also, an arrangement has been made with the Water Commissioners of the city of Chelsea by which water may be drawn from the high-service reservoir in that city in case of emergency, for supplying other cities and towns situated in that portion of the District. In consideration of this use, the Board has made repairs to the lining of the reservoir at a cost of about $4,000. This reservoir has a capacity of 916,500 gallons.

The grounds about Chestnut Hill Reservoir, Spot Pond, Fells Reservoir and Forbes Hill Reservoir, at which the tower commands an extensive view of the surrounding country, have been much resorted to in the summer season for recreation purposes. Mystic Lake, although not now used for water supply purposes, is maintained in good repair, and its waters may be used in case of emergency for the purposes of the District. The estimated capacity of this lake is now 380,000,000 gallons.

(4) Aqueducts.

The Wachusett Aqueduct was kept in use during 283 days of the year. It was emptied for a thorough cleaning, and also for the purpose of repairing some cracks in the aqueduct which had been caused by changes of temperature.

The Sudbury Aqueduct was in operation during 354 days. It was twice emptied for cleaning, and its use was discontinued also for necessary repairs to that portion of the aqueduct which crosses the Waban Bridge. There was a leakage from the aqueduct at this bridge, owing to cracks in the masonry; these were pointed or grouted and washed with cement, and the lower half of the aqueduct for the entire length of the bridge, a distance of 562.25 feet, was lined with sheet lead and otherwise reinforced. Other repairs of a minor character were required at Echo Bridge and at the Beaver Dam Brook culvert.

The Cochituate Aqueduct was in use 259 days during the year.

The flow of the Weston Aqueduct, which had been put into operation at the very end of the preceding year, was shut off for about three weeks, in order to do the finishing work upon the Weston Reservoir. At the same time some cracks in the aqueduct, which developed soon after construction, were repaired, and other finishing work was accomplished. The aqueduct was in use 320 days.

(5) Pumping Stations.

The operation of the Weston Aqueduct has enabled more than one-fourth part of the entire quantity of water consumed by the District to be supplied by gravity, and has consequently relieved, to a considerable extent, the low-service pumping station at Chestnut Hill.

The average number of gallons pumped per day at the pumping stations during the year was 95,525,000, as appears by the following table: —

NAME.	Total Capacity of Pumps (Gallons per Day).	Average Number of Gallons pumped per Day.
Chestnut Hill, high service, ...	66,000,000	31,125,000
Chestnut Hill, low service, ...	105,000,000	55,380,000
Spot Pond, ...	30,000,000	7,999,000
Arlington, ...	1,500,000	517,000
West Roxbury, ...	2,000,000	504,000
	204,500,000	95,525,000

Although the average height to which the water was pumped in the year 1904 was 86.87 feet, or 18.37 feet higher than in the preceding year, the cost per million gallons pumped was $2.615, being a reduction from the preceding year of $0.195. This decrease in cost was largely due both to the reduced price of coal and to the use of a larger proportion of anthracite buckwheat coal and screenings, which it has been found could profitably be mingled with other kinds of coal.

Tests have been made to determine the heating power and value of all the kinds of coal which have been used at the several stations.

The cost per million gallons raised 1 foot was for the Chestnut Hill high-service station $0.024, for the Chestnut Hill low-service station $0.030 and for the Spot Pond station $0.031. The cost is in each case considerably less than that of the preceding year.

(6) Pipe Lines and Pipe Yards.

No new lines of main pipes have been put in service during the year. There have been 19 leaks in pipes, 16 of which were caused by defective joints. Two leaks were discovered in the main pipes, caused by breakage, one in the 30-inch high-service main in the grounds of the Chestnut Hill Reservoir, and the other in the 16-inch high-service main in Winthrop Avenue in Revere. During the year also the 12-inch pipe line on Washington Street in Lynn, for a distance of 553 feet, was relaid on account of the damage done to it by electrolytic action.

The emergency and repair forces, that for the northern district having its headquarters at the Glenwood pipe yard and the other for the southern district at the Chestnut Hill pipe yard, have been able to do all the work of repairing and relaying that has been required.

(7) Clinton Sewerage and Filtration Works.

During the spring months, when the quantity of sewage was large, the pumps of the Clinton Sewerage Works were kept in operation during the night as well as the day. The quantity of sewage pumped and deposited upon the filter-beds has been, upon the average, 43,000 gallons per day less than during the preceding year, the quantity so pumped and deposited daily having been 740,000 gallons. This decrease in the amount of sewage is owing in part to the fact that the Clinton Water Department has continued to increase the number of metered house services, and in part to the fact that, the river being lower, there has probably been less percolation of river water into the defective local sewers.

The 8 new settling basins which have been added to the filtration beds were put into operation near the end of the year. Considerable experimenting has also been made in the methods of caring for the filter-beds, in order to improve further the character of the effluent.

The expense of pumping was somewhat increased, owing to the employment of an additional engineer for the night service. The cost per million gallons pumped was $11.99, as against $9.37 the preceding year. The cost per million gallons filtered was $8.29, as against $7.82 the preceding year.

(8) Sanitary Inspection and Regulations.

Dr. J. J. Goodwin of Clinton has been employed, as heretofore, under the supervision of the engineers in charge of construction, to examine the camps and other buildings occupied by the laborers, for the purpose of keeping such places and the grounds about which construction has been carried on in proper sanitary condition.

The general inspection of the watersheds, which has been exercised by the maintenance department, has been continued during the year under the supervision of William W. Locke, C.E., with two regular assistants. Other assistance has been rendered him by the engineers, and at times day laborers have been employed to carry out the improvements which have been required. There have been no cases of contagious disease arising within the limits of the Wachusett Reservoir, and few such cases upon the watershed. There has been a larger, but not an excessive, number of cases upon the Sudbury and Cochituate watersheds. Efficient measures have been taken in all cases to protect the purity of the water supply.

Inspection has been made of 1,530 premises in the Wachusett watershed, and of 847 premises in the Sudbury and Cochituate watersheds, the conditions of which were for some reason suspected or called for examination. The larger number of these were either found in satisfactory condition, or but slight work was required in order to make them satisfactory. In the more serious cases in the Wachusett watershed remedies have been effected, through the efforts of the inspectors, on 15 premises, and 17 premises have been partially remedied. On the Sudbury and Cochituate watersheds 148 premises have been remedied, all but 4 of them by sewer connections; and, in addition, 25 premises have been partially remedied. The local authorities have in general cooperated with the inspectors for the sanitary improvement of the region, and in no case during the year has it been necessary to resort to the courts in order to enforce the laws and regulations for the prevention of pollution.

A suit which arose in the preceding year, through the claim of the owner of one of the mill properties of the right to discharge polluting matter into the Quinepoxet River, is still pending before the courts.

It has been the policy of the Board, as previously announced, to introduce, at the expense of the Commonwealth, the works which are required for remedying the cases 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; but the engineers and inspectors have been willing to offer suggestions regarding the means by which remedies could be supplied.

The ditches which have been dug to drain swamps upon the watershed have been kept in good condition. No ditches were dug during the past year.

Samples of water from as many as 17 different points have been collected at regular intervals of a month or more, and submitted to the State Board of Health for analysis and examination. Samples have also been collected from a larger number of places weekly or fortnightly for examination by the biological force of the Board. Besides, other samples have been taken and examined from time to time, accordingly as called for, from the various reservoirs, brooks and filter-beds. Microscopic organisms have been found more abundant than usual in the Sudbury Reservoir and the Framingham Reservoir No. 3. These have caused some odor in the water, but are entirely innocuous. The organisms in Lake Cochituate have been fewer than usual, so that but for a small portion of the year has the water been found undesirable for use.

(9) Marlborough Brook.

The sewer intended to convey diluted sewage overflowing from the sewers of the city of Marlborough during heavy storms, and an additional filter-bed for purifying the overflow by filtration, which were completed at the end of the preceding year, have been in successful operation. The large filter-bed, which combines with filtration the advantages of a considerable reservoir, has taken care of the overflow from the main sewer during times of freshet. The main filter-beds have, except for portions of six days during freshets, filtered successfully all of the water received from the brook. One of the old storage basins has been much enlarged by increasing its capacity from about 2,600,000 gallons to 9,000,000 gallons. An 18-inch sewer pipe has also been substituted for the open channel, built from the end of the new overflow sewer to the filter-beds.

The analyses which have been received show that the water has generally been satisfactorily purified by the filtration.

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, 1905, 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 $20,593.60 is for the year 1904), ...	95,570 85
	$40,095,570 85
Amount approved by the Metropolitan Water and Sewerage Board for payments to December 31, 1904 (of which $2,174,498.19 is for the year 1904), ...	38,388,255 76
Balance January 1, 1905, ...	$1,707,315 09

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

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

Date.	Bonds sold.	Rate (Per Cent.).	Time (Years).	Price.	Premiums (in Amount).
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
1904, . . .	500,000	3½	39½	104 60*	23,000 00
1904, . . .	2,000,000	3½	40	104 60	92,000 00
	$38,500,000				$2,508,909 85

* These bonds were temporarily sold in 1903 to the sinking fund at par, and were subsequently, in 1904, resold from the sinking fund at this rate.

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
December 31, 1904, ...	3,519,602 92

The assessments for the year 1904, 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, ...	$12,972 76	Nahant, ...	$3,535 05
Belmont, ...	6,391 85	Newton, ...	10,359 65
Boston, ...	1,700,274 07	Quincy, ...	34,084 24
Chelsea, ...	44,507 49	Revere, ...	15,717 42
Everett, ...	33,537 19	Somerville, ...	86,736 93
Hyde Park, ...	3,091 24	Stoneham, ...	8,343 88
Lexington, ...	6,391 91	Watertown, ...	15,060 77
Malden, ...	46,499 48	Winthrop, ...	9,880 83
Medford, ...	27,519 87		
Melrose, ...	19,722 73		$2,100,800 37
Milton, ...	16,173 01		

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 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 1904,	$12,462 85

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

For the year 1904,	$315,780 81

Sums have been received during the year 1904, under the provisions of the Metropolitan Water Act, for water furnished, as follows: —

Cambridge,	$15,218 70
Framingham Water Company,	366 80
Revere Water Company,	391 00
Swampscott,	4,100 00
	$20,076 50

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,	$113 86	Nahant,	$33 14
Belmont,	59 67	Newton,	97 98
Boston,	16,475 04	Quincy,	319 96
Chelsea,	431 62	Revere,	141 99
Everett,	307 25	Somerville,	820 31
Hyde Park,	29 10	Stoneham,	60 96
Lexington,	18 06	Watertown,	140 82
Malden,	443 63	Winthrop,	87 76
Medford,	260 35		
Melrose,	188 34		$20,076 50
Milton,	46 66		

(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, 1904.		From Beginning of Work to December 31, 1904.	
Administration applicable to all parts of the construction and acquisition of the works,	. . .	$17,594 74		$239,078 75
Wachusett Dam and Reservoir: —				
Wachusett Dam,	$609,323 07		$1,983,151 99	
North Dike,	63,800 28		747,288 45	
South Dike,	106,034 16		115,541 31	
Removal of soil,	394,487 81		2,338,057 96	
Relocation of railroads,	140,683 75		821,700 77	
Roads and bridges,	83,170 66		484,475 25	
Real estate,	62,173 83		3,141,070 55	
Damages, real estate not taken, business and loss of wages,	46,616 66		469,566 42	
Other expenses,	513 16	1,506,803 38	5,382 22	10,106,234 92
Improving Wachusett watershed,		40,554 03		58,924 81
Wachusett Aqueduct,		1,978 75		1,790,237 62
Sudbury Reservoir,		-		2,922,445 21
Protection of Sudbury supply,		9,045 99		128,797 06
Improving Sudbury watershed,		3,278 84		94,754 58
Protection of Cochituate supply,		-		9,000 00
Improving Cochituate watershed,		-		8,860 68
Improving Lake Cochituate,		-		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,	$91,612 79		$2,316,010 77	
Reservoir,	55,411 77		283,454 79	
Supply pipe lines,	9,464 60		584,033 92	
Real estate, taxes and other expenses,	60,251 58	216,740 74	184,151 24	3,367,650 72
Distribution system: —				
Low service: —				
Pipe lines and connections,	$368 66		$1,751,205 67	
Pumping station, Chestnut Hill,	-		459,251 97	
Reservoir, Spot Pond,	-		578,101 58	
Gate-house and connections, Chestnut Hill Reservoir,	-		65,480 88	
Real estate and other expenses,	2,256 78		86,809 89	
Northern high service: —				
Pipe lines and connections,	249 30		440,539 28	
Spot Pond pumping station,	-		291,829 35	
Fells Reservoir, Stoneham,	-		141,392 94	
Bear Hill Reservoir, Stoneham,	111 90		38,267 70	
Real estate and other expenses,	-		14,838 05	
Amounts carried forward,	$2,986 64	$1,795,996 47	$3,867,717 31	$18,901,136 10

Construction and Acquisition of Works.	For the Year ending December 31, 1904.		From Beginning of Work to December 31, 1904.	
Amounts brought forward,	$2,986 64	$1,795,996 47	$3,867,717 31	$18,901,136 10
Distribution system — *Con.*				
Southern high service: —				
Pipe lines and connections,	5 00		504,420 55	
Pumping station, Chestnut Hill,	-		242,121 35	
Forbes Hill Reservoir, Quincy,	-		90,003 49	
Waban Hill Reservoir, Newton,	-		61,592 11	
Real estate and other expenses,	-		10,226 36	
Northern extra high service,	14 00		13,951 47	
Southern extra high service,	52 00		22,815 67	
Meters and connections,	812 74		74,901 28	
Improving Spot Pond Brook,	176 92		3,717 05	
Glenwood pipe yard,	-		33,100 59	
Chestnut Hill pipe yard,	-		11,311 26	
		4,047 30		4,935,878 49
Diversion of water, South Branch of Nashua River,*		46,723 41		1,357,431 31
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	
To Malden, Medford and Melrose (on account) for taking of Spot Pond,	$317,820 68		343,570 39	
To Newton, for Waban Hill Reservoir,	-		60,000 00	
	$317,820 68		$14,330,440 78	
Transfers of works acquired and other property to accounts for special works,	-		1,240,166 42	
	$317,820 68		$13,090,274 36	
Engineering, conveyancing, etc.,	9,706 94		33,814 54	
		327,527 62		13,124,088 90
Pipes, Valves, Castings, etc., sent first to Storage Yards, and afterwards transferred as needed to Different Parts of the Work.				
Sent to storage yards,	$921 83		$2,084,380 97	
Transferred from storage yards to works, and included in costs above,	718 44		2,014,660 01	
		203 39		69,720 96
Total for constructing and acquiring of works,		$2,174,498 19		$38,388,255 76

* Of the total expenditures from the beginning of the work, the sum of $149,102 is for Clinton sewerage system.

Maintenance and Operation.	For the Year ending December 31, 1904.
Administration,	$9,673 13
General supervision,	4,435 85
Taxes and other expenses,	30,314 05
Amount carried forward,	$44,423 03

Maintenance and Operation.	For the Year ending December 31, 1904.	
Amount brought forward,		$44,423 03
Wachusett Reservoir Department: —		
Sanitary inspection,	$2,369 79	
Buildings,	474 72	
Reservoir,	3,491 36	
		6,335 87
Wachusett Dam and Aqueduct Department: —		
General superintendence,	$1,381 49	
Dam and aqueduct,	10,473 71	
Clinton sewerage system: —		
Pumping station,	3,135 75	
Sewers, screens and filter-beds,	4,444 19	
Sanitary inspection,	67 70	
		19,502 84
Sudbury Department: —		
General superintendence,	$3,931 82	
Superintendence, Framingham office,	6,872 77	
Ashland Reservoir,	1,406 17	
Hopkinton Reservoir,	1,383 08	
Whitehall Reservoir,	252 75	
Framingham Reservoirs, 1, 2 and 3,	4,890 26	
Sudbury Reservoir,	6,308 62	
Lake Cochituate,	3,156 46	
Marlborough Brook filters,	6,547 66	
Pegan filters,	3,088 16	
Sudbury and Cochituate watersheds,	787 86	
Sanitary inspection,	2,568 83	
Sudbury and Cochituate Aqueducts,	22,651 37	
Weston Aqueduct,	7,647 30	
Biological laboratory,	2,568 84	
		74,061 95
Distribution Department: —		
Superintendence,	$12,549 03	
Arlington pumping station, pumping service,	5,354 80	
Chestnut Hill low-service pumping station, pumping service,	31,146 31	
Chestnut Hill high-service pumping station, pumping service,	32,283 07	
Spot Pond pumping station, pumping service,	11,950 08	
West Roxbury pumping station, pumping service,	6,087 31	
Arlington standpipe,	40 88	
Bear Hill Reservoir,	135 52	
Chelsea Reservoir,	4,036 01	
Chestnut Hill Reservoir,	8,813 42	
Fells Reservoir,	735 70	
Forbes Hill Reservoir,	1,247 61	
Mystic Lake, conduit and pumping station,	3,277 75	
Mystic Reservoir,	1,752 91	
Waban Hill Reservoir,	500 14	
Spot Pond,	8,990 67	
Buildings at Spot Pond,	38 39	
Amounts carried forward,	$128,939 60	$144,323 69

Maintenance and Operation.	For the Year ending December 31, 1904.	
Amounts brought forward,	$128,939 60	$144,323 69
Distribution Department — *Con.*		
Pipe lines: —		
Low service,	13,000 16	
Northern high service,	3,952 01	
Southern high service,	3,115 61	
Supply pipe lines,	812 20	
Buildings at Chestnut Hill,	1,632 30	
Chestnut Hill pipe yard,	1,481 05	
Glenwood pipe yard and buildings,	4,733 94	
Stables,	5,915 58	
Waste prevention,	4,434 65	
Venturi meters,	3,440 02	
		171,457 12
Total for maintaining and operating works,		$315,780 81

(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 1904.

(*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, 1904, and ending December 31, 1904, is $2,174,498.19; and the total amount from the time of the organization of the Metropolitan Water Board, July 19, 1895, to December 31, 1904, is $38,388,255.76.

For maintenance and operation the expenditures for the year have been $315,780.81, and from the beginning of the work, $1,912,536.44.

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, 1904.		From Beginning of Work to December 31, 1904.	
Construction of Works and Acquisition by Purchase or Taking.				
Administration.				
Commissioners,	$5,833 33		$100,976 92	
Secretary and auditor,	2,894 23		44,115 11	
Clerks and stenographers,	4,933 88		49,224 15	
Legal services,	-		2,359 00	
Travelling,	488 91		3,409 09	
Stationery and printing,	1,287 71		8,671 98	
Postage, express and telegrams,	223 75		2,563 37	
Furniture and fixtures,	44 15		4,133 44	
Alterations and repairs of buildings,	2 41		5,743 27	
Telephone, lighting, heating, water and care of building,	1,026 10		9,737 94	
Rent and taxes, main office,	603 00		3,855 80	
Miscellaneous expenses,	257 27	$17,594 74	4,288 68	$239,078 75
Engineering.				
Chief engineer and department engineers,	$16,859 42		$193,107 99	
Principal assistant engineers,	11,568 41		136,790 84	
Engineering assistants,	68,445 47		946,273 78	
Consulting engineers,	-		23,437 07	
Inspectors,	22,317 07		281,355 34	
Architects,	3,116 45		32,528 39	
Railroad and street car travel,	777 10		26,606 15	
Wagon hire,	4,308 64		42,772 96	
Stationery and printing,	905 18		24,797 08	
Postage, express and telegrams,	563 10		7,452 85	
Engineering and drafting instruments and tools,	49 22		19,225 73	
Engineering and drafting supplies,	898 17		23,916 48	
Books, maps and photographic supplies,	356 31		6,369 44	
Furniture and fixtures,	46 73		14,876 97	
Alterations and repairs of buildings: —				
Main office,	472 32		13,938 36	
Sub-offices,	111 50		2,860 07	
Telephone, lighting, heating, water and care of buildings: —				
Main office,	2,773 56		19,858 68	
Sub-offices,	2,079 38		17,447 02	
Rent and taxes, — main office,	1,809 00		11,335 75	
Rent of sub-offices and other buildings,	252 00		4,513 74	
Field offices and sheds,	13 30		1,274 49	
Clinton office building,	-		9,866 87	
Unclassified supplies,	589 31		8,175 53	
Miscellaneous expenses,	520 20	138,831 84	8,452 21	1,877,233 79
Amounts carried forward,	. . .	$156,426 58		$2,116,312 54

General Character of Expenditures.	For the Year ending December 31, 1904.		From Beginning of Work to December 31, 1904.	
Amounts brought forward, . . .	. . .	$156,426 58		$2,116,312 54
Construction.				
Preliminary work (borings, test pits and other investigations): —				
Advertising, ...	$82 60		$6,188 55	
Other preliminary work as given in detail in preceding annual report, ...	-	82 60	155,456 66	161,645 21
Contracts, Wachusett Reservoir: —				
Contracts completed and final payments made prior to January 1, 1904, . . .	-		$2,062,386 09	
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, . .	$125,723 22		394,592 50	
Bruno, Salomone & Petitti, Sect. 10, Wachusett Reservoir, Boylston and West Boylston, ...	257,999 39		424,768 56	
McArthur Bros. Co , building Sect. 2 of the Relocation of Central Massachusetts Railroad, ...	-		246,439 34	
The George M. Atkins Co., arch bridges and abutments at Oakdale, ...	5,735 63		38,528 22	
Francis A. McCauliff, masonry arch bridge at West Boylston, ...	11,233 09		11,233 09	
John F. Magee & Co., South Dike, . .	118,034 45		118,034 45	
McArthur Bros. Co., placing riprap on the westerly portion of the North Dike, . .	34,282 06		51,017 50	
McArthur Bros. Co., Wachusett Dam, .	496,528 24		1,423,940 48	
Wm. Cramp & Sons Ship and Engine Building Co., bronze grooves for Wachusett Dam, ...	3,691 00		3,691 00	
Davis & Farnum Manufacturing Co., castings for Wachusett Dam, ...	1,248 97		1,248 97	
Gibby Foundry Co., castings for Wachusett Dam, ...	1,205 53		1,205 53	
Coffin Valve Co., sluice gates for Wachusett Dam, ...	1,687 00		7,887 00	
Chapman Valve Manufacturing Co., valves for Wachusett Dam, ...	2,317 67		2,317 67	
Connery & Wentworth, superstructure of lower gate-chamber of the Wachusett Dam, ...	55,971 20	1,115,657 45	55,971 20	4,877,822 23
Contracts completed, Wachusett Aqueduct, .	-			1,447,208 55
Contracts completed, Sudbury Reservoir, .	-			1,545,028 33
Amounts carried forward, ...	-	$1,272,166 63		$10,148,016 86

General Character of Expenditures.	For the Year ending December 31, 1904.		From Beginning of Work to December 31, 1904.	
Amounts brought forward, . . .	-	$1,272,166 63		$10,148,016 86
Construction — Con.				
Contracts, protection Sudbury Supply: —				
City of Marlborough, main sewer, . .	-	9,000 00		9,000 00
Contracts completed, improving Lake Cochituate, ...	-			60,657 45
Contracts completed, protection Cochituate Supply: —				
Town of Framingham, low-level sewer, .	-			9,000 00
Contracts completed, Rosemary siphon, . .	-			5,916 96
Contracts completed, pipe line, Dam No. 3 to Dam No. 1, ...	-			17,240 22
Contracts completed, Clinton sewerage system, ...	-			66,878 22
Contracts, Weston Aqueduct: —				
Contracts completed and final payments made prior to January 1, 1904, . . .	-		$366,458 02	
T. H. Gill, ... Sect. 1,	$28 12		34,483 39	
Shanahan, Casparis & Co., . . Sect. 2,	-		197,645 17	
Sundry bills paid under this contract, .	2,397 62		2,911 80	
Shanahan, Casparis & Co., . . Sect. 3,	-		122,280 42	
Sundry bills paid under this contract, .	3,797 44		4,214 78	
Bruno, Salomone & Petitti, . . Sect. 5,	125 28		128,226 63	
Shanahan, Casparis & Co., . . Sect. 6,	-		106,805 66	
Sundry bills paid under this contract, .	6,968 05		6,968 05	
Winston & Co., . . Sects. 8 and 10,	2,000 00		146,552 09	
Winston & Co., ... Sect. 11,	5,258 39		159,892 59	
Shanahan, Casparis & Co., . . Sect. 12,	-		135,181 78	
Sundry bills paid under this contract, .	3,339 77		3,339 77	
Michael H. Keefe, ... Sect. 13,	-		11,206 05	
Columbus Construction Co., . . Sect. 13,	12,472 79		406,046 59	
Nawn & Brock, ... Sect. 14,	3,818 44		59,449 04	
Winston & Co., ... Sect. 15,	7,000 00		168,642 96	
Nawn & Brock, Weston Reservoir, Sect. 1,	6,434 33		63,778 33	
Nawn & Brock, Weston Reservoir, Sect. 2,	31,454 63		123,970 70	
Dennis F. O'Connell, supply pipe lines, Sect. 2, ...	1,500 00		71,287 87	
C. A. Dodge & Co, superstructures of the head and meter chambers, ...	4,740 00		10,804 00	
Woodbury & Leighton, superstructures of the channel and screen chambers, . .	4,780 75	96,115 61	12,484 75	2,342,630 44
Contracts completed, Distribution System, .	-		$4,383,372 31	
Deduct value of pipes, valves, etc., included in above list, transferred to maintenance account December 31, 1900, . . .	-		3,139 77	4,380,232 54
Amounts carried forward, . . .	-	$1,377,282 24		$17,039,572 69

General Character of Expenditures.	For the Year ending December 31, 1904.		From Beginning of Work to December 31, 1904.	
Amounts brought forward,	-	$1,377,282 24		$17,039,572 69
Construction — Con.				
Additional work: —				
Labor,	$60,356 83		$634,404 08	
Professional services, medical services, analyses, etc.,	81 00		1,608 99	
Travelling,	597 75		1,989 97	
Rent,	-		3,556 73	
Water rates,	45 91		1,421 08	
Freight and express,	1,496 32		11,838 71	
Jobbing and repairing,	435 73		8,452 94	
Tools, machinery, appliances and hardware supplies,	4,260 33		71,382 94	
Electrical supplies,	44 22		4,830 21	
Castings, ironwork and metals,	4,530 89		61,115 30	
Iron pipe and valves,	2,510 92		54,315 05	
Blasting supplies,	122 34		1,339 48	
Paint and coating,	174 70		4,065 60	
Fuel, oil and waste,	292 24		10,339 37	
Lumber and field buildings,	3,669 80		79,954 58	
Drain pipe,	1,274 56		8,699 48	
Brick, cement and stone,	5,439 34		23,724 36	
Sand, gravel and filling,	85 00		5,837 26	
Municipal and corporation work,	102,802 04		207,656 39	
Police service,	15,435 50		202,838 83	
Sanitary inspection,	1,205 00		11,322 18	
Judgments and settlements for damages,	2,040 67		37,294 61	
Unclassified supplies,	2,666 07		14,402 66	
Miscellaneous expenses,	137 15	209,704 31	3,038 28	1,465,429 08
Legal and expert: —				
Legal services,	-		$4,668 82	
Expert services,	-		522 74	
Court expenses,	$100 00		909 04	
Miscellaneous expenses,	-	100 00	49 05	6,149 65
Real Estate.				
Legal and expert: —				
Legal services,	-		$4,736 31	
Conveyancer and assistants,	$5,567 50		99,388 97	
Experts,	300 00		17,871 58	
Appraisers,	1,927 00		21,049 09	
Court expenses,	3,416 00		8,428 80	
Counsel expenses,	-		43 25	
Conveyancing supplies,	43 91		3,149 53	
Conveyancing expenses,	285 72		5,717 98	
Miscellaneous expenses,	336 80		3,928 12	
Settlements made by Board,	101,475 26		3,259,315 84	
Amounts carried forward,	$113,352 19	$1,587,086 55	$3,423,629 47	$18,511,151 42

General Character of Expenditures.	For the Year ending December 31, 1904.		From Beginning of Work to December 31, 1904.	
Amounts brought forward,	$113,352 19	$1,587,086 55	$3,423,629 47	$18,511,151 42
Real Estate — Con.				
Judgments,	42,928 90		136,930 23	
Taxes and tax equivalents,	-		67,917 07	
Care and disposal,	6,883 41	163,164 50	67,412 97	3,695,889 74
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,	$787 16		1,635 08	
Court expenses,	1,159 60		10,239 59	
Settlements,	38,851 66		380,867 82	
Judgments,	7,765 00	48,563 42	88,698 60	482,571 76
Claims on Account of Diversion of Water.				
Legal and expert: —				
Legal services,	-		$3,774 98	
Expert services,	$396 31		19,339 69	
Court expenses,	1,435 25		19,105 69	
Miscellaneous expenses,	-		1,222 63	
Settlements,	-		917,350 00	
Judgments,	37,463 80	39,295 36	218,358 91	1,179,151 90
Purchase of Existing Water Works.				
Legal and expert: —				
Legal services,	-		$1,878 89	
Expert services,	$1,718 96		4,369 61	
Court expenses,	3,733 33		3,733 33	
Miscellaneous expenses,	518 00		1,470 94	
Settlements and judgments,	317,820 68	323,790 97	14,330,440 78	14,341,893 55
Relocation Central Massachusetts Railroad.				
Settlements,		12,597 39		177,597 39
Total amount of construction expenditures,		$2,174,498 19		$38,388,255 76

General Character of Expenditures.	For the Year ending December 31, 1904.
Maintenance and Operation of Works.	
Administration: —	
Commissioners,	$3,500 00
Secretary, auditor and assistants,	3,767 67
Postage, printing, stationery and other supplies,	1,496 92
Travelling,	120 31
Telephone, heating, lighting and care of building,	322 90
Alterations and repairs of building,	151 68
Rent and taxes, office building,	150 00
Miscellaneous expenses,	163 65
Amount carried forward,	$9,673 13

General Character of Expenditures.	For the Year ending December 31, 1904.	
Amount brought forward,	$9,673 13	
Maintenance and Operation of Works — *Con.*		
Supervision and general superintendence: —		
Chief engineer and department engineers,	9,333 92	
Engineering and clerical assistants,	8,001 58	
Postage, printing, stationery and office supplies,	829 54	
Telephone, heating, lighting and care of offices,	1,030 16	
Travelling and incidental expenses,	1,846 64	
Alterations and repairs of buildings,	346 41	
Rent and taxes, main office,	450 00	
Miscellaneous expenses,	459 94	
Pumping service: —		
Labor,	46,150 29	
Fuel,	35,347 61	
Oil, waste and packing,	1,234 08	
Repairs and renewals,	843 90	
Small supplies and expenses,	2,469 17	
Rent, West Roxbury pumping station,	776 52	
Superintendents and assistant superintendents,	3,363 99	
Engineering assistants,	13,213 21	
Laboratory force,	1,884 02	
Sanitary inspectors,	2,779 92	
Recording and scientific instruments and supplies,	691 76	
Labor and teaming,	107,066 81	
Tools, machinery and appliances,	2,719 15	
Lumber and hardware supplies,	3,248 79	
Jobbing and repairing,	1,092 71	
Travelling,	5,224 41	
Horses, vehicles and stable expenses,	5,201 08	
Fuel, lighting and telephone,	3,973 62	
Municipal and corporation work,	35 50	
Unclassified supplies,	11,180 65	
Miscellaneous expenses,	2,313 98	
Conveyancer and assistants,	560 00	
Taxes and tax equivalents,	29,754 05	
Contracts and agreements,	955 00	
Contracts for pipes, valves, etc., bought from construction work since January 1, 1904,	1,729 27	
Total expenditures for maintenance and operation,		$315,780 81

(b) *Receipts.*

The total amount of receipts from rents, sales of property, etc., for the year beginning January 1, 1904, and ending December 31, 1904, is $53,132.95, and the total amount from the time of the organization of the Metropolitan Water Board, July 19, 1895, to December 31, 1904, is $392,652.84. The general character of these receipts is as follows: —

General Character of Receipts.	For the Year ending December 31, 1904.		From Beginning of Work to December 31, 1904.	
For distribution back to District: —				
District entrance fees,	-		$92,265 00	
Supplying water outside of District,	$19,318 70		51,656 84	
Water furnished to water companies,	757 80	$20,076 50	36,704 03	$180,625 87
To the credit of the loan fund: —				
Real estate and buildings,	$4,822 22		$19,586 48	
Labor, tools, supplies and reimbursements,	15,771 38	20,593 60	75,984 37	95,570 85
To the credit of the sinking fund: —				
Forfeiture for contracts awarded but not executed,	-		$500 00	
Rents,	$5,846 18		81,943 15	
Land products,	4,696 48		31,696 37	
Unclassified receipts and interest,	1,920 19	12,462 85	2,316 60	116,456 12
Total receipts,	. . .	$53,132 95		$392,652 84

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

Receipts from Different Works.	For the Year ending December 31, 1904.		From Beginning of Work to December 31, 1904.	
Distribution back to District: —				
Admission into Metropolitan Water District (Quincy, Nahant, Arlington, Stoneham, Milton and Lexington),	-		$92,265 00	
Supplying water to cities and towns outside of Water District (Swampscott, Lexington and Cambridge),	$19,318 70		51,656 84	
Water furnished to water companies,	757 80	$20,076 50	36,704 03	$180,625 87
Construction and acquisition of works: —				
Administration,	$12 40		$13 15	
Wachusett Dam,	-		4,897 09	
Wachusett Reservoir,	7,426 07		104,138 25	
Wachusett Aqueduct,	-		5,204 70	
Weston Aqueduct,	2,131 82		4,313 74	
Sudbury Reservoir and watershed,	19 60		7,274 76	
Distribution system,	11,569 48		54,701 74	
Diversion of water, Clinton sewerage system,	534 18		1,191 09	
Purchase of existing water works,	1,365 53	23,059 08	8,591 02	190,325 54
Maintenance and operation of works: —				
Wachusett Aqueduct,	$517 67		$3,060 61	
Wachusett Reservoir,	5,310 67		5,310 67	
Sudbury system,	1,258 84		6,856 93	
Distribution system,	2,333 01		4,279 78	
Clinton sewerage system,	577 18	9,997 37	2,193 44	21,701 43
Total receipts,	. . .	$53,132 95		$392,652 84

(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,	$11,796 81*
Due on monthly pay rolls,	3,586 51
	$15,383 32

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

Name.	Work.	Amount.
McArthur Bros. Co.,	Wachusett Dam,	$30,000 00
Busch Bros.,	Building road, Wachusett Reservoir,	600 00
Bruno, Salomone & Petitti,	Wachusett Reservoir, Sect. 10,	25,000 00
John F. Magee & Co.,	South Dike,	20,529 61
Connery & Wentworth,	Superstructure of the lower gate chamber, Wachusett Dam,	13,992 80
F. A. McCauliff,	Masonry arch bridge at West Boylston,	1,982 31
McArthur Bros. Co.,	Relocation Central Massachusetts Railroad, Sect. 2,	10,000 00
Winston & Co.,	Weston Aqueduct, Sects. 8 and 10,	147 43
		$102,252 15

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

Winthrop Parker *et al.*, trustees, $425; Martha E. Prescott, estate of, $400; Edmund F. Brigham *et als.*, $400; Bertram A. Bancroft, $115; Lucy White, $250; Pratt & Inman, $48; Charles F. C. Henderson, $800; Kayajan Serabian, $130; Anna M. Bennett, $160; P. Arvid Lundgren, $745; Walter E. Reeves, $845.

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 : —

* Miscellaneous current bills of 1904, including those coming in from time to time, after January 1, 1905, have since been paid.

Charles L. Johnson, Charles B. Sawin, city of Malden, balance, city of Medford, balance, city of Melrose, balance, Emory A. Bacon, James Dorr, Framingham Water Company, Charles W. Felt, town of West Boylston, Eliza M. Childs *et al.*, Charles J. Paine, George H. Thompson, Benjamin W. Clemmons, town of Framingham, Henry S. Milton *et al.*, trustees, Marion Preston, George A. Ward *et al.*, Edward Dooley, Harry Dutton *et al.*, Charles A. Warren, Ida M. Tay, William Dwyer.

V. SEWERAGE WORKS — CONSTRUCTION.

The Metropolitan Sewerage Works provide for the sewage of areas amounting to 193 square miles, including the whole or parts of 25 cities and towns in the Metropolitan District. The works are embraced in two systems: the North Metropolitan System, which provides for the district situated largely in the Charles River and Mystic River valleys, lying north of the Charles River, and whose sewage is carried to Deer Island and thence emptied into Boston harbor; and the South Metropolitan System, which provides for the sewage of the portion of the Charles River valley lying south of the Charles River, as well as the city of Waltham and the town of Watertown, situated on the north side of the river, and also for a portion of the Neponset River valley and the city of Quincy, and having its outlet, by the recently completed High-level Sewer, also into Boston harbor.

Within these areas have been laid 95.55 miles of main sewers, 87 miles of which were constructed by the Metropolitan boards, and 8.79 miles were purchased from the cities and towns. These areas remain the same as last year, and are more particularly described in the report of the Engineer of the Sewerage Works, which follows.

The amount expended during the past year on account of the Sewerage Works was $829,941.92, of which $184,655.82 was expended on the North Metropolitan System and $645,286.10 on the South Metropolitan System.

The total cost of the Metropolitan sewers, including 6 pumping stations and other structures used in connection therewith, has been $13,666,832.38; and of this total there is charged to the North Metropolitan System $6,086,569.91, and to the South Metropolitan System $7,580,262.47.

(1) North Metropolitan System.

The extension of the North Metropolitan Sewer through the city of Chelsea to the town of Revere, and the extension of the Cambridge branch of the sewer to the town of Belmont, both begun in the year 1903, have been constructed, and all sewers so far authorized upon this system have been completed.

Owing to peculiar difficulties in the construction of the Revere extension, resulting from the presence of quicksand, the peculiar clay and silt formation in the tunnels, and the necessity of crossing Mill Creek, it was deemed expedient to proceed with the construction of the sewer by day labor. This sewer has a total length of 7,312 feet, with substantial diameters of 54 and 48 inches except at the Mill Creek crossing, where 36-inch cast-iron pipes have been laid. The total cost of the sewer was $214,451.71. This extension was completed and opened for service on October 8.

The sewer built through portions of the city of Cambridge to the town of Belmont was completed under contract, on July 20. It has a length of 6,358 feet, and, though built in sections somewhat different from each other, has a substantial diameter of 25 inches. The expenditures for this sewer to date have amounted to $56,550.69. There are remaining unpaid some small claims for land damages.

(2) South Metropolitan System.

The work of construction on the South Metropolitan System has consisted principally of the completion of the High-level Sewer. The sewer proper had been chiefly built before the beginning of the year, and considerable progress had been made in the erection of the necessary structures. During the year the larger portion of one of the two outfall pipes in the harbor, which remained to be placed, has been laid; the superstructure of the screen-chamber and sand-catcher on Nut Island has been erected; the Ward Street pumping station has been finished, and the pumps, engines and boilers have been installed; the necessary connections between the High-level Sewer and the Charles River valley and the Neponset valley sewers have been made; and the various unfinished portions of the sewer have been completed.

The Ward Street pumping station was put in operation and the High-level Sewer was opened for service on October 14, since which

WARD STREET PUMPING STATION.

date the sewage from the portion of the Charles River valley above Vancouver Street has been pumped and discharged through the sewer from the outfall into the harbor.

Connection was made with the Neponset River valley sewer, at the junction of the sewers in Hyde Park, on November 22, and since that date the sewage from the Neponset River valley system above that point has also been discharged through the High-level Sewer.

But little more remains to be done for the entire completion of the High-level Sewer. The chief work required is the laying of a force main in Quincy, for the purpose of connecting the Quincy pumping station with the sewer; and this work will be begun as early as practicable in the coming season and will probably be performed by the employés in the maintenance department. Until this is finished the sewage from that station will continue to be disposed of through the Moon Island outfall of the city of Boston.

The final grading of the grounds about the Ward Street station and also about the screen-chamber at Nut Island has necessarily been deferred until the coming season.

A small portion of the territory in the Back Bay district of Boston, situated below Vancouver Street, is still unconnected with the High-level Sewer; and the making of this connection is awaiting arrangements which may be effected with the city of Boston for the mutual advantage of that city and of the Commonwealth, which will probably be determined early in the coming year. It is not proposed at present to discharge the sewage of small portions of Dorchester and Milton, included in the Neponset valley system with the High-level Sewer, as the areas are too low for sewage to be delivered into the High-level Sewer without pumping. Satisfactory arrangements for the disposal of the sewage of these small sections, which are not provided for by the High-level Sewer, have been made with the city of Boston.

The expenditures for the High-level Sewer up to the present date have been $5,876,751.94. The appropriations for the sewer amounted to $5,981,000. The work to be done, which is comparatively small in amount, will undoubtedly be accomplished within the appropriations.

The High-level Sewer, which has now been substantially completed, extends from near Ward Street in the city of Boston through portions of that city and through the towns of Hyde Park and Milton and the city of Quincy to Nut Island, a distance of 16.83 miles. Of the total length, 12.75 miles are constructed in open trench and 4.08 miles in tunnel. From Nut Island the sewage is conveyed through two submarine 60-inch cast-iron pipes to points in the harbor, each a little more than one mile beyond the low-water mark, where outfalls have been built. The sewer has a capacity for the daily discharge of 300,000,000 gallons of sewage.

Nut Island has been graded, and the soil removed was used principally in the construction of the embankment upon the bar connecting Nut Island with Hough's Neck in Quincy. A building, principally of brick, about 78 feet long, 60 feet wide and 40 feet in height, with a chimney 100 feet high, has been built upon the island. This building embraces a screen-chamber, where practically all the objectionable solid matters in the sewage will be intercepted, and a boiler room with boilers, which will provide the necessary steam for heating the building and operating the small engines for moving the screens. Approaching the building the sewer section has been considerably enlarged, so as to deposit sand which follows along the sewer. The solid matters intercepted at the screens will be burned in the boilers, and the arrangements are such that the sand may be removed from the sand-catcher before entering the outfall pipes.

The Ward Street pumping station includes an engine house about 65 by 120 feet, and a boiler room and accessories about 38 by 105 feet. The height of the engine house is about 55 feet. It is constructed of brick, with granite trimmings. Two pumping engines have been installed, each having a daily capacity for pumping 50,000,000 gallons. The station is also equipped with the necessary boilers, screens and other machinery.

(3) Purchases and Takings of Land.

Only one taking, required for the purpose of the Quincy force main, has been made for the Metropolitan Sewerage Works during the year, being of easements in 1.68 acres, of which .89 acre was in a street.

HIGH LEVEL SEWER — NUT ISLAND AND SCREEN CHAMBER AT END OF 1904.

List of Takings for Metropolitan Sewerage Works for the Year 1904.

No.	Location and Description.	Former Owners.	Recorded.	Purpose of Taking.
11	Quincy (from Greenleaf Street northerly through Park Lane to the easterly line of the Metropolitan Park Reservation, then from the westerly line of the Reservation through Merrymount Park, to the Quincy pumping station). Area, easements in 1.68 acres.	City of Quincy *et al.*	**1904.** Jan. 27.	High-level Sewer (Quincy force main).

Since January 1, 1904, settlements have been effected on account of the takings made in the North Metropolitan District in three cases, involving a payment of $1,550; and in cases in the South Metropolitan District two settlements have been effected, under which payments have been made amounting to $4,398.22.

Summary of Land Settlements for the Year 1904.

Location.	Area in Acres.	Number of Settlements.	Payments.
North Metropolitan District.			
Cambridge,	0.256	3	$1,550 00
Total,	0.256	3	$1,550 00
South Metropolitan District.			
Quincy,	0.865	2	$4,398 22
Total,	0.865	2	$4,398 22
Aggregate,	1.121	5	5,948 22

VI. SEWERAGE WORKS — MAINTENANCE.

(1) North Metropolitan System.

The maintenance of the North Metropolitan System involves the care of 58.004 miles of Metropolitan main sewers, into which is received the sewage of the different municipalities of the District through 558.18 miles of local sewers, having 58,987 connections. There are maintained for this system four pumping stations, — the Alewife Brook pumping station at Somerville, the Charlestown pumping station, the East Boston pumping station and the Deer Island pumping station. The total number of gallons of sewage pumped during the year has been 53,739,119,000. The population of the various municipalities and parts of municipalities embraced in the North Metropolitan District is estimated at 494,500, of which it is estimated that a population of 387,327 is directly contributing sewage. The sewers in 12 of the municipalities are separate sewers, in 5 municipalities separate and combined sewers, and in one municipality combined sewers only.

The average cost of pumping per million gallons raised 1 foot, including labor at the screens, was $0.349 at the Alewife Brook station, $0.159 at the Charlestown station, $0.065 at the East Boston station and $0.094 at the Deer Island station.

During the past year the wharf at Deer Island has been largely renewed, the water pipes at the station have been extended so as to provide additional fire protection for the dwelling houses and lockers, and considerable riprap has been deposited on the Deer Island bar over the line of the outfall sewer. Considerable repairs have been required at the ends of the Malden River siphon and in the embankment across the marsh. Necessary changes have been made by which the old Mystic valley sewer in Winchester has been relieved.

The expenditures for maintenance of the North Metropolitan System for the year have amounted to $112,047.98.

(2) South Metropolitan System.

The Metropolitan sewers in the South Metropolitan System have a total length of 37.548 miles, and these receive the sewage of the District through 406.32 miles of local sewers, having 20,117 connections.

The Ward Street pumping station, the Quincy pumping station and the screen-house and sand-catcher at Nut Island are also maintained for this system. The number of gallons of sewage pumped during the year at the Quincy pumping station has been 1,338,810,000, and at the Ward Street pumping station, from October 14 to the end of the year, 1,002,900,000. The population of the various municipalities and parts of municipalities embraced in the South Metropolitan District is estimated at 318,300, and of this population it is estimated that 147,761 are now directly contributing sewage. Of the municipalities in the District, 7 have separate sewers and 5 separate and combined sewers.

The average cost of pumping per million gallons raised 1 foot, including labor at the screens, was $0.151 at the Quincy station. Owing to the short time during which the Ward Street station has been in operation, the statistics regarding the cost of pumping at this station are not available.

Considerable work will be required from the maintenance department on account of the recent completion of the High-level Sewer, the Ward Street pumping station and the screen-house at Nut Island, in equipping these works for regular operation.

The sum of \$139,640.88 has been expended during the year for the maintenance of the South Metropolitan System.

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 report for the year 1901), ...	\$5,605,865 73
Appropriations under chapters 242, 336 and 399, Acts of 1903, .	500,000 00
Proceeds from sales of property and from other sources to December 31, 1904, ...	17,023 53
	\$6,122,889 26
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1904 (of which \$184,655.82 is for the year 1904), .	6,086,569 91
Balance, North Metropolitan System, January 1, 1905, . .	\$36,319 35

(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, 1904, .	\$800,046 27	

Neponset River Valley Sewer.

Appropriations under various acts of the Legislature (given in detail in report for the year 1901), . .	–	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, 1904 (of which \$150 is for the year 1904), . . .	903,464 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
Appropriations, chapters 230 and 246 of the Acts of 1904,	–	392,000 00
Proceeds from sales of property to December 31, 1904 (of which $2,722.68 is for the year 1904),	–	5,868 49
		$7,698,024 26
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1904 (of which $645,136.10 is for the year 1904),	$5,876,751 94	7,580,262 47
Balance South Metropolitan System, January 1, 1905,		$117,761 79

(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, 1902,	636,084 04
December 31, 1900,	454,520 57	December 31, 1903,	754,690 41
December 31, 1901,	545,668 26	December 31, 1904,	878,557 12

(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, 1904, have been as follows: —

North Metropolitan System.

Balance January 1, 1904,	$9,777 58
Appropriation under chapter 62 of the Acts of 1904,	123,000 00
Receipts from pumping and from other sources,	863 62
	$133,641 20
Amount approved by the Board for payment,	112,047 98
Balance January 1, 1905,	$21,593 22

South Metropolitan System.

Balance January 1, 1904,	$5,022 06
Appropriation under chapter 60 of the Acts of 1904,	135,000 00
Receipts from sales of property and from pumping,	29 30
	$140,051 36
Amount approved by the Board for payment,	139,640 88
Balance January 1, 1905,	$410 48

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, $75.

(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,	$8,091 81	Somerville,	$50,404 54
Belmont,	4,642 06	Stoneham,	4,962 06
Boston,	64,732 13	Wakefield,	7,652 70
Cambridge,	86,891 58	Winchester,	7,730 03
Chelsea,	24,449 79	Winthrop,	5,991 95
Everett,	18,355 96	Woburn,	10,712 66
Lexington,	2,483 43	Revere,	9,301 51
Malden,	28,884 84		
Medford,	17,918 64	Total,	$364,949 84
Melrose,	11,744 15		

South Metropolitan Sewerage System.

Boston,	$154,201 46	Quincy,	$24,698 31
Brookline,	53,933 77	Waltham,	25,189 36
Dedham,†	8,890 48	Watertown,	11,114 29
Hyde Park,	13,472 36		
Milton,	16,574 30	Total,	$360,696 29
Newton,	52,621 96		

* Given in previous reports. † Exclusive of Westwood.

(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, 1904.		From Beginning of Work to December 31, 1904.	
North Metropolitan System.				
Original system, main line and branches,	$5,508 70		$5,383,932 67	
Lexington branch,	-		68,585 15	
Everett branch,	-		54,877 12	
Wakefield branch,	-		35,698 29	
Stoneham branch,	-		11,574 10	
Chelsea and Everett outlets,	-		71,016 41	
Wakefield branch extension,	-		189,883 77	
Revere extension,	153,833 37		214,451 71	
Belmont extension,	25,313 75		56,550 69	
Total North Metropolitan System,		$184,655 82		$6,086,569 91
South Metropolitan System.				
Charles River valley sewer, main line,	-			$800,046 27
Neponset River valley sewer, main line,	$50 00		$866,545 66	
Brookline branch,	100 00		36,918 60	
Total,		$150 00		903,464 26
High-level Sewer: —				
Section 43, Quincy,	$157,743 97		$401,988 99	
Section 44, Quincy,	103,394 25		290,698 78	
Section 45, Quincy,	-		76,139 36	
Section 46, Quincy,	5,681 59		61,857 20	
Section 47, Quincy,	118 00		109,786 58	
Section 48, Quincy,	49,101 13		295,319 29	
Sections 48 and 49, Quincy,	-		81,548 64	
Section 49, Quincy,	4,694 28		169,020 18	
Section 50, Quincy,	220 00		109,570 35	
Section 51, Quincy,	175 05		87,203 68	
Section 52, Quincy,	80 53		155,800 65	
Section 53, Quincy,	-		98,042 42	
Section 54, Quincy,	10 00		101,918 39	
Section 55, Quincy and Milton,	1,735 05		305,261 34	
Section 56, Milton,	128 71		105,042 50	
Section 57, Milton,	72 13		68,783 24	
Section 58, Milton,	29 85		94,089 72	
Section 59, Milton,	58 00		104,444 62	
Section 60, Milton,	89 37		60,796 13	
Section 61, Milton,	112 93		129,598 76	
Section 62, Milton,	230 76		129,557 28	
Section 63, Milton,	169 12		127,046 45	
Section 64, Neponset River crossing,	100 00		47,499 40	
Section 65, Hyde Park,	50 00		40,695 84	
Section 66, Hyde Park,	91 00		252,952 72	
Section 67, Hyde Park, Stony Brook crossing,	108 00		32,243 33	
Section 68, Hyde Park and Roxbury,	52 24		78,493 62	
Section 69, West Roxbury,	62 50		102,033 68	
Section 70, West Roxbury,	1 50		131,375 55	
Section 71, West Roxbury,	-		91,888 22	
Section 72, West Roxbury,	5,567 04		127,881 76	
Section 73, West Roxbury,	1,069 06		494,258 92	
Section 74, West Roxbury and Roxbury,	52 42		147,296 69	
Section 75, Roxbury,	2,691 31		136,192 99	
Section 76, Roxbury, cast-iron force main,	8,900 34		79,998 39	
Section 77, Roxbury, Ward Street pumping station,	275,486 61		497,024 53	
Section 78, Roxbury, connecting sewer,	4,272 49		35,844 69	
Quincy force main,	8,564 98		8,682 01	
Charles River valley studies,	3,889 71		3,889 71	
Real estate,	5,389 85		354,442 11	
Apportionment Commission,	-		2,000 00	
Administration,	4,942 33		48,543 23	
Total,		645,136 10		5,876,751 94
Total, South Metropolitan System,		$645,286 10		$7,580,262 47
Total for construction, both systems,		$829,941 92		$13,666,832 38

Maintenance.	For Year ending December 31, 1904.	From Beginning of Work to December 31, 1904.
North Metropolitan System,	$112,047 98	$895,262 40
South Metropolitan System,	139,640 88	790,280 27
Total for maintenance, both systems,	$251,688 86	$1,685,542 67

(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, 1904: —

(*a*) *Expenditures and Disbursements.*

General Character of Expenditures.	For Year ending December 31, 1904.
North Metropolitan System — Construction.	
Commissioners,	$1,166 66
Secretary, engineer and auditor,	595 83
Clerical services,	745 33
Rent of office, Ashburton Place,	600 00
Engineering supplies,	134 41
Office supplies,	143 71
Engineers, inspectors, rodmen, laborers and others,	62,523 28
Postage, telephone and telegrams,	419 40
Books, maps, plans, blue prints and photography,	38 95
Carriage hire and travelling expenses,	366 83
Teaming and express,	197 95
Tools and repairs of same,	201 09
Brick, cement, lumber and other field supplies,	43,346 71
Contracts: —	
Jones & Meehan, old,	32 00
Revere Extension: —	
Mayo Contracting Co., Sects. 61 and 62,	9,400 07
Charles A. Haskin, Sects. 61 and 62,	37,191 58
Belmont Extension: —	
Gow & Palmer, Sect. 63,	20,276 30
Land takings, purchase and recording,	7,219 72
Experts and appraisers,	56 00
Total,	$184,655 82
Neponset River Valley Sewer — Construction.	
Contracts: —	
Edw. W. Everson, old,	$50 00
Brookline branch: —	
Experts and appraisers,	100 00
Total,	$150 00

General Character of Expenditures.	For Year ending December 31, 1904.
High-level Sewer — Construction.	
Commissioners,	$1,166 67
Secretary, engineer and auditor,	3,512 49
Clerical services,	1,236 33
Engineers, inspectors, rodmen, laborers and others,	49,224 80
Advertising,	13 88
Office supplies,	150 07
Postage, telephone and telegrams,	439 17
Books, maps, plans, blue prints and photography,	199 32
Engineering instruments and repairs of same,	5 50
Engineering supplies,	440 31
Carriage hire and travelling expenses,	1,218 99
Repairs, fittings and supplies, main office,	699 94
Rent of office, Pemberton Building,	2,812 50
Rent of office, Ashburton Place,	486 40
Rent of wharf, Quincy,	1,000 00
Teaming and express,	1,127 23
Brick, cement, lumber and other field supplies,	43,590 02
Tools and repairs of same,	1,108 79
Contracts: —	
Hiram W. Phillips, Sect. 43,	94,716 96
Camden Iron Works, Sect. 43,	56,091 28
Edward Kendall & Sons, Sect. 44,	6,315 00
Lockwood Manufacturing Co., Sect. 44,	10,932 70
Wm. H. Ellis, Sect. 44,	33,605 77
Woodbury & Leighton Co., Sect. 44,	28,440 00
Wm. H. Ellis, Sect. 46,	4,922 53
Chas G. Belden & Co., Sect. 48,	39,748 85
Joseph J. Moebs, Sect. 48,	7,113 55
Chas. G. Belden & Co., Sect. 49,	4,312 58
E. W. Everson & Co., Sect. 62,	100 00
H. P. Nawn, Sect. 73 (part),	604 12
E. W. Everson & Co., Sect. 75 (part),	2,648 88
H. P. Nawn, Sect. 76,	7,991 23
L. P. Soule & Son, Sect. 77, building,	57,375 15
Allis-Chalmers Co., Sect. 77, pumps,	153,000 00
Lockwood Manufacturing Co., Sect. 77,	9,513 20
Camden Iron Works, Quincy force main,	7,291 67
Land takings, purchase and recording,	4,569 50
Experts and appraisers,	960 00
Legal services,	200 72
Claims and allowances on contracts,	6,250 00
Total,	$645,136 10
North Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$2,507 85
Postage, printing, stationery and office supplies,	27 18
Rent, telephone, heating, lighting and care of offices,	279 09
Miscellaneous expenses,	666 44
Amount carried forward,	$3,480 56

General Character of Expenditures.	For Year ending December 31, 1904.
Amount brought forward,	$3,480 56
North Metropolitan System — Maintenance — Concluded.	
General superintendence: —	
Engineer and assistants,	4,110 12
Postage, printing, stationery and office supplies,	83 31
Rent, telephone, heating, lighting and care of offices,	476 20
Miscellaneous expenses,	292 56
Deer Island pumping station: —	
Labor,	11,296 50
Coal,	8,863 16
Oil and waste,	444 42
Water,	1,209 60
Packing,	72 30
Repairs and renewals,	436 94
Telephones and office supplies,	337 66
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	3,388 94
East Boston pumping station: —	
Labor,	10,481 68
Coal,	9,248 14
Oil and waste,	335 04
Water,	940 80
Packing,	11 78
Repairs and renewals,	312 99
Telephones and office supplies,	303 87
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	2,751 76
Charlestown pumping station: —	
Labor,	10,326 04
Coal,	4,103 91
Oil and waste,	329 87
Water,	410 40
Packing,	76 77
Repairs and renewals,	235 92
Telephones and office supplies,	317 46
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	2,263 72
Alewife Brook pumping station: —	
Labor,	3,346 13
Coal,	1,705 61
Oil and waste,	124 75
Water,	242 40
Packing,	19 77
Repairs and renewals,	216 56
Telephones and office supplies,	160 87
Care and repairs of building and grounds, electric light plant and miscellaneous expenses,	808 24
Sewer lines, labor,	17,512 86
Supplies and expenses,	6,768 84
Horses, vehicles and stable account,	4,199 53
Total,	$112,047 98

General Character of Expenditures.	For Year ending December 31, 1904.
South Metropolitan System — Maintenance.	
Administration: —	
Commissioners, secretary, auditor and assistants,	$2,913 67
Postage, printing, stationery and office supplies,	105 47
Rent, telephone, heating, lighting and care of building,	1,003 46
Miscellaneous expenses,	680 41
General superintendence: —	
Engineer and assistants,	2,188 57
Postage, printing, stationery and office supplies,	46 43
Rent, telephone, heating, lighting and care of offices,	1,064 37
Miscellaneous expenses,	17 50
Sewer lines, labor,	14,192 35
Supplies and expenses,	6,301 68
City of Boston, for pumping and interest,	85,196 24
Quincy pumping station: —	
Labor,	3,887 42
Coal,	2,461 89
Oil and waste,	44 60
Water,	248 70
Packing,	39 84
Repairs and renewals,	241 13
Telephones and office supplies,	228 06
Care and repairs of building and grounds, lighting and miscellaneous expenses,	348 61
City of Boston, for discharge of sewage,	1,000 00
Ward Street pumping station: —	
Labor,	4,794 89
Coal,	2,139 34
Oil and waste,	402 69
Water,	126 00
Packing,	103 48
Repairs and renewals,	70 76
Telephones and office supplies,	97 13
Care of building and grounds, lighting and miscellaneous expenses,	2,520 47
Nut Island screen-house: —	
Labor,	1,180 74
Coal,	1,036 50
Oil and waste,	31 60
Packing,	15 75
Telephones and office supplies,	163 99
Care of building and grounds, lighting and miscellaneous expenses,	1,229 31
Horses, vehicles and stable account,	3,517 83
Total,	$139,640 88

(*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, 1904.	From Beginning of Work to December 31, 1904.
North Metropolitan System, — construction, .	$496 80	$17,023 53
South Metropolitan System, — construction, .	2,722 68	5,977 99
North Metropolitan System, — maintenance, .	863 62	5,355 53
South Metropolitan System, — maintenance, .	29 30	141 86
Metropolitan Sewerage Loans Sinking Fund, .	75 00	760 20
Totals, ...	$4,187 40	$29,259 11

(*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, ...	$7,238 09
Due on monthly pay rolls, ...	673 89
	$7,911 98

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

Name.	Work.	Amount.
North Metropolitan Construction: —		
H. A. Hanscom & Co., ...	Sect. 56, held for claims, .	$200 00
Chas. A. Haskin, ...	Sect. 61, ...	638 40
High-level Sewer: —		
Lockwood Manufacturing Co., .	Sect. 43, screen machinery, .	1,929 30
H. W. Phillips, ...	Sect. 43, outlet, pipe laying,	9,705 23
Woodbury & Leighton Co., . .	Sect. 44, screen-house, . .	1,500 00
H. P. Nawn, ...	Sect. 55, ...	1,500 00
J. W. Bustin & Co., ...	Sect. 57, 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
E. W. Everson & Co., . . .	Sect. 75, ...	2,000 00
Allis-Chalmers Co., ...	Sect. 77, ...	51,000 00
Lockwood Manufacturing Co., .	Sect. 77, ...	1,678 80
		$76,767 90

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, heirs of John Friel, Boston Elevated Railway Company, heirs of John Gilmore, Boston & Maine Railroad, Mary Rohan, Mary E. Connolly, 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, James Doherty, Michael Niland, Fred W. Baker, Catherine A. Baker, Walter J. Baker, Freda E. Baker.

VIII. CONSUMPTION OF WATER.

The rainfall of the year was considerably below the average, but as this deficiency occurred entirely during the last three months of the year, the yield of the watersheds constituting the sources of supply for the District was but little below the yearly average.

There was, however, a decided increase in the quantity of water consumed. The average daily rate of consumption in the cities and towns supplied by the Metropolitan Works during the year was 114,876,000 gallons, — an increase of 7,728,000 gallons over that of the preceding year. Although there was an increase in consumption throughout the year, the larger part of the increase occurred during the colder months of January, February, March and December. The daily rate of consumption per person was 123 gallons, — or 4 gallons more than the rate of the preceding year.

While the extreme cold of the winter months contributed to make a larger average consumption, the summer was unusually moderate and cool, so that there was less than the usual waste of water through the use of hand hose and lawn sprinklers, and the Board was called upon to complain of but few violations of the regulations adopted regarding their use.

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

The measurement of the water supplied to each municipality in the District which the Board was, by the installation of the Venturi meters, enabled to make during the latter half of the preceding year, has been continued throughout the past year, and the results of the measurements are given in connection with the report of the Chief Engineer.

A similar variation to that previously reported is shown in the consumption of water in the different municipalities of the District. The towns of Milton and Belmont, in which all the services are metered, and the city of Malden, in which the services are about five-sixths metered, show a daily per capita consumption respectively of 41, 49 and 46 gallons. Other municipalities in which but a small proportion of the services are metered have much greater per capita consumption, the number of gallons consumed daily per capita in the cities of Quincy, Melrose, Chelsea and Boston being respectively as high as 101, 106, 113 and 143.

The records of the Venturi meters enable the engineers and local authorities to detect the existence of leaks in the pipes, and to determine the quantities of water used otherwise than for ordinary consumption. In one municipality an increase of consumption in a single day from 400,000 to 1,000,000 gallons was recorded. This increase was found to be due to a broken 8-inch pipe, causing a leakage which might otherwise have continued for a long time without detection. The records taken likewise disclose the fact that in the whole District during the extreme cold months of January and February of the past year, between the hours of 1 and 4 in the morning when the necessary use of water was at a minimum, the actual rate of consumption for the three hours was greater than that for the entire day during the summer months. The results indicated an absolute waste in many parts of the District by reason of defective fixtures, or of allowing the water continually to run in order to avoid the freezing of the pipes.

The Legislature of last year, in acting upon the special report of the Board, by the enactment of chapter 426 of the Acts of 1904, amended the provisions of the Metropolitan Water Act so as to provide that on and after the year 1906 the assessments upon all the municipalities of the District, other than the city of Boston, shall be laid one-third in proportion to their respective valuations and two-thirds in proportion to the quantities of water respectively consumed by them in the preceding year, thereby substituting consumption as an element of assessment, instead of population. In accordance, therefore, with this act, the measurements of water used by the cities and towns other than Boston during the current year, will be taken as important factors in determining the amounts of the assessments.

The Board is still of the opinion that a large proportion of the water now supplied to the District, amounting to from one-third to one-half of the entire quantity afforded, is unnecessarily used or wasted, and that it is possible and practicable to prevent the greater part of such unnecessary use or waste. The means of prevention are largely in the hands of the local authorities. By the introduction of meters, a rigorous inspection, and the speedy prevention of leakage and waste when discovered, a great reduction in consumption can be attained. It is still believed that both the municipality and the individual water taker can be interested in the checking of waste and excessive use by causing water rates to be largely dependent upon the quantity of water which is consumed.

X. ELECTROLYSIS.

Investigations have been continued in order to ascertain more definitely the extent of the injury done to the water pipes by the underground electric currents, and for the purpose of devising means by which such injurious effects may be overcome or largely reduced.

The most serious effects of the electric current upon the pipes have been found, as heretofore, in the vicinity of the power stations of the different electric railway companies. In one instance the iron of the pipe was so pitted and decomposed as to render hazardous its longer continuance, and the water main for a distance of 539 feet was relaid. Pipes have been uncovered and examined at various other points, but in this place only had the deterioration proceeded so far as to make necessary the immediate relaying of the pipe.

Experiments which have been made in applying to the pipes affected an insulating covering of asphalt and burlap have not seemed to be successful. Some success has attended the installation of insulating joints in pipes which have been particularly affected, but the observations have not been carried far enough to determine to what extent the application of insulating joints will cause a reduction of electrolytic action.

The legal proceedings which have been begun to reimburse and to protect the Commonwealth on account of such injuries have been delayed to await further the results of the experiments, in which the Board has been willing to cooperate with the railway corporations.

XI. FUTURE EXTENSION OF THE HIGH-LEVEL SEWER TO BROOKLINE, BRIGHTON AND NEWTON.

The Board was authorized, by chapter 230 of the Acts of the year 1904, "to determine the location, elevation and size of the high-level metropolitan sewer above the point where the sewage from the Charles river valley is to be received," and a special appropriation for this purpose, to the amount of $7,000, was made. This act called upon the Board to make the proper surveys and investigations necessary to fix the location of this extension. The proposed extension begins at a point near Jamaica Pond in West Roxbury and proceeds northwesterly to the town of Brookline, then continues in the same general direction through that town to the Brighton line, and thence in a general westerly direction through Brighton and the city of Newton, to the Charles River.

The High-level Sewer, designed to receive only separate sewage, which extends from the connection with the Charles River valley system in the vicinity of the Ward Street pumping station in Roxbury to Nut Island and Boston harbor, was built under the provisions of chapter 424 of the Acts of the year 1899, in accordance with the recommendations made by the Metropolitan Sewerage Commission in its special report of that year upon the subject. It was stated that the Charles River valley sewer as then already constructed would probably be sufficient for a number of years to provide for portions of Brookline, Brighton and Newton; but it was within the scheme recommended that eventually an extension of the High-level Sewer would be required for these districts, and the location of such an extension was examined, and a suggested general route was traced upon the plans then submitted.

The necessity of definitely fixing the location of the local sewers which are called for by the growing population of these higher regions, especially those which are to be built for the separate system of sewerage which will in the future be required to discharge into this extension of the High-level Sewer, caused the Legislature to pass the act of last year.

The surveys and investigations have been made in accordance with the requirements of that act, and a proper location of the proposed extension has been fixed by the Engineer of the Sewerage Works and approved by the Board. The report of the Engineer, showing this location and the proposed elevation and size of the sewer, together with the estimated cost of the construction of the various sections of the work, is made a part of his general report to the Board, and is published herewith.

The route selected for the extension starts from a point in the present High-level Sewer in West Roxbury near Jamaica Pond, at the corner of Perkins and Centre streets, and, in general, proceeds by tunnel through Perkins Street, passing near Jamaica Pond and across the line into Brookline; then under Chestnut, Kendall and Cypress streets, crossing under Walnut Street, to near Boylston Street; then by open cut in a route which passes through Gorham Avenue and Park Street, by tunnel through Winchester Street, and by open cut through Columbia Street to the Brighton line. In Brighton the route passes by open cut through Columbia Street and Commonwealth Avenue, and by tunnel under Warren and Cambridge streets and a portion of Washington Street, and continues by open cut through Washington and Tremont streets to the Newton line. In Newton the route passes through Tremont Street and other short streets to Newtonville Avenue, thence by tunnel under Mt. Ida to Cabot Park, and then by tunnels and open cuts through Newtonville and West Newton to the Charles River at Newton Lower Falls.

The total length of the proposed location is 10.18 miles. About 5.30 miles are in tunnel and 4.88 miles in open cut.

Particular attention has been given to that portion of the sewer which extends from the junction of the High-level Sewer in West Roxbury through Brookline to Oak Square in Brighton. It is anticipated that the further extension through the city of Newton will not be required for a considerable period to come.

The portion of the sewer located in West Roxbury and Brookline and in Brighton to Oak Square has a length of 24,750 feet, or 4.69 miles. Although sections at various places would differ in form, its size would vary from substantial diameters of about 6 feet to 7 feet. The elevation at the highest point, at Oak Square, in Brighton, would be 41.13 feet above Boston City Base, and at the junction with the High-level Sewer, 31.5 feet above Boston City Base, or 21.5 feet above high water in Boston harbor.

The district which would be affected by the construction of this entire extension of the High-level Sewer has an area of 48.57 square miles, having an estimated population of 153,250. At present all or nearly all of the sewage of this area is contributory to the Charles River valley sewer, and the sewage thus received has to be pumped at the Ward Street station into the High-level Sewer. It is, however, estimated that an area of 20.26 square miles, having now an estimated population of 45,350, which is likely to increase largely in the future, can by the proposed extension be discharged by gravity into the High-level Sewer, and in this manner all costs for pumping can be saved.

The estimated cost of the entire extension, as given by the Engineer, is $1,889,906 ; and the cost of that portion in West Roxbury, Brookline and Brighton, which will first be required, is estimated at $1,168,928.

It is evident that the time is fast approaching when the volume of sewage discharged into the Charles River valley sewer, which provides for the territory in question, will have reached the limit of the capacity of that sewer, and that the relief which had formerly been proposed by the extension of the High-level system into the upper portions of the territory will have to be afforded.

It was estimated, when the Charles River valley sewer was built, in the year 1892, that it would provide for an anticipated population of 183,000. The present population of the district now tributary to this sewer is about 153,000, and is rapidly increasing. The maximum per capita rate of sewage, or 225 gallons a day, which was taken for the basis of the studies made previous to the year 1892, has already been exceeded in the ordinary wet weather flows. Although the Charles River valley sewer was built to receive only separate sewage from much of the territory tributary to it, in periods of storms there is necessarily a considerable increase by ground flow and otherwise, so that at such periods the amount discharged into the sewer is now nearly equal to its capacity; and there is danger that in a comparatively few years this sewer will be at times overcharged, and the sewage will overflow so as to become offensive to portions of the District, particularly in Brighton and Brookline, through which the sewer passes. An additional advantage will be gained by the construction of the proposed extension, in that the sewage which will be received into it will be discharged by gravity, and considerable expense will be saved in the cost of pumping.

Inasmuch as the construction of the extension to Oak Square will require a period of two or three years after its building is authorized, an early consideration of the subject is important.

XII. FUTURE WORK.

The construction of the Wachusett Dam and the Wachusett Reservoir has proceeded so far that there seems but little doubt that both the dam and reservoir will in the coming year be substantially completed and made ready for use, so as to leave only some small subsidiary work to be subsequently performed.

If decided measures are taken by the municipalities of the Metropolitan District for the reduction of the present excessive consumption, the necessity of proceeding to new sources of water supply and of building further reservoirs and aqueducts will be delayed for a considerable period to come. It certainly behooves the various municipalities of the District, which have the control of the distribution of water, to promote and adopt such reasonable measures as shall postpone the necessity of providing new sources of supply and additional works therefor, and to prevent the imposition upon the people of burdens which are unnecessary.

Considerable additional work will probably be required for the abatement of sources of pollution to the water supply, for enforcing measures for stopping improper and unnecessary consumption of water through waste and leakage, and for the prevention of the deterioration of water mains arising from electrolytic action. The building of the improvement of Spot Pond Brook, called for by the legislation of last year, is dependent upon the decision of a commission to be appointed by the court. A petition for the appointment of such a commission has been made, but no action has yet been taken thereon.

With the exception of the suits of the cities of Malden, Medford and Melrose for damages on account of the taking of Spot Pond and the adjacent lands, there remain unsettled comparatively few claims for damages on account of the taking of lands for the works, for the diversion of water, for depreciation to real estate and for damages to business. It is probable that nearly all of these claims can be settled during the coming year.

The construction of the High-level Sewer and of the extensions of the North Metropolitan System of sewerage to the towns of Revere and Belmont has nearly completed all the sewerage works at present authorized. The laying of the force main from the Quincy sewerage pumping station to connect with the High-level Sewer will be accomplished early in the year.

The Board is charged with the operation and maintenance of all the various works for the supply of water to the Metropolitan District and for the disposal of the sewage. The amount required for maintenance and operation during the past year exceeded $550,000, and the putting into complete operation of the Wachusett Reservoir and of the High-level Sewer will add materially to this department of the work of the Board.

The report of the Chief Engineer, relating to the 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 11, 1905.

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, 1904.

ORGANIZATION.

Dexter Brackett, Engineer of the Distribution Department, was on March 10 also placed in charge of the Sudbury Department and of the maintenance of the Weston Aqueduct, and on May 25 was placed in charge of completing the work of construction connected with the Weston Aqueduct. In connection with these changes he was given the title of Engineer of Sudbury and Distribution Departments.

Horace Ropes, Engineer of the Weston Aqueduct Department, after having substantially completed the work under his charge, resigned on May 25 to accept a position on the New York Water Works. The department was then abolished, and the work remaining to be done was placed in charge of Mr. Brackett, as already stated.

Charles E. Wells, Engineer of the Reservoir Department, tendered his resignation toward the end of the year, to take effect in January, 1905, in order to accept an appointment on the Reclamation Service of the United States Geological Survey; and the work of his department will on January 1 be placed in charge of Thomas F. Richardson, Engineer of the Dam and Aqueduct Department, with the new title, Engineer of Dam and Reservoir Department.

Chester W. Smith, Division Engineer and Chief Inspector at the Wachusett Dam, resigned December 10 to accept a position on the Reclamation Service of the United States Geological Survey.

Charles E. Haberstroh, Assistant Superintendent, Sudbury Department, now reports to Mr. Brackett, instead of directly to the Chief Engineer.

Charles W. Sherman, Division Engineer, tendered his resignation, which took effect September 30, to accept another position.

William W. Locke, Sanitary Inspector, who formerly reported to the department engineers, now reports directly to the Chief Engineer.

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

Dexter Brackett, .	. *Engineer of Sudbury and Distribution Departments.*
Thomas F. Richardson,	. *Engineer of Dam and Aqueduct Department.*
Charles E. Wells, .	. *Engineer of Reservoir Department.*
William W. Locke, .	. *Sanitary Inspector.*
Frank T. Daniels, .	. *Principal Office Assistant.*
Samuel E. Killam, .	. *Office Assistant.*

Joseph P. Davis and Hiram F. Mills have continued as consulting engineers.

At the beginning of the year the engineering force, including those engaged upon both the construction and maintenance of the works, numbered 153, and at the end of the year 105.

In addition to the engineering force, which included the engineers engaged upon the inspection of the work, other inspectors have been employed upon masonry and earthwork. The maximum number so employed at any time during the year was 11.

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 grouting with cement of two large arch bridges of the Boston & Maine Railroad over the Stillwater and Quinepoxet rivers; the cleaning of a large portion of the Wachusett Reservoir, preparatory to filling it with water; cementing and otherwise treating the rock at the bottom of the cut-off trench of the South Dike; the construction of additional settling basins and beds at the Clinton sewage disposal works; and the fencing, seeding and other work connected with the completion of the Weston Aqueduct.

There has also been a maintenance force, exclusive of engineers, averaging 202, employed at the pumping stations and in connection with the maintenance of reservoirs, aqueducts, pipe lines and other work.

Force Employed on Works.

The force employed upon the works in 1904 was smaller than the force employed in 1903.

The largest force employed upon the works at any one time during the year was for the week ending June 11, as follows : —

	Men.		Horses.	
Contractors' forces : —				
Reservoir Department,	716		109	
Dam and Aqueduct Department,	911		118	
		1,627		227
Day-labor forces, construction,		171		30
Engineering force, including engineer inspectors and those engaged upon maintenance,		135		-
Inspectors not engineers,		9		-
Maintenance force, not including engineers,		190		22
		2,132		279

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 the year 1904 : —

Portion of Work.	Number of Contracts.	Approximate Amount.
Wachusett Reservoir,	32	$2,949,045 92
Wachusett Dam,	12	1,740,215 86
Other portions of work,	243	10,287,854 53
Totals,	287	$14,977,116 31

Amount of 6 contracts made in 1904 (approximate), ...	$95,541 26
Amount of 3 contracts unfinished December 31, 1904 (approximate),	2,388,635 00
Value of work done by contract from January 1, 1904, to December 31, 1904, ...	1,154,851 57

In the case of all contracts completed up to the present time final settlements have been made without any legal controversy.

RESERVOIR DEPARTMENT.

(The statement of the work of this department has been prepared by Charles E. Wells, Department Engineer.)

The principal work of this department during the year has been the continuation of the removal of soil from the Wachusett Reservoir and its disposal in the North Dike and in shallow flowage and highway embankments, the completion of the North Dike, the construction of highways in West Boylston and Oakdale, and the practical completion of the work connected with the relocation, raising and protection of the railroads at Oakdale.

The organization of the engineering force has been the same as during the latter part of the previous year. 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 also in charge of maintenance and forestal work. Harry J. Morrison, division engineer, has continued in charge of the inspection of the removal of soil from the reservoir below West Boylston and the supervision of contractors. Ernest H. Baldwin, division engineer, has continued in charge of the work at and near Oakdale. Frederick W. Harris, assistant engineer, has had charge of the work at the North Dike and the miscellaneous day-labor work in that vicinity. Edwin J. Pickwick, assistant engineer, has had charge of the work connected with the relocation of roads and removal of soil at West Boylston.

The total engineering force of this department has varied in number from 57 to 47, the latter being the number at the end of the year.

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.

North Dike.

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

The amount of work done during the year, also the total amount done to complete the dike, are given in the following statement: —

	To December 31, 1903.	For the Year 1904.	Total.
Soil and earth excavated from main cut-off trench (cubic yards),	499,856	-	499,856
Soil and earth excavated from secondary cut-off trench (cubic yards),	42,033	-	42,033
Total length of main cut-off trench (feet),	9,505	-	9,505
Length excavated to rock (feet),	3,130	-	3,130
Length excavated into fine sand (feet),	6,375	-	6,375
Length in which sheet piling was driven (feet),	5,239	-	5,239
Length in which sheet piling was not driven (feet),	1,136	-	1,136
Surface of rock uncovered and treated at bottom of main cut-off trench (square feet),	77,250	-	77,250
Soil from reservoir deposited in cut-off trenches and in the dike (cubic yards),	4,765,333	190,603	4,955,936
Earth and gravel taken from borrow pits and deposited in the dike (cubic yards),	198,837	6,939	205,776
Earth excavation for the construction of a small dike (coffer-dam) in Coachlace Pond (cubic yards),	19,172	-	19,172
Drain pipe laid at toe of westerly portion of dike (linear feet),	7,083	-	7,083
Screened gravel on the water slope of the dike as a foundation for riprap (cubic yards),	14,355	1,556	15,911
Riprap on the water slope of the dike (cubic yards),	81,359	41,771	123,130

The dike covers an area of 135 acres and contains 5,300,753 cubic yards of material brought from outside sources. In addition, 561,061 cubic yards of earth were excavated from cut-off trenches and for a small dike, making a total of 5,861,814 cubic yards of earth moved in connection with the construction of the dike. The dike is 10,400 feet or nearly 2 miles long on the water side at full-reservoir level, 65 feet high at the deepest place up to this level, and 1,930 feet wide at the base at the maximum section.

The depositing of screened gravel as a foundation for the riprap on the westerly portion of the dike was completed April 13, 1904. The soil filling, constituting the principal part of the dike, and consisting of a total of 4,955,936 cubic yards, was completed November 12. The placing of riprap was completed November 18.

The total cost of the dike is substantially $750,000, which may be subdivided by classes of work, as follows: —

Soil excavated from the reservoir and deposited at the North Dike, only the estimated cost of depositing it being charged to the dike, 4,956,000 cubic yards, at 5 cents,	$247,800
Excavation from cut-off trench, 542,000 cubic yards, at 18 cents,	97,560
Borrowed earth, 225,000 cubic yards, at 22 cents,	49,500
Riprap and screened gravel, 139,000 cubic yards, at 64 cents,	88,960
Drain pipe and other miscellaneous items,	11,180
Sheet piling, treatment of ledge in bottom of cut-off trench, pumping, consolidating soil with water and other day-labor work,	125,000
	$620,000
Engineering and preliminary investigations,	130,000
	$750,000

A day-labor force has been employed in finishing the slope of the dike toward the water on the easterly and westerly portions and seeding the slope of the easterly portion; lumber and tools have been removed to the Wilson Street storage yard; weeds have been mowed and burned; and nine permanent benches have been placed on the easterly portion of the dike, for the purpose of determining future settlement of the material composing the dike.

The maximum day-labor force employed at the dike was 10 men and 4 horses, for the week ending June 25.

Measurements have been made during the past three years which give interesting and important information, confirming that previously obtained with regard to the impermeability of the soil which has been used for the construction of the greater portion of the North Dike.

A small well was sunk on the down-stream slope of the dike, about 1,200 feet distant from the crest of the dike and about 500 feet from the toe. The surface of the dike at the well is about 25 feet above the high-water level of a pond at the toe of the dike, and this pond is drawn down during the summer from 4 to 6 feet below the high-water level.

During the time of these observations the Wachusett Reservoir had not been filled against the up-stream face of the dike, so that the water on that face was somewhat lower than at the down-stream toe. Notwithstanding this fact, the water in the well stands from 18 to 24 feet — averaging about 22 feet — higher than the water in the pond at the toe of the dike.

The soil, although merely dumped from cars in layers $7\frac{1}{2}$ feet in thickness, is so nearly impervious that the rainfall alone is able to maintain the ground water in this portion of the dike only a few feet below the surface of the down-stream slope.

The elevation of the water in the well rises after each heavy rain, and also shows a seasonal change, being higher after the spring floods and lower after the summer and autumn droughts. The water when highest was 2 feet below the surface of the dike, and when lowest 7 feet below.

Not only were the observations made at the well, but on two occasions, November 9, 1903, and April 21, 1904, were also made at points 25 feet apart in each direction, covering an area 400 feet long in the direction of the slope and 250 feet at right angles thereto in the vicinity of the well. These observations showed that the ground water was from 3 to 7 feet below the surface of the dike (which has a slope of from 3 to 4 feet in 100) and approximately parallel with it.

Relocation and Construction of Roads.

Considerable progress has been made by the contractors on the construction of highways at West Boylston and Oakdale.

Of the new highway which passes through Oakdale, that part between Pleasant Street and the village was opened for travel on June 15, and the remainder, to a point south of the Quinepoxet arches, on September 17.

Considerable work has also been done on Newton Street, south of the arches, and on the new location of Holden Street, which is now used for public travel. The highway across the reservoir at West Boylston was opened for public travel on December 24. The opening of these highways has permitted the discontinuance of the last of the public railroad crossings at grade in the villages of Oakdale and West Boylston.

Additional information with regard to the work on the highways mentioned may be found subsequently in this report, under the head of Contracts.

In addition to the work done by the contractors, there has been done by the day-labor forces a considerable amount of work, such as grading and seeding highway slopes; erecting and painting highway railings between West Boylston and Oakdale; constructing the false works for the arch bridge at the West Boylston crossing of the reservoir, and removing the same; constructing pipe highway culverts at the South Meadow Road, Clinton, and near the West Boylston railroad station; and constructing concrete highway culverts under Holden Street and at Malden Brook on Newton Street, Oakdale.

The maximum force employed was 23 men and 6 horses, for the week ending October 29.

Removal of Soil.

Work upon the removal of soil from the reservoir has been in progress under the contractors, the Newell and Snowling Construction Company, and Bruno, Salomone & Petitti. 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 3,943 acres. Of this, the total amount removed from the reservoir in previous years was 5,645,064 cubic yards, from 3,236 acres; in 1904, 1,115,341 cubic yards were removed from 621 acres, making a total from the beginning of the work to the end of 1904 of 6,760,405 cubic yards, or 98 per cent. of the total as at present estimated, removed from 3,857 acres.

The above total includes 160,895 cubic yards of soil stripped under contracts Nos. 273 and 275 (Dam and Aqueduct Department), from 101.4 acres near South Clinton, and 7,500 cubic yards stripped from the vicinity of the Wachusett Dam.

Of the soil removed to the end of 1904, 470,233 cubic yards were used for road embankments, 1,026,754 cubic yards for shallow flowage areas, 131,781 cubic yards for railroad embankments, 4,955,936 cubic yards for the North Dike, 160,895 cubic yards for the South Dike, 7,306 cubic yards have been placed in spoil banks and 7,500 cubic yards have been used near the Wachusett Dam. During the year 8,835 cubic yards of earth have been deposited upon the deep muck, which has been covered to a depth of about 1 foot. This amount, added to 230,011 cubic yards used for the same purpose during previous years, gives a total of 238,846 cubic yards.

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

All of the bodies from the old Beaman Cemetery have been removed to a new burial lot adjoining the West Boylston Cemetery. The new lot was graded and seeded, a gravel drive was constructed, and a substantial wall enclosing the lot was built. Excavation was carried to a depth of about 7 feet over the whole area of the old cemetery, and 65 bodies were removed. These were placed in boxes provided for the purpose, and reinterred in the new lot. The monuments, head-stones and foot-stones were removed and erected in their proper places. The excavated material was removed to the shallow flowage embankment opposite the Clarendon Mills. The work of removing the bodies was commenced on May 10 and completed on May 21.

The final cleaning of the reservoir bottom on the area to be flooded was accomplished to elevation 375. The weeds and grass were removed, and, together with the roots, etc., were burned over an area of 1,200 acres. On a considerable portion, where there was a growth of bunch grass, the ground was harrowed over with spring-tooth harrows. The grass was afterwards raked and burned. This method was somewhat more costly than mowing and raking the grass, but the results were more satisfactory.

Stumps and driftwood were removed from the channels of the Stillwater, Quinepoxet and Nashua rivers, between Oakdale and a point about 1 mile below West Boylston. This material was piled and burned. Perennials were pulled or grubbed on the portions of the reservoir from which the soil has been removed; the reservoir margin has been widened in the vicinity of Dover Pond, and also near West Boylston; driftwood has been removed from the reservoir, and burned; soil on the old Central Massachusetts Railroad embankments at Oakdale has been cast to the foot of the slopes, and covered; the bottom of the reservoir in the vicinity of the upper end has been graded, to secure proper drainage; and much other miscellaneous work has been done.

The maximum force employed was 62 men and 6 horses, for the week ending October 1.

In addition to the engineering work connected with the estimates and inspection of the removal of soil, the organic matter in 1,035 samples of soil has been determined for the guidance of the inspectors.

WACHUSETT RESERVOIR—WEST BOYLSTON MANUFACTURING COMPANY MILLS SITE BEFORE BEGINNING OF WORK AND AFTER STRIPPING OF RESERVOIR AND CONSTRUCTION OF ARCH AND EMBANKMENT.

Relocation of Railroads.

The principal part of the contract work upon the relocation of railroads was completed in 1903. Some paving has been done on the slopes of the Worcester, Nashua & Portland Division during the season of 1904, and a very small amount yet remains to be done in the vicinity of the Stillwater and Quinepoxet arches. The Boston & Maine Railroad has raised and ballasted the track on the Worcester, Nashua & Portland Division south of the Oakdale station, and has also raised and ballasted the Y track connecting the Worcester, Nashua & Portland and Central Massachusetts divisions.

The principal day-labor work in connection with the railroads has been the grouting of the masonry of the arches which carry the railroad over the Quinepoxet and Stillwater rivers, and the relaying of a considerable part of the wingwalls. This work became necessary because the wingwalls and portions of the abutments were originally laid without mortar, and, with the raising of the water in the reservoir against them, they might otherwise have failed. The waterway of the Quinepoxet arch was paved in 1902, and that of the Stillwater arch in 1903. The work of grouting the masonry and relaying the wingwalls was commenced at the Stillwater arch on June 6, 1904. A steam derrick was used to handle the materials of construction. The upper and insecure parts of the wingwalls were taken down, and when rebuilt the walls were extended to correspond with the slopes of the embankments. In rebuilding as much additional stone as was necessary was provided and all of the stone was laid in Portland cement mortar. It was necessary to take down and relay a large part of one of the wingwalls at the Stillwater arch. The grouting of the main parts of the walls proceeded at the same time. All joints were thoroughly washed out with a stream of water furnished by a steam pump through a 1-inch hose. The joints were then carefully filled at the face of the walls with rich mortar, holes being left about 5 feet apart for convenience in grouting. The filling of the joints was done a few days in advance of the grouting. A specially constructed funnel, having a spout on the side, was used in pouring the grout into the walls. The grout was prepared in an ordinary mortar box, and was composed of 3 parts of fine sand to 1 part of American Portland cement. Five or six men did the mixing with mortar hoes, and when the grout was of proper consistency, three men continued stirring the mixture while the others poured the grout into the walls. Ordinary coal hods were used in transferring the grout to the wall, the hods being filled by means of coal scoops. Substantial stagings were erected as the work progressed, and the mixing box was always kept on a level with the work and close to the wall where the grout was being used. The grout ran very freely, in some cases showing in the walls at a distance of 75 feet from the point of application. Four hundred and eighty cubic yards of rubble masonry were laid, at a cost of $4.86 per cubic yard. This includes the expense of removing the old masonry and excavating for foundations at the ends of the walls. One thousand seven hundred and thirty barrels of cement were used in the grouting, at a cost of $3 per barrel of cement. A total of 2,041 barrels of cement were used for the rubble masonry and grouting of both arches. This work was completed November 19, the Quinepoxet arch being finished at that time. The maximum force employed was 26 men and 5 horses.

The maximum day-labor force employed on the relocation of railroads was 28 men and 4 horses, for the weeks ending October 8 and 29.

Contracts, Wachusett Reservoir.

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 this 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 the placing of 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.

The operations of the contractor were continued along the same lines as during the preceding seasons. Soil has been loaded into carts and deposited in a shallow flowage embankment nearly opposite the former location of Sawyer's Mills. The remainder of the soil has been loaded into carts and, by means of dumping platforms into cars, or has been loaded directly into cars, and hauled by locomotives to the North Dike. A limited area of muck has been covered with earth to a depth of about 1 foot. The placing of screened gravel on the slope of the westerly portion of the dike was in progress at the close of 1903, and was completed April 13, 1904. The last soil was hauled to the dike November 1.

By the operation of the railway and car plant, 57,427 carloads, containing 188,772 cubic yards, were transported to the dike; this, added to the 180,513 carloads, containing 620,131 cubic yards, transported during previous years, makes a total of 237,940 carloads, containing 808,903 cubic yards, transported under this contract.

The plant consisted of 2 12-ton locomotives, 60 3-cubic-yard dump cars and 5 miles of 3-foot-gage track.

The total amount of work done has been: —

	To December 31, 1903.	In 1904.	Total.
Clearing and grubbing (acres),	298	107	405
Soil excavation (cubic yards),	696,245	274,503	970,748
Earth excavation for embankment at dike (cubic yards),	14,915	2,163	17,078
Earth excavation for covering (cubic yards),	55,245	4,479	59,724
Gravel excavation for water slope of dike (cubic yards),	29,037	4,776	33,813
Screened gravel for foundation for riprap (cubic yards),	6,776	1,556	8,332

The amount of the final estimate was $395,092.50.

The work was completed November 26.

The maximum force employed was 184 men and 38 horses, for the week ending May 21.

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 reservoir. At the beginning of 1904 it included all of the soil stripping necessary to complete the reservoir, excepting that covered by contracts of the Newell & Snowling Construction Company, John F. Magee & Co., and a comparatively small area along the Stillwater River at the upper end of the reservoir which has not yet been placed under contract. It also provided for the construction of a new channel, chiefly in rock, for the Nashua River at the highway crossing of the reservoir at West Boylston; enlarging a portion of the channel of the Quinepoxet River west of the Worcester, Nashua & Portland Division at Oakdale; building a concrete dam across the river at the upper end of this channel; paving the slopes of the railroad and highway embankments; excavating gravel to be used for protecting the slopes of embankments; and covering with earth deep deposits of muck not desirable to remove. The progress of the work was considerably in excess of the requirements of the contract at the beginning of 1904.

The methods employed by the contractors have been the same as in use during the preceding season. The soil from limited areas in the vicinity of shallow flowage and highway embankments has been loaded into carts and hauled directly to the embankments. A limited amount of soil has been placed in spoil banks. On other portions of the work, requiring a longer haul, the soil has been loaded into carts and, by means of dumping platforms into cars, or has been loaded directly into cars, and hauled to the embankments at West Boylston or Oakdale, or to the shallow flowage embankments at Oakdale.

The total number of carloads of soil hauled during the year has been 182,889, containing 580,254 cubic yards; this, added to 138,543 carloads, containing 429,617 cubic yards, hauled during 1903, makes a total of 321,432 carloads, containing 1,009,871 cubic yards.

Of the soil removed under this contract, 268,378 cubic yards were used in highway embankments, 917,524 cubic yards were used in shallow flowage embankments near Oakdale and 7,306 cubic yards were deposited in spoil banks.

The railroad plant consisted of 6 12-ton locomotives, 1 10-ton locomotive, 80 $2\frac{1}{2}$-cubic-yard dump cars, 40 3-cubic-yard dump cars, 40 $3\frac{1}{2}$-cubic-yard dump cars and 8.4 miles of 3-foot-gage track.

The work of soil removal has been prosecuted vigorously during the season. Considerable earth excavation has been done in the new channel for the river above the Quinepoxet arches at Oakdale, and the slopes have been paved. The highway embankments at Oakdale and West Boylston have been completed. The slope paving is completed on the highway embankments at Oakdale, and, with the exception of a small amount, is completed on the Worcester Street embankment at West Boylston. The excavation of the rock channel at West Boylston was completed and the water of the Nashua River turned through the channel on July 16.

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

	To December 31, 1903.	For the Year 1904.	Total to December 31, 1904.
Clearing and grubbing (acres),	67	87	154
Soil excavation (cubic yards),	496,261	696,947	1,193,208
Earth excavation (cubic yards),	38,463	52,386	90,849
Rock excavation (cubic yards),	4,917	12,026	16,943
Slope paving (cubic yards),	8,362	10,630	18,992

This contract provided for the completion of the work on or before November 1, 1905; but in view of the importance of having the reservoir in readiness for the storage of large quantities of water in the spring of 1905, a bonus was offered for the completion at the end of 1904 of those portions of the work more than 15 feet below the full-reservoir level. This bonus has been earned by the contractors, notwithstanding that the number of cubic yards of soil removed was considerably in excess of the number in the preliminary estimate of quantities of work to be done.

The maximum force employed has been 556 men and 107 horses, for the week ending September 10.

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 cross-section of the riprap and the methods of the contractor were for the greater part of the season the same as those described in the last annual report. About October 1 the work had advanced to the westerly end of the dike, and the derrick which had been used in placing the riprap was then removed. A considerable quantity of coarse riprap was then required at different places along the dike, where it had been omitted on account of the difficulty in procuring a sufficient proportion of the large stone from the excavations at the dam as the work on the dike progressed. After the removal of the derrick the cars were dumped and the stone placed entirely by laborers. The work was completed and the contractor's plant removed November 18. The total amount of riprap placed was 25,063 cubic yards; this quantity, added to the 15,751 cubic yards previously placed, makes a total of 40,814 cubic yards. These quantities represent the amount of solid rock used for the riprap, which, when in place as riprap, swelled to a volume two-thirds greater.

The amount of the final estimate was $51,017.50.

The maximum force employed was 16 men, for the week ending February 27.

Contract 277, F. A. McCauliff.

Masonry Arch Bridge at West Boylston.

On June 23, 1904, a contract was made with F. A. McCauliff for the construction of a masonry arch bridge at the highway crossing the reservoir at West Boylston. This contract called for the construction of a granite masonry arch highway bridge and wingwalls backed with concrete. The arch was to span a deep rock cut which had been excavated for the purpose of making a new channel for the Nashua River. The Board was to furnish the material for and erect and remove the false works on which the arch was to be built, and to prepare the foundations for the arch and wingwalls. Work was commenced on July 18 and completed in a satisfactory manner on September 28, two days ahead of the time required by the contract.

The principal quantities of work performed were as follows: —

Concrete masonry (cubic yards),	724
Ashlar masonry (cubic yards),	498
Face dressing of fine-pointed work (square feet),	1,096
Face dressing of rough-pointed work (square feet),	400

The value of the work, as shown by the final estimate, was $12,809.65.

The maximum force employed was 38 men and 8 horses, for the week ending September 24.

Wachusett Reservoir—Arch Bridge over the New Channel, and Highway Embankment across Reservoir at West Boylston.

Improving Wachusett Watershed.

The dam at the Palmer mill-pond in Sterling was removed, and a main ditch 1,550 feet long and 4 feet wide on the bottom was dug to make a new channel for the brook running through it. Side ditches having an aggregate length of 1,365 feet were also dug for draining the site of the pond. Considerable other work has also been done by day-labor forces in constructing cesspools, privies and filter-beds.

Forestry.

The cutting out, grading, draining and improving of interior roads has been continued. About 3 miles of these roads have been treated in this manner, for purposes of fire protection and forestry improvement. The work of cutting out mature, dead and undesirable trees, preparatory to planting, has been done over about 200 acres. About 200 acres have been planted with three and four year old white pine seedlings grown in the nurseries of the Board. This area consisted of arable land, open and brushy pasture and sprout land which had been burned over, or on which there was little but an undesirable scrub growth.

On the open areas pines were set at 10-foot intervals, with sugar maples between as fillers. These maples were natural seedlings obtained at the Lamson farm. Hickory nuts and acorns were planted to provide fillers on the brushy areas. On some partly forested areas pines only were planted, varying the intervals from 5 to 10 or more feet, according to the existing growth. Three rows of white pines 6 feet apart each way were planted along 2 miles of the southern reservoir margin near Pine Hill; 123,900 pines, 89,700 sugar maples, $7\frac{3}{4}$ bushels of hickory nuts and 4 bushels of acorns were planted.

The necessary care has been given to the Flagg and Lamson nurseries during the year. There were transplanted from seed beds to nursery rows at the Flagg nursery 23,000 two-year-old white pines. This nursery now contains 123,500 three and four year old white pines and 24,000 two-year-old pines in nursery rows. The seed beds contain approximately 23,000 white pines, 14,000 Norway spruces and 300,000 arbor vitæ, all two years old. They also contain, from seed sown in May, 1904, 105,000 white pines, 11,000 Douglas spruces, 3,000 hemlocks, 38,000 white spruces, 4,000 tamaracks, 1,000 European larches and 10,000 Scotch pines.

The Lamson nursery contains about 12,000 three, four and five year old white pines. There have been taken up and heeled in for spring planting 19,000 pines and 22,000 natural seedling sugar maples.

Furrows for fire protection have been plowed around all the areas planted this year, and replowed around areas previously planted and on fire guards where necessary.

Pine trees from the nursery, together with larger ones taken from pasture land, were planted to form a screen around the filter-beds at the Worcester County Truant School.

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 : —

Plans, specifications and estimates have been prepared for the construction of a new highway on the southerly side of the reservoir between Oakdale and West Boylston ; elevations on the reservoir bottom, as determined by the final levels taken after the completion of soil excavation, have been entered on record sheets and contour lines have been drawn covering an area of about 430 acres, making a total of 2,500 acres covered by these final records at the end of the year. Curves were plotted and tables prepared showing the capacity of the reservoir at each tenth of a foot between elevations 305 and 332. Surveys and plans were made of the Warfield estate in Holden and West Boylston, and of the Dorr property in Holden. Plans have been made for the discontinuance of parts of Newton and Pleasant streets at West Boylston, and for the discontinuance of Holden Street at Oakdale. Plans have been revised for the relocation of Holden and Newton streets at Oakdale. In addition to the surveys and plans mentioned, many others have been made in connection with the settlement of claims and for other purposes, and much miscellaneous engineering work has 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 of this department has been the construction of the Wachusett Dam and of the superstructure of the lower gate-chamber of the dam, the construction of the South 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 at the Wachusett Dam until December 10, when he resigned to accept a position in charge of the Roosevelt Dam, near Phoenix, Ariz., for the Reclamation Service of the United States Geological Survey. Mr. Smith, in addition to his duties as division engineer, acted as chief inspector at the dam during the progress of masonry construction. Moses J. Look, division engineer, has had charge of the construction of the South Dike and of the removal of soil near South Clinton. The work in the drafting office has been 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 sewerage plant. He has also had charge of the construction of some extensions to the Clinton sewage disposal system, which have been built by day labor during the year.

The engineering force has averaged 24 men for the whole year; there were also 10 masonry inspectors.

The main office of the department is in Clinton, and a branch office has been maintained at 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. There has been no material change in the plant or in the methods.

The work was carried on without interruption from the beginning of the year until December 24, when practically all work was shut down for the winter. Work upon the masonry, which was suspended on account of cold weather on December 8, 1903, was not resumed until March 24, and was again suspended on November 28. The progress on the work has been good, about 10,000 cubic yards more masonry having been laid during the past year than during any previous year. The work is considerably behind the requirements of the contract, which provides for the completion of the whole work on November 15, 1904. The dam has, however, been carried to a sufficient height to permit the storage in the reservoir of as much water as it will be feasible to store next spring. Rather more than 15,000 cubic yards of masonry still remain to be built, out of a total of 273,000 cubic yards, — an amount of work which can easily be accomplished during the coming season.

Industrial conditions have been favorable during 1904, and both common and skilled labor have been plentiful. Sufficient supplies of all kinds have been readily obtainable.

Main Dam, Gate-chambers and Terminal Structures.

When work upon the masonry was suspended in 1903, the masonry extended across the valley for a length of 739 feet, and the top of the masonry was at an average elevation of 345, or about 79 feet above the original river bed. Short masonry cut-off walls had been built at both ends of the masonry from the up-stream face of the dam to the ledge rock, to prevent water from going around the low ends. The lowest point in the masonry of the dam between the cut-off walls was at about elevation 341. The substructure of the lower gate-chamber had been built, and four 48-inch valves for controlling the flow of the water into the river below the dam, and eight 24-inch valves for controlling the flow of the water into the Wachusett Aqueduct, had been placed in this substructure.

Excavation. — When masonry work was discontinued in December, 1903, the excavation at the easterly end had been extended close up to the tracks over which stone is brought from the quarry, and these tracks were as near as possible to the cableway towers. As soon as the masonry work was suspended the tracks were removed, and later were carried across the dam on a timber trestle about 25 feet high, which rested on the masonry which had already been built. Preparations were also made to increase the span of both cableways from 1,150 feet to 1,250 feet. New tracks for the head towers were built 100 feet back of the previous tracks, and 21 feet higher. The head towers were then raised by means of screw jacks, and moved on building movers' rolls to these tracks, the cables and other ropes being taken off the towers while they were being moved. The removal of the first tower was completed on February 4, and of the other on February 27. The new tracks on which the cableways move up and down the valley were reduced in length from 500 feet, as originally built, to 150 feet.

As soon as the tracks over which stone is brought were removed, the work of excavation was resumed and was continued until July 9, when the excavation for the dam at the easterly end was completed. Some of the earth removed was used to fill the trench for the dam near the easterly end of the masonry, and the remainder was passed by derricks to the cableways, and dumped both above and below the dam on the westerly side of the valley. Considerable of the earth from between the cableway towers was placed back of the towers to form the road-bed for the new cableway tracks. In filling above the dam on the easterly side of the river, special precautions were adopted during cold weather to ensure a water-tight filling. Arrangements were made so that the earth filling would be puddled by dumping into water, this water being heated by the steam from two boilers, so as to remove any frost that there might be in the earth. The rock removed was placed outside of the earth, both above and below the dam, at the easterly end, and was used for grading the grounds below the dam.

The earth overlying the rock had a depth of about 35 feet, and was a boulder clay so hard and compact that it was found economical to loosen it by blasting. The rock uncovered was a soft black or gray schist, and the average depth of the excavation in the rock under the whole base of the dam was about 9 feet. In addition, a cut-off trench 20 feet wide was excavated to a depth of about 15 feet in the black schist, which was practically impervious to water. This cut-off trench extended a short distance under the abutment.

At the westerly end of the dam the excavation of earth and rock was substantially finished in 1903, except the westerly 40 feet of the cut-off trench in the rock. This trench, which is 20 feet wide under the main dam, was narrowed somewhat as it passed through the site of the bastion, and has a width of 17 feet at the junction with the waste-weir. The rock under the bastion was a hard granite, which was less seamy than the rock toward the lower part of the valley. It was consequently necessary to excavate this part of the cut-off trench only to a depth of 10 feet to reach rock practically free from seams, and the work was finished in May.

In excavating the cut-off trench on both sides of the valley, the method adopted in previous years, and described in the annual report of January 1, 1902, of drilling 3-inch holes 6 inches apart on both sides of the trench, was followed.

Masonry. — As previously stated, masonry construction was in progress from March 21 to November 28. When masonry work was suspended, the main dam had an average elevation of 396, equivalent to 1 foot above full-reservoir level, 130 feet above the original river bed and 188 feet above the lowest point of the foundation not in the cut-off trench. A gap about 20 feet wide, through which pass two tracks over which stone is brought from the quarry, has been left through the masonry, the bottom of this gap being at about elevation 369. If necessary, this gap can readily be built up with masonry in the early spring, so that water can be stored to elevation 380. A few of the coping stones of the dam have been set at the easterly end, near the abutment. The total length of the dam is 1,476 feet, made up of waste-weir, 452 feet; main dam, including the terminal structures, 971 feet; and corewall, which extends beyond the terminal structure at the easterly end, 53 feet. The length of the dam between terminal structures is 838 feet. The rubble-stone masonry down stream from the centre line of the dam was laid as before, with beds inclined upward 1 in 6 toward the down-stream face, until the masonry reached elevation 370. Above this elevation all of this class of masonry has been laid with practically horizontal beds.

A large part of the terminal structure at the easterly end of the dam, which is known as the abutment, has been built, some of the string course stone at elevation 415 having been set. The section of the rubble masonry corewall which was built in 1903 has been extended so as to connect with the abutment. The 6 concrete piers for supporting the floor of the abutment have been partially built. About 137 feet of the retaining wall, extending 200 feet up stream from the abutment, have been completed.

The top of the masonry at the upper gate-chamber is at elevation 396. Six ports or openings have been constructed to each of the 4 wells in the upper gate-chamber. These ports are between elevations 330 and 390, and will admit water to the 48-inch pipes through the dam. Eight sluice gates, each 6 feet high and 2.5 feet wide, which will regulate the flow of water through the dam, have been placed in the wells in the upper gate-chamber, and the gate stands for operating these gates have been set in a temporary manner.

The masonry of the terminal structure at the westerly end of the main dam, which is known as the bastion, has been built to elevation 404.

Waste Channel and Waste-weir.

Work has been in progress excavating rock from the waste channel for nearly the whole year, most of the rock excavated being hauled to the westerly portion of the North Dike, a distance of about 2 miles, to be used as riprap. After November 17 the rock was used as filling below the bastion and as riprap above the dam. During the early part of the year the work done was in the upper part of the waste channel in front of the waste-weir, where a channel of varying width and depth, but averaging about 70 feet wide and 6 feet deep, was excavated in the rock in order to furnish sufficient waterway to remove the water which may flow over the waste-weir. This channel is narrower and deeper where it passes under the location of the permanent line of the Central Massachusetts Railroad, the rock excavation being about 50 feet wide and 20 feet deep at this point. Most of the rock and all of the earth in the waste channel have been excavated, except that under the temporary location of the Central Massachusetts Railroad, which cannot be removed until the railroad is changed to its permanent location.

The earth excavation was largely finished during 1903, but a small amount of earth has been excavated near the upper end, and used for filling below the bastion. The earth slopes of the waste channel below the railroad crossing have been trimmed, and on the southerly side have been covered with soil and seeded. Some soil has been delivered on the northerly side of the channel, but has not been placed on the slopes.

The 24-inch cast-iron pipe which supplies the Lancaster Mills with water crosses the waste channel near its lower end, and the bottom of the pipe as originally laid was at the same level as the bottom of the waste channel. To ensure the safety of this pipe when water is running in the waste channel, it has been placed in a trench 5 feet deep, excavated in the rock which forms the bottom of the channel. In refilling this trench, the upper 18 inches was filled with Portland cement concrete.

At the site of the waste-weir, the rock, most of which had been uncovered the preceding year, was found to be freer from seams than in the lower part of the valley. This, together with the fact that for most of the length of the waste-weir the flow line of the reservoir is 15 feet or less above the surface of the rock below the masonry, has made it necessary to excavate but very little rock to obtain a suitable foundation. For about 165 feet from the bastion a cut-off trench 10 feet wide and about 8 feet deep was excavated under the up-stream portion of the waste-weir. In excavating this trench, 3-inch holes 6 inches on centres were drilled on the down-stream side of the trench for most of the distance. The rock from the trench was then removed, largely by blasting, but care was taken to disturb as little as possible the lower side of the trench. Under the remaining 285 feet of the waste-weir the rock was prepared for the masonry by barring and wedging, rather more than 2 feet of rock on an average being removed, though in one place it was necessary to remove over 6 feet of rotten rock before obtaining a suitable foundation.

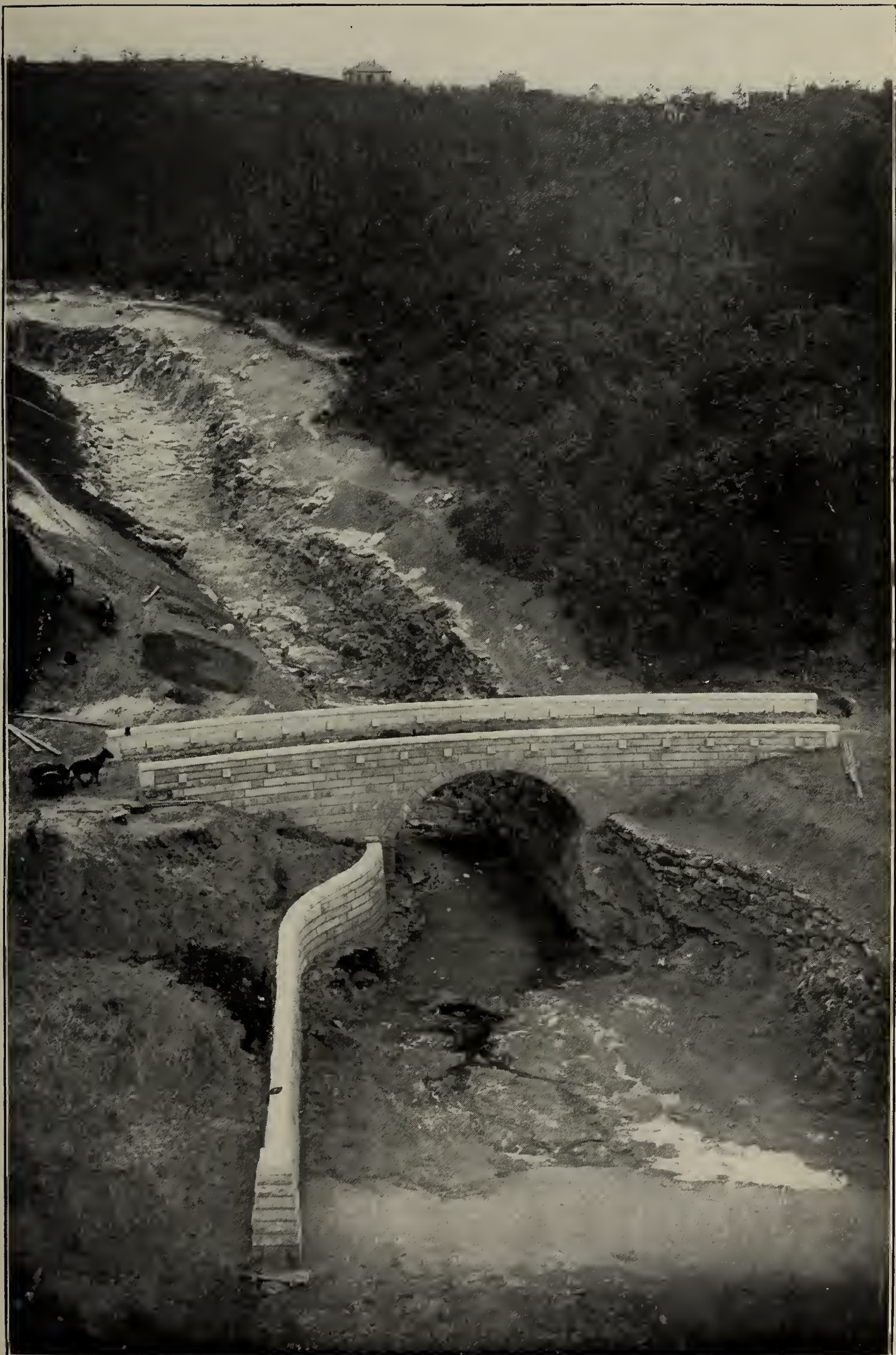
Masonry of Waste-weir and Retaining Wall.

Work was begun on masonry at the waste-weir early in June, and about 390 linear feet have been completed, leaving 60 linear feet still to be built, but the part remaining to be built is only about 7 feet high. No masonry work has been done on the small abutment at the westerly end of the waste-weir.

Extending along the easterly side of the waste channel from the bastion, to and beyond the arch bridge which will carry the tracks of the Central Massachusetts Railroad across the waste channel, is a retaining wall which has a height of over 26 feet above the bottom of the channel near the bastion; 195 linear feet of the higher part of this wall have been finished. Immediately below the waste-weir and against the retaining wall the ledge rock was lower than the surrounding rock in the waste channel. This hole has been filled, partly with rubble masonry, covered with ashlar paving 2 feet thick, and partly with Portland cement concrete masonry. The paving is $22\frac{1}{2}$ feet below the full-reservoir level.

Arch Bridge and Retaining Wall near Lower End of Waste Channel.

An arch bridge having a span of 35 feet 6 inches has been constructed across the lower end of the waste channel, affording access to the grounds below the dam from Grove Street on the westerly



HIGHWAY BRIDGE OVER THE WASTE CHANNEL OF THE WACHUSETT RESERVOIR.

side of the pond below the dam. The arch of this bridge is built of Portland cement concrete masonry, faced at the ends with stone. The stone parapet walls and face walls are curved in plan, the radius of the curve midway between the parapet walls being about 275 feet. The total length of the parapet walls, the tops of which are 3 feet 2 inches above the finished roadway, is about 131 feet, and the roadway is 20 feet wide.

Arch Bridge for the Central Massachusetts Railroad.

This bridge, which will have a span of nearly 58 feet, while not included in the original contract for the dam, is to be built by the contractor for the dam under a supplementary agreement. It crosses the waste channel at a considerable angle about 225 feet below the waste-weir. The arch will be built of Portland cement concrete faced at the ends with rubble masonry. Some work has been done preparing foundations, but no masonry has been built.

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, 1903 and 1904, the total amount of work done to the end of 1904 and the total estimated amount required by the contract: —

	To December 31, 1901.	In 1902.	In 1903.	In 1904.	Total to December 31, 1904.	Total Estimated Amount.
Earth excavation (cubic yards),	43,000	31,900	68,800	59,900	203,600	222,000
Rock excavation (cubic yards),	24,370	12,020	18,800	36,810	92,000	95,000
Rubble stone masonry (cubic yards),	28,486	65,686	69,139	76,598	239,909	252,000
Ashlar masonry (cubic yards),	65	684	2,015	4,905	7,669	8,850
Dimension stone masonry (cubic yards),	–	58	417	830	1,305	2,850
Brick masonry (cubic yards),	–	407	231	398	1,036	1,150
Concrete masonry (cubic yards),	–	5,284	1,906	914	8,104	9,350
Iron and other metal work (tons),	–	582	71	46	699	900

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.	In 1904.	Total to December 31, 1904.
Portland cement,	17,703	21,865	18,719	16,561	74,848
Natural cement,	8,892	52,896	51,533	61,739	175,060
Totals,	26,595	74,761	70,252	78,300	249,908

Of the cement used during 1904, all of the natural cement has been of the Union brand, and 12,421 barrels of the Portland cement have been of the Giant brand, both cements being manufactured by the American Cement Company of Egypt, Pa.; 4,140 barrels of Lehigh Portland cement have also been used.

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	172,251
1 part Portland cement to 2 parts sand,	1.06	31,970
1 part Portland cement to 2½ parts sand,	0.86	8,926
1 part Portland cement to 3 parts sand,	0.79	23,517

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,	1.33	995
1 part natural cement, 3 parts sand and 6 parts stone,	1.15	18
1 part Portland cement, 2½ parts sand and 4½ parts stone,	1.43	5,832
1 part Portland cement, 3 parts sand and 6 parts stone,	1.10	1,087
1 part Portland cement, 4 parts sand and 8 parts stone,	0.70	172

Miscellaneous Notes.

All masonry built before April 12 and toward the latter part of the season — masonry likely to be exposed to the action of the frost — was laid in Portland cement mortar, mixed in the proportion of 3 parts of sand to 1 part of cement. After November 3 all masonry was so laid. The water used for mixing mortar was heated after October 27. Between April 12 and November 3 most of the masonry was laid in natural cement mortar mixed in the proportion of 2 parts of sand to 1 part of cement; but Portland cement mortar mixed in the same proportions as the natural cement mortar was used, as in previous years, for the masonry in the cut-off trench, for masonry immediately above the ledge rock and in the upper gate-chamber.

The largest amount of rubble masonry laid in the dam during any week was during the week ending June 25, when 11 derricks were in operation, and 3,459 cubic yards were laid. During that week about 42 cubic yards of ashlar masonry were also laid. The average amount of rubble masonry laid per day by each mason has been 13 cubic yards, and by each derrick 56.1 cubic yards. This very large accomplishment has been possible because of the very complete appliances for furnishing materials to the work.

The building of concrete masonry has been entirely in the day-time, and the concrete has been mixed by hand.

A large amount of work has been done grading the grounds below the dam both in the bottom of the valley and on the hillsides. In connection with the construction of the Wachusett Aqueduct and Central Massachusetts Railroad tunnels large quantities of waste rock were dumped on the easterly hillside below the dam, and excavations have been made on the hillside for the dam and for the tracks on which the stone was brought to the dam. These tunnel dumps have been to a large extent removed and graded, the excavations for the tracks and for the dam have been filled, and a large part of the hillside has been covered with soil stripped from the reservoir. In the bottom of the valley the grounds around the pool and the lower gate-chamber have been graded and nearly all covered with soil obtained from the bottom of the old mill-pond. Foundations for the drives and paths below the dam, consisting of about 18 inches in depth of stone from the tunnel dumps, have been placed, and the paths have been finished with a coating of fine screened stone from these dumps.

The stone for the rubble masonry is still obtained from the quarry, about $1\frac{1}{2}$ miles from the dam. The stone for the ashlar and dimension stone masonry has all been obtained from the quarry of H. E. Fletcher & Co., at West Chelmsford, Mass.

The maximum force employed by the contractor, including the men employed at the Chelmsford quarry, was during the week ending July 30, when 778 men and 54 horses were employed. At that time 141 men were employed at the Chelmsford quarry.

Contract 276, Connery & Wentworth.

Superstructure of the lower gate-chamber of the Wachusett Dam; date of contract, March 18, 1904; amount of contract, $72,937.34.

This building covers the gates and other works used for controlling the flow of water to the Wachusett Aqueduct and to the river below the dam, and in it may be installed machinery for generating power. It is 104 feet 6 inches long, 74 feet wide, outside dimensions, and the ridge of the roof is about 59 feet above the ground. A large part of the interior of the building is taken up by one large room, 74 feet 1 inch long by 64 feet wide, the ceiling of which is about 37 feet above the floor. In addition, there are 8 smaller rooms and a large storage room at the easterly end, which will be used for various purposes in connection with the operation of the works.

The exterior walls are of fine pointed granite obtained from the quarry of H. E. Fletcher & Co. at West Chelmsford, Mass.; the interior is finished with red face brick, and the roof is covered with Conosera Spanish roof tiles.

The contractor began to set up a derrick and build an office and storage sheds on May 2, the first stone was set on May 16 and the work on the contract was completed on December 22. The maximum force employed, including the men employed at the Chelmsford quarry, was during the week ending June 18, when 110 men and 7 horses were employed. Seventy-five of these men were employed at the quarry.

The contract price for the superstructure was $72,937.34.

The work under this contract has been performed in a conscientious and workmanlike manner, and the exterior stonework has been particularly well executed.

A Gurney heating plant has been installed, and the building wired for electric lights by employés of the Board.

South Dike.

Contract 275, John F. Magee & Co.

Date of contract, December 26, 1903; amount of contract, $139,411.04.

This contract called for soil stripping from about 87 acres of the site of the Wachusett Reservoir, and the construction of the South Dike, except the placing of the heavier riprap. Included in the work is the excavation of a cut-off trench, the refilling of this trench with compacted soil from the reservoir, the excavation of soil and earth from spoil banks and borrow pits, and the placing of soil and earth in the dike, also the placing of the two lighter grades of riprap. The South Dike was fully described in the last annual report.

Work was begun under this contract on January 5, in excavating from the cut-off trench, and on January 7 an additional force was put at work excavating sand and gravel from a borrow pit and hauling same to what formerly was Carville's ice pond, where 2.7 acres of deep muck were covered to a depth of about 1 foot. Work was continued through the winter, in excavating from the cut-off trench and from borrow pits, the material being used for covering the muck and for making the fill of the dike. The winter was an unusually severe one, the snowfall being considerable and the temperature lower than in most winters, making the work difficult. The contract for this work provided that on or before April 1, 1904, the contractor should substantially complete the whole cut-off trench, and should have 200 linear feet of the lowest portion of the trench in readiness for the treatment of the rock. The contractor did not succeed in finishing the 200 feet on the date specified, owing to the severe weather; but the treatment of the rock in the higher part of the trench was commenced on March 31, and this work will be described further on. The amount of material to be handled, and the limited time available for the work, made it necessary that over 45,000 cubic yards of material per month should be handled. This required the provision of a very considerable plant, which was as follows: —

4 locomotives (2 12-ton, 2 16-ton), made by the Vulcan Iron Works, Wilkesbarre, Pa.

1 steam shovel, dipper 2¼ yards capacity, made by John Souther & Co., Boston, Mass.

80 cars for hauling soil, 3½ cubic yards capacity, made by the Ryan & McDonald Manufacturing Company, Baltimore, Md.

40 cars for hauling gravel, 3 cubic yards capacity, made by the same company as the cars for the soil.

4¼ miles of track.

The contractor also provided 40 cars of 1½ cubic yards capacity, but these cars were not used. In addition, a large number of teams were used.

The principal quantities of work done were as follows: —

Grubbing (acres),	56
Soil excavation (cubic yards),	157,786
Earth excavation (cubic yards),	36,096
Earth excavation from borrow pits (cubic yards),	224,075
Rock excavation (cubic yards),	947
Riprap (cubic yards),	7,687
Paving (cubic yards),	29

The work on this contract was completed on December 8. The maximum force employed was 365 men and 94 horses, for the week ending June 18.

Treatment of Rock in Cut-off Trench.

As before stated, this work was begun on March 31, and was done largely by a day-labor force, though at times the contractor furnished a portion of the men. After the trench was excavated to rock by the contractor, all loose and broken rock was removed by means of bars and wedges. The surface of the rock was then carefully cleaned with brooms, and washed off, by means of a hose, with water under a considerable pressure, a pipe line 3,180 feet long having been laid and connected with the water system of the town of Clinton, to furnish the water. All seams were carefully cleaned out and filled with rich Portland cement mortar, or, if large, with stone laid in mortar. Rubble masonry was built under all overhanging rock which could not be removed with bars and wedges. The entire surface treated was then covered with a thick Portland cement grout, composed of equal parts of cement and fine sand, which was applied by a broom, the surface of the rock being first wet. The total length of cut-off trench treated in this way was 1,884 feet, and the area treated was 42,280 square feet. The bottom of the trench at the lowest point is 50 feet below full-reservoir level. The work was finished May 21.

The maximum force employed was 68 men, for the week ending April 30.

CLINTON SEWERAGE SETTLING BASINS.

Eight settling basins have been added to the Clinton sewerage system. These basins are located immediately south of the filter-beds, alongside and east of the 24-inch vitrified pipe main which conducts sewage to the filter-beds. Each basin has a capacity of about 237,000 gallons, is about 320 feet long, and has a width at the water line of about 33 feet, the basins being separated from each other by longitudinal banks of soil, which have side slopes of 1½ horizontal to 1 vertical. When the basins are in operation the sewage will have an average depth of about 4 feet below the overflow. The basins are built mostly above the original surface of the ground, the surface soil forming a bottom which allows but little water to pass through. Running under the longitudinal banks which separate the basins are 6-inch vitrified pipe underdrains, the bottoms of which are 2 feet below the bottoms of the basins. These underdrains are intended to intercept any water which may pass through the soil which forms the bottoms and sides of the basins, and convey it to some small filter-beds where it can be refiltered. These small filter-beds have an aggregate area of .83 acres, and the soil removed in preparing them, together with 6 inches of soil from the six beds of the existing system from which the soil was not removed when they were built, was used for constructing the banks which form the basins. Each basin has inlet and outlet structures built of Portland cement concrete, which contain gates for controlling the flow of sewage and for emptying the basins. The basins are so arranged that all or a part of the sewage can be passed through them, or all of it can be delivered as formerly directly to the filter-beds.

The principal quantities of work done were as follows: —

Earth excavation (cubic yards),	11,720
Portland cement concrete 1 : 2½ : 4½ (cubic yards),	148
24-inch vitrified pipe laid (linear feet),	317
18-inch vitrified pipe laid (linear feet),	319
8-inch vitrified pipe laid (linear feet),	1,212
6-inch vitrified pipe laid (linear feet),	2,308

The cost of this work, which was done by a day-labor force between September 1 and November 3, including engineering, was $7,242.13. The maximum force employed was 40 men and 16 horses, for the week ending October 1.

Relocation of Central Massachusetts Railroad.

No contract work has been done on the relocation of the Central Massachusetts Railroad during the year. A day-labor force has graded the approaches to and built an overgrade timber bridge across the railroad at a farm crossing on the Moran land near West Berlin. The ends of this bridge are supported on masonry abutments, and the timber bents on masonry piers built of Portland cement concrete. A day-labor force has also built two catch-basins, and laid 210 feet of 10-inch Akron pipe to provide drainage for the roadway at the undergrade highway crossing near West Berlin.

The maximum force employed was 34 men and 7 horses, during the week ending June 25.

Roads and Bridges.

When Boylston Street was constructed in a new location, in 1898, a temporary bridge was built over a portion of the Central Massachusetts Railroad, which has since been discontinued. This bridge was removed and a permanent embankment has been built in its place. About 3,100 cubic yards of earth were handled in making the embankment. A culvert, consisting of 120 linear feet of 24-inch cast-iron pipe, was built at this place.

Mortar Experiments.

Mention was made in the last annual report of experiments made 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, but only part of them had been broken at the time of the last report. All of these briquettes have now been broken, and the results obtained indicate that mortar to which salt has been added in the proportions mentioned is about 20 per cent. stronger than when salt has not been used.

Cement Tests.

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

WESTON AQUEDUCT DEPARTMENT.

(Horace Ropes, Department Engineer to May 25, when the department was abolished, and the work remaining to be done was placed in charge of Dexter Brackett, Engineer of the Sudbury and Distribution Departments.)

At the end of the year 1903 the Weston Aqueduct and Reservoir were so nearly finished that they had been placed in service. The only contract work remaining to be done was at the Weston Reservoir, where the work was chiefly the spreading of loam over the surfaces of embankments and the completion of the screen-chamber. Along a large part of the aqueduct and around the reservoir there remained the final grading and seeding of embankments, the building of fences and the setting of stone bounds. All of this work has been completed during the year.

The engineering force engaged upon the work numbered 36 at the beginning of the year and 1 at the end of the year. In the early part of the year the force was employed in the preparation of final estimates of the work done under contracts and upon record plans. The principal engineers completed their work as follows: Marshall Nevers, division engineer, April 2; Dan B. Clark, division engineer, April 16; George W. Booth, division engineer, August 9; Walter W. Patch, assistant engineer in charge of records, drafting and computing at the Saxonville office, June 30. George A. Winsor, assistant engineer, has continued on the work throughout the year.

The branch office at Wayland was discontinued on February 29, the Saxonville office on June 30, and the Weston office on July 16.

Contracts.

Nawn & Brock, contractors for Section 14 of the Weston Aqueduct (open channel) and sections 1 and 2 of the Weston Reservoir, resumed the work of grading the embankments near the channel and reservoir on April 9, and completed all the work under their contracts on May 20. It was not feasible, on account of the cold weather in December, 1903, to remove the earth from the surfaces of the rock in the reservoir as thoroughly as was desired, and early in April the water in the reservoir was drawn down about 9 feet, and all rock surfaces to a depth of not less than 6 feet below the full-reservoir level were thoroughly cleaned.

The principal quantities of work performed under these contracts were as follows: —

Clearing and grubbing (acres),	37
Earth excavation (cubic yards),	629,890
Rock excavation (cubic yards),	8,252
Riprap (cubic yards),	3,235
Slope paving (cubic yards),	1,171
Portland cement concrete masonry (cubic yards),	3,537
Ashlar masonry (cubic yards),	46
Dimension stone masonry (cubic yards),	39

The total value of the work done, as shown by the final estimates, was $247,198.07.

The Woodbury & Leighton Company, contractors for the channel and screen-chambers, resumed work on the screen-chamber, and completed it on April 8. The amount of their contract was $12,484.75.

Additional Work on Aqueduct and Reservoir.

Early in the spring the work of building fences, setting stone bounds, grading and seeding the aqueduct embankments and the grounds around the reservoir was resumed, and continued until the latter part of October, when the work was finished. This work was done by day-labor forces, under the direction of Mr. Winsor and the superintendents of the Sudbury and Distribution Departments. It included the building of 86,543 feet of fences, the grading and seeding of 86 acres of land, the setting of about 600 stone bounds, the surfacing of a driveway 1,600 feet long from Newton Street to the screen-chamber at the Weston Reservoir, the excavation of 2,100 linear feet of drainage ditches, the laying of 230 feet of 10-inch Akron pipe at the reservoir, and the construction of a paved channel 735 feet long near the westerly portal of tunnel No. 2, for the purpose of preventing the washing of the slopes by surface water.

Gages for indicating the elevation of the water have been placed in the channel and screen-chambers at the Weston Reservoir, and in the terminal chamber of the aqueduct. Recording gages, one showing the elevation of the water in the aqueduct and one the depth of water on the measuring weir, have been placed in the head chamber near the Sudbury Dam.

Large gates provided with hoisting apparatus have been set in the siphon chambers, and stop-planks have been made for use at other chambers.

Quantity and Cost of Work done in constructing Aqueduct, Reservoir and Supply Pipe Line.

The following tables show the quantities and the cost of the work done in the construction of the aqueduct, reservoir and supply pipe line. It is a summary of the contract work, made from the final estimates, and does not include the work done by the contractors as extra work, or the engineering or the preliminary and additional work done by day-labor forces.

Quantities and Cost of Work done in the Construction of the Weston Aqueduct.

Class of Work.	Quantity.	Cost.	Cost per Unit.
Earth excavation (cubic yards),	659,231	$232,588	$0 35
Borrowed earth (cubic yards),	321,245	79,126	0 24
Overhaul (cubic yards),	380,813	4,396	0 01
Rock excavation (cubic yards),	46,735	76,735	1 64
Tunnel excavation (cubic yards),	66,201	391,162	5 91
Dry filling over arch in tunnel (linear feet),	11,838	9,819	0 83
Tunnel drainage (linear feet),	12,165	3,485	0 29
Brick masonry not in tunnel (cubic yards),	14,210	160,379	11 29
Brick masonry in tunnel (cubic yards),	76	912	12 00
Natural cement concrete masonry not in tunnel (cubic yards),	72,193	286,650	3 97
Portland cement concrete masonry not in tunnel (cubic yards),	57,883	314,120	5 43
Portland cement concrete masonry in tunnel (cubic yards),	22,451	134,575	5 99
Dimension stone masonry (cubic yards),	375	13,805	36 81
Ashlar masonry (cubic yards),	81	1,777	21 94
Face dressing of pointed work (square feet),	7,560	3,599	0 48
Face dressing of six-cut work (square feet),	162	113	0 70
Dry rubble stone masonry and paving (cubic yards),	1,077	3,309	3 07
Riprap (cubic yards),	1,065	2,488	2 34
Lumber (feet B. M.),	107	3,216	30 05
Furnishing and laying 7.5-foot steel pipe (linear feet),	4,756	101,305	21 30
60-inch Venturi meters,	2	7,200	3,600 00
Superstructures,	11	70,384	-
Iron and steel work, including 60-inch and 48-inch pipes between Sudbury Dam and head-house, pipes for culverts, castings for siphon chambers, blow-off pipes for siphons, valves and steel and iron work for connections and chambers, including, generally, the cost of hauling and laying or placing same,	-	70,000	-

Quantities and Cost of Work done in the Construction of the Weston Reservoir, including the Open Channel.

Class of Work.	Quantity.	Cost.	Cost per Unit.
Clearing and grubbing (acres), ...	37	$3,749	$101 32
Earth excavation (cubic yards), ...	641,235	198,155	0 31
Earth excavation for drain (cubic yards), ...	5,369	4,295	0 80
Rock excavation (cubic yards), ...	5,892	8,124	1 38
Rock excavation for drain and core wall (cubic yards), ...	2,360	5,900	2 50
Cleaning surface of rock (square yards), ...	5,162	516	0 10
Portland cement concrete masonry (cubic yards), ...	3,537	18,345	5 19
Dimension stone masonry (cubic yards), ...	39	1,194	30 60
Ashlar masonry (cubic yards), ...	46	830	18 05
Face dressing of pointed work (square feet), ...	1,036	425	0 41
Slope paving (cubic yards), ...	1,171	4,684	4 00
Riprap (cubic yards), ...	3,235	3,235	1 00
Furnishing and laying 18-inch and 20-inch vitrified pipe (linear feet), .	296	740	2 50

Quantities and Cost of Work done upon the Supply Pipe Lines from the Weston Aqueduct to Main Pipes near Chestnut Hill Reservoir.

Class of Work.	Quantity.	Cost.	Cost per Unit.
60-inch cast-iron pipe from terminal chamber, Weston Aqueduct, to west bank of Charles River (linear feet), ...	1,603	$32,643	$20 36
3 lines 60-inch cast-iron pipe under Charles River, laid in coffer-dam and covered with concrete, each line 345 feet long, equivalent to (linear feet), ...	1,035	43,252	41 79
48-inch cast-iron pipe, Charles River to Chestnut Hill Reservoir, including cost of resurfacing roadways and changing drains and water pipes by city of Newton (linear feet), ...	36,806	436,617	11 86
Driveway from Loring Street to terminal chamber (linear feet), . .	1,720	2,098	1 22
Cost of removing rock, and incidentally of removing earth, so that a second pipe could be laid beside the 48-inch cast-iron pipe without blasting, ...	-	11,679	-
Total, ...	-	$526,289	-

At the end of the year the Weston Aqueduct and Reservoir had not only been wholly completed, but settlements had been made for contracts, land damages and claims to such an extent that it is feasible to estimate with substantial accuracy that the final cost of the aqueduct, exclusive of the reservoir, will be $2,516,000, equal to $198,000 per mile, and of the reservoir $344,000, making a total of $2,860,000. The total cost of the supply pipe line from the terminal chamber to a point near Chestnut Hill Reservoir will be substantially $600,000.

The State Board of Health, in its report upon a Metropolitan Water Supply, estimated the cost of the Weston Aqueduct at $3,226,000. This, however, was for an aqueduct having a capacity of 250,000,000 gallons per day, as against a capacity of 300,000,000 gallons per day for the aqueduct actually built, and did not include a reservoir in Weston, which it was thought would not be necessary in the beginning, and might be built at a subsequent date. The only feature included in the State Board of Health estimate and omitted in the construction was one of the two siphon pipes, which will not be required for at least fifteen years.

Taking the works as constructed, without making any allowances, the actual cost has been $366,000 less than the original estimate; and, if an allowance is made for the reservoir which was constructed but not estimated, and for the siphon pipe which was estimated but not constructed, the difference between the actual and estimated cost of the whole work would be $580,000. A further allowance should be made because the aqueduct actually built has one-fifth more capacity than that estimated, but the amount of such an allowance cannot be readily determined.

The cost per running foot or otherwise of different portions of the aqueduct and of the reservoir have been determined, with the following results, which include the cost of construction, engineering and land, the expenses of administration, and all other cost except interest during construction: —

Where the aqueduct is a tunnel, lined with concrete masonry, the cost for the portion which has a width of 10 feet was $39 per foot, equal to $207,000 per mile.

For similar tunnels, which have a width of 13 feet 2 inches, the cost was $69 per foot, equal to $364,000 per mile.

Where the aqueduct was built of masonry in a trench, and covered with earth, the cost for the portion which has a width of 10 feet was $23 per foot, equal to $120,000 per mile.

Where it has a width of 13 feet 2 inches, the cost was $32 per foot, equal to $171,000 per mile.

The two siphons, consisting of one pipe each, with the four siphon chambers, which were built for three pipes each, cover a total length of 4,841 feet, and the cost was $45 per foot, equal to $237,000 per mile.

The single line of siphon pipe, exclusive of the siphon chambers, covers a total length of 4,726 feet, and the cost with all appurtenances was $36 per foot, equal to $191,000 per mile.

The open channel, 1,366 feet long, which was excavated where the average depth of cutting was 19½ feet, exclusive of the structures at its ends, cost $34 per foot, and exclusive of land damages $25 per foot.

The Weston Reservoir, which cost $344,000, including the screen-chamber at its lower end, serves as a substitute for 4,000 feet of aqueduct, and its cost was $86 per linear foot. As a reservoir its available capacity is about 200,000,000 gallons, making the cost per million gallons $1,720.

DISTRIBUTION DEPARTMENT.

Dexter Brackett, *Department Engineer.*

A considerable part of the time of the department engineer and his assistants has been spent upon the preparation of plans, statistics and estimates in connection with the suit brought by the cities of Malden, Medford and Melrose for damages on account of the taking of Spot Pond. A considerable part of the time of the assistants has also been taken up in making record plans of work done in previous years. There has been no actual work chargeable to construction, except the placing of a Venturi meter.

OFFICE FORCE.

Frank T. Daniels, *Principal Office Assistant;* Samuel E. Killam, *Office Assistant.*

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

For the Wachusett Reservoir, working drawings were made for the Malden Brook culvert and for the false works for the West Boylston arch.

For the Wachusett Dam there have been made general plans and details of the bastion and abutment at the ends of the dam, of the upper gate-chamber, of the highway bridge over the lower end of the waste channel, of several retaining walls, of flights of steps leading from the bottom of the valley up the hillsides to the ends of the dam, plans for grading and drainage about the dam, details of

SCREEN CHAMBER AT OUTLET OF WESTON RESERVOIR.

steel trestles for a foot bridge along the waste-weir, of steelwork for the bastion and upper and lower gate-chambers, of wooden gates and of bronze stop-plank grooves. A direct steam heating plant for the lower gate-chamber was designed, and the necessary drawings for its installation were furnished.

In connection with the relocation of the Central Massachusetts Railroad, detailed drawings were made for a masonry skew-arch railroad bridge over the upper end of the waste channel. The general design for this bridge and for the highway bridge over the waste channel were furnished by Olmsted Brothers, landscape architects. A set of 12 plans, showing in detail the relocated portions of the railroad and tracings of the same, were completed, together with a profile, and sent to the Boston & Maine Railroad.

Other drawings made included drawings for the screening apparatus at the head chamber of the Weston Aqueduct, and a drawing for the extension of the Clinton sewerage works.

The whole number of finished drawings completed during the year is 123. Besides these, various studies and minor drawings were made and a few drawings were changed to adapt them to serve as record plans.

The force employed in the drafting department numbered 7.

Samuel E. Killam has had charge of the general office, where the work is of a varied character, such as making miscellaneous investigations and computations, procuring supplies and making blue prints. Mr. Killam has also had general charge of the photographic work.

Accidents.

Five fatal accidents have occurred during the year, three at the Wachusett Dam, one upon the railroad from the quarry to the dam, and one upon the Wachusett Reservoir.

The first four accidents occurred in connection with the work of the McArthur Brothers Company. At the dam a masonry inspector had the bone of his thigh broken by being caught between a stone which was being raised and the masonry of the dam, and as a result of his injuries died thirteen weeks later; a masonry foreman was killed by the falling of the boom of a derrick; and a laborer by the falling of a large stone which slipped from the grab-hooks. A blacksmith was killed by a collision on the quarry railroad. On Section 8 of the Wachusett Reservoir a laborer was killed by falling under a train on the contractor's railroad.

MAINTENANCE.

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

The Wachusett Reservoir has been filled during the year to a greater extent than heretofore, and therefore is to a larger extent in the charge of a maintenance force; otherwise the works maintained and operated in 1904 are the same as at the end of the preceding year.

Organization of Maintenance Force.

There has been an important change in the organization of the maintenance force during the year, as already indicated briefly in the beginning of my report. The Sudbury and Cochituate works, which, after the resignation of Desmond FitzGerald, had no department engineer in charge, were on March 10 placed under the charge of Dexter Brackett, who was also at that time given the charge of the maintenance of the Weston Aqueduct.

Charles E. Haberstroh, assistant superintendent of the Sudbury Department, has charge of the maintenance and operation of the works on the Sudbury River and Lake Cochituate, the Cochituate and Sudbury aqueducts and the Weston Aqueduct, from the Sudbury Dam to the Weston Reservoir.

George E. Wilde, assistant superintendent of the Distribution Department, has charge of the maintenance and operation of the Weston Reservoir, of that portion of the Weston Aqueduct between the reservoir and the terminal chamber in Weston, and of all the reservoirs and pipe lines within the Metropolitan District.

John W. Lynch, engineer of the 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 pumping stations of the Distribution Department.

William E. Foss, division engineer, has had special charge of investigations relative to injury of water pipes by electrolytic action.

Caleb M. Saville, division engineer, has continued in charge of the operation of Venturi meters in the Metropolitan District.

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.

The force employed on maintenance, including the permanent force, the additional temporary forces engaged from time to time on special work, and such of the engineers as devoted most of their time to maintenance, averaged 220. The maximum number employed at any one time was 291.

Rainfall and Yield.

The total rainfall for the year on the Sudbury watershed has been 3.4 inches below the average, the deficiency occurring wholly in the last three months. The yield of the watersheds has been somewhat below the average, but the deficiency occurred at such times that there was no unusual lowering of the reservoirs. Statistics relating to rainfall and yield of watersheds may be found in Appendix No. 3, tables Nos. 1 to 11.

Storage Reservoirs.

The quantity of water stored in all of the storage reservoirs on January 1, 1904, was 13,136,900,000 gallons. On account of the extremely cold weather during the months of January and February the flow of the streams was small, and there was a constant lowering of the reservoirs until February 22, when they reached the lowest point, and contained 10,550,000,000 gallons.

During March the reservoirs filled rapidly, and early in April were as full as it was desirable to hold them until the freshet season was over; subsequently they were filled gradually, reaching the maximum storage of a little more than 26,000,000,000 gallons on June 8.

Until the middle of September there was an almost continual loss of storage, when the heavy rainfall on September 14 and 15 caused a gain of 1,100,000,000 gallons in a period of three days, after which the quantity stored again diminished continuously until December 27. During the last few days of the year there was a slight gain, and at the end of the year the quantity stored was 15,638,100,000 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).
1904.				
January 1,	1,760,100,000	5,226,600,000	6,150,200,000	13,136,900,000
February 1,	1,374,600,000	4,626,600,000	5,811,800,000	11,813,000,000
March 1,	1,098,500,000	5,195,100,000	5,472,000,000	11,765,600,000
April 1,	8,385,000,000	7,666,900,000	6,898,100,000	22,950,000,000
May 1,	9,863,100,000	8,112,800,000	7,460,500,000	25,436,400,000
June 1,	10,107,500,000	8,380,400,000	7,525,600,000	26,013,500,000
July 1,	9,401,900,000	8,200,900,000	7,540,200,000	25,143,000,000
August 1,	7,885,800,000	8,218,900,000	7,234,900,000	23,339,600,000
September 1,	6,807,300,000	7,951,700,000	6,503,700,000	21,262,700,000
October 1,	6,869,400,000	7,725,500,000	5,975,700,000	20,570,600,000
November 1,	7,192,800,000	6,659,600,000	5,320,000,000	19,172,400,000
December 1,	6,951,500,000	6,419,100,000	4,310,700,000	17,681,300,000
1905.				
January 1,	4,409,600,000	7,912,500,000	3,316,000,000	15,638,100,000

Wachusett Reservoir. — At the beginning of the year work on the Wachusett Reservoir was so far advanced that it was possible to store water to elevation 331.50, which is 47.50 feet above the bottom of the 48-inch cast-iron pipes through the dam. The dam itself was enough higher to permit the water to be safely raised to this height. It was raised nearly to the full height early in April and to the full height in the middle of May, where it was maintained until June 11. When at elevation 331.50 the reservoir contained 10,117,000,000 gallons of water. Most of the time after June 11 water was drawn from this reservoir in sufficient quantities to keep the Sudbury Reservoir nearly full, but for about a month, beginning October 20, the flow was stopped, to permit the Sudbury Reservoir to be drawn down.

At the end of the year the water was 33 feet above the bottom of the 48-inch pipes, and the reservoir contained 4,409,600,000 gallons of water. Between April 26 and 29 there was a rainfall of over 4 inches, which raised the water in the reservoir temporarily to elevation 331.89. At this time the gates which control the flow of water through the four 48-inch pipes which pass through the dam were fully opened, and the water flowed through at the rate of 1,231,000,000 gallons per 24 hours. Water was wasted into the river below the dam, because of lack of storage capacity, on 43 days between April 9 and June 11, the total amount of waste being about 8,600,000,000 gallons.

Sudbury Reservoir. — At the beginning of the year the water of this reservoir was at elevation 252.63, which is 6.37 feet below the stone crest of the dam. The lowest level during the year was reached on January 28, when the water stood at elevation 249.82. During February and March the reservoir was filling, and on April 4 the water reached the level of the crest of the dam. The reservoir was kept substantially full from that time until October 1. During October and November the water was lowered about 6 feet, in order to facilitate the laying of a water pipe across the reservoir at the Burnett estate in Southborough. On the completion of this work the reservoir was again filled, and on January 1, 1905, the water stood .18 of a foot above the stone crest of the dam.

The driveway from the highway to the Sudbury Dam, which had been badly worn by heavy teaming during the construction of the Weston Aqueduct, has been thoroughly repaired. A wooden building, 58 feet by 22 feet, arranged for a workshop and for the storage of tools and vehicles, has been added to the group of buildings near the Sudbury Dam. The house, barn and shed at the dam, and the house on the Bigelow place, have been painted.

A swampy area on the west side of Maple Street in Marlborough was, at the request of the city authorities of Marlborough, filled to about 12 inches above the ordinary water level. For this purpose 221 cubic yards of material were purchased, and the balance required was obtained by cutting down the higher ground to about the level of the filled area.

The *Marlborough Brook filter-beds* have been in service throughout the year, and have filtered all of the water received from the brook except for parts of six days during freshets. The beds were cleaned during the year, and the dirty sand, including sand from two previous years' cleaning of the artificial beds which had been left at the sides of these beds, was removed to a spoil bank. A layer of clean sand 2½ inches thick was spread on the surface of beds Nos. 1 and 2 and on one-half of bed No. 5. The settling reservoir was also emptied and cleaned.

The analyses which have been made monthly by the State Board of Health of the water before and after passing through the filter-beds show that the water has been generally satisfactorily purified by the filters.

Additional storage for water discharged by the brook during freshets has been provided by the enlargement of storage basin No. 18, increasing its capacity from 2,600,000 gallons to 9,000,000 gallons. The embankments surrounding the basin, 3 feet wide on top, with slopes of 3 horizontal to 1 vertical, were constructed of material excavated from the interior of the basin, and the inner slopes protected with stones taken from the excavation. About 3,300 cubic yards of material were moved in doing this work. The basin is connected by means of a 12-inch cast-iron pipe 210 feet long with the artificial filter-beds Nos. 12 and 17, so that about 8,500,000 gallons can be drawn from the basin to filter-beds Nos. 5, 6, 11, 12, 15 and 17.

The combined storage reservoir and filter-bed for taking care of the overflow from the Marlborough Brook main sewer during times of freshet has taken care of all the overflow during the year. For the greater portion of the time from February 22 until May 7 there was a flow from the sewer to the bed, although for a portion of this time the flow was due to the entrance of ground water into the overflow sewer. After May 7 there was a very small flow of ground water for some time. The largest quantity of diluted sewage stored was on April 30, when it reached elevation 270, which is 3.25 feet below the overflow into an additional storage area.

As the sewage flowing in the open channel from the end of the overflow sewer to the filter-bed gave some offence to the people residing in the house on the opposite side of Farm Road, an 18-inch Akron pipe 212 feet long was substituted for the open channel. A channel was also dug from that part of the bed into which the sewage first enters to the lower bed, so that the upper bed can be drained when desired. An 8-inch tile drain, 385 feet long, was built on the east side of Farm Road, near the toe of the filter-bed embankment, to carry away the water which percolates through the embankment, and the travelled portion of the road was raised about 1 foot for a distance of 300 feet.

Framingham Reservoir No. 3. — This reservoir was kept at or near high-water mark during the whole year.

Framingham Reservoir No. 2. — This reservoir was kept practically full throughout the year. No water was drawn from it for the supply of the Metropolitan District until August 30, but after that date a portion of the supply was drawn from this source almost continually until the end of the year. While water was being drawn from the reservoir the surface was kept near high-water mark by drawing water from the Ashland, Hopkinton and Whitehall reservoirs. On several days between September 14 and 21 water was drawn from the reservoir and discharged into Lake Cochituate.

Framingham Reservoir No. 1. — This reservoir was kept full and water was wasted over the dam from the beginning of the year until September 1. From September 14 to 18, inclusive, and September 21 to 23, inclusive, and on November 29 and 30, water was drawn from the reservoir and discharged into Lake Cochituate.

Repairs have been made to the paving in the channel of the Sudbury River below Framingham Dam No. 1, which had been displaced by the action of the water during freshets. The paving from the dam to a point below the Winter Street bridge has been relaid, and the interstices between the stones filled with fine Portland cement concrete. Below the bridge the paving was not relaid, but concrete was placed between and on the stones, making the bottom of the channel smooth. A large hole in the bed of the river, just below the paving, was partially filled with gravel excavated near by. At the upper end of the reservoir the water overflowing at the dam of Framingham Reservoir No. 3 had gradually excavated a hole which threatened to undermine the original 48-inch pipe-line leading from Framingham Reservoir No. 3 to the dam of Reservoir No. 1. The hole has been partially filled with gravel, and the surface covered with riprap to protect it against washing in the future. There were 1,016 feet of wire fence built on the property line between the land of the Commonwealth and land of Adnah Neyhart.

Ashland Reservoir. — At the beginning of the year the water in this reservoir was 4.33 feet below high water. Early in April the water reached the level of the overflow, and the reservoir remained substantially full until the last of August. During September, October, November and December water was drawn from the reservoir, and on December 27 its surface had been lowered to 192.73, or 32.48 feet below high water. At the end of the year it was 31.34 feet below high water. The joints between the coping stones of the side-walls of the wasteway at the dam have been cut out and re-pointed.

Hopkinton Reservoir. — This reservoir was 5.16 feet below high water at the beginning of the year. It was full on May 1, and remained practically full until the first week in September. During the last four months of the year water was drawn from this reservoir, and on December 27 the surface was 32.6 feet below high water. About one-third of the water drawn from the reservoir was filtered. The filter-beds were cleaned in June.

Whitehall Reservoir. — This reservoir has been kept practically full, and was not drawn upon until December 16. From that date until the end of the year 20,000,000 gallons per day were drawn, lowering its surface about 1 foot; and on January 1, 1905, it stood at elevation 336.74, or 1.17 feet below high water.

Farm Pond. — Farm Pond was practically full during the first half of the year, but was then gradually drawn down until the middle of September, when it was 1.25 feet below high water. It was then partially refilled with water drawn from Framingham Reservoirs Nos. 1 and 2. No water was drawn from the pond during the year for the use of the Metropolitan District, and it was not necessary to waste any into the Sudbury River.

Lake Cochituate. — Lake Cochituate at the beginning of the year was 1.94 feet below high water. It fell during January and February, and was 4.56 feet below high water on February 22. It was filled by May 6, and was kept practically full until July 26. The surface then fell steadily until September 14, when the surface was 3.85 feet below high water. Water was then turned into the lake from Framingham Reservoirs Nos. 1 and 2, raising its surface on October 10 to within about 1 foot of high water. The lowest point reached during the year was 5.12 feet below high water, on December 17. Water was wasted at the outlet dam in varying quantities during March, April, May and June. Water was drawn from the lake for the supply of the Metropolitan District from January 1 to April 3, April 6 to 9, April 11 to 17, April 18 to 25, May 3 to 7, July 3 to 7, July 26 to August 2, and August 6 to December 19.

All of the joints in the exterior stonework of the aqueduct gate-house were cut out and repointed, and two cornice stones which were damaged by fire several years ago were replaced by new stones. A damaged composition stem of one of the aqueduct gates was replaced by a steel stem furnished by the Coffin Valve Company. The foreman's house was painted two coats, and a trussed wire fence 592 feet long was built along the road near the house.

No water was drawn from Dudley Pond into Lake Cochituate. At the beginning of the year the pond was 3.41 feet below high-water mark. The highest elevation was 155.11, or 1.35 feet below high water, and the elevation at the end of the year was 153.12.

The surface of Dug Pond has varied between 1.5 feet above and 3 feet below the invert of the 18-inch overflow pipe.

The Pegan Brook filter-beds have been in use throughout the year whenever there was water to filter. Water was pumped to the beds during 183 days from the reservoir on Pegan Brook or from the new reservoir at the end of the intercepting ditch which collects water from the brooks formerly draining into Pegan Brook meadow. The total quantity of water pumped during the year was 223,402,500 gallons, of which 150,650,500 gallons was from Pegan Brook and 72,752,000 gallons from the intercepting ditch. The total quantity of coal consumed was 113,941 pounds, so that 1,961 gallons of water were pumped per pound of coal. The cost of operating the pumping station and caring for the filter-beds and grounds was $3,088.16, making the cost per million gallons pumped $13.82.

Sources from which Water has been taken.

An average of 88,554,000 gallons per day was drawn from the Wachusett Reservoir through the Wachusett Aqueduct into the Sudbury Reservoir. An average of 30,575,000 gallons per day was drawn from the Sudbury Reservoir through the Weston Aqueduct into the distribution system of the Metropolitan District. From Framingham Reservoir No. 3 an average of 64,827,000 gallons per day, and from Framingham Reservoir No. 2 an average of 9,004,000 gallons per day, was drawn through the Sudbury Aqueduct to Chestnut Hill Reservoir. An average of 14,984,000 gallons per day was drawn from Lake Cochituate through the Cochituate Aqueduct to Chestnut Hill Reservoir. The Spot Pond drainage area furnished 497,000 gallons per day.

Aqueducts.

The *Wachusett Aqueduct* has been in use 283 days during the year. It was very thoroughly cleaned between November 16 and 22. The work of repairing the transverse cracks in the aqueduct, due to temperature changes, was in progress at the beginning of the year, and was fully described in the last annual report. This work was carried on continuously until January 26, when it was finished. A force of about 26 men, consisting principally of masons who had been engaged during the warmer weather on the construction of the Wachusett Dam, was employed. 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 emptied for cleaning on May 5 and 6, and again on May 12 and 13. On June 23 it was emptied for the purpose of examining the Waban Bridge, and from September 14 to 18, from September 21 to 23, from October 2 to 9, and from October 23 to 30, it was emptied for the purpose of making repairs to and lining the aqueduct on the Waban Bridge. At times while the aqueduct was emptied for cleaning and for making repairs at the Waban Bridge, and also on November 29 and 30, water was run from Framingham Reservoirs, Nos. 1, 2 and 3 through the aqueduct to Lake Cochituate. The total amount diverted to the lake was 1,157,200,000 gallons, of which 963,200,000 gallons was drawn from Framingham Reservoir No. 1, 118,300,000 gallons from Framingham Reservoir No. 2, and 75,700,000 gallons from Framingham Reservoir No. 3. The daily average flow through the aqueduct to Chestnut Hill Reservoir for the year was 73,831,000 gallons, which is 24,190,000 gallons less than the corresponding quantity for the preceding year.

The leakage from the aqueduct at the Waban Bridge, due to cracks in the masonry, had increased during the past few years to such an extent as to cause a large loss of water, as well as to injure the masonry of the bridge by freezing during the winter. Upon examination, the principal cracks were found to be in the invert two feet from the centre of the aqueduct. They were sometimes on only one side of the centre, but generally on both, and were directly over the joints between stones which cover drainage galleries beneath the aqueduct. As there were few if any cracks above the springing line of the upper arch up to the highest point reached by the water when the aqueduct is in use, the repairs which were made extended only from the bottom up to the springing line. This portion of the aqueduct for the entire length of the bridge, a distance of 562.25 feet, was lined with sheet lead weighing 3½ pounds per square foot, covered on the bottom with a protective layer of Portland cement concrete $1\frac{1}{2}$ inches thick. The lead is held in place at the springing line by $2\frac{1}{2}$ by $2\frac{1}{2}$ inch angle irons, secured by $\frac{9}{16}$ inch diameter yellow metal bolts set in the masonry. Rubber tubing was placed back of the angle irons between the sheet lead and the masonry, to act as a washer to prevent leakage. The sheets of lead 9 by 14 feet were connected by the process of lead burning so as to form a continuous sheet. The layer of Portland cement concrete $1\frac{1}{2}$ inches thick was composed of fine material, in which was embedded expanded metal. Before the aqueduct was lined all cracks were pointed or grouted, and two coats of Portland cement wash were applied to the arch. All cracks in the aqueduct for 50 feet from both ends of the lining were cut out and pointed. The work has resulted in reducing the leakage to a very small quantity, which it is thought will cause no damage.

While the work at the Waban Bridge was in progress, all the cracks in the interior masonry at the Echo Bridge over the Charles River were cut out and pointed.

In September changes were made in the Beaver Dam Brook culvert, for the purpose of increasing its capacity. The work done consisted in the removal of portions of the masonry so as to enlarge the channels at the entrance and outlet, and in rounding the corners of other portions of the masonry so as to reduce losses of head. As the culvert is below the level of the water in the brook, it was necessary to operate a centrifugal pump while the work was in progress, to take care of the water.

The joints in the masonry of 14 culverts between Waban Bridge and the west siphon chamber have been cut out and repointed. The iron gratings and beams in the siphon and waste-weir chambers, and the manhole covers, have been given two coats of paint, and the iron and wooden fences at both the Echo and Waban bridges have been given one coat. There were 1,575 feet of board fence built near the Course Brook waste-weir, and 250 feet at Harrison Street in Newton Highlands; 440 feet of trussed wire fence were built in South Framingham, and posts set for 1,400 feet just east of Speen Street near the Course Brook waste-weir.

An apparatus for rating current meters has been established at the side of the aqueduct embankment near the Farm Pond gate-house.

During the year the city of Newton built a 48 by 53 inch brick sewer under the aqueduct, about 500 feet east of Woodward Street. The invert of the sewer was 27 feet below the invert of the aqueduct, and the material underlying the aqueduct was very fine sand. In order to avoid any injury to the aqueduct, compressed air was used in excavating a tunnel under the aqueduct in which to build the sewer, and the work was successfully accomplished.

The *Cochituate Aqueduct* was in use 259 days. The interior of the aqueduct, with the exception of the siphon pipes, was cleaned on April 28 to 30. The surveys for locating the aqueduct and determining the position of property bounds have been continued, and 51 alignment bounds and 52 property bounds have been set.

The *Weston Aqueduct* was in use 320 days. The flow was shut off for about three weeks in April, in order to give opportunity for completing the Weston Reservoir. At this time several cracks in the aqueduct masonry on sections 10 and 15 were cut out and pointed, and the brick masonry on Section 15 was given a coat of cement wash. From June 16 to 20 the aqueduct was shut off while the concrete bottom and sidewalls of the terminal chamber were plastered for the purpose of preventing leakage. During the last two weeks of the year the aqueduct was emptied for the purpose of cutting out and pointing the fine transverse cracks in the concrete masonry, caused by temperature changes. A force of 30 masons and 10 laborers was engaged on this work, which will be continued for a month or more during the coming year. The methods employed for this work are the same as for similar work at the Wachusett Aqueduct, described on page 151 of the last annual report.

Pumping Stations.

Seventy-four per cent. of all the water supplied to the Metropolitan Water District has been pumped at the two stations at Chestnut Hill Reservoir; the remainder was delivered by gravity.

The total quantity pumped at all of the stations during the year was 34,962,090,000 gallons, or 6,854,110,000 gallons less than during the preceding year. The cost of operating the stations was $91,411.63, equivalent to $2.615 per million gallons pumped. Although the average height to which the water was pumped in 1904 was 86.87 feet, as against 68.50 feet in 1903, there has been a decrease in the cost per million gallons pumped of $0.195, due to a reduction in the cost of repairs and fuel.

The cost per gross ton of fuel used at the Chestnut Hill high-service station was $1.41 less, at the Chestnut Hill low-service station $1.43 less, and at the Spot Pond station $0.92 less, than during the preceding year. This reduction was due both to the reduced price of coal and to the use of a larger proportion of anthracite buckwheat coal and screenings.

Notwithstanding the use of a larger proportion of the cheaper grades of fuel, the duty developed by the engines at the Chestnut Hill and Spot Pond stations was between 3 and 4 per cent. greater than during the preceding year.

Tests have been made to determine the viscosity, specific gravity and burning point of all oil, and the calorific value of all coal used at the several stations.

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.	
Bay State Fuel Company, bituminous, .	37.17	56.01	–	–	–	$5 36
Dartmouth Coal Company, bituminous,	30.87	–	–	–	–	4 79
Dartmouth Coal Company, bituminous,	–	181.90	–	–	–	4 56
Henry T. Woods, bituminous, . .	671.56	–	–	–	–	4 49
Henry T. Woods, bituminous, . .	–	820.07	–	–	–	4 46
Darrow-Mann Company, bituminous, .	919.93	720.36	–	–	–	4 35
Murrell Coal Company, bituminous, .	332.31	–	–	–	–	4 18
Dartmouth Coal Company, bituminous,	1,031.25	521.11	–	–	–	4 15
Darrow-Mann Company, bituminous, .	–	106.42	–	–	–	4 02
Dartmouth Coal Company, bituminous,	–	102.39	–	–	–	3 98
E. B. Townsend, buckwheat anthracite,	493.08	–	–	–	–	3 28
E. B. Townsend, buckwheat anthracite,	–	998.87	–	–	–	3 08
E. B. Townsend, screenings, . . .	–	10.15	–	–	–	3 67
E. B. Townsend, screenings, . . .	20.54	–	–	–	–	3 44
E. B. Townsend, screenings, . . .	–	77.30	–	–	–	3 18
Gillespie & Pierce, screenings, . .	161.63	2.49	–	–	–	2 24
Bay State Fuel Company, screenings, .	479.50	–	–	–	–	2 24
Locke Coal Company, bituminous, .	–	–	700.00	–	–	4 40
Locke Coal Company, screenings, . .	–	–	414.68	–	–	2 24
D. J. Cutter & Co., anthracite, . .	–	–	–	285.58	–	$7 28 and 7 56
Peirce & Winn Company, bituminous, .	–	–	–	–	346.30	4 48 to 5 04
Wellington-Wild Coal Company, bituminous.	–	–	–	–	22.43	4 76
Peirce & Winn Company, screenings, .	–	–	–	–	151.64	2 24
Total gross tons, bituminous, . .	3,023.09	2,508.26	700.00	–	368.73	–
Total gross tons, anthracite, . .	493.08*	998.87*	–	285.58	–	–
Total gross tons, anthracite screenings.	661.67	89.94	414.68	–	151.64	–
Average price per gross ton, bituminous.	$4 31	$4 35	$4 40	–	$4 68	–
Average price per gross ton, anthracite.	3 28*	3 08*	–	$7 36	–	–
Average price per gross ton, anthracite screenings.	2 28	3 21	2 24	–	2 24	–

* Buckwheat.

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: —

	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 4.	Totals for Station.
Total quantity pumped (million gallons),	576.20	292.86	10,522.75	11,391.81
Daily average quantity pumped (gallons),	1,574,000	800,000	28,751,000	31,125,000
Total coal used (pounds),	1,012,902	279,676	8,656,737	9,949,315
Gallons pumped per pound of coal,	568.12	1,047.14	1,215.56	1,144.98
Average head pumped against (feet),	120.69	127.90	129.30	128.83
Cost of pumping: —				
Labor,	$1,908 35	$473 27	$12,885 18	$15,266 80
Fuel,	1,866 74	471 12	15,113 17	17,451 03
Repairs,	149 64	344 10	516 16	1,009 90
Oil, waste and packing,	64 52	16 00	438 64	519 16
Small supplies,	142 09	22 03	614 26	778 38
Totals,	$4,131 34	$1,326 52	$29,567 41	$35,025 27
Cost per million gallons pumped,	$7.170	$4.529	$2.810	$3.075
Cost per million gallons raised 1 foot high,	.059	.035	.022	.024

The quantity pumped was nearly 4 per cent. greater, and the cost per million gallons pumped was $1.704 less, than during the previous year. The greater part of the reduction in the cost of pumping was due to decreased cost of fuel and repairs.

Chestnut Hill Low-service Station.

The quantity of water pumped at this station was 27.8 per cent. less than during the year 1903, the reduction being due to the use of the Weston Aqueduct.

The following are the statistics relating to operations at this station: —

	Engines Nos. 5, 6 and 7.
Total quantity pumped (million gallons),	20,268.94
Daily average quantity pumped (gallons),	55,380,000
Total coal used (pounds),	8,662,868
Gallons pumped per pound of coal,	2,339.75
Average head pumped against (feet),	54.91

	Engines Nos. 5, 6 and 7.
Cost of pumping : —	
Labor,	$15,593 00
Fuel,	15,720 63
Repairs,	1,190 77
Oil, waste and packing,	522 54
Small supplies,	837 21
Total for station,	$33,864 15
Cost per million gallons pumped,	$1.671
Cost per million gallons raised 1 foot high,	.030

The cost per million gallons pumped was $0.176 more than for the year 1903. This was due to the decrease in the quantity pumped, and to an increase of 17 feet in the average head pumped against.

Spot Pond Pumping Station.

The 20,000,000-gallon Holly engine pumped all the water at this station.

The following are the statistics relating to operations at this station : —

	Engine No. 9.
Total quantity pumped (million gallons),	2,927.47
Daily average quantity pumped (gallons),	7,999,000
Total coal used (pounds),	2,462,802
Gallons pumped per pound of coal,	1,188.67
Average head pumped against (feet),	129.33
Cost of pumping : —	
Labor,	$7,070 49
Fuel,	3,990 00
Repairs,	183 55
Oil, waste and packing,	158 40
Small supplies,	466 35
Total for station,	$11,868 79
Cost per million gallons pumped,	$4.054
Cost per million gallons raised 1 foot high,	.031

The cost per million gallons pumped was $0.52 less than during the previous year, due to the reduction in the cost of fuel, and the use during the entire year of the more economical engine.

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 6,558 hours; average, 18 hours per day.

Daily average quantity of water pumped (gallons),	504,000
Daily average quantity of coal consumed (pounds),	1,683
Gallons pumped per pound of coal,	300
Average lift in feet,	133
Cost of pumping: —	
Labor,	$2,960 14
Fuel,	2,054 34
Repairs and small supplies,	298 03
Total for station,	$5,312 51
Cost per million gallons pumped,	$28.799
Cost per million gallons raised 1 foot high,	.217

The quantity pumped was 82,000 gallons per day, or nearly 20 per cent. greater than during the year 1903, while the cost of operating remained nearly the same. The cost per million gallons pumped was $5.55 less than for the previous year.

Arlington Pumping Station.

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 8,771 hours 30 minutes; average, 24 hours per day.

Daily average quantity of water pumped (gallons),	517,000
Daily average quantity of coal consumed (pounds),	3,000
Gallons pumped per pound of coal,	173
Average lift in feet,	282
Cost of pumping: —	
Labor,	$3,089 58
Fuel,	1,989 03
Repairs and small supplies,	262 30
Total for station,	$5,340 91
Cost per million gallons pumped,	$28.199
Cost per million gallons raised 1 foot high,	.100

The cost per million gallons pumped was $3.766 less than during the year 1903, due to a reduction in the cost of fuel.

The exterior of the building has been painted.

Consumption of Water.

The daily average quantity of water consumed in the cities and towns supplied by the Metropolitan Water Works during the year 1904 was 114,876,000 gallons, equal to 123.8 gallons per inhabitant in the district supplied. In addition to the above, 631,540,000 gallons, equivalent to a daily average supply of 1,726,000 gallons, were supplied to the city of Cambridge.

The consumption in the several districts was as follows: —

	Gallons per Day.	Increase (Gallons per Day).
Southern low-service district, embracing the low-service district of Boston, with the exception of Charlestown and East Boston,	47,652,000	3,924,000
Northern low-service district, embracing the low-service districts of Somerville, Chelsea, Malden, Medford, Everett, Arlington, Charlestown and East Boston,	27,630,000	2,192,000
Southern high-service district, embracing the high-service districts of Boston, Quincy, Watertown, Belmont, and a portion of Milton,	30,610,000	1,083,000
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,	7,963,000	434,000
Southern extra high-service district, embracing the highest portions of West Roxbury and Milton,	504,000	82,000
Northern extra high-service district, embracing Lexington and the highest portions of Arlington,	517,000	13,000
Totals,	114,876,000	7,728,000

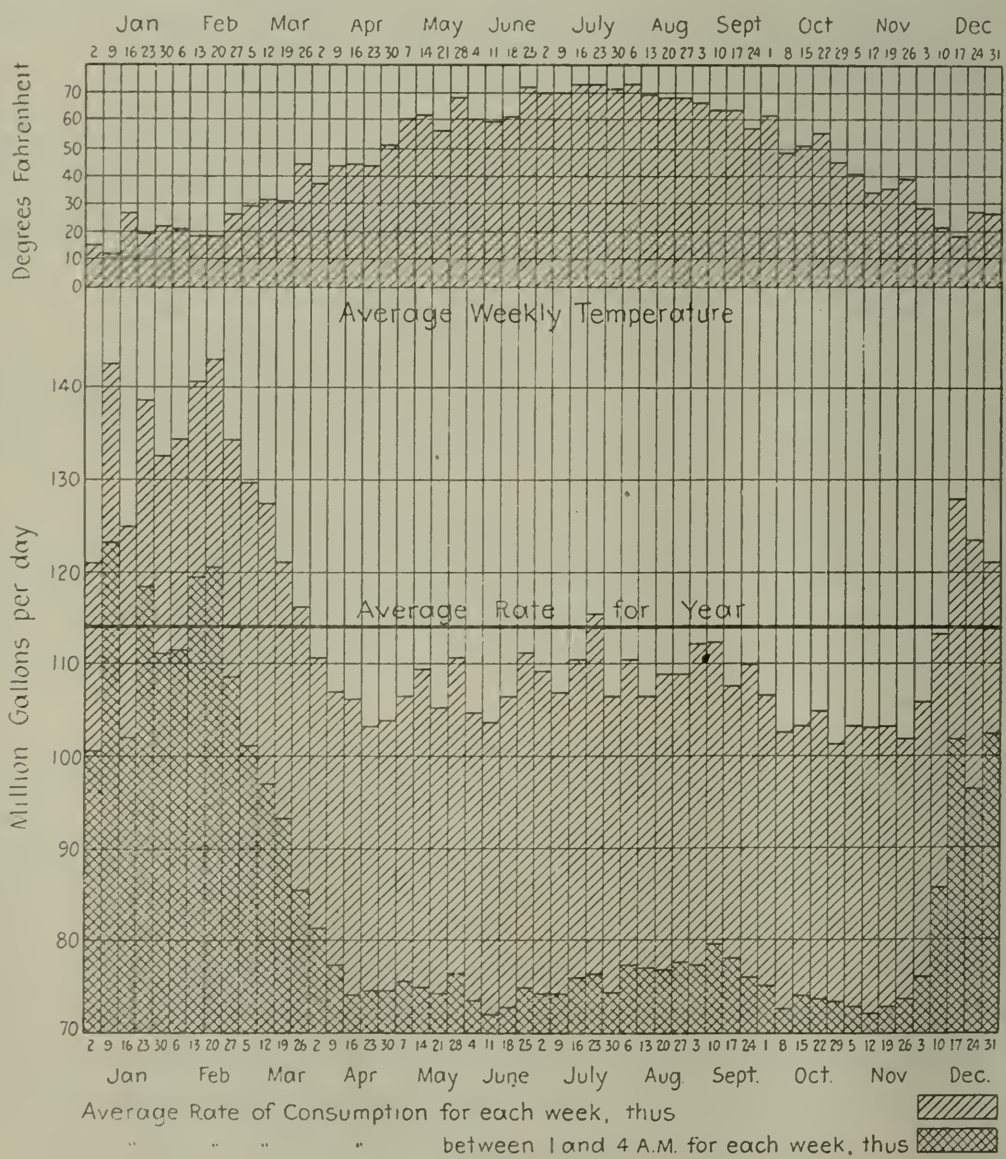
In June a portion of the Dorchester district of the city of Boston, containing about 9,000 people, was transferred from the southern low-service to the southern high-service district. With this exception the area of the several districts remains substantially the same as in 1903.

The increase of 7,728,000 gallons per day in the consumption during the past year was due to a great extent to the use of water to prevent freezing of service pipes during the unusually cold weather in January, February, March and December. In February the daily average quantity used was 139,941,000 gallons, which was 20,318,000 gallons in excess of the quantity used in February, 1903; and the daily average for the months of January, February, March and December was 13,445,000 gallons more than during the corresponding months of the previous year, while the increase for the remaining eight months of the year was 4,886,000 gallons per day.

During the past year continuous measurements have been made by means of Venturi meters of the water consumed in each city and town supplied from the Metropolitan Works. From these measurements can be determined the consumption of water at any hour of the day in any city or town; and in cases where the city or town is divided into low and high service districts, the rate of consumption in each of these districts can also be determined.

The following diagram shows the daily average rate of consumption of water in the district supplied by the Metropolitan Works for

Average Rate of Consumption in Metropolitan Water District and Average Temperature of Air at Chestnut Hill Reservoir for Each Week during 1904.



each week during the year, also the rate of consumption between the hours of 1 and 4 A.M., and the average temperature of the air for the week. It will be noticed that the largest consumption of water occurred during the weeks when the temperature was lowest, and that the rate of consumption between the hours of 1 and 4 A.M. for several weeks in January and February was larger than the 24-hour rate during the summer months.

The daily average consumption of water in each of the cities and towns supplied from the Metropolitan Works during the year 1904, as measured by the Venturi meters, was as follows: —

	Estimated Population.	Daily Average Consumption.	
		Gallons.	Gallons per Capita.
Boston,	611,830	87,680,300	143
Somerville,	70,320	6,228,300	89
Malden,	40,825	1,868,000	46
Chelsea,	37,835	4,260,500	113
Everett,	29,370	2,624,400	89
Quincy,	27,830	2,823,200	101
Medford,	22,125	1,802,900	81
Melrose,	14,445	1,525,100	106
Revere,	13,710	933,000	68
Watertown,	11,250	623,600	55
Arlington,	10,150	752,400	74
Milton,	7,740	316,300	41
Winthrop,	7,770	742,300	96
Stoneham,	6,420	558,300	87
Belmont,	5,045	248,800	49
Lexington,	3,620	282,700	78
Nahant,	2,310	131,000	57
Swampscott,	6,170	521,200	84
District,	928,770	113,922,300	123

A comparison of the figures in this table shows very plainly the great difference in the quantity of water consumed in different municipalities, and is of especial interest at the present time, for the reason that, in compliance with chapter 426 of the Acts of the year 1904, the measurements of the water used by each municipality during the year 1905 will be used in determining the assessment to be paid by each in 1906. Similar figures for each month of the year are given in Appendix No. 3, Table No. 22.

The autographic records furnished by the Venturi meters are frequently of much assistance in detecting leaks from the pipes, and in determining the quantity of water used at large fires or for other purposes in excess of the ordinary consumption. A study of these records from week to week also furnishes much information of value in determining the causes of and in preventing the waste of water. For example, the Venturi meter supplying the town of Swampscott indicated, on February 14, an increase in the consumption from 400,000 gallons to about 1,000,000 gallons per day. The local authorities were notified on February 16 that there was probably a large leak from their pipes, but it was not until February 26 that the cause was discovered and the leak repaired. Had it not been for the record of the meter, this leak, which was due to a broken 8-inch pipe, would probably have continued for a long time, as it ran into a drain without showing on the surface of the ground.

The consumption of water in the cities and towns supplied from the Metropolitan Works, as measured by the Venturi meters, is slightly less than the quantity supplied to the District, as determined by pump measurements, and by the flow of the Weston Aqueduct as measured by a Venturi meter. The total difference is less than 1,000,000 gallons per day, a large part of which is accounted for by the quantity of water used at the pumping stations, and by the leakage from the 84.21 miles of pipes and the several distributing reservoirs connected with the works, this use and leakage not being measured by the Venturi meters.

Quality of the Water.

Samples of water were collected every three months from four points, every two months from six points, and monthly from seven 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 substantially the same as during the past two years.

The following table gives a comparison of the average results of the examinations of water from a tap in Boston for the years 1900 to 1904, inclusive: —

	1900.	1901.	1902.	1903.	1904.
State Board of Health Examinations.					
Color (Nessler standard),	0.24	0.24	0.26	0.25	0.23
Total residue,	3.80	4.43	3.93	3.98	3.93
Loss on ignition,	1.20	1.64	1.56	1.50	1.59
Free ammonia,	0.0012	0.0013	0.0016	0.0013	0.0023
Albuminoid ammonia, total,	0.0157	0.0158	0.0139	0.0125	0.0139
Albuminoid ammonia, dissolved,	0.0138	0.0143	0.0119	0.0110	0.0121
Albuminoid ammonia, suspended,	0.0019	0.0015	0.0020	0.0015	0.0018
Chlorine,	0.25	0.30	0.29	0.30	0.34
Nitrogen as nitrates,	0.0076	0.0173	0.0092	0.0142	0.0110
Nitrogen as nitrites,	0.0001	0.0001	0.0001	0.0001	0.0001
Oxygen consumed,	0.38	0.42	0.40	0.39	0.37
Hardness,	1.3	1.7	1.3	1.5	1.5
Metropolitan Water and Sewerage Board Examinations.					
Color (platinum standard),	34	34	33	35	32
Turbidity,	–	2.0	2.3	2.2	2.4
Total organisms,	468	243	367	286	303
Amorphous matter,	97	38	34	36	36
Bacteria,	181	162	164	126	176

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.

More than 8 per cent. of the water supplied to the Metropolitan District passes through Spot Pond, in which the color is reduced by the bleaching action due to long storage to about two-thirds that of the water supplied to the remainder of the District.

Biological Laboratory.

The laboratory has been in charge of Burton G. Philbrick, biologist.

The samples of water have been taken weekly at twenty-nine points and fortnightly at six points on the works, and special samples have been taken from time to time from the reservoirs and the brooks entering them, and from the filters at Marlborough, Hopkinton and Lake Cochituate. There were made during the year 2,277 microscopical examinations, of which 1,756 were made in connection with the regular weekly samples, and 521 in connection with the miscellaneous samples.

The Wachusett Reservoir has had water stored in it for the whole year for the first time, and the water in it now has the characteristics of a reservoir rather than a river water, in that it contains a somewhat larger growth of microscopic organisms, and is to some extent decolorized by storage. The organisms have not been abundant, and the water has been practically free from odor. The color during the latter part of the season was much lower than that of the river water.

In the Sudbury Reservoir and in Framingham Reservoir No. 3 the microscopic organisms were more abundant in the latter half of the year than usual, causing an odor which was quite persistent, and which was reported from week to week by the biologist. The odor did not, however, become sufficiently strong to cause complaints from the water takers.

In Lake Cochituate the organisms were unusually few for nearly the whole of the year, and the water of such satisfactory quality that it could be used during the greater part of the year. In December, however, there was an abundant growth of Synura, which rendered the water for the time being unsuitable for use.

The bacteriological work for the year consisted of routine weekly examinations, monthly examinations of the main feeders of the Sudbury Reservoir, of Framingham Reservoir No. 3 and of Lake Cochituate, monthly tests of the efficiency of the Pegan and Marlborough Brook filters, and occasional miscellaneous examinations. A total of 530 samples were examined.

Sanitary Inspection.

The sanitary inspection of the Wachusett, Sudbury and Cochituate watersheds has been continued during the year, under the direction of William W. Locke, C.E., Sanitary Inspector.

Upon the Wachusett watershed there have been 10 cases of typhoid fever in Holden, 3 in Princeton and 1 in West Boylston. None of these cases were within the limits of the reservoir. The usual close watch has been kept over the camps and laborers employed within the limits of the reservoir, to see that the water supply was not polluted. The number of cases of typhoid fever upon the Sudbury and Cochituate watersheds was 20, divided as follows: Marlborough, 6; Framingham, 6; Westborough, 6; Southborough, 1; and Wayland, 1.

A summary of the work of sanitary inspection for 1904 is given in the following four 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 third table shows the improvements effected on the Wachusett watershed; and the fourth table the improvements effected on the Sudbury and Cochituate watersheds.

The headings of these tables explain themselves, except in a few instances: 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.

In the third and fourth tables 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 1904.

District.	Number of Premises inspected.*	Classification of Cases inspected.									Condition at End of Year.	
		Cesspools dug before 1904.	Cesspools dug in 1904.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
French Brook,	88	36	–	–	–	2	6	34	–	6	79	9
Muddy Brook,	32	11	–	–	–	–	4	20	–	2	30	2
Gates Brook,	138	73	3	–	–	2	9	60	–	3	132	6
Malden Brook,	16	8	–	–	–	–	1	13	–	–	15	1
Chaffin Brook,	146	34	1	–	4	6	31	78	1	4	130	16
Asnebumskit Brook,	270	110	11	2	4	27	26	110	3	12	232	38
Musquapoag,	101	22	–	–	4	–	18	58	1	12	89	12
South Wachusett Brook,	90	17	1	–	5	1	7	43	–	8	83	7
Trout Brook,	49	4	1	–	2	–	4	28	1	1	47	2
East Wachusett Brock,	212	47	1	1	7	5	25	112	–	13	198	14
Stillwater River,	170	63	3	–	4	5	17	74	–	7	163	7
Waushacum,	180	53	3	3	6	19	19	67	–	5	152	28
French Hill,	38	17	1	–	–	1	3	14	–	3	36	2
Totals,	1,530	495	25†	6	36	68	170	711	6	76	1,386	144

* 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 have been or will be ultimately torn down.

Summary of Sanitary Inspections on the Sudbury and Cochituate Watersheds in 1904.

District.	Number of Premises inspected.*	Classification of Cases inspected.									Condition at End of Year.	
		Cesspools dug before 1904.	Cesspools dug in 1904.	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	2	-	-	-	-	-	1	-	-	3	-
Framingham Reservoir No. 3,	7	5	-	-	-	-	2	-	-	-	5	2
Stony Brook,	55	41	3	-	-	1	3	8	-	4	51	4
Angle Brook,	304	168	4	-	2	19	47	30	3	18	244	60
Framingham reservoirs Nos. 1 and 2, and Cold Spring Brook.	26	17	4	-	-	-	6	2	-	1	21	5
Eastern Sudbury,	37	23	3	-	-	-	1	2	-	9	35	2
Indian Brook,	47	20	1	-	-	4	14	3	-	5	30	17
Western Sudbury,	22	14	-	-	1	1	4	4	1	6	16	6
Whitehall Reservoir,	5	3	-	-	-	-	1	2	-	-	5	-
Cedar Swamp,	54	30	2	-	-	-	4	3	1	5	49	5
Cochituate Watershed.												
Snake Brook,	37	23	6	-	-	1	9	4	-	-	28	9
Pegan Brook,	93	39	1	-	1	3	9	12	3	4	82	11
Course Brook,	6	4	-	-	-	-	1	1	-	1	5	1
Beaver Dam Brook,	116	47	1	-	-	4	12	11	4	7	103	13
Dug Pond,	35	5	-	-	-	3	7	-	-	-	25	10
Totals,	847	441	25	-	4	36	120	83	12	59	702	145

* 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 1904.

District.	Remedied by Filter-bed.	Otherwise remedied.	Partly remedied.
French Brook,	-	-	-
Muddy Brook,	-	-	-
Gates Brook,	-	-	4
Malden Brook,	-	2	-
Chaffin Brook,	-	3	-
Asnebumskit Brook,	-	2	5
Musquapoag,	-	-	-
South Wachusett Brook,	-	-	1
Trout Brook,	-	1	3
East Wachusett Brook,	1	2	2
Stillwater River,	-	2	-
Waushacum,	-	2	1
French Hill,	-	-	1
Totals,	1	14*	17

* One schoolhouse in Princeton removed to a safe location.

Sanitary Improvements effected on the Sudbury and Cochituate Watersheds in 1904.

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,	-	-	3	-
Angle Brook,	35	1	4	33
Framingham reservoirs Nos. 1 and 2, and Cold Spring Brook.	-	-	4	-
Eastern Sudbury,	-	1	3	-
Indian Brook,	-	-	1	-
Western Sudbury,	-	-	-	-
Whitehall Reservoir,	-	-	-	-
Cedar Swamp,	13	2	2	13
Cochituate Watershed.				
Snake Brook,	-	-	6	-
Pegan Brook,	36	-	1	35
Course Brook,	-	-	-	-
Beaver Dam Brook,	45	-	1	44
Dug Pond,	15	-	-	15
Totals,	144	4	25	140

Among the cesspools dug on the Wachusett watershed during the year were two, each 10 feet in diameter and 10 feet deep, for large private sanatoriums in Rutland. As the soil was poor for filtration purposes, about 450 feet of 4-inch open-jointed tile pipe were laid near the surface from each cesspool, to receive the overflow.

The work of making sewer connections in the various towns has not on the whole progressed quite as rapidly as during the preceding year.

In Natick fixtures were installed and sewer connections made with 51 houses, against 75 the preceding year.

In South Framingham 45 houses have been connected with the sewer, against 56 the preceding year.

In Marlborough there have been 35 connections, against 23 the preceding year.

In Westborough 13 connections have been made, against 10 the preceding year, — a total of 144 against 164 the preceding year.

The sanitary conditions at Hopkinton still remain somewhat unsatisfactory.

The New York, New Haven & Hartford Railroad Company has double-tracked its road from Framingham to Southborough this year, and, as the road for a portion of the distance crosses two of the reservoirs, special inspection has been necessary, to prevent the pollution of the water by the workmen.

There are in places leaks into the Cochituate Aqueduct, where it is built in deep cuttings or in tunnel. By collecting samples of water from these leaks, and analyzing them, evidence was found of pollution which was traced to two houses in Newton. Temporary measures were taken to stop the pollution, and later in the year the city of Newton extended its sewerage system, and these houses were connected with it.

A new sanitary census of the Sudbury and Cochituate watersheds was begun this year, similar to that taken in 1902 on the Wachusett watershed. This has been completed for the whole town of Southborough and portions of Natick and Ashland, and it is expected that it will be completed for the remainder of these watersheds in 1905.

Drainage of Swamps.

The ditches built to drain swamps on the Sudbury and Wachusett watersheds, having a total length of 27.4 miles, have required no special repairs during the year. The 15.55 miles of ditches tributary to the open channel require about two-thirds of the time of 2 men to maintain them in good condition. Special forces are also required at times to cut the bushes at the sides of the ditches.

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 1904 the average colors have been respectively 99 and 71, which are somewhat lower than in most previous years.

Distributing Reservoirs.

The distributing reservoirs maintained by the Board are the Weston and Chestnut Hill reservoirs; the Waban Hill and Forbes Hill reservoirs and the Forbes Hill standpipe, of the southern high-service system; Spot Pond and the Mystic Reservoir, near Tufts

College, of the low-service system; the Fells and Bear Hill reservoirs, of the northern high-service system; and the Arlington standpipe, of the northern extra high-service system.

Weston Reservoir.

Since the completion of the Weston Reservoir, in the spring, the grounds about it have been kept in good order, the grass has been cut and the hay harvested.

Chestnut Hill Reservoir.

In addition to the usual care of the gate-houses and grounds, repairs have been made at this reservoir as follows: the cover stones over the Cochituate Aqueduct, near the influent gate-house, have been reset, and the joints between the flagstones surrounding the influent and intermediate gate-houses have been repointed. At the old effluent gate-house the masonry of the steps was repointed. Three manholes on the surface water drain near the Lawrence Basin have been rebuilt. The ironwork in the terminal chamber of the Sudbury Aqueduct and in the small gate-house on the Cochituate Aqueduct near the high-service pumping station was cleaned and painted. Concrete steps have been built to replace wooden steps in front of the pumps used for drinking purposes. The walk on the reservoir embankment between the old effluent gate-house and a point near Reservoir Lane, a distance of 1,780 feet, has been resurfaced, using ashes from the pumping station, with a very light sprinkling of stone dust on the surface. During the summer from 2 to 4 men were required to police the grounds on Sundays, holidays and evenings.

Waban Hill Reservoir.

The reservoir and gate-house are in good order, and the grass on the embankments was somewhat improved in appearance, as compared with the previous year. A fence 250 feet long, with wrought-iron posts set in concrete, and wrought-iron rails, was built to replace a fence with wooden posts which were decayed. This reservoir is cared for by the force employed at Chestnut Hill Reservoir.

Forbes Hill Reservoir and Standpipe.

Both the woodwork and ironwork of the tower and reservoir gate-chamber and the iron railing around the reservoir have been painted by the attendant permanently employed at the reservoir.

Cast-iron caps have been placed on the posts of the fence surrounding the reservoir, to protect them from the weather. Observations taken during the extreme cold weather of January and February showed that the thickness of ice which formed in the standpipe did not exceed 6 inches.

Spot Pond.

The pond has remained at or near high water during the year, except on four occasions. In January and February the demand for water during the extremely cold weather caused the surface to be drawn down to about 1 foot below high water in each month. From October 3 to 10 and October 24 to 31 water was drawn from the pond for the supply of the District, while the Sudbury Aqueduct was shut off for repairs. On each of these occasions the water fell to about 1½ feet below high water. In addition to the ordinary care given to the reservoir and grounds about the pumping station, 356 cubic yards of sand and gravel and 75 cubic yards of loam have been placed on or above the shores of the pond near the corner of South and Main streets, where the embankment had settled so that the water was encroaching on the loamed area. The regular force employed, with some assistance from men detailed from other parts of the works, has devoted much time to the destruction of gypsy and brown-tail moths. The trees near the pumping station have been kept fairly clean, but the trees on about 50 acres of land at the southerly end of the pond were, at the end of the season, very badly infested with the eggs of gypsy moths. On November 7 the work of thinning out trees on the property of the Board around the pond was begun, for the purpose of improving the character of the wooded areas and of reducing the number of trees to be protected. At the end of the year 66 acres had been gone over, and about 300 cords of wood cut and so treated as to kill the eggs on it. This work is to be continued, and the eggs of the moths on the uncut trees are to be destroyed before spring. During the year 109 property bounds were set around the pond.

Mystic Reservoir.

This reservoir has been in constant use, and is in good order; but the gate-house will probably require a new roof during the coming year. The driveway has been thoroughly repaired by building new tar concrete gutters at a cost of $355, and by surfacing with 25 tons of broken stone. The tar concrete walk around the reservoir was also repaired.

Fells and Bear Hill Reservoirs.

These reservoirs are cared for by the force employed at Spot Pond. The reservoirs, with their gate-houses and grounds, are in good order.

Arlington Standpipe.

The standpipe has been in service throughout the entire year. The two lower sheets of the standpipe have been painted, in order to obliterate marks made by visitors.

Mystic Lake.

The water in the lake was kept from $2\frac{1}{2}$ to 3 feet below high water from the first of January until the middle of April. During the summer the water was kept about 1 foot below high water. In the early part of October, while work of repairing the dam was in progress, the water in the lake was lowered to about $3\frac{1}{2}$ feet below high-water mark, but was afterward raised, and on January 1, 1905, stood at elevation 14.50 above Boston city base, or $2\frac{1}{2}$ feet below high-water mark. An apron of Portland cement concrete, about 6 feet wide and 2 feet thick, has been built below the outlet dam, to prevent the water falling over the dam from excavating the gravel and undermining the concrete foundations; and the joints of the masonry piers and of the wingwalls have been repointed and grouted. The cost of the apron and pointing was about $370.

The house occupied by the attendant has been reshingled and otherwise repaired, at a total cost of about $225. The house of the Medford Boat Club has been moved to a point about 100 feet west of its former location.

Chelsea Reservoir.

In June an arrangement was made with the Water Commissioners of Chelsea, by which the Board was given permission to draw water from the high-service reservoir in cases of emergency, for supplying other cities and towns in the Metropolitan District; and in consideration of this privilege the Board agreed to make repairs to the lining of the reservoir, which had been badly cracked by the action of frost. This work was done in September by the maintenance department, at a cost of about $3,500.

The reservoir is 177 feet long and 96 feet wide, with semi-circular ends. The inner slopes were originally covered with 4-inch brick-work, laid on 4 inches of Rosendale cement concrete. The cracks were in the lining on the upper portion of the slopes, not more than 4 feet below high-water mark. The repairs consisted in removing the old lining down to a point about 6 feet below the top of the embankment, and replacing it with a much heavier lining of Portland cement concrete. The new lining had a thickness of about 2 feet at the high-water line, decreasing to 9 inches at a point 4 feet below high water, where it joined the old lining. It was put on in two layers, with a coating of asphalt between. The upper layer was put on in blocks 5 feet wide and about 10 feet long, and the upper surface given a granolithic finish.

Pipe Lines.

No extensions were made during the year to the pipe lines owned and maintained by the department. Nineteen leaks were repaired on the pipes, at a cost of $1,579. Sixteen of these were caused by defective joints, one by the breaking of a valve and two by breaks in the mains. One of the last two occurred on February 25, when a 30-inch high-service force main broke on the grounds at Chestnut Hill Reservoir, near the low-service pumping station. This break was caused by the settling of the pipe in filled material. The second break occurred on October 16, when the 16-inch high-service main supplying Winthrop broke at the corner of Beach Street, in Winthrop Avenue, Revere. The cost of repairing the break in the 30-inch pipe, including the damage to grounds, was $626.45; and the cost of repairing the break in the 16-inch pipe, including $250 paid for damage to sewer construction, was $367.53.

During October and the early part of November the 12-inch pipe line on Washington Street in Lynn, from a point 30 feet south of the north line of Suffolk Street to a point 180 feet south of the north line of Amity Street, a distance of 593 feet, was relaid, as it was very badly damaged by electrolytic action. This pipe was laid in 1898.

In July two insulating joints were set in the 48-inch pipe line crossing the Charles River between Boston and Cambridge, near the Boylston Street power station of the Boston Elevated Railway Company; and in December two additional joints were placed in the same pipe line, one on Massachusetts Avenue near the bridge over the Fitchburg Division of the Boston & Maine Railroad, and one near the Allston station on the Boston & Albany Railroad.

The Ross pressure-regulating valves on the pipes supplying Winthrop and Swampscott, which did not satisfactorily regulate the pressure, have been replaced by valves designed in this office and built by the Waters Governor Company.

The several pipe bridges have been examined, and the bridges over the Pines River were repainted.

Twenty-two recording pressure gages are now in use, connected with the distribution system at different points. The average maximum and minimum elevations of the water, due to the pressure at seventeen points in different parts of the District, are given in Appendix No. 3, Table No. 38.

Venturi Meters.

The number of meters in service in the Metropolitan Water District on January 1, 1905, was 53, the same as on January 1, 1904. A few changes have, however, been made in the size and location of the meters. Two 48-inch meters supplying the low-service district of Boston, which were located near the low-service pumping station at Chestnut Hill, were moved in April to a point on Beacon Street just below the connection between the new pipe from the Weston Aqueduct and the mains leading to Boston. This change was made in order to provide for accurate measurements of the water supplied to the Boston low-service district.

A 10-inch meter on Broadway in Chelsea was moved from its location near the bridge leading to Charlestown to a point near William Street, and a 24-inch valve was set in the pipe line at the latter place. The old location near the Chelsea bridge was very near a sea wall, through which the cold entered, so that the meter could not be used during the winter.

The 8-inch meter supplying the town of Nahant having been found to be too large to measure the minimum flow during the winter months, a 6-inch meter was set on the by-pass, and the meter register was connected in such a way as to measure the flow through either meter. A 10-inch weighted check valve was set on the main line of pipe, and so adjusted that it will open in case the meter at any time fails to furnish a sufficient supply.

Two men have devoted their entire time to the work of reading the meters, winding the registers, and cleaning, oiling, painting and repairing the registers and chambers. All of the chambers have been scraped and painted, the ironwork of the registers has been painted, and the bottom of the chambers covered with cement. Some trouble was experienced on account of freezing of the water in the registers and supply pipes during the extreme cold weather, and for the purpose of preventing this seven of the chambers were covered on the top and sides to a depth of 4 feet from the surface with an insulating coating composed of pitch and cork. The cost of this work was about $70 per chamber.

Electrolysis.

Investigations relative to the injury to the pipes caused by electric currents from the street railway systems have been continued throughout the year. In the annual report for the year 1903 detailed descriptions were given of the injury done to 48-inch pipes in Cambridge, the 24-inch pipes in Chelsea and 12-inch pipes in Lynn, and also of an experimental test of an insulating covering of asphalt and burlap which was being made by the Boston Elevated Railway Company. On April 6 this covering, which was applied in November, 1902, was removed from one length of 48-inch pipe for the purpose of examination. Before the covering was applied the pipe was carefully cleaned and the pits dug out and located. Upon removing the covering many new pits were found, and in some cases one large pit was found where there were two or three separate pits before the covering was put on. The number of pits in the pipe had increased from 80 in 1902 to 496 in 1904.

The railway engineers suggested that possibly the pits were not all dug out before the pipe was covered, and therefore recovered it for a further test. They have since made the following experimental tests, which indicate that the covering has little if any value under some circumstances.

A short piece of 4-inch pipe, covered in the same manner as the large pipe, was buried in dry earth in a box, and a cast-iron plate was buried 1.25 feet from the pipe. In one test tar was used in the covering, and in another asphaltum. The pipe and plate were connected in the regular trolley circuit of 500 volts. While the earth was dry the resistance between the pipe and the plate with the tar covering was 700 megohms, and with the asphaltum covering 34 megohms. The earth was then saturated with salt water, and the resistance quickly diminished, and after seven to ten days disappeared.

For the purpose of diminishing the injury which was being done to the two lines of 36-inch pipe crossing under the Charles River near the power station of the Boston Elevated Railway Company in Cambridge, two 48-inch insulating joints were set in July, one on either side of the river. Each of these joints was composed of two flanged pieces of 48-inch pipe, bolted together with a gasket of pure rubber $\frac{1}{2}$ of an inch thick between the flanges. The bolts joining the flanges were covered with rubber tubing $\frac{1}{8}$ of an inch thick, and the nuts were insulated from the casting by means of a washer of rubber $\frac{1}{2}$ an inch thick. The joints have a resistance of from 100 to 200 ohms when the pipe is filled with water, and are enclosed in water-proof chambers, to prevent the entrance of ground water.

These joints reduce the quantity of electricity leaving the 36-inch pipes in the river from 25 ampères to less than 5 ampères, and reduce the quantity flowing along the pipes toward the power station at a point on North Harvard Street near Franklin Street from 65 ampères to 40 ampères. The joints were expected to protect the pipes in the river, at the expense, to some extent, of other portions of the pipe line; and the measurements of currents appear to show that the effect has been substantially as expected, as the quantity of electricity leaving the pipe between Western Avenue, Brighton, and the river, was increased about 25 ampères.

As these joints reduced the quantity of electricity flowing along the pipe line, the railway company desired to set similar joints at other points, and late in the year an arrangement was made for the setting of four additional 48-inch joints. Two of these were set in December, one at Porter's Square in Cambridge and the other near the Allston station on the Boston & Albany Railroad. Both of these joints are on the same line of 48-inch pipe as the two joints set in July, one being about 500 feet south and the other 7,500 feet north of the Charles River.

As the amount of current flowing along the pipes at different times depends upon the amount of power developed at these times at the different power stations, many observations are necessary to determine the average quantity flowing even for a single day, and these have not been taken since the last joints were installed; but enough measurements have been taken to warrant the statement that the introduction of the joint at Porter's Square has substantially stopped the flow of electricity along the pipe at that point. The conditions have been changed so as to increase the amount of electricity leaving the pipe north of the joint, but there appears to be at present not more than 40 ampères flowing along and leaving the pipe line, in place of 90 ampères; and there has also been a very marked reduction in the difference of potential between the pipes and the rails of the street railway company.

The measurements thus far taken appear to indicate that the effects of setting an insulating joint somewhere near the middle of a pipe line, one portion of which is electrically positive and another negative to the car tracks, are as follows: —

1. To stop the direct flow of electricity along the pipe line at the point where the joint is set, and to reduce considerably the amount of electricity flowing along other parts of the pipe line.

2. To lower the average potential of the pipe line on the negative or power station side of the joint.

3. To raise the average potential of the pipe line on the positive side of the joint.

4. To maintain a difference of potential of several volts between the positive and negative sides of the joint, and to produce conditions tending to increase electrolytic action at that point, unless the joint is carefully located in dry ground.

5. To cause a new distribution of electrical conditions, under which the two sections of the pipe line become similar to the original line, with one portion of each positive and the other negative to the car tracks, so that the number of positive areas is increased by one for each joint.

Both in August and November, 1903, the attention of the officials of the Boston & Northern Street Railway Company was called to the serious injury which had then been done to our pipes, both in Chelsea and Lynn, by the currents of electricity returning to its power stations. Excavations made in November in Lynn showed that there were pittings in the 12-inch pipe in Washington Street .45 of an inch in depth, leaving only .25 of an inch of the original thickness of iron. As it was not deemed prudent to continue to risk the failure of this pipe line, it was relaid during the past year for a length of 593 feet. All of this pipe was laid in 1898, and when removed it was badly decomposed, and in several places very little of the original metal of the pipe remained. The officials of the

12-INCH PIPE IN WASHINGTON STREET IN LYNN, PITTED BY ELECTROLYSIS (REPLACED).

railway company were notified that the pipes were to be relaid before the work was commenced, and were asked if they desired to adopt any preventive measures, but they did not do so ; and on December 5, after the pipe was relaid, measurements showed that there were 20 ampères of electric current leaving the relaid section. It is probable that, if nothing is done to alter the conditions, it will be necessary to again relay these pipes not later than 1910.

The regular annual survey to determine the relative electrical potential of the Metropolitan pipe lines and the street railway tracks, and the amount of electricity flowing on the pipes at the several gaging stations, was made in April. In making these surveys voltmeter readings were made at each station every twelve seconds, for a period of five minutes. The figures are obtained from readings taken between 9 A.M. and 4 P.M. during the months of March and April, and do not represent the extreme results which would be obtained during the hours of maximum travel. The average of these readings, compared with similar readings made in 1903, are given in the following table. They show that the electrical pressures have been generally reduced during the past year over the entire distribution system.

Summary of Relative Potentials of Metropolitan Water Works Pipes and the Electric Car Tracks in the Metropolitan District for the Years 1903 and 1904.

Location.	Date.	Pipe Negative.				Pipe Positive.			
		Length (Linear Feet).	Difference of Potential (Volts).			Length (Linear Feet).	Difference of Potential (Volts).		
			Maximum.	Average.	Minimum.		Maximum.	Average.	Minimum.
Low-service Pipe Lines.									
Easterly 48-inch line, Chestnut Hill Reservoir to Spot Pond, via Malden.	1903	31,500	7.8	4.00	—.6	14,000	5.1	1.60	—1.6
	1904	28,150	6.4	3.97	.4	17,350	2.6	1.23	—.6
Change during year, ...	-	-	—1.4	—.03	—.2	-	—2.5	—.37	—1.0
Westerly 48-inch line, Chestnut Hill Reservoir to Spot Pond, via Medford.	1903	17,000	6.1	2.45	.3	15,700	9.0	4.00	.6
	1904	18,400	5.2	1.81	—.8	14,300	8.8	3.63	—.3
Change during year, ...	-	-	—.9	—.64	+.5	-	—.2	—.37	—.3
42-inch line, Malden to Chelsea, . . .	1903	12,700	6.5	3.55	2.5	2,600	3.6	1.09	1.0
	1904	12,300	6.2	2.81	1.4	3,000	3.6	1.07	1.0
Change during year, ...	-	-	—.3	—.74	—1.1	-	-	—.02	.0
Low-service main, Somerville to Arlington,	1903	27,250	4.3	1.60	—.6	-	-	-	-
	1904	24,350	5.0	.76	—1.2	2,900	2.1	.65	.
Change during year, ...	-	-	+.7	—.84	+.6	-	-	-	-

Summary of Relative Potentials of Metropolitan Water Works Pipes and the Electric Car Tracks in the Metropolitan District for the Years 1903 and 1904 — Concluded.

Location.	Date.	Pipe Negative. Length (Linear Feet).	Pipe Negative. Difference of Potential (Volts). Maximum.	Average.	Minimum.	Pipe Positive. Length (Linear Feet).	Pipe Positive. Difference of Potential (Volts). Maximum.	Average.	Minimum.
Supply Pipe Lines.									
Terminal Chamber of Weston Aqueduct to Chestnut Hill Reservoir.	1903 1904	13,400 14,800	4.0 5.0	.56 1.17	−1.5 −1.3	20,800 19,400	10.0 8.4	2.82 2.91	.0 −1.0
Change during year, ...	-	-	+1.0	+.61	−.2	-	−1.6	+.09	+1.0
Northern High-service Pipe Lines.									
Medford to Revere, ...	1903 1904	48,700 47,900	10.5 5.0	2.85 1.56	−.4 −1.0	5,900 6,700	2.6 1.8	.74 .47	−1.5 −1.1
Change during year, ...	-	-	−5.5	−1.29	+.6	-	−.8	−.27	−.4
Revere to Lynn, ...	1903 1904	23,850 28,850	3.4 3.0	1.92 .82	−1.2 −.6	9,550 4,550	10.4 8.8	2.59 3.67*	−2.4 1.1
Change during year, ...	-	-	−.4	−1.10	−.6	-	−1.6	+1.08	−1.3
Spot Pond to Stoneham, ...	1903 1904	- -	- -	- -	- -	10,250 10,250	27.0 21.0	19.40 12.22	12.0 3.0
Change during year, ...	-	-	-	-	-	-	−6.0	−7.18	−9.0
Southern High-service Pipe Lines.									
Belmont and Watertown to Quincy, . .	1903 1904	60,750 61,250	35.0 60.0	3.80 3.63	−.6 −1.8	2,500 2,000	2.3 1.2	.84 .44	.7 .1
Change during year, ...	-	-	+25.0	−.17	+1.2	-	−1.1	−.40	−.6
Southern Extra High-service Pipe Lines.									
West Street, Hyde Park, ...	1903 1904	- -	- -	- -	- -	1,550 1,550	17.5 13.0	10.35 7.51	5.2 3.0
Change during year, ...	-	-	-	-	-	-	−4.5	−2.84	−2.2

* This average is high on account of reduced length of the district in 1904; the average for the same length in 1903 was 4.93.

At a few points, however, the conditions are worse than in 1903. At the corner of Reservoir Lane and Boylston Street in Brookline the voltage between the pipe and the rails has increased from $2\frac{1}{2}$ to 5 volts, possibly due to increased traffic on the Boston & Worcester line. On Adams Street in Milton, near the East Milton station, the average voltage has increased from 18 volts in 1903 to 22 volts in 1904, and the maximum from 35 to 60 volts. This is due to poor track construction, and lack of return feeders on the Old Colony Street Railway Company's tracks. Early in the year the Boston & Northern Street Railway Company was notified that there was a large difference of potential between our pipes and their tracks on Main Street in Stoneham, and that a large quantity of electricity was flowing along our pipe. During the past year the railway

12-Inch PIPE in Washington Street in Lynn, pitted by ELECTROLYSIS (replaced).

company has relaid the tracks between Melrose Highlands and Stoneham Square, and provided better returns for the current, so that the conditions have been greatly improved; but even now there is considerable current flowing along our pipe in Main Street.

In January the attention of the Old Colony Street Railway Company was called to the fact that a current of from 15 to 45 ampères had been measured flowing on our 12-inch pipe in West Street in Hyde Park, with differences of from 5 to 18 volts between the pipe and the rails. In June our pipe was uncovered at several points for examination, and pits about $\frac{1}{16}$ of an inch in depth were found on several pipes. A service pipe of the Hyde Park Water Company was found to be resting upon the 12-inch pipe, making an electric contact by means of which about 10 ampères of electricity passed from the Metropolitan main to the pipes of the Hyde Park Water Company. By raising the service pipe and breaking the electric connection, the flow of electricity along our pipes was reduced about one-half.

Clinton Sewerage.

The Clinton sewage disposal works were in daily operation during the whole year. The amount of sewage pumped and filtered was about 43,000 gallons per day less than during the preceding year, notwithstanding the considerable number of additional house connections which have been made with the system. The decrease is due in part to the smaller quantity of water leaking into a very leaky section of the town sewer, located close to the river, between the Lancaster Mills and Germantown, and to the large increase in the number of water meters in Clinton, by which the waste of water is checked.

Following are statistics relating to the operation of the pumping station: —

Daily average quantity of sewage pumped (gallons),	740,000
Daily average quantity of coal consumed (pounds),	1,295
Gallons pumped per pound of coal,	570
Number of days pumping,	366
Cost of pumping: —	
Labor,	$1,389 33
Fuel,	1,092 18
Repairs and supplies,	756 91
Total for station,	$3,238 42
Cost per million gallons pumped,	$11 99
Cost per million gallons raised 1 foot high,	26

The increase in the cost of labor, as compared with the cost the preceding year, is due mainly to the employment of an additional engineer to operate the pump nights during the spring when the quantity of sewage was large. The increase in the cost of repairs and supplies is due mainly to the purchase of new plungers for the pump and the repair of the old plungers for future use, these items costing $520.

Filter-beds.

During the year 8 settling basins and about .83 of an acre of small filter-beds on which to filter the water from the underdrains of the settling basins were added, as already described in the portion of the report relating to Construction.

In the latter part of the year from 2 to 3 inches of the dirty sand or gravel were removed from the surfaces of the 19 beds from which all soil had been removed when they were built. The total quantity of material removed was 5,444 cubic yards, which was hauled an average distance of 540 feet to dispose of it. The total cost of removing the material and disposing of it was $1,858.19, or 34 cents per cubic yard. This work was done by a day-labor force.

The settling basins have been in operation continuously since November 14. The sewage is allowed to run through a basin for a time, when it is shut off and turned through another. After a week's use, sludge about 6 inches deep accumulates on the bottom of the basin near the inlet, but near the outlet there is very little. These basins have been used for too short a time to warrant any statement as to the best method of using them or as to their effect.

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.

In March, April and May the sewage was pumped nights as well as days, and for nearly a week the pump was operated continuously.

During the warmer portion of the year, from April 8 to November 27, the sewage was applied to the beds at a rate which averaged about 32,000 gallons per acre per day. For the first half hour after beginning pumping in the morning, when the sewage contains more sludge than at other times, it was turned on one of two selected beds. These 2 beds were used alternately for periods of about 3 weeks, one being in use while the other was drying and being cleaned. The remaining 23 beds were used in rotation, and all the sewage was run upon a single bed, having an area of a little less than 1 acre, for about 1½ hours, the amount per application being about 181,000 gallons, each bed being used about once in 6 days.

During the colder portion of the year, when the temperature was below 15° above zero, all the sewage of one day's pumping was turned upon one of 5 improved beds, which had been prepared with furrows 3 feet 6 inches apart. The average amount per application was 580,000 gallons, and each furrowed bed was used about once in 10 days. When the temperature was higher than 15° above zero, the sewage was applied to the beds which had not been furrowed, at the rate of 290,000 gallons per application, and each acre was used about once in 10 days.

The degree of purification was about the same as in the preceding year. Taking the year as a whole, the amount of nitrification has been about the same as in the preceding year, but much lower than in the years 1900 to 1902. It was much higher in the last half of the year than in the first. The results of chemical analyses of the sewage and effluent are given in the following table: —

[Parts per 100,000.]

	1900.	1901.	1902.	1903.	January to June, 1904, inclusive.	July to December, 1904, inclusive.	Whole Year, 1904.
Albuminoid ammonia, sewage,	1.380	1.0025	1.0517	.9233	.7467	.8467	.7967
Albuminoid ammonia, effluent,	.089	.0741	.0891	.0782	.0752	.0620	.0686
Per cent. removed,	94	91	89	92	90	93	91
Oxygen consumed, sewage,	14.84	10.73	8.85	8.65	6.72	10.42	8.57
Oxygen consumed, effluent,	1.09	.82	1.15	1.12	1.07	.91	.99
Per cent. removed,	93	91	84	87	84	91	88
Free ammonia, sewage,	3.9500	3.4533	4.3284	3.8292	3.26	4.67	3.97
Free ammonia, effluent,	1.0631	.5792	.6862	1.0185	1.08	.89	.99
Per cent. removed,	73	83	84	73	67	81	75
Nitrogen as nitrates, effluent,	.7300	.9298	.9815	.4168	.2129	.5963	.4046

The cost of maintaining the filter-beds, exclusive of the cost of removing the dirty sand or gravel from the 19 beds, has been as follows: —

Labor,	$2,198 16
Repairs and supplies,	42 15
Total,	$2,240 31
Cost per million gallons filtered,	8 29

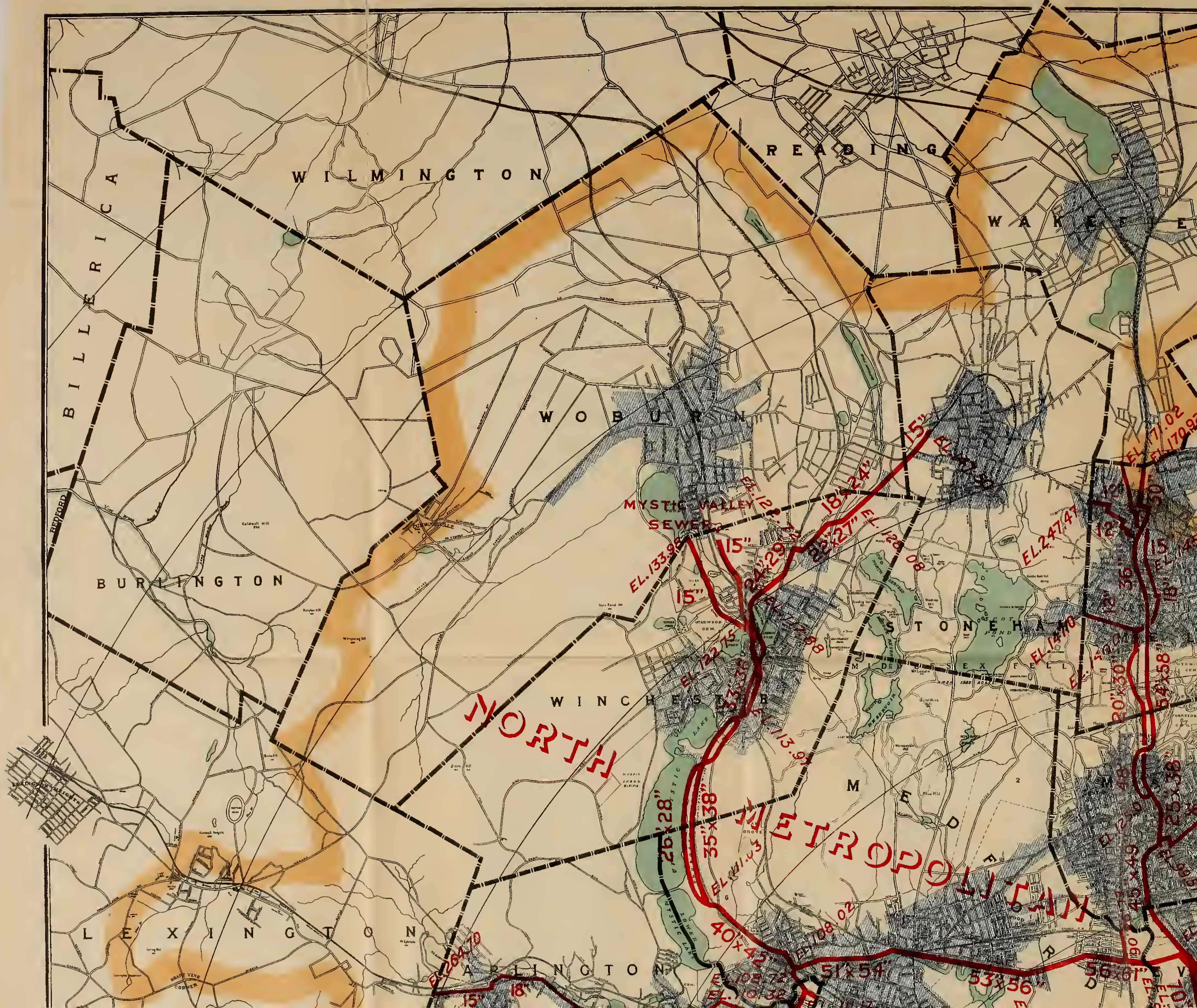
Appended to this report are tables of contracts giving the amount of work done and other information, a statement of the cement tests, a long series of tables relating to the maintenance of the Metropolitan Water Works, tables showing the length of main pipes and number of service pipes, meters and fire hydrants in the Metropolitan Water District, and a summary of statistics for 1904.

Respectfully submitted,

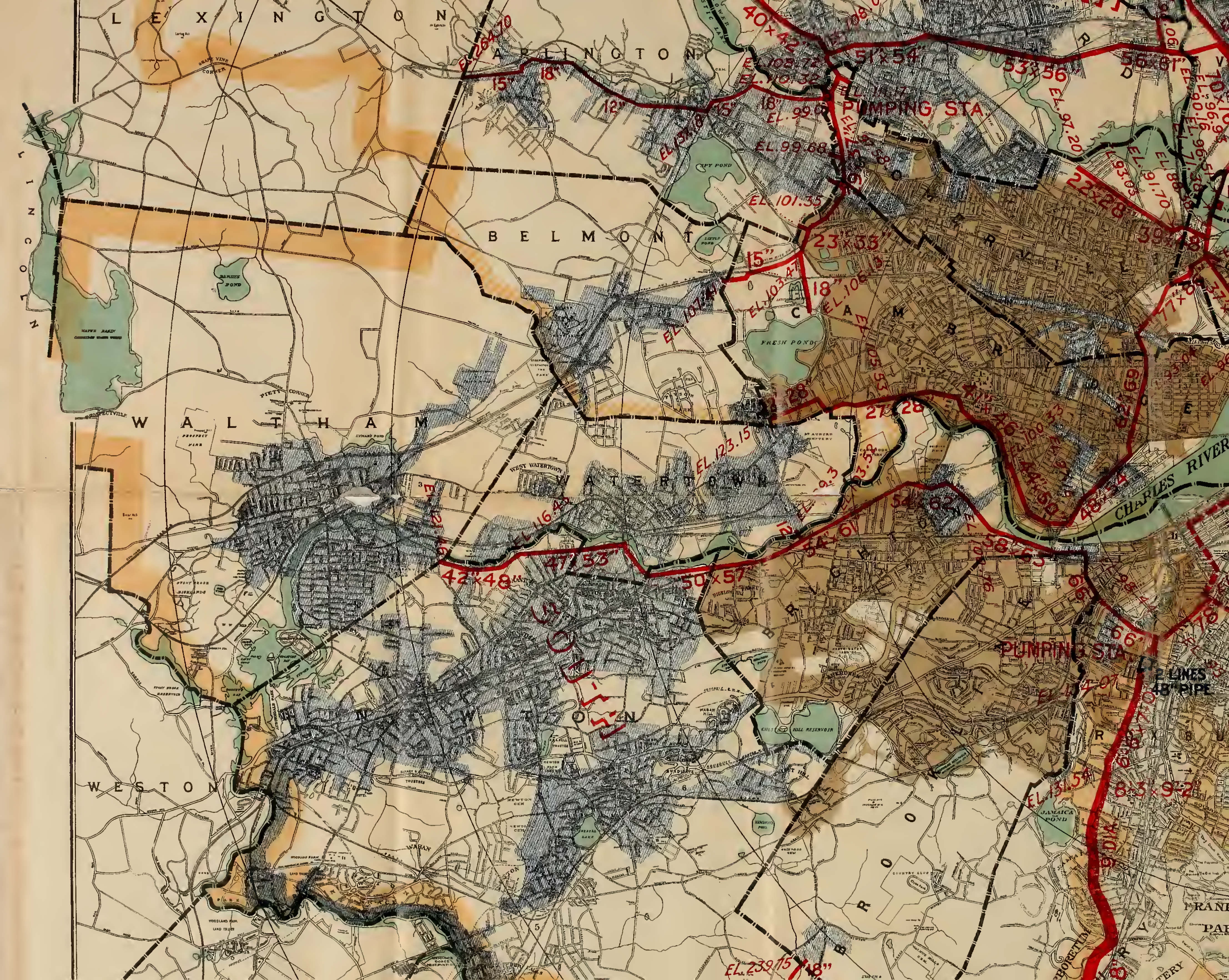
FREDERIC P. STEARNS,
Chief Engineer.

Boston, January 1, 1905.


COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN WATER AND SEWERAGE BOARD
MAP SHOWING
METROPOLITAN
SEWERAGE DISTRICT
January 1, 1905
SCALE OF MILES
SCALE OF METERS
Division Line between North and South Metropolitan Districts indicated thus
Limit of Metropolitan Sewerage District indicated thus
Completed Metropolitan Sewers indicated thus
Proposed Force Mains connecting with High Level Sewer indicated thus
Boston Main Drainage Sewers indicated thus
Areas Sewered by Combined System and Contributing Sewage to Metropolitan Sewers to Date shaded thus
Areas Sewered by Separate System and Contributing Sewage to Metropolitan Sewers to Date shaded thus
AREAS OF SEWERAGE DISTRICT
North Metropolitan Area 91 Sq. Miles
South Metropolitan Area 102 Sq. Miles
Total Area Including Water Surfaces 193 Sq. Miles
NOTE
Elevations are referred to a datum which is 100 64/100 ft. below mean low water of Boston Harbor and 100 ft. below Boston City Base
NORTH METROPOLITAN AREA
SOUTH METROPOLITAN AREA
WILMINGTON
READING
LYNNFIELD
PEABODY
SALEM
MARBLEHEAD
SWAMPSCOTT
LYNN
SAUGUS
WAKEFIELD
WOBURN
BURLINGTON
BILLERICA
STONEHAM
MELROSE
WINCHESTER
MEDFORD
REVERE
NAHANT
LEXINGTON
BELMONT
CHELSEA
WINTHROP
WALTHAM
WESTON
WELLESLEY
NEEDHAM
DEDHAM
HYDE PARK
MILTON
QUINCY
WEYMOUTH
HULL
DOVER
WESTWOOD
NATICK
SOUTH BOSTON
CHARLES RIVER
PUMPING STA.
OUTLET
MOON I.
PEDDOCKS I.
SCREEN HOUSE
MYSTIC VALLEY SEWER
FRANKLIN PARK
10 MILES

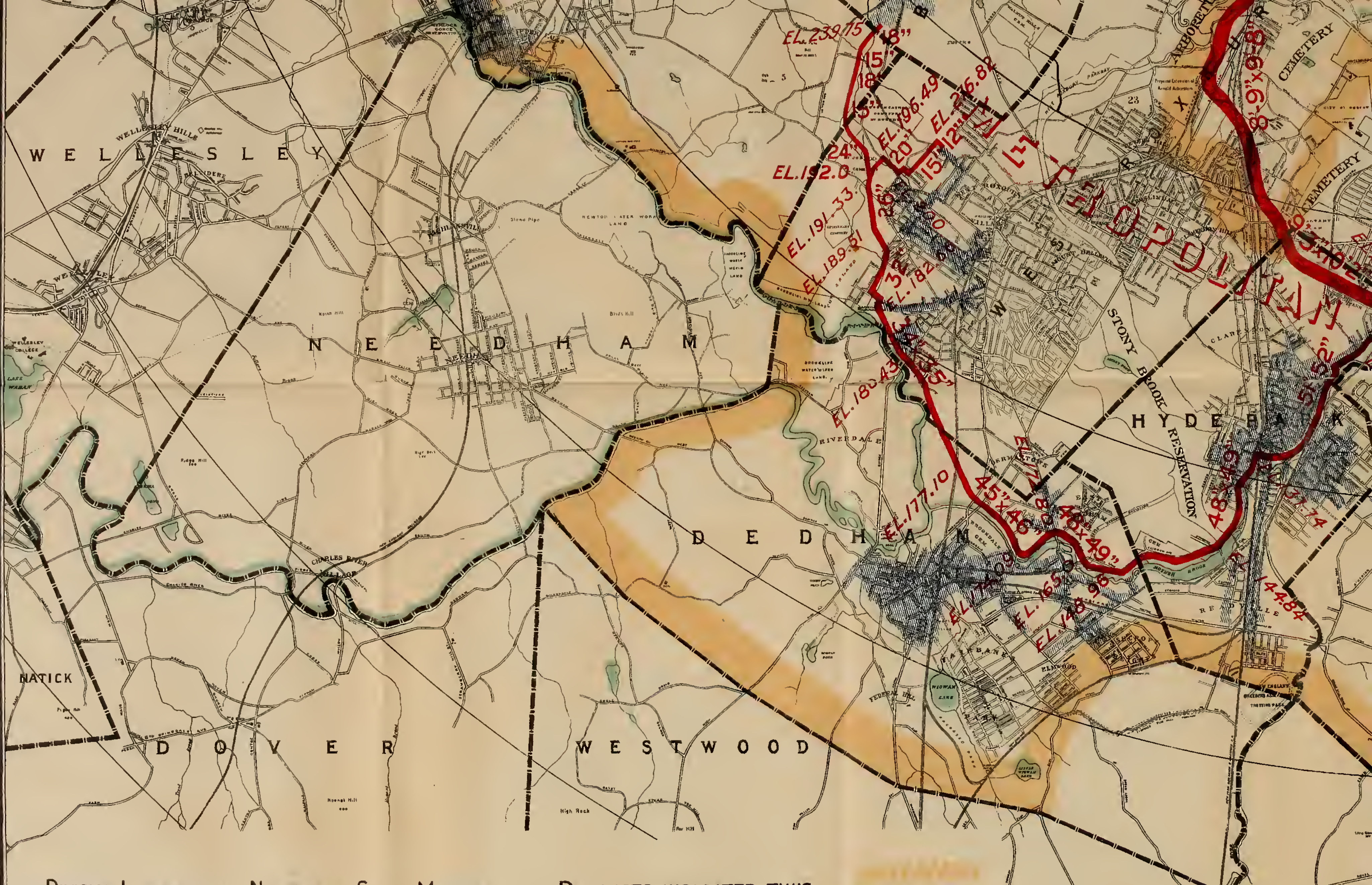

WILMINGTON
BILLERICA
READING
WOBURN
BURLINGTON
BEDFORD
WINCHESTER
STONEHAM
MEDFORD
LEXINGTON
ARLINGTON
NORTH
METROPOLITAN
MYSTIC VALLEY SEWER
MYSTIC LAKE
EL. 133.95
EL. 122.75
EL. 113.97
EL. 111.43
EL. 108.02
EL. 264.70
EL. 247.41
EL. 141.10
EL. 171.02
EL. 128.08
15"
18"x24"
24"x29"
26"x28"
35"x38"
40"x42"
51"x54"
53"x56"
56"x61"

LYNNFIELD
PEABODY
SALEM
MARBLEHEAD
SWAMPSCOTT
LYNN
SAUGUS
NAHANT BAY
LYNN HARBOR
LYNN BEACH
NAHANT
REVERE
BEACHLAND
HOLY CROSS CEMETERY
WOODLAWN CEMETERY
N
EL. 171.02
EL. 170.92
EL. 247.47
EL. 145.63
EL. 141.10
EL. 107.45
EL. 110.60
EL. 123.41
EL. 95.28
EL. 95.0



LEXINGTON
ARLINGTON
BELMONT
LINCOLN
WALTHAM
WATERTOWN
WEST WATERTOWN
NEWTON
WESTON
CAMBRIDGE
SOMERVILLE
BROOKLINE
CHARLES RIVER
PUMPING STA.
PUMPING STA.
FRESH POND
SPY POND
CHESTNUT HILL RESERVOIR
JAMAICA POND
2 LINES 48" PIPE
EL. 264.70
EL. 99.68
EL. 101.35
EL. 123.15
EL. 239.15
51"x54"
53"x56"
40"x42"
22"x28"
23"x33"
42"x48"
47"x53"
50"x57"
54"x61"
15"
18"
12"

PUMPING STA.
PUMPING STA.
PUMPING STA.
PUMPING STA.
WINTHROP
DEER I.
EAST BOSTON
BOSTON HARBOR
GOVERNORS I.
CHARLES RIVER
SOUTH BOSTON
OLD HARBOR
OUTLET
OUTLET
OUTLET
TUNNEL
MOON I.
SPECTACLE ISLAND
RAINSFORD
LOVELLS ISLAND
GALLOPS ISLAND
GEORGES I.
HULL
PEDDOCKS I.
2 LINES 60"C.I. PIPE
NUT I.
SCREEN HOUSE
EL. 110.00
SQUANTUM
NEPONSET RIVER
20" FORCE MAIN
2 LINES 48" PIPE
ROXBURY
FRANKLIN PARK
JAMAICA POND
2 MILES
4 MILES
6 MILES
8 MILES
72"x120"
72"x75"
76"
109"
100"x110"
98"x106"
40"x45"
36"x41"
19"x28"
25"x34"
EL. 94.84
EL. 92.40
EL. 99.85
EL. 98.05
EL. 74.22
EL. 93.37
EL. 88.59
EL. 113.05
EL. 103.29
EL. 104.20
EL. 131.54



Division Line between North and South Metropolitan Districts indicated thus

Limit of Metropolitan Sewerage District indicated thus

Completed Metropolitan Sewers indicated thus

Proposed Force Mains connecting with High Level Sewer indicated thus

Boston Main Drainage Sewers indicated thus

Areas Sewered by Combined System and Contributing Sewage to Metropolitan Sewers to Date shaded thus

Areas Sewered by Separate System and Contributing Sewage to Metropolitan Sewers to Date shaded thus

AREAS OF SEWE

North Metropolitan Area..

South Metropolitan Area..

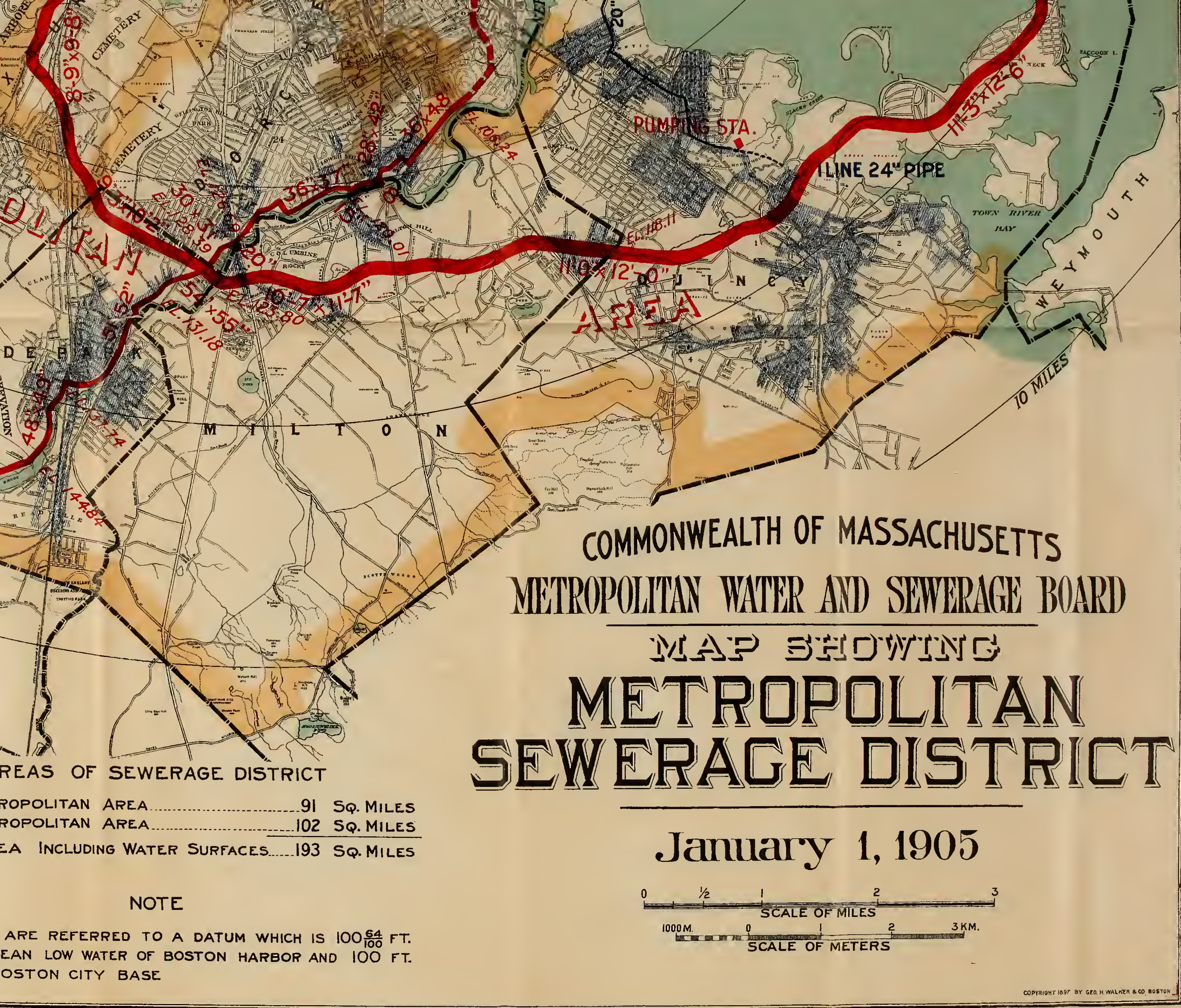
Total Area Including Wat

NO

Elevations are referred to

below mean low water of

below Boston City Base



COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN WATER AND SEWERAGE BOARD
MAP SHOWING
METROPOLITAN SEWERAGE DISTRICT
January 1, 1905
REAS OF SEWERAGE DISTRICT
ROPOLITAN AREA 91 SQ. MILES
ROPOLITAN AREA 102 SQ. MILES
EA INCLUDING WATER SURFACES 193 SQ. MILES
NOTE
ARE REFERRED TO A DATUM WHICH IS 100 64/100 FT.
EAN LOW WATER OF BOSTON HARBOR AND 100 FT.
OSTON CITY BASE
0 ½ 1 2 3
SCALE OF MILES
1000 M. 0 1 2 3 KM.
SCALE OF METERS
COPYRIGHT 1897 BY GEO. H. WALKER & CO. BOSTON
PUMPING STA.
LINE 24" PIPE
MILTON
QUINCY
AREA
WEYMOUTH
TOWN RIVER BAY
10 MILES
11'-3"x12'-6"
11'-9"x12'-0"
EL. 118.11

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, 1904.

ORGANIZATION.

The engineering organization during the year has been 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 of High-level Sewer in Roxbury, and of maintenance and construction, North Metropolitan System.
FRANK A. EMERY, . .	In charge of office, drafting room and records.

In addition to the above, there were employed at the end of the year 8 engineering and other assistants.

METROPOLITAN SEWERAGE DISTRICTS.

Areas and Populations.

During the year no changes have been made in the extent of the sewerage districts. The area of the North Metropolitan District remains at 91 square miles, and of the South Metropolitan District at 102 square miles, — a total, inclusive of water surfaces, of 193 square miles. These districts include 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, 1904.

	City or Town.	Area (Square Miles).		Estimated Population.	
North Metropolitan District.	Arlington,	5.20		10,400	
	Belmont,	4.66		5,200	
	Boston (portions of),	3.45		91,400	
	Cambridge,	6.11		102,200	
	Chelsea,	2.24		38,400	
	Everett,	3.34		30,100	
	Lexington,*	5.11		2,800	
	Malden,	5.07		42,000	
	Medford,	8.35		22,700	
	Melrose,	3.73		14,700	
	Revere,	5.86		13,900	
	Somerville,	3.96		71,700	
	Stoneham,	5.50		6,500	
	Wakefield,	7.65		10,500	
	Winchester,	5.95		8,600	
	Winthrop,	1.61		8,000	
	Woburn,	12.71	90.50	15,400	494,500
South Metropolitan District.	Boston (portions of),	20.92		155,800	
	Brookline,	6.81		25,100	
	Dedham,*	9.40		7,400	
	Hyde Park,	4.57		14,700	
	Milton,	12.59		7,900	
	Newton,	18.03		39,900	
	Quincy,	12.56		28,400	
	Waltham,	13.63		27,600	
	Watertown,	4.04	102.55	11,500	318,300
	Totals,		193.05		812,800

* Part of town.

METROPOLITAN SEWERS.

Sewers Purchased and Constructed and their Connections.

Within the Sewerage Districts there are now 95.55 miles of Metropolitan sewers. Of this total, 8.79 miles of sewers, with the Quincy pumping station, have been purchased from cities and towns of the districts, the remaining 87 miles of Metropolitan sewers having been constructed by the 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, 1904.	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	18	– –	–
Charlestown,	6' 7"×7' 5" to 1',	3.292	13	Navy Yard, Almshouse,	8
Winthrop,	9',	2.864	7	Club house,	1
Chelsea,	8' 4"×9' 2" to 1' 10"×2' 4",	5.123	7	Bakery, Rendering works, Metropolitan Water Works blow-off,	3
Everett,	8' 2"×8' 10" to 4' 8"×5' 1",	2.925	6	Metropolitan Water Works blow-off,	1
Malden,	3' 9"×4' 1" to 1' 3",	3.931*	25	Metropolitan Water Works blow-off,	1
				Private houses,	105
Melrose,	1' 10"×2' 9" to 10",	6.099†	31	Private houses,	100
Cambridge,	5' 2"×5' 9" to 1' 3",	7.167	28	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
				Stable,	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",	6.428	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,	92
Belmont,§	– –	–	3	– –	–
Wakefield,§	– –	–	1	– –	–
Revere,	4' to 3',	.048	1	– –	–
		58.004‖	226		330

* 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, 1904	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†	11	Abattoir,	3
Boston (Dorchester).	3'×4' to 2' 6"×2' 7",	2.870‡	6	– –	3
Boston (Roxbury),	6' 6"×7', 4' 0",	1.430	–	– –	–
Boston (West Roxbury).	9' 3"×10' 2" to 12",	7.011	6	Parental school,	1
				Lutheran Evangelical Church,	1
Brookline,	5' 6",	0.127	2	– –	–
Dedham,	4'×4' 1" to 3' 9"×3' 10",	2.350	4	– –	–
Hull,	60" pipe,	0.750	–	– –	–
Hyde Park,	10' 7"×11' 7" to 4'×4' 1",	4.527	13	Private buildings,	2
Milton,	11'×12' to 8",	3.600	7	– –	–
Newton,	4' 2"×4' 9" to 1' 3",	2.911	6	Private houses,	2
Quincy,	11' 3"×12' 6" to 60" pipe,	6.007	3	– –	–
Waltham,	3' 6"×4',	0.001	1	– –	–
Watertown,	4' 2"×4' 9" to 12",	0.750§	5	Factory,	2
		37.548	72		17

* 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 95 miles of Metropolitan sewers enumerated above, including seven stations, siphons and appertaining structures, may be summarized as follows: —*

North Metropolitan System,	$6,086,569 91
South Metropolitan System,	7,580,262 47
	$13,666,832 38

Construction and Additions during the Year.

The last report indicated that 93.86 miles of Metropolitan sewers had been constructed to December 31, 1903. There has consequently been added, during the year under review, a length of 1.69 miles. This includes 0.48 of a mile of High-level Sewer, authorized by chapter 424 of the Acts of 1899; 0.939 of a mile of sewer, authorized by chapter 242 of the Acts of 1903, to provide sewerage facilities for the town of Revere; 0.248 of a mile of sewer, authorized by chapter 336 of the Acts of 1903, to provide an additional outlet for the

* For detailed statement of cost, see report of Board, p. 52.

sewage of Belmont; and 0.025 of a mile of sewer in Lake Street, Winchester, — 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	494,500	558.18	387,327	78.3	226	330
South Metropolitan System.						
102.55	318,300	406.32	147,761	46.4	72	17
Entire Metropolitan District.						
193.05	812,800	964.50	535,088	65.8	298	347

Of the estimated gross population of 812,800 on December 31, 1904, 535,088, representing 65.8 per cent., were on that date contributing sewage to the Metropolitan sewers, through a total length of 964.5 miles of local sewers owned by the individual municipalities. These sewers are connected with the Metropolitan system by 298 public and 347 special connections. It appears, also, that there has been during the year an increase of 30.4 miles of local sewers connected with Metropolitan systems, and that 24 public and 8 special connections have been added.

Pumping Stations and Pumpage.

The following table shows the average daily volume of sewage lifted at each of the six Metropolitan pumping stations during the year, as compared with corresponding volumes for the previous year: —

Pumping Station.	Average Daily Pumpage.			
	Jan. 1, 1903 to Dec. 31, 1903.	Jan. 1, 1904 to Dec. 31, 1904.	Increase during the Year.	
	Gallons.	Gallons.	Gallons.	Per Cent.
Deer Island,	53,800,000	57,200,000	3,400,000	6.3
East Boston,	51,600,000	55,000,000	3,400,000	6.6
Charlestown,	29,900,000	31,100,000	1,200,000	4.0
Alewife Brook,	3,831,000	3,546,000	285,000*	7.4*
Quincy,	3,042,000	3,651,000	609,000	20.0
Ward Street (from Oct. 14 to Dec. 31, 1904),	-	12,700,000	-	-

* Decrease.

CONSTRUCTION ON THE NORTH METROPOLITAN SYSTEM.

With the completion of the branch sewer to the town of Revere and extension of the Cambridge branch to Belmont, begun in 1903, all Metropolitan sewers on this system authorized to date have been constructed. The Revere extension was opened for service on October 8, and the Belmont extension on July 20, 1904.

Details of the construction are given in the following report.

Extension to Revere.

Section 61, 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 Tunnel Work. — Charles A. Haskin, Boston, Mass.

This section comprises 2,530 linear feet of 54-inch brick sewer and 999 linear feet of 48-inch brick sewer built in open cut, and 608 linear feet of 54-inch brick sewer built in tunnel.

It joins 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 the 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.

At the beginning of the year construction by day work was already in progress, as described in the last report, and about 345 linear feet of 48-inch sewer northerly from the Eastern Division of the Boston & Maine Railroad and 600 linear feet of 54-inch sewer southerly from Bass Creek had been built. This construction was continued at an average rate of 60 linear feet a week until the remaining 2,584 feet of open cut was completed on October 12, 1904. This included portions between the Eastern Division of the Boston & Maine Railroad and Bass Creek, and a length from 600 feet south of Bass Creek to within 608 feet of the end of the section at Marginal Street.

As the construction in open cut approached Marginal Street, quicksand was encountered in the excavation. During the construction of sections 10 and 12 of the North Metropolitan trunk sewer in Marginal Street in 1892–94, difficulties with boiling quicksand occasioned serious delay and expense in the excavation. To avoid similar delay and expense on this work, a contract was arranged on May 3, 1904, with an expert in compressed air construction, and the work for a length of 608 feet north from Marginal Street was carried out by the pneumatic process in tunnel, under an air pressure of 10 pounds per square inch in excess of that of the atmosphere.

The tunnel heading was in fine silt, making it necessary to support the masonry on piling. Piles, in bents of three, about four feet on centres, were driven in advance of the tunnel heading, which was excavated over the top of the piling, and the pile caps, platform and masonry placed in position under compressed air. The masonry cross-section built was similar to that used in the open cut construction. The work was begun on May 26, and an average rate of progress of 65 feet a week was maintained until its completion on August 11, 1904.

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 Tunnel Work. — Charles A. Haskin, Boston, Mass.

This section comprises 2,788 linear feet of 48-inch brick sewer, 1,320 feet in tunnel and 1,468 feet in open cut, beginning on Crescent Avenue, at Eastern Avenue, and running northeasterly across marsh land on the 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.

The construction was fully described in the last report. At the beginning of the year about 540 linear feet in tunnel and about 639 linear feet in open cut had been completed. The work was continued at an average rate of progress of 60 feet a week in open cut and 70 feet in tunnel until its completion on April 1, 1904.

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.

This work was fully described in the last report. It covers a total length of 387 linear feet. The work of construction was continued by the methods outlined in the report until its completion early in June. All piles driven for supporting the coffer-dam were either cut off or pulled, leaving the waterway of Mill Creek unobstructed.

Extension to Belmont.

Section 63, Cambridge.

Division Engineer in Charge. — Frank I. Capen.
Contractor. — Gow & Palmer, Boston, Mass.

This 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.

The construction of this section was fully described in the last report. It comprises 4,780 linear feet of 24-inch by 28-inch and 1,031 linear feet of 22-inch by 28-inch brick sewer in open cut, and about 547 linear feet of 25-inch diameter brick sewer in tunnel. At the beginning of the year about 5,100 linear feet had been completed.

The opening on Mt. Auburn Street at Lowell Street, started on September 17, 1903, was continued until the masonry was completed on March 16, 1904, and the trench partially backfilled; but the remainder of the backfilling was postponed until late in March, when the frost had left the ground.

The tunnel headings, started in December, 1903, were continued until they were completed on March 5, 1904.

CONSTRUCTION ON THE SOUTH METROPOLITAN SYSTEM.

During the year the High-level Sewer, authorized by chapter 424 of the Acts of 1899 and fully described in earlier reports, has been practically completed and put into operation.

At the date of the last report some of the outfall pipes on Section 43 remained to be placed in the harbor. On Nut Island, Section 44, the screen-house and machinery were to be erected, and some filling and grading on the island and the near-by embankments of Section 48 remained to be finished. The connecting chamber at the end of the force-main lines, Section 76, at Parker Hill in Roxbury, remained to be completed, and the Ward Street pumping engines and other machinery to be erected.

The greater part of this work was completed early in the fall, and the pumps at the Ward Street pumping station were started on October 14, since which date the sewage from that portion of the Charles River valley above Vancouver Street, in the Back Bay district of Boston, has been pumped to the High-level Sewer.

This Metropolitan district above Vancouver Street includes most of Brookline, Newton and the Roxbury district of Boston, and the whole of Brighton, Waltham and Watertown. A connection for territory below Vancouver Street leading easterly along Huntington Avenue toward Gainsborough Street, to provide for the sewage of a portion of the Back Bay and Roxbury districts of the city of Boston, remains to be completed. The details of this connection are under discussion with the Charles River Basin Commission and the Sewer Department of the city of Boston. Until this branch is built, the sewage of this small district below Vancouver Street will continue to be pumped by the Boston Main Drainage Works.

On November 22, 1904, the Neponset River valley Metropolitan main sewer was connected with the High-level Sewer at the junction of East River and Monponsett streets, in Hyde Park; and since that date the sewage from Metropolitan territory above this point, including the whole of Hyde Park, Dedham, the West Roxbury district of Boston and part of the town of Brookline, has been disposed of through the High-level Sewer.

The trunk sewer through Quincy and Milton was opened for service on October 14, 1904.

Sewage from the Neponset valley Metropolitan area below Hyde Park, including small portions of Dorchester and Milton, will continue to be discharged through the Boston Main Drainage Works. Sewage from the Quincy pumping station, at present pumped to the Moon Island outlet at Squantum, will be delivered to the High level Sewer through 24-inch force-main pipes to be laid during the coming spring.

A detailed description of the work of the year follows.

Section 43, Quincy and Hull.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — Hiram W. Phillips, Quincy, Mass. (Two contracts.)

The section comprises two lines of 60-inch cast-iron outfall pipes, placed below the bed of Boston harbor, extending northerly from Nut Island to west of Peddocks Island. The two lines have an aggregate length of 10,844 feet.

At the beginning of the year 4,569 feet remained to be placed on the easterly line, and considerable backfilling on both lines. The contractor commenced operations for the season about May 1, and the contract work was completed on November 2, 1904. The method of placing the pipes has been fully described in earlier reports.

During the year the pipe was placed at an average rate of 1,100 feet a month. The maximum rate of 48 feet a day was maintained for nearly the entire season. While the backfilling of the easterly line was in progress, one 48-foot length of pipe was crowded off the pile platform, and had to be replaced by the contractor.

Both lines of pipe were subjected to contract tests for tightness after completion, and were found to satisfy contract requirements.

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.

Early in the year the screen-chamber, sand-catcher and building foundations were completed. About May 1 work on the screen-house chimney was begun. The house was designed by Shepley, Rutan & Coolidge, architects, and is 78 feet long by 60 feet wide and about 40 feet in height. It is built of dark red brick, with rustications of gray headers, with Quincy granite trimmings. It provides a room about 47 by 48 feet for screens and valves; a boiler room 25 by 30 feet; and a coal storage room 25 feet square, providing storage for about 200 tons of coal. In addition, the building contains a large vestibule, office and toilet room. The chimney, about 100 feet high, is placed at the easterly end of the building. The building was completed on October 15, 1904.

In the boiler room are two 80 horse-power, vertical, internally fired, tubular boilers of the Dean type, with shells $80\frac{3}{4}$ inches in diameter, each boiler having 208 tubes, 2 inches in diameter and 10 feet long. These boilers were built by Edward Kendall & Sons, Cambridge, and furnish steam for heating the building and operating the screens in the screen room.

There are four screens, two in each duplicate channel of the screen room. They are about 12 feet square, with clear openings between bars of $\frac{3}{4}$ inch, so that they will intercept practically all the floating matter in the sewage that might be found objectionable in the harbor. They are raised and lowered by small reversing engines of the Fitchburg type. The screens and connections were furnished and erected by the Lockwood Manufacturing Company of East Boston. Matters intercepted on the screens are pressed and afterwards burned under the boilers.

The house and machinery were ready for operation early in October. Considerable grading on Nut Island remains to be completed during the coming year.

Sections 45, 46 and 47, Quincy.

These contracts were completed prior to December 31, 1903.

Filling on Embankment and Completing Rock Island Road, Section 48, Quincy.

Division Engineer in Charge. — Frederick D. Smith.
Contractor. — J. J. Moebs, Boston, Mass.

For completing embankment filling, and loaming and grading the slopes, a contract was arranged early in the year, involving the placing of 6,600 yards of sand filling, 4,400 yards of loam on embankment slopes, and about 670 yards of broken stone over the line of Rock Island Road, so called, passing the embankment. The work of filling and grading commenced about June 10, and was completed about October 15, 1904.

Sections 48 to 75, inclusive.

The work through Quincy, Milton, Hyde Park and Roxbury was completed to the end of the force mains for the Ward Street pumping station at Parker Hill, Roxbury, prior to the beginning of the year, and has been fully described in earlier reports, under sections 48 to 75.

Section 76, Roxbury.

Division Engineer in Charge. — Frank I. Capen.
Contractor. — H. P. Nawn, Boston, Mass.

This section consists of duplicate lines of 48-inch cast-iron force mains and appurtenances, extending from near the Ward Street pumping station to the end of the Section 75 tunnel near the corner of St. Alphonsus and Tremont streets, Roxbury. The easterly line extends through Ward, Phillips, Conant, Oregon, Smith and St. Alphonsus streets, and the westerly through Ward and St. Alphonsus streets.

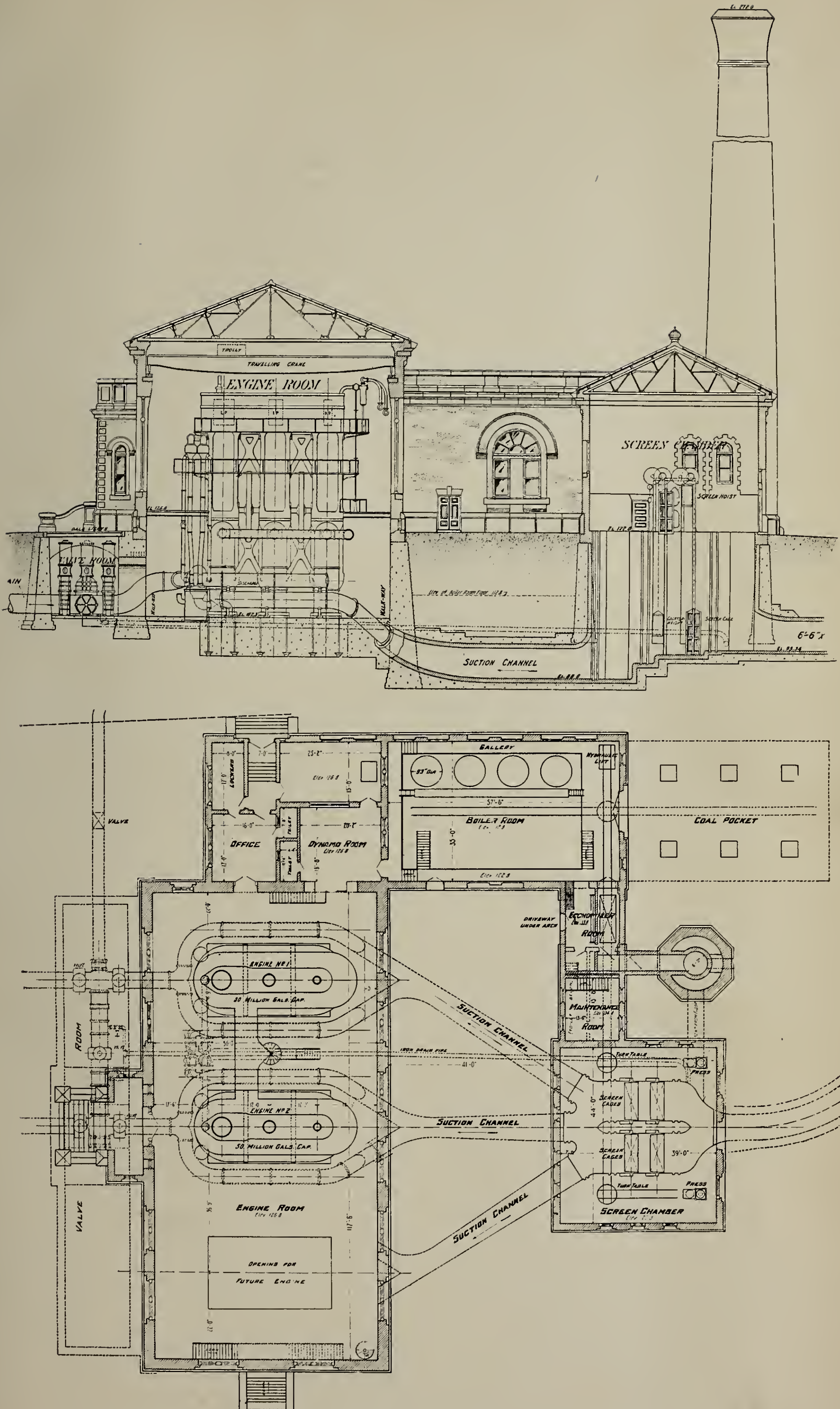
The cast-iron pipe under this contract was all laid last year, as described in the third annual report. At the beginning of the year a small amount of masonry remained to be introduced in the valve-chamber at the upper end of the pipe lines on St. Alphonsus Street. This was completed the latter part of January. During the year controlling valves have been installed in this chamber, and the lines tested for leakage. A pressure of about 60 pounds per square inch, as specified in the contract, was applied to the pipes, which were found sufficiently tight.

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 Ward Street pumping station and its connections with force mains and suction sewer.

The pumping station buildings were described at considerable length in the last annual report. At the beginning of the year the station walls were completed and the roof partially built. The



WARD STREET PUMPING STATION—VERTICAL SECTION AND GROUND PLAN.

engine house roof was finished in January, and the boiler house roof in February.

The interior finish, excepting the basement and engine room floors and the carpenter work at the main entrance on Ward Street, was completed early in May. This main entrance and the basement floor were finished in September, after the heavy parts of the machinery had been moved into the building. Work is now in progress on the finished tile floor in the engine room.

Early in the spring the work of subgrading the grounds and roads about the buildings was carried out by day labor, under the direction of the Engineer.

From April to September the 48-inch controlling valves on the force mains in the station basement, the Venturi meter on the westerly force main, and a 36-inch cast-iron by-pass pipe, extending from the force mains around the station to the suction sewer, were placed by day labor, under the direction of the Engineer.

The Allis-Chalmers Company of Milwaukee, who are furnishing and erecting the pumping engines and steam plant at the station, commenced erection early in January. The plant consists of two 50-million gallon, vertical, triple-expansion pumping engines, with steam cylinders of 21, 38 and 58 inches diameter. The pump plungers are 48 inches in diameter, with 60-inch stroke. The maximum contract lift is 45 feet. The steam is furnished by four 93-inch diameter, internally-fired, vertical tubular boilers of the Dean type, each having 308 tubes, 2 inches in diameter and 15 feet long. It is intended to use two boilers with an engine, and duplicate lines of steam piping have been arranged and installed, so that each boiler can be used with either engine.

For lighting the station, two direct-connected generators, having a capacity of 350 16-candle-power lamps each, were furnished and installed by the American Engine Company of Bound Brook, N. J.

In the screen room are four screens, two in each duplicate channel. They are about 10 feet square, with clear openings between bars of $\frac{3}{4}$ inch, so that they will intercept practically all the floating matters in the sewage that would interfere with the operation of the pumps. These screens are raised and lowered by small reversing engines of the Fitchburg type. The screens and connections were furnished and erected by the Lockwood Manufacturing Company of East Boston.

Engine No. 2 was started first on September 19, and engine No. 1 on September 24. The formal engine tests specified in the contract have not been made, but satisfactory arrangements for the use of these engines prior to their formal test and acceptance have been made by the Board with the contractor, so that the station was put into regular service for the disposal of sewage on October 14.

Connection of Section 78 (Suction Sewer) with the Charles River Valley Sewer at Ruggles Street, Roxbury (Construction by Day Labor).

Division Engineer in Charge. — Frank I. Capen.
Superintendent of Day Labor Construction. — Henry J. Wright.

During the months of July and August the actual connection between Section 78 of the High-level Sewer and Section A of the original Charles River valley main sewer was made at the corner of Vancouver and Ruggles streets. The connection involved the introduction of a bellmouth and valve-chamber along the line of the Charles River sewer. The masonry section involved a 12-inch brick arch and an invert of Portland masonry, reinforced with Portland concrete, the whole supported on a platform and pile foundation.

The chamber introduced provides for turning the sewage flow in the Charles River main sewer either to the Boston Main Drainage Works or to the Metropolitan High-level Sewer.

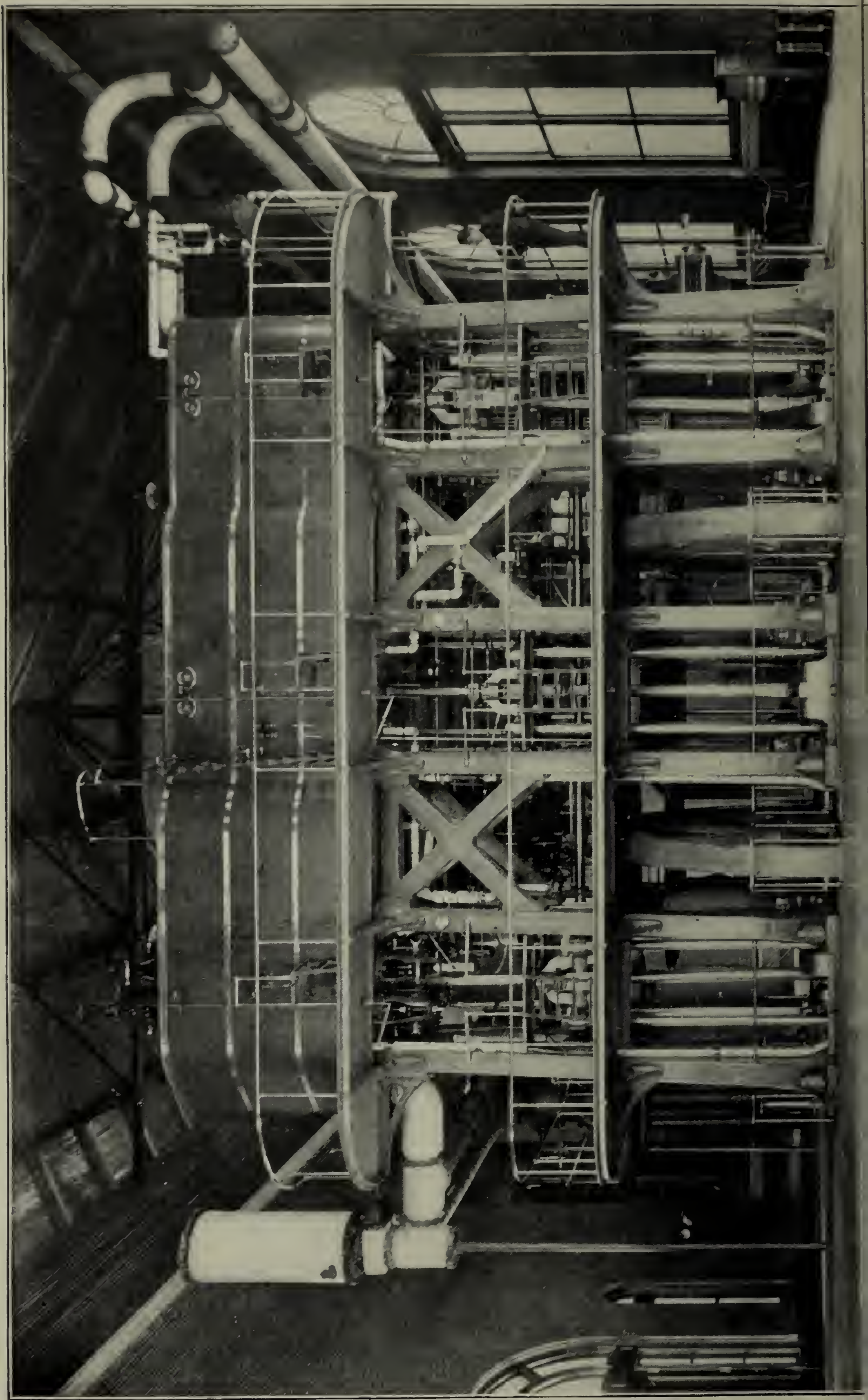
Temporarily during construction the flow in the Charles River sewer was carried across the line of the work in 48-inch cast-iron pipes.

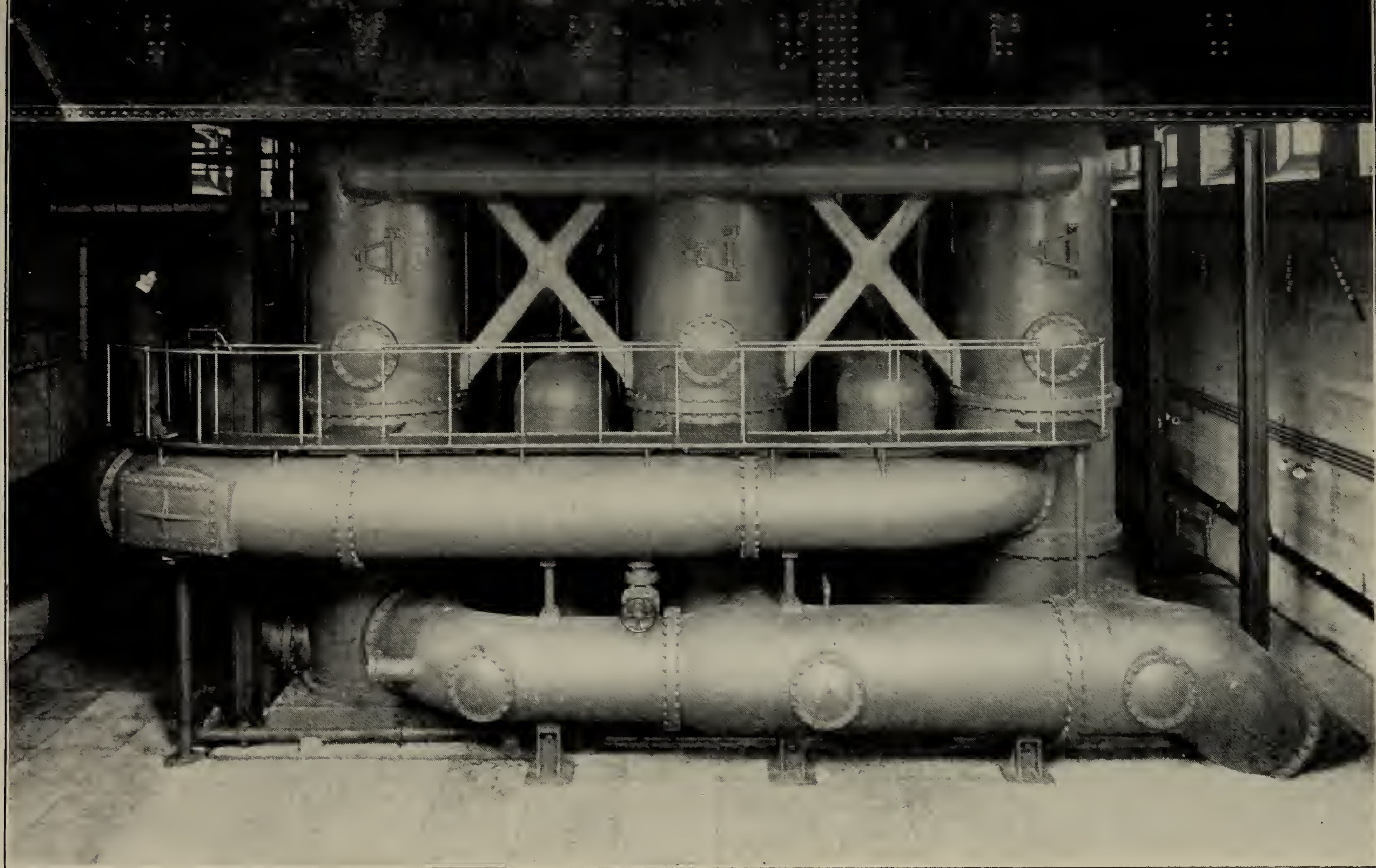
MAINTENANCE.

Scope of Work and Force Employed.

The maintenance of the Metropolitan Sewerage systems includes the operation of seven stations and 95.5 miles of Metropolitan sewers, receiving the discharge from 964.5 miles of town and city sewers at 298 points, together with the care and study of inverted siphons under streams and in the harbor.

The permanent maintenance force of 115 men includes 65 engineers and other employés at the pumping stations, and 50 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: —





PUMPING ENGINE (SHOWING BOTH ENGINE AND PUMPS) AT WARD STREET PUMPING STATION.

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, 1904.]

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, . . .	-	-	1,600†	1,600	-	-	100.0	-
Winthrop, ...	26.80	Separate, . . .	1,706	4.6	7,848	8,000	1.23	1.61	98.1	76.4
Boston (East Boston), .	21.11	Separate and combined,	5,106	8.9	45,443	48,800	0.75	2.18	93.1	34.4
Chelsea, ...	13.12‡	Combined, . . .	1,380	7.2	9,936	38,400	0.68	2.24	25.8	30.4
Everett, ...	40.74	Separate and combined,	3,715	6.3	23,404	30,100	1.77	3.34	77.8	53.0
Malden, ...	47.47	Separate, . . .	4,202	6.3	26,473	42,000	2.54	5.07	63.0	50.1
Melrose, ...	32.57	Separate, . . .	2,277	4.4	10,018	14,700	1.60	3.73	68.2	42.9
Boston (Charlestown), .	21.08	Separate and combined,	5,086	7.9	40,179§	41,000	0.67	1.27	98.0	52.8
Cambridge, ...	117.58	Separate and combined,	14,386	7.0	100,702	102,200	4.94	6.11	98.5	80.9
Somerville, ...	84.60	Separate and combined,	12,784	5.5	70,312	71,700	3.27	3.96	98.0	82.6
Medford, ...	48.39	Separate, . . .	3,116	6.4	19,942	22,700	2.48	8.35	87.8	29.7
Winchester, ...	20.82	Separate, . . .	879	5.6	4,922	8,600	1.05	5.95	57.2	17.6
Woburn, ...	12.34‖	Separate, . . .	875	5.9	5,162	15,400	0.89	12.71	33.5	7.0
Stoneham, ...	10.94	Separate, . . .	497	4.5	2,237	6,500	0.59	5.50	34.4	10.7
Arlington, ...	19.18	Separate, . . .	864	6.6	5,702	10,400	1.63	5.20	54.8	31.3
Belmont, ...	8.66	Separate, . . .	270	7.6	2,497¶	5,200	0.89	4.66	48.0	19.1
Wakefield, ...	10.80	Separate, . . .	285	5.6	1,596	10,500	0.40	7.65	15.2	5.2
Lexington,** . . .	-	- -	-	-	-	2,800	-	5.11	-	-
Revere, ...	21.28	Separate, . . .	1,559	6.0	9,354	13,900	1.31	5.86	67.3	22.4
Totals, . . .	558.18	- -	58,987	6.6	387,327	494,500	26.69	90.50	78.3	29.5

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1904.
† 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.
¶ Including 2 connections with McLean Hospital, having an estimated population of 445.
** Lexington not 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, 1904.]

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,	1,464	15.8	23,131	24,400	1.20	1.61	94.8	74.5
Boston (Brighton),	53.12	Separate and combined,	2,519	5.9	14,862	24,400	3.16	3.74	60.9	84.5
Brookline,	56.67	Separate and combined,	2,958	7.0	20,706	25,100	3.24	6.81	82.5	47.6
Newton,	99.00	Separate,	4,932	6.3	31,072	39,900	6.77	16.88	77.9	40.1
Watertown,	31.30	Separate,	1,574	5.3	8,342	11,500	1.78	4.04	72.5	44.1
Waltham,	38.53	Separate,	2,686	8.9†	23,905	27,600	2.41	13.63	86.6	17.7
Boston (Dorchester),	15.61	Separate and combined,	1,166	6.8	7,929	46,600	0.90	4.89	17.0	18.4
Milton,	6.19	Separate and combined,	94	6.0	564	7,900	0.35	12.59	7.1	2.8
Hyde Park,	18.68	Separate,	799	7.9†	6,312	14,700	0.99	4.57	42.9	21.7
Dedham,	14.11	Separate,	238	5.0	1,190	7,400	0.71	9.40	16.1	7.6
Boston (Roxbury),	-	- -	-	-	-	31,300	-	1.23	-	-
Boston (West Roxbury),	5.62	Separate,	188	7.2	1,354	29,100	0.32	8.92	4.7	3.6
Quincy,	45.52	Separate,	1,499	5.6	8,394	28,400	2.27	12.56	29.6	18.1
Totals,	406.32	- -	20,117	7.3	147,761	318,300	24.10	100.87	46.4	23.9

* Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1900 extended to 1904.

† 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, 1904.]

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,	558.18	Separate and combined,	58,987	6.6	387,327	494,500	26.69	90.50	78.3	29.5
South Metropolitan,	406.32	Separate and combined,	20,117	7.3	147,761	318,300	24.10	100.87	46.4	23.9
Totals,	964.50	-	79,104	6.8	535,088	812,800	50.79	191.37	65.8	26.5

CAPACITY AND RESULTS.

The following tables summarize the pumping records for the year for the Metropolitan stations: —

NORTH METROPOLITAN SYSTEM.

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: 45,900,000 foot-pounds.
Average quantity raised each day: 57,200,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.45 to $3.90 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).
1904.						
January,	1,603,900,000	51,700,000	40,600,000	90,400,000	10.74	44,000,000
February,	1,630,100,000	56,200,000	46,200,000	87,300,000	10.88	45,000,000
March,	2,462,700,000	79,400,000	61,100,000	124,800,000	11.72	51,900,000
April,	2,407,400,000	80,200,000	52,600,000	145,000,000	11.77	57,100,000
May,	2,458,800,000	79,300,000	60,600,000	119,200,000	11.66	57,800,000
June,	1,624,500,000	54,200,000	43,100,000	72,400,000	10.55	44,700,000
July,	1,492,900,000	48,200,000	40,800,000	58,100,000	10.60	41,200,000
August,	1,364,400,000	44,000,000	36,600,000	57,800,000	10.11	41,200,000
September,	1,423,600,000	47,500,000	37,300,000	89,800,000	10.10	42,500,000
October,	1,390,700,000	44,900,000	37,300,000	65,300,000	10.21	41,300,000
November,	1,447,600,000	48,300,000	42,600,000	74,600,000	10.50	40,900,000
December,	1,613,400,000	52,000,000	44,900,000	92,700,000	10.84	43,600,000
Total,	20,920,000,000	-	-	-	-	-
Average,	-	57,200,000	45,300,000	89,800,000	10.81	45,900,000

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 10-foot lift.
Average duty for the year: 56,000,000 foot-pounds.
Average quantity raised each day: 55,000,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first-quality Cumberland, costing from $3.30 to $3.90 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).
1904.						
January,	1,541,900,000	49,700,000	38,600,000	88,400,000	15.19	52,600,000
February,	1,572,100,000	54,200,000	44,200,000	85,300,000	15.31	50,500,000
March,	2,400,700,000	77,400,000	59,100,000	122,800,000	15.51	58,800,000
April,	2,347,400,000	78,200,000	50,600,000	143,000,000	15.53	61,100,000
May,	2,396,800,000	77,300,000	58,600,000	117,200,000	15.57	60,500,000
June,	1,564,500,000	52,200,000	41,100,000	70,400,000	15.27	57,200,000
July,	1,375,900,000	44,400,000	37,800,000	53,100,000	15.17	54,400,000
August,	1,297,400,000	41,900,000	34,600,000	55,800,000	15.26	56,600,000
September,	1,363,600,000	45,500,000	35,300,000	87,800,000	16.13	55,300,000
October,	1,328,700,000	42,900,000	35,300,000	63,300,000	16.14	55,100,000
November,	1,387,600,000	46,300,000	40,600,000	72,600,000	16.29	56,200,000
December,	1,551,400,000	50,000,000	42,900,000	90,700,000	16.34	53,100,000
Total,	20,128,000,000	-	-	-	-	-
Average,	-	55,000,000	43,200,000	87,500,000	15.64	56,000,000

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: 43,200,000 foot-pounds.
Average quantity raised each day: 31,100,000 gallons.
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.
Coal used: first quality Cumberland, costing from $3.45 to $4.38 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).
1904.						
January,	1,000,600,000	32,300,000	26,600,000	48,600,000	8.05	40,900,000
February,	966,100,000	33,300,000	28,300,000	49,300,000	8.07	42,100,000
March,	1,198,800,000	38,700,000	31,300,000	57,900,000	8.43	51,100,000
April,	1,161,000,000	38,700,000	29,200,000	64,000,000	8.43	52,900,000
May,	1,171,000,000	37,800,000	31,300,000	51,800,000	8.38	53,900,000
June,	875,800,000	29,200,000	24,500,000	34,500,000	7.84	39,600,000
July,	865,000,000	27,900,000	24,200,000	34,400,000	7.77	39,000,000
August,	858,700,000	27,700,000	24,200,000	36,200,000	7.72	41,200,000
September,	842,000,000	28,100,000	22,800,000	49,000,000	7.75	42,300,000
October,	765,500,000	24,700,000	20,800,000	34,400,000	7.97	36,900,000
November,	786,800,000	26,200,000	23,200,000	39,300,000	7.81	39,200,000
December,	902,700,000	29,100,000	24,200,000	46,700,000	7.85	39,800,000
Total,	11,394,000,000	-	-	-	-	-
Average,	-	31,100,000	25,900,000	45,500,000	8.01	43,200,000

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: 17,900,000 foot-pounds.
Average quantity raised each day: 3,546,000 gallons.
Force employed: 3 engineers.
Coal used: first quality Cumberland, costing from $3.71 to $4.73 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).
1904.						
January,	110,062,000	3,550,000	2,692,000	7,167,000	12.96	18,200,000
February,	116,379,000	4,013,000	2,881,000	7,580,000	12.98	20,400,000
March,	183,565,000	5,921,000	3,968,000	8,996,000	12.49	24,400,000
April,	156,351,000	5,212,000	3,788,000	9,173,000	12.41	22,200,000
May,	158,906,000	5,126,000	3,380,000	7,875,000	12.45	22,100,000
June,	101,217,000	3,374,000	2,598,000	4,677,000	12.83	16,600,000
July,	84,397,000	2,723,000	1,994,000	4,027,000	13.15	16,100,000
August,	69,408,000	2,239,000	1,545,000	3,526,000	13.25	13,800,000
September,	81,272,000	2,709,000	1,616,000	6,400,000	13.25	15,800,000
October,	74,171,000	2,393,000	1,868,000	3,574,000	13.23	14,300,000
November,	74,625,000	2,487,000	2,120,000	4,554,000	13.25	14,600,000
December,	86,766,000	2,799,000	2,414,000	6,335,000	13.29	15,900,000
Total,	1,297,119,000	-	-	-	-	-
Average,	-	3,546,000	2,572,000	6,157,000	12.96	17,900,000

South Metropolitan System.

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: 36,400,000 foot-pounds.
Average quantity raised each day: 3,651,000 gallons.
Force employed: 3 engineers and 1 screenman.
Coal used: first-quality Cumberland, costing from $4.20 to $5.04 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).
1904.						
January,	81,296,000	2,622,000	2,291,000	3,182,000	36.32	29,900,000
February,	98,621,000	3,401,000	2,591,000	5,427,000	37.73	35,500,000
March,	177,415,000	5,723,000	4,675,000	8,391,000	36.12	40,500,000
April,	161,500,000	5,383,000	4,608,000	8,367,000	36.62	43,200,000
May,	185,903,000	5,997,000	5,080,000	7,654,000	39.25	43,500,000
June,	131,342,000	4,378,000	2,900,000	5,227,000	33.84	42,200,000
July,	96,760,000	3,121,000	2,480,000	4,419,000	36.10	35,900,000
August,	80,153,000	2,586,000	2,347,000	3,157,000	36.50	34,200,000
September,	80,270,000	2,675,000	2,225,000	3,882,000	35.90	34,200,000
October,	80,113,000	2,584,000	2,396,000	3,527,000	36.19	32,800,000
November,	84,070,000	2,712,000	2,533,000	3,605,000	36.04	32,500,000
December,	81,367,000	2,625,000	2,059,000	3,132,000	37.72	32,900,000
Total,	1,338,810,000	-	-	-	-	-
Average,	-	3,651,000	3,015,000	4,998,000	36.53	36,400,000

Ward Street Pumping Station.

At this station are two vertical, triple-expansion pumping engines, of the Allis-Chalmers type, operating reciprocating pumps, the plungers of which are 48 inches in diameter with a 60-inch stroke.

Contract capacity of pumps: 50,000,000 gallons each, with 45-foot lift.
Average quantity raised each day from October 14, 1904 to December 31, 1904: 12,700,000 gallons.

Table of Approximate Quantities at the Ward Street Pumping Station of the South Metropolitan System.

Months.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).
1904.				
October,*	183,900,000	10,200,000	6,900,000	13,500,000
November,	406,700,000	13,600,000	7,900,000	27,500,000
December,	412,300,000	13,300,000	10,800,000	23,100,000
Total,	1,002,900,000	-	-	-
Average,	-	12,700,000	8,500,000	21,400,000

* From October 14 only.

In the following tables the total cost of pumping and the rate per million foot-gallons at each of five pumping stations are shown in detail: —

Average Cost per Million Foot-gallons for Pumping at the Deer Island Station.

Volume (20,920 Million Gallons) × Lift (10.81 Feet) = 226,145 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$11,368 51	$0.05027
Coal,	7,330 20	.03241
Oil,	192 02	.00085
Waste,	74 47	.00033
Water,	1,209 60	.00535
Packing,	72 30	.00032
Miscellaneous supplies and renewals,	916 44	.00405
Totals,	$21,163 54	$0.09358

Average Cost per Million Foot-gallons for Pumping at the East Boston Station.

Volume (20,128 Million Gallons) × Lift (15.64 Feet) = 314,802 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$10,550 24	$0.03351
Coal,	7,997 52	.02540
Oil,	253 77	.00081
Waste,	55 77	.00018
Water,	940 80	.00299
Packing,	11 78	.00004
Miscellaneous supplies and renewals,	536 89	.00171
Totals,	$20,346 77	$0.06464

Average Cost per Million Foot-gallons for Pumping at the Charlestown Station.

Volume (11,394 Million Gallons) × Lift (8.01 Feet) = 91,266 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$9,985 88	$0.10942
Coal,	3,156 35	.03458
Oil,	171 30	.00188
Waste,	70 49	.00077
Water,	410 40	.00449
Packing,	76 77	.00084
Miscellaneous supplies and renewals,	669 51	.00734
Totals,	$14,540 70	$0.15932

Average Cost per Million Foot-gallons for Pumping at the Alewife Brook Station.

Volume (1,297.119 Million Gallons) × Lift (12.96 Feet) = 16,811 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$3,377 09	$0.20089
Coal,	1,630 38	.09698
Oil,	110 91	.00659
Waste,	40 57	.00241
Water,	242 40	.01442
Packing,	19 77	.00118
Miscellaneous supplies and renewals,	447 76	.02664
Totals,	$5,868 88	$0.34911

Average Cost per Million Foot-gallons for Pumping at the Quincy Station.

Volume (1,338.81 Million Gallons) × Lift (36.53 Feet) = 48,907 Million Foot-gallons.

Items.	Cost.	Cost per Million Foot-gallons.
Labor,	$3,888 97	$0.07952
Coal,	2,583 85	.05283
Oil,	26 95	.00055
Waste,	10 43	.00021
Water,	201 86	.00413
Packing,	39 84	.00082
Miscellaneous supplies and renewals,	633 15	.01294
Totals,	$7,385 05	$0.15100

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 2,084 cubic yards during the year. This is equivalent to about 2.7 cubic feet for each million gallons of sewage pumped at Deer Island.

Care of Special Structures.

During the year the wharf at Deer Island has been reinforced with 50 new oak piles, and some of the stringers and a portion of the planking have also been renewed. The cast-iron water piping in the grounds about the pumping station has been extended during the year to improve the fire protection at the dwelling house and lockers, involving the placing of about 1,000 feet of 4-inch and 6-inch pipe and 2 hydrants. About 400 tons of riprap have been deposited on Deer Island bar over the line of the outfall sewer.

Heavy riprap has been placed on the earth slopes about the shore structures at both ends of the Malden River siphon, and the embankment over the sewer across the marsh on the Everett side of the siphon has been repaired. This work has involved the placing of 500 tons of stone.

The sewage flow in the old Mystic valley sewer in Winchester has at times surcharged the sewer, so that it has been found desirable to connect the Cummingsville branch, Section 47, with the low-level sewer, Section 44, built in 1893. This connection was made by the maintenance force during the year. About 130 feet of 18-inch Akron pipe, reinforced with concrete, were laid at an average depth of 10 feet from near the junction of Lake and Main streets, through Lake Street, to the lower end of the siphon under the Wedge Pond culvert. The siphon is thus abandoned and a free outlet at a lower level obtained for the Cummingsville branch, thereby to a great extent relieving the old Mystic valley sewer.

Studies of sewage flow in the Metropolitan sewers, siphons and outfall pipes indicate freedom from deposits and satisfactory conditions in general.

FUTURE EXTENSION OF THE METROPOLITAN SEWER INTO THE HIGHER TERRITORY OF BROOKLINE, BRIGHTON AND NEWTON.

The Board was directed, by chapter 230 of the legislative Acts of 1904, "to determine the location, elevation and size of the Metropolitan High-level Sewer above the point where the sewage from the Charles River valley is to be received."

South Metropolitan System.

Chapter 424 of the legislative Acts of 1899 constituted the South Metropolitan System by combining the original Charles River Metropolitan district, the original Neponset valley Metropolitan district, the city of Quincy, and parts of the Dorchester, Roxbury and West Roxbury districts of the city of Boston. The system as at present constituted provides for the drainage of 102 square miles of Metropolitan territory in Suffolk, Norfolk and Middlesex counties, and includes the whole or parts of 9 cities and towns, having a present population of 318,000, as set forth in the following table, and outlined on the general map accompanying this report: —

Table No. 1. — *Showing Areas and Populations in South Metropolitan District December 31, 1904.*

City or Town.	Area (Square Miles).	Population, December 31, 1904.
Boston (portions of),	20.92	155,800
Brookline,	6.81	25,100
Dedham,*	9.40	7,400
Hyde Park,	4.57	14,700
Milton,	12.59	7,900
Newton,	18.03	39,900
Quincy,	12.56	28,400
Waltham,	13.63	27,600
Watertown,	4.04	11,500
Totals,	102.55	318,300

* Part of town.

The higher portions of this district, embracing an area of 64 square miles, with a present population of 179,000, are at sufficient elevation to permit their sewage to be collected in a trunk sewer and conveyed by gravity to an outlet in the harbor. The sewage from the 39 square miles of lower territory, with a present population of 139,000, will always need to be pumped. This division of the South Metropolitan territory into high-level and low-level sections is outlined on the general map and set forth in the following tables: —

TABLE No. 2. — *Showing Area of South Metropolitan District that may be drained by Gravity, with Estimated Population December 31, 1904.*

CITY OR TOWN.	Area (Square Miles).	Population, December 31, 1904.
Boston,	15.09	103,400
Brookline,	5.49	13,100
Dedham,*	9.40	7,400
Hyde Park,	4.57	14,700
Milton,	11.50	7,200
Newton,	13.35	25,700
Quincy,	4.30	8,000
Totals,	63.70	179,500

* Part of town.

TABLE No. 3. — *Showing Area of South Metropolitan District the Sewage from which will require Pumping, with Estimated Population December 31, 1904.*

CITY OR TOWN.	Area (Square Miles).	Population, December 31, 1904.
Boston,	5.83	52,400
Brookline,	1.32	12,000
Milton,	1.09	700
Newton,	4.68	14,200
Quincy,	8.26	20,400
Waltham,	13.63	27,600
Watertown,	4.04	11,500
Totals,	38.85	138,800

The High-level Sewer.

Chapter 424 of the Acts of 1899 further authorized the construction and operation of a main sewer and appurtenances, known as the High-level Sewer, for the disposal of sewage from this South Metropolitan area by gravity. This trunk sewer has been under construction for the past four years, and has but recently been completed and put into operation. It is designed to receive and carry by gravity the sewage from the 64 square miles of high-level territory outlined in Table No. 2. Sewage from the original Charles River district is at present lifted to it by pumps at a station on Ward Street in Roxbury. The sewage of parts of the city of Quincy will be pumped to it at a station in Merrymount Park in that city. A small district of about 2 square miles, from which sewage may eventually be raised to the High-level Sewer, includes portions of Dorchester and Milton, extending from Hyde Park to Granite Bridge. It is at present tributary to the lower portion of the original Neponset valley Metropolitan sewer, and will probably continue to discharge into the Boston Main Drainage Works for some years.

The High-level Sewer, so far as authorized by legislative acts and already constructed and in operation, has a length of about 17 miles, extending from the Ward Street pumping station in Roxbury to an outlet in the outer harbor a mile below Nut Island in Quincy. The outfall works involve two lines of 60-inch cast-iron pipe laid below the bed of the harbor, from the outlet to Nut Island. A screen-house, sand-catcher and gate-chamber for regulating the sewage flow are located on the island. At this point the sewer is about 11 feet wide and 12 feet high. Its invert, by the Metropolitan Sewerage base, which is 100 feet below the city of Boston base, is at elevation 110, or mean high water of the harbor. It extends through Quincy, follows along Unkety and Pine Tree Brook valleys in Milton to Hyde Park, thence passing through the Neponset-Stony Brook divide, along the westerly side of the Stony Brook valley to near the easterly side of Jamaica Pond, at the junction of Perkins and Centre streets in Jamaica Plain, where a branch has been left for future extension of the works into the higher territory of Brookline, Brighton and Newton. At this point it is about 9 feet in diameter, and its invert elevation is about

131.5 feet, or 21.5 feet above mean high water of the harbor. From here the sewer is 6 feet 6 inches wide and 7 feet high, and extends northerly through Parker Hill to near the junction of St. Alphonsus and Smith streets in Roxbury, connecting with two 48-inch force mains from the Ward Street pumping station, which convey to it the sewage from the original Charles River main sewer. A detailed description of this construction is given in the eleventh and twelfth reports of the Metropolitan Sewerage Commission and the first to fourth reports of the Metropolitan Water and Sewerage Board.

Present Need of defining Location for Extension of High-level Sewer.

Section 8 of chapter 424 of the Acts of 1899 provides that only separate sewage from new districts shall be received into the High-level Sewer. Chapter 383 of the Acts of 1903 requires that "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." Chapter 465 of the Acts of 1903 provides for a park basin in the Charles River valley above Craigie Bridge. All these facts foreshadow an early construction of separate systems of sewerage by municipalities of the South Metropolitan District which at present have combined sewers.

The town of Brookline and the Back Bay, Brighton, Roxbury, West Roxbury and Dorchester districts of the city of Boston are now largely sewered on the combined system. To proceed intelligently with the design for separate systems of sewerage for these districts requires detailed information relating to the future extension of the High-level Sewer. Studies to develop this information are authorized by the recent legislative action (chapter 230, Acts of 1904), directing the Board to define the location and size of this extension.

District Involved in Study for Extension of the High-level Sewer.

Metropolitan areas that may be traversed by this extension are set forth in the following table: —

TABLE NO. 4. — *Showing Areas Involved in Study for Extension of the High-level Sewer above Jamaica Plain.*

CITY OR TOWN.	Area (Square Miles).	CITY OR TOWN.	Area (Square Miles).
Boston: —		Newton,	18.03
Back Bay district,	1.61	Waltham,	13.63
Brighton district,	4.27	Watertown,	4.04
West Roxbury (part of),	0.18	Total,	48.57
Brookline,	6.81		

Anticipated Volume of Sewage.

To determine the size for the extension of this sewer through the territory set forth above involves certain approximations of the volume of sewage to be anticipated in future years. In public works of this character provision is usually made for a generation. The High-level Sewer already constructed was intended to provide for anticipated conditions in the year 1940, and it would seem proper to provide for this extension to the same date. Sewage which reaches an intercepting sewer of this character is made up largely of public and private water supplies, leakage of ground water into the sewer, and a small amount of surface water. It is usual to estimate its volume by a per capita rate.

Population.

Several forecasts of population on Metropolitan areas have been prepared by the engineers of the Metropolitan Water Board, Metropolitan Sewerage Commission and State Board of Health. There is a substantial agreement in all these forecasts, and the populations adopted for this study and set forth in the following table are as liberal as any that have been suggested.

TABLE NO. 5. — *Forecasts of Populations for Areas Involved in Studies for the Extension of the High-level Sewer above Jamaica Plain, from A.D. 1905 to 1940.*

City or Town.	Estimated Populations.							
	1905.	**1910.**	**1915.**	**1920.**	**1925.**	**1930.**	**1935.**	**1940.**
Boston: —								
Back Bay district,	24,400	28,000	31,000	34,500	39,000	45,000	52,000	60,000
Brighton district,	24,400	31,000	38,200	47,100	57,100	68,000	80,000	93,000
West Roxbury (part of),	350	550	850	1,250	1,700	2,200	2,800	3,500
Brookline,	25,100	32,500	41,000	50,000	61,000	73,000	86,000	101,000
Newton,	39,900	52,500	66,000	80,000	95,000	111,000	127,000	144,000
Waltham,	27,600	34,000	40,800	49,000	58,800	69,000	79,000	89,000
Watertown,	11,500	14,500	17,500	21,000	25,500	30,500	36,000	42,000
Totals,	153,250	193,050	235,350	282,850	338,100	398,700	462,800	532,500

A subdivision of these populations has been prepared, indicating what may be anticipated on areas drained by gravity, and what may be assumed to be permanently tributary to the low-level system, as set forth in the following table: —

TABLE NO. 6. — *Population in High-level and Low-level Areas Involved in Studies for the Extension of the High-level Sewer above Jamaica Plain, from A.D. 1905 to 1940.*

[Parts of Brookline and Newton are permanently tributary to the Neponset valley and existing High-level Sewer, and anticipated populations in such areas are not included in this table.]

City or Town.	Estimated Populations.															
	1905.		1910.		1915.		1920.		1925.		1930.		1935.		1940.	
	High Level.	Low Level.	High Level.	Low Level.	High Level.	Low Level.	High Level.	Low Level.	High Level.	Low Level.	High Level.	Low Level.	High Level	Low Level.	High Level.	Low Level.
Boston: —																
Back Bay District,	-	24,400	-	28,000	-	31,000	-	34,500	-	39,000	-	45,000	-	52,000	-	60,000
Brighton,	7,500	16,900	9,500	21,500	11,600	26,600	14,500	32,600	17,500	39,600	20,500	47,500	24,000	56,000	27,500	65,500
West Roxbury (part of),	350	-	550	-	850	-	1,250	-	1,700	-	2,200	-	2,800	-	3,500	-
Brookline,	12,300	12,000	17,000	14,000	22,500	16,000	28,000	18,500	35,000	21,500	42,000	25,000	50,000	28,500	58,500	33,000
Newton,	25,200	14,200	33,500	18,000	41,500	22,500	50,000	27,000	58,500	32,000	68,000	37,000	77,500	42,500	88,000	48,000
Waltham,	-	27,600	-	34,000	-	40,800	-	49,000	-	58,800	-	69,000	-	79,000	-	89,000
Watertown,	-	11,500	-	14,500	-	17,500	-	21,000	-	25,500	-	30,500	-	36,000	-	42,000
Total high level,	45,350	-	60,550	-	76,450	-	93,750	-	112,700	-	132,700	-	154,300	-	177,500	-
Total low level,	-	106,600	-	130,000	-	154,400	-	182,600	-	216,400	-	254,000	-	294,000	-	337,500

From this table it appears that the total present population on areas tributary by gravity to an extension of the High-level Sewer may be 45,350, and that in 1940 it may have increased to 177,500; and that the present population on the low-level pumped area may be 106,600, and in 1940 may have increased to 337,500.

Per Capita Rate to be used in Determining Size of Sewer.

The amount of sewage per capita to be provided for in the earlier years in the district under discussion may be judged practically from the Boston Main Drainage and the Metropolitan Sewerage Works, which have both been in operation many years. The latter receives sewage from areas sewered about equally on the separate and combined systems, not unlike the present condition of the territory to be traversed by the proposed extension of the High-level Sewer. In 1898 an extended study was prepared by the Engineer of the Metropolitan Sewerage Works, involving a comprehensive review of volumes of sewage from both works. Per capita rates deduced from that study and adopted for the High-level Sewer already built, designed ultimately to receive sewage from separate sewers only, are as follows: —

	1905.	1940.
Yearly average flow of sewage,	147	175
Maximum dry weather flow,	165	200
Maximum flow during storms,	251	300

Studies of sewage flows in Metropolitan sewers since 1898 indicate that the above conclusions from earlier studies are fully justified.

This extension of the High-level Sewer above Jamaica Plain is to receive sewage from cities and towns that are now or in the near future probably will be sewered on the separate system, from which practically all surface waters will be excluded. The present water supply of many of these cities and towns is comparatively small, not more than one-half of the average water supply of the whole Metropolitan District which was involved in establishing the above rates, so that 300 gallons per capita might appear unnecessarily liberal for fixing the size of this extension. Some of the municipalities, however, are already provided with separate sewers designed on a rate exceeding 200 gallons per capita when running full, and many of these local sewers are now occasionally surcharged. This sewer will be located at considerable distance inland from the Charles River, so that occasional overflows into the river cannot be provided to relieve any future lack of capacity. It is also possible that in the future a larger area and population than now studied may be made tributary to this extension.

The increased sizes of sewer resulting from this liberal rate per capita will add but a small percentage to the cost of the work. There is a persistent increase in water consumption in the whole Metropolitan District. Population is advancing at phenomenal and unanticipated rates, particularly in the outlying sections to be traversed by this extension, and all experience gained from the operation of the Metropolitan Works dictates the most liberal treatment for extensions into outlying territory. The rates already adopted for the earlier high-level construction and set forth above are therefore felt to be justified for this extension and have been adopted in this study.

The volume of sewage estimated from the before-mentioned rates of flow per capita and the population given in the tables is set forth in Table No. 7 : —

TABLE NO. 7. — *Showing Daily Volume of Sewage Anticipated from High and Low Level Territory Involved in Study for Extension of High-level Sewer above Jamaica Plain, from 1905 to 1940.*

[In Gallons.]

City or Town.	1905.						1910.					
	High Level.			Low Level.			High Level.			Low Level.		
	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.
Boston: —												
Back Bay district,	-	-	-	3,587,000	4,026,000	6,124,000	-	-	-	4,228,000	4,760,000	7,224,000
Brighton,	1,102,000	1,237,000	1,882,000	2,484,000	2,789,000	4,242,000	1,434,000	1,615,000	2,451,000	3,246,000	3,655,000	5,547,000
West Roxbury (part of),	51,000	58,000	88,000	-	-	-	83,000	94,000	142,000	-	-	-
Brookline,	1,808,000	2,030,000	3,087,000	1,764,000	1,980,000	3,012,000	2,567,000	2,890,000	4,386,000	2,114,000	2,380,000	3,612,000
Newton,	3,704,000	4,158,000	6,325,000	2,087,000	2,343,000	3,564,000	5,058,000	5,695,000	8,643,000	2,718,000	3,060,000	4,644,000
Waltham,	-	-	-	4,057,000	4,554,000	6,928,000	-	-	-	5,134,000	5,780,000	8,772,000
Watertown,	-	-	-	1,691,000	1,898,000	2,887,000	-	-	-	2,189,000	2,465,000	3,741,000
Total high level,	6,665,000	7,483,000	11,382,000	-	-	-	9,142,000	10,294,000	15,622,000	-	-	-
Total low level,	-	-	-	15,670,000	17,590,000	26,757,000	-	-	-	19,629,000	22,100,000	33,540,000

TABLE NO. 7. — *Showing Daily Volume of Sewage Anticipated, etc.* — Continued.

[In Gallons.]

City or Town.	1915.						1920.					
	High Level.			Low Level.			High Level.			Low Level.		
	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.
Boston: —												
Back Bay district,	-	-	-	4,805,000	5,425,000	8,215,000	-	-	-	5,485,000	6,210,000	9,384,000
Brighton,	1,798,000	2,030,000	3,074,000	4,123,000	4,655,000	7,049,000	2,305,000	2,610,000	3,944,000	5,183,000	5,868,000	8,867,000
West Roxbury (part of),	132,000	149,000	225,000	-	-	-	199,000	225,000	340,000	-	-	-
Brookline,	3,487,000	3,937,000	5,962,000	2,480,000	2,800,000	4,240,000	4,452,000	5,040,000	7,616,000	2,942,000	3,330,000	5,032,000
Newton,	6,433,000	7,262,000	10,997,000	3,487,000	3,937,000	5,962,000	7,950,000	9,000,000	13,600,000	4,293,000	4,860,000	7,344,000
Waltham,	-	-	-	6,324,000	7,140,000	10,812,000	-	-	-	7,791,000	8,820,000	13,328,000
Watertown,	-	-	-	2,712,000	3,062,000	4,638,000	-	-	-	3,339,000	3,780,000	5,712,000
Total high level,	11,850,000	13,378,000	20,258,000	-	-	-	14,906,000	16,875,000	25,500,000	-	-	-
Total low level,	-	-	-	23,931,000	27,019,000	40,916,000	-	-	-	29,033,000	32,868,000	49,667,000

TABLE No. 7. — *Showing Daily Volume of Sewage Anticipated, etc.* — Continued.

[In Gallons.]

City or Town.	1925.						1930.					
	High Level.			Low Level.			High Level.			Low Level.		
	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.
Boston: —												
Back Bay district,	-	-	-	6,357,000	7,215,000	10,881,000	-	-	-	7,515,000	8,550,000	12,870,000
Brighton,	2,853,000	3,238,000	4,883,000	6,454,000	7,326,000	11,048,000	3,424,000	3,895,000	5,863,000	7,932,000	9,025,000	13,585,000
West Roxbury (part of),	277,000	314,000	475,000	-	-	-	367,000	418,000	629,000	-	-	-
Brookline,	5,705,000	6,475,000	9,765,000	3,504,000	3,977,000	6,000,000	7,014,000	7,980,000	12,012,000	4,175,000	4,750,000	7,150,000
Newton,	9,535,000	10,822,000	16,321,000	5,216,000	5,920,000	8,928,000	11,356,000	12,920,000	19,448,000	6,179,000	7,030,000	10,582,000
Waltham,	-	-	-	9,584,000	10,878,000	16,405,000	-	-	-	11,523,000	13,110,000	19,734,000
Watertown,	-	-	-	4,156,000	4,717,000	7,114,000	-	-	-	5,094,000	5,795,000	8,723,000
Total high level,	18,370,000	20,849,000	31,444,000	-	-	-	22,161,000	25,213,000	37,952,000	-	-	-
Total low level,	-	-	-	35,271,000	40,033,000	60,376,000	-	-	-	42,418,000	48,260,000	72,644,000

Table No. 7. — *Showing Daily Volume of Sewage Anticipated, etc.* — Concluded.

[In Gallons.]

City or Town.	1935.						1940.					
	High Level.			Low Level.			High Level.			Low Level.		
	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.	Average Daily Flow.	Maximum Dry Weather Flow.	Maximum Storm Flow.
Boston: —												
Back Bay District,	-	-	-	8,892,000	10,140,000	15,236,000	-	-	-	10,500,000	12,000,000	18,000,000
Brighton,	4,104,000	4,680,000	7,032,000	9,576,000	10,920,000	16,408,000	4,813,000	5,500,000	8,250,000	11,463,000	13,100,000	19,650,000
West Roxbury (part of),	479,000	546,000	820,000	-	-	-	613,000	700,000	1,050,000	-	-	-
Brookline,	8,550,000	9,750,000	14,650,000	4,874,000	5,557,000	8,351,000	10,237,000	11,700,000	17,550,000	5,775,000	6,600,000	9,900,000
Newton,	13,252,000	15,112,000	22,707,000	7,267,000	8,287,000	12,452,000	15,400,000	17,600,000	26,400,000	8,400,000	9,600,000	14,400,000
Waltham,	-	-	-	13,509,000	15,405,000	23,147,000	-	-	-	15,575,000	17,800,000	26,700,000
Watertown,	-	-	-	6,156,000	7,020,000	10,548,000	-	-	-	7,350,000	8,400,000	12,600,000
Total high level,	26,385,000	30,088,000	45,209,000	-	-	-	31,063,000	35,500,000	53,250,000	-	-	-
Total low level,	-	-	-	50,274,000	57,329,000	86,142,000	-	-	-	59,063,000	67,500,000	101,250,000

Relief for the Existing Charles River Main Sewer.

Until an extension of the High-level Sewer to the territory proposed shall have been constructed, the volume of sewage from both high and low districts, set forth in Table No. 7, will continue to be tributary to the existing Charles River valley sewer. The capacity of this sewer and its relation to volumes of sewage flow from the whole district are set forth graphically on diagrams Nos. 1, 2 and 3 : at Vancouver Street, in the Back Bay district of Boston ; above Brookline, at the Brighton-Newton line; and at the end of the Charles River main sewer in Newton.

From the table and diagrams it appears that as early as 1907 overflows during storms will undoubtedly occur through Brighton and Brookline, and that dry weather flows may fill the sewer about 1915 through the same territory. The large pumps of the Ward Street station will doubtless quicken the flow of sewage in the lower section of this main sewer. It is not anticipated that they can materially delay the date when storm overflows will occur. Relief for this district should be provided at an early date, before the storm overflows become so frequent and offensive as to be objectionable in the lower Charles River basin. Above Brighton, through the city of Newton, relief may be delayed for ten years, until 1915 or later.

The future condition of the existing Charles River valley main sewer after it shall have been relieved by the proposed extension above Jamaica Plain is exhibited on diagrams Nos. 4, 5 and 6. From these diagrams it appears that storm overflows from this sewer may be expected from 1920 to 1925, and that dry weather flows may fill the sewer in the year 1930 or later.

DIAGRAM NO. 1. — *Comparison of the Estimated Flow of Sewage and the Capacity of the Charles River Valley Sewer at Vancouver and Ruggles Streets, Back Bay, using Total Estimated High-level and Low-level Populations.*

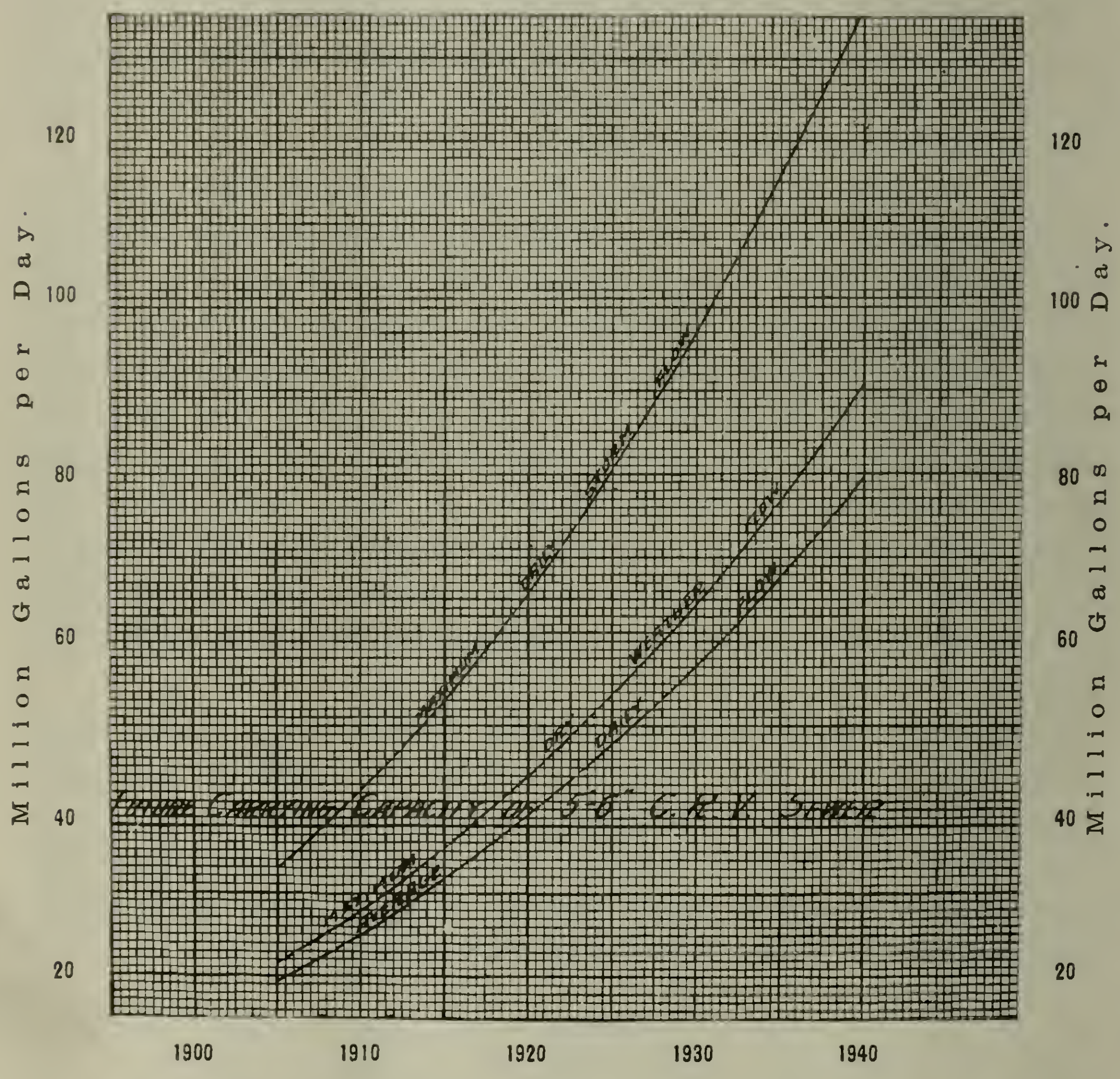


DIAGRAM No. 2.—*Comparison of the Estimated Flow of Sewage and the Capacity of the Charles River Valley Sewer at Cottage Farm, Brighton, using Total Estimated High-level and Low-level Populations.*

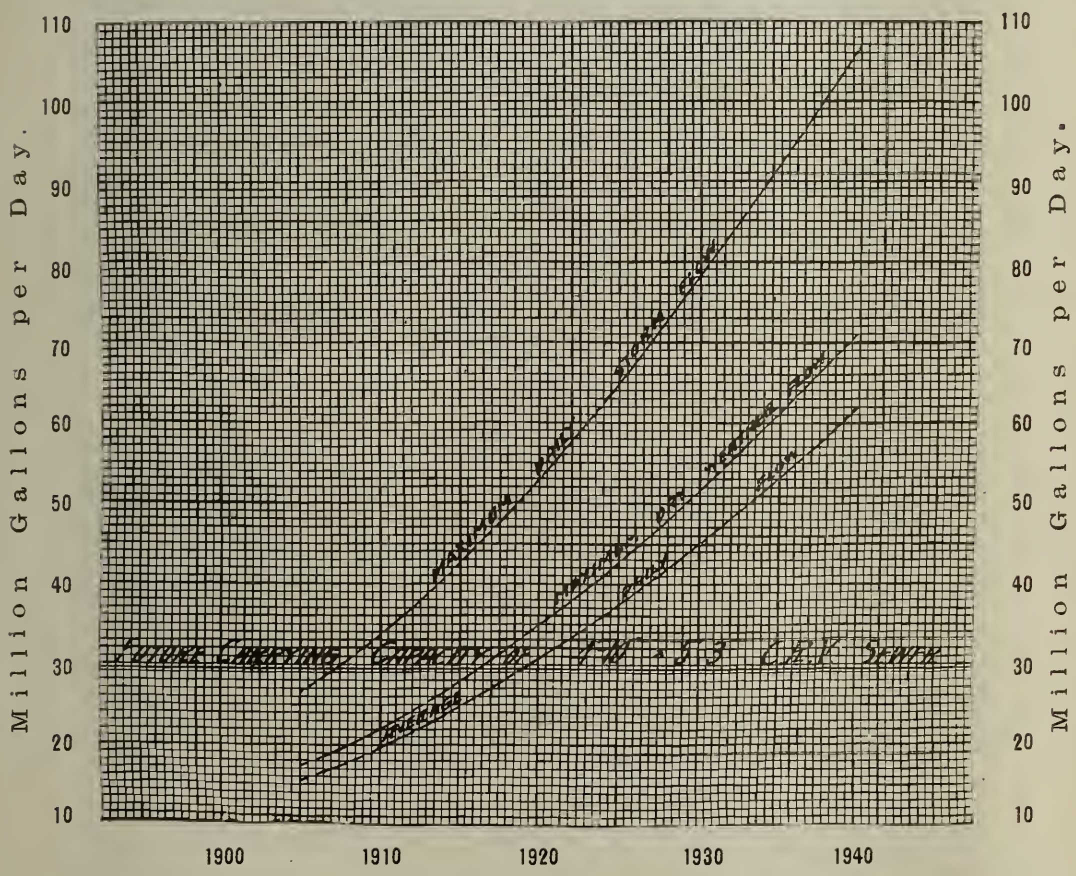


Diagram No. 3. — *Comparison of the Estimated Flow of Sewage and the Capacity of the Charles River Valley Sewer at Cheesecake Brook, Newton, and at Newton-Brighton Town Line, using Total Estimated High-level and Low-level Populations.*

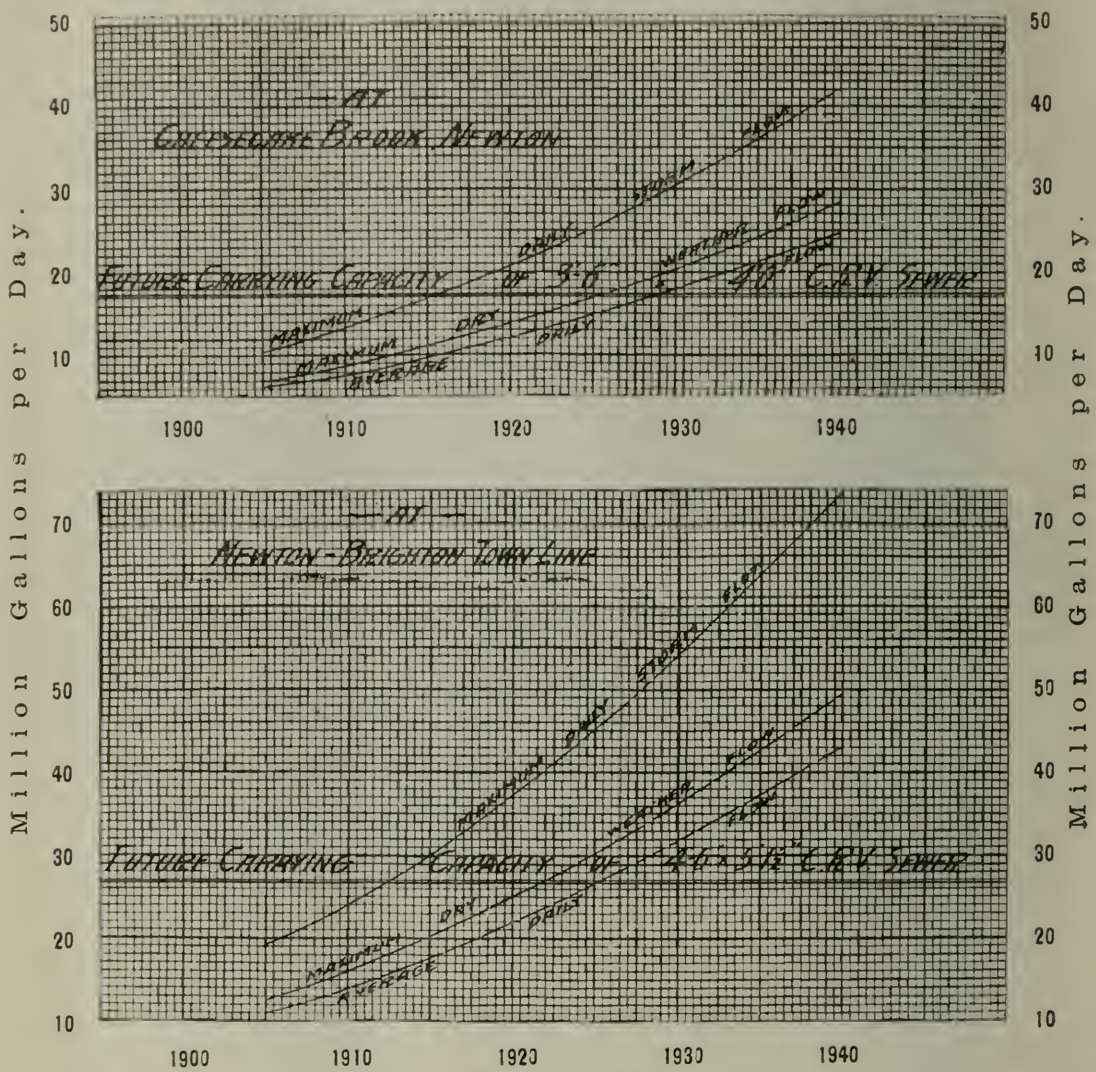


Diagram No. 4.— *Comparison of the Estimated Flow of Sewage and the Capacity of the Charles River Valley Sewer at Vancouver and Ruggles Streets, Back Bay, using Total Estimated Low-level Populations.*

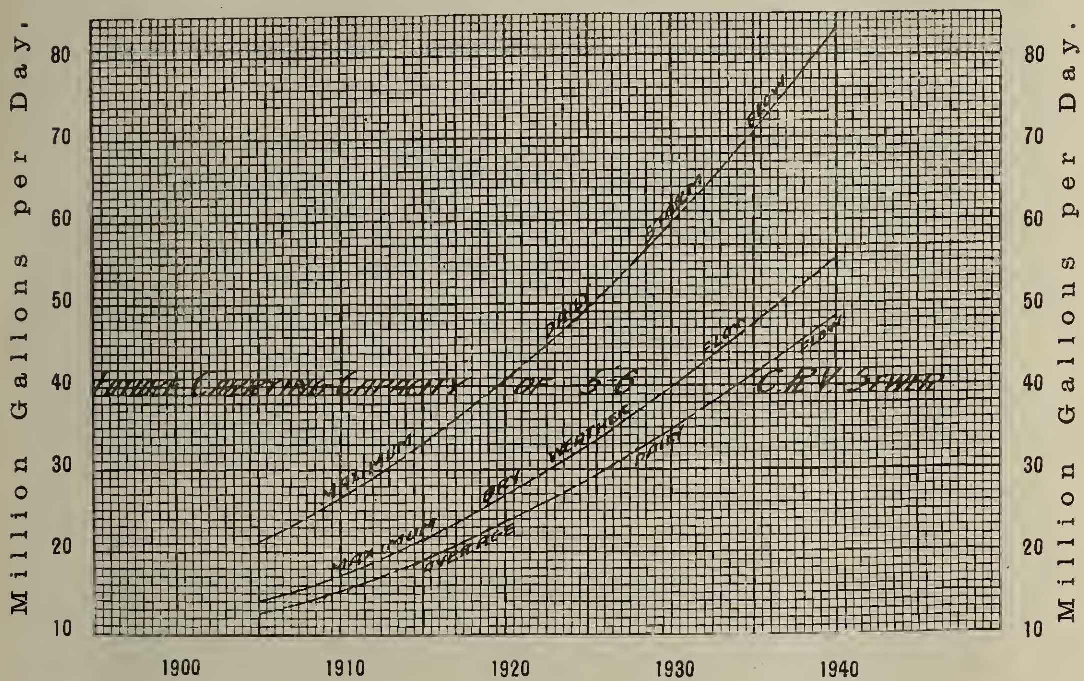


Diagram No. 5.— *Comparison of the Estimated Flow of Sewage and the Capacity of the Charles River Valley Sewer at Cottage Farm, Brighton, using Total Estimated Low-level Populations.*

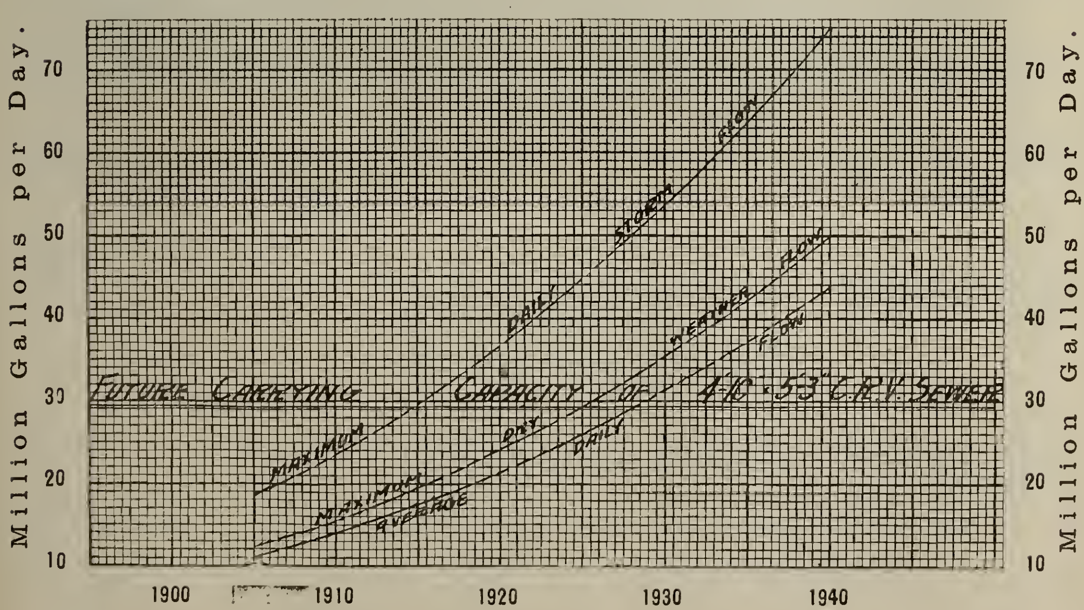
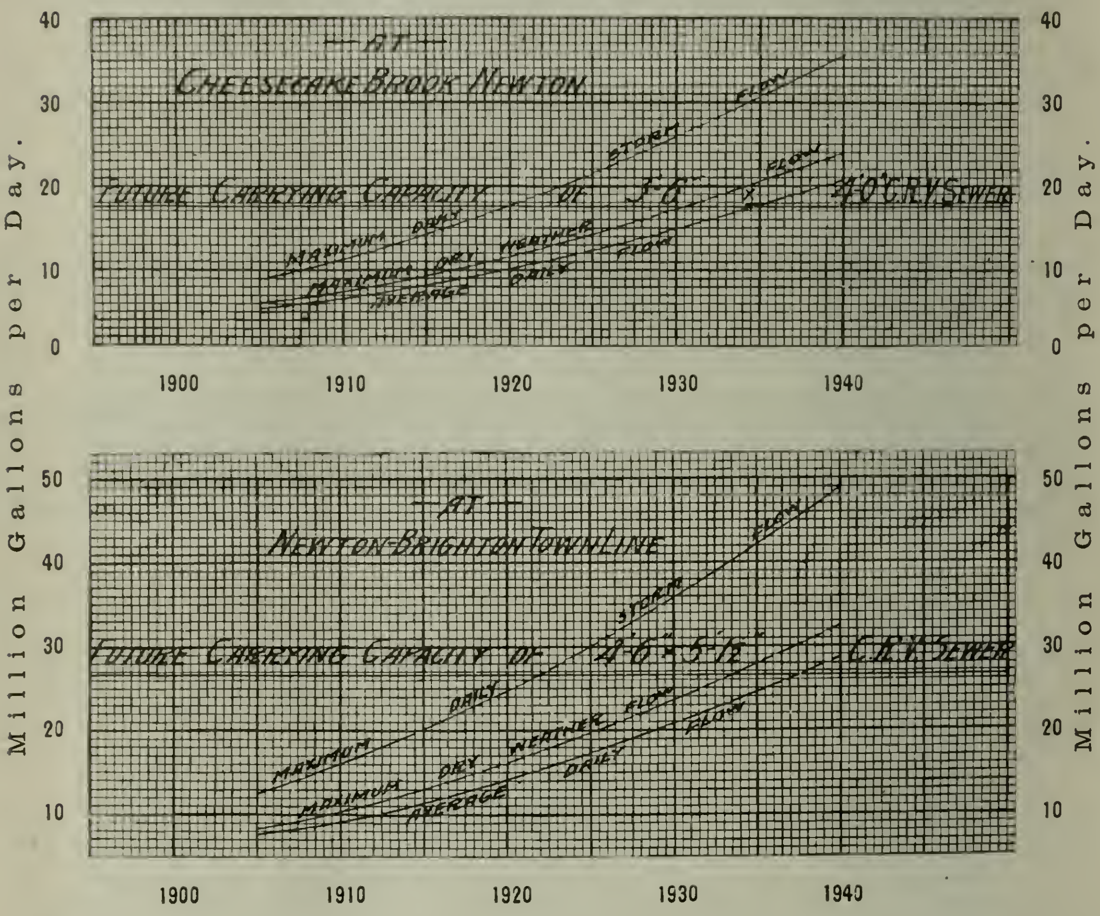


DIAGRAM NO. 6. — *Comparison of the Estimated Flow of Sewage and the Capacity of the Charles River Valley Sewer at Cheesecake Brook, Newton, and at Newton-Brighton Town Line, using Total Estimated Low-level Populations.*



Possible Future Additions to the South Metropolitan System.

Under authority of chapter 65 of the Resolves of 1899, the State Board of Health reviewed the project for a high-level gravity sewer for the relief of the Charles and Neponset River valley Metropolitan areas, and, among other suggestions in relation thereto, recommended that small areas in the towns of Weston, Wellesley and Needham, along the westerly border of the Charles River, be added to the South Metropolitan District. By legislative act, the district is limited at present by the easterly border of the Charles River at Newton and Waltham. The South Metropolitan District and the area recommended to be added are both outlined on the general map.

The present population on the area that may be added west of the Charles River is about 2,800, and in 1940 may be 15,000. This area is so located that its drainage may be collected without pumping in an existing main sewer of the city of Newton, which extends from near the end of the Charles River Metropolitan sewer through Auburndale and Newton Lower Falls. If at a future date this portion of Weston, Wellesley and Needham should be added to the South Metropolitan District by legislative act, its drainage may be provided for by purchasing a length of about 7 miles of local main sewer of the city of Newton, and incorporating it as a section of the Metropolitan System. This length of sewer is shown on the general map and outlined in Table No. 8: —

TABLE NO. 8. — *Newton Main Sewers that may be purchased to provide for Drainage of Wellesley and Needham.*

SIZE.	Length (Miles).	Location.	Remarks.
24"×36", ...	5.15	From Charles River valley sewer along Cheesecake Brook, Watertown, Washington and Border streets, private land, Commonwealth Avenue, Bourne and Charles streets, along Charles River, St. Mary's, Concord and Washington streets.	4.45 miles earth open cut, .68 mile rock open cut, .02 mile earth tunnel.
20"×30", ...	2.13	In Washington Street, Quinobequin Road and along Charles River to Eliot Street.	1.43 miles earth open cut, .59 mile rock open cut, .11 mile rock tunnel.
20" cast-iron pipe, . .	.05	Along Charles River near Echo Bridge,	Rock open cut.
6", 8" and 16" cast-iron pipe siphons.	.07	Across Charles River near Echo Bridge,	Rock cut.
Total, . . .	7.40		

This length of sewer was constructed by the city of Newton at a cost of $289,000. It would be necessary to extend pipes across the Charles River at several points where drainage of this added district will naturally collect, and these pipes and the purchase of the local sewer of the city of Newton would involve an expenditure of about $300,000 to provide for the future drainage from these added areas. The drainage from so small a population as outlined for these areas can safely be provided for in the existing Newton sewer for many years. The addition of these areas to the South Metropolitan District will hasten the necessity of future relief for the Charles River main sewer by a few years.

Extension of High-level Sewer recommended.

The extension recommended is outlined on the general plan and profile accompanying this report. The lengths, sizes and elevations of the sewer are set forth in Table No. 9: —

TABLE No. 9. — *Showing Lengths, Sizes and Elevations of the Extension of High-level Sewer as recommended.*

City or Town.	Location.	Size.	Length.	Elevation.		Remarks.
				From	To	
West Roxbury,	Perkins Street,	6' 6"×7',	700	132.00	132.23	Rock tunnel.
	Perkins and Chestnut streets,	7' diameter,	2,385	132.23	133.05	Air tunnel.
Brookline,	Chestnut and Kendall streets,	7' diameter,	1,915	133.05	133.67	Air tunnel.
	Kendall and Cypress streets, Brington Road, private land, Gorham Avenue, Greenough, Washington and Park streets.	6' 6"×7',	4,475	133.67	135.15	Rock tunnel and earth open cut.
	Park, Beacon and Winchester streets, private land and Columbia Street.	6' 3"×6' 6",	5,370	135.40	137.20	Earth open cut and earth tunnel.
Brighton,	Columbia Street, Commonwealth Avenue, Warren, Cambridge and Washington streets.	5' 9"×6',	7,955	137.20	139.88	Open cut, rock tunnel and earth tunnel.
	Washington Street,	60" cast-iron pipe,	1,200	139.88	140.88	Open cut.
	Washington and Tremont streets,	5' 9"×6',	2,553	140.88	141.76	Open cut.
Newton,	Tremont, Park and Vernon streets,	5'×5' 3",	2,700	142.05	143.13	Open cut.
	Vernon and Eldredge streets, private land, Hollis and Centre streets.	60" cast-iron pipe,	1,650	143.13	144.00	Open cut.
	Mt. Ida Street, private land, Lewis Street, private land and Cabot Park.	5'×5' 3",	3,200	144.00	145.28	Rock tunnel and earth open cut.
	Private land, Norwood Avenue, Harvard Street and Washington Park.	60" cast-iron pipe,	1,400	145.28	146.02	Open cut.
	Washington Park,	5'×5' 3",	1,390	146.02	146.58	Open cut.
	Walnut Street, Highland and Elmwood avenues, Austin Street, Clark Place, private land, Margin, Lincoln and Washington streets.	4' 3"×4' 6",	8,182	146.83	150.92	Earth and rock open cut and rock tunnel.
	Washington Street,	4',	8,682	151.40	156.83	Earth open cut, rock and earth tunnel.

Total length = 53,757 feet = 10.18 miles.

From this table it appears that the extension recommended involves a length of 10 miles of trunk sewer, varying in size from 7 to 4 feet in diameter. The anticipated volumes of sewage, outlined in Table No. 7, at the rate of inclination recommended, will fill the sewers to about two-thirds of their height. The minimum inclination or rate of grade adopted will produce scouring velocities when the sewer is running one-fourth full. This will probably be its condition when constructed and put into operation.

The location recommended is at considerable distance inland from the Charles River, and, as shown on the profile, the construction necessarily involves a series of deep excavations where the sewer pierces the divides between brooks, followed by a series of shallow excavations crossing the valleys. Near Oak Square in Brighton, and in Vernon, Eldredge, Hollis, Norwood and Harvard streets in Newton, the arch of the sewer will approach so near to the street surface that the introduction of short lengths of 60-inch cast-iron pipe is recommended. Passing these locations, it will be necessary to construct short lengths of small local lateral sewers, to intercept house drains that may be broken off by the Metropolitan sewer.

In the sewer route recommended no attempt has been made to follow the outline of the high-level district, the location following generally in public highways and along the shortest and most direct line. Two short branch lines would, however, be required in Brighton, reaching out to the borders of the district to intercept local main sewers, as indicated on the general map.

Beginning near the corner of Centre and Perkins streets in Jamaica Plain, the construction will follow westerly through Perkins Street in rock tunnel at a depth of about 70 feet below the surface for a distance of 700 feet, where the construction will leave the rock and enter strata of wet sand and gravel, passing the northerly end of Jamaica Pond. To secure impermeability to masonry and maintain the present level of the water of the pond, the sewer will need to be constructed by pneumatic process along Perkins Street, Jamaica Plain, and Chestnut Street, Brookline, for a distance of about 4,300 feet, to the corner of Chestnut and Kendall streets in Brookline, where rock will again be encountered. Beyond Chestnut Street the route recommended follows along Kendall and Cypress streets to Boylston Street in rock tunnel, for a distance of 1,500 feet. Beyond Boylston Street the route follows in earth cut, generally in sand and gravel, at an average depth of 20 feet, through Cypress Street, Brington Road and private land under the Boston & Albany Railroad near the Brookline Hills station, through the Brookline playground, to the corner of Gorham Avenue and Davis Street; and thence through Gorham Avenue, Greenough, Washington and Park streets, a total distance of 2,975 feet. In Park Street, near Washington Street, the size of the sewer will be reduced from 6 feet 6 inches by 7 feet to 6 feet 3 inches by 6 feet 6 inches. The sewer will continue through Park, Beacon and Winchester streets in open cut at an average depth of 25 feet to a point in Winchester Street near Beacon Street, a distance of 2,150 feet; here it will enter earth tunnel about 35 feet below the surface, extending through Winchester Street and private land to Columbia Street, a distance in tunnel of 2,125 feet. Following through Columbia Street in open cut in sand and gravel for a distance of 1,095 feet, the size will again be reduced to 5 feet 9 inches by 6 feet near the Brookline-Brighton boundary line.

In Brighton the route recommended follows westerly in Columbia Street and Commonwealth Avenue, in open cut in sand and gravel at a depth of 20 feet, for a distance of 1,255 feet to near Allston Street. Beyond Allston Street the construction will enter rock tunnel about 60 feet below the surface, extending along Commonwealth Avenue and Warren, Cambridge and Washington streets for a distance of 5,100 feet to near Parsons Street; thence continuing in Washington Street to near Lake Street in earth tunnel at a depth of 30 feet below the surface, for a distance of 1,100 feet.

A 20-inch by 26-inch branch line in rock tunnel through Cambridge Street from Saunders Street, and a 24-inch by 28-inch branch line in sand and gravel open cut and in tunnel partly in earth and partly in rock through Market Street from Mapleton Street will enter the main sewer at Warren and Washington streets, respectively, reaching out to the northerly border of the high-level district.

Beyond Lake Street the sewer will be constructed in open cut at a depth of 18 feet, generally in sand and gravel, for a distance of 500 feet; thence continuing in Washington Street in shallower open cut for a distance of 1,200 feet, necessitating the introduction of 60-inch cast-iron pipe in place of the usual masonry sewer. From this section of iron pipe the line recommended continues in open cut at an average depth of 22 feet for a distance of 1,893 feet through Washington Street to Oak Square and through Tremont Street; thence partly in rock and partly in earth open cut for a distance of 660 feet to the Brighton-Newton boundary line, where the size will be reduced to 5 feet by 5 feet 3 inches.

In Newton the route will follow along Tremont Street in rock tunnel for a distance of 2,060 feet; and thence in earth and rock cut for a distance of 640 feet through Tremont, Park and Vernon streets. Beyond this point, for a distance of 1,650 feet, 60-inch cast-iron pipe will be introduced in Vernon and Eldredge streets, private land, Hollis and Centre streets to near Mt. Ida Street. Beyond the iron pipe, for a distance of 348 feet in Mt. Ida Street to Newtonville Avenue, the usual masonry sewer will be constructed in sand and gravel. From Newtonville Avenue westerly the sewer will be located in rock tunnel under Mt. Ida at a maximum depth of 150 feet, largely under private land and in Lewis Street to near East Side Parkway, a distance of 2,450 feet. Through Cabot Park the route will follow in open cut at an average depth of 12 feet for a distance of 402 feet to Laundry Brook. Beyond the brook a section of 60-inch cast-iron pipe will extend for a distance of 1,400 feet through private land, Norwood Avenue, Harvard Street and Washington Park; followed by a 5-foot by 5-foot 3-inch masonry sewer at a depth of about 15 feet through Washington Park to Walnut Street, a distance of 1,390 feet. Beyond Washington Park the sewer will be reduced to 4 feet 3 inches by 4 feet 6 inches, and will continue through Walnut Street and Highland Avenue, Elmwood Avenue and Austin Street in sand and gravel at an average depth of 14 feet, for a distance of 1,908 feet. From this point the sewer will enter rock tunnel at a depth of 25 feet below the surface for a distance of 1,324 feet through Austin and Mt. Vernon streets, Clark Place and private land; thence in rock and earth cut at an average depth of 14 feet through private lands along the Boston & Albany Railroad and Margin Street to near Putnam Street, a distance of 3,125 feet. From Putnam Street the route recommended follows through Margin, Lincoln and Washington streets in sand and gravel cut about 13 feet deep for a distance of 1,825 feet to Cheesecake Brook at Auburn Street. The sewer will cross Cheesecake Brook by a 36-inch cast-iron pipe siphon. Beyond the brook the sewer will be reduced in size to 4 feet in diameter, and will continue in Washington Street in sand and gravel cut at an average depth of 16 feet to near Greenough Street, a distance of 1,325 feet. At this point the sewer will enter rock tunnel under Washington Street at an average depth of about 50 feet below the surface and extend for a distance of 6,000 feet; thence through an earth tunnel for a distance of 1,357 feet to the Newton main sewer in Newton Lower Falls near the corner of Washington Street and Quinobequin Road, the end of the proposed High-level Sewer extension.

Estimate of Cost.

The following is an estimate of the cost of constructing an extension of the High-level Sewer from the corner of Centre and Perkins streets, Jamaica Plain, over the route shown on the general map and outlined in the foregoing description: —

TABLE No. 10. — *Estimated Cost of Extension of High-level Sewer above Jamaica Plain through West Roxbury, Brookline, Brighton and Newton.*

Location.	Size.	Average Depth.	Length.	Cost per Foot.	Cost.	Total Cost.	Remarks.
West Roxbury: —							
In Perkins Street from Centre Street to a point about 200 feet west of South Huntington Avenue,	6' 6"×7',	-	700	$40 70	$28,490 00	-	Rock tunnel.
In Perkins and Chestnut streets to the boundary line between West Roxbury and Brookline,	7' diameter,	-	2,385	77 00	183,645 00	-	Air tunnel.
Total,	- -	-	-	-	$212,135 00	-	
Engineering and contingencies, 15 per cent.,	- -	-	-	-	31,820 00	-	
Total cost in West Roxbury,	- -	-	-	-		$243,955 00	
Brookline: —							
In Chestnut and Kendall streets from the boundary line between West Roxbury and Brookline to a point near Kendall Place,	7' diameter,	-	1,915	77 00	$147,455 00	-	Air tunnel.
In Kendall and Cypress streets to near Boylston Street,	6' 6"×7',	-	1,500	40 70	61,050 00	-	Rock tunnel.
In Cypress Street, Brington Road, private land, Gorham Avenue, Greenough, Washington and Park streets to a point about 30 feet north of Washington Street,	6' 6"×7',	19.0	2,975	23 00	68,425 00	-	Earth open cut.
In Park, Beacon and Winchester streets to a point 100 feet north of Beacon Street,	6' 3"×6' 6",	25.0	2,150	24 00	51,600 00	-	Earth open cut.
In Winchester Street and private land,	6' 3"×6' 6",	-	2,125	46 00	97,750 00	-	Air tunnel.
Amounts carried forward,	- -	-	-	-	$426,280 00	$243,955 00	

TABLE NO. 10. — *Estimated Cost of Extension of High-level Sewer above Jamaica Plain through West Roxbury, Brookline, Brighton and Newton* — Continued.

LOCATION.	Size.	Average Depth.	Length.	Cost per Foot.	Cost.	Total Cost.	Remarks.
Amounts brought forward,	- -	-	-	-	$426,280 00	$243,955 00	
Brookline — *Concluded.*							
In private land and Columbia Street to the Brighton boundary line,	6' 3"×6' 6",	15.0	1,095	$17 40	19,053 00	-	Earth open cut.
Total,	- -	-	-	-	$445,333 00	-	
Engineering and contingencies, 15 per cent.,	- -	-	-	-	66,800 00	-	
Total cost of construction,	- -	-	-	-	$512,133 00	-	
Rights of way,	- -	-	-	-	17,000 00	-	
Total cost in Brookline,	- -	-	-	-		529 133 00	
Brighton: —							
In Columbia Street and Commonwealth Avenue to a point 50 feet west of Allston Street,	5' 9"×6',	19.0	1,255	20 00	$25,100 00	-	Earth open cut.
In Commonwealth Avenue, Warren, Cambridge and Washington streets to Parsons Street,	5' 9"×6',	-	5,100	34 50	175,950 00	-	Rock tunnel.
In Washington Street to a point 200 feet east of Lake Street,	5' 9"×6',	-	1,100	42 50	46,750 00	-	Earth tunnel.
In Washington Street to a point 300 feet west of Lake Street,	5' 9"×6',	18.0	500	19 50	9,750 00	-	Earth open cut.
In Washington Street to near Montfern Avenue,	60" cast-iron pipe,	10.0	1,200	23 50	28,200 00	-	Earth open cut.
In Washington Street to Oak Square,	5' 9"×6',	16.0	750	18 00	13,500 00	-	Earth open cut.
Branch lines in Cambridge, Market, Bennett and Washington streets,	20"×26",	-	2,250	16 00	36,000 00	-	Tunnel.
	24"×28", 15", 12",	12.0	2,800	3 20	8,960 00	-	Earth open cut.
Total,	- -	-	-	-	$344,210 00	-	
Engineering and contingencies, 15 per cent.,	- -	-	-	-	51,630 00	-	
Total cost in Brighton to Oak Square,	- -	-	-	-		395,840 00	
Amount carried forward,	- -	-	-	-	-	$1,168,928 00	

TABLE NO. 10. — *Estimated Cost of Extension of High-level Sewer above Jamaica Plain through West Roxbury, Brookline, Brighton and Newton* — Continued.

LOCATION.	Size.	Average Depth.	Length.	Cost per Foot.	Cost.	Total Cost.	Remarks.
Amount brought forward,	- -	-	-	-	-	$1,168,928 00	
Brighton — *Concluded.*							
In Washington and Tremont streets to about 700 feet east of Brighton boundary line,	5' 9"×6',	24.5	1,143	$23 00	$26,289 00	-	Earth open cut.
In Tremont Street to the Newton-Brighton boundary line,	5' 9"×6',	27.5	660	33 00	21,780 00	-	Earth and rock open cut.
Total,	- -	-	-	-	$48,069 00	-	
Engineering and contingencies, 15 per cent.,	- -	-	-	-	7,210 00	-	
Total cost of construction Oak Square to Newton line,	- -	-	-	-		55,279 00	
Newton: —							
In Tremont Street to a point about 300 feet east of Park Street,	5'×5' 3",	-	2,060	23 50	$48,410 00	-	Rock tunnel.
In Tremont, Park and Vernon streets to a point 100 feet west of Park Street,	5'×5' 3",	14.0	640	15 50	9,920 00	-	Rock and earth open cut.
In Vernon and Eldredge streets, private land, Hollis and Centre streets to Mt. Ida Street,	60" cast-iron pipe,	9.5	1,650	23 00	37,950 00	-	Earth open cut.
In Mt. Ida Street to Newtonville Avenue,	5'×5' 3",	17.5	348	15 50	5,394 00	-	Earth open cut.
In private lands and Lewis Street,	5'×5' 3",	-	2,450	23 50	57,575 00	-	Rock tunnel.
In private land and Cabot Park to Laundry Brook,	5'×5' 3",	11.0	402	13 50	5,427 00	-	Earth open cut.
In private land, Norwood Avenue, Harvard Street and Washington Park to a point 100 feet west of Harvard Street,	60" cast-iron pipe,	7.0	1,400	22 00	30,800 00	-	Earth open cut.
In Washington Park to Walnut Street,	5'×5' 3",	15.0	1,390	13 00	18,070 00	-	Earth open cut.
In Walnut Street, Highland and Elmwood avenues and Austin Street to a point about 300 feet west of Elmwood Avenue,	4' 3"×4' 6",	14.0	1,908	11 50	21,942 00	-	Earth open cut.
In Austin and Mt. Vernon streets, Clark Place and private land to a point about 500 feet west of Clark Place,	4' 3"×4' 6",	-	1,324	21 00	27,804 00	-	Rock tunnel.
Amounts carried forward,	- -	-	-	-	$263,292 00	$1,224,207 00	

TABLE No. 10.—*Estimated Cost of Extension of High-level Sewer above Jamaica Plain through West Roxbury, Brookline, Brighton and Newton*—Concluded.

LOCATION.	Size.	Average Depth.	Length.	Cost per Foot.	Cost.	Total Cost.	Remarks.
Amounts brought forward,	- -	-	-	-	$263,292 00	$1,224,207 00	
Newton — *Concluded.*							
In private land along Boston & Albany Railroad and in Margin Street to a point about 200 feet east of Putnam Street,	4′ 3″×4′ 6″,	14.0	3,125	$14 80	46,250 00	-	Earth and rock open cut.
In Margin, Lincoln and Washington streets to Cheesecake Brook,	4′ 3″×4′ 6″,	13.5	1,825	12 20	22,265 00	-	Earth open cut.
In Washington Street to a point about 300 feet west of Greenough Street,	4′ diameter,	16.0	1,325	11 40	15,105 00	-	Earth open cut.
In Washington Street to a point 300 feet west of Beacon Street,	4′ diameter,	-	6,000	21 50	129,000 00	-	Rock tunnel.
In Washington Street to the Newton main sewer, near Quinobequin Road,	4′ diameter,	-	1,357	21 00	28,497 00	-	Earth tunnel.
Branch sewers and changes in sewers and drains,	- -	-	-	-	30,980 00	-	
Total,	- -	-	-	-	$535,389 00	-	
Engineering and contingencies, 15 per cent.,	- -	-	-	-	80,310 00	-	
Total cost of construction,	- -	-	-	-	$615,699 00	-	
Rights of way,	- -	-	-	-	50,000 00	-	
Total cost in Newton,	- -	-	-	-		665,699 00	
Total estimated cost of High-level Sewer above Jamaica Plain over the route shown upon the general map, and outlined in the accompanying report,	- -	-	-	-	-	$1,889,906 00	

This estimate of cost is based upon the provision that in the air tunnels the masonry sections shall be of rings of Portland brickwork 8 inches and 12 inches in thickness; that the arches of the rock tunnels shall be lined with Portland concrete, and the inverts shall be paved with a 4-inch lining of Portland brickwork, reinforced with Portland concrete; that in the rock and earth sections in the open cut trenches the arches shall be of brick, laid in Rosendale cement in dry ground and in Portland cement where water is encountered, and the inverts shall be lined with 4 inches of Portland brickwork, reinforced with Portland concrete; and that the cast-iron pipe sections shall be entirely surrounded by Portland concrete.

From the foregoing table it appears that the construction of the proposed extension from the junction with the High-level Sewer near the corner of Centre and Perkins streets, Jamaica Plain, to Oak Square in Brighton, the part which is needed at the earlier date, is estimated to cost $1,168,928; that the construction of the remainder of the sewer, from Oak Square to the end at Newton Lower Falls, is estimated to cost $720,978; and that the cost of the entire extension over the route recommended is estimated at $1,889,906.

Respectfully submitted,

WM. M. BROWN,
Engineer Sewerage Works.

BOSTON, January 1, 1905.


NORTH METROPOLITAN SYSTEM
BOSTON MAIN DRAINAGE DIST
PUMPING STA.
OUTLET
OUTLET
OUTLET
2 LINES 60" C.I. PIPE
AREA RECOMMENDED BY STATE BOARD OF HEALTH TO BE ADDED TO SOUTH METROPOLITAN SYSTEM.
SEE REPORT ON DISPOSAL OF SEWAGE INTO BOSTON HARBOR 1900
OUTLINE OF AREA TRIBUTARY TO PROPOSED EXTENSION
FRANKLIN PARK
NOTES
South Metropolitan Sewers indicated thus
High Level Sewer Extension indicated thus
North Metropolitan and Boston Main Drainage Sewers indicated thus
Newton Main Sewers indicated thus
Area tributary to High Level Sewer by gravity shaded thus
Area tributary to High Level Sewer by pumping shaded thus
COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN WATER AND SEWERAGE BOARD
MAP SHOWING
SOUTH METROPOLITAN SYSTEM
WITH EXTENSION OF HIGH LEVEL SEWER
ABOVE JAMAICA PLAIN
Jan. 1, 1905
SCALE OF MILES
WELLESLEY
NEWTON
BRIGHTON
BROOKLINE
WEST ROXBURY
CHARLES RIVER
SAND AND GRAVEL
ROCK
TUNNEL
4'-0" DIA.
GRADE 1:1600
36" C.I. PIPE SIPHON
GRADE 1:2000
GRADE 1:2500
GRADE 1:3000
EXISTING HIGH LEVEL SEWER 8'-3" x 9'-2"
PROFILE OF EXTENSION OF HIGH LEVEL SEWER
Elevations are referred to a datum which is 100 feet below mean low water of Boston Harbor and 100 feet below Boston City Base
SCALE OF PROFILE
GEO. H. WALKER & CO. BOSTON

NORTH METROPOLITAN SYSTEM
BELMONT
CAMBRIDGE
SOMERVILLE
WALTHAM
WATERTOWN
NEWTON
WESTON
LINCOLN
FRESH POND
CHESTNUT HILL RESERVOIR
JAMAICA POND
FRANKLIN PARK
ARBORETUM
CEMETERY
PUMPING STA.
48" PIPES
BOSTON MAIN DRAINAGE DI
AREA RECOMMENDED BY STATE
TO BE ADDED TO SOUTH ME
OUTLINE OF AREA TRIBUTARY TO PROPOSED EXTENSION
ROXBURY
Elev. 121.47
Elev. 120.30
Elev. 106.2
Elev. 141.16
Elev. 133.0
Elev. 137.20
Elev. 95.42
Elev. 136.00
Elev. 132.08
Elev. 131.49
Elev. 145.58
Elev. 239.75
4'-7" x 5'-3"
5'-0" x 5'-3"
6'-3" x 6'-6"
6'-6" x 7'-0"
4'-3" x 4'-6"
4'-0"
18"

THE GRAVES
WINTHROP
EAST BOSTON
BOSTON HARBOR
N
OUTER BREWSTER
GREAT BREWSTER
DEER I.
GOVERNORS I.
LOVELLS ISLAND
OUTLET
GALLOPS ISLAND
GEORGES I.
SOUTH BOSTON
SPECTACLE ISLAND
LONG ISLAND
RAINSFORD
HULL
OLD HARBOR
THOMPSON ISLAND
HULL GUT
PEDDOCKS I.
OUTLET
OUTLET
MOON I.
BUMKIN I.
2 LINES
60"C.I. PIPE
SHEEP I.
SQUANTUM
Elev. 110.00
NUT I.
GRAPE I.
DRAINAGE DIST.
RACCOON I.

...D BY STATE BOARD OF HEALTH
...S SOUTH METROPOLITAN SYSTEM.
(SEE REPORT OF DISCHARGE OF SEWAGE
INTO BOSTON HARBOR 1900)
OUTLINE OF
WELLESLEY
NEEDHAM
DEDHAM
WESTWOOD
WEST ROXBURY
HYDE PARK
STONY BROOK RESERVATION
MILT
DORCHESTER
CEMETERY
Elev. 216.82
Elev. 180.43
Elev. 174.09
Elev. 137.4
Elev. 123.0
18"
15"
34"x 36"
48"x 49"
51"x 52"
9'3"x 10'2"
36"x 37"
NOTES
South Metropolitan Sewers indicated thus
High Level Sewer Extension indicated thus
North Metropolitan and Boston Main Drainage Sewers indicated thus
Newton Main Sewers indicated thus
Area tributary to High Level Sewer by gravity shaded thus
Area tributary to High Level Sewer by pumping shaded thus

COMMONWEALTH OF MASSACHUSETTS

METROPOLITAN WATER AND SEWERAGE BOARD

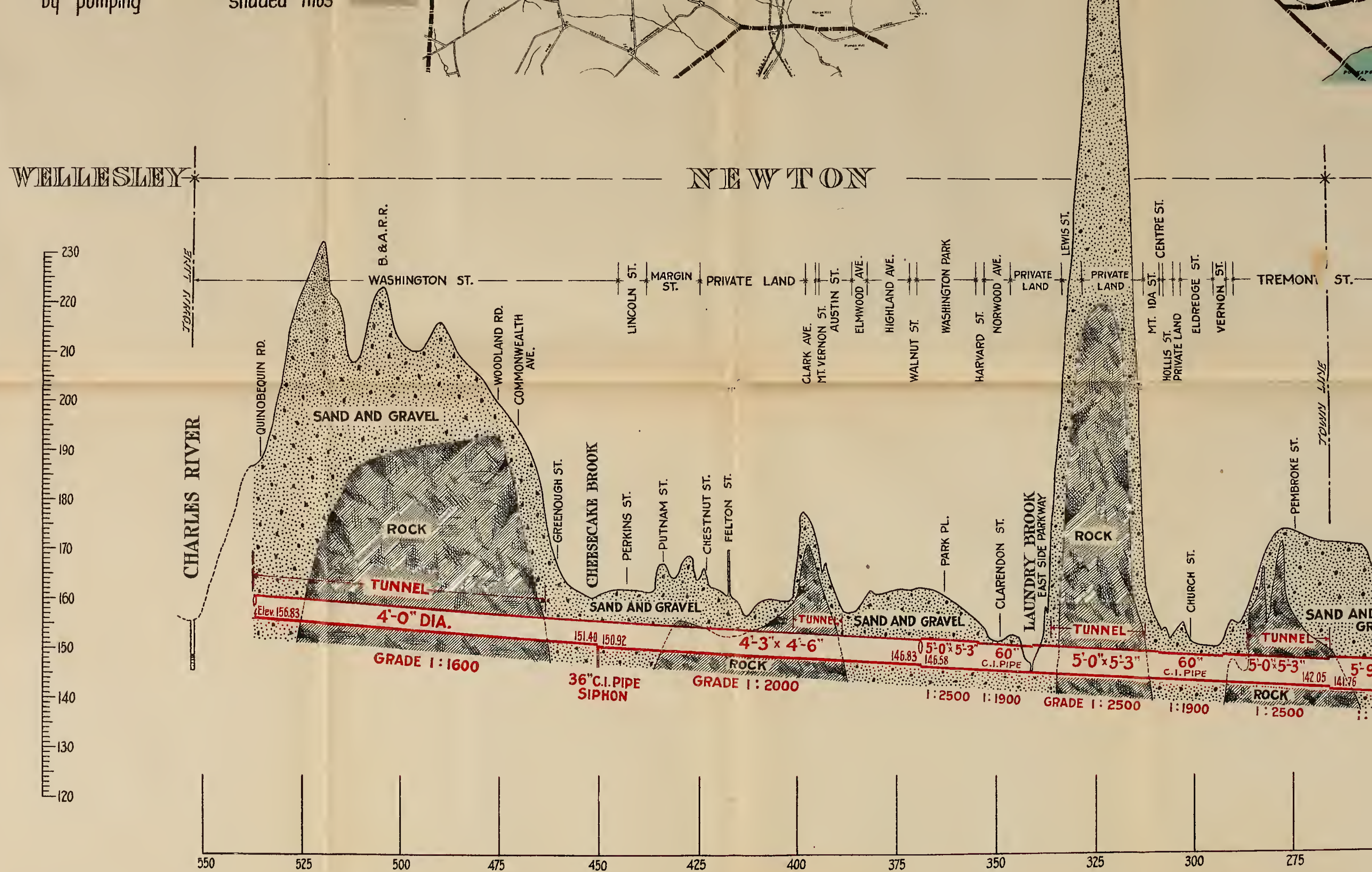
MAP SHOWING

SOUTH METROPOLITAN SYSTEM

WITH EXTENSION OF HIGH LEVEL SEWER
ABOVE JAMAICA PLAIN

Jan. 1, 1905

0 ½ 1 2 3
SCALE OF MILES



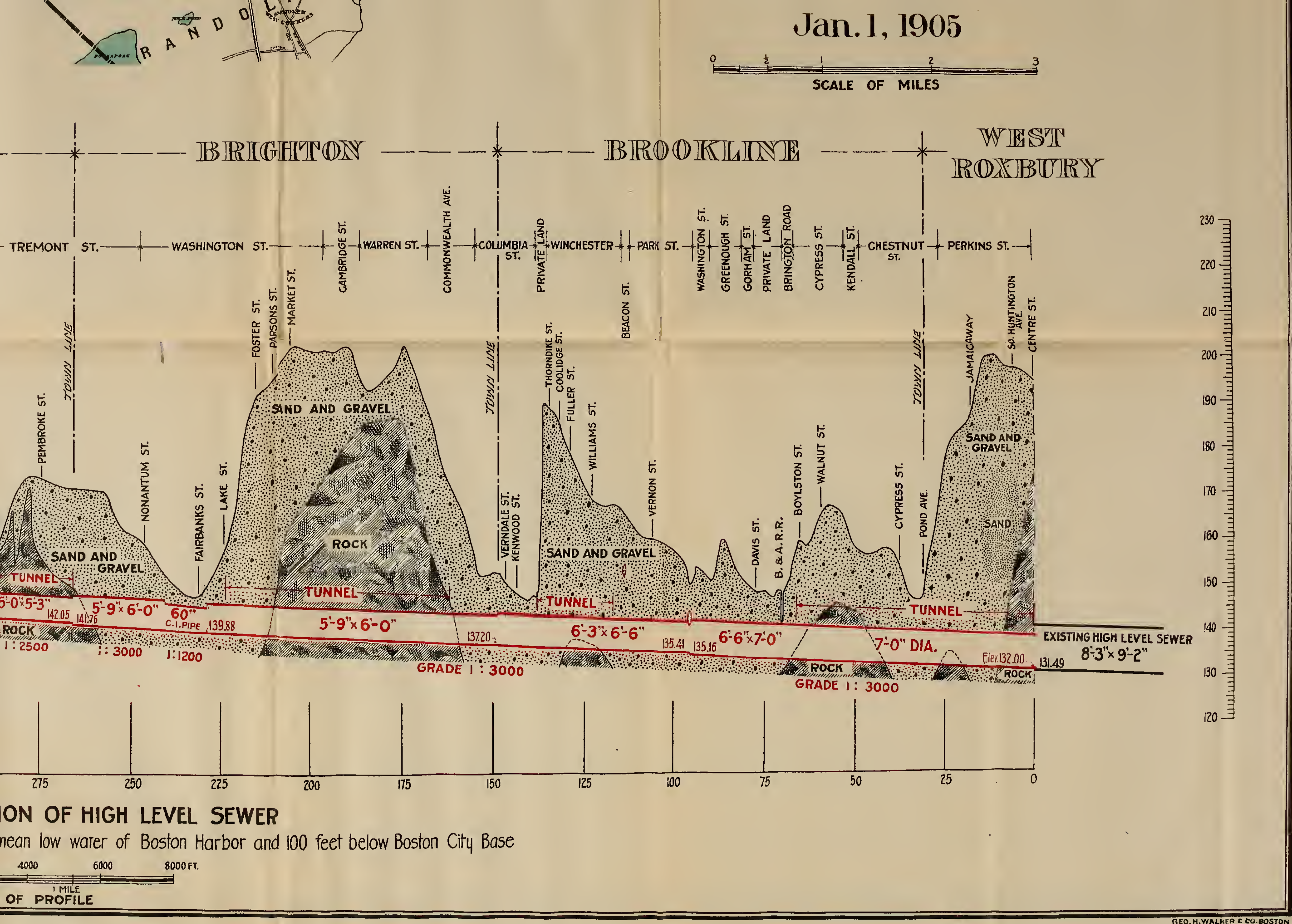
PROFILE OF EXTENSION OF HIG

Elevations are referred to a datum which is $100\frac{64}{100}$ feet below mean low water

0 1000 2000 4000 6000

1 MILE

SCALE OF PROFILE



Jan. 1, 1905
0 ½ 1 2 3
SCALE OF MILES
BRIGHTON
BROOKLINE
WEST ROXBURY
TREMONT ST.
WASHINGTON ST.
CAMBRIDGE ST.
WARREN ST.
COMMONWEALTH AVE.
COLUMBIA ST.
PRIVATE LAND
WINCHESTER
PARK ST.
WASHINGTON ST.
GREENOUGH ST.
GORHAM ST.
PRIVATE LAND
BRINGTON ROAD
CYPRESS ST.
KENDALL ST.
CHESTNUT ST.
PERKINS ST.
TOWN LINE
PEMBROKE ST.
NONANTUM ST.
FAIRBANKS ST.
LAKE ST.
FOSTER ST.
PARSONS ST.
MARKET ST.
VERNDALE ST.
KENWOOD ST.
THORNDIKE ST.
COOLIDGE ST.
FULLER ST.
WILLIAMS ST.
BEACON ST.
VERNON ST.
DAVIS ST.
B. & A. R.R.
BOYLSTON ST.
WALNUT ST.
CYPRESS ST.
POND AVE.
JAMAICAWAY
SO. HUNTINGTON AVE.
CENTRE ST.
SAND AND GRAVEL
ROCK
SAND
TUNNEL
5'-0"x5'-3"
142.05
141.76
5'-9"x 6'-0"
60" C.I. PIPE
139.88
1 : 2500
1 : 3000
1 : 1200
137.20
GRADE 1 : 3000
6'-3"x 6'-6"
135.41
135.16
6'-6"x 7'-0"
7'-0" DIA.
Elev. 132.00
131.49
EXISTING HIGH LEVEL SEWER 8'-3"x 9'-2"
230
220
210
200
190
180
170
160
150
140
130
120
275
250
225
200
175
150
125
100
75
50
25
0
ION OF HIGH LEVEL SEWER
mean low water of Boston Harbor and 100 feet below Boston City Base
4000 6000 8000 FT.
1 MILE
OF PROFILE
GEO. H. WALKER & CO. BOSTON

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	210†	Excavating soil, . . .	3	$377,830 00	$360,870 00*	Newell & Snowling Construction Company.
2	257	Excavating soil, . . .	6	449,300 00	414,987 50*	Bruno, Salomone & Petitti.
3	264†	Arch bridges and abutments.	8	42,470 00	37,335 00*	The George M. Atkins Company.
4	268†	Placing riprap on the westerly portion of the North Dike.	-‡	-‡	-‡	The McArthur Brothers Company.
5	277†	Masonry arch bridge, West Boylston, Mass.	8	14,820 00	12,888 00*	F. A. McCauliff, Fitchburg, Mass.
		Total, ...	. .	. . .	. . .	. . . . . .

Contracts relating to the

6	195	Wachusett Dam, . .	11	$1,680,870 00	$1,603,635 00*	McArthur Brothers Company.
7	245	Section 2 of relocation of Central Massachusetts Railroad (extension of Contract No. 195).	-‡	-‡	-‡	McArthur Brothers Company.
8	263†	Sluice valves for Wachusett Dam.	-‡	-‡	7,887 00	Coffin Valve Company,
9	275†	South Dike of Wachusett Reservoir.	4	124,285 00	118,570 00*	John F. Magee & Co., .
10	276†	Superstructure of lower gate-chamber of Wachusett Dam.	7	76,563 00	72,595 00*	Connery & Wentworth, Boston, Mass.
11	278†	Bronze grooves for Wachusett Dam.	-‡	-‡	3,691 00	The Wm. Cramp & Sons Ship and Engine Building Company, Philadelphia, Pa.
12	279†	Valves for Wachusett Dam; 4 36-inch, 1 20-inch, 1 12-inch, 1 10-inch.	2	2,345 00	2,317 67*	Chapman Valve Manufacturing Company, Indian Orchard, Mass.

* Contract based upon this bid. † Contract completed.

‡ Competitive bids were not received on this contract.

Appendix No. 1.

the Year 1904 — Water Works.

Reservoir Department.

1904 have been given in previous reports.]

7. Date of Contract.	8. Date of Completion of Work.	9. Prices of Principal Items of Contracts made in 1904.	10. Value of Work done Dec. 31, 1904.	
Aug. 1, '01,	Nov. 26, '04,	- -	$395,092 50	1
Dec. 27, '02,	-	- -	450,000 00	2
April 16, '03,	Dec. 23, '03,	- -	38,528 22	3
May 16, '03,	Nov. 18, '04,	- -	51,017 50	4
June 23, '04,	Sept. 28, '04,	For Portland cement concrete masonry, $5.75 per cu. yd.; ashlar masonry, $16 per cu. yd.	12,809 65	5
. . .	. . .	. . . .	$947,447 87	

Dam and Aqueduct Department.

Oct. 1, '00,	-	- -	$1,454,340 00	6
April 18, '02,	-	- -	256,439 34	7
April 30, '03,	April 7, '04,	- -	7,887 00	8
Dec. 26, '03,	Dec. 8, '04,	- -	139,411 04	9
Mar. 18, '04,	Dec. 22, '04,	For whole work, $72,595, ...	72,937 34	10
May 25, '04,	Aug. 8, '04,	For whole work, $3,691, ...	3,691 00	11
July 15, '04,	Dec. 16, '04,	For whole work, $2,317.67, ...	2,317 67	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	280†	34,740 lbs. castings for Wachusett Dam.	6	$1,346 17	$1,215 90*	Davis & Farnum Manufacturing Company, Waltham, Mass.
2	281†	76,945 lbs. castings for Wachusett Dam.	6	2,596 89	2,431 46*	Gibby Foundry Company, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . . . .

Contracts relating to the

	1.	2.	3.	4.	5.	6.
3	199†	Section 2, Weston Aqueduct.	8	$234,581 50	$200,477 00*	Shanahan, Casparis & Co.
4	200†	Section 3, Weston Aqueduct.	9	131,226 10	127,507 50*	Shanahan, Casparis & Co.
5	203†	Section 6, Weston Aqueduct.	14	121,497 00	120,646 50*	Shanahan, Casparis & Co.
6	204†	Section 12, Weston Aqueduct.	16	139,197 50	134,096 50*	Shanahan, Casparis & Co.
7	205†	Section 13, Weston Aqueduct.	9	364,884 00	346,290 00*	Michael H. Keefe, assigned on Oct. 12, 1901, to Columbus Construction Company.
8	211†	Sections 8 and 10, Weston Aqueduct.	11	155,508 50	146,139 00*	Winston & Co., . .
9	212†	Section 11, Weston Aqueduct.	10	157,270 00	148,635 00*	Winston & Co., . .
10	213†	Section 15, Weston Aqueduct.	5	197,556 00	171,645 00*	Winston & Co., . .
11	218†	Section 14, Weston Aqueduct.	10	68,364 00	58,490 00*	Nawn & Brock, . .
12	219†	Section 1 of the Weston Reservoir.	11	64,971 25	59,587 50*	Nawn & Brock, . .
13	220†	Section 2 of the Weston Reservoir.	9	90,152 50	88,292 50*	Nawn & Brock, . .
14	267†	Superstructures of channel, and screen chambers of the Weston Aqueduct.	7	12,475 00*	9,150 00	Woodbury & Leighton Company.
15	271†	Superstructures of head and meter chambers of the Weston Aqueduct.	5	12,325 00	10,804 00*	C. A. Dodge & Company.
		Total, ...	. .	. . .	. . .	. . . . . .

Contracts relating to the

	1.	2.	3.	4.	5.	6.
16	235†	Laying water pipes in Newton.	6	$53,121 75	$50,976 00*	D. F. O'Connell, . .
		Total, ...	. .	. . .	. . .	. . . . . .

* Contract based upon this bid. † Contract completed.

YEAR 1904 — WATER WORKS — *Continued.*

Dam and Aqueduct Department — Concluded.

7. Date of Contract.	8. Date of Completion of Work.	9. Prices of Principal Items of Contracts made in 1904.	10. Value of Work done Dec. 31, 1904.	
Aug. 12, '04,	Dec. 20, '04,	For all castings, $0.035 per lb., ...	$1,248 97	1
Aug. 12, '04,	Dec. 31, '04,	For all castings, $0.0316 per lb., ...	2,536 63	2
. . .	. . .	. . . .	$1,940,808 99	

Weston Aqueduct Department.

May 9, '01,	Oct. 9, '03,	- -	$205,159 54	3
May 9, '01,	Oct. 9, '03,	- -	131,062 48	4
May 9, '01,	Sept. 26, '03,	- -	116,641 31	5
May 9, '01,	Oct. 7, '03,	- -	142,021 55	6
May 20, '01,	Nov. 11, '03,	- -	417,252 64	7
Aug. 28, '01,	Nov. 21, '03,	- -	150,101 77	8
Aug. 28, '01,	Nov. 14, '03,	- -	159,892 59	9
Aug. 28, '01,	Nov. 28, '03,	- -	183,374 58	10
Nov. 26, '01,	May 20, '04,	- -	59,449 04	11
Nov. 26, '01,	May 20, '04,	- -	63,778 33	12
Nov. 26, '01,	May 20, '04,	- -	123,970 70	13
June 4, '03,	April 8, '04,	- -	12,484 75	14
July 6, '03,	Nov. 28, '03,	- -	10,804 00	15
. . .	. . .	. . . .	$1,775,993 28	

Distribution Department.

April 7, '02,	April 21, '03,	- -	$71,287 87	16
. . .	. . .	. . . .	$71,287 87	

CONTRACTS MADE AND PENDING DURING THE YEAR 1904 — WATER WORKS — *Concluded.*

Summary of Contracts.*

	Value of Work done December 31, 1904.
Wachusett Reservoir, 6 contracts,	$1,086,858 91
Relocation of Central Massachusetts Railroad, 1 contract,	256,439 34
Wachusett Dam, 7 contracts,	1,544,958 61
Weston Aqueduct and Reservoir, 13 contracts,	1,775,993 28
Distribution Department, 1 contract,	71,287 87
Total of 28 contracts made and pending during the year 1904,	$4,735,538 01
248 contracts completed from 1896 to 1903, inclusive,	10,525,722 64
	$15,261,260 65
Deduct for work done on 11 Sudbury Reservoir contracts by the city of Boston,	512,000 00
Total of 287 contracts,	$14,749,260 65

* 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 natural cements used by the Dam and Aqueduct, and Reservoir departments during the years 1896 to 1900, inclusive.

2. Long-time tests of Portland cements used by the Dam and Aqueduct, and Reservoir departments during the years 1896 to 1900, inclusive.

3. Tests of cements used in the construction of the Wachusett Dam and other works at the Wachusett Reservoir during the years 1901 to 1904, inclusive.

4. 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 of the year 1897.

Summary of Tests of All Brands of Natural Cement, of which Nine Aqueduct and Reservoir Departments

	BRAND.	Number of Barrels used.	Composition of Briquette.	Tensile Strength. Two Years. Number of Briquettes.	Tensile Strength. Two Years. Pounds per Square Inch.
1	Beach,	8,380	Neat,	64	467
			1 to 1,	64	316
2	Hoffman,	45,345	Neat,	106	467
			1 to 1,	106	327
3	Norton,	60,877	Neat,	60	440
			1 to 1,	60	295
4	Union,	900	Neat,	22	409
			1 to 1,	22	570
	Total,	115,502	Neat,	252	456
			1 to 1,	252	338

Summary of Tests of All Brands of Portland Cement, of which Nine Aqueduct and Reservoir Departments

	BRAND.	Number of Barrels used.	Composition of Briquette.	Tensile Strength. Eighteen Months. Number of Briquettes.	Tensile Strength. Eighteen Months. Pounds per Square Inch.
1	Atlas,	18,509	Neat,	65	848
			2 to 1,	65	324
2	Brooks-Shoobridge,	5,706	Neat,	5	674
			2 to 1,	5	521
3	Giant,	15,394	Neat,	55	598
			2 to 1,	55	426
4	Iron Clad,	7,778	Neat,	34	769
			2 to 1,	34	396
5	Stettin-Girstow,	979	Neat,	8	665
			2 to 1,	8	370
6	West Kent,	3,394	Neat,	19	586
			2 to 1,	19	522
	Total,	51,760	Neat,	186	721
			2 to 1,	186	395

Hundred Barrels or More were used on Construction Work by the Dam and from 1896 to 1900, inclusive.

Tensile Strength — Concluded.						
THREE YEARS.		FIVE YEARS.		SEVEN AND ONE-HALF YEARS.		
Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	
50	482	23	506	10	462	1
50	349	24	369	10	420	
91	495	51	514	10	468	2
91	347	51	364	10	357	
54	456	28	479	3	452	3
54	314	27	325	3	371	
10	474	4	476	3	485	4
10	617	4	576	3	551	
205	480	106	501	26	465	
205	352	106	363	26	405	

Hundred Barrels or More were used on Construction Work by the Dam and from 1896 to 1900, Inclusive.

Tensile Strength — Concluded.								
TWO YEARS.		THREE YEARS.		FIVE YEARS.		SEVEN AND ONE-HALF 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.	
80	813	64	814	38	794	7	1,034	1
80	325	64	336	38	307	7	495	
55	702	53	696	30	698	13	672	2
55	447	53	449	30	443	13	448	
55	622	45	618	24	633	2	727	3
55	422	45	414	24	401	2	497	
34	800	26	826	18	838	2	698	4
34	394	26	378	18	369	2	378	
51	714	42	709	22	695	10	684	5
53	340	42	332	21	300	10	363	
59	589	51	570	29	562	17	548	6
59	434	51	424	29	391	17	409	
334	707	281	701	161	702	51	686	
336	389	281	389	157	365	51	424	

Summary of Tests of Cement used in the Construction of the Wachusett Dam

	Brand.	Number of Barrels used. At Dam.	Number of Barrels used. Totals.	Composition of Briquette.	Fineness. Per Cent. Residue on No 50 Sieve, 2,500 Meshes to Square Inch.	Fineness. Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Square Inch.	Fineness. Per Cent. Residue on No. 180 Sieve, 32,400 Meshes to Square Inch.	Wire Tests. Minutes to Bear Light Wire.	Wire Tests. Minutes to Bear Heavy Wire.	Tensile Strength. One Day. Number of Briquettes.	Tensile Strength. One Day. Pounds per Square Inch.
	Portland cement: —										
1	Alpha, . . .	150	491	Neat, .	.4	10.9	28.6	158	347	47	694
				2 to 1, .	-	-	-	-	316	-	-
2	Alsen, . . .	225	355	Neat, .	.4	11.2	26.4	116	291	31	625
				2 to 1, .	-	-	-	-	306	-	-
3	Atlas, . . .	3,064	3,763	Neat, .	.2	9.0	22.4	113	354	207	571
				2 to 1, .	-	-	-	-	287	-	-
4	Catskill, . .	-	305	Neat, .	.4	7.0	22.3	130	300	10	476
				2 to 1, .	-	-	-	-	298	-	-
5	Giant, . . .	62,659	65,641	Neat, .	.5	9.5	23.0	138	379	3,810	590
				2 to 1, .	-	-	-	-	378	-	-
6	Helderberg, . .	200	212	Neat, .	.2	5.0	19.9	173	480	23	383
				2 to 1, .	-	-	-	-	450	-	-
7	Iron Clad, . .	4,260	4,540	Neat, .	.1	4.2	17.1	86	304	222	652
				2 to 1, .	-	-	-	-	293	-	-
8	Lehigh, . .	4,140	10,733	Neat, .	.1	8.2	22.0	217	484	960	531
				2 to 1, .	-	-	-	-	481	-	-
9	Star, . . .	-	1,200	Neat, .	.5	9.8	24.4	154	336	51	691
				2 to 1, .	-	-	-	-	356	-	-
10	Stettin-Girstow, .	-	2,200	Neat, .	.7	8.3	21.3	62	178	252	377
				2 to 1, .	-	-	-	-	351	-	-
11	Whitehall, . .	150	150	Neat, .	.3	8.3	27.5	180	360	20	736
				2 to 1, .	-	-	-	-	450	-	-
	Total, . . .	74,848	89,590	Neat, .	1.8	10.7	22.5	142	380	5,633	574
				2 to 1, .	-	-	-	-	381	-	-
	Natural cement: —										
12	Union, . . .	175,060	175,060	Neat, .	1.0	6.3	13.7	66	133	6,689	174
				1 to 1, .	-	-	-	57	112	-	-
				2 to 1, .	-	-	-	-	-	-	-

Summary of Tests of Cements used in the Construction

	Brand.	At Dam.	Totals.	Composition of Briquette.	No. 50 Sieve.	No. 100 Sieve.	No. 180 Sieve.	Light Wire.	Heavy Wire.	Number of Briquettes.	Pounds per Square Inch.
	Portland cement: —										
13	Atlas, . . .	-	91,875	Neat, .	.2	9.4	20.0	58	331	4,356	423
				2 to 1, .	-	-	-	-	417	-	-
14	Giant, . . .	-	7,653	Neat, .	.3	9.5	20.7	69	303	430	420
				2 to 1, .	-	-	-	-	366	-	-
15	Saylor's, . .	-	2,200	Neat, .	.2	6.2	18.0	161	479	127	214
				2 to 1, .	-	-	-	-	544	-	-
16	Lehigh, . .	-	5,160	Neat, .	.1	9.7	20.8	134	344	207	374
				2 to 1, .	-	-	-	-	515	-	-
	Total, . . .	-	106,888	Neat, .	.2	9.4	20.0	65	333	5,120	415
				2 to 1, .	-	-	-	-	420	-	-
	Natural cement: —										
17	Hoffman, . .	-	98,347	Neat, .	1.1	6.8	-	27	61	4,485	138
				1 to 1, .	-	-	-	26	63	-	-
18	Union, . . .	-	14,738	Neat, .	1.0	6.8	13.1	40	90	832	157
				1 to 1, .	-	-	-	27	73	-	-
	Total, . .	-	113,085	Neat, .	1.1	6.8	-	29	65	5,317	141
				1 to 1, .	-	-	-	26	64	-	-

and Other Works at the Wachusett Reservoir, 1901 to 1904, Inclusive.

TENSILE STRENGTH — Concluded.																		
SEVEN DAYS.		TWENTY-EIGHT DAYS.		THREE MONTHS.		SIX MONTHS.		NINE MONTHS.		ONE YEAR.		EIGHTEEN MONTHS.		TWO YEARS.		THREE 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	1,021	5	1,026	5	1,029	5	1,091	5	1,063	5	1,015	5	1,029	5	1,034	–	–	1
47	474	5	428	5	445	5	405	5	452	5	406	5	340	5	320	–	–	
32	776	15	753	5	761	5	834	5	723	5	813	5	825	5	824	–	–	2
32	373	15	433	5	413	5	447	5	380	5	393	5	381	5	382	–	–	
206	837	167	848	20	801	20	848	20	823	20	899	20	873	15	833	–	–	3
207	384	167	450	20	444	20	445	20	459	20	422	20	404	15	393	–	–	
10	855	10	903	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4
10	393	10	477	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
3,750	860	3,533	887	290	864	285	898	285	879	215	893	190	911	145	881	100	920	5
3,814	403	3,536	450	290	455	285	450	265	445	210	435	190	409	145	408	100	377	
23	843	23	933	5	906	5	881	5	872	5	897	5	870	5	896	–	–	6
23	301	23	409	5	377	5	380	5	402	5	386	5	389	5	372	–	–	
218	700	221	712	25	714	25	788	25	769	25	807	25	885	25	851	–	–	7
218	403	222	451	25	474	25	486	25	497	25	488	25	505	25	504	–	–	
959	871	591	879	20	897	15	907	15	927	15	898	5	1,074	5	1,050	–	–	8
959	396	591	499	20	447	15	481	15	426	15	456	5	426	5	447	–	–	
51	927	28	924	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9
51	433	28	428	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
251	475	251	538	15	597	15	664	15	692	15	709	15	728	–	–	–	–	10
250	281	252	378	15	448	15	496	15	486	15	486	15	481	–	–	–	–	
20	946	13	970	5	996	5	971	5	874	5	1,047	–	–	–	–	–	–	11
20	434	13	478	5	474	5	445	5	431	5	352	–	–	–	–	–	–	
5,567	839	4,857	859	390	845	380	882	380	864	310	881	270	899	205	881	100	920	
5,631	396	4,862	452	390	453	380	453	360	449	305	439	270	419	205	416	100	377	
6,684	225	2,548	298	345	358	310	405	–	–	230	437	–	–	160	484	65	500	12
6,664	185	2,540	278	345	411	310	490	–	–	230	553	–	–	160	624	65	660	
1,360	116	1,307	197	275	290	230	382	–	–	170	421	–	–	94	461	–	–	

of the Weston Aqueduct, 1901 to 1904, Inclusive.

4,346	664	2,266	718	490	745	275	757	–	–	183	750	93	741	39	832	9	876	13
4,169	284	3,141	401	523	470	291	446	–	–	191	402	90	405	58	398	10	406	
431	659	228	707	98	762	82	764	–	–	66	759	25	808	12	835	–	–	14
405	323	268	402	102	482	89	476	–	–	91	449	23	433	15	436	–	–	
130	719	104	792	73	780	85	830	–	–	65	822	34	830	29	848	–	–	15
127	269	103	398	67	410	78	397	–	–	61	350	24	449	38	340	–	–	
210	639	169	730	64	744	49	765	–	–	48	769	20	827	10	971	–	–	16
208	314	166	455	68	491	49	490	–	–	50	418	20	433	10	434	–	–	
5,117	664	2,767	721	725	750	491	772	–	–	362	767	172	778	90	853	9	876	
4,909	288	3,678	403	760	468	507	448	–	–	393	418	157	419	121	388	10	406	
4,474	164	2,569	253	220	320	159	355	–	–	186	350	92	380	58	369	5	340	17
4,415	128	2,586	242	217	335	168	383	–	–	146	355	99	349	51	333	5	305	
833	205	409	269	63	312	52	356	–	–	32	394	25	402	15	404	–	–	18
833	174	431	246	69	345	51	395	–	–	30	467	20	501	15	541	–	–	
5,307	170	2,978	255	283	318	211	355	–	–	218	357	117	378	73	376	5	340	
5,248	136	3,017	242	286	338	219	386	–	–	176	374	119	374	66	380	5	305	

APPENDIX No. 3.

TABLE No. 1. — *Monthly Rainfall in Inches at Various Places on the Metropolitan Water Works, in 1901.*

Place.		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Wachusett Watershed.	Princeton,	3.25	2.70	3.67	7.27	2.93	3.51	3.83	3.91	5.68	1.95	1.57	2.61	42.88
	Jefferson,	4.53	2.80	3.50	7.25	3.43	3.78	4.76	3.54	5.72	1.92	1.58	2.98	45.79
	Sterling,	3.50	2.43	3.22	6.93	3.02	3.54	3.14	3.59	5.22	1.70	1.61	2.87	40.77
	Boylston,	4.80	2.72	3.21	8.35	2.58	2.94	3.63	3.67	4.57	1.56	1.73	3.06	42.82
Sudbury Watershed.	Sudbury Dam,	4.64	2.86	2.57	8.38	2.84	3.36	2.24	4.32	4.80	1.58	1.68	2.80	42.07
	Framingham,	4.70	3.00	2.69	8.78	2.44	2.70	2.14	3.41	5.64	1.51	1.73	2.96	41.70
	Ashland Dam,	4.63	3.06	2.76	8.99	2.70	2.27	1.57	3.81	6.08	1.69	1.73	3.11	42.40
	Cordaville,	5.52	3.08	2.85	9.31	2.60	2.86	1.89	3.92	6.69	1.78	1.80	2.81	45.11
Lake Cochituate,		4.75	3.11	2.78	8.68	2.14	2.86	1.80	3.32	6.78	1.66	1.84	2.39	42.11
Chestnut Hill Reservoir,		5.64	2.96	2.79	9.18	3.28	2.75	1.48	2.74	5.75	2.21	1.81	2.81	43.40
Spot Pond,		5.74	3.08	2.99	9.42	3.98	3.56	1.51	3.47	5.38	1.89	1.75	2.34	45.11
Average of all,		4.70	2.89	3.00	8.41	2.90	3.10	2.55	3.61	5.67	1.77	1.71	2.80	43.11
Average, Wachusett watershed,		4.02	2.66	3.40	7.45	2.99	3.44	3.84	3.68	5.30	1.78	1.62	2.88	43.06
Average, Sudbury watershed,		4.87	3.00	2.72	8.87	2.65	2.80	1.96	3.86	5.80	1.64	1.73	2.92	42.82

TABLE NO. 2. — *Rainfall in Inches at Jefferson, Mass., in 1904.*

DAY OF MONTH.	January.	February.	March.	April	May.	June.	July.	August.	September.	October.	November.	December.
1,	-	-	0.57†	0.90‡	-	-	0.50	*	-	-	-	-
2,	*	-	-	-	-	*	0.10	0.54	0.04	-	-	-
3,	0.85†	-	0.75‡	-	-	0.52	-	-	-	-	-	-
4,	-	-	-	-	-	-	-	-	-	-	-	-
5,	-	-	-	-	-	0.12	2.03	-	-	*	-	0.12†
6,	-	0.30†	-	-	-	*	-	-	-	0.22	-	-
7,	-	0.13	*	0.35	-	1.28	-	-	-	-	-	-
8,	*	-	1.00	-	-	-	-	0.27	*	0.08	-	0.03†
9,	0.30†	-	-	*	0.63	-	-	-	*	-	-	-
10,	-	-	-	1.21	*	-	-	*	0.37	-	-	-
11,	-	-	-	-	0.25	-	-	0.92	-	-	-	-
12,	-	-	-	0.21	-	-	-	-	-	0.40	-	*
13,	0.85‡	-	-	-	-	-	0.08	-	-	-	*	0.50†
14,	-	*	-	-	*	-	-	0.11	*	-	1.30‡	-
15,	-	0.28†	0.05†	-	0.15	-	-	-	4.09	-	-	-
16,	0.21†	-	-	0.35†	-	0.07	-	-	-	-	-	-
17,	-	-	-	-	*	-	-	-	-	-	-	*
18,	-	-	0.38†	-	*	-	0.75	-	-	-	-	0.38†
19,	-	0.20†	*	0.05†	0.63	-	-	-	-	-	-	-
20,	0.15†	-	0.15	-	0.25	-	-	1.70	-	-	-	-
21,	*	-	-	-	-	-	-	-	-	1.10	-	0.04†
22,	*	1.00	*	-	-	-	*	-	-	0.05	-	-
23,	1.25‡	-	0.15	-	-	-	*	-	-	-	-	-
24,	-	0.38†	-	-	-	-	*	-	0.23	-	-	-
25,	-	-	-	0.07	0.08	0.09	0.75	-	-	-	-	0.16†
26,	0.68†	-	-	*	0.52	-	-	-	0.13	0.07	-	*
27,	-	-	-	*	0.60	-	-	-	-	-	0.03†	*
28,	-	0.23‡	-	*	-	-	-	-	-	-	-	1.75‡
29,	*	0.28†	-	4.07	-	*	0.55	-	0.73	-	*	-
30,	0.24†	-	-	0.04	0.32	1.70	-	-	0.13	-	0.25	-
31,	-	-	0.45‡	-	-	-	-	-	-	-	-	-
Total,	4.53	2.80	3.50	7.25	3.43	3.78	4.76	3.54	5.72	1.92	1.58	2.98

Total for the year, 45.79 inches.

* Rainfall included in that of following day. † Snow. ‡ Rain and snow.

TABLE NO. 3. — *Rainfall in Inches at Framingham, Mass., in 1904.*

Day of Month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	–	–	0.16†	0.98	0.01	–	0.04	*	–	–	–	–
2,	*	–	–	–	–	*	0.02	0.85	–	–	–	–
3,	1.26†	–	0.49‡	–	–	0.31	–	–	–	–	–	–
4,	–	–	–	–	–	–	–	–	0.02	–	–	–
5,	–	*	–	–	–	–	0.43	0.02	–	*	–	0.19†
6,	–	0.39‡	–	–	–	*	0.10	–	–	0.16	–	–
7,	–	0.05	0.79	0.18	–	0.57	–	–	–	–	–	–
8,	*	–	–	*	–	0.07	–	0.44	0.29	*	–	0.03†
9,	0.69†	–	–	0.60	0.88	–	–	–	0.06	0.02	0.02†	–
10,	–	–	–	1.22	0.08	–	–	0.45	–	0.03	–	–
11,	–	–	–	*	–	–	–	0.09	*	0.04	–	–
12,	–	–	–	0.28	–	–	–	–	0.60	*	–	*
13,	0.65‡	–	–	–	–	–	0.15	0.04	–	0.60	1.55‡	0.42†
14,	–	*	–	–	–	–	–	0.23	*	–	–	–
15,	–	0.50†	0.18†	*	0.32	–	–	–	3.66	–	–	–
16,	0.09‡	–	–	0.40†	–	–	0.05	0.18	–	–	–	–
17,	–	–	–	–	–	–	–	0.01	–	–	–	*
18,	–	–	0.41‡	–	0.35	–	–	–	–	–	–	0.47†
19,	–	0.20†	0.07	0.11‡	0.27	–	–	*	–	–	–	–
20,	0.06†	–	–	0.03†	0.02	–	–	1.10	–	*	0.03	–
21,	*	*	–	–	–	0.41	–	–	–	0.52	–	–
22,	*	0.84	0.01‡	–	–	–	*	–	–	–	–	–
23,	1.04‡	–	0.20	–	0.02	–	*	–	–	–	–	–
24,	–	0.35‡	–	0.08	–	–	*	–	0.14	–	–	–
25,	–	–	–	–	0.02	0.32	0.64	–	–	–	–	*
26,	0.67‡	–	–	*	0.03	–	0.54	–	0.06	0.14	–	0.12†
27,	–	–	–	*	0.26	–	–	–	–	–	0.04†	*
28,	–	0.16	–	*	–	–	–	–	–	–	–	1.73
29,	0.22†	0.51†	–	4.88	–	–	0.17	–	0.77	–	0.09	–
30,	–	–	–	0.02	0.18	1.02	–	–	0.04	–	–	–
31,	0.02	–	0.38‡	–	–	–	–	–	–	–	–	–
Total,	4.70	3.00	2.69	8.78	2.44	2.70	2.14	3.41	5.64	1.51	1.73	2.96

Total for the year, 41.70 inches.

* Rainfall included in that of following day. † Snow. ‡ Rain and snow.

Table No. 4. — *Rainfall in Inches at Chestnut Hill Reservoir in 1904.*

Date.	Amount.	Snow or Rain.	Duration.
Jan. 2, Jan. 3,	1.15	Snow.	7.10 A.M. to 10.30 P.M.
Jan. 8, Jan. 9,	1.09	Snow.	2.30 P.M. to 3.30 P.M.
Jan. 12,	0.03	Snow.	7.00 A.M. to 7.00 P.M.
Jan. 13,	1.18	Snow and rain.	11.00 A.M. to 10.45 P.M.
Jan. 16,	0.09	Snow.	3.20 P.M. to 6.15 P.M.
Jan. 20,	0.08	Snow.	5.50 A.M. to 11.30 A.M.
Jan. 21, Jan. 22,	1.04	Snow and rain.	2.45 P.M. to 10.40 P.M.
Jan. 23,	0.10	Rain.	1.45 P.M. to 6.30 P.M.
Jan. 26,	0.73	Rain and snow.	3.45 P.M. to 10.50 P.M.
Jan. 29,	0.15	Snow.	5.50 A.M. to 8.00 P.M.
Total,	5.64		
Feb. 6,	0.46	Snow and rain.	1.00 A.M. to 9.00 P.M.
Feb. 14, Feb. 15,	0.77	Snow.	7.00 P.M. to 5.30 P.M.
Feb. 19,	0.21	Snow.	6.10 A.M. to 5.45 P.M.
Feb. 21, Feb. 22,	0.98	Rain.	11.23 P.M. to 1.45 P.M.
Feb. 24,	0.33	Snow.	4.30 A.M. to 3.30 P.M.
Feb. 28,	0.15	Rain.	2.00 P.M. to 4.30 P.M.
Mar. 1,	0.06	Rain and snow.	1.00 A.M. to 7.00 A.M.
Total,	2.96		
Mar. 1,	0.15	Snow.	7.00 A.M. to 4.30 P.M.
Mar. 3,	0.47	Rain.	5.00 A.M. to 8.15 P.M.
Mar. 7, Mar. 8,	0.96	Rain.	5.45 P.M. to 4.30 A.M.
Mar. 15,	0.14	Snow.	5.50 A.M. to 8.00 P.M.
Mar. 18,	0.40	Snow and rain.	5.50 A.M. to 5.30 P.M.
Mar. 19, Mar. 20,	0.07	Rain.	8.30 P.M. to 12.20 A.M.
Mar. 22, Mar. 23,	0.27	Snow and rain.	6.05 A.M. to 9.45 A.M.
Mar. 31, Apr. 1,	0.33	Snow and rain.	5.35 P.M. to 7.00 A.M.
Total,	2.79		
Apr. 1,	1.01	Rain.	9.00 A.M. to 6.10 P.M.
Apr. 7,	0.17	Rain.	7.50 A.M. to 1.20 P.M.
Apr. 8, Apr. 10,	1.42	Rain.*	9.25 P.M. to 3.05 A.M.
Apr. 11,	0.06	Rain.	3.20 A.M. to 5.05 A.M.
Apr. 12,	0.32	Rain.	5.00 A.M. to 10 45 A.M.
Apr. 16,	0.38	Snow.	2.10 A.M. to 12.30 P.M.
Apr. 19,	0.25	Snow.	5.15 P.M. to 11.20 P.M.
Apr. 24,	0.10	Rain.	2.15 A.M. to 5.45 A.M.
Apr. 26,	0.10	Rain.	9.30 P.M. to 7.00 A.M.
Apr. 27, Apr. 30,	5.37	Rain.*	7.00 A.M. to 6.30 P.M.
Total,	9.18		
May 9,	0.79	Rain.	6.10 A.M. to 8.00 P.M.
May 10,	0.14	Rain.	5.20 P.M. to 6.30 P.M.
May 15,	0.24	Rain.	7.00 P.M. to 10.30 P.M.
May 18, May 20,	1.15	Rain.*	9.30 A.M. to 1.30 P.M.
May 25,	0.28	Rain.*	7.00 P.M. to 8.45 P.M.
May 27,	0.40	Rain.*	1.10 P.M. to 1.40 P.M.
May 30,	0.28	Rain.	2.40 P.M. to 9.30 P.M.
Total,	3.28		
June 2,	0.57	Rain.	12.25 P.M. to 7.00 P.M.
June 7,	0.50	Rain.*	3.15 A.M. to 7.30 A.M.
June 7, June 8,	0.05	Rain.	10.00 P.M. to 2.00 A.M.
Jnne 21,	0.20	Rain.*	1.20 P.M. to 1.40 P.M.
June 21, June 23,	0.10	Rain.	4.00 P.M. to 12.45 A.M.
June 25,	0.30	Rain.*	6.30 P.M. to 9.00 P.M.
June 26,	0.18	Rain.*	1.30 P.M. to 2.40 P.M.
June 28, June 30,	0.85	Rain.	11.05 P.M. to 11.45 P.M.
Total,	2.75		
July 1,	0.02	Rain.	7.00 A.M. to 8.30 A.M.
July 5,	0.44	Rain.	4.20 P.M. to 9.50 P.M.
July 13,	0.09	Rain.	5.55 A.M. to 11.40 A.M.
July 17,	0.19	Rain.	7.30 P.M. to 9.00 P.M.
July 22, July 25,	0.61	Rain.	8.30 P.M. to 1.30 A.M.
July 27,	0.06	Rain.	2.00 A.M. to 6.00 A.M.
July 29,	0.07	Rain.	2.25 A.M. to 3.35 A.M.
Total,	1.48		
Aug. 1, Aug. 3,	0.96	Rain.	6.25 P.M. to 8.00 A.M.
Aug. 6,	0.19	Rain.	12.30 A.M. to 4.15 A.M.
Aug. 8,	0.03	Rain.	6.50 A.M. to 8.30 A.M.
Aug. 11,	0.41	Rain.	5.50 P.M. to 5.55 P.M.
Aug. 14,	0.08	Rain.	1.05 A.M. to 3.00 P.M.
Aug. 16,	0.04	Rain.	3.30 P.M. to 6.00 P.M.
Aug. 20, Aug. 21,	1.03	Rain.	5.00 A.M. to 2.30 A.M.
Total,	2.74		
Sept. 4,	0.02	Rain.	2.35 A.M. to 3.25 A.M.
Sept. 8, Sept. 10,	0.28	Rain.	7.00 P.M. to 12.15 A.M.
Sept. 11, Sept. 12,	0.51	Rain.	11.45 P.M. to 9.10 P.M.
Sept. 14, Sept. 15,	3.84	Rain.	11.10 A.M. to 8.30 A.M.
Sept. 24, Sept. 26,	0.30	Rain.	8.30 P.M. to 6.15 P.M.
Sept. 29, Sept. 30,	0.80	Rain.	12.45 P.M. to 1.15 P.M.
Total,	5.75		

* Thunder shower.

TABLE No. 4. — *Rainfall in Inches at Chestnut Hill Reservoir in 1904* — Concluded.

Date.	Amount.	Snow or Rain.	Duration.	Date.	Amount.	Snow or Rain.	Duration.
Oct. 5,	0.32	Rain.	9.15 P.M. to 11.20 P.M.	Dec. 5,	0.21	Snow.	5.00 P.M. to 11.05 P.M.
Oct. 9,	0.02	Rain.	12.50 A.M. to 2.25 A.M.	Dec. 8,	0.06	Snow.	10.00 A.M. to 6.00 P.M.
Oct. 11,	0.14	Rain.	3.30 A.M. to 4.30 P.M.	Dec. 12, Dec. 13,	0.15	Snow.	6.00 P.M. to 6.30 A.M.
Oct. 12, Oct. 13,	0.92	Rain.	1.20 P.M. to 3.30 A.M.	Dec. 16, Dec. 18,	0.71	Snow.	1.55 A.M. to 10.30 A.M.
Oct. 21,	0.64	Rain.	12 55 A.M. to 2.45 P.M.	Dec. 26, Dec. 28,	1.68	Snow and rain.	11.45 P.M. to 10.00 A.M.
Oct. 26,	0.17	Rain.	11.15 A.M. to 5.15 P.M.	Total,	2.81		
Total,	2.21						
Nov. 13, Nov. 14,	1.66	Rain.	8.30 A.M. to 5.00 A.M.				
Nov. 21,	0.05	Rain.	2.55 A.M. to 5.10 A.M.				
Nov. 29, Nov. 30,	0.10	Rain.	8.00 P.M. to 1.25 A.M.				
Total,	1.81						

Total for the year, 43.40 inches.

TABLE NO. 5. — *Rainfall in Inches on the Wachusett Watershed, 1897 to 1904.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
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
1904,	4.02	2.66	3.40	7.45	2.99	3.44	3.84	3.68	5.30	1.78	1.62	2.88	43.06
Total,	28.94	33.09	40.29	36.00	27.60	35.15	35.48	36.55	28.24	30.04	30.15	39.01	400.54
Average,	3.62	4.14	5.04	4.50	3.45	4.39	4.43	4.57	3.53	3.75	3.77	4.88	50.07

NOTE. — 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, 1904, Princeton, Jefferson, Sterling and Boylston.

TABLE No. 6. — *Rainfall in Inches on the Sudbury Watershed,* 1875 to 1904.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
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
1904,	4.87	3.00	2.72	8.87	2.65	2.80	1.96	3.86	5.80	1.64	1.73	2.92	42.82
Total,	126.19	130.14	137.79	108.25	100.32	92.58	110.11	121.66	99.58	126.76	118.70	114.46	1,386.54
Average,	4.21	4.34	4.59	3.61	3.34	3.09	3.67	4.05	3.32	4.23	3.96	3.81	46.22

* 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, 1904, 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 1904.*

MONTH.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	Mean for 8 Years, 1897-1904.
January,	796,000	1,563,000	2,092,000	796,000	519,000	1,676,000	1,265,000	659,000	1,171,000
February,	931,000	1,635,000	1,090,000	4,054,000	356,000	1,401,000	2,133,000	927,000	1,563,000
March,	2,760,000	3,088,000	2,776,000	3,722,000	2,718,000	3,992,000	3,423,000	3,008,000	3,186,000
April,	1,632,000	2,027,000	3,376,000	1,580,000	4,986,000	2,159,000	2,238,000	2,984,000	2,623,000
May,	1,163,000	1,390,000	862,000	1,382,000	2,729,000	1,031,000	569,000	1,498,000	1,328,000
June,	1,181,000	828,000	561,000	578,000	985,000	410,000	2,131,000	762,000	929,000
July,	1,442,000	333,000	354,000	217,000	477,000	292,000	624,000	497,000	530,000
August,	896,000	1,325,000	236,000	197,000	512,000	297,000	474,000	355,000	536,000
September,	380,000	676,000	250,000	127,000	320,000	241,000	375,000	494,000	358,000
October,	243,000	1,509,000	245,000	282,000	647,000	950,000	689,000	347,000	614,000
November,	1,283,000	2,170,000	430,000	875,000	517,000	635,000	634,000	343,000	861,000
December,	2,275,000	2,061,000	359,000	1,570,000	3,234,000	1,848,000	954,000	440,000	1,593,000
Average for year,	1,253,000	1,551,000	1,051,000	1,264,000	1,507,000	1,248,000	1,285,000	1,025,000	1,273,000
Average for driest 6 months,	886,000	1,013,000	312,000	377,000	576,000	471,000	626,000	413,000	637,000

* 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, to 2.4 per cent. in 1903, and to 3.6 per cent. in 1904.

Table No. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1904.*

Month	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 1904* — Continued.

MONTH.	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 1904* — Concluded.

MONTH.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	Mean for 30 Years, 1875-1904.
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	477,000	1,217,000
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	882,000	1,861,000
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	2,999,000	2,986,000
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	3,294,000	2,116,000
May,	636,000	360,000	915,000	1,246,000	511,000	1,312,000	2,954,000	743,000	351,000	1,745,000	1,141,000
June,	174,000	399,000	962,000	530,000	66,000	316,000	753,000	303,000	1,987,000	419,000	522,000
July,	231,000	95,000	658,000	231,000	19,000	—18,000	306,000	66,000	445,000	62,000	193,000
August,	229,000	57,000	591,000	1,107,000	—35,000	—34,000	424,000	135,000	307,000	170,000	291,000
September,	89,000	388,000	182,000	369,000	94,000	65,000	305,000	178,000	130,000	397,000	238,000
October,	1,379,000	592,000	94,000	1,160,000	115,000	186,000	412,000	506,000	492,000	191,000	506,000
November,	2,777,000	659,000	909,000	1,986,000	304,000	663,000	474,000	444,000	363,000	289,000	868,000
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	269,000	1,082,000
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	931,000	1,081,000
Average for driest six months,	460,000	314,000	564,000	777,000	93,000	194,000	445,000	271,000	388,000	228,000	435,000

* 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 1904.*

[Watershed=119.00 square miles.]

Month.	Quantity of Water discharged through Wachusett Aqueduct (Gallons per Day).*	Quantity of Water wasted into River below Dam (Gallons per Day).	Storage.†		Total Yield of Watershed (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
			Gain (Gallons per Day).	Loss (Gallons per Day).				
January,	87,365,000	2,487,000	-	11,341,000	78,471,000	4.02	1.176	29.3
February,	117,266,000	2,624,000	-	9,590,000	110,300,000	2.66	1.547	58.1
March,	107,806,000	5,136,000	244,955,000	-	357,897,000	3.40	5.361	157.7
April,	95,060,000	202,727,000	57,350,000	-	355,137,000	7.45	5.149	69.1
May,	106,868,000	73,719,000	-	2,377,000	178,210,000	2.99	2.671	89.3
June,	105,410,000	16,537,000	-	31,287,000	90,660,000	3.44	1.315	38.2
July,	110,287,000	2,061,000	-	53,235,000	59,113,000	3.84	0.886	23.1
August,	78,390,000	2,300,000	-	38,461,000	42,229,000	3.68	0.633	17.2
September,	54,367,000	2,123,000	2,300,000	-	58,790,000	5.30	0.853	16.1
October,	28,361,000	2,181,000	10,810,000	-	41,352,000	1.78	0.620	34.8
November,	46,103,000	2,377,000	-	7,717,000	40,763,000	1.62	0.591	29.0
December,	125,803,000	1,929,000	-	75,426,000	52,306,000	2.88	0.784	27.2
Total,	-	-	-	-	-	43.06	21.586	-
Average for year,	88,580,000	26,156,000	7,275,000	-	122,011,000	-	-	50.2

* 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 1904.*

[Watershed from 1875 to 1878 inclusive = 77.764 square miles; in 1879 and 1880 = 78.238 square miles; and from 1881 to 1904 inclusive = 75.2 square miles.]

MONTH.	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.		Total Yield of Watershed (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
							Gain (Gallons per Day).	Loss (Gallons per Day).				
January,	87,365,000	85,806,000	32,352,000	619,000	710,000	23,703,000	-	19,912,000	35,884,000	4.87	0.851	17.5
February,	117,266,000	86,604,000	33,276,000	631,000	1,069,000	46,590,000	15,441,000	-	66,345,000	3.00	1.472	49.0
March,	107,806,000	70,442,000	32,323,000	529,000	1,984,000	131,958,000	96,081,000	-	225,510,000	2.72	5.349	196.8
April,	95,060,000	93,273,000	15,430,000	510,000	2,270,000	198,637,000	32,610,000	-	247,690,000	8.87	5.685	64.0
May,	106,868,000	85,077,000	30,452,000	548,000	1,736,000	112,997,000	7,258,000	-	131,200,000	2.65	3.112	117.7
June,	105,410,000	85,783,000	28,040,000	550,000	770,000	27,887,000	-	6,133,000	31,487,000	2.80	0.723	25.8
July,	110,287,000	73,081,000	33,216,000	564,000	429,000	10,355,000	-	2,703,000	4,655,000	1.96	0.111	5.6
August,	78,390,000	58,384,000	34,194,000	516,000	403,000	13,468,000	-	15,823,000	12,752,000	3.86	0.303	7.8
September,	54,367,000	68,280,000	35,293,000	523,000	340,000	1,523,000	-	21,760,000	29,833,000	5.80	0.685	11.8
October,	28,361,000	63,755,000	36,868,000	545,000	297,000	1,500,000	-	60,245,000	14,358,000	1.64	0.348	21.2
November,	45,790,000	62,007,000	33,403,000	533,000	230,000	2,507,000	-	31,157,000	21,733,000	1.73	0.499	28.8
December,	125,803,000	93,403,000	30,626,000	565,000	323,000	1,500,000	19,642,000	-	20,255,000	2.92	0.481	16.5
Total,	-	-	-	-	-	-	-	-	-	42.82	19.619	-
Av. for year,	88,554,000	77,104,000	31,316,000	553,000	879,000	47,616,000	1,112,000	-	70,025,000	-	-	45.8

* Not including quantities of water wasted in cleaning aqueduct, which were not discharged into Sudbury Reservoir.

† Including quantities of water wasted from aqueduct.

TABLE NO. 11. — *Cochituate System. — Statistics of Flow of Water, Storage and Rainfall in 1904.*

[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,	-	21,165,000	419,000	-	-	10,490,000	11,094,000	4.75	1.05	22.1
February,	-	21,248,000	545,000	-	-	7,566,000	14,228,000	3.11	1.26	40.5
March,	-	18,974,000	506,000	1,523,000	29,103,000	-	50,106,000	2.78	4.73	170.4
April,	-	7,820,000	1,463,000	47,887,000	87,000	-	57,257,000	8.68	5.24	60.4
May,	129,000	2,322,000	1,268,000	18,006,000	3,310,000	-	24,777,000	2.14	2.34	109.5
June,	80,000	-	567,000	4,520,000	953,000	-	5,960,000	2.86	0.55	19.1
July,	-	6,439,000	297,000	-	-	6,013,000	723,000	1.80	0.07	3.8
August,	-	20,552,000	287,000	-	-	15,981,000	4,858,000	3.32	0.49	14.8
September,	9,200,000	23,187,000	340,000	-	-	3,343,000	10,983,000	6.78	1.00	14.8
October,	24,690,000	23,797,000	332,000	-	5,006,000	-	4,445,000	1.66	0.42	25.3
November,	3,647,000	22,967,000	300,000	-	-	10,377,000	9,243,000	1.84	0.85	46.0
December,	-	11,777,000	290,000	-	-	3,555,000	8,531,000	2.39	0.80	33.7
Total,	-	-	-	-	-	-	-	42.11	18.80	-
Average for year,	3,162,000	15,003,000	550,000	5,950,000	-	1,522,000	16,819,000	-	-	44.6

* Not including the watershed of Dudley Pond.

† From Framingham reservoirs, Nos. 1, 2 and 3.

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.	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.
					No. 1. Flash Boards 169.27.	No. 2 Flash Boards 177.12.	No. 3. Flash Boards 186.50.					
Jan. 1, 1904, . .	133.17	142.42	158.59	162.26	167.70	175.97	183.37	220.90	252.63	299.84	337.89	305.90
Feb. 1, 1904, . .	132.99	140.94	158.55	162.89	167.78	176.09	183.36	221.56	250.94	301.22	337.17	303.39
March 1, 1904, . .	132.78	139.90	158.57	162.24	167.90	176.20	183.44	221.25	252.53	301.53	336.47	301.30
April 1, 1904, . .	132.89	143.92	158.84	162.62	167.95	176.24	183.93	224.16	258.65	303.63	337.54	327.78
May 1, 1904, . .	133.45	143.93	159.46	163.32	168.61	177.41	184.98	225.01	259.52	305.12	338.96	330.96
June 1, 1904, . .	133.97	144.33	159.23	162.87	169.49	177.29	186.01	225.32	259.96	305.05	338.56	331.46
July 1, 1904, . .	134.17	144.44	158.88	163.21	169.43	177.22	185.40	225.23	259.65	305.04	338.69	330.00
Aug. 1, 1904, . .	133.06	143.71	158.39	163.08	169.30	177.12	185.05	224.99	259.76	304.78	338.51	326.58
Sept. 1, 1904, . .	132.16	141.56	158.13	163.10	167.87	175.42	184.95	223.81	259.14	304.83	338.46	323.91
Oct. 1, 1904, . .	133.94	141.10	158.56	163.58	167.47	177.61	185.08	219.70	258.57	300.44	338.24	324.07
Nov. 1, 1904, . .	132.17	141.81	158.25	161.49	168.27	176.46	185.04	213.74	255.96	293.17	337.74	324.89
Dec. 1, 1904, . .	132.04	140.37	158.10	162.91	164.92	176.90	184.23	205.67	255.52	286.46	337.90	324.28
Jan. 1, 1905, . .	133.98	139.84	158.14	163.57	166.65	177.09	184.25	193.87	259.18	273.52	336.74	317.00

TABLE NO. 13. — *Average Daily Quantity of Water flowing through Aqueducts in 1904, by Months.**

Month.	Wachusett Aqueduct into Sudbury Reservoir (Gallons).	Weston Aqueduct into Metropolitan District (Gallons).	Sudbury Aqueduct into Chestnut Hill Reservoir.			Cochituate Aqueduct into Chestnut Hill Reservoir (Gallons).
			From Framingham Reservoir No. 3 (Gallons).	From Framingham Reservoir No. 2 (Gallons).	Total (Gallons).	
January,	87,365,000	32,010,000	85,806,000	–	85,806,000	21,165,000
February,	117,265,000	33,042,000	86,604,000	–	86,604,000	21,248,000
March,	107,806,000	33,048,000	70,442,000	–	70,442,000	18,974,000
April,	95,060,000	8,063,000	93,273,000	–	93,273,000	7,290,000
May,	106,868,000	30,907,000	83,713,000	–	83,713,000	2,290,000
June,	105,343,000	28,036,000	85,673,000	–	85,673,000	–
July,	110,287,000	33,017,000	73,081,000	–	73,081,000	6,439,000
August,	78,390,000	33,044,000	56,207,000	2,177,000	58,384,000	20,552,000
September,	54,367,000	34,405,000	36,250,000	22,797,000	59,047,000	23,187,000
October,	28,361,000	36,020,000	25,787,000	13,258,000	39,045,000	23,797,000
November,	45,790,000	32,489,000	27,100,000	31,260,000	58,360,000	22,967,000
December,	125,803,000	32,352,000	54,845,000	38,558,000	93,403,000	11,777,000
Average,	88,554,000	30,575,000	64,827,000	9,004,000	73,831,000	14,984,000

* Not including quantities wasted while cleaning and repairing aqueducts and the Weston Reservoir, and not including 3,162,000 gallons per day diverted through the Sudbury Aqueduct to Lake Cochituate.

TABLE No. 14. — *Statement of Operations of Engines Nos. 1 and 2 at Chestnut Hill High-service Pumping Station for the Year 1904.*

Allowed for slip: Engine No. 1, 13.36 per cent. January to August, inclusive.
Engine No. 1, 11.29 per cent. September to December, inclusive.
Engine No. 2, 3.81 per cent.

Month.	Engine No 1. Total Pumping Time. Hrs.	Engine No 1. Total Pumping Time. Min.	Engine No 1. Amount pumped, corrected for Slip (Million Gallons).	Engine No. 2. Total Pumping Time. Hrs.	Engine No. 2. Total Pumping Time. 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,	249	-	94.60	-	-	-	94.60	173,344	17,346	10.0	545.74	120.58	54,820,000	63,360,000
February,	285	05	109.09	-	-	-	109.09	255,017	26,552	10.4	427.78	121.40	43,260,000	50,000,000
March,	64	20	25.55	-	-	-	25.55	94,627	12,443	13.2	270.29	121.11	27,270,000	31,520,000
April,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May,	66	10	25.81	-	-	-	25.81	40,459	3,794	9.4	637.93	120.67	64,120,000	74,100,000
June,	87	05	33.24	-	-	-	33.24	47,480	6,110	12.9	700.08	119.36	69,610,000	80,450,000
July,	138	15	55.21	-	-	-	55.21	78,873	9,425	11.9	700.00	119.30	69,560,000	80,390,000
August,	63	45	25.22	-	-	-	25.22	36,169	4,457	12.3	697.28	120.46	69,970,000	80,860,000
September,	93	10	38.42	-	-	-	38.42	53,452	6,473	12.1	718.78	120.98	72,440,000	81,540,000
October,	10	25	4.42	-	-	-	4.42	6,155	700	11.4	718.12	121.55	72,710,000	81,850,000
November,	191	45	80.67	-	-	-	80.67	112,244	12,235	10.9	718.70	121.27	72,600,000	81,720,000
December,	214	55	81.19	7	30	2.78	83.97	115,182	13,387	11.6	727.46	120.56	73,060,000	82,240,000
Total and average,	1,463	55	573.42	7	30	2.78	576.20	1,012,902	112,922	11.1	568.12	120.69	57,120,000	65,400,000

During December, 1,000,000 gallons of the water pumped by Engine No. 1 were diverted to low service, and Engine No. 2 was run to ascertain its condition. 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 1904.*

[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,	-	-	-	-	-	-	-	-	-	-
April,	-	-	-	-	-	-	-	-	-	-
May,	51	15	48.16	47,207	5,107	10.8	1,020.19	126.29	107,320,000	115,960,000
June,	-	-	-	-	-	-	-	-	-	-
July,	48	25	45.52	41,150	4,853	11.8	1,106.20	128.10	118,040,000	127,540,000
August,	-	-	-	-	-	-	-	-	-	-
September,	-	-	-	-	-	-	-	-	-	-
October,	-	-	-	-	-	-	-	-	-	-
November,	211	50	199.18	191,319	22,014	11.5	1,041.09	128.25	111,220,000	120,170,000
December,	-	-	-	-	-	-	-	-	-	-
Total and average,	311	30	292.86	279,676	31,974	11.4	1,047.14	127.90	111,560,000	120,540,000

TABLE NO. 16. — *Statement of Operations of Engine No. 4 at Chestnut Hill High-service Pumping Station for the Year 1904.*

[3 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,	742	45	923.05	766,320	77,866	10.2	1,204.52	127.77	128,200,000	132,140,000	1,017.65	32.827
February,	690	40	864.90	704,608	76,109	10.8	1,227.49	130.23	133,160,000	137,250,000	973.99	33.585
March,	740	15	925.93	812,210	113,841	14.0	1,140.01	129.39	122,870,000	126,650,000	951.48	30.693
April,	720	-	864.05	703,306	81,594	11.6	1,228.55	128.38	131,380,000	135,420,000	864.05	28.802
May,	690	30	840.95	680,711	91,051	13.4	1,235.40	128.96	132,710,000	136,790,000	914.92	29.514
June,	716	20	872.20	706,734	100,898	14.3	1,234.13	128.08	131,670,000	135,720,000	905.44	30.181
July,	694	40	862.40	700,638	97,760	14.0	1,230.88	129.30	132,570,000	136,650,000	963.13	31.069
August,	742	50	923.95	758,412	105,924	14.0	1,218.27	129.09	131,000,000	135,030,000	949.17	30.618
September,	717	-	913.93	731,551	96,372	13.2	1,249.30	130.18	135,470,000	139,640,000	952.35	31.745
October,	744	-	950.78	783,148	97,725	12.5	1,214.05	130.63	132,110,000	136,170,000	955.20	30.813
November,	505	55	632.76	533,668	67,482	12.6	1,185.68	130.11	128,510,000	132,460,000	912.61	30.420
December,	744	-	947.85	775,431	86,235	11.1	1,222.35	129.63	131,990,000	136,050,000	1,031.82	33.285
Total and average,	8,448	55	10,522.75	8,656,737	1,092,857	12.6	1,215.56	129.30	130,920,000	134,950,000	11,391.81	31.125

TABLE No. 17. — *Statement of Operations of Engines Nos. 5, 6 and 7 at Chestnut Hill Low-service Pumping Station for the Year 1904.*

[3 per cent. allowed for slip.]

Month.	Engine No. 5. Total Pumping Time.	Engine No. 5. Amount pumped, corrected for Slip (Million Gallons).	Engine No. 6. Total Pumping Time.	Engine No. 6. Amount pumped, corrected for Slip (Million Gallons).	Engine No 7. Total Pumping Time.	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.
	Hrs. Min.		Hrs. Min.		Hrs. Min.											
January,	691 15	823.60	703 15	848.18	444 55	508.86	2,180.64	70.343	923,732	10.8	2,360.68	59.61	59.65	60.90	117,840,000	121,430,000
February,	615 15	705.01	613 35	705.81	543 25	621.68	2,032.50	70.086	923,338	11.4	2,201.25	62.20	62.34	62.34	114,220,000	117,700,000
March,	331 10	353.39	644 25	698.56	652 30	700.89	1,752.84	56.543	757,345	11.7	2,314.45	59.46	56.16	56.70	109,970,000	113,320,000
April,	579 35	715.42	447 50	551.22	661 05	808.98	2,075.62	69.187	763,690	11.3	2,717.88	50.56	51.03	49.84	114,110,000	117,590,000
May,	711 –	808.90	394 25	460.08	376 25	422.99	1,691.97	54.580	684,815	13.0	2,470.70	53.19	52.49	52.94	108,950,000	112,270,000
June,	575 20	619.83	653 20	703.46	213 05	245.16	1,568.45	52.282	655,122	12.6	2,394.13	53.99	53.62	55.51	107,820,000	111,110,000
July,	688 50	671.13	442 45	436.11	338 –	338.15	1,445.39	46.625	595,016	14.0	2,429.16	51.85	50.65	53.47	104,950,000	108,150,000
August,	664 45	694.51	383 10	370.12	314 45	366.94	1,431.57	46.180	584,585	13.6	2,448.87	49.76	49.93	48.95	101,170,000	104,260,000
September,	336 –	410.36	229 –	274.22	607 –	733.80	1,418.38	47.279	648,670	12.9	2,186.60	53.88	56.98	52.46	97,890,000	100,880,000
October,	424 10	473.94	178 45	202.47	354 10	420.41	1,096.82	35.381	490,163	10.7	2,237.66	43.59	56.59	57.61	95,740,000	98,660,000
November,	489 20	635.53	529 30	692.97	140 15	184.30	1,512.80	50.427	671,885	10.8	2,251.58	52.60	51.55	43.21	95,610,000	98,530,000
December,	550 50	692.55	668 20	835.44	449 20	533.97	2,061.96	66.515	964,507	11.8	2,137.84	58.79	58.12	59.72	104,640,000	107,830,000
Total and average,	6,657 30	7,604.17	5,888 20	6,778.64	5,094 55	5,886.13	20,268.94	55.380	8,662,868	12.0	2,339.75	54.30	55.43	55.12	107,030,000	110,290,000

TABLE NO. 18. — *Statement of Operations of Engine No. 9 at Spot Pond Pumping Station for the Year 1904.*

[3 per cent. allowed for slip.]

MONTH.	Total Pumping Time. Hrs.	Total Pumping Time. Min.	Amount pumped, corrected for Slip (Million Gallons).	Daily Average 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,	317	-	259.07	8.357	241,736	40,347	16.7	1,071.71	129.50	115,610,000	119,230,000
February,	327	35	262.15	9.040	231,875	35,220	15.2	1,130.57	129.06	121,540,000	125,350,000
March,	293	05	233.54	7.534	197,973	32,503	16.4	1,179.66	129.44	127,200,000	131,190,000
April,	274	20	214.54	7.151	179,280	28,281	15.8	1,196.68	129.66	129,250,000	133,300,000
May,	300	15	232.20	7.490	193,901	30,861	15.9	1,197.52	129.56	129,240,000	133,290,000
June,	315	20	249.23	8.308	202,014	29,360	14.5	1,233.73	129.30	132,880,000	137,040,000
July,	346	40	277.94	8.966	217,213	27,467	12.6	1,279.57	128.16	136,600,000	140,880,000
August,	338	45	273.01	8.807	213,004	25,628	12.0	1,281.71	128.15	136,820,000	141,110,000
September,	324	10	260.40	8.680	206,187	23,509	11.4	1,262.93	128.93	135,640,000	139,890,000
October,	285	45	228.17	7.360	188,254	22,836	12.1	1,212.03	131.50	132,770,000	136,930,000
November,	259	55	206.43	6.881	177,533	20,691	11.7	1,162.77	129.93	125,850,000	129,790,000
December,	292	10	230.79	7.445	213,832	26,174	12.2	1,079.30	129.36	116,300,000	119,940,000
Total and average,	3,675	-	2,927.47	7.999	2,462,802	342,877	13.9	1,188.67	129.33	128,060,000	132,070,000

Table No. 19. — *Average Daily Consumption of Water, during the Year 1904, in the Cities and Towns supplied 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.	Average Daily Consumption (Gallons).	Estimated Population.	Consumption per Inhabitant (Gallons).
January,	134,479,000	917,300	147
February,	139,941,000	919,100	152
March,	120,392,000	920,900	131
April,	105,800,000	922,700	115
May,	108,450,000	924,500	117
June,	107,825,000	926,600	116
July,	110,096,000	928,600	119
August,	109,477,000	930,700	118
September,	110,866,000	932,700	119
October,	105,220,000	934,800	113
November,	105,034,000	936,800	112
December,	121,986,000	938,900	130
For the year,	114,909,000	927,800	124

Table No. 20. — *Average Daily Consumption of Water, in Gallons, from the Low Service System (1904).*

Month.	Southern Low Service.	Northern Low Service.	Total Low Service Consumption.
	Boston, excluding East Boston and Charlestown.	Portions of Charlestown, Somerville, Chelsea, Everett, Malden, Medford, East Boston and Arlington.	
January,	57,242,000	35,627,000	92,869,000
February,	58,976,000	37,783,000	96,759,000
March,	52,165,000	29,519,000	81,684,000
April,	45,164,000	24,347,000	69,511,000
May,	45,691,000	25,158,000	70,849,000
June,	44,398,000	24,547,000	68,945,000
July,	44,547,000	24,789,000	69,336,000
August,	44,954,000	24,388,000	69,342,000
September,	43,963,000	26,076,000	70,039,000
October,	41,958,000	24,659,000	66,617,000
November,	43,162,000	23,991,000	67,153,000
December,	50,168,000	30,715,000	80,883,000
For the year,	47,676,000	27,609,000	75,285,000

TABLE No. 21. — *Average Daily Consumption of Water, in Gallons, from the High Service and Extra High Service Systems (1904).*

MONTH.	SOUTHERN HIGH SERVICE. Quincy, Watertown, Belmont, and Portions of Boston and Milton.	SOUTHERN EXTRA HIGH SERVICE. Portions of Boston and Milton.	NORTHERN HIGH SERVICE. Revere, Winthrop, Swampscott, Nahant, Stoneham, Melrose, and Portions of Boston, Chelsea, Everett, Malden, Medford, Somerville and Saugus.	NORTHERN EXTRA HIGH SERVICE. Lexington and Portion of Arlington.
January,	32,344,000	447,000	8,339,000	480,000
February,	33,155,000	458,000	9,072,000	497,000
March,	30,256,000	432,000	7,542,000	478,000
April,	28,372,000	421,000	7,049,000	447,000
May,	29,092,000	491,000	7,508,000	510,000
June,	29,478,000	525,000	8,300,000	577,000
July,	30,522,000	600,000	9,018,000	620,000
August,	30,176,000	548,000	8,846,000	565,000
September,	31,143,000	571,000	8,554,000	559,000
October,	30,228,000	517,000	7,348,000	510,000
November,	30,030,000	499,000	6,886,000	466,000
December,	32,576,000	536,000	7,492,000	499,000
For the year,	30,610,000	504,000	7,993,000	517,000

TABLE NO. 22. — *Average Daily Consumption of Water in Cities and Towns supplied from Metropolitan Works, as measured by Venturi Meters — 1904.*

City or town,	Boston.		Somerville.		Malden.		Chelsea.		Everett.		Quincy.		Medford.	
Population supplied,	611,830.		70,320.		40,825.		37,835.		29,370.		27,830.		22,125.	
	Gallons.		Gallons.		Gallons.		Gallons.		Gallons.		Gallons.		Gallons.	
Month.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day	Per Capita.	Per Day	Per Capita.	Per Day.	Per Capita.
January,	103,119,400	170	7,834,500	113	1,965,000	50	6,268,200	169	3,311,600	115	2,730,700	100	1,868,800	86
February,	105,446,600	174	8,175,300	118	2,020,600	50	6,613,200	177	3,428,600	119	2,807,800	102	1,957,300	90
March,	93,957,200	154	6,456,500	93	1,849,600	46	5,152,500	138	2,847,000	98	2,850,400	103	1,721,200	79
April,	81,915,100	134	5,606,200	80	1,705,200	42	3,750,300	100	2,594,300	89	2,626,800	95	1,567,700	72
May,	83,275,300	136	5,757,800	82	1,898,000	47	3,685,200	98	2,453,500	84	2,617,900	95	1,698,900	77
June,	81,448,100	133	5,858,500	83	1,997,800	49	3,535,300	93	2,438,600	83	2,898,500	104	1,895,300	86
July,	82,777,800	135	6,058,300	86	1,989,000	48	3,594,400	95	2,471,000	84	3,142,900	113	2,020,900	91
August,	82,835,300	135	5,796,700	82	2,004,900	49	3,598,600	95	2,269,600	77	3,052,200	109	1,923,900	86
September,	83,896,700	137	5,741,300	81	1,877,200	45	3,521,600	92	2,285,800	77	3,055,100	109	1,901,900	85
October,	80,221,400	130	5,226,000	74	1,666,700	40	3,263,700	85	2,247,100	76	2,748,500	98	1,706,900	76
November,	80,748,500	131	5,234,600	73	1,662,400	40	3,347,900	88	2,342,900	78	2,606,100	92	1,688,400	75
December,	92,935,200	151	7,042,000	99	1,785,400	43	4,854,300	127	2,826,600	94	2,742,600	97	1,692,100	75
For the year,	87,680,300	143	6,228,300	89	1,868,000	46	4,260,500	113	2,624,400	89	2,823,200	101	1,802,900	81

TABLE NO. 22. — *Average Daily Consumption of Water in Cities and Towns, etc.* — Continued.

City or town,	MELROSE.		REVERE.		WATERTOWN.		ARLINGTON.		MILTON.		WINTHROP.	
Population supplied,	14,445.		13,710.		11,250.		10,150.		7,740.		7,770.	
	GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.	
MONTH.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.
January,	1,556,000	109	1,122,300	84	578,800	52	793,700	80	282,800	37	803,700	107
February,	1,645,500	115	1,200,300	89	584,900	53	828,700	83	301,500	40	834,100	110
March,	1,615,100	113	925,400	69	550,200	50	675,200	67	296,300	39	737,500	97
April,	1,421,900	99	807,600	60	528,500	47	648,700	65	260,800	34	673,100	88
May,	1,439,300	100	875,900	64	598,000	53	746,100	74	340,400	44	662,600	86
June,	1,527,300	106	931,200	68	693,100	62	821,100	81	373,400	48	746,800	96
July,	1,588,600	110	995,600	73	721,800	64	959,600	95	386,800	50	860,900	111
August,	1,576,300	109	999,500	72	639,000	57	796,500	78	369,200	47	878,900	112
September,	1,552,600	107	890,600	64	677,100	60	788,200	77	385,900	49	796,000	101
October,	1,448,800	99	785.200	56	629,100	55	637,200	62	282,300	36	638,300	81
November,	1,445,900	99	752,100	54	626,400	55	629,400	61	267,300	34	597,600	75
December,	1,489,100	102	922,500	66	654,800	57	706,400	68	248,100	32	677,300	85
For the year,	1,525,100	106	933,000	68	623,600	55	752,400	74	316,300	41	742,300	96

TABLE NO. 22. — *Average Daily Consumption of Water in Cities and Towns, etc.* — Concluded.

City or town,	Stoneham.		Belmont.		Lexington.		Nahant.		Swampscott.		Metropolitan District.	
Population supplied,	6,420.		5,045.		3,620.		2,310.		6,170.		928,770.	
	Gallons.		Gallons.		Gallons.		Gallons.		Gallons.		Gallons.	
Month.	Per Day	Per Capita	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.
January,	535,300	84	226,700	46	202,600	56	108,700	80	395,900	77	133,709,700	146
February,	567,800	89	224,000	45	238,800	66	64,000	47	661,100	128	137,600,100	150
March,	541,100	85	210,100	42	250,700	70	43,900	32	352,500	68	121,032,400	132
April,	516,900	81	212,200	43	249,500	69	40,000	29	291,600	56	105,416,400	114
May,	538,300	84	250,800	50	273,200	76	88,000	37	430,900	70	107,630,100	116
June,	567,000	88	292,000	58	318,100	88	198,700	58	630,300	87	107,171,100	115
July,	583,600	91	353,500	70	341,700	95	281,600	72	789,500	102	109,917,500	118
August,	575,200	90	284,600	56	332,900	92	281,000	72	806,200	104	109,020,500	117
September,	616,900	96	291,900	57	335,200	92	249,900	74	675,200	93	109,539,100	117
October,	639,000	99	216,500	42	299,300	82	100,300	42	478,000	76	103,234,300	110
November,	502,400	78	213,600	41	266,900	73	60,800	43	374,500	70	103,367,700	110
December,	510,100	79	208,300	40	281,100	77	50,300	36	380,800	71	120,007,000	128
For the year,	558,300	87	248,800	49	282,700	78	131,000	57	521,200	84	113,922,300	123

TABLE No. 23. — *Consumption of Water in the Metropolitan Water District, as constituted December 31, 1904, the Town of Swampscott and a Small Section of the Town of Saugus; 1893–1904.*

[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	83,654,000
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.	1904.
January,	96,442,000	100,055,000	111,275,000	118,435,000	125,176,000	137,771,000
February,	103,454,000	98,945,000	117,497,000	117,268,000	122,728,000	143,222,000
March,	90,200,000	97,753,000	105,509,000	108,461,000	111,977,000	123,334,000
April,	86,491,000	89,497,000	93,317,000	103,153,000	107,179,000	108,688,000
May,	89,448,000	87,780,000	95,567,000	106,692,000	111,589,000	111,715,000
June,	97,691,000	98,581,000	103,420,000	110,002,000	105,590,000	111,209,000
July,	96,821,000	107,786,000	106,905,000	108,340,000	107,562,000	113,584,000
August,	92,072,000	102,717,000	102,815,000	107,045,000	103,570,000	112,836,000
September,	91,478,000	103,612,000	102,103,000	107,752,000	106,772,000	114,188,000
October,	89,580,000	98,358,000	103,389,000	106,560,000	103,602,000	108,290,000
November,	86,719,000	93,648,000	101,324,000	105,175,000	103,477,000	108,054,000
December,	85,840,000	97,844,000	113,268,000	125,434,000	114,721,000	125,119,000
Average for the year,	92,111,000	98,059,000	104,645,000	110,345,000	110,277,000	118,114,000
Population,	854,870	877,698	903,000	928,300	953,600	978,900
Consumption per inhabitant,	107.8	111.7	115.9	118.9	115.6	120.7

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.		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.		
	1904.																	
48601	Jan. 13	Slight.	Slight.	.32	34	Faintly vegetable.	Distinctly vegetable.	3.90	1.45	.0028	.0114	.0106	.0008	.30	.0120	.0001	.44	1.0
48764	Feb. 1	Slight.	V. slight.	.29	32	Faintly unpleasant.	Faintly unpleasant.	3.95	1.60	.0030	.0124	.0106	.0018	.30	.0120	.0000	.36	1.0
48942	Feb. 29	Slight.	Cons.	.33	35	Faintly unpleasant.	Faintly unpleasant.	3.20	1.20	.0020	.0132	.0112	.0020	.22	.0120	.0001	.42	0.6
49136	April 4	Decided.	Cons.	.26	30	Faintly vegetable.	Faintly vegetable.	2.80	1.00	.0022	.0104	.0088	.0016	.19	.0050	.0000	.32	0.6
49372	May 5	Slight.	Slight.	.26	30	Faintly vegetable.	Distinctly vegetable.	2.40	1.10	.0014	.0118	.0084	.0034	.22	.0040	.0001	.38	0.6
49621	June 6	V. slight.	V. slight.	.31	34	None.	Faintly unpleasant.	3.10	1.30	.0052	.0168	.0148	.0020	.19	.0020	.0001	.40	1.0
49979	July 5	Slight.	Slight, mostly sand.	.28	32	Faintly unpleasant.	Faintly unpleasant.	3.00	1.30	.0078	.0178	.0132	.0046	.19	.0030	.0003	.39	0.8
50465	Aug. 1	V. slight.	Slight, also cyclops.	.21	27	V. faintly vegetable.	Faintly vegetable.	2.95	1.30	.0042	.0192	.0138	.0054	.18	.0020	.0001	.33	1.0
51211	Sept. 13	V. slight.	Cons.	.11	19	Distinctly vegetable and earthy.	Distinctly vegetable and earthy.	2.75	1.30	.0044	.0128	.0108	.0020	.22	.0020	.0000	.30	0.8
51570	Oct. 6	Slight.	Slight.	.11	19	Faintly vegetable cucumber odor.	Distinctly vegetable cucumber odor.	3.00	1.15	.0022	.0174	.0140	.0034	.23	.0010	.0001	.29	1.1
51919	Oct. 31	V. slight.	Slight.	.11	19	V. faintly vegetable.	Distinctly vegetable and unpleasant.	2.60	1.30	.0016	.0154	.0118	.0036	.23	.0010	.0001	.31	1.0
52330	Dec. 5	V. slight.	Slight.	.11	19	None.	Faintly vegetable.	3.10	1.15	.0018	.0166	.0148	.0018	.30	.0040	.0000	.34	1.4
Av.	....	....	.. ..	.22	28	....	....	3.06	1.26	.0032	.0146	.0119	.0027	.23	.0050	.0001	.36	0.9

TABLE No. 25. — *Chemical Examinations of Water from Sudbury Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.		Color.		Odor.		Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Nessler Standard.	Transformed to Platinum Standard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1904.																	
48580	Jan. 11	Slight.	V. slight.	.40	39	Faintly unpleasant.	Distinctly unpleasant.	3.85	1.65	.0040	.0176	.0148	.0028	.32	.0140	.0003	.52	1.3
48753	Feb. 1	Slight.	Slight, cyclops.	.42	40	Faintly vegetable.	Distinctly vegetable.	4.20	1.70	.0056	.0158	.0136	.0022	.32	.0130	.0001	.49	1.1
48935	Feb. 29	V. slight.	V. slight.	.30	33	None.	Distinctly oily, uroglena.	4.00	1.30	.0036	.0138	.0106	.0032	.30	.0170	.0000	.39	1.6
49129	April 4	V. slight.	V. slight.	.28	32	Faintly vegetable.	Faintly unpleasant.	3.50	1.25	.0066	.0104	.0086	.0018	.26	.0100	.0001	.36	1.3
49350	May 2	V. slight.	Cons.	.23	28	Faintly vegetable.	Distinctly vegetable.	3.45	1.55	.0032	.0174	.0126	.0048	.26	.0100	.0001	.32	1.3
49600	June 6	V. slight.	Slight.	.25	29	Distinctly vegetable.	Distinctly vegetable.	3.30	1.25	.0022	.0142	.0116	.0026	.27	.0110	.0002	.39	1.1
49964	July 5	V. slight.	Cons.	.17	24	Faintly vegetable.	Distinctly vegetable.	3.05	1.25	.0296	.0190	.0156	.0034	.23	.0040	.0001	.32	1.1
50475	Aug. 2	V. slight.	Slight.	.11	19	V. faintly vegetable.	Faintly vegetable and unpleasant.	3.00	1.15	.0008	.0134	.0120	.0014	.22	.0060	.0001	.31	0.8
51076	Sept. 6	V. slight.	Slight.	.10	18	Distinctly vegetable.	Distinctly vegetable.	2.90	1.10	.0020	.0126	.0110	.0016	.23	.0050	.0000	.30	0.8
51501	Oct. 3	None.	Slight.	.10	18	Faintly unpleasant, decaying algæ.	Distinctly unpleasant, decaying algæ.	2.65	0.95	.0018	.0142	.0134	.0008	.24	.0010	.0000	.28	1.3
51930	Nov. 1	V. slight.	Slight.	.08	15	V. faintly vegetable.	Distinctly vegetable and unpleasant.	2.70	1.15	.0022	.0176	.0150	.0026	.26	.0020	.0000	.27	1.3
52327	Dec. 5	V. slight.	V. slight.	.13	20	Faintly unpleasant organisms.	Distinctly unpleasant organisms.	3.15	1.35	.0020	.0140	.0120	.0020	.25	.0020	.0001	.30	1.4
Av.	....	....	....	.21	26	....	....	3.31	1.30	.0053	.0150	.0126	.0024	.26	.0079	.0001	.35	1.2

TABLE NO. 26. — *Chemical Examinations of Water from Spot Pond, Stoneham.*

[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.		
	1904.																	
48565	Jan. 11	None.	V. slight.	.08	15	None.	Faintly vegetable.	4.35	2.00	.0022	.0162	.0138	.0024	.34	.0010	.0002	.31	2.0
48932	Feb. 29	None.	V. slight.	.10	18	Faintly unpleasant.	Faintly unpleasant.	4.10	2.70	.0062	.0180	.0174	.0006	.35	.0030	.0001	.29	1.7
49346	May 2	V. slight.	Slight.	.11	19	Faintly vegetable.	Faintly vegetable.	3.90	1.45	.0016	.0144	.0112	.0032	.31	.0070	.0001	.26	1.7
50043	July 11	None.	V. slight.	.08	15	Faintly unpleasant.	Distinctly unpleasant, fishy.	3.75	1.50	.0016	.0164	.0126	.0038	.30	.0010	.0002	.29	1.1
51154	Sept. 12	V. slight.	V. slight.	.05	9	Faintly vegetable.	Faintly vegetable.	3.45	1.20	.0002	.0144	.0114	.0030	.29	.0050	.0000	.23	1.1
51983	Nov. 7	V. slight.	Slight.	.08	15	V. faintly vegetable.	Faintly vegetable.	3.30	1.60	.0014	.0140	.0132	.0008	.29	.0020	.0000	.27	1.3
Av.	....	....	....	.08	15	....	....	3.81	1.53	.0022	.0156	.0133	.0023	.31	.0032	.0001	.27	1.5

TABLE No. 27. — *Chemical Examinations of Water from Lake Cochituate.*

[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.					
	1904.																	
48574	Jan. 11	V. slight.	Slight.	.24	29	Faintly vegetable.	Distinctly vegetable.	5.05	2.15	.0054	.0276	.0242	.0034	.52	.0050	.0007	.43	2.3
48757	Feb. 1	None.	V. slight, cyclops.	.22	27	Faintly vegetable.	Distinctly vegetable	4.75	2.00	.0022	.0168	.0150	.0018	.50	.0090	.0002	.38	2.2
48937	Feb. 29	V. slight.	V. slight.	.24	29	Faintly unpleasant.	Faintly unpleasant.	5.50	2.10	.0012	.0222	.0212	.0010	.51	.0110	.0002	.46	2.2
49127	April 4	Decided.	Slight.	.26	30	Faintly vegetable.	Faintly vegetable.	4.90	1.80	.0026	.0164	.0158	.0006	.48	.0100	.0001	.44	2.1
49359	May 2	V. slight.	Cons.	.30	33	Distinctly vegetable.	Distinctly vegetable.	4.70	1.90	.0036	.0172	.0148	.0024	.51	.0110	.0001	.51	2.1
49603	June 6	V. slight.	Slight.	.27	31	Faintly vegetable.	Distinctly vegetable.	4.65	1.85	.0018	.0190	.0144	.0046	.49	.0100	.0002	.42	2.3
49960	July 5	V. slight.	Slight.	.20	26	Faintly unpleasant.	Faintly unpleasant.	4.60	1.70	.0026	.0216	.0174	.0042	.47	.0060	.0002	.56	1.8
50470	Aug. 1	None.	Slight.	.16	23	None.	V. faintly vegetable.	4.75	1.70	.0028	.0184	.0170	.0014	.47	.0050	.0001	.43	2.0
51071	Sept. 6	V. slight.	Cons.	.10	18	None.	Faintly vegetable.	4.95	1.95	.0008	.0220	.0168	.0052	.50	.0050	.0000	.41	1.7
51506	Oct. 3	V. slight.	Cons.	.13	20	None.	Faintly vegetable.	4.50	1.55	.0016	.0210	.0156	.0054	.49	.0020	.0001	.38	2.1
51913	Oct. 31	Slight.	Slight.	.17	24	V. faintly vegetable.	Distinctly vegetable.	4.90	1.90	.0018	.0190	.0160	.0030	.52	.0100	.0001	.41	2.0
52321	Dec. 5	V. slight.	Slight.	.24	29	Faintly unpleasant.	Distinctly cucumber.	4.95	2.05	.0032	.0164	.0142	.0022	.49	.0040	.0001	.37	2.1
Av.	....	....	....	.21	27	....	....	4.85	1.89	.0025	.0198	.0169	.0029	.50	.0073	.0002	.43	2.1

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.					
	1904.																	
48568	Jan. 11	V. slight.	V. slight.	.26	30	None.	Faintly vegetable.	4.50	1.80	.0038	.0150	.0138	.0012	.39	.0080	.0004	.39	2.0
48748	Feb. 1	V. slight.	V. slight.	.28	32	Faintly vegetable.	Distinctly vegetable.	4.65	1.75	.0034	.0114	.0108	.0006	.40	.0120	.0000	.37	1.7
48926	Feb. 29	Slightly milky.	Slight.	.32	34	None.	None.	4.40	1.75	.0028	.0134	.0114	.0020	.38	.0160	.0001	.39	1.7
49122	Apr. 4	V. slight.	Slight.	.24	29	Faintly vegetable.	Faintly vegetable.	3.65	1.65	.0026	.0098	.0092	.0006	.33	.0160	.0002	.37	1.6
49343	May 2	V. slight.	Slight.	.22	27	Faintly vegetable.	Distinctly vegetable.	3.50	1.30	.0020	.0104	.0088	.0016	.26	.0200	.0001	.43	1.4
49593	June 6	V. slight.	Cons.	.25	29	V. faintly vegetable.	Faintly vegetable.	3.35	1.25	.0014	.0108	.0102	.0006	.27	.0170	.0000	.30	1.3
49952	July 5	V. slight.	Cons.	.20	26	Faintly vegetable.	Distinctly vegetable.	3.50	1.45	.0010	.0144	.0118	.0026	.26	.0110	.0000	.28	1.0
50463	Aug. 2	None.	Slight.	.12	20	Faintly vegetable.	Faintly vegetable.	3.65	1.65	.0036	.0154	.0136	.0018	.28	.0110	.0000	.32	1.1
51066	Sept. 6	V. slight.	Slight.	.25	29	Faintly vegetable.	Distinctly vegetable and cucumber.	4.00	1.70	.0012	.0160	.0148	.0012	.35	.0060	.0001	.43	1.4
51512	Oct. 4	V. slight.	Slight.	.11	19	Faintly vegetable.	Faintly vegetable.	4.10	1.55	.0014	.0182	.0148	.0034	.42	.0060	.0001	.36	1.8
51907	Oct. 31	V. slight.	V. slight.	.22	27	V. faintly unpleasant.	Faintly unpleasant and fishy.	3.90	1.60	.0014	.0160	.0140	.0020	.39	.0050	.0000	.38	1.7
52317	Dec. 5	V. slight.	V. slight.	.31	34	None.	Faintly unpleasant.	3.95	1.60	.0026	.0160	.0126	.0034	.40	.0040	.0001	.47	1.6
Av.	....	....	....	.23	28	....	....	3.93	1.59	.0023	.0139	.0121	.0018	.34	.0110	.0001	.37	1.5

TABLE NO. 29. — *Averages of Examinations of Water from Various Parts of the Metropolitan Water Works. — 1904.*

[Parts per 100,000.]

LOCALITY.	Samples Collected.	COLOR.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
							ALBUMINOID.							
		Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
Quinepoxet River, Holden,	Bi-monthly,	.49	46	3.94	1.64	.0078	.0281	.0211	.0070	.33	.0043	.0001	.64	0.7
Stillwater River, Sterling,	Bi-monthly,	.37	37	3.37	1.41	.0062	.0200	.0172	.0028	.23	.0032	.0001	.51	1.0
Wachusett Reservoir, Clinton,	Monthly,	.22	28	3.06	1.26	.0032	.0146	.0119	.0027	.23	.0050	.0001	.36	0.9
Marlborough (Walker's) Brook,	Monthly,	.44	42	15.91	4.43	.2204	.0461	.0282	.0179	2.51	.1189	.0055	.56	5.8
Marlborough Brook filter-beds, effluent,	Monthly,	.14	21	1.39	-	.1051	.0159	-	-	1.97	.1895	.0006	.30	5.1
Sudbury Reservoir, surface,	Monthly,	.21	27	3.31	1.30	.0053	.0150	.0126	.0024	.26	.0079	.0001	.35	1.2
Framingham Reservoir No. 3, near dam,	Quarterly,	.20	26	3.49	1.31	.0021	.0147	.0123	.0024	.27	.0225	.0001	.33	1.3
Hopkinton Reservoir, surface,	Quarterly,	.46	43	3.71	1.74	.0040	.0213	.0183	.0030	.33	.0045	.0001	.60	0.8
Ashland Reservoir, surface,	Quarterly,	.52	48	3.60	1.75	.0026	.0188	.0165	.0023	.27	.0030	.0000	.65	0.9
Framingham Reservoir No. 2, near dam,	Quarterly,	.55	50	3.86	1.81	.0031	.0213	.0184	.0029	.30	.0067	.0001	.67	1.0
Lake Cochituate,	Monthly,	.21	27	4.85	1.89	.0025	.0198	.0169	.0029	.50	.0073	.0002	.43	2.1
Terminal chamber, Sudbury Aqueduct,	Bi-monthly,	.27	32	3.82	1.49	.0029	.0139	.0121	.0018	.30	.0100	.0001	.42	1.4
Spot Pond,	Bi-monthly,	.08	15	3.81	1.53	.0022	.0156	.0133	.0023	.31	.0032	.0001	.27	1.5
Tap in Revere,	Bi-monthly,	.07	13	3.57	1.25	.0016	.0131	.0113	.0018	.31	.0040	.0001	.25	1.6
Tap at State House,	Monthly,	.23	28	3.93	1.59	.0023	.0139	.0121	.0018	.34	.0110	.0001	.37	1.5
Tap in Quincy,	Bi-monthly,	.20	26	3.91	1.54	.0011	.0128	.0115	.0013	.34	.0146	.0001	.37	1.7

Table No. 30. — *Chemical Examinations of Water from a Faucet in Boston, from 1892 to 1904.*

[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.	Albuminoid. Dis-solved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
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
1904, . .	.23	28	3.93	1.59	.0023	.0139	.0121	.0018	.34	.0110	.0001	.37	1.5

Table No. 31. — *Colors of Water from Various Parts of the Metropolitan Water Works, 1904. (Means of Weekly Determinations.)*

[Platinum Standard.]

Month.	Wachusett Reservoir.	Sudbury Reservoir.				Framingham Reservoir No. 3.	Spot Pond.	Fells Reservoir.
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Mid-depth.	Mid-depth.	Effluent Gate-house.
January, ...	48	52	47	44	48	41	25	23
February, . . .	38	44	44	44	38	40	23	20
March, ...	39	35	37	37	59	37	24	20
April, ...	39	36	36	36	44	33	22	20
May, ...	39	34	36	35	45	33	20	20
June, ...	40	33	33	33	40	34	20	19
July, ...	39	27	27	29	38	28	20	19
August, ...	30	24	24	25	32	24	19	18
September, . . .	25	22	23	23	27	24	21	18
October, ...	23	21	22	22	25	25	21	18
November, . . .	21	17	17	17	31	20	19	18
December, . . .	23	19	17	17	24	18	20	18
Mean, . . .	34	30	30	30	38	30	21	19

TABLE No. 31 — *Concluded.*

[Platinum Standard.]

Month.	Lake Cochituate. Surface.	Lake Cochituate. Mid-depth.	Lake Cochituate. Bottom.	Lake Cochituate. Influent Streams.*	Chestnut Hill Reservoir. Inlet (Sudbury Aqueduct).	Chestnut Hill Reservoir. Inlet (Cochituate Aqueduct).	Chestnut Hill Reservoir. Effluent Gate-house No. 2.	Northern Service. Tap at Glenwood Yard, Medford (Low Service).	Northern Service. Tap at 44 Clarendon Street, Malden (High Service).	Southern Service. Tap at 244 Boylston Street, Boston (Low Service).	Southern Service. Tap at 1 Ashburton Place, Boston (High Service).
January,	34	34	36	56	42	35	41	-	-	43	41
February,	26	29	30	72	41	29	37	-	-	39	38
March,	33	31	33	77	37	32	35	-	-	36	34
April,	38	37	41	78	34	31	33	32	20	33	32
May,	36	34	34	91	35	-	33	31	20	34	33
June,	33	32	40	82	35	-	34	34	20	34	34
July,	31	33	55	62	30	30	28	29	19	30	30
August,	27	31	74	47	25	25	24	23	17	25	25
September,	27	32	93	48	38	27	32	32	18	29	32
October,	27	29	104	62	36	29	30	28	19	26	29
November,	33	33	48	57	45	32	39	34	24	29	37
December,	32	29	30	63	34	28	32	32	18	27	31
Mean,	31	32	52	66	36	-	33	-	-	32	33

* 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. 32. — *Temperatures of Water from Various Parts of the Metropolitan Water Works, 1904. (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.]

[Degrees Fahrenheit.]

Month.	Wachusett Reservoir. Surface.	Sudbury Reservoir (Depth at Place of Observation 54.5 Feet). Surface.	Sudbury Reservoir. Mid-depth.	Sudbury Reservoir. Bottom.	Sudbury Reservoir. End of Open Channel.	Framingham Reservoir No. 3 (Depth at Place of Observation 20.5 Feet). Surface.	Framingham Reservoir No. 3. Mid-depth.	Framingham Reservoir No. 3. Bottom.	Lake Cochituate (Depth at Place of Observation 62.0 Feet). Surface.	Lake Cochituate. Mid-depth.	Lake Cochituate. Bottom.
January,	32.4	32.3	33.0	34.3	33.2	34.1	35.0	35.8	34.6	35.6	36.0
February,	33.8	31.9	32.8	34.4	32.0	33.9	35.0	36.0	34.9	36.0	37.1
March,	33.1	32.8	33.3	33.8	35.0	35.6	36.3	36.7	36.0	36.8	37.8
April,	40.6	44.3	43.7	42.7	37.8	45.5	45.3	45.3	43.3	42.5	41.6
May,	55.4	59.3	56.4	54.6	55.0	61.3	59.8	57.5	59.7	46.9	45.4
June,	66.4	68.9	65.3	63.5	63.8	70.3	68.7	67.1	67.4	47.8	45.8
July,	67.3	75.3	72.5	69.8	70.0	75.5	73.5	70.8	71.8	49.0	45.3
August,	71.0	73.5	72.9	72.3	71.5	73.3	72.7	71.8	71.2	49.3	46.8
September,	68.2	66.7	66.0	65.7	66.3	67.3	66.5	66.4	65.3	50.5	47.0
October,	56.7	57.5	56.1	55.6	55.5	55.0	55.0	40.0	55.8	51.5	46.8
November,	44.1	41.5	42.3	42.4	40.2	40.6	41.4	40.0	44.8	43.1	42.2
December,	35.0	33.5	36.0	37.4	34.8	34.3	35.3	35.8	32.5	34.0	36.3
Mean,	50.3	51.5	50.9	50.5	49.6	52.2	52.0	50.3	51.4	43.6	42.3

Table No. 32 — *Concluded.*

[Degrees Fahrenheit.]

Month.	Chestnut Hill Reservoir. Effluent Gate-house No 2.	Spot Pond (Depth at Place of Observation 28.0 Feet). Surface.	Mid-depth.	Bottom.	Northern Service. Tap at Glenwood Yard, Medford (Low Service).	Tap at 44 Clarendon Street, Malden (High Service).	Southern Service. Tap at 244 Boylston Street, Boston (Low Service).	Tap at 1 Ashburton Place, Boston (High Service.)
January,	35.5	33.5	34.0	34.5	-	-	37.9	37.5
February,	36.1	34.1	35.9	36.0	-	-	38.1	37.2
March,	36.5	35.8	36.5	37.4	-	-	38.3	37.9
April,	44.8	42.8	42.7	42.8	42.5	42.3	46.6	45.8
May,	59.6	58.1	57.4	53.3	55.0	51.4	57.7	58.0
June,	67.6	67.8	66.9	59.3	61.6	58.5	67.0	67.3
July,	73.1	73.7	72.7	63.1	68.3	64.8	71.2	71.4
August,	73.9	72.6	72.2	66.8	69.1	66.6	73.0	72.8
September,	67.8	66.3	65.7	66.7	65.6	64.1	68.0	68.0
October,	56.4	56.7	56.3	56.3	58.5	59.0	57.7	57.2
November,	43.1	39.5	39.5	39.6	47.2	50.3	46.0	45.8
December,	36.2	34.8	35.4	35.4	39.1	41.4	38.8	38.7
Mean,	52.6	51.3	51.3	49.3	-	-	53.4	53.1

Table No. 33. — *Temperatures of the Air at Three Stations on the Metropolitan Water Works, 1904.*

[Degrees Fahrenheit.]

Month.	Chestnut Hill Reservoir. Maximum.	Minimum.	Mean.	Framingham. Maximum.	Minimum.	Mean.	Clinton. Maximum.	Minimum.	Mean.
January,	43.0	—17.0	20.5	45	—24	18.3	37.5	—16.0	14.9
February,	47.5	—8.0	21.1	48	—5	20.2	47.0	—7.0	17.6
March,	71.0	2.0	34.4	68	0	34.3	67.0	—4.0	31.2
April,	70.0	22.0	45.3	73	20	45.2	70.0	21.0	43.2
May,	89.0	34.0	61.7	89	34	60.8	85.0	38.0	60.9
June,	94.5	39.0	63.8	92	39	64.1	90.5	35.5	63.3
July,	93.5	47.0	71.5	93	48	70.8	90.0	49.0	69.9
August,	91.5	44.0	68.4	90	44	67.1	86.5	46.0	66.9
September,	88.0	29.5	62.4	85	25	61.1	81.0	27.0	59.6
October,	75.0	25.0	49.4	75	20	48.3	74.5	22.0	47.7
November,	58.0	10.0	36.2	58	6	35.1	54.0	10.0	33.4
December,	46.5	2.0	23.6	48	—7	22.7	49.5	—4.5	20.9
Average,	-	-	46.5	-	-	45.7	-	-	44.1

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, 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
Length laid or relaid during 1904 (feet),	-	174	-	-	-	80	-	7	-	638	51	12	60	1,022
Gate valves in same,	-	-	-	-	-	1	-	-	-	2	2	-	3	8
Air valves in same,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Length abandoned during 1904 (feet),	-	174	-	-	-	80	-	7	-	597	81	-	-	939
Gate valves in same,	-	-	-	-	-	-	-	-	-	-	4	-	1	5
Air valves in same,	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Length owned and operated January 1, 1905 (feet),	9,069	171,100	8,075	46,626	26,922	46,651	57,088	54,394	26	21,609	614	1,597	858	444,629*
Gate valves in same,	-	42	-	39	28	37	38	62	1	69	13	12	15	356
Air valves in same,	5	102	3	35	4	19	34	29	-	9	-	-	-	240

* 84.21 miles.

TABLE NO. 35. — *Statement of Cast-iron Hydrant, Blow-off and Drain Pipes laid to January 1, 1905, 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, 1904 (feet),	352	293	2,214	4,418	173	315	2,649	1,150	11,564
Length laid during 1904 (feet),	-	-	36	-	-	-	-	8	44
Length abandoned during 1904 (feet),	-	-	-	-	-	-	-	14	14
Total length in use January 1, 1905 (feet),	352	293	2,250	4,418	173	315	2,649	1,144	11,594
Valves set to January 1, 1904,	-	-	18	75	1	1	54	39	188
Valves set during 1904,	-	-	-	-	-	-	-	-	-
Valves abandoned during 1904,	-	-	-	-	-	-	-	1	1
Total valves in use January 1, 1905,	-	-	18	75	1	1	54	38	187

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	21,609	614	1,597	-	858	-	-	444,629	84.21
Boston,	-	33,494	16,813	23,104	43,113	88,379	244	80,198	93,695	-	193,492	-	1,165,647	131,289	585,190	-	1,333,270	-	87,039	3,874,967	733.90
Somerville,	-	-	-	-	-	-	-	-	3,596	387	2,071	8,037	78,984	46,818	90,271	-	194,033	-	20,525	444,722	84.23
Malden,	-	-	-	-	-	-	-	-	-	-	-	9,152	65,397	23,579	69,840	-	195,091	-	69,196	432,225	81.87
Chelsea,	-	-	-	-	-	-	-	-	-	-	2,380	-	-	39,501	25,570	-	126,935	-	9,617	204,003	38.64
Quincy,	-	-	-	-	-	-	-	-	2,679	-	20,040	-	23,511	32,166	86,505	994	210,214	948	97,719	474,776	89.92
Everett,	-	-	-	-	-	-	-	2,484	2,900	-	2,233	206	5,570	37,406	18,275	-	128,221	-	30,790	228,085	43.20
Medford,	-	-	-	-	-	-	-	-	673	-	6,775	9,784	24,658	30,119	65,951	-	87,895	-	47,164	273,019	51.71
Melrose,	-	-	-	-	-	-	-	-	-	-	5,178	2,920	23,075	10,545	23,464	-	105,386	-	70,672	241,240	45.69
Revere,*	-	-	-	-	-	-	-	-	-	-	22,650	5,700	7,380	8,550	16,511	-	65,282	-	69,492	195,565	37.04
Watertown,	-	-	-	-	-	-	-	-	-	-	400	12,127	5,959	4,169	19,261	-	108,872	-	13,239	164,027	31.06
Winthrop,*	-	-	-	-	-	-	-	-	-	-	-	-	4,000	4,800	20,447	-	26,264	-	71,928	127,439	24.14
Belmont,	-	-	-	-	-	-	-	-	-	-	-	-	2,161	12,302	13,696	-	73,371	-	283	101,813	19.28
Nahant,	-	-	-	-	-	-	-	-	-	-	-	-	150	11,550	4,850	-	32,740	-	35,100	84,390	15.98
Arlington,	-	-	-	-	-	-	-	-	-	-	-	-	31,804	20,036	21,359	-	82,598	-	30,564	186,361	35.29
Swampscott,	-	-	-	-	-	-	-	-	-	-	-	-	12,072	13,634	13,217	-	47,294	-	9,110	95,327	18.05
Stoneham,	-	-	-	-	-	-	-	-	-	-	-	-	4,525	4,725	2,975	-	85,092	-	12,829	110,146	20.86
Milton,	-	-	-	-	-	-	-	-	-	-	103	44	22,331	16,630	31,807	-	101,923	-	12,497	185,335	35.10
Lexington,	-	-	-	-	-	-	-	-	-	-	-	-	9,000	2,264	6,860	-	42,037	-	32,960	93,121	17.64
Total feet,	9,069	204,594	24,888	23,104	89,739	115,301	244	129,333	160,631	387	309,716	47,996	1,507,833	450,697	1,117,646	994	3,047,376	948	720,724	7,961,220	-
Total miles,	1.72	38.75	4.71	4.38	17.00	21.84	.05	24.49	30.42	.07	58.66	9.09	285.57	85.36	211.68	.19	577.15	.18	136.50	-	1,507.81

* 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,	90,571	4,748	7,919
Somerville,	11,055	1,275	986
Malden,	6,750	4,759	404
Chelsea,	6,357	126	296
Quincy,	5,378	184	661
Everett,	4,853	78	504
Medford,	4,142	218	489
Melrose,	3,307	105	284
Revere,	2,623	60	127
Watertown,	1,767	1,666	322
Winthrop,	1,891	25	117
Belmont,	651	651	153
Nahant,	425	71	65
Arlington,	1,806	115	357
Swampscott,	1,171	-	125
Stoneham,	1,327	26	103
Milton,	1,127	1,127	283
Lexington,	660	12	94
Total,	145,861	15,246	13,289

Table No. 38. — *Average Maximum and Minimum Monthly Heights, in Feet, above Boston City Base, to which Water rose, at Different Stations on the Metropolitan Water Works.*

1904. Month.	Low-service.														Southern High-service.			
	Boston Engine House, Bulfinch Street.		Allston Engine House, Harvard Street.		Medford, Mystic Reservoir.		Medford Water Works Office, High Street.		Somerville City Hall Annex, Walnut Street.		Malden Water Works Shop, Green Street.		Chelsea Water Works Office, Park Street.		Boston Metropolitan Water Works Office, 1 Ashburton Place.		Watertown Water Works Office, Main Street.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
January, .	123	114	186	181	166	164	167	165	166	163	163	160	152	144	247	238	261	259
February, .	123	115	187	184	166	165	166	165	168	165	161	158	147	138	246	238	263	260
March, .	133	121	189	182	166	164	167	165	168	164	162	159	155	147	248	239	263	260
April, . .	139	128	184	174	166	163	166	165	166	162	163	160	161	153	248	239	263	260
May, . .	150	125	181	174	166	163	166	163	167	162	163	159	162	151	248	237	262	259
June, . .	152	128	186	176	167	164	166	164	168	165	163	160	163	153	247	236	262	257
July, . .	153	127	186	178	167	164	166	164	168	164	163	160	163	152	246	237	263	257
August, .	147	126	183	174	167	164	166	164	168	164	163	160	163	154	246	237	261	257
September, .	139	126	186	177	167	164	167	164	169	165	163	160	163	154	247	236	262	258
October, .	134	128	180	174	165	162	166	164	167	163	163	160	162	153	247	238	261	258
November, .	134	127	187	177	167	164	167	165	170	166	164	163	162	156	248	238	260	258
December, .	127	120	180	173	167	164	167	165	170	166	165	162	157	151	246	237	262	259
Averages,	138	124	185	177	166	164	166	164	168	164	163	160	159	151	247	238	262	259

TABLE No. 38. — *Average Maximum and Minimum Monthly Heights, in Feet, above Boston City Base, etc.* — Concluded.

1904. Month.	Southern High-service — Concluded.						Northern High-service.								Northern Extra High-service.	
	Belmont Town Hall, Pleasant Street.		Milton Water Works Office, Adams Street.		Quincy Water Works Shop.		Somerville Pumping Station, Cedar Street.		Malden City Hall.		Revere Water Works Office, Broadway.		Lynn Engine House, Union Square.		Lexington Town Hall, Massachusetts Avenue.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
January,	258	252	248	243	235	223	268	258	266	264	256	250	254	245	390	376
February,	260	253	247	243	232	219	265	255	269	266	253	244	252	241	390	374
March,	258	253	249	244	235	220	268	259	269	267	260	254	259	251	390	373
April,	260	253	249	244	238	224	268	260	269	267	263	254	261	251	384	372
May,	262	252	248	241	239	222	268	256	269	266	261	250	258	245	387	372
June,	262	250	247	240	238	214	266	255	268	264	262	243	257	230	388	370
July,	262	254	247	239	236	211	267	257	268	264	259	235	253	223	385	369
August,	259	254	246	242	238	213	268	259	267	263	260	234	256	222	386	369
September,	259	253	247	243	236	215	268	258	268	264	261	238	258	230	386	368
October,	259	254	248	246	237	219	268	265	270	267	264	252	263	249	388	371
November,	259	255	247	242	238	222	270	261	270	267	266	256	265	255	386	376
December,	260	256	247	241	237	222	270	260	270	267	264	254	262	254	381	370
Averages,	260	253	248	242	237	219	268	259	269	266	261	247	258	241	387	372

Appendix No. 4.

Water Works Statistics for the Year 1904.

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, 1904.
Boston,	560,892	610,300
Somerville,	61,643	70,000
Chelsea,	34,072	37,800
Malden,	33,664	40,700
Newton,*	33,587	39,000
Everett,	24,336	29,200
Quincy,	23,899	27,700
Medford,	18,244	22,000
Hyde Park,*	13,244	14,500
Melrose,	12,962	14,400
Revere,	10,395	13,400
Watertown,	9,706	11,200
Arlington,	8,603	10,100
Milton,	6,578	7,700
Stoneham,	6,197	6,400
Winthrop,	6,058	7,700
Belmont,	3,929	5,000
Lexington,	3,831	4,100
Nahant,	1,152	1,400
Total population of Metropolitan Water District,	872,992	972,600
Swampscott,†	4,548	5,200
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.

26 per cent. from gravity.
74 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: Quemahoning, Georges Creek Cumberland, Pocahontas and Cumberland steam; anthracite: buckwheat and screenings. Price per gross ton in bins: bituminous $4.15 to $5.36, buckwheat $3.28, screenings $2.24 and $3.44. Average price per gross ton $3.87. Per cent. ashes, 12.4.

Chestnut Hill Low-service Station: —

Builders of pumping machinery, Holly Manufacturing Company.

Description of coal used: — Bituminous: Quemahoning, Georges Creek Cumberland, Pocahontas and Cumberland steam; anthracite: buckwheat and screenings. Price per gross ton in bins: bituminous $3.98 to $5.36, buckwheat $3.08, screenings $2.24 to $3.67. Average price per gross ton $3.97. Per cent. ashes, 12.0.

Spot Pond Station: —

Builders of pumping machinery, Geo. F. Blake Manufacturing Company and Holly Manufacturing Company.

Description of coal used: — Bituminous: Georges Creek Cumberland; anthracite: buckwheat and screenings. Price per gross ton in bins: bituminous $4.40, buckwheat $3.75, screenings $2.24. Average price per gross ton $3.65. Per cent. ashes, 13 9.

	Chestnut Hill High-service Station.		
	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 4.
Daily pumping capacity (gallons),	16,000,000	20,000,000	30,000,000
Coal consumed for year (pounds),	1,012,902	279,676	8,656,737
Cost of pumping, figured on pumping station expenses,	$4,131.34	$1,326.52	$29,567.41
Total pumpage for year, corrected for slip (million gallons),	576.20	292.86	10,522.75
Average dynamic head (feet),	120.69	127.90	129.30
Gallons pumped per pound of coal,	568.12	1,047.14	1,215.56
Duty on basis of plunger displacement,	65,400,000	120,540,000	134,950,000
Cost per million gallons raised to reservoir,	$7.170	$4.529	$2.810
Cost per million gallons raised one foot,	0.059	0.035	0.022

	Chestnut Hill Low-service Station. Engines Nos. 5, 6 and 7.	Spot Pond Station. Engine No. 9.
Daily pumping capacity (gallons),	105,000,000	20,000,000
Coal consumed for year (pounds),	8,662,868	2,462,802
Cost of pumping, figured on pumping station expenses,	$33,864.15	$11,868.79
Total pumpage for year, corrected for slip (million gallons),	20,268.94	2,927.47
Average dynamic head (feet),	54.91	129.33
Gallons pumped per pound of coal,	2,339.75	1,188.67
Duty on basis of plunger displacement,	110,290,000	132,070,000
Cost per million gallons raised to reservoir,	$1.671	$4.054
Cost per million gallons raised one foot,	0.030	0.031

Consumption.

Estimated total population of the nineteen cities and towns supplied wholly or partially during the year 1904,	927,800
Total consumption, gallons,	42,057,180,000
Average daily consumption, gallons,	114,909,000
Gallons per day to each inhabitant,	123.9

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,	.02	13.71
Length in use, miles,	84.21	1,507.81
Stop gates added,	3	–
Stop gates now in use,	356	–
Service pipes added,	–	1,343
Service pipes now in use,	–	145,861
Meters added,	–	882
Meters now in use,	–	15,246
Fire hydrants added,	–	178
Fire hydrants now in use,	–	13,289

* 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	44	Section 63, Belmont Extension, Cambridge, 22 in by 28 in., 24 in. by 28 in. and 25 in. diameter brick sewer in open cut and tunnel.	7	$49,691 50	$45,288 00	Gow & Palmer, Boston, Mass.
2	45	Pile driving, in advance of excavation, on Sections 61 and 62, Revere Extension, Chelsea.	-	-	-	Mayo Contracting Co., Boston, Mass.
3	46	Part of Section 62, Revere Extension, Chelsea, 48 in. brick sewer in tunnel.	-	-	-	Chas. A. Haskin, Boston, Mass.
4	50	Part of Section 61, Revere Extension, Chelsea, 608 linear feet of 54 in. brick sewer in tunnel.	-	-	-	Chas. A. Haskin, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . . . .

Contracts relating to the

5	16	Section 77, High-level Sewer, Roxbury, pumping plant for Ward Street pumping station.	3	$207,000 00	$204,000 00	Allis-Chalmers Co., Milwaukee, Wis.
6	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.
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	35	Parts of Section 44, High-level Sewer, Quincy.	4	133,845 00	125,554 60	W. H. Ellis, Boston, Mass.
9	33	Section 46, High-level Sewer, Quincy.	3	40,328 00	37,044 00	W. H. Ellis, Boston, Mass.
10	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.

Appendix No. 5.

the Year 1904 — Sewerage Works.

North Metropolitan System.

7. Date of Contract.	8. Date of Completion of Work.	9. Prices of Principal Items of Contracts made in 1904.	10. Value of Work done Dec. 31, 1904.	
Sept. 14, '03,	Apr. 23, '04,	– –	$47,273 69	1
Oct. 9, '03,	June 24, '04,	– –	13,802 80	2
Oct. 23, '03,	Apr. 14, '04,	– –	27,902 68	3
May 3, '04,	Aug. 18, '04,	For completed sewer in tunnel, except piling to be furnished and placed by the Board, $21 per linear foot.	12,768 00	4
. . .	. . .	. . . .	$101,747 17	

South Metropolitan System.

Jan. 17, '02,	–	– –	$153,000 00	5
May 28, '02,	Sept. 29, '04,	– –	94,592 96	6
Oct. 8, '02,	May 31, '04,	– –	227,140 93	7
June 11, '03,	May 26, '04,	– –	114,850 23	8
June 11, '03,	May 14, '04,	– –	29,453 38	9
June 9, '03,	Jan. 23, '04,	– –	29,366 06	10

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	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.
2	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.
3	39	Part of Section 44, High-level Sewer, Quincy, screen-house on Nut Island.	6	29,971 00	29,940 00	Woodbury & Leighton Co., Boston, Mass.
4	40	Quincy pumping station, force-main line, 299 tons 24-inch cast-iron pipe and special castings.	3	7,857 60	7,238 50	Camden Iron Works, Camden, N. J.
5	47	Easterly line of Section 43, High-level Sewer, Quincy and Hull, 2,265 tons 60-inch cast-iron pipe and special castings.	2	64,617 80	56,966 70	Camden Iron Works, Camden, N. J.
6	49	Screening machinery for the Nut Island screen-house, and the Ward Street pumping station of the High-level Sewer, Quincy and Roxbury.	2	31,100 00	24,054 00	The Lockwood Manufacturing Company, Boston.
7	48	Additional filling on embankments and completing Rock Island Road over Section 48, High-level Sewer, Quincy.	4	9,570 00	7,500 00	Joseph J. Moebs, Boston, Mass.
		Total, ...	. .	. . .	. . .	. . . .

THE YEAR 1904 — SEWERAGE WORKS — *Continued.*

South Metropolitan System — Concluded.

7. Date of Contract.	8. Date of Completion of Work.	9. Prices of Principal Items of Contracts made in 1904.	10. Value of Work done Dec. 31, 1904.	
June 30, '03,	Nov. 2, '04,	- -	$99,511 04	1
Aug. 14, '03,	Nov. 1, '04,	- -	6,315 00	2
Sept. 11, '03,	Oct. 20, '04,	- -	29,940 00	3
Dec. 21, '03,	May 31, '04,	- -	7,291 67	4
Dec. 21, '03,	Aug. 27, '04,	- -	56,091 28	5
May 19, '04,	Nov. 3, '04,	Nut Island screening machinery, $12,862; Ward Street screening machinery, $11,192.	24,054 00	6
May 23, '04,	Oct. 21, '04,	Earth excavation and filling on embankments, $0.54 per cu. yd., loam and peat excavation and placing on slopes of embankments, $0.65 per cu. yd., placing rock ballast, $1 per cu. yd. in place.	7,113 55	7
. . .	. . .	. . . .	$878,720 10	

CONTRACTS MADE AND PENDING DURING THE YEAR 1904 — SEWERAGE WORKS — *Concluded.*

Summary of Contracts.*

	Value of Work done December 31, 1904.
North Metropolitan System, 4 contracts,	$101,747 17
South Metropolitan System, 13 contracts,	878,720 10
Total of 17 contracts made and pending during the year 1904,	$980,467 27

* In this summary the cost of day work, and contracts charged to maintenance are excluded.

Appendix No. 6.

LEGISLATION OF THE YEAR 1904 AFFECTING THE METROPOLITAN WATER AND SEWERAGE BOARD.

ACTS OF 1904.

[Chapter 30.]

An Act making an appropriation for printing and binding the annual report of the metropolitan water and sewerage board.

Be it enacted, etc., as follows:

Report of the metropolitan water and sewerage board.

Section 1. The sum of twenty-five hundred dollars is hereby appropriated, to be paid out of the treasury of the Commonwealth from the ordinary revenue, for printing and binding the annual report of the metropolitan water and sewerage board, the cost of the same to be assessed and collected by the treasurer and receiver general equally upon and from the metropolitan water and metropolitan sewerage districts.

Section 2. This act shall take effect upon its passage. [*Approved January 30, 1904.*

[Chapter 60.]

An Act making an appropriation for operating the south metropolitan system of sewage disposal.

Be it enacted, etc., as follows:

South metropolitan system of sewage disposal.

Section 1. A sum not exceeding one hundred and thirty-five thousand dollars is hereby appropriated, to be paid out of the South Metropolitan System Maintenance Fund, for the cost of maintenance and operation of the south metropolitan system of sewage disposal, comprising a part of Boston, the cities of Newton, Quincy and Waltham, and the towns of Brookline, Watertown, Dedham, Hyde Park and Milton, during the year ending on the thirty-first day of December, nineteen hundred and four.

Section 2. This act shall take effect upon its passage. [*Approved February 6, 1904.*

[Chapter 62.]

An Act making an appropriation for operating the north metropolitan system of sewage disposal.

Be it enacted, etc., as follows:

North metropolitan system of sewage disposal.

Section 1. A sum not exceeding one hundred and twenty-three thousand dollars is hereby appropriated, to be paid out of the North Metropolitan System Maintenance Fund, to provide for the cost of maintaining and operating the system of sewage disposal for the cities of Boston, Cambridge, Somerville, Malden, Chelsea, Woburn, Medford, Melrose and Everett, and the towns of Stoneham, Winchester, Arlington and Belmont, known as the North Metropolitan System, during the year ending on the thirty-first day of December, nineteen hundred and four.

Section 2. This act shall take effect upon its passage. [*Approved February 6, 1904.*

[Chapter 186.]

An Act to extend the time for filing petitions for damages and offers of surrender of real estate under the act to provide for a metropolitan water supply.

Be it enacted, etc., as follows:

1899, 342, § 1, etc., amended.

Section 1. Section one of chapter three hundred and forty-two of the acts of the year eighteen hundred and ninety-nine, as amended by section one of chapter one hundred and eight of the acts of the year nineteen hundred, and by section one of chapter four hundred and ninety-eight of the acts of the year nineteen hundred and one, is hereby further amended by striking out the word "four", in the seventeenth line, and inserting in place thereof the word: — five, — so as to read as follows: —

Time within which certain petitions for damages, etc., may be filed extended.

Section 1. Petitions under the provisions of section fourteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, or of section one of chapter four hundred and forty-five of the acts of the year eighteen hundred and ninety-seven, and acts in amendment thereof or in addition thereto, for the determination of damages for the taking of real estate may be filed, as provided by law, within two years after the actual taking by right of eminent domain of such real estate or of any interest therein, and petitions for the determination of damages for the taking of water rights where no land is taken in connection with such water rights, and for the determination of all other damage provided for in said acts, and offers of surrender of real estate provided for in said acts, may be filed on or before the first day of July in the year nineteen hundred and five.

SECTION 2. This act shall take effect upon its passage. [*Approved March 29, 1904.*

[CHAPTER 230.]

AN ACT TO AUTHORIZE THE METROPOLITAN WATER AND SEWERAGE BOARD TO DETERMINE THE LINES AND GRADES OF THE HIGH LEVEL METROPOLITAN SEWER ABOVE THE POINT WHERE THE SEWAGE OF THE CHARLES RIVER VALLEY IS TO BE RECEIVED.

Be it enacted, etc., as follows:

SECTION 1. The metropolitan water and sewerage board is hereby authorized to determine the location, elevation and size of the high level metropolitan sewer above the point where the sewage from the Charles River valley is to be received. Location, etc., of high level metropolitan sewer.

SECTION 2. To meet the expenses of determining the said location, as provided in section one, the treasurer and receiver general is authorized to issue scrip or certificates of debt in the name and on behalf of the Commonwealth, and under its seal, to an amount not exceeding seven thousand dollars in addition to the amounts authorized to be issued under the provisions of chapter four hundred and twenty- our of the acts of the year eighteen hundred and ninety-nine, and of chapter three hundred and fifty-six of the acts of the year nineteen hundred and three; and all the provisions of said acts shall apply to this additional loan. Treasurer and receiver general to issue scrip or certificates of debt, etc.

SECTION 3. This act shall take effect upon its passage. [*Approved April 12, 1904.*

[CHAPTER 246.]

AN ACT TO PROVIDE FOR EXPENSES INCURRED IN THE CONSTRUCTION OF THE HIGH LEVEL GRAVITY SEWER FOR THE RELIEF OF THE CHARLES AND NEPONSET RIVER VALLEYS.

Be it enacted, etc., as follows:

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, and chapter three hundred and fifty-six of the acts of the year nineteen hundred and three, shall, with the approval of the governor Treasurer and receiver general to issue scrip or certificates of debt, etc.

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 three hundred and eighty-five thousand dollars, in addition to the amounts authorized to be issued under the provisions of said chapters; and the provisions of said chapters 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 April 22, 1904.*

[CHAPTER 273.]

AN ACT TO AUTHORIZE THE LAYING OF WATER PIPES OR MAINS UNDER OR OVER TIDE WATER.

Be it enacted, etc., as follows:

Certain water pipes or mains may be carried under or over tide waters, etc.

SECTION 1. The metropolitan water and sewerage board, and the water board, water commissioners or superintendent of any city or town in the metropolitan water district, in exercising the powers or discharging the duties conferred or imposed by chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five and acts in amendment thereof and in addition thereto, may carry and conduct any aqueduct, conduit, pipe, drain or wire under or over tide waters or the waters of Boston harbor by such methods and in such manner as the board of harbor and land commissioners shall approve.

SECTION 2. This act shall take effect upon its passage. [*Approved April 29, 1904.*

[CHAPTER 299.]

AN ACT TO CONFIRM A CERTAIN AGREEMENT BETWEEN THE METROPOLITAN WATER AND SEWERAGE BOARD AND THE CITY OF MARLBOROUGH, RELATIVE TO BUILDING AN ADDITIONAL MAIN SEWER AND FILTER BEDS FOR SAID CITY.

Be it enacted, etc., as follows:

Certain agreement between city of Marlborough and metropolitan water and sewerage board confirmed.

SECTION 1. The agreement signed by the mayor of the city of Marlborough, for that city, and by the metropolitan water and sewerage board, for the Commonwealth, dated October five, nineteen hundred and three, and recorded with Middlesex south district registry of deeds, book 3091, page 101, providing for the construction and maintenance of an additional main sewer and filter beds for the disposal of a part of the sewage of said city, as a substitute for the additional main sewer provided for by chapter four hundred and forty-three of the acts of the year nineteen hundred and three, is hereby ratified and confirmed; and all action taken, all construction work done and all payments made under said agreement in the construction of said additional main sewer and filter beds, are hereby ratified, approved and made valid, as fully as if such additional main sewer had been constructed in accordance with the provisions of said chapter.

SECTION 2. This act shall take effect upon its passage. [*Approved May 6, 1904.*

[CHAPTER 311.]

AN ACT RELATIVE TO THE EMPLOYMENT OF MECHANICS AND LABORERS IN THE CONSTRUCTION OF PUBLIC WORKS.

Be it enacted, etc., as follows:

R. L. 106, § 14, amended.

Chapter one hundred and six of the Revised Laws is hereby amended by striking out section fourteen and inserting in place thereof the following: — *Section 14.* In the employment of mechanics and laborers in the construction of public works by the Commonwealth, or by a county, city or town, or by persons contracting therewith, preference shall be given to citizens of the Commonwealth, and, if they cannot be had in sufficient numbers, then to citizens of the United States; and every contract for such works shall contain a provision to this effect. Any contractor who knowingly and wilfully violates the provisions of this section shall be punished by a fine of not more than one hundred dollars for each offence. [*Approved May 9, 1904.*

Preference to be given to citizens in the employment of mechanics and laborers.

Penalty.

[CHAPTER 314.]

AN ACT TO REGULATE REMOVALS AND SUSPENSIONS FROM OFFICE AND EMPLOYMENT IN THE CLASSIFIED CIVIL SERVICE.

Be it enacted, etc., as follows:

SECTION 1. Every person holding office or employment in the public service of the Commonwealth or in any county, city or town thereof, classified under the civil service rules of the Commonwealth, shall hold such office or employment and shall not be removed therefrom, lowered in rank or compensation, or suspended, or, without his consent, transferred from such office or employment to any other except for just cause and for reasons specifically given in writing.

Persons holding office in the public service not to be removed, etc., without cause.

Notice to be given, etc.

SECTION 2. The person sought to be removed, suspended, lowered or transferred shall be notified of the proposed action and shall be furnished with a copy of the reasons required to be given by section one, and shall, if he so requests in writing, be given a public hearing, and be allowed to answer the charges preferred against him either personally or by counsel. A copy of such reasons, notice and answer and of the order of removal, suspension or transfer shall be made a matter of public record. [*Approved May 9, 1904.*

[CHAPTER 317.]

AN ACT RELATIVE TO DAMAGES FOR THE TAKING OF PROPERTY BY RIGHT OF EMINENT DOMAIN.

Be it enacted, etc., as follows:

Payment of damages for the taking of property by right of eminent domain, etc.

SECTION 1. In all cases of property, real or personal, taken by right of eminent domain, or subjected to restrictions, limitations or regulations by the Commonwealth, or by any county, city or town therein, the Commonwealth or such county, city or town may, at any time after such taking, or after the imposition of such restrictions, limitations or regulations, estimate and award to any person, city, town or corporation injured by such taking or by such imposition, the damages recoverable therefor, and may offer in writing to pay to such person, city, town or corporation the amount of such award, with interest thereon, as provided by law, from the date of such taking or such imposition, together with taxable costs if a petition or other proceeding for assessment of such damages is pending. The person, city, town or corporation to whom or to which such offer is made, may reject or accept the same, and acceptance thereof may be either in full satisfaction of all damages so sustained, or as a payment *pro tanto* without prejudice to any right to have said damages assessed by a jury or other competent tribunal. After notice of such offer, made as aforesaid, or payment of the amount thereof, if payment be made, no interest shall be recoverable, except upon such amount in damages as shall, upon final adjudication, be in excess of the amount of said offer:

Proviso.

provided, that all taxable costs accruing subsequently to said offer shall be recoverable by the petitioner in all cases.

SECTION 2. This act shall take effect upon its passage. [*Approved May 9, 1904.*

[Chapter 349.]

An Act to provide for the protection of persons furnishing materials or labor for public works.

Be it enacted, etc., as follows :

Section 1. Officers or agents who contract in behalf of any county, city or town for the construction or repair of public buildings or other public works shall obtain sufficient security, by bond or otherwise, for payment by the contractor and subcontractors for labor performed or furnished and for materials used in such construction or repair; but in order to obtain the benefit of such security the claimant shall file with such officers or agents a sworn statement of his claim within sixty days after the completion of the work.

Protection of persons furnishing materials or labor for public works.

Section 2. This act shall take effect upon its passage. [*Approved May 19, 1904.*

[Chapter 388.]

An Act relative to printing and binding certain public documents.

Be it enacted, etc., as follows :

. . . .

Section 2. Boards, commissions and heads of departments having charge of preparing and printing documents relating to their various departments shall not incorporate therein any statistics unless the same shall be approved by the state board of publication.

Statistics not to be printed in public documents without approval of board of publication.

Section 3. This act shall take effect upon its passage. [*Approved May 31, 1904.*

[Chapter 406.]

An Act to provide for the improvement of Spot Pond brook by the metropolitan water and sewerage board.

Be it enacted, etc., as follows :

Section 1. The metropolitan water and sewerage board shall improve or change the channel of Spot Pond brook between Spot pond in the town of Stoneham and tide water in the city of Malden substantially in accordance with the plans and recommendations of the board contained in its report to the general court of nineteen hundred and three, being house document number one thousand and eighty-seven of that year.

The metropolitan water and sewerage board to improve Spot Pond brook, etc.

May take lands, easements, etc.

SECTION 2. The board, for the purpose aforesaid, may from time to time take, in fee or otherwise, by purchase or otherwise, for the Commonwealth or for the city of Malden or for the city of Melrose, as the board shall determine, lands, easements, rights and other property, and, in order to take any property by right of eminent domain, shall sign and cause to be recorded in the registry of deeds for the county and district in which the property to be taken is situated a description thereof as certain as is required in a common conveyance of land; the recording shall constitute the taking.

Damages.

SECTION 3. Any person whose property is injured by the taking, or by changing the channel of said brook, altering its course, or diverting the waters thereof or increasing or diminishing the daily flow of said waters, may have compensation therefor as determined by agreement with the board, and if the parties cannot agree upon the damages, they may be determined by a jury of the superior court for the county in which the property is situated under the provisions, so far as they may be applicable, of chapter forty-eight of the Revised Laws, upon petition therefor by the board or person filed in the clerk's office of the court within one year after the taking, changing or altering, and the petitioner shall have judgment for the amount determined, with interest on the excess of the amount over the award of the board and costs if the amount is greater than the award of the board; otherwise the petitioner shall recover no interest and shall pay costs.

Commissioners to be appointed, powers and duties.

SECTION 4. Any justice of the supreme judicial court sitting in equity for the county of Suffolk, on application of the metropolitan water and sewerage board or of the city of Malden or of the city of Melrose, within three months after the passage of this act, shall, after such notice as the court shall order, appoint three commissioners, and may appoint a new commissioner on the occurring of any vacancy. The commissioners, after such notice as they shall deem proper, shall hear the parties and make award of the proportion in which the expenses of carrying out this act shall be paid by the metropolitan water district, the city of Malden, and the city of Melrose. The commissioners shall take into consideration in making their award the responsibility of said parties in connection with the present condition of said brook and the waters thereof, their rights in, to and over said brook and the waters thereof, their rights in, to and over said Spot pond, its waters and watershed so far as they relate to said brook, and the benefits which will accrue to said parties from the proposed improvements; and shall make their award on these bases and return it into court with a statement of the questions of law raised by either party and the findings of the commissioners thereon.

Findings and award, etc.

SECTION 5. Any justice of the said court sitting in equity for the county of Suffolk may accept the findings and award, and either party may except thereto; or the justice may report the case with such of said questions of law as either party may request to the supreme judicial court of the Commonwealth. Said court may determine the questions submitted and accept the award, or may amend and accept the award, or may remand the award to the commissioners for further hearing, report and acceptance, in accordance with said determination: *provided, however*, that if the city of Malden by vote of its city council, or the city of Melrose by vote of its city council, or the metropolitan water and sewerage board, shall, within four months after the acceptance of the award, file with the court objection to carrying on the work, it shall not be begun until the objection be withdrawn, but if no such objection be filed, or be filed and withdrawn within one year thereafter, the clerk of the court shall notify the parties thereof, and the work shall thereupon proceed as hereinbefore provided. The metropolitan water and sewerage board shall pay the compensation and expense of the commission as approved by the court, and during and after the completion of the work shall keep the channels, conduits and culverts in repair and pay the expense thereof, and the compensation and expenses so paid shall be assessed and repaid as the expense of construction is to be repaid.

Proviso.

Payment of compensation and expense of commission, etc.

Metropolitan Water Loan.

SECTION 6. The other expenses incurred in carrying out the provisions of this act shall be paid by the Commonwealth, and the treasurer and receiver general shall, from time to time, on request of the board, issue and sell notes, bonds or scrip of the Commonwealth to an amount not exceeding two hundred and twenty-five thousand dollars, designated on the face thereof, Metropolitan Water Loan, and use the proceeds to meet said expenses and to meet the interest and sinking fund requirements of the loan until the award has been accepted, and the provisions of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five and acts in amendment thereof and in addition thereto shall, so far as they may be applicable, apply to said loan.

Certain provisions of law to apply.

Payment of loan, etc.

SECTION 7. The cities of Malden and Melrose shall respectively pay to the treasurer of the Commonwealth each year the interest and sinking fund requirements of such part of the loan aforesaid as shall be equal to the amount of said expenses which the cities respectively are required by the award to pay, and the interest and sinking fund requirements of the remainder of the loan shall be paid by all the cities and towns in the metropolitan water district, as other expenses of the water works are paid.

Assessment and collection of betterments.

SECTION 8. The commissioners shall, within six months after the completion of the work of construction, if in their opinion any land receives a benefit from the improvement authorized by this act beyond the general benefit to all land in said cities, determine the value thereof, and assess upon the land a proportional share of the cost of such improvement, not exceeding the value of the benefit; and any party so assessed may have the amount of the assessment determined by a jury of the superior court of the county in which the land is situated, under the provisions, so far as they may be applicable, of chapter fifty of the Revised Laws, but without interest or costs, if the assessment is not less than the amount determined by the jury, and the assessment shall constitute a lien upon the land assessed until paid. Every such assessment shall be certified by the clerk of said court to the collector of the city in which the land lies, and collected by him in the manner provided for the collection of taxes, and the proceeds thereof shall be paid to the treasurer of the Commonwealth and used to meet the interest and sinking fund requirements of the loan authorized by this act.

When to take effect.

SECTION 9. Except as otherwise provided herein this act shall take effect upon its passage. [*Approved June 3, 1904.*

[CHAPTER 410.]

AN ACT RELATIVE TO THE PRINTING AND DISTRIBUTION OF CERTAIN PUBLIC DOCUMENTS.

Be it enacted, etc., as follows:

R. L. 9, § 7, amended.

Section seven of chapter nine of the Revised Laws is hereby amended as follows: — . . . By striking out the words "forty-five hundred", in the one hundred and eighteenth line, and inserting in place thereof the words: — six thousand, — so that the paragraph beginning with the one hundred and eighteenth line will read as follows: — Of the metropolitan water and sewerage board, six thousand copies. [*Approved June 3, 1904.*

Report of metropolitan water and sewerage board.

[Chapter 426.]

An Act relative to the apportionment of the annual assessments required for the construction and maintenance of the metropolitan water system.

Be it enacted, etc., as follows:

Apportionment of annual assessments for construction and maintenance of the metropolitan water system.

The treasurer and receiver general of the Commonwealth, for the purpose of making the apportionment to the cities and towns in the metropolitan water district of the amount required in each year to pay the interest, sinking fund requirements and expenses of maintenance and operation of the metropolitan water system provided for by section nineteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, as amended by chapter four hundred and eighty-nine of the acts of the year nineteen hundred and one, shall, in the year nineteen hundred and six and in each year thereafter, apportion to the city of Boston the proportion of such amount which the valuation of that city for the preceding year bears to the total of all such valuations of all cities and towns in said water district: *provided, however*, that there shall be included only one fifth of the total valuation of every such city and town which has not reached the safe capacity of its present sources of supply in a dry year or of the sources of supply of the water company by which it is supplied, as determined by the metropolitan water and sewerage board and certified to said treasurer, or which has not made application to said board for water; and the remainder to the other cities and towns in said district, one third in proportion to their respective valuations for the preceding year and the remaining two thirds in proportion to the consumption by the cities and towns respectively in the preceding year of water received from all sources of supply as determined by said board and certified to said treasurer, including however only one fifth of the total valuation and not including any consumption of water for any such city or town which has not reached the safe capacity of its present sources of supply or of the sources of supply of the water company by which it is supplied as aforesaid, or which has not made application to said board for water; and *provided, further*, that any city or town assessed upon its full valuation which obtains a part of its water supply from its own works or receives a supply from a water company shall be allowed and credited in its apportionment with a sum equal to twelve dollars for each million gallons of water furnished as aforesaid, as determined by said

Proviso.

Proviso.

Payment of assessments.

board and certified to said treasurer. The treasurer shall in each year notify each city and town of the amount of its assessment, and the same shall be paid by the city or town into the treasury of the Commonwealth at the time required for the payment and as part of its state tax. [*Approved June 4, 1904.*

[Chapter 431.]

An Act relative to the approval of certain official bonds.

Be it enacted, etc., as follows:

Approval of certain official bonds.

Section 1. The official bonds given by persons designated to receipt for advances of money by the metropolitan park commission and the metropolitan water and sewerage board, which have heretofore been approved by the auditor of accounts, shall hereafter be approved by the treasurer and receiver general.

Section 2. This act shall take effect upon its passage. [*Approved June 4, 1904.*

[Chapter 436.]

An Act relative to compensation for damages occasioned in the town of Boylston by the construction of the metropolitan water system.

Be it enacted, etc., as follows:

Compensation for damages occasioned in town of Boylston by the construction of the metropolitan water system.

Section 1. The owner of any real estate situated in that part of the town of Boylston on the southerly and southeasterly side of the metropolitan water basin known as the Wachusett reservoir, and within the limits of the Nashua river watershed, not taken but directly or indirectly decreased in value by reason of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five and amendments thereof, entitled "An Act to provide for a metropolitan water supply", or by the doings of the metropolitan water board or of the metropolitan water and sewerage board thereunder, shall have the same right to damages for such decrease in value, to be determined and recovered in the same way, as is provided for owners of certain real estate in the town of West Boylston by section fourteen of said chapter: *provided*, that the petition required by said section is filed within two years after the passage of this act; but no owner shall have the right to surrender his real estate to the Commonwealth in the manner provided in said chapter.

Proviso.

Certain rules and regulations not to consti-

Section 2. The rules and regulations of the state board of health or of the metropolitan water and sewerage board now or hereafter in force for the sanitary protection of water or sources of water supply shall not constitute an element of damage within the meaning of this act.

tute an element of damage.

SECTION 3. This act shall take effect upon its passage. [*Approved June 8, 1904.*

[CHAPTER 457.]

AN ACT TO AUTHORIZE THE TOWN OF REVERE TO SUPPLY ITSELF WITH WATER.

Be it enacted, etc., as follows :

SECTION 1. The town of Revere may supply itself, its inhabitants and such inhabitants of the town of Saugus as are now supplied with water or may hereafter make application to be supplied with water under the provisions of section seven of chapter three hundred and eighty-two of the acts of the year eighteen hundred and eighty-nine, with water for the extinguishment of fires and for domestic and other purposes, obtaining the same from the metropolitan water supply district, as provided in chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five and acts in amendment thereof and in addition thereto, may establish fountains and hydrants and relocate or discontinue the same, and may regulate the use of such water and fix and collect rates to be paid for the use of the same.

Town of Revere may supply itself, its inhabitants and certain inhabitants of Saugus with water.

May obtain water from metropolitan water supply.

May establish hydrants, etc., regulate the use of water, etc.

SECTION 2. Said town for the purposes aforesaid may hold and convey the water to be furnished by the metropolitan water supply district as hereinbefore provided, and may also take, by purchase or otherwise, and hold all lands, rights of way and easements necessary for holding, storing, purifying and preserving such water and for conveying the same to any part of said town; may erect on the lands thus taken or held proper dams, reservoirs, buildings, fixtures or other structures; may make excavations, procure and operate machinery, and provide such other means and appliances as may be necessary for the establishment and maintenance of complete and effective water works; may construct and lay conduits, pipes and other works, under and over any lands, water courses, railroads, railways or public or private ways, and along any such way in such manner as not unnecessarily to obstruct the same; and for the purpose of constructing, maintaining and repairing such conduits, pipes or other works, and for all proper purposes of this act, said town may dig up any such lands, and may enter upon and dig up any such ways in such manner as to cause the least hindrance

May hold and convey water furnished by metropolitan water supply district.

May take and hold lands, etc.

to public travel thereon. The title to all land taken or purchased under the provisions of this act shall vest in said town, and the land so taken may be managed, improved and controlled by the board of water commissioners hereinafter provided for, in such manner as they shall deem for the best interests of said town: *provided*, that nothing in this section shall be construed as authorizing said town to acquire, enter upon or make use of land of the Commonwealth in said town for said purposes, unless the consent of the officers of the Commonwealth having control of such land has first been obtained.

Proviso.

Land of Commonwealth not to be used, etc.

. . . .

Payment of loan, etc.

SECTION 6. The town shall provide at the time of contracting the loan for such annual proportionate payments thereof as will extinguish the same at maturity, and after the town has passed a vote to that effect the sums required for this purpose and for payment of interest on the loan shall be assessed and collected annually in the same manner in which other taxes are assessed and collected. The town shall also raise annually by taxation a sum which with the income derived from water rates will be sufficient to pay the current annual expenses of operating its water works, including therein any annual payment to said metropolitan water board.

Payment to metropolitan water board included.

. . . .

Powers and duties.

SECTION 10. Said commissioners shall fix such prices or rents for the use of water as shall produce annually as near as may be a net surplus over operating expenses, including therein any annual payment to said metropolitan water board, and interest charges equal to two per cent of the total amount of the bonds, notes or scrip issued under this act, after paying all current expenses of operating the water works, and interest upon loans, and after payment of all expenses of new construction not exceeding three thousand dollars in any one year after the original construction. The net surplus aforesaid shall be paid into the treasury of the town. Said commissioners shall annually render an account of all their doings, and shall be governed by the provisions of section fifteen of chapter twenty-seven of the Revised Laws and acts in amendment thereof and in addition thereto, except as otherwise provided herein.

Payment to metropolitan water board to be included in expense account.

. . . .

When to take effect, etc.

SECTION 12. This act shall be submitted to the voters of said town at any annual town meeting or at a special meeting duly called for the purpose, at which the check list shall be used, and it shall take effect upon its acceptance by two thirds of the voters present and voting thereon at any such meeting. If the act is accepted at an annual town meeting, the water commissioners herein provided for may be elected at the same meeting. [*Approved June 9, 1904.*

RESOLVES.

[CHAPTER 28.]

RESOLVE TO PROVIDE FOR THE PAYMENT OF A SUM OF MONEY FROM THE METROPOLITAN SEWERAGE LOAN TO HANNAH M. McCARTHY.

Resolved, That there be allowed and paid out of the Metropolitan Sewerage Loan authorized by section fourteen of chapter four hundred and twenty-four of the acts of the year eighteen hundred and ninety-nine, the sum of seven hundred and fifty dollars, to Hannah M. McCarthy, widow of Patrick D. McCarthy who was killed on the twenty-sixth day of May in the year nineteen hundred and two by an accident in a metropolitan sewer in Roxbury, while in the discharge of his duties as an employee of the metropolitan water and sewerage board. [*Approved March 31, 1904.*

Hannah M. McCarthy.

[CHAPTER 98.]

RESOLVE TO PROVIDE FOR THE APPOINTMENT OF A COMMITTEE TO INVESTIGATE THE LOCAL SEWERAGE SYSTEMS WITHIN THE METROPOLITAN SEWERAGE DISTRICT.

Resolved, That the governor, with the advice and consent of the council, is hereby authorized to appoint a committee of three persons, of whom one shall be a member of the metropolitan park commission, one a member of the Charles River basin commission, and one a member of the board of harbor and land commissioners, and of whom one shall be designated by the governor as chairman. The said committee shall investigate the extent, condition and usefulness of the sewerage systems of the cities and towns within the metropolitan sewerage district, but not now included in the metropolitan sewerage system, and especially shall ascertain whether or not any parts of such local sewerage systems should, in their judgment, be purchased and maintained by the metropolitan water and sewerage board. The members of the committee shall serve without compensation, and shall report to the next general court on or before the fifteenth day of January in the year nineteen hundred and five. [*Approved June 3, 1904.*

Committee to investigate certain sewerage systems, etc., appointment, etc.

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AFFECTING THE

METROPOLITAN WATER AND SEWERAGE BOARD.

A.

B.