AN INVESTIGATION OF THE LANSING WATER SUPPLY

Thesis for the Degree of B. S.

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1911

THESIS

An

Investigation

Of the Lansing Water Supply.

By

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The Investigation of the Lansing Water Supply.

Introduction.

The investigation of the Lansing City Water Supply was undertaken as our thesis with the idea of showing just what the prevailing conditions of the water system are, with the view of determining its adequacy for a growing city.

It is proposed to criticise favorably or otherwise, and to recommend improvements. We base our criticisms and recommendations on references taken from treatises on good water supply methods as presented by recognized authorities. We will not attempt to mention our authority on conclusions reached for each part of the system, but prefer to summarise here.

Our authorities are: "Public Water Supply" by Turneaure and Ruhsel; "Water Work's Management and Maintenance" by Hubbard and Kiersted; "Treatise on Hydraulics" by Merriman; "Water Supply Engineering" by Folwell; Water Supply Papers, No. 172, U.S. Geological Survey; Geological Survey Reports; and "Chemical Analysis of Water" by Mason.

We are much indebted to Professors Vedder and Rosing for their suggestions, also to several city officials and state officials for data and information, some of whom are Mr. C.D. Dodge, superintendent of Water Board, Mr. W.B. Kirby, Secretary of Water and Light Board, and Mr. Hugo R. Delfs, Chief of Fire Dept.

and also to Dr.M.L.Holm,State Bacteriologicalist;Mr.Allen, State Geologist; Prof.Barrows,professor of geology at M.A.C. and also to the engineers at the various stations for their courtesy and help.

Source.

The water supply of the City of Lansing is a strictly ground water supply,as the city obtains its intire supply from deep bored wells ranging from 230 to 300 feet in depth. These wells are located in four different parts of the city,and while they are not of the same depth,the supply is derived from the same strata of sandstone. This is shown by the records of well borings and water analysis very conclusively.

Lansing is situated in the Coal Basin of Southern Michigan. This basin extends over a considerable portion of the southern peninsula,and has the general shape of a saucer. It is composed of a carboniferous limestone formation,followed by a complex sandstone and shale with intermediate seams of coal. From this coal measure is drawn the water for all deep driven wells of this vicinity.

The true source of the water is indefinite,but it is plain to be seen that it comes from dome remote catchment area where the upper impervious strata outcrops allowing the percolating surface water to reach the coal measure.

As the knowledge of source is necessary for an inteligent analysis of water,it is known that Lansing's supply is intirely free from surface waters of the immediate vicinity by the fact that the boring of the wells has never affect the water in the shallow dug wells that are in the neighborhood

hood, also the absence of tubercles in the pipes, which result from organisms which are found only in the surface waters. The temperatures of the water is nearly constant, showing it to be a ground supply.

Very little trouble has been experianced by contamination in this system, as the wells which are bored, are protected by a six inch steel casing, which was driven, in all cases, as far as possible into the bed rock. By this method all surface waters are eliminated.

The only trouble in the way of epidemics, experianced in the system, occurred in the winter of 1908, when a serious outbreak of winter cholera was traced to the Townsend St. substation wells. Here it was found that the steel casing of one of the wells leaked, and this well was within a few feet of a trunk sewer. This was remedied by sinking a four inch pipe inside of the six inch one. After this no more trouble was experianced.

This experiance, though, serves to make plain the necessity of the utmost precaution in the selection of the sites of wells, and the operation of boring and tubing.

The location of the wells is well adapted to the topographical conditions of the city. As the city is practically level, and with no chance of using a gravity system, the main station was located at a central point, and as the city grew, it became obviously true that substations would have to be placed in different parts of the city to increase the pressure, especially as the system was not designed and laid out to fulfill the present conditions.

Exhaustibility.

The exhaustibility of the Lansing water supply has never been truly tested. It is certain from the infromation to be obtained from the city officials that it merely a question of a short time when the city will have to take steps toward finding a new source, or to adding to the source now being used.

This is shown by the fact that the main pumping stat tion could take care of the city's consumption, if it could be run at its full capacity, but the wells at the main station have by their actions, shown that they are being drawn from at their maximum capacity. We are positive that the sinking of new wells in connection with those already in operation at the main station would do no good, as ground water is governed by a few well known factors-

1.- No more water can be continuously taken out of the ground than goes into it.

2.- The yield of the ground water is dependent upon the character and extent of the catchment area, and the depth of the saturated water bearing material.

3.- The velocity of flow of ground water depends upon the character of the material through which it must pass in gravitating from a higher to a lower level.

The extent of the catchment area of these deep wells is difficult to determine, as it involves a study of the geological conditions, which we are not able to make in the time alloted. We are reasonable certain, though, that its boundaries are not in the immediate vicinity of Lansing.

The first well built for the system was a dug well merely penetrating the gravel. The well was 21 feet in diameter and 28 feet deep. It was built under the direction of Mr.Coates,a hydraulic engineer. The water obtained was of good quality,and the supply was reported to be inexhaustable, but in less than ten years it was intirely gone oweing,no doubt to excavations into the bed at various places,which served as taps to draw off the water.

The deep wells were then bored,and while they will always,no doubt,yield water of the same standard,they will become less efficient as new wells are sunk into the same strata in and about the city.

The seasons will have no effect upon the yield of the wells,except that the demands made upon the system by the consumer may make a shortage in the supply.

Plant.

The plant of the Lansing City Water Works consists of one main and three substations,whichare located in different parts of the outskirts of the city.

The main station,which was constructed at the begining of the present system,is located in connection with the City Lighting Plant on Cedar St,near Michigan Ave.,and and about 100 yards from the bank of the Grand River. It is equipped with a 18 x 36 tandem Holly Pump,and has a capacity of 5,000,000. gallons per day. This pump was installed in 1893 and has been in almost continuous service since. It is however in good shape,and handles the exacting demands upon it in good fashion. In connection with this Holly pump are two 2,500,000 gallon Worthington Pumps,which are used as auxillaris in case of brake down.

The main station pumps from 27 deep wells which are b bored in a close vicinity to the station. The main station has been in operation since 1885 and owing to its central location will no doubt continue to be the site of the water works system.

The first one of the substations was established on Townsend St, at the intersection of Isaac St., and about 200 yards from the bank of the Grand River. At present this station is not in use, the services of the other stations being adequate. There are eleven deep wells at this station ranging from 215 to 245 feet deep.

The second station was built in North Lansing on the bank of the Grand River, near the Seymore St. bridge. This station is equipped with a 10 x 12 vertical triplex pump manufactured by the Gould Mfg.Co. It is run at a constant speed of 35 strokes per minute by a 75 horse power Allis Chambers Motor.

This station is operated ten hours per day, thereby keeping the northend pressure up during the heaviest consumption hours of the day. At this station there are four six inch wells ranging from 335 to 360 feet in depth. The pump, when working at full capacity, operates on the wells with a vacuum of 23 inches under standard conditions, however a vacuum of 18.5 inches is generally maintained.

The third substation is located on Pennsylvania Ave., at the Grand Trunk R.R. crossing. It is equiped with a Fairbanks and Marsh 14 x 12 reciprocating pump with a capacity of 1 million gallons per day. This station is the newest of the substations and is run intermittently to save the wells at the mainstation.

The pumps at the substations are motor driven. The current is supplied from the City Lighting Station, which is run in connection with the main water station.

All three of the substations are small neatly furnished brick structures. The pumping machinery is embedded on concrete at about 12 feet below the surface of the ground so as to make the lift as small as practicable. The stations are in charge of two men, one for night and one for day work, to operate the pumps upon orders from the main station.

Systems.

The water system of Lansing is what is known as the direct stand pipe system. The water is pumped from all the stations directly into the system from their various locations. On Cedar St. at the main station is located a steel standpipe, which is used as an equaliser for the system. The standpipe is 122 feet high and is 18 feet in diameter. Leading away from the station, to the standpipe, and in the other direction across the Grand River to Washington Ave. are 16 inch mains. These are the largest mains in the system, and have no auxillaries in case of a break down. At the standpipe at Cedar St. and at the intersection of Washington and Allegan St. the large mains branch out into the system, distributing water to the various parts of the system. A condition showing that the system was installed when the city was smaller and less flourishing is shown by the fact that no regular lateral system, distributing water to the various portions of the city, is used.

but in some cases as can be seen by the map of the system accompanying this thesis, there are two mains in a single street or again the large mains drop to small ones. This can obviously be seen to be contrary to good practice as the accompanying loss of head would be considerable, and would largely depreciate the pressure and hence the efficiency of the mains.

The average size of the mains throughout the system is six inches through, though in short side streets these drop to four inches.

Along with the size of the mains comes another criticism of the system, that is in the number of dead ends, which can be seen in the accompanying map. Dead ends in mains are not only a violation of good practice, but are detrimental to the system and may become a positive menace to the consumers. As water soon becomes stagnant where there is no circulation, bacteria increase rapidly.

Consumption.

The quantity of water furnished to a city from its supply system is a most important item. Without an ample supply of water in an inland city, the city will suffer from al lack of proper sanitary practices.

The consumption of a city is figured per capita per day. In good American practice the amount should be from 75 to 100 gallons. In order to determine the consumption of Lansing, considerable trouble was encountered, because of the lack of apparatus to measure the true amount of water pumped. This comes about fromthe fact that the amount of water pumped at the two substations is not measured in any way, the pumping being done intermittantly merely to remove the drain upon the wells

the wells at the main station.

At the main station is a steam pump which is provided with a revolution counter by which the number of strokes are recorded. This multiplied by the displacement of the pump, with a consideration for slippage and leakage, gives a fair estimate of the amount of water pumped.

To find the amount pumped by the substations a careful record of the number of pumps and the time they were in operation is kept by the men in charge, and as the speed of these pumps are nearly constant, an estimate could be made by computing the displacement of them. These results are not absolutely correct, though, we feel they are as close an estimate of the amount pumped as ever has been taken.

Owing to the lack of time, the test made by us was for eight successive days, and the weather during this was fair spring weather which will give a fair average and not a maximum demand, as desired.

The record from the main station was as follows:

	Strokes Day	Strokes Night	Strokes Total	Gallons Pumped.
April [illegible]	10 [illegible]	[illegible]	[illegible]	1 [illegible]
" [illegible]	[illegible]	[illegible]	1[illegible]	11[illegible]1 [illegible]
" [illegible]	[illegible]	[illegible]	1[illegible]	1 [illegible] 1[illegible]
" [illegible]	[illegible]	[illegible]	17 1[illegible]0	1 [illegible]
" [illegible]	[illegible]	[illegible]	17 [illegible]	1 [illegible]
" [illegible]	1[illegible]	[illegible]	1[illegible]	1 [illegible]
" [illegible]7	[illegible]	[illegible]	1[illegible]	1 [illegible]
" [illegible]	1[illegible]	[illegible]	1[illegible]	1 [illegible]
				11 [illegible] total.

Data on pump at Main Station.

Diameter of cylinder ------------------------------ 1[illegible] inches.

Length of stroke ------------------------------ [illegible] "

Slip ------------------------------ [illegible]

Strokes recorded on gauge.

Displacement of pump,

$$\frac{3.1416 \times 18 \times 18 \times 30 \times 2}{4 \times 231} = 79.[illegible] \text{ gallons per stroke.}$$

79.2 x .05 = 3.96 gallons lost by slip.

79.2 - 3.96 = 75.24 gallons per stroke.

Record from Pennsylvania Substation.

Date.	Hours Run.	Amount Pumped in Gallons.
Apr. 21	5	200 000
22	10	482 000
23	5	293 000
24	7	280 000
25	10	408 000
26	6	240 100
27	7	[illegible] 200
28	6	240 100
		2 408 600 Total.

Data for Pennsylvania Substation.

Diameter of Cylinders ---------------------------- 14 inches.

Length of Stroke ---------------------------------- 18 "

Strokes per Min. ---------------------------------- 44 "

Kind of pump-------------------------------------- Double.

Displacement of Pump.

$$\frac{3.1416 \times 14 \times 14 \times 44 \times 2 \times 60}{4 \times 231} = 42\ 220 \text{ gallons.}$$

An allowance of 5% was made for slippage.

42 220 x .05 = 2 111 gallons.

42 220 - 2 111 = 40 109 gallons pumped per hour.

Record for the North End Substation.

Diameter of cylinder------------------------------ 10 inches.

Length of Stroke ---------------------------------- 12 "

Strokes per Min.----------------------------------- 25 "

Slip -- 5 %

Triplex Pump.

Displacement.

$$\frac{3.1416 \times 10 \times 10 \times 12 \times 3 \times 60}{4 \times 231} = 25\ 700 \text{ Gallons per hour.}$$

Slip 5 %, 25 700 x .05 = 1 285 gallons.

25 700 - 1 285 = 24 415 gallons per hour.

This station runs ten hours per day, therefore 244 150 gallons is the amount pumped per day.

Averages per Day at Stations.

Main Station -------------------------------------	1 [illegible]41 [illegible]70 gal.
Pennsylvania -------------------------------------	[illegible]31 000
North End --	244 150
Total -------	1 [illegible]

Amount per capita per day,

$$\frac{1\ [illegible]}{[illegible]} = 65.[illegible] \text{ gallons per capita per day.}$$

The results as found are quite satisfactory for a city situated as Lansing is. As a city having a population and location as Lansing, 65 gallons per capita should furnish an ample supply especially as many draw their domestic supply from their own wells and soft water cisterns. But it must be also born in mind that this test was run in the spring, the weather being quite mild, therefore it might fall short during the hot summer months.

Quality.

The quality of the water is one of the most important topics in investigating the water supply of a city, and it is of vital importance in its health and welfare.

The qualities of water that users are most interested in are:

1st. Its sanitary quality.

2nd. Its Attractiveness.

3rd. Its Hardness.

4th. Its temperature.

This is summarized in Doctor [illegible]ojke's diffinition, "An ideal water is clear, tasteless, gives no nitrate reaction, contains a small amount of earthy and alkaline salts, some carbonic acid gas, and has a temperature of about [illegible]° Fahr."

As an analysis of water is of little value unless the kind of water is known, it must be kept in view that the Lansing water is deep ground water. The following analyses, both chemical and bacteriological were performed by Dr. [illegible], State bacteriologist. The water for these tests was taken from taps in the system so that fair conditions should be met with. One sample was collected in the spring of 1911 and the other late in the summer of 1912.

The results of these analyses show that under normal conditions, the water is perfectly satisfactory to all concerned. Its attractiveness is excellent. The hardness is a little excessive making it unsatisfactory for laundry and boiler purposes.

Water from deep wells possesses entirely different characteristics and cannot be regarded in the same category as that from shallow wells. Usually such wells penetrate alternate layers of porous and impervious materials, or rock and are supplied by the rainfall on remote catchment areas.

As a rule the water from such wells is practically sterilized by a prolonged and slow process of filtration. A visual survey can scarcely be made of the catchment area, except where the geological structure of the surrounding territory is is known by extended surveys. And a bacterial analysis of the a water is scarsely necessary because prolonged filtration deprives the water of bacterial life. A chemical examination is practically all that is necessary, and this is to determine the amount and character of the disolved mineral matter.

Analysis of City Water Collected at State Capitol.

Color	None.	
Odor	None.	
Turbidity	None.	
Sediment	None.	
N as Free Ammonia	.0[illegible]	
N as Albuminous Ammonia	.0[illegible]	Parts
N as Nitrites	None	
N as Nitrates	None.	per
Chlorine	1[illegible].[illegible]	
Oxygen Consumed	[illegible].[illegible]	Million.
Alkalinity	[illegible]	
Hardness	[illegible]	
Ignited Solids	[illegible]	
Iron	.[illegible]	

Bacteriological Analysis.

Colonies per cc. at Room Temp.	1[illegible].
" " " " Inc. "	[illegible].

Presumptive tests for B.Coli.

Gas Production on Lactose B.

1cc.	None.	Red Colonies L. A.	None.
[illegible] cc.	None.	B. Coli	None.
Acidity	None.	Potability	Probably Safe.
Turbidity	Marked. P		
Indol Production			None.

This sample was taken an the second floor of the Capitol, drawn from the city tap after allowing the water to rum about 5 minutes, and the water was still found to be warm, indicating that the water then comming had been for some time in the pipes of the building.

[illegible]

[illegible]

[illegible]

[illegible]

Fire Service.

To provide sufficient fire protection in a city the size of Lansing at the present time, the hydrant system and the water pressure should be such that fifteen streams of water would be available at any one time, discharging 250 gallons of water per minute in business and 175 gallons in residencial districts.

To give streams of this size with nozzles 1 1/8 inches in diameter, such as are now used, would require a pressure of at 35 pounds for 175 gallon streams. This with 400 feet of hose would require a hydrant pressure of at least [illegible] or 70 pounds to take care of the loss of from 10 to 11 pounds incurred by friction in the hose.

For the 250 gallon streams, the pressure at the nozzle should be 45 pounds per square inch, and the loss in the hose from 11 to 15 pounds, making a hydrant pressure of at least 100 to 110 pounds.

These pressures refer to those obtained when the stream is flowing.

We find that as far as pressure is concerned, it is ample for the conditions expressed as the mains carry pressure nearly constant at 70 pounds, while the extra needed pressure is gotten from the auto fire engines, which have been recently installed in the Department.

The auto fire engines in the Lansing Fire Department are the latest development in the fire fighting line, and in a level city like Lansing, they are particularly effective.

There are two engines, manufactured by the Webb Motor Fire

Apparatus Co. [illegible] capable [illegible] streams [illegible] from hydrants with 70 pounds pressure [illegible] pounds with hydrants having the water at rest. [illegible] for ordinary fires, but for a conflagration [illegible] hydrant, [illegible]

[illegible] within the city limits [illegible] regular [illegible] have been employed [illegible], [illegible] private [illegible].

[illegible] fire [illegible] No. [illegible].

[illegible]

[illegible]

No.	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible] in [illegible], [illegible] protect [illegible] [illegible].

[illegible], [illegible] except [illegible] furnished by the fire department.

[illegible] conclusion of this thesis, this feature will be taken up with the view of improving it.

Test of Auto Fire Engine of Lansing Fire Dept.

Location of Test ---------- Michigan Ave., and Capitol.

Size of main--------------- 8 inches.

Size of Hydrant barrel ---- [illegible] inches.

Test	No. Lines	Length of Lines	Nozzle Size	Nozzle Press.	Engine Press.	Discharge in gallons per minute
1	1	[illegible] ft.	1 1/[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	"	"	[illegible]	1[illegible]	[illegible]
[illegible]	[illegible]	"	"	[illegible]	[illegible]	[illegible]
4	[illegible]	"	Siamese. 1 1/[illegible]	[illegible]	1[illegible]	[illegible]
5	[illegible]	"	1 1/[illegible]	[illegible]	1[illegible]	[illegible]
[illegible]	[illegible]	"	"	[illegible]	[illegible]	[illegible]

Location of Test---------- River St. and [illegible] St.

Size of Main------------- 6 inches.

Size of Hydrant Barrel---- [illegible] inches.

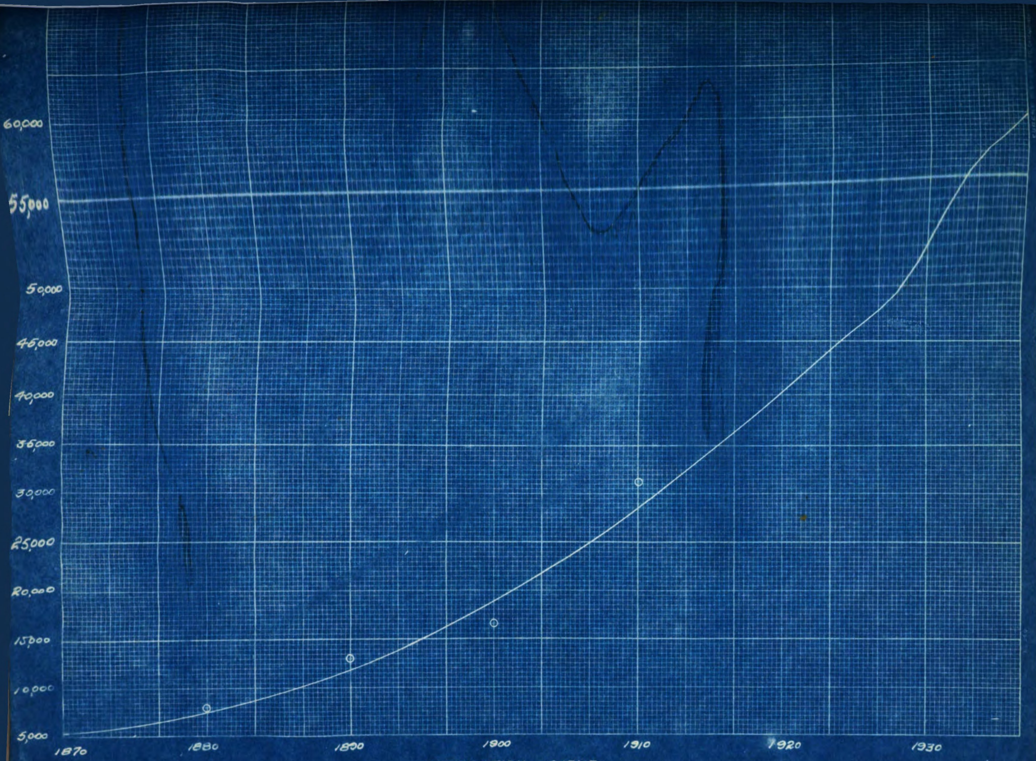
Test	No. Lines	Length of Lines	Nozzle Size	Nozzle Press.	Engine Press.	Discharge in gal. per minute.
1	[illegible]	1[illegible] ft.	1 1/2"	[illegible]	1[illegible] #	1[illegible]
2	[illegible]	"	2"	50 #	110 #	[illegible]

These tests show that with the aid of auto fire engines pressures of sufficient proportions are to be obtained at nearly all fire hydrants.

Population.

The population of Lansing has been very rapid in growth in the last ten years of its cities development. This is shown by the population curve which accompanys this thesis.

This rapid growth, which is due to the large manufacturing interests which are being developed in Lansing, is causing the



POPULATION CURVE

city to be built up, and the opening of new additions to the city which will in a short time will have to be brought within the city's limits. This adding to the city will in a very short time mean the extension of the present water system and will be another drain upon the already limited water supply of the city.

The extension of the system into these additions will also necessitate the operation of outlying substations for their entire supply, so as to obtain the required pressure for good service, especially for fire protection.

This extension should be done with the view of further extension, that is large laterals should be laid which will carry to the distributing system the amount of water required without a large loss due to friction, which would be incurred by extension of the 6 inch mains which are now extending in the outlying districts.

Administration.

The Water Works system of Lansing is associated with the Public Light system, being managed by a city Water and Light board. The members of this board are appointed by the Mayor and confirmed by the council. One commissioner is appointed each year for a period of six years. The commission is strictly non-partisan and serves without pay.

Rates.

The entire revenue derived by the water works system is gotten from the special tax levied upon the consumers or by the sale and special tax where meters are used.

A uniform rate has been established as follows.

Annual unmetered per year,

Sink and washstand---------------------------------- $ 4.00
(General Purposes.)

Closet	$ 2.50	
Bath	2.50	
Lawn	2.00	

When sold by meter rates, the cost is:

1000 gallons or less	.40	per thousand
10 000 gal. to 50 000 gal.	.10	" "
50 000 " " 100 000 "	.08	" "
1 000 000 gallons	.05	" "

The use of meters should be established especially in a system of this sort as rapidly as possible, as it is the best possible manner to prevent waste of water by consumers as well as making a uniform expense, the consumers paying for the water they use.

In Lansing the use of meters is especially desired, as the supply of water is limited, and should be used to the best possible maximum.

Finances.

The money with which the Lansing system was constructed was furnished by bond issue in the spring of 1885 when the system was organized.

The original bonded indebtedness was $ 125 000.00 . Of this indebtedness, bonds to the value of $ 75 000 have matured and been paid out of the earnings of the system, leaving bonds outstanding to the amount of $ 50 000 unmatured.

The construction account up to June 1.1910 was:

Main pipe line, 71 miles	$ 320 701.61
6320 Service connections	63 602.4[illegible]
2935 Meters	40 538.36

Real Estate Pumps, etc	----------------------------	$ 1[illegible] [illegible].15
34 Wells	----------------------------------	26 969.93
	Total------	5[illegible]1 957.55

A conservative estimate of the value of the system would be $ [illegible] 000.00 .

Conclusion.

As a result of our investigation we find that the water system at the present time fulfills the requirements as to quality, but the quantity is an item which must be considered cheifly in the further development of the Lansing System.

As shown by the consumption dealt with in this thesis, that the amount used per capita during the spring months amounts to 65 gallons. This amount falls within the amount that good authorities place in good practice.but it is very probable that the maximum used during the summer months should approach 100 gallons per capita.

The amount that should be supplied is two times the average consumption plus the maximum fire service demand. This maximum is never fulfilled as the pressure in the outlying districts drops during the heavy consumption hours so that the domestic service is greatly impaired,to say nothing of the possible fire demand.

This feature we will attempt to discuss by the suggestion and criticism of two possible methods of improvement.

The first is the installation of a high pressure system as designed by Messers C. .Kee and E.C. llis,in their 1911 Thesis report. This system as designed as being now under consideration by the Lansing Water Board.

This high pressure system is to be installed for public use only, and the water to be pumped directly into the system and drawn drawn from the Grand River, which would be an inexhaustible supply.

The use of this system would greatly reduce the demands upon the present system, the supply from which would be used intirely for domestic purposed, thus saving to the people of Lansing their present water supply. for drinking and cooking, as it could not be improved in quality.

The installation of this system as now proposed is to be laid by laying it first in the main business streets of the city, as a neucleus, and by extonding a small amount each year, gradually completing the system. In the building of the system by this method, it relieves the necessity of incurring another bonded indebtedness, as the cost will be covered by the earnings of the systems and by special tax, which would be relieved by decreased insurance rates which would surely follow the installation of such a system.

The one serious fault of installing such a system by small pieces is that in all probability, that unless carried out under the direction of one engineer, it would not be laid in accordance with good practice. By this we mean the careful consideration and locations of principle mains followed by laterals and the distributing system which would give to the city the best possible results for the least expended amount, whereas if the system was entirely laid under properly executed plans and specifications it would immediately releave the present situation and become a source of satisfaction to its users.

We base this claim upon the [illegible] all cities derive [illegible] the extension of [illegible] can be cited as one. The [illegible] supply demand. [illegible] inadequate for their needs.

Another feature [illegible] installation of a high pressure [illegible] the fact that [illegible] pipes in [illegible], which will [illegible] in need of.

We are positive [illegible] the installation of such a system is a question that should be [illegible] the people of Lansing [illegible] of their system.

[illegible] first [illegible] the installation of a filtration plant [illegible] improvement of the [illegible].

[illegible] of such [illegible] comes from the fact that [illegible] supply of the city must be [illegible]. [illegible] filtration [illegible] practicable [illegible] its supply [illegible] inexhaustible.

[illegible] suggest the build- ing [illegible] above [illegible] upon this [illegible] relates the river at every street intersection.

[illegible] condition [illegible] it is a [illegible] of [illegible]rican cities, is [illegible] to the city, [illegible] should be made to correct it.

[illegible] question arises, could not [illegible] down in the [illegible] central [illegible] be [illegible]. This can be answered, but [illegible] the [illegible] consumers and no matter what [illegible] of [illegible] men. If the [illegible] opinion [illegible] otherwise, [illegible] would fail.

[illegible] location, a typical analysis of the water [illegible].

[illegible] River Water.

[illegible] River above [illegible]'s [illegible].

Alkalinity	[illegible]		
Ammonia	[illegible]		
Dissolved solids	[illegible]		
Chlorine	[illegible]		Parts per
Nitrates	[illegible]		million.
Nitrites	[illegible]		
Iron	[illegible]		
[illegible]	[illegible]		
Total hardness	[illegible]		

The alkalinity [illegible] in the form of [illegible] [illegible], [illegible] as [illegible] condition. [illegible] of [illegible].

[illegible], [illegible] and [illegible] presence of chlorine [illegible] presence of contamination [illegible] ground [illegible] more or less high in chlorine. [illegible] of [illegible] is a favorable [illegible] of the absence of sewage in solution.

The filtration plant would be built in two parts. The first or sedimentation plant, to separate all solid matter from the water that would tend to clog the filter beds. The use of a coagulent would necessarily be called for to collect the suspended matter and for softening the water for domestic purposes.

In the suggestion of such an improvement as the filtration plant, we take into consideration these items:

It would be a permanent supply.

The centralization of the entire system could be made as efficient as possible.

The use of satisfactory water for all purposes would be secured.

One system would made the least complication possible.

In the present system there are several criticisms to be made. The most prominent is the number of dead ends contained in the system. No regular cross lateral plan seems to have been followed out. The lines are merely extended along a street as far as needed, and there are allowed to terminate. We are informed that the lines are regularly flushed, but even if flushed daily, the water could be nothing but unsatisfactory oweing to the corrosion of the iron mains.

The lack of data and notes of the present system is quite apparent. The knowledge of the system seemingly to be vested in the memory of some of the officials.

No knowledge of the consumption of the water is known by the officials. An approximate amount is determined by records at the main station, but in checking their data, we found that errors must necessarily be introduced by the non-recognition of slippage. The water from the substations is pumped directly [illegible] [illegible]

[illegible] near future [illegible]

will not [illegible] of [illegible].