REPORT

ON

Milwaukee Water Works,

SUBMITTED BY

E. S. CHESBROUGH,

CIVIL ENGINEER,

TO

HIS HONOR THE MAYOR

AND THE

COMMITTEE ON WATER WORKS,

OF THE

CITY OF MILWAUKEE,

October 28th, 1868.

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REPORT.

CHICAGO, OCTOBER 28TH, 1868.

To His Honor the Mayor, and the Committee on Water Works, Milwaukee.

GENTLEMEN:—In seeking to supply a city with water the first and most important question should be, where is the available source from which to obtain this supply in undoubted purity and in sufficient quantity, not only for present, but for probable future wants? Where several such sources present themselves, it is evident that the one from which the city could be supplied most economically should be selected.

Fortunately in the case of Milwaukee there are several sources from which the city might be supplied, either of which in the absence of the other, would be considered very satisfactory as compared with the water, especially that of wells, now used in many cities of this and other countries. Well waters in large cities while they retain their coolness and clearness, and are drank with pleasure by those accustomed to them, often become contaminated by infiltrations, from privies, cess-pools, stables, &c., which are causes or promoters of disease. Three principal sources present themselves for the supply of Milwaukee; these are Lake Michigan, the Milwaukee River and the small lakes west of the city, sufficiently elevated to supply water without the aid of pumping machinery, or, as usually expressed, by gravitation alone.

The quality of the water in two of these sources, the Lake and the River, together with that of the town pump, has been analyzed by Mr. Gustavus Bode, of the firm of John H. Tesch & Co., of Milwaukee, and a copy of his report to the Mayor will be found in appendix A.

It will be seen from that analysis that the water of Lake Michigan is chemically much purer than that of Milwaukee River, and there can be no doubt of its pleasanter taste. It is said however, that for washing purposes, the water of the River is preferred to that of the Lake. If this is generally the case it must be owing to a neutralizing effect upon each other, of the various constituents of the river water.

No analysis has been obtained of the water of the small lakes, but from Dr. Lapham's description of the district in which they lie, it is not probable that they would, throughout the year, furnish as pure a supply as that of the river above the city. For reasons which will be given further on, no surveys have been made to these lakes, or recommended with reference to the proposed supply of Milwaukee.

PROJECTS FOR OBTAINING WATER FROM LAKE MICHIGAN.

A great many projects might be suggested for this purpose, all however mainly dependent upon the point from which the water is to be taken, and the reservoir site to be chosen: for a variety of modes of conveying, elevating and distributing the water might be adopted for either project.

Owing to the situation of the city with reference to the lake shore and the mouth of the river, and to the effect of prevailing winds, it will be taken for granted in the discussion of this subject, that some point *north* of the entrance to the harbor should be selected and that this should be as far north as a reasonable regard to cost of construction would allow. This will be necessary to avoid the possibilities of having the supply to the city injured by the constantly increasing amount of filth that must flow out from the river as the city increases in population.

With regard to the point from which the lake water should be taken it is evident there is no restriction, such as there is with reference to a reservoir site, and therefore the question of reservoirs will be considered first.

The advantages usually expected from reservoirs in cities are, 1st, the greater ease with which a constant supply can be given day and night from a uniform elevation. 2d, the ability to make repairs between the reservoir and the source of supply, without depriving the inhabitants of water; and the opportunity afforded of letting turbid water become clear by settling. The first mentioned advantage is a constant one, and frequently of very great importance, especially where most of the supply for a city is required within twelve or sixteen hours of the day. In this case a much smaller engine, working twenty-four hours in the day, with the aid of a reservoir, would answer the purpose, than would be necessary if there was no reservoir. To obtain this advantage however, a very large reservoir is not necessary, one holding a little over half a day's supply being sufficient. The second advantage in case of a serious accident, or the necessity for extensive repairs, would be great, and for this purpose a large reservoir is important. The third advantage is one that would be desirable in Milwaukee, as the Lake water is occasionally turbid much further out than it would be practicable to take it ; but it could hardly be considered a necessity. The greatest turbidity ever found in the lake water at a short distance from the shore would not have any effect upon its healthfulness, and any objection to its looks could easily be removed by filters in private houses.

If, however, it should be deemed important to supply the city at all times with perfectly clear water, then as large a reservoir as practicable would be required.

In case the supply should come from the Milwaukee River, a reservoir sufficiently large for settling turbid water would be exceedingly desirable if not absolutely essential.

Surveys have been made of three reservoir sites: 1st, the high ground in the Sixth ward, just west of the mill-dam; 2d, a portion of the high ground in the Fourth Ward on the north side of Spring St. and west of 23d st.; and 3d, of the block belonging to the city in the First Ward, and considered as appropriated for the purpose of a reservoir.

The results of the surveys show that it would be practicable to construct a reservoir with a top water level of 150 feet above the Lake, with dams of earth, and holding when full upwards of 33,000,000 U. S. gallons, in the Sixth Ward; a much larger one of the same height in the Fourth Ward; but that it would be very expensive to construct one of earth the same height above the Lake, and containing only 10,000,000 gallons in the First Ward. By reducing the height of the reservoir 35 to 40 feet and extending its limits outside of the city property, it would be quite feasible to obtain one of a much larger capacity; but this would be at the sacrifice of a very great advantage in the supply of buildings in elevated portions of the city, and in the extinguishment of fires. For these reasons it has been thought best not to consider any height less than 150 feet above the Lake for the top water level of a reservoir. Even with this height there would be danger of frequent complaint of scarcity of water in the elevated portions of the city, at any great distance from the reservoir. The experience of all large cities supplied with water through pipes of the usual sizes, from a common reservoir, fully proves this.

Owing to what appeared to be the desire of the committee, the first plan and estimate were made for a reservoir capable of holding 20,000,000 gallons, in the Sixth Ward. From the irregularity of the ground it was a work of some time and labor to determine the most economical form and position for such a reservoir. In doing this it was ascertained that the ground would admit of a still larger reservoir and consequently other trials and estimates were made until it was found that without going north of the south line of Lee Street it would be quite practicable to obtain one capable of holding 33,000,000 gallons. As to the necessity or desirableness of a reservoir of this size or even of one capable of holding 20,000,000 gallons, this question will be discussed further on.

On the supposition that it might be desirable to begin with as small a reservoir as practicable and enlarge hereafter, plans and estimates have been prepared for reservoirs holding 2,000,000, 3,000,000 and 10,000,000 gallons. The circumstances under which it might be advisable to make a temporary use of one of them, will also be mentioned below.

In the construction of a reservoir it is proposed to have the top water level 20 [illegible] above the bottom. This depth would be abundantly sufficient to prevent the [illegible]wth of aquatic plants and to preserve the water comparitively cool. The [illegible]nks are to be raised 3 feet above the top water level, and 12 feet broad there. [illegible]he banks are to slope each way, one and a half horizontal to one perpendicular, all vegetable loam must be carefully removed from the basis of the banks, which are to be made in layers of earth six inches thick, each layer to be thoroughly consolidated before the next is put on. The inside slope is to be covered first with two feet of puddle, then with one foot of broken stone or gravel, and then with a paving one foot thick of rubble stone.

The outside slope of the bank is to be covered with vegetable loam eighteen inches thick, and then carefully sodded over. In the center of the top of each bank there is to be a gravel walk six feet wide and three inches thick, on a layer of broken stone twelve inches thick; the remaining three feet on each side to be made as the surface of the outside slope.

In the actual construction of the work, it will probably be found better to put more gravel between the puddle and the stone paving, near the top of the dam, than one foot, on account of the action of frost.

It is proposed to lead the influent pipes into the reservoir through an arched chamber of masonry in the dam, and to take out the effluent pipes through a similar structure.

In case a large sized reservoir should be adopted, it is proposed to build a wall of masonry or earthen dam across its middle and thus be able to use one portion ordinarily as a settling reservoir. Should repairs or cleansing be necessary, one division could be emptied and the other used for supplying the city. In this case the influent and effluent pipes should enter and leave the reservoir in the line of the dividing wall. An overflow well, and a passage controlled by gates between the two divisions should be built in the wall, or dividing dam.

If a small sized reservoir should be adopted, it is proposed to connect the influent and effluent pipes around the outside of the reservoir, so that, in case this should require cleansing or repairs, the supply to the city need not be cut off, though it would be less uniform and require greater care in working the engines. This method of connecting the influent and effluent pipes will be seen on the drawings.

The natural soil in which the reservoir, if in the Sixth Ward, would be made, is sufficiently retentive to require very little if any puddling on the bottom. For convenience in cleansing, the bottom should be paved with cobble stones or covered with 6 inch of concrete, and graded with a slight inclination to one point from which the bottom could be drained.

There is reason to believe the natural soil at the bottom of the other reservoirs would be very retentive, but the same proof of it is not at hand.

The results of estimates of reservoirs in different parts of the city will now be stated.

The details of those estimates will be found in appendix B.

Locality.	Height in feet of top water above Lake.	Capacity in U. S. Wine Gallons	Earth or Masonry.	Cost.
Sixth Ward............	150	2,000,000	Earth.	$35,952 22
" "	150	3,000,000	"	40,000 00
" "	150	10,000,000	"	82,510 17
" "	150	20,000,000	"	135,817 55
" "	150	33,000,000	"	264,154 03
First Ward......	150	10,000,000	"	268,392 57
" "	150	3,000,000	Masonry.	139,362 79

On account of the distance of the Fourth Ward Reservoir from any of the proposed pumping works, it has been left out of the present comparison, but it might be made very useful hereafter in case enlargements should be needed. Many other sizes and forms of reservoirs could be suggested, but the foregoing are believed to be enough, so far as this branch of the subject is concerned, to decide upon a general plan.

The next branch of this subject to be considered is the *plan of getting water to the reservoirs.* This must depend very much upon the source from which the supply is to be taken. For obtaining Lake water, four leading projects have been considered : one by means of a tunnel from a point 3000 feet out from the shore, on a line about N.W. to pumping works on the west side of Milwaukee River just below the dam, and thence by a force main to the Sixth Ward Reservoir ; one by means of a flexible cast iron inlet pipe from a point 700 feet out in the Lake to pumping works about 100 yards north of the line proposed for the tunnel, thence by a force main to the Sixth Ward Reservoir : this will be called *No. 1 Lake Shore Project* : one by means of a flexible cast iron inlet pipe from a point about 700 feet out in the Lake, to pumping works on the shore opposite the proposed First Ward Reservoir, and thence by a force main to the Sixth Ward Reservoir ; this will be called *No. 2 Lake Shore Project ;* and one commencing about 500 feet north of the last mentioned, and connecting with the First Ward Reservoir ; this will be called *No. 3 Lake Shore Project.* These plans will be more minutely described in the order in which they have been mentioned. 1st, The tunnel plan. This was suggested in consequence of the success of the Chicago Lake Tunnel, and the apparently similar advantages for constructing such a work in Milwaukee. It is proposed to make it 6250 feet long, but in all other respects substantially the same as that work which is 10,567 feet long.

See drawings 1 and 2 for further particulars.

The advantages of the tunnel over plans for taking the water near the shore, would be much greater freedom from turbid water caused by easterly winds, and the consequently more frequent necessity of cleansing the reservoir and flushing the pipes. If the experience of Chicago may be taken as a guide, there would be much less trouble with ice, and far less annoyance from small fish. Whether there would be much less trouble from offensive river water during or just after heavy freshets is by no means certain, for at such times the river may send its water two or three miles out into the lake, there to be driven in whatever direction the prevailing winds may take it.

The cost of the Chicago Lake Tunnel was $457,845, including an acknowledged profit to the contractors of at least $50,000, as well as all extras, preliminary surveys and other expenses, superintendence, contingencies and every other items of expense paid by the city, through the Board of Public Works, from the first inception of the tunnel, till after the introduction of water into it. Supposing the ground at Milwaukee to be equally favorable to the construction of such a work, and estimating its cost in proportion to its length, then one for your city would cost $271,000—say $280,000. It is true this mode of estimating does not allow quite enough for the crib and shaft work, but the error on this account could not exceed $10,000, which could be more than made up by taking advantage of the experience gained at Chicago.

Is it certain that the ground at Milwaukee is as favorable as it was at Chicago, for the construction of such a work? This question can only be decided by making extensive borings at a cost of several thousand dollars, and as no appropriation for such an expenditure has been made, they, of course, have been omitted. They could be made at any time hereafter, should the committee upon further consideration deem the tunnel plan the most desirable.

It is proposed to make the upper part of the land shaft of the tunnel, a gate chamber containing three compartments, one to admit water from the lake, and two furnished with gates to control the flow of water to the pumping wells. The land shaft to be located east of the canal, and the pumping wells on the west of the canal, just west of the Humboldt Avenue. The short tunnels from the gate chamber to the pumping, to be circular, 4½ feet in diameter and constructed in other respects like the main tunnel. The pumping wells to be circular, 32 feet in diameter each, and 26¼ feet deep below the level of the canal, or twelve feet below low water of the lake. These wells to be formed by building their curbs first on the surface of the ground and then sinking them by excavating the earth from within them. This process seem judicious on account of the troublesome nature of the soil above the clay, which is not reached in that vicinity, till you get about 12 feet below the surface. The bottom of these wells to be formed by heavy oak timbers and planking, concrete and brick masonry, resting on each other. On these bottoms thus prepared the foundations for the pumps and engines are to be placed, In the first construction of the works it would not be necessary to sink more than one of these wells. By making it a little oval in form and placing a division wall across it in connection with the foundation of the engine, it could be made to answer the purpose of two wells, so that one compartment might be in use, while the other was empty for the purpose of repairing the pumps or cleansing the well. (See drawing No. 3.) The probable cost of the gate chamber, one pumping well and the connecting tunnel, judging from the cost of similar work at Chicago would be $40,000, including the various contingencies which it is so difficult to estimate, before commencing works of this kind.

The Engine House and grounds have been considered carefully, and plans prepared. (See Drawings 3 and 4.) The great variety of plans that might be presented for such a purpose by judicious and well instructed persons, would make it presumptious to say that those laid before you are the best that could be arranged. The most that has been aimed at was to show how a building could be erected, sufficient for present purposes, at the same time admitting of additions or enlargements to meet future wants, and yet such as would look well in both cases.

By examining the drawing it will be seen that a building is proposed with a centre and two wings fronting on the river. The centre to be 92 by 64 feet, and each wing 64 by 45 feet. The centre to be two and a half stories high, and the wings one and a half each. The foundations to be of rough stone masonry, the walls to be of brick and the roof to be mostly of wood, the chimney to be 110 feet high above the main floor of the centre building, eight sided, 13 feet across at the base and tapering to 8 feet near the top and to be built of brick. In the first construction of the works only the centre building would be necessary, the western half of which could be used for the boiler room, repair shop and offices. In order to provide storage room for coal, sheds would have to be built near the engine house. For this purpose it is proposed to grade the steep ground at each end and back of the engine house, and to build retaining walls and slips as shown on the drawings.

The estimated cost of the Engine House and grounds complete, according to this plan is $60,000—but at first it is believed that work to the value of $25,000 might be omitted, leaving an expenditure of only $35,000. A still further reduction in the first outlay might be made by substituting wood for brick. Though objectionable in some respects, especially on account of fires, it would have the advantage of giving a sufficiently long time to determine by actual experience what the future wants of the city will require in the way of permanent buildings than can be done at present. Besides, eight or ten years hence, the city authorities might feel much more able to erect a structure in which all classes would delight, it being well known that the Pumping Works of a large city are one of its chief attractions, not only to its own inhabitants, but to strangers. There is scarcely an engine house of this kind in the country, more than two or three years old, the owners of which do not desire it was either larger, or more convenient or more attractive in appearance.

Next in order comes the question of *Pumping Engines.* Much examination has been given to this subject, yet much uncertainty remains. Fortunately this uncertainty, so far as the interest of large cities are actually concerned, is of no great practical importance, notwithstanding so much has been said and written to prove the contrary.

Several important points must be kept in view when an attempt is made to decide upon the relative merits of different kinds of pumping engines, such as first cost, quantity of fuel required to perform a given amount of work, cost of maintenance, (including salaries, repairs, oil, waste, &c.,) durability and liability to serious accidents. A simple glance at these points will show how utterly impossible it is to decide upon the relative merits of different kinds of pumping engines by trials of only a day or two in duration, even if those trials were always conducted by the ablest and fairest persons to be found. Only years of such actual use as is required in the supply of cities, can settle beyond a doubt some of these questions. Economy of fuel alone, though very important, is not the only item to be taken into consideration. The condition of the engines as to deterioration must be taken into account. A few years since, it was the very general belief, that Cornish Engines were decidedly the best, not only for draining deep mines, but for supplying cities with water. This belief is not so prevalent as it was, either in this country or Great Britain. Now it is known that equally satisfactory results have been obtained by other forms of engines.

For the present purposes of this report it will be considered sufficient to include an amount known to be enough to secure the erection of twc pumping engines with all their appendages complete, capable, each, of supplying the city with 7,500,000 gallons daily, or, not less than 50 gallons to each inhabitant, until the population becomes 150,000. For this purpose $125,000 is known to be sufficient, whether a crank and fly wheel, or a Worthington engine be adopted. If it should be thought best to adopt a Cornish Beam Engine, about 50 per cent. more should be added. There will be time enough to decide fully upon the form of engine after the general plan of the works shall have been adopted.

To attempt a description of the different forms of engines above mentioned, would uselessly encumber this report, and it will be considered sufficient to say that Cornish engines have been adopted in Lousiville, Jersey City and Cleveland, Crank and, fly wheel engines in Brooklyn, Chicago and St. Louis, and Worthington engines in Cambridge, Charleston and Newark, while all these will be found soon in Philadelphia, that city having recently contracted for a Worthington engine.

It is proposed to connect the pumping works with the reservoir by a two feet cast iron main, at an estimated cost of $900, or, for 1400 lineal feet $12,600, supposing the 33,750,000 gallon reservoir to be adopted, or, for 1200 lineal feet, in case the 3,000,000 gallon one should be adopted, $10,800. In either case it is proposed to avoid going across property that does not belong to the city or the R. R. Co.

In connection with the tunnel and other plans that fix the reservoir in the Sixth Ward, it is proposed to lay down the following large mains to supply the general distribution throughout the city, viz: 11,260 lineal feet of 24 inch pipe from reservoir via North Hubbard, Lloyd and Fourth streets to Spring street, 26,030 lineal feet of 16 inch pipe on Fourth street, south of Spring to near the Menomonee River, thence via Union Lake across the River; Main and Division streets, and across the River to the Reservoir; and between Main and Forest, on Wisconsin and Spring streets crossing the River.

10,290 lineal feet of 12 inch pipe on Wisconsin street, between Marshall and Main; on Vliet, between Fourth and Eleventh; on Spring, between Fourth and Eleventh, and on Walker, between Greenbush and Jones.

9,880 lineal feet of 8 inch pipe on Marshall street between Division and Wisconsin; on Main between Division and River; on Buffalo between Main and Jackson, and on Eleventh, between Walnut and Spring.

More careful future examinations may show desirable changes in this arrangement of large mains, but for present purposes this project is deemed sufficient. It will be seen that it provides for a complete circuit from the reservoir through the west, south and east portion of the city back to the reservoir, also for a connection on Wisconsin and Spring streets, between the east and west side mains, which would be of great importance in case any portion of the main circuit should be interupted by accidents or other causes.

It is proposed to make the river crossings by means of wrought iron syphon pipes let down into beds prepared for them by dredging.

The following is an estimate of the probable cost of the system of large distributing mains, viz :

11,260 lineal feet, 24 inch pipe laid at $9.00 - -	$101,340 00
26,030 " " 16 " " " " 5.50 - -	143,165 00
10,290 " " 12 " " " " 3.50 - -	36,045 00
9,880 " " 8 " " " " 2.40 - -	23,712 00
Allowance for extra cost of 1200 lin. feet of syphon pipe above regular cost of 24 in. pipe, including dredging and all other expenses, at $17.00 - - - -	20,400 00
Two 24 inch stop cocks, - - - - - -	600 00
Ten 16 inch stop cocks, - - - - - -	2,000 00
Four 12 inch stop cocks, - - - - - -	500 00
Four 8 inch stop cocks, - - - - - -	320 00
Eight 6 inch blow offs, - - - - - -	400 00
	$325,452 00

The arrangement of smaller distributing pipes, including all those of 6 and 4 inch diameter would be essentially the same, whatever general plan of supplying the city might be adopted. The quantity of these pipes to be laid down will depend upon the views of those in authority at the time with regard to the estimated amount of actual revenue or public benefit that would justify the necessary outlay, without attempting to designate streets or localities in which such pipes should be laid, it will be considered sufficient for present purposes, to assume that before the works can be completed, not less than 50 miles will be demanded. Calling one half 6 inch and the other 4 inch, and allowing $1.60 a running foot as an average cost of both sizes, this rate will be found sufficient according to Chicago experience to cover all expenses of laying, repairs of streets, stop-cocks, fire hydrants, superintendence and contingencies, at present prices for labor and materials. Fifty miles or 264,000 lineal feet would then cost $422,400.

The following recapitulation of the cost of the different items, going to make up the total of the tunnel project, is based on the adoption for purposes of comparision, of 10,000,000 gallon reservoir :

Tunnel, crib and shafts, - - - - - - -	$230,000 00
Gate chamber, pumping wells and connections, - -	40,000 00
Engine house and grounds, - - - - - -	60,000 00
Pumping engines, - - - - - - - -	125,000 00
Force main, - - - - - - - - -	12,000 00
Reservoir, (10,000,000 gallons,) - - - - -	82,510 00
Large distributing mains, - - - - -	328,432 00
General distribution, - - - - - - -	422,400 00
	$1,350,342 00

The next project in order is, *No. 1 Lake Shore*, occupying nearly the same ground as the tunnel project, but taking the water from a point much nearer the shore.

To avoid the uncertainties and risks of a tunnel, in the present lack of absolute knowledge with regard to the nature of the ground, it is proposed to take the water from a point about 700 feet from the shore. There are three general modes of accomplishing this ; one by means of a basin, extending a short distance along the shore and out into the Lake, to protect the inlet entrance from being suddenly choked up with drifting sand and gravel ; one by means of a covered and protected aqueduct, rigid in structure, either of wood, masonry or iron ; and one by means of a flexible iron pipe, laid in a dredged trench, deep enough to be out of danger. The first of these modes, adopting a break-water of piles, filled in with stones, would be the cheapest, but much the most expensive to maintain, not only on account of the perishable nature of the pile work, but on account of the tendency of the basin to fill up gradually with sand. If solid masonry should be adopted instead of pile-work, this would be very expensive and would not prevent the basin from filling up with sand entirely, though probably would to some extent.

The second mode is very difficult to construct in a satisfactory manner, and liable so to change the shore ultimately, unless laid quite deep, as to cause the inlet entrance to fill with sand.

The third mode, though quite expensive at first, would be free from the objections against the other two. It consists of a cast iron pipe with flexible joints. In principal for such purposes, this is no new thing, having been adopted by the great Watt for crossing the Clyde at Glasgow. Various modifications of it have been used at different times and in different countries since. For the purposes of this report it is proposed to adopt the patent of Mr. John Ward, of Jersey City, who has recently been very successful in putting down such pipes and who estimates the cost at about $1.00 per inch in diameter for each running foot of pipe, but who of course would require a careful survey of the shore and bottom of the lake, with the necessary soundings before making a proposition to do the work. A length of 750 feet of 36 inch pipe, would be ample for a sufficient quantity of water for many years to come, and go far enough out to avoid all probable troubles from floating ice, and would be much less likely, to harbor small fish, than a basin would. The estimated cost of this would be $28,800.

The pumping wells and their connections with the inlet pipe, need not be so deep by several feet as those for the tunnel project, but as the difficulties that may be encountered from boulders, and a great influx of water cannot be estimated with certainity, an allowance of $25,000 will be made for these items. It is hoped that at least a quarter of this would not be needed.

For the Engine House, the plan suggested for the Tunnel project would be sufficient for this. The estimated cost will therefore be the same with the addition of $5,000 for a stronger protecting wall against the waves of the Lake.

The pumping engines will be considered the same for this as for the tunnel project, although theoretically, they should be a little more expensive to meet the greater strain required to pump through a longer force main.

There should be on top of the hill, just above the pumping works, a coal yard, the land for which will be estimated at $5,000, fencing and sheds say $3,000, a coal chute from the top of the hill to the boiler room, say $1,500, and a stairway for visitors, as well as the workmen, say $1,500. It would be safe and expedient to have a stand pi, e on top of the hill, connected with the force main ; but this need not be over 80 feet high, and might be constructed without an enclosing tower, yet, with sufficient ornament not to appear unsightly. at an expense not exceeding $5,000.

The force main between the pumping works and the reservoir, would be 4,800 feet long, it is proposed to make it 2 feet in diameter, crossing the river and canal just below the dam, by wrought iron syphons of the same diameter—4,800 feet, at $900, would cost $43,200. The extra for the syphon, would be $4,000, and as the pipes must go through private property part of the distance, something should be allowed for land damages, say $5,000, making in all $52,200.

Reservoir and distributing pipes would be the same for this as for the Tunnel project.

A recapitulation then of No. 1 Lake Shore Project would stand thus, viz :

Inlet flexible pipe	$28,800
Pumping well and connection with inlet pipe	25,000
Engine house and grounds, including shore protection	60,000
Pumpings engines,	125,000
Coal yard, chute and steps.	11,000
Stand pipe,	5,000
Force main,	52,200
Reservoir, (10,000,000 gallon.)	82,510
Large distributing pipes,	328,432
General distribution,	422,400
	$1,140,342

No. 2 Lake Shore Project takes the water from a point, the same distance from the shore as No. 1, but nearly a mile further from the mouth of the river, or, on the line of North Street extended to the lake. A similar inlet pipe, engine house, pumping engines, reservoir and distribution being proposed, the only difference being in the force main, which would be 7,450 feet in length, passing southward along Fifth Avenue, thence along the street leading to the south end of Harrison St., and thence along the line of North St. to the reservoir, crossing the river with a syphon 400 feet long. The total estimated cost of this force main is $71,050.

A little over 800 feet of its length, and upwards of $7,000 of cost could be saved, if the rights of way could be secured along the line of North St. extended eastward It would be better to pay that sum than not to diminish the length of the force main as much as possible.

The items of estimated cost of No. 2 Lake Shore project, would then stand thus, viz :

Inlet flexible pipe,	$28,800
Pumping wells and connection.	25,000
Engine house and grounds,	60,000
Pumping engine,	125,000
Coal yard, &c..	11,000
Stand pipe,	5,000
Force main.	71,050
Reservoir,	82,510
Large mains.	328,432
General distribution.	422,400
	$1,159,192

No. 3 Lake Shore Project takes the water about 500 feet further from the mouth of the river than No. 2.

The inlet pipe, pumping wells, engine house, pumping engines, coal yard, &c. would be the same as on No. 2. There would be no need of a stand pipe, and the force main would be but 1000 feet long, 2 feet in diameter and costing at $9.00 per foot, $9,000. The reservoir to be on the square owned by the city in the First Ward, and considered as set apart for this purpose. For the purpose of comparing the different projects, a reservoir containing 10,000,000 gallons with top water level 150 feet above the Lake has been adopted. Its estimated cost as stated before is $268,398. One, 35 to 40 feet lower could be constructed for one-third this amount, but the saving of cost could not compensate for the loss of head in the higher parts of the city ; in fact a large part of the north-western section would be without any supply most of the time. For that part of the city a reservoir with a top water level of 150 feet above the Lake, would not be one inch to high.

From the reservoir, it is proposed to lay a two feet main along Second Avenue, Prospect, Division, Chestnut and Fourth Sts., to Spring St., a distance of 14,850 feet—16 inch pipes from the Division St., along Main southward to the river, thence along Lake St. to Union, thence northward across the Menomonee and along Fourth St. to Spring St., also a sixteen inch pipe southward from Lake St. along Greenbush St. to Railroad St.; also on Fourth, from Chestnut to Walnut, making in all 19,120 feet of 16 inch pipe—12 inch pipe on Marshall St., from Division to Lyon; on Wisconsin St., from Main to Marshall; on Vliet St., from Fourth to Eleventh; on Spring St., from Fourth to Eleventh, and on Walker St., from Greenbush to Jones, making in all 11,610 feet of 12 inch pipe; and 8 inch pipe on Main St., from Division to River; on Marshall, from Wisconsin to Division; on Buffalo, from Main to Jackson and on Eleventh, from Walnut to Spring, making all 9.880 feet of 8 inch pipe. The estimated cost of these large mains would be

14,850—24 inch pipe at $9.00	$133,650
19,120—16 " " " 5.50	105,160
11,610—12 " " " 3.50	40,635
9,880— 8 " " " 2.40	23,712
Extra allowance for 900 lineal feet in 3 syphons at 17.00	15,300
Stop cocks and blow offs,	4,000
	$322,457

The general distribution would be the same by this project as by the others. The estimated cost of the different items of No. 3 Lake Shore Project would then stand thus, viz:

Inlet flexible pipe,	$28,800
Pumping wells and connections,	25,000
Engine house and grounds,	60,000
Pumping engine,	125,000
Coal yard, &c.,	11,000
Force main,	9,000
Reservoir,	268,393
Large mains,	322,457
General distribution,	422,400
	$1,272,050

The next project in order is that of taking the supply from the Milwaukee River, and pumping it up by water power from the canal just west of Humboldt Avenue. This will be called the *River Project*. No detailed plans or estimates have been prepared of the buildings and machinery necessary for this purpose, but such information has been obtained by correspondence and otherwise as, it is believed, will be sufficient for purposes of comparison.

Waiving for the present the question of comparative purity of the River water, it is very important to be assured that there will be at all times, not only a sufficient quantity for the present, and probable future wants of the city, but enough besides to raise that quantity to the requisite height for distribution—Dr. Lapham informs me, that in the fall of 1867, the quantity of water passing through the canal, was only equivalent to 100 horse power. Now if provisions is to be made for a population of 150,000 with 50 gallons daily to each, the theoretical horse power to raise this quantity 150 feet high, would be $\frac{7,500,000\times8\times150}{24\times60\times33,000}=189.1$. But to this should be added at least one-fourth, to allow for friction of machinery and pipes, and effect of backwater making 236.3. The probability is, that 250 horse power would be a moderate estimate. It is therefore evident, that at times, from the very commencement of the work a steam engine would have to be in readiness to meet a state of low water which has already occurred and which, owing to the constant improvement in the drainage and cultivation of the country, is more likely to occur hereafter.

Supposing however there should be no serious objection to the construction and occasional use of a steam engine, it is desirable to know what might be saved in the first cost of the works by this plan, and what in the annual maintenance. Nothing could be said in the first cost in the Force Main, Reservoir, Large Distributing Main and General Distribution. These items, as estimated for the three first described projects, amount to $845,342. To this should be added the cost of wheels and pumps, foundations, flume and gates, house and damages to mill owners on the canal by taking so much of their water ; also the Auxiliary Steam Engine. They are now erecting at a contracted cost of $56,800 at Philadelphia a turbine and pumps with flume and head gates to elevate 7,948,000 gallons daily, 96 feet high or only two-thirds the work of raising 7,500,000 gallons 150 feet high. Fifty per cent. added to 56,800 dollars, would make $85, 200. The foundations and building at a moderate estimate would cost $30,000 more. The auxiliary engine, boiler room and chimney, at least $50,000, and, if $34,800 be added for damages to mill owners, the total of these items would be $200,000, which added to $845,342 would make the total estimate of the River project $1,045,342.

The average cost of raising 1,000,000 gallons of water, 150 feet high by steam, judging from the returns of several of the large cities of our country, was $16. in 1867—This for 7,500,000 gallons daily for 365 days, would be $43,800. The cost of raising 1,000,000 gallons 96 feet high at Fairmount, is reckoned at $2.00 or for 150 feet, say $3.00. The cost of raising 1,000,000 gallons 186 feet high at Montreal appears to be about $3.00 Allowing for difference of currency and prices of labor, that would make the cost rather more than $3.00 for 150 feet high in Milwaukee. 7,500,000 daily for 365 days at $3.00 per million, would cost $8,217. The occasional use and expense of the steam engine should be added to this. If one-tenth of the total annual cost by steam, or $4,380 be added, it would not be extravagant. The probable saving then by the use of water power with occasional use of steam, would be $43,800—less $12,597 or $32,203 per annum, whenever it should become necessary to pump 7,500,000 gallons daily.

The following is a recapitulation of the different projects thus far considered:

Designation.	Estimated cost of construction.	Estimated cost per annum of pumping 7,500,000 gallons.
Lake Tunnel..........	$1,350,342 00	$43,800 00
No. 1 Lake Shore.......	1,140,342 00	43,800 00
No. 2 " "	1,150,192 00	43,800 00
No. 3 " "	1,272,050 00	43,800 00
River..............	1,045,342 00	12,597 00

It will thus be seen that the River project would be not only cheaper to construct, but much cheaper to maintain than the others. Would that difference justify its adoption in preference to the others? The answer to this question depends upon others, which it would be folly in your engineer to attempt to determine. He can only state probabilities as they exist in his mind.

Would the citizens, be generally satisfied with the River water? If they would be, in its present condition, can it be preserved in the future from greater impurities? With regard to the first of these questions, intelligent citizens of Milwaukee appear to differ among themselves. With regard to the second, if the experience of other cities in this and other countries, be taken as a guide, the answer must be no. Baltimore and Hartford have abandoned their river supplies, and Philadelphia and Cincinnati have seriously agitated the question of seeking purer sources; the former still considering the subject, and the latter having fallen hopelessly back upon the Ohio, on account of the very hard water of any other available source.

If river water should be introduced and prejudice to any considerable extent exist against it, the revenue from water rents would be seriously affected, unless there was power to tax the property holders, whether they wanted water or not. It is not enough in a large city, to give the people what you feel satisfied is pure and wholesome water, but it is necessary to keep it above the suspicion of impurity, otherwise they refuse to take it, or demand a supply from new sources, even at an enormous cost.

Should these considerations lead to a preference of the Lake plans, which should be chosen? The tunnel project is the most expensive and the most uncertain, with regard to contingencies. No. 1 Lake Shore is the least expensive, but as No. 2 would cost only about $18,000 more, and takes the water nearly a mile further from the mouth of the River, it should have the preference.

It may be asked here, why take the water from so near the shore, when Chicago has had to abandon its shore supply, and Cleveland and Buffalo, are seeking to get rid of the evil of theirs? The difference between Milwaukee and Chicago in this respect is very great. In the first place, Chicago River is very stagnant, compared with Milwaukee River. The former sends out its filthy accumulations in occasional and large quantities, while the latter being a constantly running stream never becomes so filthy as the former, and very seldom affects the Lake far out. The point at which it is proposed to take the water at Milwaukee, is nearly three miles from the mouth of the River, while the Chicago pumping works are only one-fifth that distance from the mouth of the Chicago River; and yet, Chicago was supplied from the shore, for nearly ten years before serious complaints were made of the quality of the water furnished. The complaints at Cleveland, are said to be only in the winter, and to be caused principally by the oil refineries. At Buffalo, they take their supply from *below* the city, and at a point near, and sometimes over which, the discharge of their river flow. Should the supply from the Lake shore for Milwaukee, become affected by the River, not very probable at present, the city no doubt, would be in a much better position a few years hence, to go a mile or so further out into the Lake, either by means of a flexible pipe or a tunnel, than at present.

The possibility of obtaining a supply from some of the small lakes, west of the city by gravitation alone, as New York, Boston, Baltimore and Albany receive theirs, has been already mentioned. Dr. Lapham, who has furnished so much valuable information for this report, states the distance to the nearest lake that would afford a sufficient quantity at a suitable elevation, to be not less than 30 miles by any practicable route. Supposing the quality of the water to be unexceptionable, the cost of an aqueduct of that length, such as those supplying the cities of Boston and Baltimore, and as small as convenience would allow, would be at least $2,000,000. Supposing the ground to be the most favorable that could be found for such a work, that is a dividing ridge of just the right height all they way, requiring no costly excavations or embankments, no bridges or culverts, and leaving out dams, gate houses, waste, rivers, land and land damages, fencing, &c., the cost could not be less than $1,500,000. If these items be added, the cost at a moderate estimate would be upwards of $2,000,000, making no allowance for a large storing reservoir, which has been found necessary, both in New York and Boston, to enable the cities to supply themselves, while making necessary repairs to their aqueduct. The brick work alone, in the cheapest part of the Baltimore aqueduct, cost $50,000 a mile, before the war, when prices were much lower than they are now. These considerations are deemed sufficient to set aside, for the present, the claims of this project. The time may come, before the present generation passes away, when neither $2,000,000 nor $5,000,000 would be looked upon as a serious objection to gravitation works, provided the supply in quality and quantity was all that could be desired.

In almost every city, during the discussion of a proposed water supply, there are persons who advocate the claims of Artesian Wells, on account of there supposed economy. Very little attention has been paid to them in the preparation of this report, for the following reasons, viz: The quality of the water to be obtained, is always a matter of great uncertainty, the quantity cannot be estimated before hand, neither the height to which it will rise above the surface, and of course, the cost must be a matter of great doubt, till the completion of the works. Artesian Wells that have answered all expectations for the limited purposes for which they were intended, especially in densely populated districts, have failed sometimes in consequence of other wells being a quarter or half a [mile off, sometimes from exhaustion of the subterranean reservoir that supplied them, and sometimes the quality of the water has become suddenly disagreeable. Although several of the largest cities in the old and in the new worlds have attempted to obtain supplies in this way, not one of any important magnitude is known to rely wholly or principally upon such a method.

In determining whether to construct such works as those just considered, it is usually deemed very important to know the probable amount of revenue to be obtained from them. This depends not only upon the number of inhabitants, but upon the comparative characters as to quality and abundance of the existing supply and of that to be introduced, and upon the power of the city to tax every householder along the line of pipes laid, whether he choose to take the water or not. These are questions which the committee can answer better than their engineer. It can be safely said however, if the analysis of well water taken from the town pump near the City Hall, by Mr. Bode, is any criterion by which to judge of the well water of Milwaukee generally, it requires no prophet to say that it will soon be very unsafe to use it. The experience of all large cities has been, that sooner or later, they have been obliged to abandon their wells and natural fountains for most domestic uses and for many important manufacturing purposes. To aid the committee in coming to some conclusion with regard to this matter, the tabular statement of the receipts from water rents in most of our important cities has been prepared. (See appendix C.)

An examination of that statement will show that but one of the western cities mentioned, obtained a water revenue of over one dollar per annum, for each inhabitant of the entire population during the first ten years after the water was introduced, and that none of them have since obtained more than one dollar and a half per annum, for each inhabitant. The actual value however of an abundant supply of pure and wholesome water to a city, cannot be measured entirely, or even principally by the revenue to be collected in dollars and cents. The importance of such a supply to public buildings, for the extinguishment of fires, for increasing the growth of manufactures, and most to be desired of all, for improving the sanitary condition of the city, and consequently its general prosperity, cannot be estimated by a money standard. New York never has received, and probably never will, in direct water taxes, the interest on the cost of her works and current expenses, yet who that knows that city believes for moment she could be induced by any amount of money to go back to her original mode of supply.

In view of the fact that the population of Milwaukee, is not yet 150,000, and may not be for some years to come, and in view also of the present necessity of having the works built by private capitalists who are likely to be governed by the prospect of a sufficient revenue to justify their outlay, it becomes a question of great practical interest,—to know what portion, if any, of the expenditures provided for in the estimated cost could be safely omitted in the first construction.

To begin with the largest items, let the pipes be taken. The estimate for these including the the force main, but not the inlet, amounts to $821,882. Could they not the be made smaller or of cheaper materials, than cast iron. It would not be prudent or advisable to make the pipes for the general distribution any smaller than 5 and 4 inches. All experience in other cities proves this. The large mains, if somewhat smaller, would no doubt answer the purpose for a few years, but it would not be long before others would be called for. To illustrate the importance of having large mains, especially for extinguishing fires, take the one proposed from the Sixth Ward Reservoir to the crossing of Spring and Fourth Streets, a distance of about 11,500 feet. A 24 inch pipe of this length would deliver 5,000,000 gallons daily with a loss of only 15 feet head, while a 16 inch pipe of the same length could not deliver the same quantity in the same time without a loss of 105 feet head. The difference between these two might cause more loss in a single fire than the larger pipe would cost. It would also make the difference, when the supply for the city exceeded 5,000,000 daily, between having the water in the upper stories of the houses, and not having it in even the basements in some portions of the city. It might not be necessary for a few years to lay down all the branches of the large mains, but they would be required for a population of 150,000.

With regard to a cheaper kind of pipe it would be folly to attempt to use it for the large mains. For the small distributing pipes, possible for the 8 inch mains, cement lined sheet iron pipes might be used, if faithfully made and laid down, and great care taken never to put them in newly made or yielding ground, and a saving of perhaps $100,000 in the first cost be effected by it. Such pipes have given great satisfaction in some towns and small cities and have caused great disappointment in others. The propriety of laying them in Milwaukee is, to say the least, doubtful. Wooden pipes of the smaller sizes, wrapped with strips of iron, spirally, and both coated and lined with a bituminous preparation, have recently come into use in some cities in New York, and appear to give good satisfaction. There are about as cheap as the cement lined pipes, and would probably be safer in yielding soils, but they have not been used extensively, sufficiently long, to prove their durability or their merits, as compared with other kinds.

By adopting temporarily a small reservoir of 2,000,000 to 3,000,000 gallons, a saving of $40,000 might be made ; but this could hardly be allowable, if the River project should be selected. In that case a 20,000,000 reservoir would be very desirable to let the frequently turbid water settle.

With regard to pumping engines, it would not be wise to erect machinery that would have to be removed or supplemented in a few years.

By using a temporary structure instead of substantial buildings for the Engine House, some $35,000 might be saved in the first cost, and in the end prove a wise course, as the city, whenever it comes into possession of the works, will be in a better position than at present, to erect a handsome and convenient structure.

Possibly from $200,000 to $250,000 might be saved in the first cost of the works, by doing as above mentioned. The works would however, be worth about as much less as the saving in the first cost.

It would take about two years to construct the works. Interest on the expenditures for construction, and perhaps commissions for the sale of bonds, should be added to the probable cost of the works, but how much, it is not easy to say, as so much depends upon the state of the money market, as well as the times and rates of payments to the contractors.

It should be mentioned here, that while 50 miles of 6 and 4 inch pipes for general distribution are considered ample, for the probable wants of the city, on the first completion of the works, it would no doubt, be necessary to add to them annually hereafter, so that by the time the population reached 150,000, the total length of pipes required for the general distribution will probably be 100 miles; thus increasing the cost of the works up to that time, whatever the additional 50 miles of pipes may cost.

It would be well to secure all the ground that would ever be needed for the largest size of reservoir suggested, so that in case it should ever be thought advisable to construct it, the city might not be compelled to pay, not only high rates for land but to remove costly buildings.

CONCLUSION.

From a careful examination of the foregoing statements, it will be seen, that in the present state of knowledge on the subject, the choice of a plan for supplying the city of Milwaukee with water, lies between "No. 2 Lake Shore" and the "River Project." The former has decidedly the advantage with regard to purity of source at present, and, with the power of making extensions out into the Lake, of maintaining that purity for all time to come. The latter has somewhat the advantage in first cost, and very much so in the probable future cost of pumping. In most cities, if such an alternative were presented, the choice would undoubtedly be made of the Lake supply; but if under your peculiar circumstances you should feel compelled to adopt the River Project, or none, you may congratulate yourselves upon having so good a source of supply to begin with, and trust to the future growth and wealth of the city to construct new pumping works, on the Lake Shore, or a tunnel from the west side of the River, to a point as far out into the lake as may be desirable.

As soon as it shall be determined which project is to be adopted, and whether the works are to be cut down at first to suit a population not much exceeding the present, instead of providing for the probable wants of the city, ten years hence, the full details of the different portions of the work can be arranged and specified; but till then, such a labor would be uselessly expensive and require more time than can be now spared.

What is now presented, is believed to be all that is necessary to enable the Committee to make a judicious selection and recommendation to the City Council of a general plan. After that however, it will be very important to give further consideration to some of the details of whatever plan may be adopted.

The surveys necessary for the preparation of this report, were made by Mr. Theo. D. Brown, of Milwaukee; the drawings and calculations of quantities, by

Mr. R. V. Beaumann, of Chicago ; and Mr. J. C. Chesbrough, has assisted in revising estimates, preparing statistical information and other labors necessary to present the plans and report in their present shape. The Committee as well as their engineer, are much indebted to Dr. I. H. Lapham, for the very valuable information he has so kindly furnished.

Respectfully submitted,

E. .S CHESBROUGH,

Civil Engineer.

APPENDIX "A."

To the Honorable Edward O'Neill, Mayor of the City of Milwaukee :

I herewith present the result of an analysis of three samples of watert analyzed at the request of Dr. H. Huebschmann. The samples of lake water were taken at the foot of Mason St. ; of water from the Milwaukee River, above the dam ; and of spring water, from the public pump, on Market Square. The inclosed table shows the quantities of soluble matter contained therein, the simple substances and the manner in which they are combined. The quantity in each case analyzed, was 1,000 grammes, and the result is expressed in grammes ; but in order to make the matter more clear to those who are not accustomed to the computation of French weights, I have given the corresponding value in Troy grains, calculated for one gallon.

The water all contains more or less of the same soluble matter, but the proportion and amounts greatly vary in the different samples. The salts they contain are harmless, and are, in fact such as are necessary to make them palatable as a beverage, for perfectly pure or distilled water is insipid ; whereas, on the other hand, water containing the salts of lime and magnesia in excess is hard and unfit for manufacturing and ordinary purposes. Besides the soluble salts, the water analyzed contains free carbonic acid, and the river water, a trace of organic matter, too small to be weighed.

Experience has shown, that water holding in solution not over sixteen grains to the gallon is wholesome, and, as neither the lake nor river water contain them in objectionable quantities, they may be said to be preferable to the spring water analyzed, and well adapted to culinary and all other general purposes.

Signed, GUSTAVUS BODE,

of John H. Tesch & Co.

The annexed table shows the analyzed three kinds of Milwaukee water, expressed in French grammes—the quantity analyzed in each case being 1,000 grammes.

	Lake.	River.	Spring.
Total Soluble Matter........	0.1484	0.2772	1.4653
Sulphuric Acid......	0.0051	0.0037	0.0922
Chlorine..................	0.0034	0.0022	0.2509
Silicic Acid................	0.0150	0.0524	0.0396
Oxyde of Calcium..........	0.0514	0.0601	0.1997
Oxyde of Magnesium........	0.0134	0.0470	0.1649
Carbonic Acid........	0.0330	0.0999	0.3466
Oxyde of Sodium...........	0.0669	0.0067	0.2278
Combined as follows:			
Choloride of Sodium........	0.0056	0.0037	0.4134
Sulphate of Soda...........	......	0.0666	......
Sulphate of Lime.	0.0086	......	0.1567
Carbonate of Lime..........	0.0755	0.1073	0.2419
Carbonate of Magnesia......	0.0313	0.0987	0.3463
Silicic Acid................	0.0160	0.0524	0.0396

In Grains, calculated for one gallon U. S. Standard measure.

	Lake.	River.	Spring.
Total Soluble Matter........	8.3041	15.4963	78.5682
Sulphuric Acid	0.4243	0.2027	2.3656
Chlorine........	0.3295	0.1232	14,5384
Silicic Acid................	0.9775	2.9176	2.2128
Oxyde of Calcium..........	3.0619	3.3896	14.1592
Oxyde of Magnesium.......	1.9607	2.6272	9.2141
Carbonic Acid............	1.9779	5,5464	19.6572
Oxyde of Sodium	0.5197	0.3741	12.7288
Combined as follows:			
Chloride of Sodium........	0.4425	0.3660	23.0992
Sulphate of Soda..........	......	0.4721	......
Sulphate of Lime..........	0.6097	......	8.7560
Carbonate of Lime.........	4.3489	6.9993	17.4064
Carbonate of Magnesium....	1.9345	5.5873	23.3504
Silicic Acid................	1.0311	3.0313	2.2128

APPENDIX "B." NO. 1.

ESTIMATED COST OF A PROPOSED RESERVOIR IN THE SIXTH WARD, MILWAUKEE, TO HOLD 2,000,000 U. S. GALLONS.

9731	Cubic Yards	Excavation	at 25 cents		$2,432 75
7839	" "	Embankment	50 "		3,919 50
1683	" "	Puddle	1.50 "		2,524 50
546	" "	Rubble Stone	3.00 "		1,638 00
572	" "	Paving	6.00 "		3,432 00
1434	" "	Outside slope	75 "		1,075 50
740	Square "	Concrete on bottom	1.25 "		925 00
2150	" "	Turfing	25 "		537 50
600	Lineal Feet	Gravel Walk	1.00 "		600 00
		Influent & Effluent Pipe Chambers.			4,000 00
400	Lineal feet of 2 feet pipe laid		8.50 "		3,400 00
	Stop Cocks				1,000 00
	Sewer and pipe for drainage				3,000 00
	Fencing and slope				1,200 00
	Land and Damages				3,000 00
					$32,684 75
	Superintendence and Contingencies 10 per cent				3,268 47
					$35,953 22

APPENDIX "B" No. 2.

ESTIMATE COST OF A PROPOSED RESERVOIR OF MASONRY IN THE FIRST WARD, MILWAUKEE, TO HOLD 3,000,000 U. S. GALLONS.

1706	Cubic Yards	Excavation,	at 25 cents		$426 50
19,477	" "	Filling,	.60 "		11,686 20
654	" "	Puddle,	1.75 "		1,144 50
9939	" "	Rubble Masonry,	1000		99,390 00
1953	Square "	Pavement	1,25 "		2,441 25
57	Cubic "	Brick work,	15.00 "		855 00
135	" "	Coping,	30.00 "		4,050 00
		Cut Work, &c.,			1,500 00
200	Lineal feet of 2 feet pipe,		8.50 "		1,700 00
		Stop Cocks			1,000 00
		Sewer for draining and pipe			2,500 00
					$126,693 45
		Superintendence and Contingencies,			12,669 34
					$139,362 79

APPENDIX "B," No. 3.

ESTIMATED COST OF A PROPOSED RESERVOIR IN THE SIXTH WARD, MILWAUKEE, TO HOLD 10,000,000 U. S. GALLONS.

35,895	Cubic Yards	Excavation,	at 25 cents	$8,973 75
27,674	" "	Embankment,	.50 "	13,837 00
2,482	" "	Puddle	1.50 "	3,723 00
1,223	" "	Broken Stone underpaving,	3.00	3,669 00
1,279	" "	Paving	6.00 "	7,674 00
5,628	Square "	Concrete on bottom	1.25 "	7,035 00
7,770	" "	Slope Dressing	25 "	1,942 00
7,770	" "	Turfing,	25 "	1,942 50
1,050	Lineal feet	Gravel walk,	1.00 "	1,050 00
		Influent and Effluent pipe Chambers,		5,000 00
725	Lineal feet,	2 feet pipe laid,	8.50	6,162 50
		Three-2 feet, and one-1 foot Stop Cocks,		1,000 00
		Sewer and Pipe for drainage,		3,000 00
		Fencing and slope,		2,500 00
		Land not belonging to the city,		7,500 00
				$75,009 25
		Superintendence and Contingencies, 10 per cent		7,500 92
				$82,510 17

APPENDIX "B," No. 4.

ESTIMATED COST OF A PROPOSED RESERVOIR IN THE SIXTH WARD, MILWAUKEE, TO HOLD 20,000,000 U. S. GALLONS.

51,257	Cubic Yards	Excavation,	at 25 cents	$12,814 25
1,108	" "	Filling,	25 "	277 00
55,685	" "	Embankment,	50 "	27,842 50
4,318	" "	Puddle,	1.50 "	6.477 00
2,159	" "	Broken Stone,	3.00 "	6,477 00
2,159	" "	Paving	6.00 "	12,954 00
3,300	" "	Dressing Slopes,	75 "	1,475 00
13,419	Square "	Concrete 6 in. on bottom,	1.25 "	16,733 75
10,000	" "	Turfing,	25 "	2,500 00
1,570	Lineal feet	gravel walk,	1.00 "	1,570 00
		Influent and Effluent pipe chambers,		6,000 00
1,100	Lineal feet	2 feet pipe laid,	8.50 cents	9,350 00
		Stop Cocks,		1,000 00
		Sewer and pipe for drainage,		3,000 00
		Fencing and slopes,		3,000 00
		Land and damages,		12,000 00
				$123.470 50
		Superintendence and Contingencies,		12,347 05
				$135.817 55

APPENDIX "B," No. 5.

ESTIMATED COST OF A PROPOSED RESERVOIR IN THE SIXTH WARD, MILWAUKEE, CAPACITY 33,778,046 U. S. GALLONS.

59,415 Cubic Yards Excavation	at 20 cents	....	$11,883 00
104,815 " " Embankment	50 "	....	52,407 50
7956 " " Puddle inside slope	1.50 "	....	11,934 00
15,841 Square " Outside slope dressing	30 "	....	4,752 30
15,841 " " Turfing	50 "	....	7,920 50
18,648 " " Concrete on bottom	1.25 "	....	23,310 00
4087 Cubic " Rubble inside slope	3.00 "	....	12,261 00
4087 " " Pavement	6.00 "	....	24,522 00
2100 Lineal feet Gravel Walk	1.00 "	....	2,100 00
3565 Cubic Yards Rubble Masonry in Div. Dam.	10.00 "	....	35,650 00
243 " " Brick " " "	20.00 "	....	4,860 00
81 " " Copying " " "	40.00 "	....	3,240 00
800 Lineal feet 2 feet pipe laid	8.50 "	....	6,800 00
Stop Cocks			1,500 00
Sewer and pipe for drainage			3,500 00
Fencing and slope			3,500 00
Land and damages			30,000 00
			$240,140 30
Superintendence and Contingencies.			24,014 03
			$264,154 03

APPENDIX "B." No. 6.

ESTIMATED COST OF A PROPOSED RESERVOIR IN THE FIRST WARD, MILWAUKEE. CAPACITY 10,000,000 U. S. GALLONS.

261,939 Cubic Yards Embankment	75 cts "	...	$196,454 25
3,187 " " Puddle,	1,75 "	......	5,577 25
1,564 " " Rubble stone,	3.00 "	......	4,692 00
1,493 " " Paving,	6.00 "	......	8,958 00
5,278 Square " Concrete on bottom,	1.25 "	......	6,597 50
16,519 " " Slope dressing outside and turfing,	75 cts	......	12,389 25
1,050 Lineal feet Gravel walk,	1.00 "	......	1,050 00
650 " " Outside connecting pipe,	8.50 "	......	5,525 00
Stop Cocks,			1,000 00
1,750 Fencing,			1,750 00
			$243,993 25
Superintendence and Contingencies,			24,399 32
			$268,392 57

APPENDIX "C."

Water Supply and Reservoir—and Population of Several Large Cities.

Name of City.	Date.	Daily Supply in U.S. Gallons.	Water Rents.	Population.	Gallons per Inhabitant.		Water Rent per Inhab't	Remarks.
Boston.	1850	5,837,900						
"	1855	10,346,300						
"	1860	17,238,000	$334,544	177,902	97			
"	1865		450,340					
New York	1850						1.07	
"	1855		674,736	629,810			.94	
"	1860		767,169	813,669			1.34	Taken from Census Reports.
"	1865		974,333	726,386				
Philadelphia	1845	6,142,654	135,465		20.7		.43	
"	1850	5,841,851						
"	1855	11,700,786	327,176	450,000	26		.73	Taken from Report 1865
"	1860	20,382,066	494,424	566,000	36		.87	
"	1865	30,281,019	595,661	725,000	41		.82	17.18 per millon in 1865
"	1866	29,180,396	626,000	750,000				
Brooklyn	1860	3,439,300	256,400	266,661	13		.96	New York Gallons
"	1865	9,643,150	419,106	296,378	32½	2	1.41	
"	1867	12,896,160						
Jersey City	1865-6		141,909					
" "	1866-7		153,193					
Chicago	1860	4,690,673	131,162	109,260				
"	1864-5		229,626	178,492				
Cincinnati	1860	5,000,000	170,308	161,044			1.05	
"	1865	5,616,981	270,321	193,252			1.40	
Detroit	1855	1,487,141	35,000		29¾			Aproximate
"	1860	2,383,661	50,000		32			
"	1865	2,875,380	84,041					
Cleveland	1857	348,664			73¼			
"	1850	710,984	16,987		14.1			
"	1865	1,417,153	41,019		21 8			

Average receipt for 19 cities in 1859, was 7 cents per 1000 gallons.