Report of the Joint board consisting of the Metropolitan park commission and the State board of health : upon the improvement of Charles River from the Waltham line to the Charles River bridge. April, 1894.

REPORT OF THE JOINT BOARD

UPON THE

IMPROVEMENT OF CHARLES RIVER

1894

D'Arcy Power

HOUSE . . . . No. 775.

REPORT OF THE JOINT BOARD

CONSISTING OF THE

METROPOLITAN PARK COMMISSION

AND THE

STATE BOARD OF HEALTH

UPON THE

IMPROVEMENT OF CHARLES RIVER

FROM THE WALTHAM LINE TO THE
CHARLES RIVER BRIDGE.

APRIL, 1894.

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1894.

[Chap. 475, Acts of 1893.]

AN ACT

TO PROVIDE FOR THE IMPROVEMENT OF CHARLES RIVER.

Be it enacted, etc., as follows:

SECTION 1. The board of metropolitan park commissioners, established under the provisions of chapter four hundred and seven of the acts of the year eighteen hundred and ninety-three, and the state board of health, sitting as a joint board, shall investigate the sanitary condition and prepare plans for the improvement of the beds, shores and waters of the Charles river, between Charles river bridge and the Waltham line on Charles river, and for the removal of any nuisances therefrom, and report with their recommendations to the next general court on or before the first Wednesday in February.

SECTION 2. Said commissioners may employ engineers and experts and incur such expenses as may be necessary to carry out the provisions of this act, and may expend for such purpose a sum not exceeding five thousand dollars. All bills shall be approved and filed with the auditor and allowed in the same manner as other claims against the Commonwealth.

SECTION 3. This act shall take effect upon its passage. [*Approved June 10, 1893.*

[Chap. 57, Resolves of 1894.]

RESOLVE

EXTENDING THE TIME FOR THE REPORT OF THE JOINT BOARD APPOINTED TO INVESTIGATE THE SANITARY CONDITION OF THE CHARLES RIVER.

Resolved, That the time allowed for the filing of the report of the joint board appointed under chapter four hundred and seventy-five of the acts of the year eighteen hundred and ninety-three, providing for the investigation of the sanitary condition of Charles river and the preparation of plans for the improvement of the beds, shores and waters of the Charles river, is hereby extended until the first Wednesday in May in the present year, but if it is not feasible for said board to make said report on or before the first Wednesday in May it is hereby authorized to report to the next general court. [*Approved April 20, 1894.*]

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The Lower Basin at Hamburg is bordered by streets, promenades and landings. (Plates I. and II.) The bridge which divides the Lower from the Upper Basin (Plate III.) permits the passage of omnibus steamboats. The shores of the Upper Basin (Plates IV. and V.) are picturesquely treated in the manner of the banks about the Back Bay Fens. Both basins swarm with small steamers and pleasure craft. (Plate V.).

The border of the much larger basin of Charles River is generally an alley and a row of back yards (Plates VIII. and IX.). Only at the Charlesbank (Plates X. and XI.) is the shore handsomely walled. Above the basin the marsh banks of Charles River tend to become occupied by cheap, ugly and unhealthy buildings (Plate XII.). The marshes and bluff in their natural condition (Plates XIII. and XIV.) are not unbeautiful, and when a dam shall exclude the tide the marshes will become meadows fringed with trees and shrubbery (Plate XV.). The manner in which the people of London make use of a stream like what the Charles may become is shown in Plate VI., and the way in which light boats are carried past dams is illustrated in Plate VII.

REPORT OF THE JOINT BOARD

UPON THE

IMPROVEMENT OF CHARLES RIVER.

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

The undersigned, members of the joint board, consisting of the Board of Metropolitan Park Commissioners and the State Board of Health, to whom was referred, by chapter 475 of the Acts of 1893, the investigation of the sanitary condition, and the preparation of plans for the improvement of the beds, shores and waters of the Charles River, between Charles River bridge and the Waltham line on Charles River, and for the removal of any nuisance therefrom, respectfully submit the following report: —

The two boards named in the act met for organization August 10, 1893. H. P. Walcott was elected chairman of the joint board and H. S. Carruth, secretary. At a later date F. P. Stearns, C. E., was appointed engineer to the board, and Messrs. Olmsted, Olmsted and Eliot were asked to consider the subject of the improvement of the river, to submit a report thereon and to prepare a plan of the improvements recommended. Mr. Eliot had been a member of the Charles River Improvement Commission appointed under authority of chapter 390 of the Acts of 1891, had acquired complete familiarity with the actual condition of the river, and had made, in a public document, valuable suggestions for its improvement. Dr. Robert W. Greenleaf of Boston was asked to make a sanitary survey of the district designated in the act.

The members of the board have personally examined the river and its banks at many times and under various conditions. They have carefully considered the reports made to them by the experts employed, and have reached the following conclusions.

The position of the Charles River, in its relation to the metropolitan district, has necessarily a very great influence upon the health and comfort of the people living in its vicinity. So long as the stream was comparatively unpolluted its banks were occupied at eligible sites by dwellings of the better sort. The increase of pollution and the consequent nuisance occasioned by it have driven from the banks those who could afford to establish new homes in more attractive regions, and the places of these have been taken by a population less sensitive because they cannot afford to avoid offensive surroundings, or by manufactories that seek the stream for commercial advantage or to be at a distance from neighbors likely to complain of offensive processes incident to the business carried on. Even in those portions of the river where the vast quantities of salt water brought in by the tide so far diminish the degree of pollution that offensive odors are not observed except at low tide and in consequence of local causes, and where some of the finest residences of the Back Bay district of the city of Boston are to be found, — even here the river has ceased to be a welcome neighbor except so far as the views to the distant hills to the north and west are enhanced by the water in the not too near foreground, a foreground consisting of a poorly kept alley-way behind a line of unsightly sheds and stables situated at the rear of the lots on the north side of Beacon Street, a rude stone wall, upon which grow tufts of seaweed and unsightly grasses, holding as sponges do the floating putrescible materials that come in contact with them, and at the base of the wall, at low tide, a muddy expanse of many acres, marred by rubbish of every description.

So many of the great cities of the world have made use of the banks of rivers and basins as sites for their finest public and private buildings and ornamental grounds that we cannot escape from the conviction that the disinclination to so use the Charles River within the limits under consideration rests either upon nuisances already in existence or the apprehension of danger to health. The river runs through the very centre of the metropolis and upon its shores should naturally be placed its most attractive structures, its monuments and its finest dwellings. It does not seem appropriate that this territory, so favored by position, lying at the very heart of our great city

and upon the borders of a stream not necessarily offensive, should be condemned to its present ignoble and noxious uses. If any streams or any lowlands are to be so used in the vicinity of Boston it would be well that they should be as far as possible from the centre. An enumeration of the people who are actually resident upon the territory which lies within a distance of two miles upon either bank of the river, throughout the district now under consideration, shows a population of not less than 500,000. Here in the future will probably be found, as now, the bulk of the metropolitan population.

The banks of the river and the exposed flats have become from year to year more offensive until, on certain portions of the river, the people living near the stream have been exposed to the disagreeable and probably injurious emanations therefrom. So far reaching had this nuisance become that during the summer of 1892 a very large portion of the territory of Old Cambridge was subject to its influence, and a petition was addressed to the State Board of Health signed by hundreds of householders, and by nearly all the practising physicians of that portion of the city, praying that some relief might be given from a condition of things believed to be positively injurious to health, and known to be so offensive that windows had to be closed during the period of low tide in the river.

The medical profession believes that the gases arising from decomposing organic materials are injurious to health; it has not been proved, however, that these gases do produce some one distinct disease, but rather that the continued breathing of them lowers the vital resistance and predisposes the person exposed to them to diseases of various kinds and all degrees of severity. But even if the physicians are in error in believing such emanations to be a danger to health, it is quite certain that the owners of lands or houses on the borders of such foul smelling streams suffer a pecuniary loss in the diminished value of their property, a loss from which they should be protected if it be practicable to do so.

In recent years it has been thought that the steady progress of malaria in the valley of the Charles has had a very close connection with the increasing pollution of the stream; the careful examination into this subject by Dr. Greenleaf does not show, however, that the cases of malarial fever have been in

such near connection with the river as to make it probable that the contaminations of its waters have had any direct influence upon the spread of the disease. Dr. Greenleaf, in the course of a house-to-house survey of the district adjoining the river, did, indeed, discover cases of malarial fever, but a satisfactory explanation of their occurrence was almost invariably found, either in local conditions not dependent upon the state of the river, or else by exposure of the affected individuals in localities known to have become malarial in recent years. His observations lead to the same conclusions in this inquiry that other competent authorities have drawn in all parts of the world, that the most important condition to be sought for defence against the malarial infection is a thorough drainage of the soil, together with a maintenance of the water contained therein at an unchanged level.

Two plans occur to us for the relief of the conditions thus briefly sketched, assuming in both cases that the Metropolitan Sewerage System, now nearly completed, will remove the more serious forms of pollution: —

First. To dredge all flats now exposed, and to continue the embankment constructed in the substantial and attractive form used by the city of Boston at the Charlesbank, ultimately carrying this construction through the whole length of the estuary and upon both banks.

Second. To maintain the water in the river through a greater or less length in its course at a permanent high level by the construction of a dam.

The objections to the first plan are these: While the river would rise and fall against a vertical wall, thus exposing the smallest possible surface at the banks, even this surface would soon become defaced by growths more or less offensive, as has already happened to the recently constructed walls in the Charles River basin. The embankment would be many miles in length, would entail very extensive fillings of low lands in order to render such lands available for any public use or profitable private occupation, and the general effect would not be pleasing to the eye, except when the water is at or near high tide, and lastly, the difficulties of the construction of walls on account of poor foundation and their great expense would preclude for the present at least the building of them.

JUNGFERNSTIEG, A STREET ON THE LOWER ALSTER BASIN.

Having a due regard to the imperative need of some measure of relief in this valley, it does not seem safe to longer delay the adoption of a sufficient remedy, and we, therefore, recommend the second plan, the erection of a dam high enough to keep even extreme tides out of the basin and the maintenance of the water at a permanent level, in accordance with the plan of our engineer, F. P. Stearns, C.E., herewith presented.

The place selected for the dam is about 600 feet above Craigie's bridge, where the river is not more than 1,100 feet wide. The details of this structure have been so thoroughly considered that we confidently believe that it will answer the purposes for which it is designed, the maintenance of a nearly permanent level at all times, and no greater interference with commerce than would be produced by the operation of a drawbridge, — indeed, not so much, should the drawbridge happen to lie on the line of a railroad. Provision has been made for a lock in the dam capable of receiving the largest vessels used upon the river; and it is obvious that commerce directed to the upper portions of the stream would gain much from the power to ascend the river independently of the rise and fall of the tide. Vessels which might have occasion to be moored at the wharves on the river above the dam would find in this new condition of things the great advantage of floating at all times. How great this gain would be can be understood when it is stated that the river bed is practically exposed at the United States Arsenal at Watertown at low tide.

Estimates have been made for a dam to be 100 feet in width, and there would thus be provided a foundation for another roadway into the city of Boston from East Cambridge and the country beyond of permanent character, a means of approach to the city likely to be much needed when the time comes for the reconstruction of Craigie's bridge.

The landscape architect would also be able to connect this structure with the public lands on both banks of the river by such additional fillings and rounding of the corners as would materially increase the area of these grounds and add new features of attraction.

We cannot convince ourselves that the harbor will be noticeably injured by the loss of the large quantities of water discharged by the outgoing tide. The opinions of the experts

who have from time to time examined the harbor have in recent years been considerably modified, possibly in view of the unimpaired value of the harbor, notwithstanding the great decrease in the water areas of the Charles River and other basins. If the river below the site of the dam is only to serve the purpose of conveying the waters of the Charles and Miller's rivers to the sea, such diminution of its area as has already taken place will be of little consequence, for a smaller channel than the present would be sufficient to carry all that the Charles River alone could ever empty into it.

The more certain formation of ice on the basin created by the dam ought not, in the absence of any considerable amount of winter commerce on the Charles, to be anything but favorable to the use of this stretch of several miles of river for skating, one of the best of winter exercises and sports. The probable more ready freezing of the channel of Boston Harbor below the dam would be an inconvenience if the constant movement of tugs and ferry boats were not quite certain to break up the ice almost as soon as formed.

The fear is often expressed that such basins as this may become, by reason of an insufficient current and the accumulation of organic matter in them, sources of nuisance and a menace to the public health. The statistics contained in the engineer's report show that there will be a very considerable movement of this sheet of water, and with the improvement in the quality likely to follow the operation of the new metropolitan sewer but little danger of such contamination of the water or such accumulation of filth on the bottom of the basin as could produce offensive smells or conditions dangerous to health. But should the unexpected, nevertheless, happen, the openings in the dam would easily allow of the admission of such quantities of salt water as would keep the basin in a perfectly satisfactory condition by establishing in it a very considerable circulation at each tide. We are fortunately, however, not without examples of basins quite similar to this, situated also in the midst of large populations, and in the most conspicuous example, the world-renowned Alster Basin, the water park of the city of Hamburg, there is no means of introducing any water beyond that flowing in the comparatively insignificant Alster. This basin is very shallow and has a muddy bottom,

ALSTERDAMM, A STREET ON THE LOWER ALSTER BASIN.

but is surrounded by some of the best private houses of this flourishing and wealthy port, and the water surface of the basin and its shores constitute the most frequented places of resort in the city. During the terrible cholera epidemic of 1892, when Hamburg suffered, as few European cities ever have suffered, from this pestilence, the wards in which lie the Alster Basins showed the lowest death rates in the city. We do not intend to say that cholera spreads only where there is filth, but it is true that the conditions among which it finds its widest extension are those of unsanitary surroundings.

There is no question probably in the mind of any sanitary observer that a river of moderately pure water flowing at a constant level between clean banks is much to be preferred to a similar stream which is subject to a rise and fall of many feet twice in the twenty-four hours. Streams of the latter description constantly deposit upon the banks the material floating on the surface, material that occasions little offence while surrounded and saturated with water, but rapidly decays when exposed to the sun and air upon the shores of the river.

Whatever care may be taken of the Charles River in the time to come, if it remain an estuary, there is no doubt in our minds that the banks, sloping as now to the stream, will be more or less a nuisance; dwellings will, so far as possible, not be erected in its neighborhood, or, if they are built here, will be of the sort which are compelled to seek undesirable, consequently cheap, land. A population will be established here which will resist most obstinately and naturally the destruction of their homes, and one more, and perhaps the greatest, opportunity to permanently improve the incomparable situation of Boston and its suburbs will have passed away.

In order to protect the low-lying portions of the territory within the valley of this portion of the Charles River, it has seemed advisable to us to make the permanent level in this basin somewhat lower than that of ordinary high tides. The level which seems most advantageous is that of two feet and six inches below such tides. It is well known that exceptionally high tides have done much injury throughout the estuary of the river, both by flooding and by interference with sewers, and we may reasonably expect that still more will be occasioned on account of the increased occupation of these lowlands

whenever we again have such tides as that which occurred at the time of the destruction of the Minot's Ledge light-house in 1851, or, indeed, tides of much lower height. The forlorn marshes that now border upon the river would become, without the expenditure on them of a dollar, fertile meadows, scarcely needing treatment to become attractive places for recreation; and capable, with treatment, of becoming scenes of great beauty, as the designs of the landscape architects so clearly show. Some solicitude has, in recent years, been manifested in regard to the preservation of the piles upon which are placed the foundations of so many valuable buildings in the Back Bay district of Boston. The maintenance of a basin at a constant level considerably above that at which, by city ordinance, these piles are cut off will probably increase the security of such substructures. We believe that the amount of organic or putrescible material at present deposited on the banks and bed of the river need not present any serious obstacle to the carrying out of this plan. The completion of the whole design will be a matter of years, the addition of the most serious kind of pollution, sewage, will cease, probably, in the course of a year, the narrowing of the stream in the present basin is rapidly going on, with consequent diminution of deposit, and whatever remains after this will be profitably removed to the banks of the stream for such fillings as may be necessary to prepare the river for its new functions.

Whatever plan is adopted for the future treatment of the river, it seems to us essential that all the lands indicated on the plan presented by the landscape architects should be at once acquired. The mere fact that it was public property would alone, we think, improve the value of all the adjoining lands to such an extent as to make the purchase a wise business transaction.

The lowering of the grade of the water in the proposed basin below high tide would help the city of Cambridge to an easier solution of a question which will sooner or later require the expenditure of large sums of money. The freight line of the Boston & Albany Railroad to East Boston now crosses all the main roads leading from Cambridge to Boston. A separation of grades, when this becomes necessary, will be very expensive; depressing the railroad tracks to such an

LOWER ALSTER BASIN, LOOKING TOWARD THE UPPER BASIN.

extent as to allow the streets to remain unchanged is impossible; the present grade of the railroad crossing on Main Street, Cambridgeport, is about six feet above ordinary high tide. When the water level in this basin is reduced by two feet and a half it is clear that a lowering of the tracks can then be made, which will very materially reduce the cost of elevating the half dozen or more much travelled avenues now crossing the railroad at grade.

We now call your attention to the plan proposed by the landscape architects (page 36 of this report). Your board has not thought it advisable, at the present time, to recommend any additional taking of land on the Cambridge side of the river below West Boston bridge. Cambridge has recently acquired an extensive water front between West Boston and Craigie bridges for park purposes, but the remaining portions of this frontage are occupied for commercial uses, and have quite recently been improved by the expenditure of large sums of money. The consequent enhancement of value leads us not to approve of this recommendation of our landscape architects, the more especially as the strip of land taken by the city of Cambridge does not appear to have been acquired with the intention of making it a portion of a continuous parkway.

By chapter 435 of the Acts of 1893 permission has already been given to the city of Boston to construct on her side of the Charles River, beginning at West Boston bridge and ending at the Back Bay Fens, an embankment of a width not to exceed, in the rear of Beacon Street, one hundred feet, but subject to the condition that the filling thus made "shall not be used for building purposes, or for any other purpose than for ornamental grounds and a parkway."

The description in this act of the line to be followed in making the filling of the first section of the proposed embankment, that from West Boston bridge to the rear of Beacon Street, provides a broader margin than seems to us necessary on this side of the basin. We propose that so much of the act as relates to the filling on the easterly side of the basin and in continuation of the Charlesbank be so amended that the filling authorized shall not exceed 150 feet until the intersection with a line perpendicular to the harbor line at the southerly line of Mt. Vernon Street; thence continuing southerly and west-

erly on a curved line to the embankment in the rear of Beacon Street, to be hereafter described.

It may fairly be inferred from a careful examination of Plates VIII. and IX. that the owners of estates on the north side of Beacon Street west of Otter Street have no very great interest in the appearance of their houses and outbuildings as seen from the basin or the bridges crossing it. Whether this new basin will be attractive enough to induce the owners of these properties to so far change the external appearances of their houses as to make them worthy adjuncts to the superb location offered to them is a question which we find it difficult to answer. And yet upon the answer to this question really depends the solution of one of the most serious problems in connection with the improvement of the basin. We believe that this water-park, if formed in accordance with the plans submitted, deserves surroundings of a character equally dignified and attractive with itself.

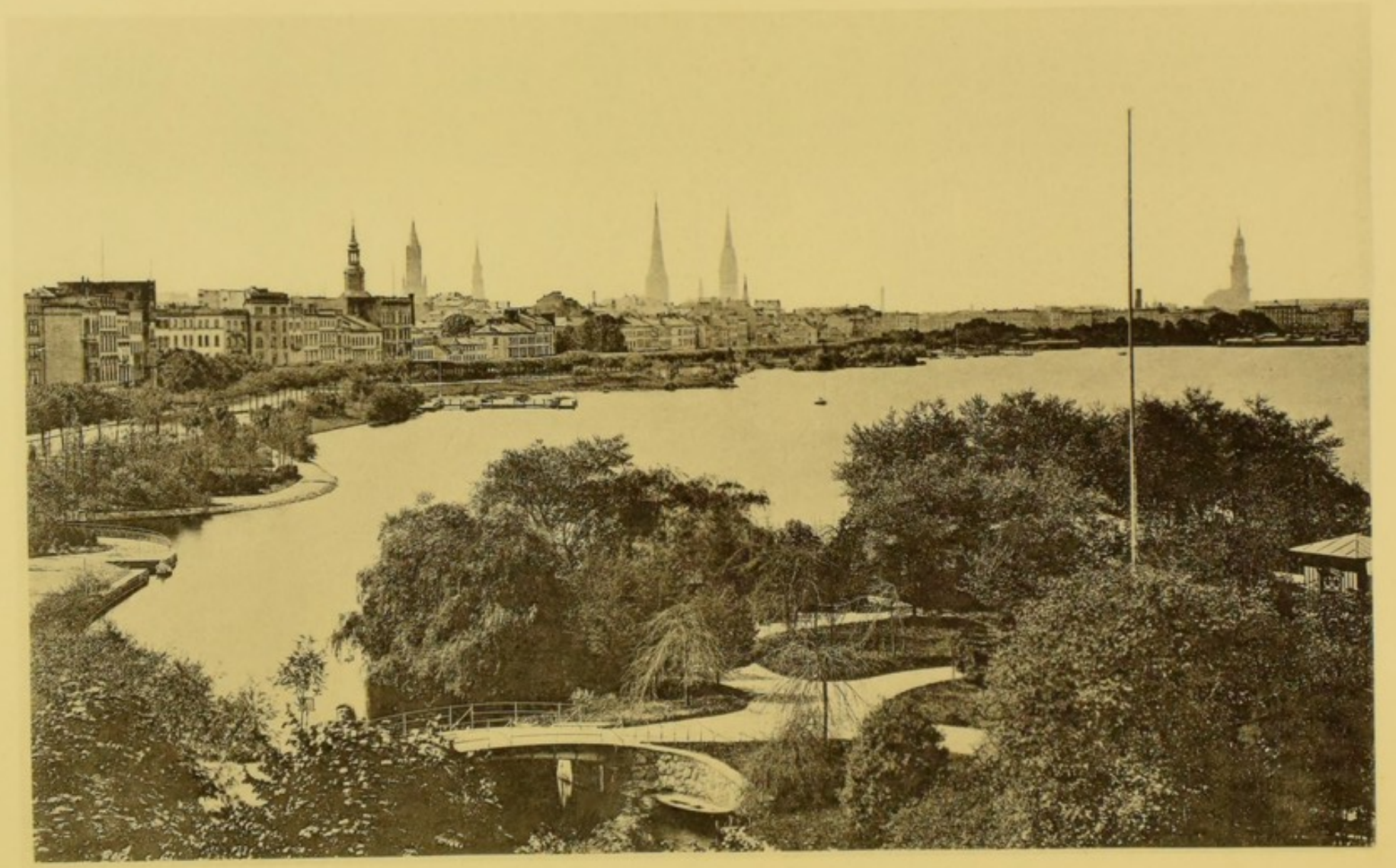
Two views of the problem present themselves to us: —

First. To advise the filling, to the north of the passageway in rear of Beacon Street, of a wider strip than that of 100 feet now authorized by chapter 435 of the acts of 1893, but not to exceed 150 feet; in the expectation that gradually the hoped-for improvement in the abutting estates will be effected.

Second. To recommend the construction of a wider embankment than that provided for by existing legislation, in order that a portion of the land so filled may be prepared for building sites.

After due deliberation we have concluded to present a plan for your consideration in accordance with the second view above stated.

It does not seem probable to us that the houses now standing on Beacon Street below Otter Street are likely to be adapted to the surroundings of the new basin; the large sums of money already spent upon their Beacon Street fronts would seem to preclude the change; moreover, these fronts to the south have always commanded higher prices than similar lots on the opposite side of the street, and the preference will undoubtedly be maintained. But it does seem to us essential that the houses situated on the borders of the basin should also front upon it, not only for the adornment of the basin, but also for



UPPER ALSTER BASIN, LOOKING TOWARD THE CITY.

the benefit that would accrue to it from the better policing and care which all public grounds receive when the neighboring householders walk through them habitually, or constantly have them under view. The back alley which now runs along the border of Charles River in the rear of Beacon Street would undoubtedly be well kept and inviting, where it is now neglected and repulsive, if the owners of the adjacent properties ever themselves made use of it.

The sale of the land prepared for building sites, if carried on as successfully as such transactions have hitherto been by the Commonwealth, would yield a large sum of money to be devoted to the repayment of the expenses of improvements herein recommended.

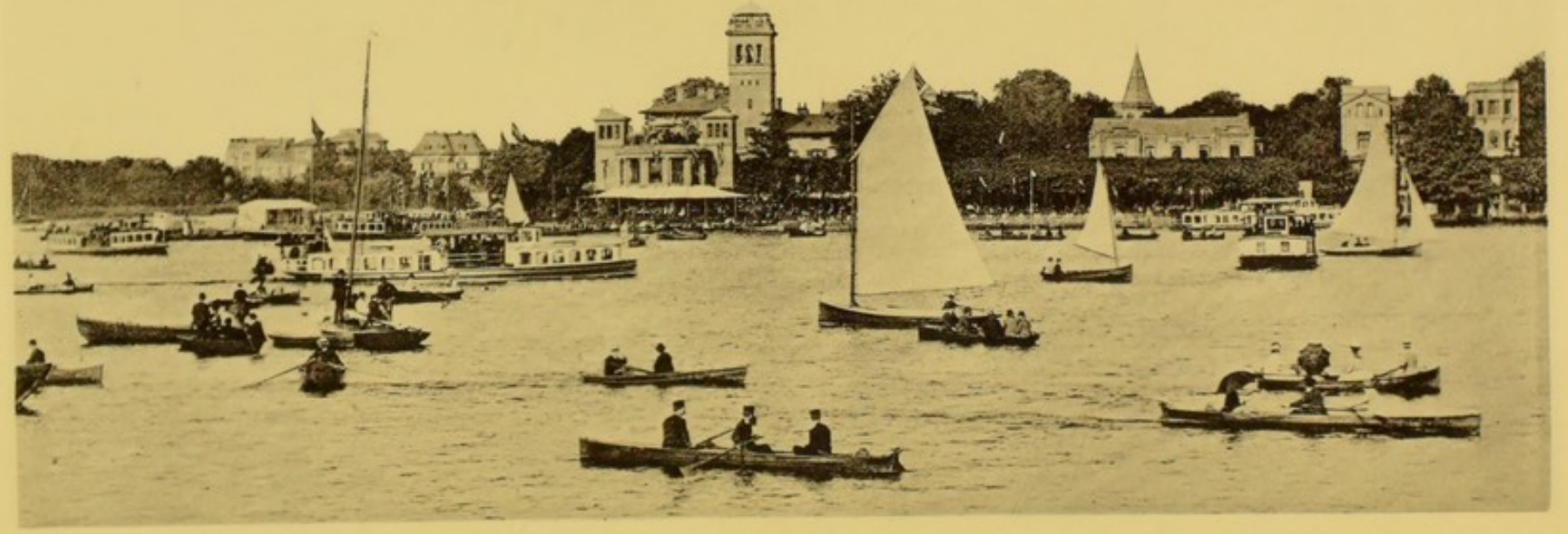
We, therefore, propose that, instead of a strip of ornamental ground in the rear of Beacon Street of a width not to exceed 100 feet, provision be made by which the Board of Harbor and Land Commissioners may be authorized to cause to be filled a space to the north of the present wall in the rear of Beacon Street not to exceed 300 feet in distance therefrom and extending in a line parallel therewith to the westerly line of the Back Bay Fens. One hundred and twenty feet in width of this, immediately to the north of the existing alleyway, to be filled to a grade proper for house lots, so much thereof as may be needed for streets and public open spaces to be reserved and the remainder to be sold. The money received therefor to constitute a fund, from which shall be defrayed the cost of building the dam, making the necessary fillings, and of such other expenses as may result from carrying out the plan of improvements herewith submitted. The remaining strip of 180 feet in breadth to be prepared in accordance with designs to be furnished by the Board of Park Commissioners, and to be used only for parkways and ornamental grounds.

It will be noticed that we recommend a somewhat wider strip in the rear of Beacon Street between the building line and the water than is designated on the plan of the landscape architects. We do so for the purpose of having a wider belt of trees and shrubs than has been thought by them to be necessary. Though the rapidly approaching use of the opposite Cambridge shore for building purposes will have a tendency to break the force of strong winds from the northwest, it is desirable to have a plan-

tation, if only of shrubs and small trees, to still further diminish their force. The shore line of the basin above the Back Bay Fens and up to the Cottage Farm bridge on the Boston side of the river should also, in our opinion, be moved to the north. Whether the additional territory so gained should be used partly for new building sites or for purely ornamental grounds has been a subject for some difference of opinion between your commission and the landscape architects. The latter advise the creation of new building lots in addition to the ornamental grounds. We think that it is not advisable to narrow the stream at this point further than may be necessary for procuring the ornamental grounds alone. Our recommendation is that the harbor line be removed to the north a distance of 150 feet from the Back Bay Fens to the new bridge drawn upon the plan, and above this bridge gradually narrowing till it reaches a width of 50 feet at the Cottage Farm bridge; that this new territory be connected with the filling in the rear of Beacon Street by appropriate curves, and be prepared for park uses by the Land and Harbor Commissioners in accordance with plans prepared by the Park Commissioners.

With the exceptions thus noted we are in cordial agreement with the recommendations of the landscape architects, whose advice we have sought, and therefore urge the prompt acquisition of all the lands indicated upon their plan, by means of legislation similar to that already employed by the Metropolitan Park Commissioners under authority of chapter 407 of Acts of 1893.

We are aware that some of the changes which have been advised by us may meet with much opposition from those who have interests in the houses on the northern side of Beacon Street below Otter Street. We have, therefore, endeavored to ascertain whether this situation had a value that could be measured by the valuations on the books of the assessors of the city. A result of the comparison of relative values on three of the principal residential streets of the Back Bay is here given.



A VIEW ON THE UPPER ALSTER BASIN.

Assessed Value of Land on Back Bay Streets, excluding Corner Lots.

Block.	Name of Street.	South Side. Rate per Sq. Foot.	North Side. Rate per Sq. Foot.	Ratio.
Arlington St. to Berkeley St., .	Commonwealth Ave.,	$6 58	$8 36	130
Arlington St. to Berkeley St. .	Marlborough St., .	4 45	4 75	107
Arlington St. to Berkeley St., .	Beacon St., . .	5 00	5 75	116
Dartmouth St. to Exeter St., .	Commonwealth Ave.,	6 03	8 03	133
Dartmouth St. to Exeter St., .	Marlborough St., .	4 05	4 46	110
Dartmouth St. to Exeter St, .	Beacon St., . .	4 48	5 50	120

It appears from this table that the difference in values, excluding corner lots, between the two sides of these three streets, respectively, while somewhat greater on Beacon Street than on Marlborough Street, is much less on Beacon Street than on Commonwealth Avenue. The Beacon Street lots are deeper than those on Commonwealth Avenue, and, perhaps, have a somewhat smaller value per square foot on this account than they would otherwise have, notwithstanding the fact that the owners of houses on the north side of Beacon Street are enabled to have stables on their own lots. When we consider the hardships that may appear to be inflicted upon owners of property on the water side of Beacon Street, who will lose the views over the river and the direct action of the breezes from over the water surfaces, we have also to remember the many thousands who will enjoy this breathing place and the attractive shores during the four months or more when the houses on Beacon Street are deserted by their owners.

What the value of the land to be created by this improvement would be we do not venture to estimate; opinions of those familiar with such matters vary widely; one or two persons have even asserted that the land would have no value above the cost of the filling; but, inasmuch as the city of Boston already has under consideration the making of an embankment, as provided for by chapter 435 of the Acts of 1893, we have only to estimate the expense of filling a strip 120 feet wide. This admits of accurate calculation, and could be done for less than fifty cents a square foot. Whether the new land would have a greater value than this is a question which all would answer, we think, in the affirmative.

The lowest value of the new land, estimated by those who have attached any value to it, is sufficient to cover all the expenses of the dam and the making of the land. If some of the higher estimates were taken it might safely be assumed that all the land which is included in the taking recommended for metropolitan park purposes could be procured without inflicting any burden upon the metropolitan district.

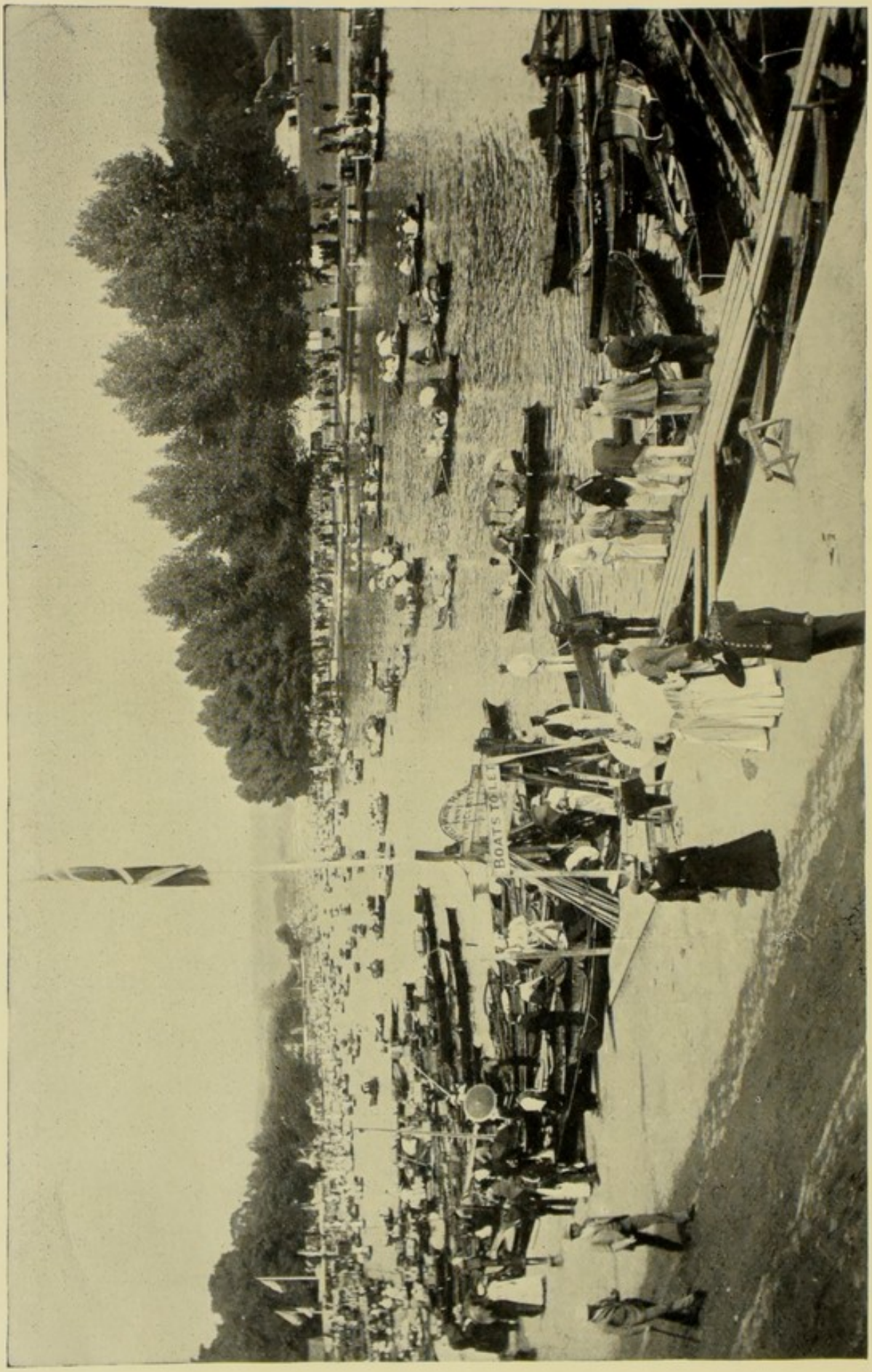
Mayor Mathews, in an inaugural address delivered in the year 1891, before the city council of Boston, used the following words: —

> We have in this basin the opportunity for making the finest water park in any city in the country; an opportunity which should be grasped before it is too late.
>
> The eventual solution of this whole problem should, I think, be an imitation of the plan adopted by the city of Hamburg, under similar circumstances. We should dam up the stream at the narrowest point between Charlestown and Boston, and lay out a series of parks and boulevards along the basin thus created.

We have incorporated in this report copies of photographs showing various aspects of the Alster Basin in Hamburg. They tell their story so effectively that minute description is hardly needed. Hamburg lies on the east bank of the Elbe, at a distance of seventy miles from the German Ocean, and is the most important commercial city of the German Empire. The population of the city and suburbs exceeds 600,000. The climate is harsh and fully as much exposed to cold and disagreeable winds as Boston is. The thermometer does not indicate so low degrees of temperature, but the difference between the two cities in this regard is not very great. In former times the Alster was a small stream flowing through the centre of the city and entering the Elbe at right angles to the latter's course. At the entrance of the Alster into the Elbe an estuary was formed which sheltered the small vessels engaged in the commerce of those days.

With the growth of the city larger and more convenient docks were formed on the Elbe; and the formation of the Alster Basin was begun at a point about a mile distant from the entrance of the Alster into the Elbe; dams across the stream were constructed with suitable contrivances for the passage of mastless vessels.

PLATE VI.



BOATING ON THE THAMES, NEAR LONDON, ENGLAND.

(From report of Metropolitan Park Commissioners, 1893.)

Constant improvements have been going on in this water park, some the results of the needs of a growing city and some from efforts to increase the attractions of the basin and its borders. There are two basins, an upper and a lower, separated by the bridge shown in Plate No. III.

The views Nos. I. and II. present scenes upon the lower basin. About this are ranged some of the finest of the private houses, the principal hotels, and such shops as are usually found in the better quarters of a city.

Plate IV. is a view across a portion of the upper basin, looking into the city and towards the bridge which separates the two basins.

It will be noticed that the lower water park is treated in a formal way with walls, straight lines of street, and rows of trees; in the upper basin walls are replaced by beaches; the shore lines no longer run parallel to the streets, and the trees and shrubbery are grouped in effective masses. At points more distant from the city and on the upper reaches of the river, very little attempt has been made to improve the naturally pleasing variation of banks but slightly elevated above the stream and verdant meadows interspersed with trees, shrubbery and gardens.

We desire to call attention to the evidences of appreciation of all these charms shown by the life everywhere manifest, — the little steamer makes its rounds from one point to another on the water park; row-boats are plenty, and when some much-frequented place of resort on the stream is reached, as shown in Plate V., the popular enjoyment of it all should convince this community that much labor and expense could be profitably invested in procuring for the metropolitan district the opportunity for the same innocent enjoyments. We have a framework for such scenes far superior to that possessed by Hamburg, and the expense of preparation is not excessive.

That all this outdoor life is not peculiar to the German nation is well shown by the illustration Plate VI. (from report of Metropolitan Park Commissioners, 1893), of boating on the Thames. Nothing of all this has hitherto been possible in the estuary of the Charles, although some suggestion of the possibilities in this direction may be obtained from the rapidly growing use of the comparatively inaccessible fresh-water basin

further up the stream extending from Waltham to Riverside. The repulsive appearance of the shores of the estuary at the lower stages of tide, the foul odors along its banks and flats, and the difficulties experienced in passing under the low bridges at high tide, have combined to make boating and the use of the stream by small steamboats unattractive and, in a measure, dangerous.

In conclusion, your board feels that no treatment of the Charles River can be entirely satisfactory which does not regard the condition of the river above and in Waltham. At the boundary of that city, by the terms of the act under which we are directed to make our investigation and report, our labors end.

We have not thought that it was necessary to submit herewith the drafts of such legislation as might seem to be required for carrying out our recommendations. We are aware that the very serious changes proposed require the co-operation of the United States, the State and various municipalities. But the questions only differ in degree from some which have already been satisfactorily determined by existing commissions whose organizations are sufficiently complete to enable them to promptly undertake the execution of so much of these plans as it may seem wise to the Commonwealth to enter upon.

HENRY P. WALCOTT,
Chairman.

PHILIP A. CHASE,
WILLIAM B. DE LAS CASAS,
ABRAHAM L. RICHARDS,
Board of Metropolitan Park Commissioners.

HIRAM F. MILLS,
FRANK W. DRAPER,
JOSEPH W. HASTINGS,
GERARD C. TOBEY,
JAMES W. HULL,
CHARLES H. PORTER,
State Board of Health.

BOSTON, MASS., April 27, 1894.

CHARLES F. ADAMS and WILLIAM CHASE of the Metropolitan Park Commission are absent in Europe.

FINANCIAL STATEMENT.

Appropriation,		$5,000 00
Expenditures to April 27, 1894: —		
Services of engineers and assistants,	$2,732 60	
Services of landscape architects,	500 00	
Landscape architects' assistants and expenses,	234 12	
Stenographer and clerk,	63 34	
Travelling expenses,	54 11	
Photographs,	27 12	
Test wells and pits,	21 12	
Drawing materials,	14 95	
Miscellaneous expenses,	16 36	
		3,663 72
Balance unexpended at date,		$1,336 28

REPORT OF THE ENGINEER.

To H. P. Walcott, M.D., *Chairman of Joint Board on the Improvement of Charles River.*

Sir: — Acting under your instructions, I have considered from an engineering and sanitary point of view the question of the improvement of Charles River between the Charles River bridge and the Waltham line, and respectfully submit the following report.

The act creating the joint board requires that it shall investigate the sanitary condition and prepare plans for the improvement of the beds, shores and waters of the river, and for the removal of any nuisances therefrom. In treating this question it will be convenient to consider, first, the present physical and sanitary condition of the river; then in a general way various methods of improvement; and, finally, in more detail, the special plan of improvement recommended.

The Present Condition of the River.

The physical features of the river and the territory near its banks, from the Waltham line to its mouth, are shown as far as practicable on Plan No. 1.

The total length of the portion of the river under consideration is 10.8 miles, of which 1.7 miles, from the Waltham line down to the lower dam at Watertown, are non-tidal, and 9.1 miles, from this dam down to the Charles River bridge, are affected by the tides, which have a mean rise and fall of ten feet. The area of the water surface at mean high tide, above a line drawn across the river 600 feet above Craigie's bridge, is 960 acres, and at mean low tide 651 acres, leaving 309 acres of flats and sloping banks exposed at low tide. Of the exposed flats and banks 179 acres are below the Cottage Farm bridge, and 130 acres above it.

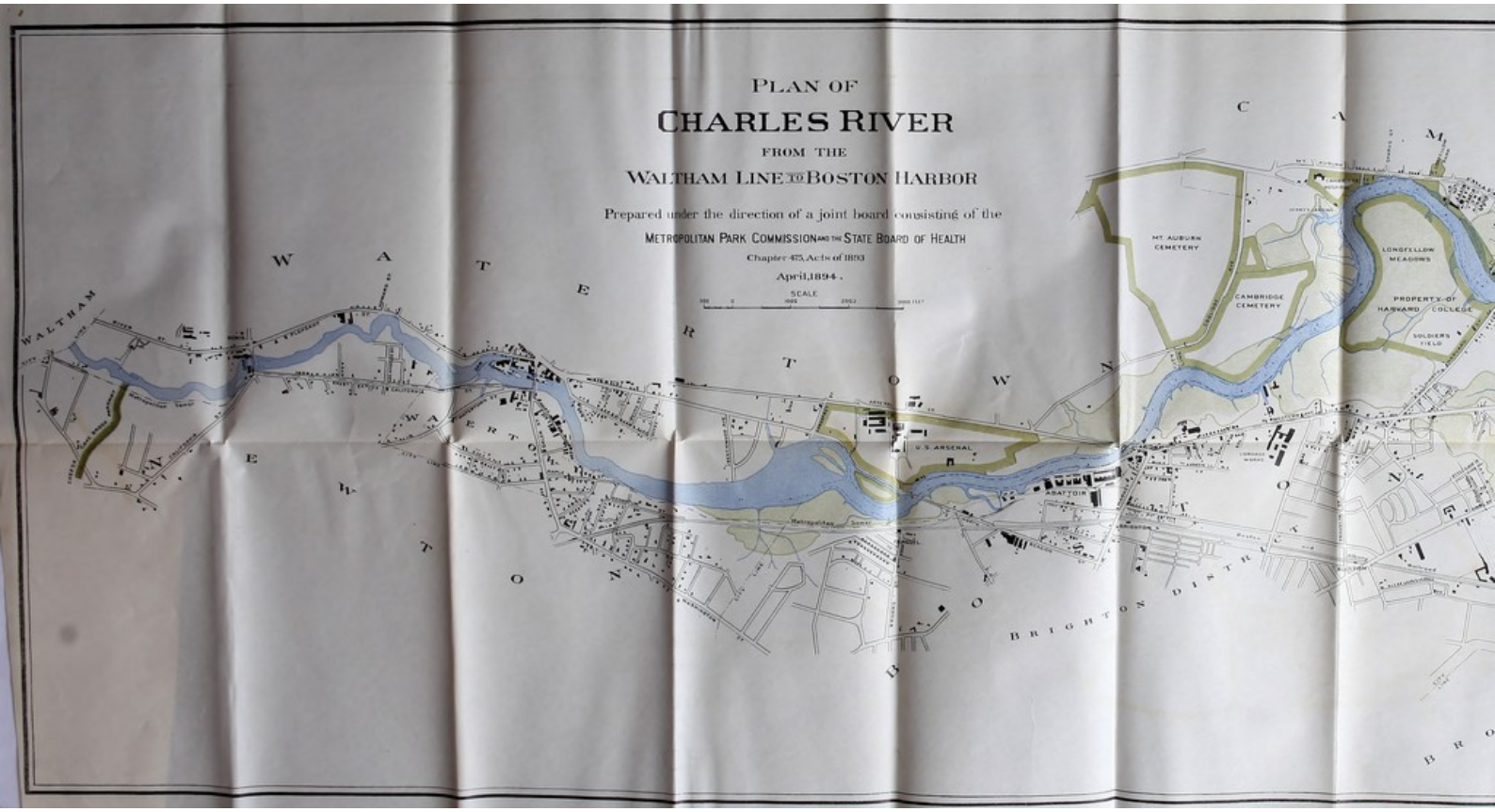
There are two dams across the river; one, three-fourths of a mile below the Waltham line, is owned by the Ætna Mills and is located at Bemis station in Watertown. The fall of the river at this dam is 4.8 feet. The other is the lower dam

already referred to, and is located near the central village of Watertown. The fall at this dam is 5.8 feet.

Above the lower dam at Watertown the river has a drainage area of 270 square miles; but, as one-third of the flow at East Dedham may be legally diverted through Mother Brook into the Neponset River, the effective drainage area at the Watertown dam is 204 square miles. The ordinary summer flow of the stream at this point may be reckoned at 62 cubic feet per second (40,000,000 gallons per day), and the minimum flow is not more than half of this amount. The average daily flow throughout a series of years, upon the assumption that one-third of the water is diverted at Mother Brook, is about 340 cubic feet per second (220,000,000 gallons per day) and the maximum flow of the stream during the highest known freshet, namely, that of February, 1886, was about 4,900 cubic feet per second (3,167,000,000 gallons per day) at the dam of the Boston Manufacturing Company at Waltham; and by estimation 5,200 cubic feet per second at the Watertown dam. A more detailed statement with regard to the freshet flow of Charles River may be found in Appendix No. 1.

The level of the high tide extends up to the foot of the Watertown dam, but the salt water does not go up to within about half a mile of this point. For a mile below the Watertown dam the bed of the stream is considerably above the level of low tide, and when the tide is down the upland water flows through this portion of the river with a rapid current. Below this section, for a distance of about three-fourths of a mile, to a point opposite the United States Arsenal, the river widens until it has an abnormal width, and deepens until its bottom is about at the level of low tide.

From the Arsenal, for a distance of about 4.4 miles, down to Essex Street, which is nearly opposite the Cottage Farm station on the Boston & Albany Railroad, the river flows in a circuitous course through extensive marshes and gradually increases in width and depth so that the area of its cross-section at different points is nearly proportional to the amount of tide water passing them. The marshes, except where they are protected by dikes, are overflowed by the higher tides, sometimes to a depth of two or even three feet. Short sections of this portion of the river have been walled, but as a rule there are sloping muddy shores exposed at low tide.


PLAN OF
CHARLES RIVER
FROM THE
WALTHAM LINE TO BOSTON HARBOR
Prepared under the direction of a joint board consisting of the
METROPOLITAN PARK COMMISSION AND THE STATE BOARD OF HEALTH
Chapter 475, Acts of 1893
April, 1894.
SCALE
WALTHAM
WATERTOWN
NEWTON
CAMBRIDGE
BOSTON
MT. AUBURN CEMETERY
CAMBRIDGE CEMETERY
LONGFELLOW MEADOWS
PROPERTY OF HARVARD COLLEGE
SOLDIERS FIELD
U.S. ARSENAL
ABATTOIR
BRIGHTON DISTRICT

PLAN No.1


Explanation.
Public or quasi-public ownership, thus:
Marsh areas overflowed by spring tides, thus:
Mean high tide, thus:
Mean low tide, thus:
Contour 13 feet above Boston City Base, thus:
Harbor lines, thus:
Storm water or sewage outlets, thus:
Contours of river bottom below mean low water, thus:
6 feet ... 12 feet ... 18 feet ... 24 feet
Intermediate contours, thus:
SOMERVILLE
BOSTON
CHARLESTOWN DISTRICT
MASSACHUSETTS
BRIDGE
CHARLES
RIVER
BOSTON
BROOKLINE
LONGFELLOW MEADOWS
PROPERTY OF HARVARD COLLEGE
SOLDIERS FIELD
BEACON PARK
COTTAGE FARM
ESPLANADE
LINE OF EMBANKMENT AUTHORIZED BY LEGISLATURE IN 1891

The marshes subject to flooding by the tide, above Cottage Farm, as indicated by a green tint upon Plan No. 1, have a total area of 524 acres and a total assessed valuation of $343,000, equal to an average of $655 per acre. This acreage includes 26 acres already acquired by the city of Cambridge for park purposes, 86 acres controlled by Harvard College, and 32 acres in Beacon Park which is now owned by the Boston & Albany Railroad Company.

At Cottage Farm the river widens rapidly into a broad basin, which extends down to Craigie's bridge, a distance of 2½ miles. This basin has a maximum width at the present time of more than a half mile, but the width will become a little less than a half mile when the filling is carried out to the harbor lines now established. On the Boston side of the river this section has been walled, and there are no flats of any considerable extent exposed at low tide, except in the vicinity of Harvard bridge, where flats three-fourths of a mile long and about 700 feet wide are uncovered at low tide. On the Cambridge side, in the vicinity of Harvard bridge, the river for a distance of three-fourths of a mile has been walled on the harbor lines; and, when the improvement now in progress at this place is completed, the flats behind the wall will have been filled and those in front of the wall will have been excavated to below the level of low tide. Above this improvement and below it down to the West Boston bridge there are extensive flats both inside and outside of the harbor lines. Near the widest part of the basin these flats extend out from the harbor line on the Cambridge side a distance of about 1,400 feet, or more than half way across the basin.

Between West Boston and Craigie's bridges, on the Cambridge side of the river, walls have been built on the harbor line a portion of the way; but the remaining portion is neither walled nor filled, so that there are extensive flats exposed at low tide, mainly, however, within the harbor lines.

Running inland from this portion of the river are two canals, intended to furnish an additional length of water front for commercial purposes; one, known as Broad canal, leaves the river a short distance below the West Boston bridge, and the other, only partially constructed at the present time, has its entrance from the river a short distance above Craigie's

bridge. Broad Canal receives much sewage and polluting matter from local sources, and has been the subject of much complaint in recent years.

From Craigie's bridge down to Charles River bridge, a distance of a little more than half a mile, the river varies in width between harbor lines from 700 to 1,100 feet, and is very much obstructed by piles driven to support railroad and highway bridges and other structures owned by the railroads. On the northerly side of this portion of Charles River is a waterway known as Miller's River. This is not a stream, but a canal similar in character to those already mentioned in Cambridge, only larger and more accessible.

The tidal portion of the river is crossed by twelve highway bridges, one bridge for teams owned by the Fitchburg Railroad, and six railroad bridges, all of which, with the exception of the highway bridge at Watertown, where there is only a very small depth of water even at high tide, are provided with draws. The openings in the draws have a width of about thirty-six feet, with the following exceptions: the draws of all divisions of the Boston and Maine Railroad have recently been widened to forty feet; and that in the North Beacon Street bridge, leading from Brighton to Watertown, has a width of about thirty feet.

Traffic.

The total number of vessels of all kinds and of cargoes passing through the different highway bridges in 1893 is given in the following table: —

Name of Bridge.	Location.	No. of Vessels of all kinds.	No. of Cargoes.
Charles River,	Boston to Charlestown,	8,387	2,425
Warren,	Boston to Charlestown,	6,199	2,001
Craigie's,	Boston to Cambridge,	3,699	1,193
West Boston,	Boston to Cambridge,	2,649	417
Harvard,	Boston to Cambridge,	2,387	260
Essex Street,	Boston to Cambridge,	1,117	195
Cambridge Street,	Boston to Cambridge,	939	152
Western Avenue,	Boston to Cambridge,	769	124
North Harvard Street,	Boston to Cambridge,	220	38
Western Avenue,	Boston to Watertown,	25	3
North Beacon Street,	Boston to Watertown,	2	–

In comparing the records of 1881 and 1893 it is found that the number of vessels of all kinds passing Craigie's bridge in both directions has remained nearly constant, the number in 1881 being 3,673, and in 1893, 3,699. If tugs are omitted from the list the corresponding numbers are 3,250 and 2,515, indicating a marked decrease in the number of vessels other than tugs. Records kept by the draw-tender at the West Boston bridge, for the past four years, of the contents of the vessels passing through the draw, taken in connection with other records, show that although the number of cargoes has decreased in this time from 474 to 417 the tonnage has increased from 118,000 to 147,000.

The following tables give instances of the traffic up and down the river as compared with the traffic across it over some of the highway and the railroad bridges. The number of cargoes passing through the railroad bridges is assumed to be the same as the number passing through Craigie's bridge as given in the foregoing table. For the traffic across the highway bridges the record of the travel in June and September, 1892, from 6 A.M. to 7 P.M., as given in the annual report of the street department of the city of Boston, has been used. The railroad traffic is taken from the Railroad Commissioners' report for the year ending June 30, 1893.

Craigie's Bridge.

Number of cargoes per day passing through draw,	3.27
Number of foot passengers crossing bridge per day,	6,927
Number of teams crossing bridge per day,	4,552
Number of cars crossing bridge per day,	493
Number of car passengers crossing bridge per day,	11,221

West Boston Bridge.

Number of cargoes per day passing through draw,	1.14
Number of foot passengers crossing bridge per day,	3,584
Number of teams crossing bridge per day,	2,953
Number of cars crossing bridge per day,	1,059
Number of car passengers crossing bridge per day,	28,592

Northern Railroads.

Number of cargoes per day passing through draws,	3.27
Number of passengers crossing bridges per day,	76,751

A more detailed statement of the widths of drawbridge openings, the amount of traffic through them, and the amount of traffic across the various bridges will be found in Appendix No. 2.

Results of Sanitary Examination.

The character of the water in the non-tidal portion of Charles River has been a subject of investigation by the State Board of Health from time to time for many years; and in the summers of 1892 and 1893 special examinations were made of the tidal portion of the river, both by making analyses of the water at different points under different tidal conditions, and by personal examinations of the beds and shores of the stream and of the various sources of pollution.*

To state briefly the results of these examinations, I may say that the upland water of Charles River when it reached the Watertown dam, although so much polluted that it could not be used for drinking purposes, was not polluted to such an extent as to make the river offensive to those living near the banks of the stream, except, possibly, in places where local pollution had caused a deposit upon the shores. In passing below the Watertown dam, although the water received some added polluting matter from local sources, it did not become foul until a point was reached where polluting matter was brought up from further down stream by the flood tide. This was in the wide portion of the river already referred to, just above the arsenal, where the currents were sluggish and suspended matters had a tendency to deposit. As large areas of the bed of the river are exposed at this place at low tide it will be seen that the conditions are favorable for the formation of offensive deposits upon the flats; and it is a fact that this was the most offensive portion of the river, although very little sewage entered it directly.

In the 4.4 miles extending from the portion of the river just referred to down to Cottage Farm, the upper portion received the discharge from public sewers in Brighton and much refuse

* The results of the examinations of the tidal portion of the river in the summer of 1892 are given at length in the annual report of the State Board of Health for that year. A very complete investigation of all sources of pollution along the river and its tributaries was made by the engineering department of the city of Boston in 1892, and the results are recorded in the annual report of the City Engineer.

matter from the abattoir, and the lower portion the discharge from many public sewers in Cambridge. The amount of upland water was not large enough to dilute this great amount of polluting matter so as to make it inoffensive; and as the amount of sea water decreases with the distance up stream, the water in the upper portion of this length was more polluted than in any other part of the river; there were also deep deposits of sewage matter upon the sloping banks exposed at low tide. In the lower portion of this length, where there was much more dilution with sea water, the water was less polluted and the flats were covered with a much thinner deposit of sewage matter.

Further down the river on the Boston side a limited amount of sewage was discharged from the houses on the water side of Beacon Street; and on the Cambridge side of the river, just below the West Boston bridge and at Craigie's bridge, were two sewer outlets through which the greater part of the sewage of Cambridge and Somerville and the refuse from the pork-packing establishments in these cities were discharged. These large sewers caused offensive deposits to form upon the flats near them, and made the flats further up the river more objectionable than they would otherwise have been. Notwithstanding the great amount of sewage turned into this portion of the river, the water was purer than at points further up stream, owing to the very great dilution by the vast amount of sea water which entered this portion of the river.

The examinations showed clearly that the river was in an unsanitary condition, and they also showed that the chief cause was the discharge of sewage into the stream from Cambridge and Somerville and the Brighton district of Boston. Since these examinations were made the discharge of sewage from the Brighton district has ceased, but the discharge from Cambridge and Somerville still continues, and cannot be stopped until the metropolitan sewer is put in operation and the local sewers are connected with it.

Sanitary Condition of River after Metropolitan Sewerage System is put in Operation.

The Metropolitan Sewerage System is now approaching completion and will be put in operation before very long, so that it is well to consider whether this alone will effect the complete sanitary improvement of the river, or whether conditions will still exist which will make some further improvement necessary.

The sewers in Boston, Brookline, Cambridge and Somerville were built to convey storm water as well as sewage, and, even after the ordinary flow of sewage from all of these places is diverted by intercepting sewers, will continue to overflow into the river during heavy rains, carrying into it some of the washings from the streets and some dilute sewage. The sewers in Newton, Watertown and Waltham have been built to take sewage only, and there should be no overflow into the river from them, but all of the street water will ultimately reach the river either over the surface or through covered drains. The river in its upper portion, beyond the limits of the metropolitan district, receives sewage and other polluting matter from the towns and factories, and will continue to receive these matters unless greater restrictive measures than are now in force are adopted.

At low tide extensive flats will be exposed in the tidal portion of the river, and they will be more or less offensive even when the sewage is kept out of the river. The marshes also will be covered by the higher tides. In addition to these conditions, unless there are restrictions to prevent, the marshes are likely to be covered by a cheap class of dwellings, which cannot be other than unsanitary; and factories are likely to be built along the banks of the river, making it more difficult to prevent the water of the river from being polluted.

It will therefore be seen that the sanitary problem to be solved is the prevention of pollution of the water, flats and shores; the treatment of the flats so that they will not be exposed to taint the air; the prevention of the flooding of the marshes by high tides; and the further prevention of the use of these marshes as unsanitary dwelling places or as the location of factories which may produce wastes to pollute the

stream. The solution of this problem in the most satisfactory manner involves the public ownership of the banks of the stream; and in the present case it seems eminently desirable not only that the river and its banks should be made wholesome, so that the air supplied from this great open space to the adjacent population will be pure instead of vitiated, but that advantage should be taken of the great opportunity here offered for making the river and its surroundings beautiful and of value to the public as a pleasure resort.

General Methods of Improvement.

In order to render any method of improving the river successful, it is essential that the pollution of its waters should cease, or be restricted to such an extent that the water will not be in any way objectionable to those living or passing near it. This requirement could be met in the beginning by preventing the entrance of sewage and offensive manufacturing wastes from cities, towns and factories upon the borders of the river within the metropolitan district; but it may also be necessary before long to restrict or prevent the discharge of polluting matter into the upper portions of the stream.

After the pollution of the water has been stopped there are two general methods of improvement which can be adopted. One is to permit the tide to continue to ebb and flow in the river, and to wall the stream and dredge the flats to below the level of low tide, so that the only surfaces exposed by the fall of the tide will be the vertical faces of the walls. It would be necessary in connection with this method of improvement, however, to fill the marshes, or enclose them with dikes, so as to prevent them from being overflowed at high tide. The other method is to prevent the ebb and flow of the tide in the river by building a dam across it to maintain the water in the basin above the dam at a nearly constant level, somewhat lower than the level of mean high tide. A dam for this purpose should have its top above the level of the highest tides that have ever occurred, and should contain gates to discharge enough water at low tide to maintain the proper level in the basin. During the portion of the high tide when the water below the dam is higher than that in the basin above it, the

flow of the river entering the basin at its upper end would cause the water in it to rise a very little if the dam were located far down stream, and to a greater extent if the dam were located further up the river. If the dam were located very far up stream, the basin formed by it would be so small that the ordinary spring flow of the river would cause the overflow of the marshes. With a dam as far down stream as Craigie's bridge, all overflow of the marshes could be avoided, even during freshets as large as the greatest of which there is any record.

Various sites for a dam have been considered, among which may be mentioned one nearly opposite the United States Arsenal at Watertown, another at North Harvard Street, nearly opposite Harvard College, a third near Cottage Farm, and others toward the lower end of the river at or near West Boston, Craigie's and Charles River bridges. A dam near the arsenal at Watertown would provide for the improvement of only a very small section of the river, and, while it would prevent the water from lowering to uncover the offensive flats in this vicinity, it would create too small a basin to prevent the frequent flooding of the marshes by the upland water at high tide. Similar objections may be urged against a dam at North Harvard Street, although to a less degree.

The site near Cottage Farm is a more favorable one, as it would provide for the improvement of nearly all of the portion of the river bordered by marshes, and it would interfere with navigation and with the tidal currents in Boston Harbor to a less degree than a dam further down stream; moreover, the basin above the dam would be sufficiently large to prevent any frequent overflow of the marshes by freshet water. A detailed study of the flow of the river for four years and of the tides during the same period indicated that with a dam at this point the marshes were likely to be overflowed about six times in four years.

With regard to the choice of locations toward the lower end of the river it may be said that the construction of a dam at Charles River bridge presents many difficulties, that there is a much greater amount of navigation past this point than past the bridges above the railroads, and that the portion of the river between this bridge and Craigie's bridge is occupied

almost wholly by railroads which would not derive sufficient benefit from the improvement to warrant the adoption of this location in preference to one above the railroads; moreover, there are in this portion of the river no flats of any considerable extent exposed at low tide.

Above the railroads the first available site is at or near Craigie's bridge, and there are many reasons why a dam should be located at this place. It is further down stream than any other available site, and consequently provides for the most extended improvement that it is practicable to make, and it is located at the extreme lower ends of the park improvements in the cities of Boston and Cambridge and below the portions of these cities where residences border upon the river. The number of vessels passing Craigie's bridge is less than one-half the number passing Charles River bridge, and, by moving the dam up stream from the bridge 400 feet or more, a portion of the vessels which pass through Craigie's bridge and unload at docks along the canal just above the bridge will not have to pass through the dam.

The site at or near West Boston bridge is less desirable because it diminishes the extent of the improvement and leaves the Charlesbank of the Boston park system, and the lower end of the Cambridge park improvement, cut off from the proposed full basin.

After a careful consideration of the whole question, I reached the conclusion that it would be far better and cheaper to improve the river by the construction of a dam than to wall it and dredge the flats; and that the best location for a dam was a short distance above Craigie's bridge. It is unnecessary in this place to discuss in detail the reasons which led to this conclusion, since they will appear to a sufficient extent in the following description and discussion of the plan of improvement recommended.

Plan of Improvement Recommended.

It is proposed to construct a dam across the river about 600 feet above Craigie's bridge, which is to contain a lock of sufficient size for the largest vessels that are likely ever to go up this river, and additional openings for the discharge of the flow of upland water. The water above the dam is to be kept at such height as may be found most desirable, but it is now expected that this height will be the same that is now maintained in the Back Bay Fens, namely, 8 feet above Boston city base (about 2 feet 6 inches below ordinary high tide). The area of the basin above the dam after it has been diminished by filling out to the harbor line below Cottage Farm will be 758 acres.

It has been recognized from the inception of the plan outlined that it will materially change the relations of the river to the adjacent territory and to navigation, and that it will diminish to some extent the currents in Boston Harbor. It is also recognized that there might be difficulty in the construction of a dam at a point where so large a volume of water passes in and out at every tide, and in taking care of the great amount of upland water which will flow down the river during extreme freshets. All of the points mentioned have therefore been very carefully considered, and many of them will be referred to in detail in the following pages.

Proposed Dam.

The length of the dam from the wall of the Charlesbank on the Boston side to the harbor line on the Cambridge side of the river is 1,170 feet. About 250 feet out from the Boston side it is proposed to construct a lock having a length of 300 feet between gates, a width of 40 feet, and a depth of 10 feet below mean low tide. The lock is to be provided with iron gates at each end, which will move horizontally upon rollers into recesses on the Boston side. It is also to be supplied with openings through which water can be admitted or discharged, so as to fill and empty it quickly. The space between the lock and the present Charlesbank wall is to be filled solidly with earth, and

the power-house for operating the lock is to be located upon this filled area. From the lock to the Cambridge side the dam below the level of low water is to be a wide embankment of earth, but above the low-water level it is to consist of earth retained between masonry walls, and is to be 100 feet wide. It is proposed to drive a row of sheet piling in the middle of the dam to render it more secure. There is no doubt as to the stability of the proposed dam if constructed of suitable earth, because the pressure upon it would not at any time be great, nor would it continue long in one direction.

The most difficult problem to solve in connection with the construction of the dam is the shutting off of the flow of tide-water into and out of the basin. The quantity of water which must pass the location of the dam as long as the tide rises and falls in the basin is very large, and although it now passes this location without causing any disturbance, the currents will continue to increase in strength as the dam is built up and the area through which the water can pass becomes more and more restricted. The order in which the work should be constructed and the character of temporary works for shutting off the water have been carefully studied, and there is no doubt but that the work can be successfully accomplished.

It is found that after building the lock and leaving it open for the passage of water it will be feasible to dump earth for forming the embankment of the dam until it is brought up nearly to the level of low tide. Upon this embankment, as a foundation, temporary works can be constructed which can be closed during a single tide and thus form an effective temporary dam. By means of the lock the water in the basin can be kept at such height as may be found most desirable until the completion of the dam.

As already indicated, there are to be openings through the dam for the discharge of the upland water. These are located between the lock and the Cambridge shore and are to consist of ten openings six feet high and six feet wide. The openings are to be controlled by gates and to have sufficient capacity to discharge the flow of the river except at times of high freshets; and at such times it is proposed to use the lock as an additional water-way. In all ordinary operations of the lock, a gate would be moved only when the water was at the same level on both

sides of it, but it is thought that there might be times during freshets when it would be desirable to move the gates with the water at different levels on the two sides, and they have therefore been designed with this in view.

The lock as designed is not in line with the present draw through Craigie's bridge, and as it has to be built within a coffer-dam, which cannot be located where the water is very deep, it is not feasible to place it in line with the existing draw. It will therefore be desirable to relocate the draw in the bridge so that it will be in line with the lock. This could be done simultaneously with the construction of the dam, or, if Craigie's bridge is to be reconstructed before long, the relocation of the draw might be deferred for a time.

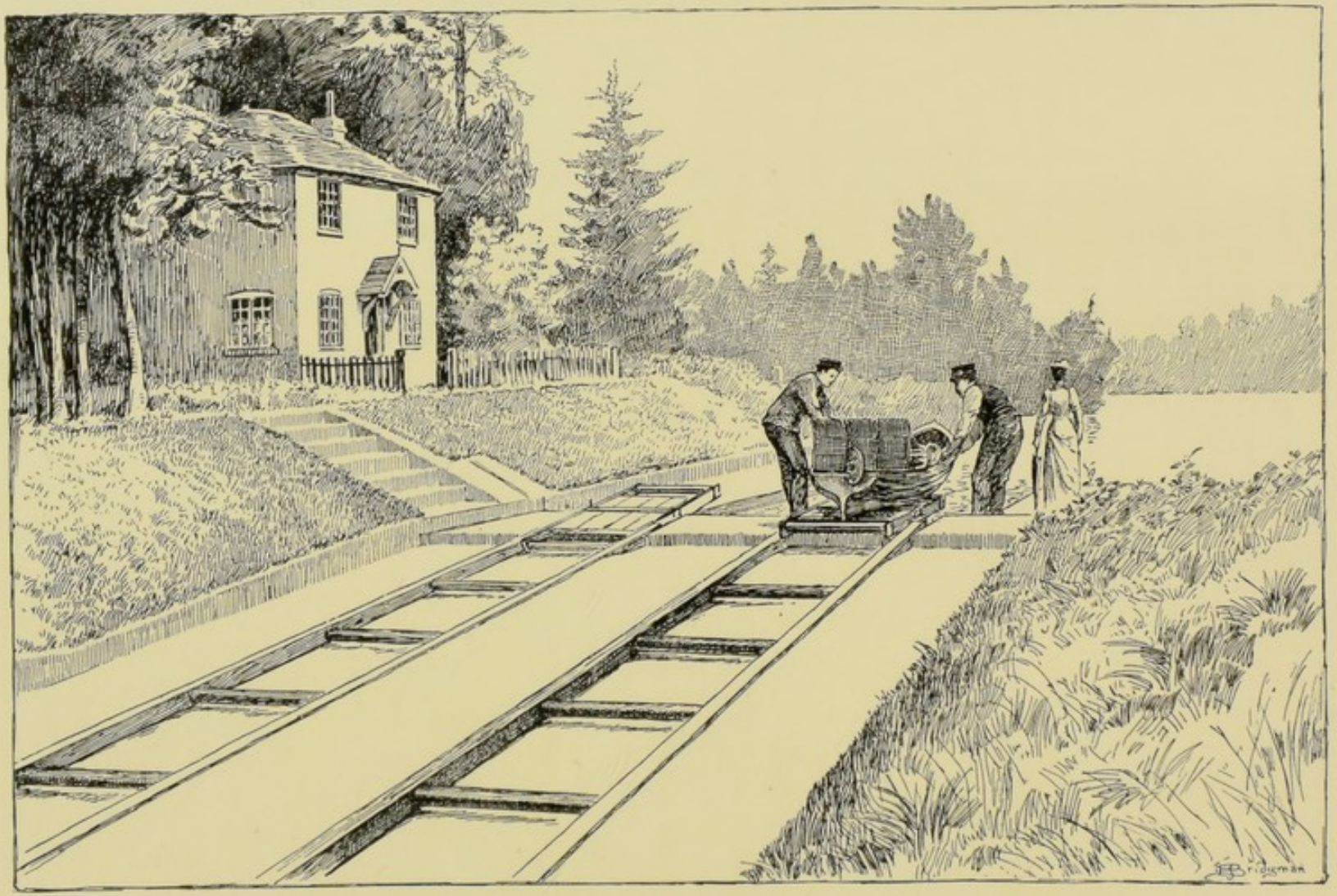
It will be feasible to provide a more convenient passage for small boats than is afforded by the lock already described, either by providing runways (See Plate VII.) or by other suitable means which have not yet been worked out in detail.

The plans of the dam have been made in sufficient detail to show that it is entirely feasible to construct a dam and lock at this place, and are also sufficient for making an approximate estimate of the cost of the work, which amounts to $660,000. This estimate includes the cost of the dam and all of its appurtenances from the Charlesbank to the harbor line on the Cambridge side. Beyond the harbor line are flats which would have to be filled in order to wholly complete the dam, but as these flats have already been taken by the city of Cambridge as a part of the park system and are to be filled for this purpose the cost of extending the dam beyond the harbor line has not been included in the estimate.

Sanitary Condition of the Water in the Proposed Basin.

I have already indicated that while the tidal portion of the river is at present in an unsanitary condition, it is, nevertheless, in a very much better condition than it would be if it were not for the vast amount of sea water which enters the river at every tide to dilute the sewage. It is obvious, therefore, that if a dam were to be constructed which would prevent the entrance of sea water *before the sewage is diverted into the Metropolitan sewer* the condition of the river would be more

PLATE VII.



A RUN-WAY ON THE THAMES. Drawn by Lewis J. Bridgman, after a photograph by F. L. Olmsted, Jr.

(From report of Metropolitan Park Commissioners, 1893.)

unsanitary than at the present time, because the amount of upland water is too small to dilute the great amount of sewage now entering the basin to a sufficient extent to make it inoffensive. When, however, the sewage is diverted so that none will enter the river except the very limited amount of dilute sewage which will overflow into it during heavy rains, the conditions will be entirely changed, and it is under these conditions that the subject will be considered more in detail.

The basin to be formed by the dam will contain 3,300,000,000 gallons of water, and with the average flow of the river this will be replaced once in 15 days; during the drier portions of the year it will be replaced about once in 82 days; and during the high flow of the river in the spring of the year as often as once a week. The present population upon the area which drains into the river above the proposed dam is 321,000.

At all times during the year the flow of upland water will be sufficiently large to prevent the water in the basin from becoming objectionable through the decomposition of the organic matter discharged into the stream, but during the drier portions of the year there may be some danger that the pollution of the water will be great enough to favor the growth of Algæ, or other minute organisms often found in water, to such an extent that these organisms may cause the water to have a turbid appearance and even to emit a perceptible odor. It is not expected that there will be any serious trouble from this cause, but should there be, it would be feasible to renew the water in the basin much more frequently by admitting sea water. By admitting enough sea water at every tide to raise the level in the basin six inches, and discharging a corresponding amount at every low tide, the quantity of water passing in and out in 13 days would be equal to the total contents of the basin.

The sewage deposits now on the flats and shores of the tidal portion of the river will disappear quite rapidly through the agency of the currents, aided by the action of the waves and of floating ice, and by decomposition. If the dam should be constructed and the basin filled before these deposits disappear they might have an objectionable effect upon the character of the water in the basin, but this effect would be temporary rather than permanent, and in any case the water in the basin would be less objectionable than the exposed flats.

Feasibility of Maintaining the Water above the Dam at a Constant Level.

The proposed dam across the river is intended to keep the water above it at a practically constant level, about 2 feet and 6 inches below the level of mean high tide; during the lower portion of the tide it will prevent the water from passing out of the basin, and during the higher portion of the tide it will prevent the sea water from entering. As, however, the upland water will continue to enter the basin at its upper end, and cannot be discharged from it at high tide, it is obvious that the water in the basin will rise somewhat at such times. With the ordinary summer flow of the river the rise will be half an inch; with the average flow of the river it will be two inches, and with the ordinary flow of the river during the wettest portion of the year it will be about four inches. It will therefore be seen that under all ordinary conditions the water can be kept at a practically constant level, and if it is desired that it shall not rise above the normal level it will only be necessary to draw it enough below this level at low tide to allow for the storage of upland water at high tide.

There remains for consideration the effects of extraordinary freshets such as that of February, 1886, which is memorable for the damage it did in Boston in the valley of Stony Brook and in many other places in the State. A freshet of this kind would not reach its maximum at the lower end of the river until one or two days after the end of the heavy rainfall causing the freshet, so that there would be sufficient warning to permit the water in the basin to be drawn down to an unusually low level by means of the lock and other openings at the dam. Taking 6,000 cubic feet per second as the amount of water which would flow into the basin during a freshet as great as any of which there are records, and assuming at the same time successive tides considerably higher than the average, careful estimates show that the water in the basin can be prevented from rising more than two feet above the normal level, or, in other words, at its highest level it would still be six inches lower than mean high tide and more than six inches below the surface of the marshes.

It is of course possible that larger freshets may occur than

any of which there are records, and the works as designed will take care of such freshets, though they may cause the flooding of the marshes. It does not seem necessary to enlarge the works to make provision for this remote contingency, because the damage which would be done by flooding the low lands with fresh water for a day or two would not be large enough to warrant any considerable additional expenditure.

The improvements in the metropolitan district by the construction of streets and buildings, and particularly by the construction of large drainage channels like the new Stony Brook channel, will all tend to increase the amount of flood-water entering the basin from this district; but they will also tend to discharge these local floods into the basin more quickly than at present, so that their effect will have passed away before the main flood comes from the upper portion of the river. It does not therefore seem probable that the maximum quantity of flood-water to be taken care of will be increased by the building up of the metropolitan district.

Effect upon Navigation.

The proposed lock will permit the passage at low tide of vessels drawing ten feet, and at high tide of vessels drawing eighteen feet of water.

Above the dam the constant level at which it is proposed to hold the water is seven and one-half feet higher than ordinary low tide, and two and one-half feet lower than ordinary high tide. It is thought that the comparatively high level at which the water will be held, together with the more favorable conditions thereby presented for vessels lying at docks, more than offsets any disadvantage due to the fact that the water will not at any time rise to the present level at high tide.

It is expected that the lock as designed can be operated without difficulty in winter, but navigation may be retarded at this season of the year owing to the fact that ice will form more readily upon the fresh-water basin than upon the river in its present condition, so that it will be more difficult to keep a channel open in winter.

For small steamboats, launches and other pleasure boats, which could pass under the bridges, the proposed conditions would be vastly more favorable than the present ones; and

there is no doubt but that the constant high level of the water, and the more agreeable condition of the banks of the stream which would result from this improvement, would lead to a vast increase in the amount of boating upon the river.

Effect upon Boston Harbor.

The view is quite prevalent among those who have not made a study of the question that it is essential to the preservation of Boston Harbor that the tidal currents should not be reduced by any diminution of the tidal prism such as would be caused by the filling or cutting off by dams of the bays and estuaries at the upper end of the harbor. This view seems to have been derived partly from the fact that it is essential to the preservation of some harbors, where there are alluvial bottoms and strong currents, that the currents should not be interfered with; and partly from the reiteration of this view by a Board appointed in 1859 by the General Government at the request of the city government of Boston. This Board elaborately investigated the question of the preservation of Boston Harbor and made in all ten reports, the final one being made in 1866. It held the view that, in order to prevent any reduction of the currents which it deemed essential to the preservation of the harbor, there should be no encroachments upon the tidal prism of its upper arms, unless a compensation *in kind* was made by a corresponding enlargement of the tidal prism at some other place similarly situated. This doctrine of compensation was frequently referred to, and in its final report the Board stated that the upper harbor of Boston *could not*, in its opinion, *afford to lose another cubic yard of tide water;* it also recommended, as a matter of primary importance, the passage of a law prohibiting any further displacement of the upper harbor tide-water without compensation *in kind*.

In 1866 the Board of Harbor Commissioners was created; and in 1867 it made investigations to determine whether some other solution of the problem of compensation could not be worked out. It was concluded by this Board, with the approval of a United States Advisory Council which succeeded the United States Board first referred to, that the preservation of the har-

bor might be accomplished better by dredging in the harbor itself than by dredging elsewhere to maintain the existing capacity of the tidal basins of the upper harbor. The Board of Harbor Commissioners, referring to the new plan, say, "Under this plan the scouring force is the dredging machine instead of the current of water."

Since the time of these reports encroachments upon the tidal prism by filling have been going on almost continuously, and not only has there been no difficulty in preserving the original depth of the harbor, but through the dredging operations which have been carried on it has been materially deepened, and the areas dredged maintain their depth.

The Board of 1859 evidently expected that a rapid decrease in the depth of the harbor would follow the diminution of the tidal prism by filling; but the following quotation from a report of a Board of United States engineers made thirty years later indicates that the harbor has deteriorated but little, if any, from this cause. This Board, in referring to a comparison of surveys made under its direction in 1888 with surveys made in 1835 and 1861, made the following statement: —

"If no improvement had been made in the harbor to deepen the natural water-ways by artificial dredging between 1835 and 1888, it might have been possible to trace, during that interval, the changes which have been wrought through the agency of natural forces, modified by the artificial encroachments of structures along and projecting from the shore, or by the filling in of interior tidal reservoirs. But much desultory dredging has been done by the State and the General Government at different times since 1860, usually without increase to the tidal prisms, and as data are still wanting to enable the board to analyze causes and effects sufficiently to formulate a satisfactory theory of the action of the forces in operation, it considers it best to defer any discussion of the physics of the harbor until the subject can be more thoroughly investigated."

It is the testimony of those who are best acquainted with the harbor at the present time that there has not been any material shoaling in the upper harbor which can be attributed to the action of the currents, or to the diminution of these currents caused by encroachment upon the tidal prism. It is

now considered necessary to rely upon dredging for any deepening in the upper harbor or in the main channel as far down as a point below Castle Island.

There are two reasons why, in my opinion, the maintenance of the present currents in the upper harbor is not essential to its preservation. In the first place, the currents at the present time are not strong enough to cause an effective scouring of the bottom, and, in the second place, under the conditions which now exist and which will exist more fully in the future, no considerable quantity of solid matter will find its way into the harbor to cause it to shoal.

The materials which may enter a harbor and cause shoaling are: —

1. Sewage and street wash discharged from sewers and drains.
2. Silt and other matters brought down by rivers.
3. Material washed from the shores by the waves.
4. Material thrown into the harbor from docks and vessels.

In addition to these sources from which new material may enter a harbor, the material in its bottom may be shifted by currents.

Under the conditions which prevailed before the main drainage works of the city of Boston were completed, in 1884, all of the sewage of the city and such portions of the solid matter in the street wash as were not intercepted by catch-basins were emptied directly into the harbor; but since these works were put in operation, practically all of the sewage and a very large proportion of the material washed from the streets have been diverted from the harbor. The lighter matters have been discharged through the main sewer at Moon Island into the outgoing tide, and the heavier matters have been retained in a deposit sewer, just beyond the pumping station, and removed on scows to a dumping place outside of the harbor. The amount of material removed in scows in 1892 was 6,466 cubic yards. When the Metropolitan Sewerage System is put in operation the sewage and a part of the street wash from other cities bordering upon the arms of the upper harbor will also be diverted, so that the discharge of solid matter from sewers and drains into the harbor will practically cease.

The second cause by which harbors are sometimes filled,

namely, by the discharge of silt and other matters brought down by rivers, is not operative in the present case. In the first place, the rivers are not silt-bearing streams, and, in the second place, they are well provided with settling basins in which any suspended matters may deposit before reaching the harbor.

At the upper end and just beyond the tidal portion of Mystic River are the lower and upper Mystic lakes. A short distance up the Charles River from its tidal portion is the great millpond of the Boston Manufacturing Company at Waltham, and on the Neponset River there are millponds, and the extensive Fowl Meadows just above Readville

The washing of the shores by the waves, particularly in the outer and more exposed portions of Boston Harbor, has undoubtedly carried more material into it to deposit and form shoals than has been carried into it by any other cause. The coarser portions of the material washed down from the land, such as the sand and gravel, remain comparatively near the source from which they are derived, forming gravelly beaches or bars, and the lighter portions float off to be deposited at greater distances where there are sluggish currents.

Under the present conditions but little erosion of this kind can occur in the upper portion of the harbor, and the amount is diminishing from year to year with the constantly increasing extent of shore line protected by walling or otherwise. In the lower and exposed portions of the harbor, the high cliffs of many of the islands and headlands give evidence of the enormous amount of material which has been washed away by the sea. Nearly all of the shores in the vicinity of the main ship channels have been protected from further washing by the construction of permanent sea walls. The points which remain unprotected are so far from the upper harbor that it does not seem probable that its depth will be affected to any considerable extent by the drift of material from these sources.

The dumping of material into the harbor from docks and vessels is now prohibited by law, and the amount of material entering the harbor from such sources is obviously not very large. It is also true that much of the material which enters the harbor in this way is so heavy that it would not be moved by the existing currents.

With regard to the drift of material from one point in the bottom of the harbor to another, it is not thought that this occurs to any considerable extent at the present time in the upper portion of Boston Harbor, partly on account of the feeble currents, and partly because the bottom of much of this portion of the harbor is a stiff clay which is not easily moved; and it is obvious that less material would be moved if the currents were diminished.

The channels between the inner and outer harbor, and those in the outer harbor with few exceptions, are now maintained without dredging, and it is important that there should be no change in the currents which would injuriously affect these channels. It does not seem, however, that there is anything to fear with regard to this portion of the harbor from damming Charles River. In the main ship channel, between Deer Island and Long Island, the water has a depth of nearly 60 feet at low tide, and the current which will remain at this place will be sufficient to maintain a deep channel for all time. Further down the main ship channel are places where there is no current lengthwise of the channel at the present time, and it is obvious that shutting off a very small portion of the tide-water cannot injuriously affect these portions of the channel.

A reduction in the currents of the upper harbor may cause the ice to form in winter somewhat more rapidly than at present; but it does not seem probable, with the large number of vessels and tugs passing in and out, and the continuous rise and fall of the tide, that there will be any serious trouble from this cause.

While I think it improbable that the proposed improvement will have enough effect upon the depth of water in Boston Harbor or upon the formation of ice therein to be noticeable, yet, if it should, adequate compensation could be made by a small expenditure for dredging and ice breaking.

Effect upon Sewerage Systems in the Filled Lands bordering upon the River.

The proposed improvement will have the same general effect upon the sewerage systems in all filled lands bordering upon the river, so that it will be sufficient for the present purpose to consider only its relation to the portion which has been most highly improved, namely, the filled lands in Boston known as the Back Bay district.

In this part of the city there is one sewer passing through the Public Garden, which takes the sewage and storm-water from what is known as the Church Street district; and other sewers in Berkeley, Dartmouth, Fairfield and Hereford streets, which take the sewage and storm-water from the filled lands as far south as to the Boston & Albany Railroad on Berkeley Street, and to the New York, New Haven & Hartford Railroad on Dartmouth Street and streets west of it. The bottoms of these sewers are about one foot above the level of mean low tide at their outlets and from two to five feet higher at Boylston Street. The tops of the sewers are as a rule below the level of mean high tide. All of these sewers are connected with the west side intercepting sewer of the Boston main drainage works, the bottom of which is about two feet below mean low tide; but are also provided with tide gates through which any surplus storm-water may be discharged into Charles River.

In dry weather, or when there is only a moderate rain, there is a free discharge from the local sewers into the intercepting sewer. When there is a heavier rain, regulators which are provided to prevent this sewer from being overcharged begin to close and let only a constant quantity of water into the intercepting sewer. The remainder of the storm-water passes out freely through the tide gates when the tide is low; but, if the tide is high, cannot pass out until the water in the local sewers has risen above the level of the tide, so as to produce sufficient head or pressure to force the tide gates open. The sewer from the Church Street district has no regulator upon it, but is permitted to discharge freely into the intercepting sewer at all times. This district is favored in this way because the cellars

would otherwise be subject to frequent flooding during storms occurring at high tide.

The established grade for cellars on the Back Bay is twelve feet above Boston city base; and, as the tide quite frequently rises above this level, it is a matter of surprise that so little trouble has occurred in the past from the flooding of cellars in this district by heavy storms occurring simultaneously with high tides. That some trouble has occurred, however, may be seen by reference to the following quotation from the annual report of the Superintendent of Streets of Boston for 1892: —

"Trouble was experienced last year on the Back Bay from the flooding of cellars during an unusually heavy rain, which occurred at about the time of high tide.

"Whenever an extraordinarily heavy rain occurs, there will be danger of flooding cellars in low districts, because the surface water from the streets must fill the sewer system to a level somewhat higher than that of the tide before it can force its way out.

"The tide often rises above the established grade of cellars; and, although it does not remain long at its extreme height, if a heavy rain happens to occur at the same time the cellars will be in danger unless the *volume* or storage capacity of the sewer system is large enough to *store* the storm-water until the tide has subsided.

"A calculation has been made of the *storage capacity*, or the length of time required to fill each of the four Back Bay sewer systems mentioned below with different amounts of rainfall: —

	Rate of Rainfall.	
	1 Inch per Hour.	2.70 Inches per Hour.
Berkeley Street,	14 minutes.	5 minutes.
Dartmouth Street,	14 "	5 "
Fairfield Street,	15 "	5 "
Hereford Street,	12 "	4 "

"Two and seventy one-hundredths inches per hour is the rate at which the rain fell in the storm referred to, Aug. 12 and 13, 1892. It will be seen that the storage capacity of these systems is very little.

"A method of giving relief to these old systems is to build larger storm-water outlets into Charles River.

"The sewers which have been built on the Back Bay the past two years have all been built large enough to afford more storage capacity."

It was found upon examination that the Berkeley Street sewer had a means of relief which was quite certain to prevent the flooding of cellars in that district while the present conditions exist. This sewer passes under the tracks of the Providence Division of the New York, New Haven & Hartford Railroad, and the drainage system of the tracks and yards of this railroad is connected with the sewer. The tracks from Berkeley Street out to the crossing of the Boston & Albany Railroad are about three feet lower than the established grade of cellars, and there is an opportunity when this sewer becomes surcharged for the water to flow back upon the railroad property, and in this way protect the cellars. The railroad officials state that for the last six years the flooding has occurred on an average about three times a year, and has caused much inconvenience. The water rises several inches over the tracks, remains there a few hours and then disappears. The flooding was thought to occur at the time of the high tide.

No special means of relief from flooding were found in the Dartmouth, Fairfield or Hereford Street districts.

With the level of the water in the proposed basin maintained constantly at Grade 8, all danger of flooding cellars in this district will be averted, and the flooding of the railroad would occur very rarely, if at all, because the water in the sewers will only have to rise a little above Grade 8 in order to discharge freely into the river.

For the past three years the city in extending the sewerage system of the Back Bay district has been building sewers large enough to afford more storage capacity than was furnished by the older sewers. This has been done to lessen the danger of flooding; and yet the danger will be greater with the larger sewers under the present conditions with regard to the rise of the tide than it would be with sewers of the original size and the water maintained at Grade 8 in the proposed basin.

It may, therefore, be fairly claimed that the value of the proposed improvement to the sewerage system of the Back Bay will be greater than the difference between the cost of the two

sizes of sewers. I have made no estimates to determine just how large a sum of money this difference represents, but it probably amounts to several hundred thousand dollars.

The assessed value of land and buildings in the district from which the storm-water may overflow into Charles River between the Public Garden and the Back Bay Fens is $102,000,000.

Under the present conditions the tide gates in the sewers can be readily inspected at low tide. With the water in the basin maintained constantly at Grade 8 it would be necessary to provide a direct-acting gate outside of the tide gates, which could be closed so that the tide gates could be opened for inspection. The water between the tide gates and the direct-acting gate could be permitted to flow back through small gate openings in the tide gates into the intercepting sewer. This is, so far as known, the only unfavorable effect which the proposed improvement would have upon the sewerage systems in filled lands, and is obviously a matter involving but little expense and not interfering with the proper inspection of the tide gates.

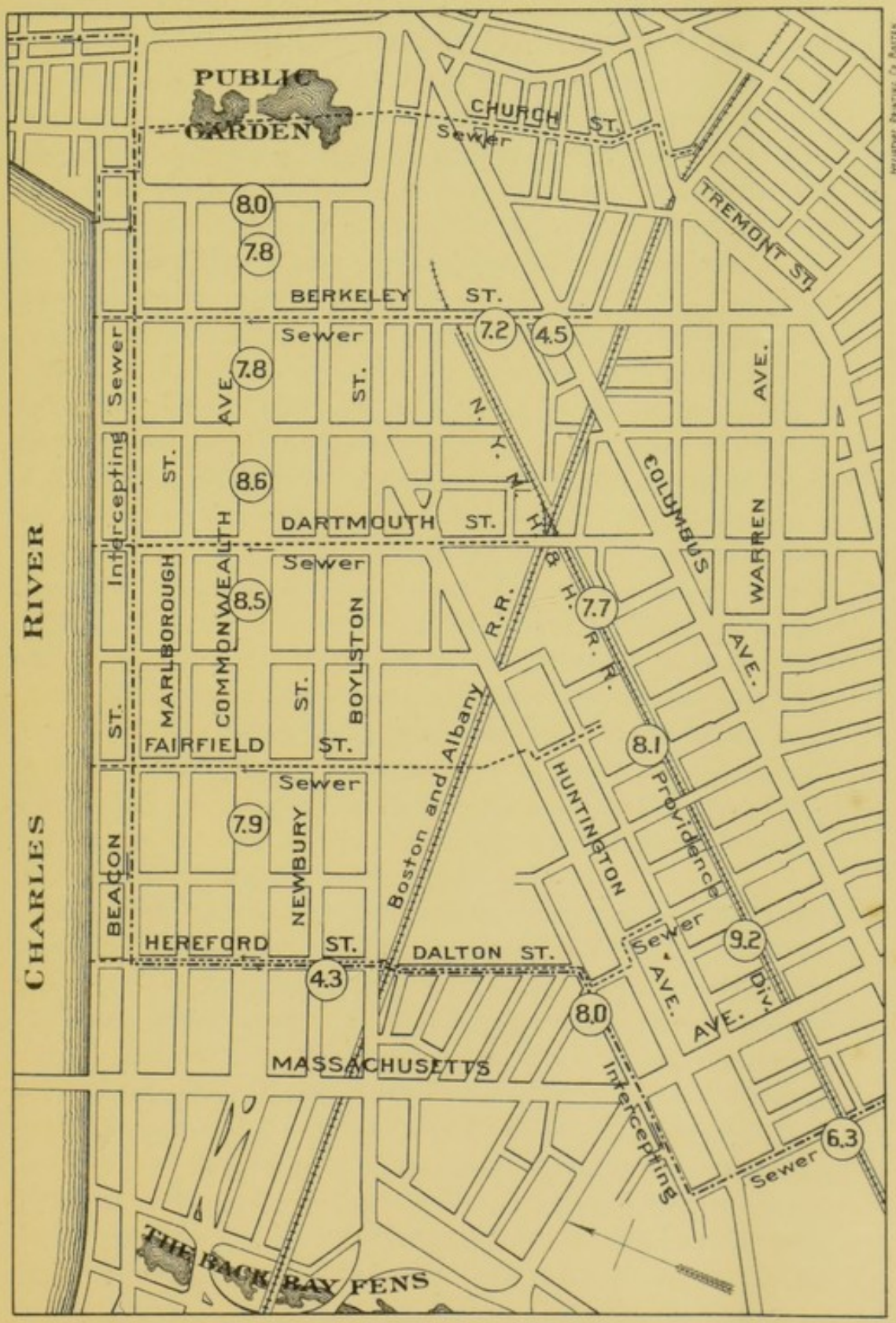
Effect upon Height of Ground Water in Filled Lands.

In this case, as in the last, the Back Bay district will be selected as a representative of other filled lands. In this district the buildings are nearly all supported on piles which under existing laws should be cut off not higher than Grade 5, but some of them have been cut off at a higher level. The established grade for the cellars is, as before stated, Grade 12. It is necessary, therefore, that the ground water should remain high enough to cover the piles so as to prevent their decay; and it is desirable to keep it as far below the bottom of the cellars as possible, so as to render them less damp and thereby improve the sanitary condition of the houses.

In 1878, before the construction of the main drainage works, pipes were driven in the ground at various places over the Back Bay district to ascertain the height of the ground water; and it was found that it was nearly level at Grade 7.7 over the whole district. These observations were repeated in 1885, after the main drainage works had been in operation more than a year, and the ground water was found at practically the same level as in 1878.

PLAN SHOWING HEIGHT OF GROUND WATER IN BACK BAY DISTRICT, BOSTON.

NOTE—Figures in circles show elevation of surface of ground water in feet above Boston City Base.



It was thought important, as a part of the present investigation, to determine anew the height of the ground water over the whole of this district, and to determine whether it was governed by the height of the water in Charles River or by leakage into the sewers in the district. Many of the pipes driven in 1878 were found, and the height of the water in them was observed; and, in addition, the height of water was observed in other pipes which had been sunk by private parties within the district, and in pits dug in various places for the purpose. The results of these observations are given in detail in Appendix No. 3, and the heights as observed on Jan. 1, 1894, are given upon Plan No. 2.

It is the general experience, under all ordinary circumstances, that water in the ground near a river has a very decided slope toward it; but by reference to the plan it will be seen that in this district the slope is, if anything, in the other direction. For instance, at Berkeley Street, near Commonwealth Avenue, the surface of the ground water is at Grade 7.8, while about a quarter of a mile further from the river, in the New York, New Haven & Hartford Railroad yards, the surface of the ground water is at Grade 7.2. Still further west on Berkeley Street, at the corner of Columbus Avenue, the water in a driven well stood at Grade 4.5, but it is thought that this may not properly represent the ground water of the region. At Commonwealth Avenue, between Dartmouth and Exeter streets, the surface of the ground water was at Grade 8.5, while a third of a mile further from the river, at the New York, New Haven & Hartford Railroad, the grade was only 7.7 feet.

The lower level of the ground water at a considerable distance from the river in these cases indicates clearly that the height of the ground water is governed for the most part by leakage into the sewers and not by the height of the water in Charles River. This view is also supported by an observation near the corner of Hereford and Newbury streets, which showed that the surface of the ground water was below the level of half tide, and by another at the New York, New Haven & Hartford Railroad, near Gainsborough Street, which showed the water to be less than half a foot above this level. The water would not have been so low if its height had been governed by that of the water in the river, and the low level in both of these cases must therefore be attributed to leakage into the sewers.

The level of the water in the proposed basin would obviously have a greater effect upon the level of the ground water in the immediate vicinity of the river than at the points further back where the observations were made, and in districts having few sewers than in those having many. It is not, therefore, desirable that the level of the water in the proposed basin should be raised much, if any, above the general level of the ground water in these districts; and Grade 8, which is substantially the present level of the ground water in the Back Bay District and the height maintained in the water-way of the Back Bay Fens, was therefore chosen.

As the present level of the ground water in districts further up the river is higher at the present time than in the Back Bay District, it is not thought that the proposed grade will injuriously affect the height of the ground water in any of the filled districts.

Effect upon Marshes.

The proposed improvement will not only prevent the flooding of the marshes, but, by draining them and by substituting fresh water for salt water, will change their character materially, so that they may be used for park and many other purposes with very little improvement. They should not be used as sites for dwellings unless they are filled to the height now required by law, because the proposed improvement will not materially change the level of the ground water.

Relation to the Storm-Water Discharge from Stony Brook and Muddy River.

The new overflow channel of Stony Brook, completed in 1889, at an expense of about $700,000, was designed with reference to discharging the waters of the greatest freshet that is liable to occur for a long time in the future with the tide in Charles River as high as Grade 13. The maintenance of the water in this river under all circumstances at a level not higher than Grade 10 will furnish even a freer discharge than at the present time, so that the proposed improvement will give the Stony Brook channel a somewhat larger discharging capacity than it now has. In a similar way the discharge of the flood

VIEW AT HIGH TIDE IN REAR OF BEACON STREET FROM HARVARD BRIDGE.

VIEW AT LOW TIDE IN REAR OF BEACON STREET FROM HARVARD BRIDGE.

waters of Muddy River will be facilitated. The old channel of Stony Brook, which conveys the ordinary flow of water to Charles River, will be rendered somewhat less accessible for examination than it now is, but it will operate as effectively as in the past to discharge the ordinary flow of the stream and the water which enters it during storms below the point where the water can be diverted into the new channel.

Relation to present Parks and to proposed Park Improvements along the River.

The existing park improvements along the river are the Charlesbank and the Back Bay Fens. The maintenance of a full basin is obviously favorable to the Charlesbank; and the conditions at the Back Bay Fens will also be more favorable, because the water will become fresh instead of brackish and will not rise as high in the event of heavy freshets as under present conditions.

In the construction of new parks along the river the conditions will be very much more favorable when the water is kept at a constant level. The greater attractiveness of a full basin is so obvious that it is necessary only to refer to it. Walls or beaches bordering water which is maintained at a constant level will remain clean, while with a varying level, such as is caused by the rise and fall of the tide, the walls become slimy, and sloping beaches muddy and unattractive in appearance.

Plates VIII. and IX., showing the river wall back of Beacon Street at high and low tide, illustrate some of these features. A comparison between the two shows the greater attractiveness of the high-tide view, and the dirty appearance of the wall between the levels of high and low tide is shown by the low-tide view. Plates X. and XI., showing views of the modern wall which has been built in front of the Charlesbank, illustrate in a similar way the less attractive features of the low-tide view.

There is a further advantage in the constant level of the water that the walls need not be carried, even in the widest portions of the basin where the waves will be highest, more than 2 or $2\frac{1}{2}$ feet above and below the level of the water, so that they will be very small structures in comparison with the walls, which, under present conditions, are required to rise above the level

of the highest tide and to extend nearly to low water. It is desirable that the walls under the present conditions should extend below the level of mean low water so that their foundations will not be exposed to view even during the low water of spring tides; but the great cost and difficulty involved prevents the walls from being carried as low as is desirable.

The saving in the cost of walls alone between the proposed dam and Cottage Farm would more than offset the whole cost of building the dam and lock; and there would be a very large further saving in expense in the narrower portion of the river from Cottage Farm to the Watertown dam, where gravel beaches, which could be formed at a very small expense, would make a very satisfactory shore, or, if a wall should be thought desirable, it could be a very small affair rising but little above the level of the water.

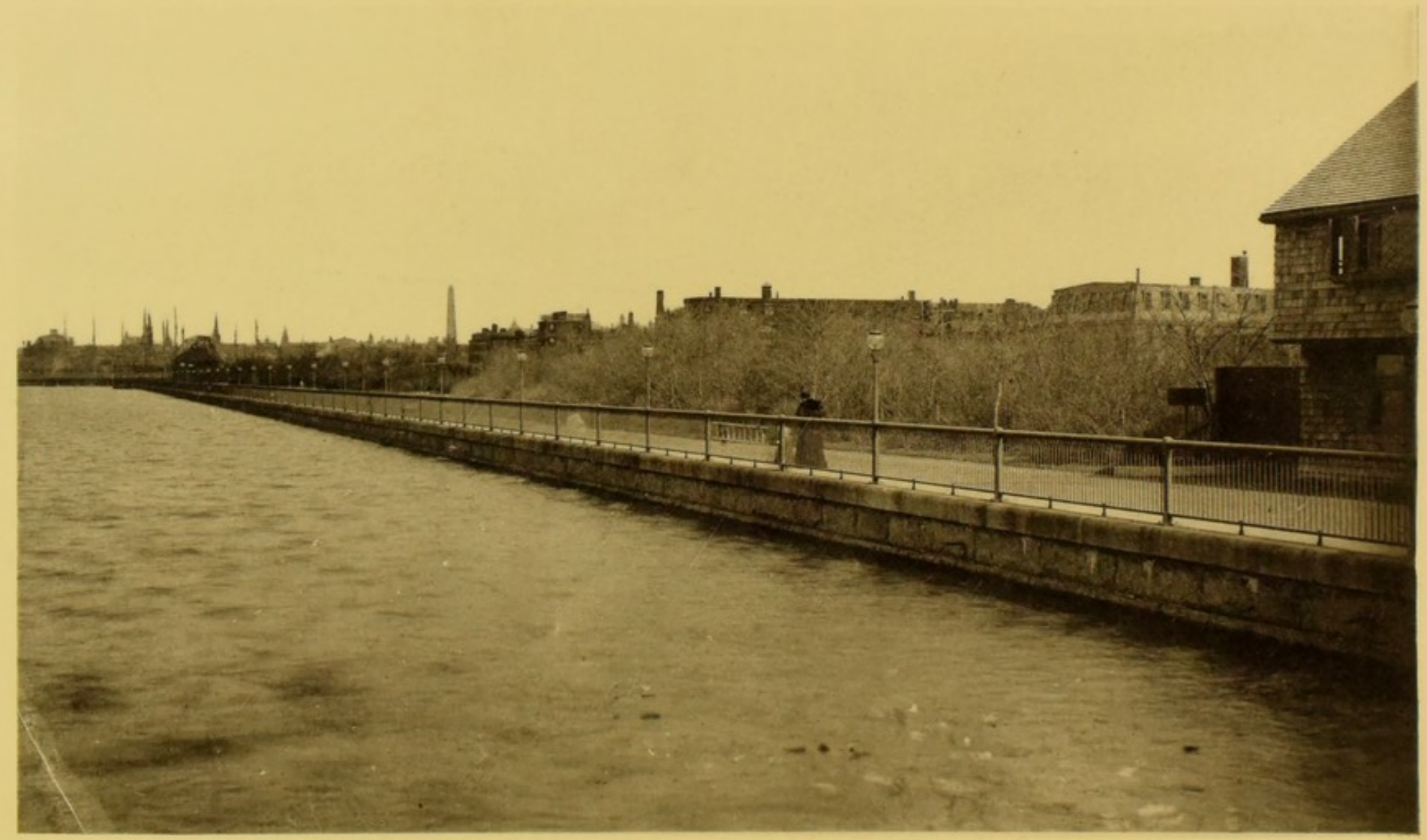
Possible Shoaling of the Proposed Basin.

It has been suggested, at times, that if a basin should be created at Charles River by building a dam it would act as a settling basin and the water would become shoal in consequence. Under past and present conditions there have been, and are, no scouring currents over the flats in the wider portions of the Charles River basin, and yet a comparison of soundings made in 1835 and in 1887 show that there has not been any noticeable shoaling.

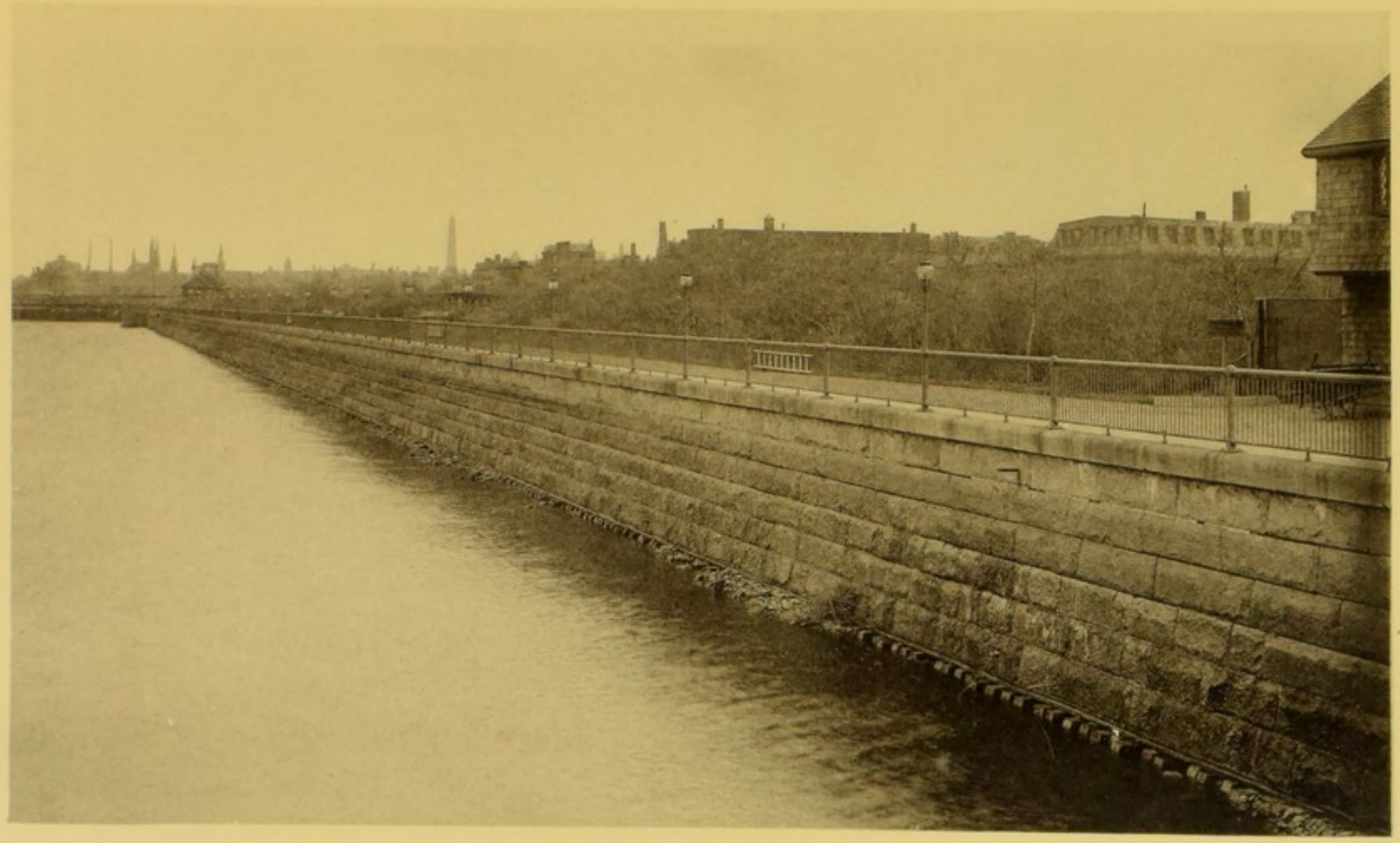
In regard to future shoaling, it seems only necessary to state that under present conditions there is no source from which any large amount of solid matter can enter the basin to cause it to shoal; the process of deepening the basin is now going on as material is being dredged from it for filling the adjacent land, and it seems altogether probable that this deepening will continue in the future as further improvements are made.

Cost.

The estimated cost of constructing the proposed dam and lock, with power house and all appurtenances, is $572,000, and to this sum has been added 15 per cent. for engineering, superintendence and contingencies, equal to $85,800, making the total estimated cost of the dam $657,800, or, in round num-



VIEW OF CHARLESBANK AT HIGH TIDE FROM WEST BOSTON BRIDGE.



VIEW OF CHARLESBANK AT LOW TIDE FROM WEST BOSTON BRIDGE.

bers, $660,000. In making this estimate it has been the aim, by using liberal prices for the different classes of work and by allowing a liberal margin for contingencies, to make the estimated cost equal the amount which would actually be spent in the construction of the work.

The plans for the improvement of the basin as a whole have not been made in sufficient detail to be used as a basis for estimates of cost. Some idea, however, of the relative cost of different methods of improvement may be obtained from the following approximate estimates of the cost of detached portions of the work.

The cost of walling the basin from the Charlesbank to Cottage Farm on the Boston side, and from the proposed dam to Cottage Farm on the Cambridge side, with a wall similar to that at the Charlesbank, would be $1,300,000; while a wall of similar character, but of the much smaller dimensions which would be sufficient if the water were kept at a constant level, would cost $475,000, making a saving by the latter plan of $825,000.

The cost of continuing the walling of the river from Cottage Farm up to a point three-fourths of a mile below Watertown, with a wall like that at the Charlesbank, would be about $2,500,000, while with the water maintained at a constant level a suitable shore might be made of gravel with little expense. If, however, a wall should be thought desirable, instead of a gravel beach, it might be a smaller wall than upon the borders of the broader basin; and the cost of such a wall from Cottage Farm to the point three-fourths of a mile below Watertown would be $430,000.

If the improvement of the river were to be made without shutting out the tide it would ultimately be necessary not only to wall the stream, but to dredge the flats between the harbor lines to such a depth that they would not be exposed at low tide, and to fill the marshes. The cost of such dredging and of disposing of the material upon the flats back of the harbor line and upon the marshes would amount to $500,000; and the cost of filling the marshes which are now flowed by the tide above Cottage Farm to the height to which the Back Bay has been filled, with gravel brought by the railroads, would amount to upwards of $1,000,000.

In conclusion, I will state that, as a result of all my studies of various methods of improving the river and of utilizing the open space which it affords, so that it will have the greatest value to the densely populated district through which it flows, I have become thoroughly convinced that the best results can be obtained by the construction of the proposed dam to maintain the water at a constant level, and the public ownership and improvement of the banks of the stream. The advantages of this plan to the metropolitan district are many and far-reaching, and the disadvantages few and comparatively insignificant.

I desire to express my indebtedness to Mr. X. H. Goodnough and to Mr. William M. Brown, Jr., for the valuable assistance which they have rendered in collecting information and in preparing plans and estimates.

Respectfully submitted,

FREDERIC P. STEARNS,
Engineer.

BOSTON, MASS., April 16, 1894.

THE CAMBRIDGE MARSH NEAR BOYLSTON STREET.

REPORT OF THE LANDSCAPE ARCHITECTS.

H. P. WALCOTT, M.D., *Chairman of Joint Board on the Improvement of Charles River.*

SIR: — We have the honór to report as follows upon the improvement and best utilization of Charles River and its borders between Waltham line and Craigie bridge. Wherever the words "Charles River" or "the river" are used in this paper, they are to be understood to refer only to this portion of the total length of the stream.

The problem presented by the existence of the channel, flats and marshes of Charles River in the heart of the metropolitan district of Boston has long been the subject of public discussion; and, although this discussion has been thus far almost barren of results, it has at least served to familiarize the metropolitan community with the nature of the river and the history of its pollution and defacement. This discussion has also developed the fact that public authority over the river and its borders is unfortunately divided between the United States, the State, three cities and one town. If absolute deference were to be paid to each and every public authority and private interest concerned, no satisfactory solution of the problem of the river could ever be reached, because these authorities and interests are conflicting; therefore, in our discussion of the subject we make no attempt to reconcile conflicting interests or to conform to the supposed or alleged desires of any governing body or interested person. We first inquire, What is the most important service which Charles River renders, or may be made to render, to the welfare of the dense population of its valley? and after this mode of usefulness has been explained, it will be our endeavor to set forth a logical scheme of improvement such as will develop the natural usefulness of the river in the highest possible degree.

It is not for us to attempt to suggest the proper way of executing the improvement to be proposed. We are warranted in assuming that a way can be found to carry out any scheme which can be shown to be conducive to the greatest good of the greatest number.

The principal function of every river is the discharge of surface waters. The channel of the Charles conveys to the ocean the surface drainage of two hundred square miles. The estuary of the river is navigable by coasting vessels, and the considerable volume of the fresh-water river has led to the use of the stream as a convenient conduit of factory wastes and sewage. These modes of usefulness, however, are evidently subsidiary to the primary or fundamental usefulness of the stream as a common drain. The use of the stream as a sewer may be discontinued, as, in fact, it soon will be, and the use of the stream by commerce may be abandoned when that use shall be found to conflict with more profitable uses. On the other hand, the service of the channel as a drain will inevitably become of ever-increasing importance as population thickens in the river valley. Every additional roof and street built within the water-shed enhances the rapidity of the flow of rain water towards the water courses and adds to the volume of the floods in the river. A due regard for public economy demands that the channel of every brook flowing through a closely settled district should not only be kept free from obstruction but be made capable of enlargement. It is vastly cheaper to acquire early, through public authority, ample space for the safe conveyance of the increasing floods of such streams, than it is to clear away obstructions and remove buildings after damaging overflows have demonstrated the necessity of so doing. The costly case of Stony Brook in Roxbury teaches the need of prompt action in this important matter. Meanwhile, it is satisfactory to be assured that, however inadequate the channels of the tributary brooks of Charles River may be, or may become, the open channel of the river itself will doubtless be sufficiently capacious for all time. This channel has a width of one hundred feet at the Waltham line, two hundred feet at the head of the tide in Watertown and five hundred feet at Cottage Farm, where the river expands into the so-called basin.

MARSH AND BLUFF NEAR COOLIDGE STREET.

The length of the channel from Waltham line to Cottage Farm is eight miles, and the total area of the open water-way between these points is about three hundred acres. This is the considerable space which must permanently be kept open in order to provide a safe way of escape for the floods of the Charles River water-shed.

It is next to be noted that well-distributed open air space is just what every crowded district must possess, if the public health is to be preserved, and that many cities have been compelled to pay large sums of money in order to secure public open spaces no larger than that which nature has freely given to the cities of the lower valley of the Charles. If the crowded districts of the valley care to reap the advantage of this free gift of nature, they have only to take possession of the banks of the river. Money spent in making the existing natural open spaces accessible and enjoyable will surely yield a greater return, both in public health and pleasure, and in profits from the increased assessable values of adjoining lands, than it could yield if it were spent in buying detached inland tracts. This is an obvious truth, and already the municipalities of Boston and Cambridge have taken action accordingly. Boston has secured and constructed the very popular public ground called the Charlesbank, and proposes to construct, eventually, a public promenade along the whole shore of the basin. In this part of the river the use of the banks for commercial purposes has already been abandoned in favor of the more profitable use thereof for purposes of residence and recreation. Cambridge is engaged in acquiring the larger part of her long frontage on the narrow river as well as the border of the basin.

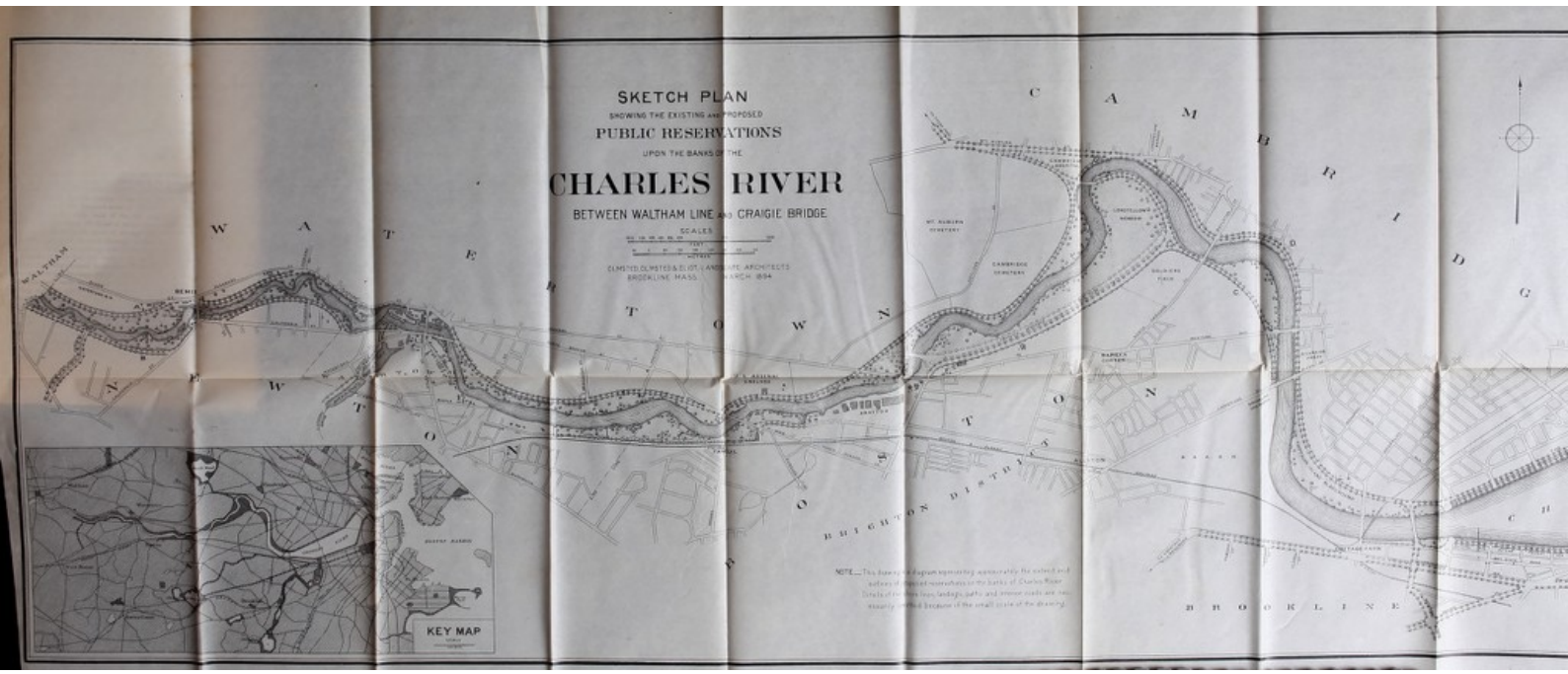
It appears, then, that the acquisition for the public of the remaining portions of the river bank ought to be accomplished at once, either by the separate towns and cities concerned, or by some central authority empowered to act for all. This is not an extravagant proposition; it is dictated by considerations of real economy. Open space is needed. Nowhere west of the State House can so much well-distributed space be had for so little money as on the banks of Charles River. Furthermore, there is every reason to believe that, if the proposed reservation were to be bounded by roads affording build-

ing frontages, the private owners of the adjoining lands and the public treasury would alike be financially benefited.

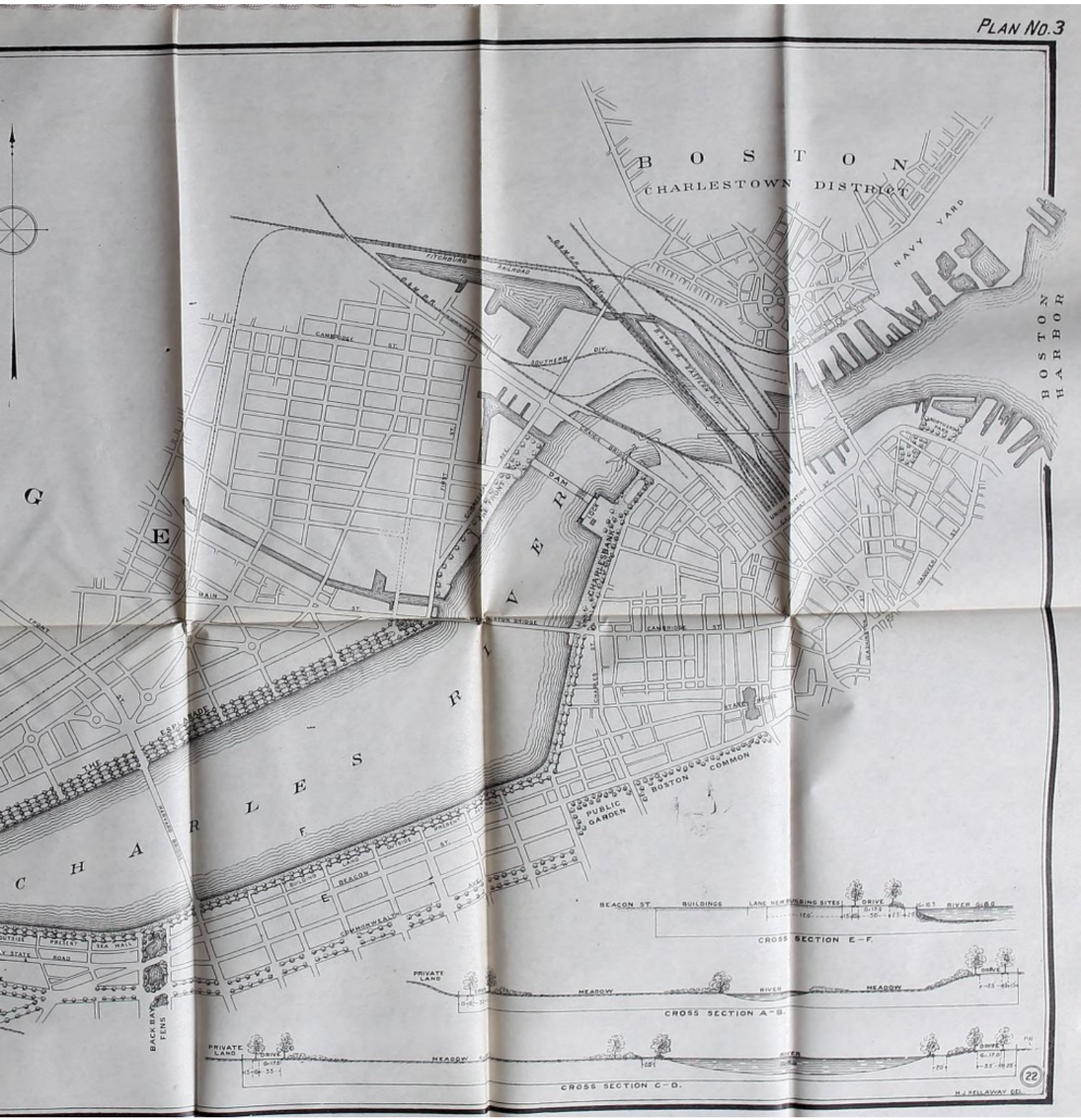
In this connection it should be noted that private capital begins to perceive that the highest possible value will be obtained for the river lands only when they are made attractive to the builders of dwellings and apartment houses. The Charles River Embankment Company is laying out nearly a mile of the Cambridge shore of the basin in a style which is calculated to induce the building of fine residences; and, in order to establish values beyond a doubt, the company has presented to the city of Cambridge an esplanade upon the river front, extending the whole length of its domain and measuring two hundred feet in depth. The owners of large tracts of land lying further up the stream would doubtless give their river banks in a similar spirit, if by so doing they might secure the advantage of a frontage upon a continuous river road and reservation. Not that it is to be expected or desired that all the banks of the river should become new "Back Bay" districts. Obnoxious industries would doubtless be banished from the valley by the enhanced land values which may be expected to result from making the river bank a reservation, but manufactories of the higher sort would probably remain and be established on lands not remote from the reservation; and if the low lands of the valley should eventually become the seat of a population of well-housed working people, who would find refreshment on the public river bank at the noon hour and in summer evenings, a most desirable result would be secured. Playgrounds for children would naturally be provided at intervals along the banks.

The advantage which would be reaped by the towns and cities of the river valley from the joint possession of a thoroughly pleasant route of travel to and from Boston is so obvious that it need only be mentioned. Roads built upon the boundaries of the proposed reservation would provide a continuous parkway from Waltham to the heart of Boston.

Upon the accompanying plan the heavy line indicates the outer boundary of the lands proposed to be acquired for the public domain, and adjacent lines indicate the existing and proposed boundary roads. It is professionally incumbent upon us to urge the prompt acquisition by public authority of all the land


SKETCH PLAN
SHOWING THE EXISTING AND PROPOSED
PUBLIC RESERVATIONS
UPON THE BANKS OF THE
CHARLES RIVER
BETWEEN WALTHAM LINE AND CRAIGIE BRIDGE
SCALES
OLMSTED OLMSTED & ELIOT, LANDSCAPE ARCHITECTS
BROOKLINE, MASS. MARCH 1894
WATERTOWN
CAMBRIDGE
BROOKLINE
KEY MAP

PLAN No. 3


BOSTON
CHARLESTOWN DISTRICT
NAVY YARD
BOSTON HARBOR
CHARLES RIVER
CHARLES RIVER DAM
CHARLESBANK
PUBLIC GARDEN
BOSTON COMMON
THE ESPLANADE
BACK BAY FENS
CAMBRIDGE ST.
BEACON ST.
COMMONWEALTH AVE.
FITCHBURG RAILROAD
CROSS SECTION E-F.
CROSS SECTION A-B.
CROSS SECTION C-D.
PRIVATE LAND
MEADOW
RIVER
DRIVE
BUILDINGS
H.J. KELLAWAY DEL.
22

within the heavy lines. The few commercial and industrial establishments which now stand within these lines would not necessarily be required to move away at once. Whatever public authority shall undertake the acquiring of the proposed reservation may well permit these concerns to occupy their present sites perhaps for years, at all events until money shall be forthcoming wherewith to begin the necessary work of construction. This work may be long postponed, but it can never be even begun unless the land is acquired, and the land can never be obtained so cheaply as it may be to-day.

It is now desirable to return to the consideration of the river as a drain, — a topic which was temporarily abandoned in order to point out that because it is a drain it is also an open space, and an open space of which advantage should be taken for the benefit of both the public and the land owners most concerned.

For a large part of the district under consideration, namely, for all the low lands along the river east of the United States arsenal, the river as it exists to-day is a very inefficient drain. Between the arsenal and Cottage Farm there border upon the river as many as five hundred acres of unfilled or only slightly filled salt marsh, while back of the salt marshes in Brighton and Cambridge there lie about as many more acres only very slightly raised above the level of average high water. When the tide is out there is ready drainage for this land; when the tide is in there is no drainage and the lands are drowned.

Engineers know but two ways of remedying poor drainage. Either the badly drained lands must be raised, or the level of the water in the drainage channels must be lowered. To raise the drowned lands in question to a drainable elevation with filling material costing fifty cents per cubic yard would cost two million dollars. To build a dam and a lock by which the high tide would be kept out and the water in the river maintained at a constant level sufficiently low to make all the marshes drainable would cost perhaps half a million. The important sanitary and financial advantages to be derived from the construction of such a dam and lock are detailed in the accompanying report of the engineer, and need not be repeated here.

We have already urged, and shall continue to urge, the acquisition of a continuous river-bank reservation, whether the river is to remain a tidal estuary or not; but it is evident that if the tide could be excluded and the resulting fresh-water stream maintained at a fairly constant level the problem presented by the shores of the stream would be greatly simplified. Thus, if the surface of the water were to be maintained at Grade 8, as is proposed by the engineer, not only would the marshes within the reservation become drainable at once, and without filling, but the low mud banks would, with a little assistance, become quickly clothed with trees and bushes. The cost of sea walls and ripraps would be avoided, and the appearance of the stream would be greatly improved.

It would be well to make sure that eight feet should be the minimum depth of water in the fresh-water channel, because a less depth would encourage an undesirable growth of water plants. It would also be advisable to exclude salt water as completely as possible, if only because it would injure fresh-water plants growing upon the banks. If proper precautions were taken, the effect of the proposed dam upon the proposed public reservation would evidently be wholly favorable. Accordingly, while the accompanying plan has been drawn to represent the boundaries of a reservation such as must be recommended whether the stream be salt or fresh, the banks of the stream are shown as they might be if the surface of the stream were to be maintained at Grade 8 by a dam situated as recommended by the engineer. Shore lines, landings, bridges, paths, sidewalks, and roads within the reservation are not accurately defined upon the plan, both because the scale of the drawing is too small, and because these details may more properly be devised by whatever executive authorities shall have charge of the work in the future.

In briefest form we have outlined a scheme of improvement such as will develop in the highest possible degree the natural usefulness of the river as an open space and as a drain. It only remains to describe the accompanying plan in greater detail, for which purpose we divide the river into three sections, as follows: first, the fresh-water section; second, the marsh section; third, the basin section.

The Fresh-Water Section, — Waltham Line to Watertown Bridge.

This is the only fresh-water section of Charles River with which the present inquiry is concerned. The stream here meanders tranquilly through a chain of open meadows generally bordered by low bluffs. Dams at Bemis and Watertown detain the natural current and spread the water surface in an agreeable manner. Neither the meadows nor the bluffs are as yet much occupied by buildings except in the near neighborhood of the two dams.

The public reservation outlined upon the accompanying plan begins arbitrarily at the Waltham line, in accordance with the terms of the act of the Legislature creating your commission, and extends eastward between boundaries which it is proposed shall be formed by existing or prospective public roads, affording frontage for the adjacent private building land. River Street, Watertown, follows the brink of the north side bluff, and therefore would form the most desirable north boundary. It is only for the sake of economy in land that the plan shows the reservation bounded by a new road proposed to be built parallel with River Street upon the level of the meadow. This road would necessarily ascend to River Street to avoid the Bemis Mills.

On the south side the road boundary of the reservation would first lie upon a little bluff occupied at the present time by two or three buildings; then it would cross the unoccupied level of Cheesecake Brook valley, and would reach California Street by following the brink of a second and higher bluff, from which is obtained a view up stream, including Prospect Hill in Waltham.

It should be noted in passing that Cheesecake Brook has already been included in a public reservation bounded by a road upon each bank, and that both the adjacent land owners and the public of Newton are well pleased therewith.

The mills at Bemis cannot be included in the reservation, for obvious reasons; but they are easily passed by River Street and California Street, and the existing buildings are not a serious blot upon the landscape of the river valley.

Eastward from Bemis the north side boundary had best be the existing Pleasant Street; but, as before, for reasons of economy, the plan proposes a new road approximately parallel with Pleasant Street as far as Howard Street, from which point Pleasant Street itself should form the boundary down to Watertown dam, where the reservation is necessarily again interrupted by mill buildings.

On the south side California Street is proposed as the boundary as far as Chapel Street, and again from the Newton-Watertown line to Watertown bridge. Between these points the boundary may be fixed upon a new road, which should curve out to the brink of the bluff at the end of Los Angeles Street and then curve back again, as shown upon the plan. Abreast of Watertown dam connection can easily be made with the public reservation which the city of Newton proposes to create along the course of Laundry Brook.

The Marsh Section,—Watertown Bridge to Cottage Farm.

This middle section of the river is characterized by extensive areas of salt marsh which border the wandering channel. Here and there the marsh has been filled and a bit of sea wall built, but more than nine-tenths of the total length of the river bank is still in its natural state. The marshes are generally unoccupied.

The plan suggests that a bridge should eventually be built in continuation of California Street, and that the public reservation should include the narrow strip of land which lies between Wheeler Street and the river, so that the continuity of the river drive may be unbroken. East of the end of Wheeler Street the boundary should be a new road, which may pass the end of Irving Street, follow the top of the bluff across the Stickney estate, cross the end of Beechwood Street, and reach North Beacon Street bridge by filling a large part of the shallow expansion of the river which lies opposite the end of Prospect Street.

On the south side of this section of the river the Boston & Albany Railroad is built on an embankment not far from the

MARSH AND BLUFFS NEAR ARSENAL STREET.

river's edge, while several commercial establishments occupy the river bank in the neighborhood of the village of Watertown. It is desirable that the land which lies between the Boston & Albany Railroad and the stream should be made part of the public reservation, but more than this seems impracticable.

Continuing eastward, the plan suggests on the north bank a drive through the grounds of the United States Arsenal, passing in rear of the wharf, and a street connection on the south side of the river, by which travel may pass in rear of the great buildings of the abattoir. East of the abattoir it is again possible to secure a river drive on the south bank as well as on the north. The plan proposes that this drive should follow a long curve from Western Avenue at the foot of Market Street to the north-west corner of the Soldier's Field of Harvard College. On the broad and level marshes which will adjoin this section of the river drive it will be possible to obtain a mile-long course for driving, unbroken by any cross roads. We know of no other so favorable an opportunity for the making of a "speedway."

From Soldier's Field to the works of the Brookline Gas Company, at River Street bridge, the plan shows the boundary of the reservation established upon a curved road, a branch of which may in the future follow the edge of the river past the Longfellow Meadow, and so over a new bridge to Mount Auburn and Fresh Pond. Beyond the Brookline Gas Company's works the Boston & Albany Railroad controls the river bank as far as Cottage Farm, so that no new frontage can be developed by the construction of a road. Moreover, people driving on the river roads will find their shortest way to Boston by crossing the river at Western Avenue bridge and recrossing it at Cottage Farm.

It is proposed that the north side road on the boundary of this section of the reservation should be placed about half way between the river and the existing Coolidge Street, and that after passing Cambridge Cemetery and the Cambridge Hospital it should connect at Mt. Auburn Street with the river road, the site of which has already been acquired by the Park Commission of the city of Cambridge. This road must find its way between the water and the buildings of the riverside wards of

Cambridge as best it may. At certain points, as, for instance, at the Riverside Press, space for the broad driveway and promenade is all that can be had. At other places, as, for instance, at Captain's Island, space valuable for playgrounds has been secured between the drive and the stream. It is understood that the Cambridge Park Commission proposes to remove, in time, the few commercial establishments which at present stand in the way of the construction of this drive and park.

The Basin Section,—Cottage Farm to Craigie Bridge.

The existing bridge at Cottage Farm is crossed at grade by the tracks of the freight branch of the Boston & Albany Railroad. There is no need that both this bridge and the river road should be carried over these tracks. Moreover, the present bridge does not connect with any highway leading to the south. For these reasons and others we have deemed it best to suggest the discontinuance of the existing bridge and the building of a new structure a short distance further east. In the suggested position the bridge would not only connect Cambridge and the river roads more conveniently with Boston, but it would also make good connection by way of Audubon Road with the new parkway along Muddy River, and so with all the Boston parks and all the southern suburbs. This new bridge would also mark the point of entrance of Charles River into the basin, while the view from the bridge down the whole length of the basin to the State House would be very fine.

Above this bridge the shores of the reservations proposed by the plan would be irregular and clothed with trees and bushes, except where it might be desirable that the public should reach the water's edge at beaches or boat-landings. Below this bridge the shores of the basin would be treated formally with low walls or curbs of stone, broken by bastions affording views over the water, landings for use of steam or electric passenger boats, docks for row-boats and the like.

The Cambridge side of the basin is already provided with a broad public reservation which is now almost continuous. On the other hand, the Boston side of the basin, except between

THE FRESH-WATER RIVER NEAR WATERTOWN WATER WORKS.

Craigie bridge and West Boston bridge, is bordered either by the back yards of private buildings or by a narrow alley which gives access to back yards and stables. It has seemed to us that the open basin is quite broad enough to permit of the insertion of one additional row of buildings adjacent to the existing waterside alley, and the construction of a driveway and promenade on the waterside of this new row. On this plan it may be expected that buildings of an agreeable aspect will gradually be constructed fronting on the basin, while the money which will be obtained from the sale of this building land will certainly pay the whole cost of filling and finishing the drive and promenade.

The dam which is shown upon the plan as connecting the completed Charlesbank with the newly acquired reservation on the Cambridge side called The Front is fully described in the engineer's report. It is proposed that a lock should be built in this dam, primarily for the accommodation of the United States Arsenal, and secondarily to serve the purposes of such industrial establishments as may linger on the river bank or be built near it. Coal is now practically the only freight carried up the stream, and the delivery of coal is not incompatible with the enjoyment of the river bank by the general public. It is significant, however, that "all-rail" coal is now offered for sale in Brighton and Newton near the river. The case of the Charles is wholly different from that of Chicago River, for example, — a stream which is the only harbor of a great commercial city. Boston, with Charlestown, East Boston and South Boston, possesses ample harbor frontages below the mouths of all her rivers.

Charles River, freed from sewage, from defiling industries, from mud flats and from mud banks, and dedicated with its borders to the use and enjoyment of the public as a drainage channel, an open space, a parkway, a chain of playgrounds and a boating course, will perform its highest possible service to the metropolitan community, and will return to the community profits both tangible and intangible, which will annually increase.

Your obedient servants,

OLMSTED, OLMSTED & ELIOT.

April 16, 1894.

APPENDIX No. 1.

Freshet Flow of Charles River.

The highest freshet from the Charles River, of which there is any record, occurred in February, 1886, and was caused by a very heavy warm rain, which melted a large quantity of snow already on the ground.

It was found upon examination that the best records from which to estimate the flow of the river at this time were kept by the Boston Manufacturing Company, at Waltham, and they consisted of measurements of the height of the water above the dam, taken four times in the twenty-four hours, at nearly equal intervals of time.

In the vicinity of Boston the rain began at 7.45 A.M., Thursday, February 11, and ended at 2.45 P.M., Saturday, February 13. The rain which fell until late on the evening of the 11th was mostly absorbed and retained by the snow, and then came the twenty-four hours of heaviest rainfall, which carried off the snow and produced the freshet. In Boston the total rainfall during this storm was 5.62 inches, of which 4.45 inches fell during the twenty-four hours of heaviest rainfall. It is estimated that the snow was equivalent to two additional inches of rainfall.

From the records at Waltham it was learned that the water rose rapidly during Friday, February 12, and Saturday, February 13. No records were kept on Sunday, February 14, but on the following Monday, Tuesday and Wednesday the water remained at the maximum height, and it was probably at the same height on Sunday.

By means of the Waltham records, taken in connection with measurements of the dam and information obtained from those present at the works at the time of the freshet regarding the

amount of water which passed through the wheels, it was feasible to estimate, with a fair degree of accuracy, the amount of water flowing in the river, and the quantity finally determined upon, as representing the maximum rate, was 4,900 cubic feet per second.

This estimate seemed to be a satisfactory one, but it was thought desirable to verify it by comparing the total amount which flowed off during the freshet with the amount which might be expected to flow off from a watershed of this size after such a rainfall, and with the amount which flowed off per square mile from the contiguous Sudbury River watershed. In order to do this it was necessary to determine not only the flow at Waltham, but also the amount of water which flowed from the Charles River at Dedham through Mother Brook into the Neponset River.

For this purpose flood marks were found above and below bridges which cross Mother Brook and their relative height was determined, as was also the size of the bridge openings. With this information as a basis it was estimated that the amount of water diverted from the Charles River through Mother Brook, when the freshet was at its height, amounted to 900 cubic feet per second, making the maximum freshet flow of the whole stream above Waltham 5,800 cubic feet per second.

The watershed of the Charles River above Waltham has an area of 248.1 square miles and the maximum flow was, consequently, 23.4 cubic feet per second per square mile. The maximum flow from the Sudbury watershed during this freshet was 41 cubic feet per second per square mile.

This difference in the results would have caused doubt as to the accuracy of the Charles River estimate, had it not been known that floods upon this river were likely to be greatly modified and retarded by the very extensive meadow areas which border this river at Dedham and for many miles above South Natick. By estimating the flow of the river for a whole week and comparing the results with measurements of the Sudbury, made by the engineers of the city of Boston and given in the report of the Boston Water Board for 1886 (page 71), the results given in the following table were obtained.

Table showing the Comparative Flow of the Charles and Sudbury Rivers during the Week of the Great Freshet in February, 1886.

DATE.	Total Flow.				Flow per Sq. Mile.	
	Charles River.			Sudbury River.	Charles River.	Sudbury River.
	At Waltham.	Through Mother Brook.	Total.			
	Cubic Feet per Second.	Cubic Feet per Second.	Cubic Feet per Second.	Cubic Feet per Second.	Cubic Feet per Second.	Cubic Feet per Second.
Friday, Feb. 12, .	1,216	223	1,439	1,421	5.8	18.9
Sat., " 13, .	4,365	802	5,167	3,086	20.2	41.0
Sun., " 14, .	4,900	900	5,800	1,992	23.4	26.5
Mon., " 15, .	4,900	900	5,800	1,296	23.4	17.2
Tues., " 16, .	4,900	900	5,800	825	23.4	10.9
Wed., " 17, .	4,900	900	5,800	663	23.4	8.8
Thurs., " 18, .	4,476	822	5,298	553	21.4	7.4
Totals and avs.,	29,657	5,447	35,104	9,836	20.2	18.7

The total watershed above the point of measurement at Waltham is 248.1 square miles, and of the Sudbury above the point of measurement, 75.2 square miles.

The results given in the table show clearly the conservative character of the flow of the Charles River during freshets. They also show that the total flow per square mile from the Charles during the whole week was somewhat greater than from the Sudbury, notwithstanding the much higher flow of the Sudbury when the freshet was at its height.

The slight difference between the week's flow per square mile of the Charles and Sudbury can be more than accounted for by the difference in the rainfall upon the two watersheds. The rainfall during this storm was greatest in Rhode Island and diminished rapidly going toward the northwest until it was only an ordinary rainfall in the northwesterly part of Massachusetts. The average rainfall at points on or near the Charles River watershed was 5.57 inches and the rainfall on the Sudbury River watershed was 4.64 inches. If two inches are added in each case to allow for the water derived from melted snow, the relative average flow of the Charles and Sudbury during the whole freshet should have been as 21.3 to 18.7. It is probable that the relative quantities would have been very nearly as given in the table if another day's flow had been included,

because the freshet upon the Charles River had not wholly ended upon the last day given in the table. It was, therefore, concluded that the estimated freshet flow of the Charles River had been verified in a satisfactory manner by the comparison with the flow from the Sudbury River watershed.

Appendix No. 2.

List of Charles River Bridges, giving Width of Openings for Vessels.

Name of Bridge.	Location.	No. of Openings	Width of Openings.
			Ft. In.
Charles River,	Boston to Charlestown,	1	36 0
Warren,	Boston to Charlestown,	1	36 3
Fitchburg Railroad (for teaming freights),	Boston to Charlestown,	1	35 11
Fitchburg Railroad,	Boston to Charlestown,	1	36 0
Boston and Maine Railroad, Western Division,	Boston to Charlestown,	1	40 0
Boston and Maine Railroad, Eastern Division,	Boston to Charlestown,	1	40 0
Boston and Maine Railroad, Southern Div. (passenger),	Boston to E. Cambridge,	1	40 0
Boston and Maine Railroad, Southern Div. (freight),	Boston to E. Cambridge,	1	40 0
Craigie's,	Boston to E. Cambridge,	1	35 10
W. Boston, { Boston side, / Cambridge side,	{ Boston to Cambridge,	2	{ 35 8 / 36 0
Harvard, { Boston side, / Cambridge side,	{ Boston to Cambridge,	2	{ 36 8 / 36 8
Grand Junction Railroad,	Boston to Cambridge,	1	35 10
Essex Street,	Boston to Cambridge,	1	36 0
Cambridge Street,	Boston to Cambridge,	1	36 3
Western Avenue,	Boston to Cambridge,	1	36 0
North Harvard,	Boston to Cambridge,	1	36 0
Western Avenue,	Boston to Watertown,	1	36 0
North Beacon Street,	Boston to Watertown,	1	30 2
Galen Street,	In Watertown,	–	–

Draw-Tenders' Reports.

Giving the Number of Vessels passing through the Highway Bridges across Charles River from Feb. 1, 1893, to Feb. 1, 1894.

Name of Bridge.	Steamers.	Sailing Vessels.	Tugs.	All Others.	Total No. Vessels.*	Total No. of Cargoes.*	Total No. of Openings.
Charles River,	30	2,690	3,175	2,352	8,247	2,450	5,871
Warren,	7	2,655	1,983	1,520	6,165	2,021	5,234
Craigie's,	323	1,544	1,163	588	3,618	1,182	3,232
West Boston,	2	526	1,267	803	2,598	415	1,699
Harvard,	27	562	1,732	–	2,321	257	1,736
Essex Street,	23	180	717	218	1,138	201	742
Cambridge Street,	–	149	608	186	943	151	567
Western Avenue,	–	132	481	137	750	120	449
North Harvard,	–	54	131	36	221	38	139
Western Avenue,	–	6	18	14	38	3	32
North Beacon St.,	1	–	1	–	2	–	2

* It may be noticed that the figures in the columns marked with an asterisk do not agree with those given on page 4. This is due to the fact that the figures on page 4 are for the year ending Dec. 1, 1893, while the figures in the above table are for the year ending Feb. 1, 1894, except the number of cargoes at Craigie's Bridge, which is for the year 1893.

Table showing Contents of Vessels passing Craigie's Bridge during the Year ending Nov. 30, 1893.

Month.	Coal (Tons).	Stone (Tons).	Lumber (Feet, B. M.).	Sand and Gravel (Tons).	Oil (Gallons).	Wood (Cords).
1892.						
December,	17,903	1,039	1,312,000	730	–	–
1893.						
January,	6,370	495	206,000	–	–	–
February,	926	280	–	–	–	–
March,	10,532	502	459,000	–	–	–
April,	14,539	6,139	1,196,000	120	–	191
May,	20,803	8,869	1,211,000	2,750	–	217
June,	12,920	10,025	1,868,000	1,385	–	610
July,	27,113	7,976	2,254,000	3,005	–	410
August,	26,226	4,229	3,150,000	2,780	–	220
September,	31,193	2,129	1,752,000	1,485	–	221
October,	22,043	2,043	1,095,000	1,670	600,000	228
November,	32,897	1,570	1,811,000	1,420	409,000	210
Total for the year,	223,465	45,296	16,314,000	15,345	1,009,000	2,307

Table showing Contents of Vessels passing West Boston Bridge during the Year ending Nov. 30, 1893.

Month.	Coal (Tons).	Stone (Tons).	Lumber (Feet, B. M.).	Sand and Gravel (Tons).	Oil (Gallons).	Wood (Cords).
1892.						
December, . .	8,254	125	191,000	100	–	120
1893.						
January, . .	–	–	26,000	–	–	–
February, . .	–	–	–	–	–	–
March, . . .	3,798	–	–	–	–	–
April, . . .	6,294	1,155	253,000	356	–	70
May, . . .	16,010	2,620	570,000	100	–	60
June, . . .	12,463	3,757	761,000	575	–	538
July, . . .	9,923	4,954	497,000	420	–	339
August, . . .	11,235	827	496,000	562	–	198
September, . .	15,489	925	376,000	120	–	50
October, . . .	14,609	220	443,000	263	600,000	145
November, . .	18,880	673	35,000	390	409,000	110
Total for the year,	116,955	15,256	3,648,000	2,886	1,009,000	1,630

In addition to the freight shown in the above tables there were smaller quantities of other materials, amounting in all to about 7,448 tons at Craigie's Bridge and 3,008 tons at West Boston Bridge.

Traffic over Highway Bridges across Charles River.

Name of Bridge.	Date.	Foot Passengers.	Teams.	Cars.	Car Passengers
Charles River, . .	June 29, 1892,	6,855	3,565	–	–
Warren, . . .	June 29, 1892,	14,335	6,550	2,320	–
Craigie's, . . .	Sept. 17, 1892,	6,927	4,552	493	11,221
West Boston, . .	Sept. 17, 1892,	3,584	2,953	1,059	28,592
Harvard, . . .	Sept. 17, 1892,	1,487	1,576	146	5,355
Craigie's, . . .	Sept. 8, 1893,	6,704	5,517	496	11,928
West Boston, . .	Sept. 8, 1893,	5,428	3,015	923	20,743
Harvard, . . .	Sept. 8, 1893,	2,515	2,690	270	10,612

Number of Passengers carried Daily across Charles River by Railroads for the Year ending June 30, 1893.

Name of Railroad.	Passengers to Boston.	Passengers from Boston.	Total Passengers.
Fitchburg, ...	5,712	6,192	11,904
Boston and Maine, ...	32,585	32,262	64,847
Total, ...	38,297	38,454	76,751

Appendix No. 3.

Heights of Ground Water in Filled Lands.

Note. — The figures give heights in feet above Boston city base, which is .64 feet lower than mean low tide.

Back Bay District.

Location.	Jan. 1878.	Feb. 1878.	Mar. 1878.	Mar. 1885.	Dec. 1893.	Jan. 1, 1894.
Commonwealth Avenue, near Arlington Street,	–	8.3	8.5	7.9	7.6	8.0
Commonwealth Avenue, between Arlington and Berkeley Streets,	–	8.1	8.2	8.1	7.7	7.8
Commonwealth Ave., between Berkeley and Clarendon Streets,	–	7.9	8.1	7.9	7.6	7.8
Commonwealth Avenue, between Clarendon and Dartmouth Streets,	8.0	8.1	8.2	8.3	8.4	8.6
Commonwealth Avenue, between Dartmouth and Exeter Streets,	7.8	7.9	8.1	8.0	8.2	8.5
Commonwealth Avenue, between Fairfield and Gloucester Streets,	7.1	7.3	7.5	7.5	7.5	7.9
Newbury Street, near Hereford Street,	–	–	–	–	–	4.3
N. Y., N. H. & H. R.R. yard at Berkeley Street,	–	7.6	7.5	6.7	7.5	7.2
Columbus Ave., corner Berkeley St.,	–	–	–	–	–	4.5
N. Y., N. H. & H. R.R., near Yarmouth Street,	–	–	–	–	–	7.7
N. Y., N. H. & H. R.R., near Garrison Street,	–	–	–	–	–	8.1
N. Y., N. H. & H. R.R., between Massachusetts Ave. and W. Newton St.,	–	–	–	–	–	9.2
N. Y., N. H. & H. R.R., near Gainsborough Street,	–	–	–	–	–	6.3
Corner Caledonia and Falmouth Sts.,	–	–	–	–	–	8.0
Brighton.						
Beacon Park, near B. & A. R.R.,	–	–	–	–	10.7	–
Cambridge St., opp. N. Harvard St.,	–	–	–	–	8.7	–
No. 298 N. Harvard St., near Coolidge Road,	–	–	–	–	10.6	–
Western Ave., opp. Cordage Works,	–	–	–	–	12.6	–
No. 495 Western Ave., near Market St.,	–	–	–	–	14.0	–
Cambridge.						
Chestnut St., near Grand Junction R.R.,	–	–	–	–	14.0	–
No. 10 Somerset Street,	–	–	–	–	8.2	–