REPORT

OF THE COMMITTEE ON

WATER WORKS,

APPOINTED BY THE

CITY COUNCIL

APRIL 14, 1866,

WITH THE ANALYSIS OF

LAKE AND RIVER WATERS

BY

PROF. HENRY M. SEELY,

AND THE REPORT OF

WM. J. McALPINE,

HYDRAULIC ENGINEER.

BURLINGTON:
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CITY OF BURLINGTON.
IN BOARD OF ALDERMEN, }

JULY 23D, 1866.

Voted. That the Report of the Committee on Water Works, appointed April 14th, be accepted, and that the Mayor be authorized to have two hundred copies of said report, with the accompanying documents printed for general distribution.

J. R. HICKOK, *Clerk.*

REPORT OF THE COMMITTEE ON WATER WORKS TO THE BOARD OF ALDERMEN.

Your Committee upon the subject of Water Works, respectfully report:

Our City can be supplied with an abundance of water from the Lake by the use of steam power, from Winooski River by the use of water power, and from the rivers in Jericho by gravitation. At no distance less than about eleven miles can we obtain a supply of water by gravitation, from any place, and as this would involve an expense of not less than about $500,000, such a mode of obtaining water is out of the question at this time. The supply of water for our City must therefore be taken from the Lake, or from Winooski River, and in selecting as between the two, we must have especial reference to the quality of the water in each, and the relative cost and expense of constructing, operating and maintaining water works, taking their supply from each respectively.

The subject being an entirely new one to the Committee, it is not to be denied that we commenced the discharge of our duties in a somewhat general and unsystematic way, but the little light that we thus obtained from various sources, soon convinced us that undue haste in adopting any system or plan of water works for the City, might result very injuriously to the prosperity of the City. It is probably true, that at the time of the appointment of your Committee, a majority of our citizens were fully convinced, that although it was well enough to examine other sources, after

all, the Lake was the true source from whence to supply the City with water, and such, at that time, was the conviction of a majority of your Committee. But, as we proceeded with our investigations, it became apparent to us that if suitable works were built to supply the City with water from the Lake, the cost of constructing and the annual expense of operating and maintaining such works would considerably exceed the public estimate, and we therefore turned our attention to the River. Much has been said against the water of Winooski River, so much, that the Committee expected to find it much inferior, in quality to that of the Lake, and in the outset began their investigation by making inquiries of those who had been accustomed to use it more or less for many years, and the information we thus obtained, was of a character so favorable to the good quality of the water, that we felt authorized to incur the expenses of having that and the Lake water analyzed. The result of an analysis of about one quart of water taken from the River at an ordinarily low stage of water and corked up in a bottle marked No. 1 and the like amount of water taken from the Lake about 300 feet west from the west end of Mr. Lindsley's wharf, corked up in a bottle marked No. 2, may be found in the report of Prof. Seeley, which we herewith submit.

We are now satisfied that the quality of the River water is as good if not better than the Lake water.

Some weeks ago we sent for James McDonald, of Albany, a practical builder of water works, for the purpose of acquiring through him such information as we needed to enable us to present to your Board the best plan of water works for the City. Mr. McDonald came, made examinations of the different points from which the water might be taken from

the Lake or River, the proper places for reservoirs, laying pipe, &c., and though he gave us much valuable information and proposed to contract for the building of the works, at a proper time, he was unable to give us any plan, specification or estimates, not being a Hydraulic Engineer.

We then engaged Wm. J. McAlpine, an experienced Hydraulic Engineer, and in company with Mr. McDonald, Mr. McAlpine came on and made such investigations as he deemed necessary for the purpose of reporting plans, specifications and estimates and his report is herewith submitted.

Mr. McAlpine has made his estimates with reference to supplying the city with water. *First* from the Lake by steam power. *Second*, from the River at or near the upper dam at Winooski, by water power. *Third*, from the River near the first Railroad Bridge above Winooski, by water power, and *fourth* from the River near the Railroad Bridge below Winooski by steam power.

His estimate of the cost of the works built according to his plans (not including the cost of the present water works) at the several points referred to, is as follows :

At the first point with iron pipes, $193,095, part cement $181,000.

At the second point with iron pipes, $149,100, part cement $135,350.

At the third point with iron pipes, $165,535, part cement $150,785.

At the fourth point with iron pipes, $167,055, part cement $154,000.

His estimate of the annual cost of operating and maintaining the works when delivering a half million gallons of water daily if raised by steam power, is $5000, if raised by water power, is $1,750, and when delivering a million gallons daily, if by steam power, $9,000, by water power 3,000.

It is not to be presumed that Mr. McAlpine is entirely correct in his estimates, but as we believe him to be substantially so, and as he makes the difference in the cost of the works and the annual expense of operating and maintaining them so much in favor of what he calls his second plan, your Committee havedecided to recommend to you the adoption of this plan, that is, to take the water from the River at or near the upper dam at Winooski.

Mr. McAlpine assumes that the City will unite with mill owners at this point in the erection of a new dam at a cost to the city of ten thousand dollars, which he includes in his estimate of the works at this point.

From enquiries which the committee have made of those who are to be affected in taking the water at this point, we are confident that all water rights necessary to carry out the plan of the Engineer, can be secured upon terms which will not materially vary his general estimate of the cost of his second plan, but to avoid any difficulties that might arise by an unconditioned adoption of this plan, we recommend the adoption of this plan upon the condition that all water rights and privileges required for the successful operation of the plan can be secured upon just and reasonable terms.

The report of Mr. McAlpine is quite extended, but as it will be before you, we have only referred to some of the important results at which he arrives—deeming that sufficient for our present purpose

Some of the bonds authorized by the City, have been printed and are in the hands of the Committee and the residue of them will soon be here.

Respectfully submitted.

T. E. WALES,
L. BARNES,
O. A. DODGE,
P. D. BADLOU,
} Committee.

July, 23 1866.

REPORT OF PROF. HENRY M. SEELY.

MIDDLEBURY. VT. JULY 10, 1856.

L. BARNES, ESQ.,

DEAR SIR:—I hasten to report the result of the analysis of the sample of water marked *No.* 1 and *No.* 2, received from you last week.

They have been examined with care, so far as the time allowed. As Dr. Eddy wrote you there are facts in regard to the character of the waters, which would require much time and not a little expense to determine. These could not be attempted in the space of ten days. The presence or absence of nitrates and the actual as well as the relative action of the waters on lead are questions of inportance if they are to be brought in contact with lead.

I hope, however, the determination of the character of the respective waters, brief as has been the examination, will be of some service in guiding you to a correct decision in regard to the source of supply for the City.

Both waters are slightly alkaline. This alkalinity, however, is feebly marked alike in both.

Both are of good color and not stained by organic matter.

Both hold undissolved matters in suspension and to make either a good water for culinary and particularly for drinking purposes it must be filtered.

No. 1, probably holds more matter in suspension ; but this matter is sooner deposited than in

No. 2, which holds the matter in a more flocculent condition and does not deposit it for a long time.

Both hold in solution a small amount of organic matter.

No. 1, contains according to experiment a shade more of

this organic matter than *No.* 2, which is so far as this is concerned *very* slightly purer.

Both have their own degrees of hardness. An arbitrary standard which need not be described here, was adopted for the determination of their relative hardness which gave uniform results.

This proved that *No.* 1, is *softer* than *No.* 2, still there is a difference which is marked and constant.

The summing of the matter as far as experiment goes is in favor of *No.* 1, which is softer though containing perhaps a trifle more of organic and suspended matter than *No.* 2.

There is not that wide difference in the two waters which would place one far above the other, and in determining which shall be used, probably other facts as expense, etc., will influence the decision.

Permit me to direct attention to an investigation, which can be made only on the ground, to wit; the liability of either to be disturbed by freshets.

The one roiled by every rain, is certainly less desirable than one which is clear from spring to fall.

One sanitary measure, let me suggest—that of forbidding the use of leaden pipes, faucets or reservoirs in the distribution conveyance or storing of the water.

Yours very respectfully,

HENRY M. SEELY.

REPORT OF Wm. J. Mc ALPINE, CIVIL ENGINEER.

STOCKBRIDGE, MASS., JULY 16th, 1866.

To the Mayor of the City of Burlington and the Water Committee :

GENTLEMEN :—In submitting the following report on a water supply of your City, it is proper to remark that I was advised by you that the adjacent country within a reasonable distance was not sufficiently elevated to furnish a supply by gravity, and the examination might be confined to two sources, viz: from the Lake and from the Winooski River near the village.

In company with Mr. Linsley I examined a site for a dam and pumping works at the foot of the gorge in the river below the Railroad bridges, which obviated many of the objections to the river project.

The Winooski river approaches the City as it flows northward, and by following Gough Street and a short cut to the river, a steam engine and pumps placed there would throw the water into the proposed Gough Reservoir through a pipe not exceeding 2,000 feet in length.

The present examination is confined to these four plans :

The population of the City is about ten thousand, which will require, for all purposes, a present daily supply of half a million of gallons. To provide for a future increased population and a larger demand for manufacturing and other purposes, the works should be arranged for enlargement to supply one million of gallons daily without the loss of any of the first expenditure

The machinery should have sufficient power to elevate a

million of gallons of water into the Reservoir in twenty-four hours, and for the present will supply the City by being run but twelve hours daily.

The Reservoir capacity should be equal to twenty days supply or ten millions of gallons, and in an exigency by an economical use of the water, this supply might be made to last a month, and if the rule is strictly adhered to, of keeping the Reservoirs always full, this provision would allow ample time for the making of all ordinary repairs.

At an early day duplicate machinery ought to be provided, and I regard this as so important that if the means provided for the works are not sufficient, I would recommend the Committee to omit laying pipes in some of the least occupied streets and apply the money to duplicating the machinery.

In the case of the first plan where the water is proposed to be obtained from the Lake, I would recommend a small non-condensing engine, and direct acting pumps sufficient to elevate half a million of gallons into the lower Reservoir which could be set up for about $6,000 ; and in the case of the second plan where the water is proposed to be taken from the Winooski river, near the village, I would recommend that both of the wheels and setts of pumps proposed should be put in, which would increase the cost of that plan about $5,000.

The several plans herein discussed are as follows :

THE FIRST PLAN.

The supply of water to be taken from the Lake.

The drains and sewers of the City are and will be chiefly discharged into the Lake at the south end of the City, where the manufacturers will also chiefly be located ; the refuse from which will reach the Lake.

The location of the pump-well should be where the water will receive the least impurity from these sources.

It is stated that the drift, both at the surface and along the bottom of the Lake near the shore in front of the City, is almost always southerly, and this has determined the location of the works at the north end of the City.

The water should be taken from a considerable depth below the surface of the Lake, and from not too near the bottom, so as to secure the purest water at the most equable temperature at all seasons of the year.

A detailed description of the works necessary to carry out the several plans will be found in the annexed specifications. A general description of the first plan is as follows :

A large rectangular pier of timber filled with stones will be sunk in the Lake, nearly in the line of the prolongation of North Street, where the water is twelve or fourteen feet deep, which it is estimated will be at two hundred and thirty feet beyond the line of the present Railroad wharf.

Within this pier will be placed the pump-well and a conduit leading from it to the west face of the pier. Over this well will be placed the pumps, and adjacent thereto, the steam engine, and in a contiguous room the boilers. The whole of which will be enclosed in a brick building, covered with an iron frame and slated roof.

The engine will require to be of about fifty-four horse power when elevating the water into the lower reservoir, and about one hundred horse power when elevating it into the upper reservior. This increase of power will be obtained by raising the temperature of the steam, and the boiler and all parts of the machinery of the engine, pumps and mains must have the strength to resist this increased pressure of

steam on one side, and of the highest head of water on the other.

The pump main will be carried from the pumps to the shore on a solid crib of timber and stone sunk into the Lake and enclosed in a large box filled with charcoal or tan bark, to prevent the water from freezing, and from thence along North Street to the Reservoir at the corner of Gough Street, the water in which will be at an elevation of about two hundred feet above the Lake.

This Reservoir will be of sufficient size to contain eight millions of gallons, with a provision to add to it another section of the same capacity. Both Divisions will require about eight acres of land.

From opposite this Reservoir the size of the pump main will be reduced and extended along Gough to College Street and thence across the University Grounds to a Reservoir on the west slope of the ridge east of the College. The upper Reservoir will be of sufficient size to contain four millions of gallons, with a provision to add another section of the same capacity, requiring about six acres of land.

At the Gough Street Reservoir there will be a stop cock in the branch of the pump main, and another in the extension of the main leading to the upper Reservoir, so that when the lower one is full the cocks in the branch may be closed, and the water forced into the upper Reservoir.

I have been advised that the portion of the City which will be supplied from the upper Reservoir will require not to exceed one-fourth of the whole quantity of water, and when the works are first started, the engine run one day in each week will furnish this supply to the upper Reservoir.

By means of a pipe of ten inches in diameter from the pump main through Locust, and continued by pipes of eight

and six inches through Church Street, and another line of the same size from the pump main through Champlain Street, the supply of water to the central and lower portions of the City will be obtained directly from the Pumps while they are in operation, and when they cease working, the supply will be obtained from the lower Reservoir through the pump main and the above mentioned connections.

While the engine is forcing the water into the upper Reservoir, the whole of the pipes will be subjected to the head due to its elevation, and at other times the pipes in the lower division will have only the head due to an elevation of the lower Reservoir. The pressure on the distribution pipes will also be increased by the head of water necessary to overcome the friction of the water in the pump mains, which will be equal to a head of nearly one hundred feet when the engine is forcing the water into the upper Reservoir.

The inconvenience of this greater head at times can only be obviated by laying an independent supply main along side of the pump main in North Street, which would involve an expense greater than to increase the thickness of the distribution pipes to meet the increased pressure.

It may be here remarked that the house service pipes and plumbing must also provide against the highest head of water.

This great head may at any time be made available and useful in the event of conflagrations, by opening the connecting cocks between the upper and lower services, and in many cases will enable the use of hose without the intervention of fire engines.

The annexed specifications and estimates provide for one of Worthington's most approved Engine and Pumps, or

any other approved plan of Engines and Pumps which will perform the duty required without increased cost of running.

It is not intended to prescribe the use of Worthington's Engine and Pumps in preference to any other. Machinery of suitable character, can be used for this purpose, at an increased cost of a few thousand dollars, which will elevate the water as cheaply as the former.

In prepairing the dimensions of the Engines and Pumps, I have relied upon the statement furnished me, that one-fourth of the water would be required to be elevated into the upper Reservoir. From a personal inspection of that portion of the City, I am satisfied that one-eighth of the water so elevated would give it an ample proportionate supply.

The simplest arrangement of the pumping machinery to meet this problem, would be to use one set to elevate the water into the lower reservoir and another to elevate it from thence to the upper one, and for the latter purpose a simple non-condensing Engine could be used.

This arrangement would reduce the first cost of the pumping machinery from two to three thousand dollars, but would add to the annual cost of raising one-fourth of the water to the upper reservoir, a sum more than twice as great as the interest on the saving in the first cost.

The case, however, would be different if but one-eighth of the water had to be raised into the upper Reservoir, in which event, I would decidedly recommend that the Pumping Machinery be separated, and the one at the Lake should be arranged for only raising the water into the lower Reservoir, and a more simple Engine and Pumps be used for raising it to the upper one.

I have not worked out this plan, but can do so in a short time, if desired by the Committee.

THE SECOND PLAN.

The supply of water to be taken from the River near the village of Winooski.

It is understood that the proprietors of the present water power will concede to the City a preference right, sufficient to elevate an ample supply of water for the use of the City into a Reservoir above the highest occupied portion of the City.

Although the present requirements of the City is but a half a million gallons daily, and the future estimate is but one million, it would be judicious to specify the right to divert one and a half to two millions daily and acquire the preference right of the water power necessary to elevate it to the required height. The preference right of the use of 4,000 cubic feet per minute, (which is supposed to be about one-fourth of the water in the stream in its lowest stages,) would be an ample provision for any future demand for these works.

It is understood that the water proprietors are also willing to pay two-thirds of the cost of the new dam and of the flowage damages.

The estimates of the cost of the second plan are based upon these assumptions.

The new dam will be built a short distance above the old one, on a reef of rocks which extend entirely across the river, the shores of which are also of rock extending above the level of the proposed flowage line in the highest water.

This dam will flow about one hundred acres of land an average depth of four feet and will contain one hundred

and thirty millions of gallons and besides gaining an increased head of eight feet, will nearly double the quantity of water, if the other powers are only run through the day. The value of the Pond may be ascertained by assuming that when the whole power of the water is occupied (say six hundred horse power) and one-half of the machinery in the lowest stages of the stream is not used during the night (twelve hours) the saving of the water which would (without the pond) run to waste at night would add twenty-five per cent. to the whole power used, or more than twice as much as will ever be required for the use of the city. The storage capacity of the Pond which would be saved at every heavy rain, would be equal to a week's supply of the water used for power by the City, and four month's supply for that portion which would be diverted for the use of the City.

These advantages are the inducements to the water proprietors in the proposed concessions to the City, and are evidently fair and equal between the parties.

The proposed dam will be a substantial and durable structure, made of framed timbers, and firmly bolted together and compactly filled with stone, and the bottom timbers of the dam firmly bolted to the rock. The Bulk-head will be a structure of stone protected by timber with cast iron regulating gates, and a flume of six feet in diameter, estimated at 500 feet length, extending to a forebay in the basement of the Pump House. The Pump House is twenty-six by thirty-six feet, the basement of stone masonry and the next story of brick.

The Water Wheels are placed on opposite sides of the forebay, and each are arranged to drive an independent

pair of Plunger Pumps, and also, if necessary, to be disconnected and attached to the pumps of the opposite wheel.

One of these wheels has power sufficient to elevate a million of gallons of water into the University Reservoir in twenty-four hours, and the other one the same quantity in twelve hours. Either of these wheels will perform one-half of the above duty where there is the greatest amount of back water.

The pumping main being so much shorter than in the first plan, the friction of the water will be less and allow the pump main to be reduced to eight inches interior diameter. It will be extended through the Reservoir and connected directly with the distribution pipe, so that the supply of water to the City may be kept up when the reservoir is emptied for repairs or cleaning.

The reservoir will be placed on the same site as that proposed for the first plan, but will contain ten million of gallons with a provision to add another section of the same capacity.

The suply mains for the distribution, will be a pipe of ten inches diameter from the reservoir to and through College Street to White Street and thence down College by a pipe of eight and six inches to Water Street, with one of eight through White, another of six inches northward through Pine, and another southward of the same size through Champlain. A six inch supply main will also be extended through Green and Pearl to Church Street.

In other particulars the distribution will be the same as in the other plans.

The pumping mains in all of the plans are made with increased thickness of iron for three different heads of water, to which they will be subjected.

There will also be three check valves and air chamber in each pump main, to provide against the shock of the water which might from any cause fall back in the main.

THE THIRD PLAN.

From the River near the Railroad Bridges. The dam will be about one hundred feet long of heavy stone masonry, shouldered in the rock at the sides and bottom of the chasm, with a tunnel driven through the side rock for a flume, and a bulkhead, regulating gates, forebay water wheels, Pumps and Pump houses substantially the same as described in the second plan.

The dam will be built to give twelve feet head at the ordinary stages of water, and to provide against back water and the increased friction in the pump main, the water wheels must be of nearly twice the power of those proposed in the second plan.

The pumping main is assumed to be eight thousand feet long and will deliver the water into the University Reservoir as before described.

The Reservoir and Distribution will be the same as described in the second plan.

THE FOURTH PLAN.

The water is to be taken from the River below the Mills, and elevated by steam power through a pipe of eight inches diameter into a Reservoir at the corner of Gough and North Streets, and from thence to the University Reservoir.

The basement story of the Pump-house will be twenty feet high and composed of stone masonry laid in Hydraulic cement mortar. The well will be built in the basement with masonry, and will be twelve feet deep and ten feet diameter.

The arrangement of the Engine, Pumps, Engine and Coal

House, Pump Main Reservoir and Distribution will be the same as for the first plan.

The distribution on the several plans is exhibited in the annexed schedule of pipes, stop cocks, and hydrants.

The City will be divided into three water districts by lines of stop cocks, which will permit the water to be shut off from either without interrupting the supply to the other divisions and permit repairs or additions to be made.

The Fire Hydrants are placed at the corners of all the larger blocks and at the alternate corners of the small blocks, and at all dead ends and neighborhoods where water will be required beyond where the pipes are proposed to be laid.

In consequence of the unusual head of water to which the pipes will be subjected, I have estimated the cost of heavier pipes than usual. This increased weight of pipe will be particularly necessary in the first plan, where the pipes are subjected to an increased pressure, and to the shocks which will sometimes occur where the water is pumped directly into the supply main, and which can only be obviated by a costly stand pipe and very large air vessel.

The estimates for pipes do not include new pipes in those streets where suitable pipes have been laid by the present Water Company, as it has been assumed that the old pipes will be used as far as possible in the new works. An estimate, however, is appended to show the additional cost of new pipes of the requisite size in the place of all of the old pipes proposed to be used. The new pipes would generally be larger than those now in the streets, be more durable and furnish a more complete supply.

I have no information on the subject of the present condition of the old pipes, to enable me to determine whether

they will stand the increased head to which they would be subjected by their connection with the new supply.

The use of wrought iron pipes lined upon the outside, and inside, with hydraulic cement, has now come into general use and are highly approved of by the Water Commissioners and Engineers who have used them. They can be substituted with safety and advantage for all of the pipes in the distribution not subject to shocks. If used they will save about twenty per cent. on the cost of the iron pipes, which has been estimated for.

The estimated cost of the several plans are as follows:

First Plan.—From the Lake.

Pier in the Lake, and to connect with the shore,	$9,000	
Pump well, screens, boxing pump main, Piles, &c.,	3,600	
Engine boiler & coal houses, and chimneys,	11,300	
Steam engine, boilers, pumps and fixtures,	22,000	
Pumping main, check valves, and fixtures,	27,500	
Gough Street and University Reservoir,	30,000	
Distribution pipes, stop cocks and hydrants,	69,000	
Land for two Reservoirs and right of way pump mains assumed at,	6,500	
Water right in the Lake, and purchase of old water works, not included in the estimate,		
Engineering, Superintendence, Inspection and pipe testing,	5,000.	183,900
Contingencies 5 per cent.,		9,195
Total,		$193,095

Exclusive of the cost of the old water works and damages.

The saving by the use of cement lined pipes where it would be safe to use them, would be about $12,000.

Second Plan.—*From the Winooski, near the Village.*

Dam and land damages $30,000, one-third is	$10,000	
Flume, forebay, tail race, &c.,	3,500	
Wheel house, &c.,	6,000	
Water wheels, pumps and geering,	6,500	
Reservoir, including land,	22,500	
Pump main, valves, etc.,	10,900	
Distribution pipes, cocks, hydrants, etc.,	77,600	
Engineering, Inspection, etc.,	5,000.	
		142,000
Add 5 per cent. for contingencies,		7,100
Total,		$149,100

Exclusive of the purchase of the old works. The saving by the use of Cement lined pipes would be $13,750.

The cost of replacing the old water works, pipes with new ones of Iron, would be $24,600, and with Cement lined would be $19,000.

Third Plan.—From the Winooski, near the Railroad bridges. The dam and flowage damages at this place will cost about half as much as at the village—and will furnish a large surplus of power which can doubtless be sold. The sum of $10,000 however, will be charged to this project for the cost of the dam, tunnel, etc., for which sum, a sufficient water power could be made, if it should be decided not to connect any other works with those of the City.

ESTIMATE.

Dam, etc.,	$10,000

3,600 feet extra length of Main, including land, right of way, check valves, etc., $3,25,	11,700	
Extra cost of water wheels and fixtures,	3,000.	$24,700
The cost of the second plan, exclusive of the cost of the dam,		132,000
		156,700
Add 5 per cent. for contingencies		7,835
Total,		$164,535

If Cement lined pipes are used for the distribution, it will save as in the second plan $13,750.

FOURTH PLAN.—From the Winooski, below the Mills.

Pump well, Engine boiler, Coal houses and Chimney,	$12,500	
Steam Engine, Pumps and fixtures,	22,000	
Pumping main, Valves, etc.,	14,100	
Reservoir, Land, Distribution, and Superintendence as in first plan,	110,500.	159,100
Add 5 per cent. contingencies,		7,955
Total,		$167,055

If Cement lined pipes are used for the distribution, it will save $13,000.

COMPARISON OF THE PLANS.

The questions to be considered under this head are :

1st. The purity of the water proposed to be furnished, with reference chiefly to domestic use.

2d. The cost of introducing the required amount of water.

3d. *The cost of operating and maintaining the works.*

4th. The permanence of the pumping machinery.

5th. The probabilities of interference or interruption by the operations of private interests.

1. PURITY.

I have had no access to any analysis of the waters from the several localities proposed for the supply, but in the case of the Lake water, its constant use by the citizens of Burlington and other places on its border, and on the steamers, shows it to be of excellent quality for domestic use, and of fair quality for steam boilers.

The natural waters of the Winooski River are derived from a water shed chiefly of the primitive rocks and flow down the abrupt declivities of the hills and mountains so rapidly, and with less than the usual permeation into the soil, that the pure rain water must reach the streams without absorbing any considerable amount of the earthy salts or minerals, and the water when it first reaches the tributaries of the River must therefore be very soft and pure.

The River flows over a rocky, and in some cases an alluvial bed, but as this alluvial is mainly the decomposition of the primitive rocks, the water cannot be much affected, and it ought to show by analysis more than the usual good quality of River water.

The water in the Winooski, derived, as it is, from the same character of water shed as the Lake ought to show the same quality. The only advantage in favor of the Lake water being, that it has precipitated the minute earthy matter which the motion of the river keeps in suspension.

In ordinary times these particles of suspended earthy matter in the river water are not observable except in large

bodies of water, and are not objectionable for domestic uses. In times of flood the river will contain a large quantity of this suspended matter, and it will require several days of quietness in the Reservoir to precipitate these impurities. But as the Reservoir will contain twenty days' supply of water, there will be but little difficulty arising from this turbid water, and it will be entirely obviated when the second division of the Reservoir is made.

The large pond proposed for the second plan will also act as a settling Reservoir, and greatly purify the water.

On the fourth plan it is proposed to take the water from the river below the village of Winooski and the mills at that place, in passing, which, the water will receive more or less deterioration.

It may be remarked that the Lake water is exposed to deterioration by a prevalence of winds which will drift the drain and sewerage matter discharged from the City, the refuse from the mills and vessels, and the floating garbage in the port to the entrance of the pumps' well, sometimes, to an extent which will prevent the use of the water for several days in succession.

In carefully considering the subject the relative purity of the waters would be in the following order :

First.—From the Lake.

Second.—From the Winooski river at the gorge, and but little inferior to the Lake.

Third.—From the Winooski river above the village, and nearly equal to the Lake.

Fourth.—From the Winooski river below the village, and not suitable for domestic uses, unless it is purified by quiescence or filtration.

2. COST OF THE WORKS.

The estimated cost of the several plans exclusive of the purchase of the old works are as follows :

First plan, with Iron pipes—

	$193,095	with part cement	lined	pipes,	$181,000
Second plan,	$149,100	" "	"	"	135,350
Third plan,	164,535	" "	"	"	150,785
Fourth plan,	167,055	" "	"	"	154,000

The cost of substituting new pipes for the old ones would be if of Iron, $24,600—of cement, 19,000

To the first plan should be added the cost of the water front and reparian right where the engine and pumps are placed in the Lake. But in the comparison of the cost of the first three plans it may be omitted, as an offset to a possible increase in the purchase of the preference right to the water power of the Winooski river.

3. COST OF OPERATING AND MAINTAINING THE WORKS.

The annual cost of running the engine and pumps, including the labor, coal, oil, repairs, &c., on the first and fourth plans when delivering half a million of gallons per day will be $5000, and when delivering a million of gallons, $8,000 ; an extra attendant will also be required at the Reservoirs which will add $1,000 to the cost of operating, and there will be a little more expense in the repairs of the other parts of the work than on the second and third plans.

The annual cost of repairs of the dam and pumping works on the second and third plans, and the wages of an attendant will be, when delivering half a million of gallons daily, $1,750, and when delivering a million gallons, $3,000.

The difference in the annual expenses of operating, and maintenance will be about $4,000 in favor of the river

plans when the works are first started, and $6,000 when they are delivering a million of gallons daily. These sums represent the interest on $55,000, and $85,000 respectively ; and in making the comparison of the cost of the several plans, one or the other of these sums should be charged against the first and fourth plans.

4. THE PERMANENCE OF THE PUMPING MACHINERY.

The works proposed for the first and fourth plans are, on the whole, less liable to accident and injury than the two other plans. The strain upon the machinery and pipes while working are much greater in the first plan, and future enlargements of the wharfing in the harbor may compel the construction of a new pier and supply conduit further out in the Lake.

The dam and works at the river in the second and third plans are provided against the effect of the greatest floods and the plans of the pumping machinery are arranged of great strength, and duplicated so that but little danger of interruption is anticipated.

The formation of ice about the pumping machinery is provided against by a heating apparatus in the wheel pit, and the same provision is made in the pump room on the first plan.

Upon a consideration of the whole question the permanency of the works may be considered as about equal in all of the plans.

5. CONNECTION WITH PRIVATE INTERESTS.

In the first, third and fourth plans the works will be entirely independent of private interests.

The second plan contemplates an arrangement with the water proprietors by which the City obtains a preference

in the use of the water power to an extent equal to the utmost anticipated requirement, and the right of diversion of an ample supply of water for any possible wants of the City.

If this agreement is consumated between all of the parties interested, it will entirely protect the interests of the City and prove mutually advantageous to all concerned.

If the other proprietors should fail to perform their share of the repairs of the dam and bulk-head, the extra expenditure would not be of much account for many years.

Upon a careful consideration of the whole subject of a water supply for the City, I do not hesitate to recommend the adoption of the second proposed plan, if a fair and equitable arrangement can be made with the water proprietors, and if not, that the third plan shall be adopted.

The drawings which I have made to enable me to prepare and estimate upon these several plans will be copied and forwarded to you.

Respectfully submitted,

WM. J. McALPINE,

Civil Engineer.

DISTRIBUTIONS.

In Street.	FROM	TO	SIZE OF PIPE. FROM LAKE	FR. RIVER.	
North &c.,	Pumps,	Gough Res	10 Diam.(L	Diameter.	Pumping Main.
"	Water,	Maiden L.,	4 (L)	3	
"	Maiden Lane,	Gough,	.....	3	
A	Champlain,	George,	4 (L)	3	
Monroe,	"	"	4 (L)	3	
Pearl,	Locust,	Church,	.....	8	Supply Main.
Pearl,	William,	Gough,	6 (U)	6	
Cherry,	Champlain,	White,	4 (L)	3	
Bank,	Church,	"	4 (L)	3	
College,	Front,	Gough,	6 (U & L)	-	Supply Main.
"	"	Champlain	.....	4	
"	Champlain,	St. Paul,	.....	6	Supply Main.
"	St. Paul,	White,	.....	8	" "
"	White,	Green,	.....	10	" "
From corner of	College and	Green to rs	8 (U)	10	" "
Main,	Old Pipe,	Willard,	3 (U)	3	
King,	Water,	St. Paul,	4 (L)	3	
South,	"	"	4 (L)	3	
Adams,	Church,	Union,	4 (L)	3	
In Streets north	of North	Street.			
Water,	North,	1 block nor	4 (L)	3	
Champlain,	"	2 " "	4 (L)	3	
Locust,	"	2 N & N E,	4 (L)	3	
Winooski Av.,	"	1 "	4 (L)	3	
Maiden Lane,	"	2 blocks N,	4 (L)	3	
Gough & Green,	"	College,	8 (U)	-	Supply Main.
" "	"	Main,	.....	4	
" "	Main,	College,	.....	6	Supply Main.
Green,	College,	Main,	4 (U)	4	
Williams,	Old Pipe.	Main,	4 (U)	4	
Willard,	"	Maple,	3 (U)	3	
Maiden Lane,	North,	Old Pipe,	4 (L)	3	
White,	Pearl,	College,	4 (L)	8*	*Supply Main.
Locust,	North,	Pearl,	10 * (L)	3	* " "
Church,	Pearl,	Main,	8 (L)	.....	" "
"	Main,	King,	6 (L)	.....	" "
"	King,	Adams,	4 (L)	.....	
"	College,	"	4 (L)	.....	
St. Paul,	Pearl,	South,	4 (L)	3	
Murry & George	North,	Pearl,	4 (L)	3	
Pine,	Pearl,	College,	.....	6	Supply Main.
"	College,	South,	.....	3	
"	Bank,	"	4 (L)		
Champlain,	North,	College,	8 * (L)	4	Supply Main.
"	College,	South,	6 (L)	6	" "
"	South,	One block,	4 (L)	3	
Water,	Cherry,	Main,	4 (L)	3	
Front,	Pearl,	College,	4 (L)	3	
Elm,	Adams,	Spuce,	4 (L)	3	

*NOTE—The letter "L" appended to the size of the pipes in the column headed "from the Lake" indicates that the supply of water will be distributed under the head of the Lower Reservoir except when the Pumps are run to fill the upper Reservoir. These pipes to deliver the same quantity of water must therefore be as much larger as the difference in head viz. as the square root of 200 & 300. The thickness of these pipes must be sufficient to resist the head of water from the upper Reservoir.

Stop Cocks.	Size of Pipes.	Inches From Lake.	River.
At Pumps at Lake	10	10	
" " " River,	8		8
" lower Reservoir,	10 & 8	18	
" upper Reservoir.	8	8	16
" corner of College and Green,	6 & 8	8	6
" " of College and Williams.	4		4
" corner of College and Willard,	3		3
" corner of College and White,	10, 8 & 6	6	18
" corner of College and Church,	4 & 3	4	3
" corner of College and St. Paul,	do.	4	3
" corner of College and Pine.	6 & 4	4	6
" corner of College and Champlain.	8 & 4	8	4
" corner of College and Water.	4 & 3	4	3
" corner of College and Front.	do.	4	3
" corner of Church and Main.	do.	4	3
" corner of Church and Adams.	do.	4	3
" corner of Pearl and Gough.	6	6	
" corner of North and Maiden Lane.	4 & 3	4	3
" corner of North and Winooski Av.	do.	8	6
" corner of Pearl and White.	6	6	6
		110	98

HYDRANTS AT THE CORNERS OF THE FOLLOWING STREETS.

Green and Main,
Green and College,
Green and Pearl.
Green and North.
William and Main.
William and College.
William and Pearl.
Willard and Maple.
Willard and Main.
Willard and College.
Willard and near Pearl.
Union and Adams.
Union and Main.
Union and College.
Maiden Lane and Pearl.
Maiden Lane and North.
Maiden Lane and end of pipe.
Winooski Avenue and North.
Winooski Avenue and Pearl.
White and College.
Locust and end of pipe.
Locust and North.
Locust and Pearl.
Church and Cherry.
Church and College.
Church and King.
Church and Adams.
Elm and Spruce.
St. Paul and Pearl.
St. Paul and Bank.
St. Paul and Main.
St. Paul and South.
North and Murry.
George and A.
Pine and Cherry.
Pine and College.
Pine and King.
Champlain and end of pipe.
Champlain and North.
Champlain and A.
Champlain and Pearl.
Champlain and Bank.
Champlain and Main.
Champlain and Maple.
Champlain and end of pipe.
Water and end of pipe.
Water and A.
Water and Pearl.
Water and Cherry.
Water and College.
Water and King.
Water and end of pipe.
Front and North.
Front and A.
Front and Pearl.
Front and Cherry.
Front and College.

57, say 60.

FIRST PLAN—SUPPLY FROM THE LAKE.

SPECIFICATIONS.

FOUNDATION PIER IN THE LAKE.

A crib of 120 by 80 feet is to be sunk in the Lake at 150 feet from the wharf line and connected with the wharf by a crib 150 feet long and 15 feet wide. The top of the crib is to be six feet above the level of the water. These cribs will be twenty feet wide at the bottom and eighteen feet wide at the top. Below water they will be formed of four courses of Pine dock logs, not less than six inches diameter at the small end, and ties of the same size, seven feet apart bolted at each intersection.

A floor will be laid of similar logs at two feet above the bottom. *Above* the level of the water the face of the dock, will be of squared white pine timber and the rear and ties as before mentioned. The face sticks will be bolted at each end and at spaces of not less than fifteen feet apart.

The whole is to be filled with stone, with a coating of gravel one foot deep on top. A well chamber ten feet square, extended to a depth of ten feet below water, and with an opening to the west front of the crib of the same size, shall be built up to the level of the water, with square timber and a floor of squared sticks twelve inches deep and planked with two inches pine plank. Above the level of the water the well chamber shall be carried up of masonry.

Similar cribs shall be put in under the Engine and Boiler and for the wharf extending to the shore. Piles shall be driven to give additional support to the chimney, Engine, etc. The piles are to be driven at three feet apart to a depth at least ten feet into the Lake bottom, and to be not less than seven inches diameter at the small end.

The floor of the Engine, Boiler and coal houses is to be made of Pine timbers 40 feet long, 12 inches square, placed on and bolted to the piles and covered with three inch pine plank.

The Roadway on the Pier and that leading to the shore is to be covered with gravel one foot deep.

2. ENGINE HOUSE, BOILER AND COAL HOUSE.

The Engine and Boiler house will be of Brick, 40 feet square and 20 feet high to the spring of the rafters, with an iron framed roof, covered with slate.

The foundation walls will be placed at the level of low water and carried up with the stone to the cut stone water table placed at eight feet above the water. The walls will be two and a half feet broad at the bottom and two feet at the top, made of large, well shaped and bonded stone laid in Hydraulic cement morter.

Similar foundation walls shall be laid under the Engine and Boilers, around the pump, well and under the party wall.

The walls of the buildings will be laid up of smooth hard brick, in hydraulic cement fourteen inches thick, viz: an outside wall of twelve inches, an air space of two inches and an inner wall of four inches, well bound into the outer wall. Above the eaves the gable walls will be ten inches thick. All the face brick will be pressed.

The party wall between the Engine and Boiler room will be eight inches thick furred out and plastered. There will be two doors in the Engine and one in the Boiler room, each six by nine feet, with an arched door light, and three small doors and sixteen large windows, besides two semi-circular ones in the gable ends. All of the doors and windows shall have cut stone caps and sills. The windows are

to be glazed with heavy plate glass 12 x 16, set in balanced sash. The doors are to be hung with heavy strap hinges, latches and locks, and in front a platform and steps of cut stone.

A floor is to be laid over head in the Engine and Boiler room, and the walls and ceilings are to be furred out lathed and plastered and finished with a white hard finish.

Furnace, heating pipes, and registers are to be put up in Engine Boom and Machine Shop.

3. CHIMNEYS.

The chimney will be 60 feet high above the flue entrance, supported by 40 piles as before mentioned, wihch are to be covered by a timber platform of 15 feet square, composed of timber 12 inches square and plank two inches thick. The chimney shall be laid up with best hard brick, with two flues, each of 500 square inches area. An air space shall be built around these flues and the two walls will be banded together. The top of the chimney to be neatly finished off and surmounted with a coping of cut stone.

4. PUMPING MAIN TO THE MAIN LAND.

The crib to sustain this pipe will be 15 feet wide and 150 long and made as described for the other cribs.

The box containing the pipe, shall be six feet square, the bottom placed 1 foot below low water, of 3 inch pine plank, spiked to dock sticks which must be flatted for that purpose.

The pipe will be laid in the centre of this box and the box filled with Charcoal, Tan Bark or some other suitable non-conducting material.

5. ENGINE AND PUMPS.

The Engine and Pumps will be Worthington's improved condensing Engine with expansion attached and a sufficent

power to elevate one million of gallons of water per day, viz: 750,000 gallons 200 feet high through a pipe 10 inches in diameter, 6,000 feet long with steam not exceeding 20 pounds per square inch on the steam piston, and 250,000 gallons through the same pipe and another of 8 inch diameter, 4,000 feet long, into a reservoir 300 feet above the Lake.

Any other steam engine and pumps of a design approved of by the engineer which will perform the above duty, at no greater cost of running, may be substituted. Or, the work may be done with two engines, the upper one being placed at the lower Reservoir and the pump draw its water from either the pump main or the Reservoir, (which ever has the most pressure) by a self acting valve.

In all cases the engines and pumps must be calculated to perform one-third more duty than above stated to allow for their being sometimes out of repair.

A duplicate non-condencing engine and pumps shall be provided capable of delivering half a million of gallons in 24 hours into the lower Reservoir.

6. A COAL-HOUSE 40 FEET SQUARE AND 20 FEET HIGH to the eaves shall be built of wood on the crib, made of very heavy timbers, and firmly girted, braced and secured to resist the pressure of the house full of coal; the roof to be slated.

7. PUMPING MAIN.

That portion of the Main to an elevation of 100 feet above the Lake shall be 10 inches interior diameter and 7-8 of an inch thick. That portion from 100 to 200 feet above the Lake shall be 10 inches in diameter, and 3-4 of an inch thick, and that portion from 200 feet above the Lake to the upper

Reservoir shall be eight inches diameter, and 5-8 of an inch thick. There shall be inserted three check valves with an air chamber at each, and a check valve on the end of the pipes into each Reservoir.

There shall be a waste pipe with a stop cock placed at the pumps with a branch pipe, stop cock and air chamber, at the lower Reservoir, and also one in the 8 inch pipe near the same, also a stop cock and chamber at the upper Reservoir.

8. LAYING PIPES.

The trenches of all the pipes shall be dug so as to cover the pipes with at least 5 feet of earth in the shallowest places, and on regular grades so arranged that there shall be no part of the pipes which will not drain off, and no crowning places for the air to gather in. The pipes shall be laid on straight lines and when required, with the largest curves. The earth under and alongside of the pipes shall be selected of the best material, and rammed in firmly so as to secure an even support. The remainder of the trench shall be carefully and evenly filled so as to produce no unequal settlement.

The joints of the pipe shall be made by inserting a gasket and packing it well and a rim of clay rope around the end of the socket, and filling the joint with most ductile lead and caulking the same.

The stop cocks shall be set in wooden boxes with Iron covers.

9. RESERVOIRS.

The Gough Street Reservoir shall be made in two Divisions, each containing 8 millions of gallons, and the University Reservoir also in two Divisions, each containing 4 millions of gallons. But one Division of these Reservoirs will be built at present, but the works will be arranged with reference to the future use of both Divisions.

The enclosing banks will be finished off with 16 feet width of top, slopes on both sides of 2 horizontal to 1 vertical, and carried up 4½ feet above the surface of the water on the front and 3½ on the rear. The water will be 12 feet deep but arranged to be filled up at certain periods to 13½ feet depth.

The excavation will be made of such depth as to furnish just enough material to form the banks, (exclusive of the puddling unless the excavation is suitable for puddling,) and will be dug to such depth as will allow the puddling in the bottom to be 1½ feet thick, and covered with 4 inches of clean gravel or coarse clean sand. The excavation will also be widened so as to give room for the side puddle walls, which will be 12 feet wide (on a horizontal line) at the bottom and 6 feet wide at the top, and will be carried up to a level 1 foot below the top of the bank. These puddle walls will be faced with clean gravel 1 foot thick, (at right angles to the face of the bank.) A slope wall will be laid on the inside face of the banks, commencing at a level 1½ feet below the top of the bank and carried down to a level 7½ feet below it, where it will rest on a berme of four feet in width.

The wall will be laid with the stones at right angles to the face of the bank and made one foot thick. The stone to be of good well shaped paving stone, and well bedded in clean sand.

The rear slopes, top and inner border to the slope wall of the banks, shall be turfed with good sods, or the soil from

the excavations shall be saved and put on the above surfaces and sowed with clover and grass seed. The soil under the embankment shall be removed and the surface of the natural ground rendered loose so that the embankment will unite closely with it.

The embankment shall be made by selecting the most impervious materials and placing them adjacent to the puddle walls, and the stone and more pervious material in the outer portion of the bank.

The side puddle walls shall be carried up evenly with the adjacent embankment, and the embankment shall be put on in regular layers of a foot in depth and kept nearly level in all directions and with no breaks or slopes of less than 4 to 1.

When the bottom of the Reservoir is of an impervious material, it shall be ploughed up very deep, the stones taken out and the material puddled and covered with clean gravel.

The puddling shall be done as follows: The material shall be formed of not less than one-fourth part of clay, nor more than three-fourths of clay or loam, and the remainder of fine gravel or coarse sand.

It shall be laid on in regular courses of six inches in thickness, and then wet throughout, being careful not to use too much water, so as to make the mass like jelly. It is then to be cut and cross cut with spades (not shovels) until the whole mass is thoroughly incorporated together. A succeeding course must not be put on until the first one has properly set—and as soon as it is set, it must be covered with a layer of earth to protect it from sun checking. No teams must be allowed to cross the puddle unless when it is covered with a foot deep of earth.

The supply main shall be carried into the reservoir ten feet beyond the foot of the bank and turned up by a quadrant pipe to three feet above the bed of the bottom, where

the pipe will be expanded by a bell mouth of twice the diameter of the pipe, and covered with a spherical screne of heavy copper wire, and the whole set in a wooden box (anchored) with an opening in front, protected by wooden grating. The distribution pipe will be arranged in the same manner.

An iron drain pipe of eight inches diameter, provided with a stop cock and chamber, shall be laid from the lowest corner of the reservoir to the outside of the bank, and thence by a glazed tile drain pipe of the same size to some suitable place to waste the water.

The Reservoir shall be enclosed by a picket fence of five feet hight, with suitable gates and locks.

10. DISTRIBUTION.

The pipes shall be laid in the several streets, of the sizes named and given in the annexed schedule, and in the manner described in the 8th specification.

The City will be divided into three water districts by lines of stop cocks on the north side of College street and on the east side of White street.

The stop cocks will be set in wooden boxes with an iron cover at the grade of the streets, lettered on top *"Burlington Water Works*, 1866."

Sixty hydrants will be placed at the street corners stated in the annexed schedule, each of which will be connected with the street main by a four inch pipe. Hydrants or blow off cocks will be placed at all of the dead ends and at four of the lowest pipe ends. The dead ends will be capped.

The pipes which will have more than 150 feet head, will be tested with a pressure of 300 pounds per square inch, and those of less than 150 feet head, with a pressure of 200 pounds per square inch.

Wrought iron pipes lined upon the outside and inside

with hydraulic cement, may be substituted for all of the dis- distribution pipes. The metal for pipes of more than 150 feet head, shall be of No. ——— sheet iron, and of less than that head, of No. ——— sheet iron.

When complete, the pipes may be tested by a direct pressure of a head of water equivalent to 500 feet above the Lake.

SECOND PLAN.

SPECIFICATIONS FOR THE SUPPLY FROM THE WINOOSKI RIVER.

1. DAM ACROSS THE RIVER.

The dam will be located at the reef of rocks — feet above the old dam and it will be raised to a level ten feet above low water, or to give 16 feet head above the lower mill pond and allowing for back water, will give at all times not less than ten feet head of water.

The dam will be commenced by laying an apron 12 feet wide, just below the reef, by bedding four timbers in the rock across the stream and bolting them to the rock, and covering them with three inch pine plank well spiked and filling the spaces between and below the apron timbers with stone. The timbers must be flatted to a thickness of 12 inches and the bolts will be put in one in every ten feet, length of each timber, and long enough to penetrate the solid rock, at least one foot--and secured by a fox tail wedge or if practicable by leading and a screw and nut on top.

The rock will be trenched out to receive these timbers or if two low it will be built up under them by large heavy stone. The front of the dam will be built up on a batter of an inch to the foot, resting on and bolted to the apron and the rear slope formed of plank laid on a slope of 2 to 1 and spiked to the purline plates.

The base of the dam will be formed by bedding 4 longi- tudinal timbers in the rocky reef across the river as before described, upon these will be erected bents of pine timber at every six feet consisting of one sill of 10 by 12 inches locked into and bolted to the stringers, and a cap of the same size formed to give the top slope of 2 to 1.

The front posts will be 12 inches square and the other three 10 inches square, framed into the caps and sills, so as to be at right angles to the face of the dam, and braced to the caps and to the longitudinal sills. Twelve purlines of 6 by 12 inches will be notched into the caps and bolted to them at the ends and middle of each perline.

The covering plank will be of white oak 12 feet long 8 inches thick at the upper end and 3 inches at the lower end, and spiked to the perline with two spikes at the upper and lower ends and one at each crossing. The lower section of plank will be of pine 3 inches thick, bolted in the same manner.

In the deepest part of the channel, a discharge conduit will be built of two orifices, each of 2 by 3 feet, formed by square timber of 12 by 12 extending entirely through the dam and covered at the upper end by a scuttle gate of 3 inch oak plank resting on the planking of the dam, with a gate stem of 4 by 8 inches, extending to within one foot of the ridge and bolted to it.

The lower face of the dam will be planked with 3 inch oak plank, spiked to girts framed into the lower ends of the bents.

The upper toe of the dam shall be secured by concrete masonry, laid in such form as will make it water tight.

The whole dam will be filled up solid with stone laid in the form of a dry wall and very compact and packed close

around, and under all of the timbers, and before the upper course of oak plank is put on the water shall be allowed to rise and flow through the dam, and gravel shall be filled in as long as the water will wash the gravel into the stone filling.

When the dam is complete, a bank of gravel shall be filled in on a slope of 6 to 1. At the west end of the dam, a trench shall be excavated 20 feet wide and to the level of the lowest part of the bed of the stream below the dam, in which will be placed a bulkhead of stone masonry laid in hydraulic cement. The east wall will be 25 feet long by 10 feet wide on the bottom and carried up 8 feet above the top of the dam. The east side shall be recessed so as to connect it firmly and in a water tight manner with the dam.

Posts shall be let into the face of the masonry and firmly bolted, on which shall be spiked fender plank to protect the face of the wall. At the head of this stone pier shall be placed a triangular crib of timber filled with stone for an ice breaker and protection. At the lower end will be built a wall for the tail race, of heavy stone laid dry.

The west wall of the bulkhead will correspond with the east one, but will be partly formed of the natural rock, and it will be made to flare more open above the line of the dam.

In both walls and on the rock below three recesses shall be made! the upper one to receive the screens, the second to receive the regulating gates and the third one to form the lower end of a forebay.

These recesses on each side shall be formed of cut stone, giving a shoulder of one foot. The walls shall be laid up of well shaped large sized sound stone, the stone carefully bedded in morter, made of one part best hydraulic cement

and two parts of pure clean coarse sharp sand. The walls to be coped with cut stone.

The screens will be composed of oak timbers 8 by 12, viz: a cap sill, five posts and two girts. The screw of 2 by 6 inch plank set edgewise. The frame will be bolted to the wall and let into and made water tight in the rock at the bottom.

The gate frame shall be secured in the same manner and made of the same kind and size of timber. The corner posts will be 12 inches square, and the gate posts 8 by 12 with a girt framed in at about $3\frac{1}{2}$ feet above the bottom, the remainder of the face shall be planked up with 2 inch pine plank.

There will be seven gates of Cast Iron, each $2\frac{1}{2}$ by $3\frac{1}{2}$ feet set in a faced frame of Cast Iron. The gate stems will be of Wrought Iron $2\frac{1}{2}$ inches in diameter, with a screw and wheel crank to work them at the top, but two of these gates will be put in at present.

At the lower recess a frame of oak timber will be put in the same as the gate frame, with posts and girts to suit the flume leading from it and an iron screen placed in front. If other parties are to use the water from the bulkhead, a partition of timbers and plank will be placed between the gate and lower frame, to make an independent forebay.

The east end of the dam shall be secured to the natural rock and to a wall of masonry with a return wing.

If the water power is used by other parties on the east side of the river, the dam will be connected with their bulkhead as described for the west side.

2. FLUME OR RACE-WAY AND FOREBAY.

A flume of six feet interior diameter shall extend from the bulkhead to the wheel house, which it is assumed will be within 500 feet below the dam. The flume will be form-

ed of staves of white pine plank, clear stuff, 2½ by 3 inches, curved and bevelled to the arc and radial lines. The hoops will be placed 12 inches apart, of the best, No. — Iron and provided with gibs and keys.

The flume shall be laid as nearly straight as possible and the rock excavated, or a wall raised to bring it to the proper grade.

The forebay shall be 12 feet square on the inside and 20 feet high. The foundation shall be of pine timber, 12 inches square, closely bedded to the rock and covered with three inch pine plank well spiked.

The frame shall be made of pine timber, posts caps and girts all of 12 inches square, and tied with 12 rods of wrought iron of 1½ inches diameter, (six in each direction.)

It will be planked on the outside (to preserve the frame from decay), with 4 inch pine plank for one-third of the heighth ; 3 inches thick for the next one-third in hight and 2 inches for the upper one-third in heighth.

The foundation and frame of the forebay will be extended, and form the frame for the water wheel and pumps

3. WATER WHEELS AND PUMPS.

The water wheel shall be a turbine of Boydens, Tylers, or some other pattern approved of by the Water Committee, and which shall practically work up to within twenty per cent of the theoretic power of the water.

The framing for the wheel will depend upon the kind of wheel used, and shall be made unusually strong, and well braced to the forebay and covering building.

The wheel pit is to be built so as to put a water wheel on each side of the flume, each of which are to be attached to an independent set of pumps, but so arranged that each wheel can be attached to the opposite set of pumps.

The first wheel is to be large enough when working at ene-half of the theoretic power of the water to elevate half a million of gallons per day, through a pipe of 8 inches diameter, 5,000 feet long into a Reservoir at an elevation of 300 feet above the Lake.

The second wheel to be of such size as when working at 75 per cent of the theoretic power of the water, it will elevate twice as much water as the first wheel, and with buckets so arranged as to use but one-half of the water when so desired. But one of these water wheels will be put in at present.

The Pumps will be in pairs, two for each wheel and driven by speer geering from the water wheel shaft, speeded to give a motion of 150 feet per minute to the water.

The frame or harness of the wheel and pumps will be of white oak timber 16 inches square, the caps of sufficient length to extend across the forebay and form a foundation for the pumps.

The cross caps will be faced with a cast iron plate, turned over on the upper corner with wings extending 2½ feet along the side plates, and the same distance down the posts, and well bolted thereto, so as to give great firmness to the frame. This plate shall be fitted to receive the journal boxes of the wheel shaft and two pump shafts.

The wheel and pump shafts shall be of wrought iron 6 inches in diameter, the former 20 feet long, and the two latter each 12 feet long and set in a heavy cast iron step bolted and braced to the girts of the harness.

The motion will be given to the pumps by a steel crank pin set in the arm of the speer wheels on the pump shafts.

A heavy cast iron bed frame will be placed on the harness

cap, of sufficient length and width to carry the pumps of both water wheels and the valve chamber, connecting pipes and main between them.

The bed frame will be made in two sections, one for each set of pumps with flanges arranged to bolt them together.

Each pump will have its own suction pipe of 10 inches diameter, extending into the fore-bay to a depth of 8 feet below the level of the top of the dam, with a rose piece and check valve at the bottom, and another valve near the pump chamber. Near the foot of each pump will be placed the upper valve, and a connecting pipe between them with a branch leading into the pumping main, another to the second set of pumps, and a third one for waste, which will be fitted with a stop-cock.

The pumps will have a chamber of 14 inches diameter, and a plunger of 9 inches diameter with 3 feet length of stroke.

The guide frames will be of cast iron and connected for each pair of pumps.

The connecting rod of the pumps shall be of wrought iron $3\frac{1}{2}$ inches diameter, and trussed with rods of one inch diameter, and provided with a gib and a key, and adjustment for lengthening or shortening the rod. The speer wheel shall be provided with an arrangement for altering the crank pin to shorten the stroke to two feet instead of three feet. The suction pipes, valve, chambers, connecting and waste pipes, and supply main shall all be faced and accurately fitted so that each piece may be used for either of the set of pumps.

The cast and wrought iron for the pumps and pipes, except the lower section of the suction pipe, and the upper section of the pumping main shall be of the best Charcoal

iron. The valves and the lining of the journal boxes shall be of composition metal, and the valves, seats and guides shall be faced and planed. The plunger, crank pin, connecting rod and truss bolts shall be turned and polished, and all of the iron except the bright work shall be painted with three coats. The suction pipes shall rest on a frame of wood, framed into the forebay timbers and supported by a post under each pipe. The rose piece shall be expanded and bolted to the frame. These pipes will be enclosed in a wooden box with gratings of wood on top.

4. PUMP HOUSE.

The foundation walls enclosing the forebay and wheel pit shall enclose a clear space of 26 x 36 feet with an arched opening for the tail raceway and a swinging grate.

The walls shall be two feet thick at the bottom and 18 inches at the top, and carried up to a level of two feet above the top of the dam, and shall be formed of well shaped stone laid as coarse rubble, in hydraulic cement mortar.

The upper story of the pump house shall be of brick 26 x36 feet, and 12 feet high to the spring of the rafters.

The house shall be built as before described for the engine house.

5. RISING MAIN.

Shall be of cast iron 8 inches interior diameter, $\frac{3}{4}$ of an inch thick where it has more than 200 feet head of water, $\frac{5}{8}$ of an inch when it has less than 200 and more than 100 feet head, and half an inch thick when it has less than 100 feet head.

There will be 3 check valves and air chambers, and a stop-cock at the Reservoir.

The specifications for the pump main from the Lake will be applied to this main.

6. UNIVERSITY RESERVOIR.

The University Reservoir will be built as before described, but large enough to contain ten millions of gallons in each Division with 13½ feet depth of water.

The pump main will enter the east side of the Reservoir and be extended across and connect with the distribution main on the west side of the Reservoir. A stop-cock will be placed in this connecting pipe.

The arrangement of the pump main distribution pipe and drain pipe at the Reservoir will be as before described.

7. DISTRIBUTION.

The pipes shall be laid as before described, and of the sizes named in the several streets in the annexed schedule.

The City will be divided into three water districts by lines of stop-cocks on the north side of College street and on the east side of White street.