THEESIS

CHICAGO WATER SUPPLY

SPRING 1884

Hubert A. Stevens
Chicago Water Supply

General Remarks.

In commencing a discussion of a question of such vital importance as this, not only perhaps to the people who inhabit the city, but also a question indirectly affecting a community widely spread, it would not be out of place to devote some little space to the history of Chicago as related to its developed water system. In the present case, however, I believe the history and knowledge of our water department is sufficiently well understood, so as to need but brief mention.

While Chicago was first settled water was obtained as is usual in such cases, either from wells or directly from the lake or rivers, which was then in a state of natural purity being unpolluted by the refuse of a vast city; but as the town grew this method became insufficient and gave way to Hydraulic Companies, the first of which drew its supply from the lake, using an iron pipe extending out 150 ft into the lake, supported on wooden crib work,
Drawing through this pipe, by means of a small engine, what was required and forcing it through wooden means to wherever it was to be used.

The efficiency of this method of working, becoming need to supply the demand, another company was incorporated in 38, which built a crib five or a hundred ft from shore and which was calculated to supply a population of 100,000 persons. This served its purpose till in 1868 we find the water beginning to be highly charged with foreign matter discharged from the river. They issued various plans for supplying the city with plenty of pure water, the one finally adopted terminating in our present system. Before proceeding further let us see what has been the progress, and the benefits derived from the works all ready mentioned.

There are certain propositions which command the ready assent of every citizen, first abundance of pure water for health, water for protection against fire, for mechanical, manufacturing and all other purposes to which it can be usefully and profitably employed. The growth and prosperity of Chicago imperatively demand this.
Whatever other inconveniences or necessities of its situation may be disposed with, this cannot be, and situated as it is on the shore of one of the finest bodies of fresh water on the Globe, a body of water absolutely pure, except so far as it may be contaminated by the effect of sewers, it is a crime against nature not to have it in every dwelling, office shop in abundance as well as in its native purity.

One great fault with the water works of this city has proved to be their insufficiency to meet the demands of a rapidly growing city, and yet at the time the first Hydraulic Co was incorporated with its 20 horse power engine, James Long made a contract to do all the pumping for the company during the next ten years for the use of the surplus power to be derived from the engine. It was found necessary long before this contract had expired to use not only the surplus power, but to add more engines.

Again, when the second company put up its works and based their estimate on the probability of an increase of the population to 100,000 souls in 15 years, we see how much they underestimated for when this time was reached Chicago numbered 200,000.
The same short sightedness once more prevailed, we putting up the
present works works & crib; for not only have new tunnels and
equipes had to be constructed but already they too have about
reached their maximum capacity. Thus we are arrived
at a very important epoch with the all absorbing question:
how to provide one of man’s greatest blessings in such a-
abundance and purity that we may never be reproached by
the generations to come, with that short sightedness & silliness
which characterizes so many public movements.

The principle cause of complaint during the last few years
has been in regard to the character of the water delivered which
sometimes contains a high degree of contamination with the
sewerage matter from the river, so that in the next undertaking
which shall have for its object the solution of this problem
much trouble and expense will be entailed in providing
not only plentiful but a pure supply of water.
Theories in regard to manner of Supply

In order to accomplish this desideratum with a certainty, various schemes have been projected, the only trouble being that those which accomplish this result beyond a doubt, are not practical at present, being looked on as visionary. These I will merely mention and pass on to a discussion of some which do not seem so absurd to the popular mind. In order to be absolutely sure of pure water we must make it a primary principle that no sewage matter and the like be allowed to flow into our source of supply within a radius of many miles and to effectively accomplish this result in the present case we must 1st either prevent the Chicago river from flowing into the lake by means of the Illinois and Michigan Canal, or otherwise, or 2nd fill up the river or so divert its course as to cause it to flow into Lake Calumet by a canal from the S. Branch to the lake. 3rd To inaugurate a system of separate sewerage by means of which all refuse or could be disposed of by chemical or other methods. 4th As a last resort take water from some inland lake like Lake Geneva Wis. and convey it hence in an aqueduct.
By any one of these methods we should accomplish our end, but as yet
general opinion has not reached a point sufficiently advanced to
warrant such gigantic undertakings, so let us proceed to discuss some
more popular notions.

Two of the more immediate theories are first to convey water
by means of an aqueduct (from some point North of the city as Cross's
Point) which shall be connected with a crib, situated 2 1/4 miles from
shore and with a system of reservoirs into which the water is to be
pumped from the crib. These reservoirs being situated on the bluffs
so ft. above the water level, it is stated that the water would need no
further pumping to reach the city. Second, to extend the present
system of works far beyond the reach of the contaminating influence
of the river, by placing the crib 4 to 5 miles North-East of the present
situation and connecting the two by tunnels. The new crib to be of
such size, strength, durability as to supply a population of 200,000
inhabitants for centuries. Of the two plans we decidedly prefer
the latter, for obvious reasons. To put the first plan into operation
the present works must necessarily be abandoned, an aqueduct 20
or more miles long must be constructed at a cost of many millions.
and also sufficient reservoirs to hold the water necessary for several

day supply, with new engines necessary to pump the water from
the crib into them, all this in addition to a crib and tunnels that
must be constructed however you work it. Now suppose we should go
to all this unnecessary labor and expense would we be any better
off than we were are at present? Not at all for the numerous
little towns that are springing up all along the shore North of
the city, will soon discharge sewerage matters enough into the
lake, to very effectually put an end to the purity of the water
near the shore. In the other place which it is estimated would cost
but a third as much, latter, we still continue to use the present means
of supply—Tunnels, engines and crib—so that there would be no
lost from that source. We are at a distance from the shore and from
the sickening and disgusting effect of any sewerage pollution,
that may be discharged from the seaward towns along the shore,
so great as to be confidently beyond all reasonable expectation of
contamination. We are supplied with water fresh & cold instead
of water that has been allowed to stand in a reservoir for hours,
and to reduce it to its original temperature of the lake water.
by artificial means, would cost hundreds of thousands of dollars
as the consumers every season. For these if for no other reason, it seems
proper to devote the most time to this mode of supply as it offers
us the greatest inducements for the time spent.

The present System of Supply

Before entering further into this discussion it would be well to
consider some of the more important features of the present system,
in order to more clearly understand what follows.

The 3 essential elements of the present system are its crib
tunnels and the engines necessary to force the water from the
tunnels through the various mains to wherever it may be em-
ployed. The power that is necessary to do this work is distributed
between 14 engines on the North Side, having an estimated capacity
of 72 million gals per day, and two engines on the west side with
an estimated capacity of 60 million. However the actual work to be
obtained from them, is much less than this, and where as at the
present, in acting together and pumping 80 million a day they are
doing nearly this utmost.
Tunnels. As to the tunnels, of which there are two one is 5 ft 2 inches in vertical diameter and 7 ft 6 in. long; the other is 7 ft vertical diameter both connected with the crib by stone culverts by shafts. The capacity of these tunnels is estimated at 150 million a day allowing a flow of 4 ft a second which is certainly more than sufficient for the present.

These tunnels were built on what is known as the Cheesbury system. The first one running from the N. D. Water Works due East for two miles to the crib, the second parallel to it under the lake but branching off and continuing under the city in a S. W. direction to the W. D. Water Works a distance of over 4 miles. The tunnels were lined with brick 8 to 12 in. thick in thickness laid in cement of the best quality. The bottom of the tunnel at the East end is 46 ft below the city datum and has a gradual slope towards the shore of two feet per mile thus falling 4 feet in the whole distance.

Crib. It consists essentially of a pentagonal shaped framework that would be inscribed in a circle 98 ft diameter, originally 40 feet high, but since built to about 60 ft, and containing within itself a well of 20 ft diameter from which the water is taken to supply the city. The interior and exterior walls, besides intermediate walls are joined together by walls for at right
angles with these, the whole systen formed a pentagonal annular
as shown by the photograph. Between these walls loose rubble
stone was placed, to give it the necessary weight for sinking.
This breakwater was built on a flooring of 12 in. white pine timber
laid close together, the outer and inner vertical faces a middle wall
were all of the same size and material, except the upper ten feet of the
outside which was of white oak to withstand better the action of ice.
Between these walls are bracs variously extended, as so to give the whole
structure a rigid consistency. Here were used in its construction,
760,000 ft of lumber, board measure, 150 tons of iron bolts, 1500 tons of
rubble stone and weighs 5'700 tons. The crib stands 12 ft above the
water line giving a maximum area of 1200 ft which can be ex-
pended to one sweep of the wind and waves reckoning the resistance
as perpendicular. Rectangular openings each 4 ft wide x ft high
were made for the admission of water to the interior, at 4, 11, 20 ft
below the water surface respectively, to be used as time showed
which was the proper depth, from which to draw water. These
openings and wells 4 ft sq. from base to top of breakwater were
timbered around in the same careful manner as the rest of the crib.
Each well was provided on its sides or inner face with slides for a temporary gate, should ever occasion require. Dueing to storms which sprung up while the crib was being put in place, the exact location that had been determined upon was not realized, but instead the crib settled on the side of a round bar so that the South-East corner was 3/4 feet higher than the N.-West as represented in diagram, also the unions and middle angle joints had parted over as such which produced considerable to its stability. A considerable tremor is of the felt during large storms, and when considerable fields of ice are passing. On several occasions, the broken masses lodged on the south side of the crib, forming banks several hundred feet long and reaching from the the bed of the lake to 10 or 15 feet above the surface. Lately this has been considerable discussion as to the safety of the crib, several prominent engineers having stated, as their opinion, its insecurity of with.
standing long the tremendous forces that may be brought to bear upon it may fail in several ways: 1st, the ice being overturned as a whole by wind and wave, 2nd, the upper part might be sheared off by the action of the ice fields, 3rd, the points by giving away in places might cause a rapid disintegration either by allowing ports to be washed away or the whole structure as it were to be squeezed. It is almost an impossibility to determine these points with accuracy, owing to the complexity of forces acting. But we may obtain a slight idea of the force that would be required to exist to destroy the crib by overturning as follows. If we know the height, breadth, weight, specific gravity and amount of surface exposed to the action of the elements we can calculate the required force to overturn thus. Take the crib as being 50 ft high, 12 ft being above the water, having a diameter of the circumscribing circle as 120, 12,000 tons the weight of the air, and the specific gravity of water 62,400 cu ft being immersed and 55,000 cu ft being above water we have the weights standing about 2000 tons. Now

\[ F = \frac{W x (\frac{d}{2} - 50)}{12} = 9000 \]

tons and since we have an exposed surface taking the rest as pulp of about 1700 sq. ft this would require a pressure of 5.3 tons per
sog. feet for overturning. This is by far a greater force than it is
within the limits of possibility to bring to bear, in an inland lake.
Altemeier in his treatise on harvesters gives examples of wave
and wind forces measured by a dynamometer, in cases exceeding
3 tons per sq. foot, but these are rare and were taken in the most
exposed place of the broad ocean, where the fetch of the waves was
hundreds of miles. But the average maximum in different local
areas range from 1 to 3 tons per sq. ft., and it is hardly likely that
we even with our North Easters, could ever record a force exerted
of more than 10 tons per sq. ft. As we may infer, if the crib were
as strong in regard to the other particulars as it is safe in regard
to this we should have nothing to fear. But the safety of the
crib from destruction in other ways is not so clear. If as we
have seen during the placing of the crib in position, the joints
opened during a storm and cracks were made extending through
the entire structure by a pressure of less than 3 tons per sq. ft.
by the storm on the pier, settle, what shall we expect when
we have a force of 10 tons per sq. ft. acting perhaps on the outer
angle? As the bracing is arranged, it is as capable of resisting
external force as well as external & should a force sufficient
to over come the friction of the ballast, as to displace it verti-
cally in addition to the .3 lm per ft for bracing we see no
reason for believing that the crib would withstand it. In the
swaying motion that is perceptible in storms, it is the yielding
of the bracing that causes the rocking as the crib is fixed imm-
oveable at the bottom.

Position.
The crib as before stated is situated about 2 miles from shore to the
North East of the river's mouth, as will be seen by examining
the map of the harbor. On first thought it might appear strange
that a site apparently directly in the path the river would take
after flowing into the lake, should be chosen, but we find that the
river does not follow the direction that it might naturally be supposed
to follow i.e. a north-east direction, as would perforce be necessary
for all water in Lake Michigan that reaches Lake Huron to pursue,
and rather has a tendency to flow to the South East following
the line of shore around the South Arm of the lake till it
reaches the Michigan shore where the tendency of the water is to flow
That this is the case I presume will not be questioned, for the evidence furnished by the gradual filling up of the South eastern portion of the lake with sand, would go to confirm it.

It may be explained possibly as follows. The prevailing winds at Chicago are the N. E. & S. W. the S. W. for 9 months & then N. E. W. for the other 3 months (May, August & July) Now what little currents there are in the lake may take the direction as indicated in the diagram because the N. E. winds would tend to set the water on the west side of the lake in motion more than on the east both shores being protected by high bluff then the S. W. winds blowing over towards the E side of the lake and striking the bluffs there would aid to produce this circular motion, although we might well suppose that it would set it revolving in one opposite direction for part of the year. It was the writer's intention to have some experiments made to settle this point a little more definitely but circumstances did not permit. There are also various theories of subsidence, but until we can have some facts as to the direction of currents it would be well not to
furnished foundation for any important conclusions or such suppositions. The sand found in the water when an N. E. wind prevails is thought due to an undercutting produced by the surface water being returned as an undercut, after having struck the shore, laden with sand.

Fullerton Ave. Pumping Works.

Another important element that has crept into the question of water supply as affecting the position of the crib, is the N. R. P. Water designed to free the North Branch of the Chicago River from the mass of muck, which otherwise would collect there, forming a stagnant flotidatous open sewer. It was originally intended to force the water to flow from the N. Branch into the lake, by pumping an enormous quantity of water from the lake into the river, but for reasons known only to the engineer in charge the direction of the flow has been entirely changed, by pumping the water from the river directly into the lake at a point 2 miles N. W. of the crib, where it is left to mingle with the water we drink. For as it rises through the shaft through which it passes from the tunnel into the lake, it settles all around on the bottom.
for many yards, and as in the course of a few years, by the continual discharge of this filth which is stirred up and spread by every storm that occurs, it has at last reached the crib and it is stated by a diver who was employed to make the observations, that through the holes opening there is continually pouring a stream of this black filth.

A New Crib

Having now inquired into the essential features of the present crib, and the conditions and circumstances affecting its usefulness, let us examine the advantages which spring up in the consideration of a new crib and its location. The proposed structure differs essentially from that of the present crib, in being shaped like a truncated cone having an average diameter of 15 ft which includes a well hole at its center of 50 ft in width. The substructure is to be constructed of the usual form of crib work, built on the principle of a spider wheel of a depth sufficient for 60 ft of water. There are 3 retaining walls including inner and outer, of 6x12 inch timber the inner & outer ones to be of oak timber & the middle walls of white pine, breaking joints alternately on each course. Two courses of retaining walls being equal to one 12x12 radical
course of timber, which extend from the outer to the inner wall and act in the double capacity as tie and straining beams to resist the shocks of the sea and large fields of floating ice. In addition to this form of structure, and in order to make the whole doubly secure and able to withstand the fury of the elements at all seasons, there are strengthening and bracing walls dividing the well or chamber into 4 compartments, by running through the entire structure from outside to outside, at right angles to each other and extending as before stated through the centre of the well hole. The intervening spaces between the retaining walls and radial beams, is to be filled with concrete or other material that may be suitable for rendering the structure perfectly solid. We also see 8 openings for the admission of water instead of 8 which is a great improvement for when we consider 500 000 gallons of water pouring through 8 orifices only 4 x 5 ft. We judge in 24 hours we can easily imagine the strength of the current produced which is so swift, that if fish once get into it, it is impossible for them to get out for striking against the well gates they are unable to turn and so stay until removed by
the gates being raised. In other details as shown by the photographs it is much like the crib previously described.

The much larger size, the shape, plan of bracing, and method of filling with solid stone work, all tend to assure us of the perfect solidity of the structure as compared with the present one. A crib of this shape it would be impossible to destroy by any such means and agencies as in any such manner as were reviewed in describing the present one.

A provision which is made to protect it from floating ice by incasing it in a steel armored throughout the exposed portion is a wise one, for during one storm of a few winter past gone by, the ice caused a groove over 8 inches deep into the exposed side.

Its Position

Has been approximately determined, at from 6 to 7 miles north east of the present crib, where the water is 60 ft. deep. The various depths and distances out where location was sought are shown in the sketch below. The object in seeking to great a depth is to
confining to the lowest depths. Another we say, that water should be taken from the top, as every foreign substance in water has a tendency to sink, and the lower you go the worse the water is in this respect. The lake is described as coming with infusoria which, when alive live near the surface but as they die slowly gravitate towards the bottom, forming in palpable mud, and pumped from a great depth we should have full benefit of their diseased and pestilential carcasses.

A third view is that water should be taken from about the middle when the depth is as great, as it is proposed to have it for the new city, for the different foreign matters is described as separating into layers the heaves going to the bottom and the lights staying near the top. All these various arguments have their objections. For instance in the first we are told that the water from the rivers will flow out over the top of the lake. Let us see about it.

In summer the rivers water is usually warmer than the lake water, and the theory of its flow would agree very nicely with what we might imagine would take place, but take it in winter, when the water is colder in the rivers than in the lake.
then the river water will go to the bottom carrying along with it its suspended matter which as the water gets colder and more dense would lie in the increase, and which after flowing into the depths of the lake, would have no tendency to rise owing to the less up grasp of the waters above. This in results we should have the impurities at the bottom and in summer at the top. We may reject the 2nd theory on much the same grounds, the part relating to the influence being so absurd to notice. As for the 3rd if we are going to have the effal in different layers shall we omit the one at the middle? It seems to me the only way to escape the impurities of the river is to go out beyond their reach, then for reason of more uniformity of temperature go to the bottom for your supply of water.

**The Water**

**Its inhabitants**— Mr. H. B. Thomas a gentleman who for many years has made the microscopic study of the lake waters a specialty, says that the condition of the waters at present is vastly different from the water of 10 years ago in regards to its population.
At that time, the principle insect life was found in the distance, but now there are found only the lowest forms of infusoria and filthy aninaculcule. This change he attributes to the action of the Fullerian works already spoken of. At the present time for a year back we have been having fairly good waters but this is only due to the height of the lake which has attained its maximum, and prevents the river from spreading its flood so much. This maximum is reached every 12 years and at that in 77 we may expect again to hear the water justly denounced by people wonder what the cause may be.

**Height**

That this is a fact may be seen by consulting the statistics as given below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Min.</th>
<th>Max.</th>
</tr>
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<tbody>
<tr>
<td>1872</td>
<td>72</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>73</td>
<td>74</td>
</tr>
<tr>
<td>1874</td>
<td>74</td>
<td>747</td>
</tr>
<tr>
<td>1875</td>
<td>74</td>
<td>747</td>
</tr>
<tr>
<td></td>
<td>79</td>
<td>80</td>
</tr>
<tr>
<td>1880</td>
<td>80</td>
<td>83</td>
</tr>
</tbody>
</table>

In 1871 the height of water in the lake above the city datum was 2 ft 6 in.
Its flow in river — It is supposed to be a demonstrated fact that water is of itself a purifier; that by its</p> <p>flooding influence, refuse is washed away & destroyed. This is the foundation of the present system of coders. Being unwilling to keep the beverage matter himself, the city sends it south. But certain conditions principally the low water in the lake & the high waters in the canal and Illinois river, bring it back again. If the height of waters in the lake were a practical bar to the flow northward it has been shown by figures of the max hrs. that there is an intervening period every 6000 years of low water. At that period the reverse flow northward would have to be most appraised. The result is that the refuse which has stagnated in its flow south is brought up again and emptied into the lake at a point near the crib. Being brought into direct contact with with the supply of drinking water, scientists and analysts have sought to determine whether the refuse figure polluted it.

Its Pollution — It was proved that it did by the study increase of organic matter found in the lake at an approach to the harbor mouth. Two miles beyond the crib
it contained .0008 grains of organic matter to the U. S. gallon.

SOURCES OF POLLUTION. The first and most important source was
in 1847, the North Branch of the Chicago River. It came from
dairies, breweries, distilleries, and a hundred other institutions of
a similar character. A careful estimate a year ago showed
that 300 tons of animal excreta and decaying animal matter
were weekly discharged into the N. Branch. How much this
amount has been increased since then it is impossible to say
but a low estimate places it at 800 tons weekly. The second
source of pollution is the natural flow of the refuse N. and E.
This flow has its greatest impetus from the Ogden Westworth
ditch which empties the surplus waters of the Aux Beunes river
into the canal. As the canal is the outlet of the Chicago river,
and the river is the sewer of the city, it follows that the Chicago
river must in times of a water flood or sheet empty its full
water into the lake. These two are the two currents which
carry the pestilential horrors into the drinking waters.

Now as to its effect...
denial of the proposition that the refuse of the city is putrid
not that it is carried into the lake & mixed with the
drinking water & whatever may be the spanning as to its effect
on health, there is no doubt as to its pollution. The water of the
lake 2 miles beyond the crew contains the following suspension per
W.S. gallon. CaCl₂ 4.1039
MgCl₂ 1.3911
CaSO₄ 0.5201
SiO₂ 3.510

The Bridgeport Pumping Works erected during the last bad period
and now in working order have as good a failed in their purpose,
which was to send all of Chicago's filth through the Illinois and
Michigan canal into the Illinois river, thence to the Mississippi,
by pumping storied water from the S. Arm into the canal.
The works themselves work to perfection, and it is said they
are capable of emptying the Chicago river in 24 hours but the
canal after one hour pumping is so full that canal boats
find it impossible to pass under the bridges and for
a far more weighty reason their use has been all but
abandoned at present. It is on account of the cities that are situated along the banks of the canal and rivier, which are obliged to receive all the falls and rollness (10,000,000) gallons per day, which with good cause might bring unlimited suits against the city for damages, it is for this reason that Chicago has deemed it wise to shut down the works. At present as before stated the non activity of these works is not noticed but wait till low water in the lake comes and then when instead of the water being almost ready to flow down the canal without pumping it reverses in the opposite direction with a velocity that will carry its flow out for beyond the city, then we shall hear from all sides the cry of Water is a good Water at any price.

**Purification.** It is a popular belief that organic impurities rapidly disappear through oxidation. In other words that water has an inherent power of self purification. The practice of this theory is supposed to have operated in the case of the canal. Indeed it is an established fact that when the water is high in Lake Michigan the refuse flows southward.
and being diluted with a large volume of water the object is done to prevent a visible odor or any noticeable odor from the waste from the plant. However, there is some proportion disinfected by the report of the committee on sewerage and pollution of streams to the Mass. State Board of Health. The report says: "It would appear from the experiment, that in a flow of a dozen or 20 miles as much as 20 or 30% of ordinary sewerage impurity might in summer months be destroyed by oxidation. It must be borne in mind, however, that for all we know, the portion remaining unaltered may be the very portion injurious to health. If certain diseases be propagated by germs, by living organisms, we may well suppose that such germs would live although dead organic matter might be destroyed." This also is partially true in relation to the organic matter, that may be carried to the crib and our only safety considering the present state of the knowledge on this subject is, to place the crib so far from a direction from the river mouth opposite looked which the current takes that it would be impossible to be anyway
influenced by whatever might be the condition of the lake
rises or amount of matter polluting it.

It is with regret and feelings of how great is the
incompleteness of this essay that for the lack of time
and space it becomes necessary for me to stop
leaving with almost bare mention many important
factors of this great question of which each in
itself would form a text upon which volumes
could be written. But with this for an outline,
it is the writer's intention at an early date
to take up each topic separately and devote to
it the time and attention it deserves.
# Experiments on water to determine the amount of organic matter and its laws of variation

<table>
<thead>
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<th>Date</th>
<th>Organic Matter</th>
<th>Sedimentary Matter</th>
<th>Wind</th>
<th>Ther</th>
<th>Remarks</th>
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<tr>
<td>Feb 16</td>
<td>0.2201</td>
<td>2.104</td>
<td>S.W</td>
<td>97°</td>
<td>Snow melting slightly</td>
</tr>
<tr>
<td>17</td>
<td>0.2919</td>
<td>4.520</td>
<td>S.E</td>
<td>45°</td>
<td>Rain</td>
</tr>
<tr>
<td>26</td>
<td>0.9791</td>
<td>3.061</td>
<td>S-W-K</td>
<td>43°</td>
<td>Melting</td>
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<tr>
<td>29</td>
<td>0.1763</td>
<td>4.208</td>
<td>W-SW</td>
<td>2-3°</td>
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<td>Mar 4</td>
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<tr>
<td>9</td>
<td>0.2204</td>
<td>4.211</td>
<td>N.W</td>
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</tr>
<tr>
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<td>44°</td>
<td>Rain</td>
</tr>
<tr>
<td>16</td>
<td>0.1983</td>
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<td>S-E</td>
<td>54°</td>
<td>&quot;</td>
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<tr>
<td>19</td>
<td>0.3966</td>
<td>5.127</td>
<td>E</td>
<td>44°</td>
<td>Wind N. 8 for 3 days Heavy rain &amp; quite severe storm</td>
</tr>
<tr>
<td>26</td>
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<td>6.048</td>
<td>E</td>
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<td>0.3746</td>
<td>6.972</td>
<td>S.E</td>
<td>58°</td>
<td>&quot;</td>
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<td>22</td>
<td>0.3966</td>
<td>9.072</td>
<td>N.E</td>
<td>40°</td>
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</table>
Method.

The organic matter was determined by what is known as the permanganate process. The sedimentary matter by weighing weighed filters dried at 100°C. Permanganate of potash is a deeply colored crystalline salt soluble in water, to which even if the solution be very dilute, it communicates a marked pink color. This compound which contains a considerable proportion of oxygen possesses the property of oxidizing with more or less readiness most forms of organic matter being itself destroyed in the process and losing its characteristic color. By successive additions of permanganate solution of known strength until the color persists it is possible to determine how much permanganate is destroyed by a known volume of water. The method used is that given by Bolton in which his results of oxygen required to dry organic matter is multiplied by 5 to give grams per gallon. This method is chiefly useful for making series of experiments as above to determine the relative amounts at different times. As yet these results are not of sufficient accuracy to be of much value but should the experiments be extended over a considerable time we should soon be able to predict the influence the wind waves of high water in the lake had on carrying
the rivers posteluis to mingle with our drinking water and indirectly the distance from the rivers mouth that it would be necessary to locate the new tribut.
Photographs.

Frontispiece — Branchalls design for a new crib

Number 1 — Plan & Elevation of present crib

2 — Vertical Section

3 — Plan of present building & grounds

4 — Vertical Section of entire system

5 — Plan & Elevation of apparatus used in pumping turbols shafts

6 — One of the present engines at W. Side Works

7 — Vertical Section of Branchall aquaport

8 — Plan of same

9 — Part sections at different levels

10 —

11 — Chicago Harbor

12 — Single engine at Bridgeport pumping works

13 — Plans & Sections

14 — Microscopic life found in Chicago water by B.D. Jones

15 — Engine on W. Division W. Works

16 — Sketch of Water Works.
Plan and Elevation of Lake Crib.
PLAN OF NEW BUILDINGS TOWER & GROUNDS
OF PUMPING WORKS.
Shewing Shape and of Towers Shells and Floors of the
several delivery Mains.