THESIS

THE WATER SUPPLY OF OWOSSO, MICHIGAN

J. B. CHYNOWETH

1920

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The Water Supply

of

Owosso, Michigan.

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By

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Introduction

The investigation of the water supply of Owosso was undertaken with the idea of showing just what the prevailing conditions of the water system are, with the view of determining its adequacy and efficiency. It is proposed to criticise favorably or otherwise and to recommend needed improvements in different parts of the system. Criticisms, recommendations, and conclusions are based on references taken from treatises of good water supply methods as presented by recognized authorities. The authority in most cases being:

1. Public Water Supply, Turneaure and Russell
2. Hydraulics, Hughes and Safford
3. Compressed Air, Harris
4. Clean Water and How to Get It, Hazen
5. U.S. Geological Survey Monograph Vol.LIII
6. Water Supply of Municipalities, U.S. Geological Survey

The author wishes to thank H.K.Vedder, professor of the Civil Engineering Department, who suggested this subject to him after his failure to find sufficient data on a former thesis.

To Professor Rich of the Public Department of Health, Jack Rosevere, Commissioner of Public Works, C.L.Raymond, City Engineer and Professor Ren Saxton, gratitude is expressed for the helpful suggestions and time spent on this investigation.

History:

The history of the Owosso waterworks is similar to that of many others in the United States. It might be said that it just grew up. About thirty years ago it was the practise for city fathers to install a waterworks at the least amount amount and as furture growth forced extra requirements on the plant, additions were made at the least expense and the least trouble to the city officials.

The water supply system of Owosso was built at a time when a wave of waterworks building swept the country. Orginally the plant installed was a small affair, with about two thirds of the present equipment. Two Gordon stem steam pumps with boiler plant and the necessary plant equipment, together with the watur supply of eight flowing wells; a small storage reservoir and twelve miles of distribution mains, completed the layout. The cost was about $92,000.

Thirty years have elapsed since thenand many additions and improvements have been made. The distribution milage has increased from twelve to thirty two miles of pipe. New wells have been added while others have been abondoned. Additional land has been purchased and the pumping plant enlarged. New equipment has been added as follows:-

a. In 1895 a large covered reservoir was built.

b. In 1909 the old boiler equipment was removed and two new Scotch Marine type boilers were installed.

c, In 1910 a Laidlaw-Dunn Gordon Cross Compound Duplex Air Compressor and air lift pumps were installed.

History continued:

d. In 1912 the Snow pumps were installed.

e. In 1915 the brick coal shed was built.

f. In 1918 the workshop on Comstock Street purchased.

Source:

Owosso is situated a little north of the central part of Shiawassee County, Michigan. During the glacial period this county and the surrounding region were covered by the North American glacier as it moved southward to the northern part of Indiana where progress was halted and reversed. During the backward journey, at successive intervals, terminal moraines were deposited, one of which passes through Fort Wayne, Indiana. As the glacier retreated eastward from this moraine it uncovered what is now the upper Maumee valley. However it continued to occupy the lower part of that valley and therefore to obstruct its normal northward drainage. As a result a lake known in geological terms as Lake Maumee was formed between the moraine and the receding ice front. Later as the ice front was halted, new moraines were formed from the debris of the glacier and the area of Lake Maumee was changed, thus making the area smaller. One of these moraines is known as the Defiance moraine which followed the following course,-from Defiance, Ohio, north to a point the same latitude as Port Huron, through Lansing and north to Manistee; thence it turned south and passed through Chicago. When the ice front retreated from this moraine it fell back a long way to the eastward and opened an outlet somewhere near Imlay in Lapeer County, Michigan. This outlet passed just north of Durand, south of Owosso and carried at one time the water of the large glacial Lake Maumee.

The sand and gravel in these beach ridges and on lake beds frequently serve as a source of water supply in wells, water being found at the base of the sand and gravel. (Flowing Wells and Municipal Water Supplies in the Southern Part of the Southern Peninsula, published by the United States Geological Survey, November 1919) It is to this geological formation that Owosso must look for her water possibilities. The greater supply comes from wells driven thruogh sand and gravel to a depth of fifty to seventy-five feet. The geological formation is clearly shown from the following Driller's Reports of Wells in Owosso.

Well No. 2

Characters	Width in feet	Depth in feet	Remarks
Soil	2	2	Near Pump House
Clay	5	7	
Sand	15	22	
Coarse Sand	5	27	
Gravel	3	30	
Clay	3	33	
Gravel	2	35	
Water Flowed	5	40	
Fine Sand	6	46	
Quick Sand	6	52	
Coarse Sand	16	68	
Gravel & Water Flow	15	73	

Well No. 3.

Character	Width in f et	Depth in feet	Remarks
Muck	7	7	Located 200 feet east of Well No.2 on the same line.
Sand	5	12	
Gravel	1	13	
Clay	14	27	
Sand	15	42	
Clay	1	43	
Gravel	12	55	
Quick Sand	13	68	
Gravel with Flow	3	71	

Well No.4.

Clay	3	3
Bravel	6	9
Clay	9	18
Quick mSand	16	34
Clay	6	40
Gravel	13	53
Quick Sand	13	66
Gravel	7	73
Water Gravel	1	74

Well No. 5.

Character	Width in feet	Depth in feet	Remarks
Soft Clay	3	3	Does not flow as strongly as other wells do. There are large quantities of coarse sand mixed with the gravel, presumably keeping the water back.
Quagmire	6	9	
Gravel	23	32	
Quick Sand	6	38	
Clay	5	43	
Gravel with Flow	5	48	
Clay	6	54	
Quick Sand	3	57	
Clay	4	61	
Quick Sand	11	72	
Gravel with Flow	13	85	

Well No. 6.

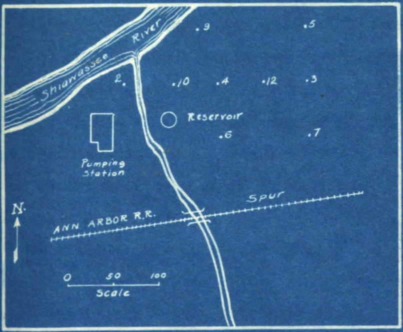
Muck	4	4	One of the best
Gravel	3	7	
Clay	11	18	
Gravel	8	26	
Clay	13	39	
Gravel with Flow	2	41	
Quick Sand	16	57	
Coarse Sand	10	67	
Gravel with Flow	4	71	

Well No.7.

Character	Width in feet	Depth in feet	Remarks
Soft Mire	22	22	A failure, gravel at 70 feet has quick sand below it which prevents flow.
Gravel	17	39	
Clay	4	43	
Gravel with Flow	11	54	
Coarse Sand	13	67	
Gravel	3	70	
Quick Sand	15	85	
Blue Clay	5	88	
Quit Drilling			

Well No. 8.

Yellow Clay	4	4	This well was a failure at this depth but a dynamite cartridge placed at 43 feet below the surface blew the casing off.
Sand	12	16	
Clay	21	37	
Gravel with Flow	10	47	
Clay	10	57	
Sand	9	66	
Gravel	2	68	
Quick Sand	9	77	
Clay	4	81	
Fine Sand	9	90	



Distribution of wells at Owosso Waterworks.

Yield:

The subject of yield is of prime importance in connection with any water works, since its success depends materially upon the reliability of the source. A thorough study of the subject would necessitate considerable investigation. Annual reports of rainfall , data on the percolation of a given area and information on abnual evaporation are all of great value.

The yiled of a water bearing area is dependent on three things: (1) No more water can be continuously taken out of a well, than goes into it; (2) The yield of the ground water is dependent upon the character and extent of the câloulated area; (3) The velocity of flow of ground water depends upon the character of material through which it must pass in gravitating from a higher to a lower level.

Rainfall is the chief source of water and yield is dependent upon the amount of rain during successive seasons. One 6f the duties of the United States Weather Bureaus is to keep a careful record of the rainfall in inches. Monthly and annual precipitation tables are published in which any required information of this subject may be found. There is no such station at Owosso, nor are reports of the immediate vicinity obtainable. East Lansing is sufficiently close to warrant the use of data compiled at that point.

From a pamphlet printed and published for the Weather Bureau, known as "Monthly and Annual MeteorologicalSummary and Comparative Data for the Year Ending December 31, 1919, of Lansing, Michigan" the following data on rainfall was obtained:

Monthly and Annual Precipitation

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1900	1.17	3.44	1.88	2.00	4.17	2.57	4.15	2.98	0.89	2.77	5.10	0.50	31.62
1901	1.51	1.83	2.94	2.16	2.42	3.57	5.08	2.49	1.67	4.61	1.21	3.00	32.49
1902	0.43	0.44	3.16	1.70	4.92	7.28	7.13	0.68	5.88	1.53	2.46	2.89	38.50
1903	1.30	1.58	1.25	4.40	2.63	6.38	3.79	6.73	2.86	2.01	1.45	1.75	35.93
1904	2.83	3.30	3.45	0.50	2.40	2.49	1.97	3.26	2.35	1.90	0.04	1.42	25.90
1905	1.07	1.25	3.15	1.49	5.17	7.47	5.75	3.92	3.21	1.75	2.25	2.54	39.02
1906	1.99	1.12	1.86	2.43	3.05	4.61	2.23	4.35	0.76	2.36	2.66	1.85	9.27
1907	3.97	0.25	2.84	2.81	2.32	2.37	4.30	2.87	4.68	2.22	1.83	4.19	34.55
1908	1.89	3.19	2.19	2.15	5.59	1.23	1.03	3.99	0.65	0.82	1.82	2.08	26.63
L909	2.16	2.36	0.90	5.96	2.44	2.86	2.56	1.61	1.51	0.71	3.74	2.91	9.72
1910	2.52	2.65	0.40	2.48	4.13	1.95	1.53	1.76	2.74	2.27	1.37	1.28	5.08
1911	1.43	1.77	1.21	3.11	2.67	3.77	1.75	1.48	5.05	5.00	3.40	1.58	31.12
1912	0.80	2.04	1.92	3.12	6.57	0.97	5.06	2.19	3.37	3.44	2.86	1.20	33.50
1913	3.10	1.65	3.76	3.10	2.22	1.01	2.85	5.60	1.53	3.30	2.38	0.55	31.05
1914	2.98	0.79	1.52	2.90	4.66	4.11	1.65	3.33	2.65	2.81	1.40	1.57	30.37
1915	1.54	2.10	o.78	1.00	2.74	3.96	5.17	4.63	6.55	0.70	2.23	1.01	32.41
1916	3.11	0.69	3.09	1.91	5.13	5.39	0.09	1.58	2.17	2.53	1.68	2.11	28.48
1917	1.55	0.62	2.88	5.59	3.37	4.54	3.06	1.47	4.60	3.44	0.82	0.74	32.68
1918	2.08	3.04	3.58	1.97	2.89	2.07	1.96	1.44	2.88	3.21	3.22	3.61	31.95
1919	0.36	1.50	3.48	4.13	4.39	3.18	1.69	4.03	2.61	2.90	2.44	0.86	31.47
N'ml	2.09	2.02	2.36	2.54	3.58	3.40	3.22	2.63	2.62	2.33	2.41	2.08	31.08

Note: The averages are for the years 1883-1919 and not for the years 1900-1919.

Yield Continued:

Of the rain which falls, a part passes off immediately into the streams and forms what may be called the flood flow; a part is evaporated directly from the surface of the ground; and a portion percolates into the ground. Of the last portion a part is caught by vegetation, passes upward and evaporates from the leaves, the remainder passing on downward and laterally sooner or later finding its way water-bearing stratum.

The part which passes downward and laterally is the part in which the water engineer is interested. Water will not percolate as well in clay as it will in sand. Consequently, experiments have been made and the percent of percolation of the rainfall in inches for different classes of soils determined. For a region such as Owosso, in which the soil is more or less sand and gravel, the percolation is from twenty-five to thirty percent of the rainfall. (Table No.19 Public Water Supply). Thus eight to ten inches reaches wells or springs and contributes to the water supply of Owosso.

The investigation of the area and character of the ground contributing to the wells is a complex subject, and one that should be carried on by an expert.A contour map of the region shows that approximately one hundred forty-six acres contributes water to the supply.

146 x 43,560 = 6,400,000 square feet.

If ten inches a year is that part of the rainfall which percolates into the ground and 6,400,000 square feet is the contributing area , 6,400,0000x 10 = 64,000,000 cubic feet of water, which will be the capacity of the area for a year.

Yield Continued:

There are 7.481 U.S. gallons to one cubic foot of water. 64,000,000 x 7.481 = 477,000,000 gallons which the area will supply in one year.

The velocity of flow can be determined by two methods: (1) The velocity of flow of a ground water stream is a function of the hydraulic gradient or slope and the resistance to flow offered by the particles of soil. The slope is determined by borings sunk to the ground-water level, care being taken to measure it in the direction of the greatest declivity. The slope is then found by determining the height to which the water will rise in tubes sunk to the porous stratum. The size of the grain and compactness of the material will influence the flow. Samples of the soil are taken at the time of boring. This method , however, is tedious and uncertain unless one is experienced with it.

(2) The rate of flow of ground water may be directly determined by tracing the movement of a soluble salt introduced into the ground water stream. This method is the best and is used in practice more generally than the first method. Three or four borings are sunk to ground water,on a line in the direction of flow. A large dose of salt is then put into the upper hole, and at frequent intervals analyses are made of water drawn from each hole below until the salt content has reached its maximum in each case. This experiment was to have been performed but due to the inaccessibilityies of the wells, which were built up with masonry , the experiment was not carried out. However, comparing the soil, the nature of the country, and the compactness with other localities of similar natures, the velocity is assumed to be about ten feet per day.(Public Water Supply) P.101.

Yield Continued:

The velocity of flow, the porosity of the material, and the cross section of the porous stratum at right angles to the direction of flow having been determined, the total rate of flow will be the product of these three factors or Q = velocity x the are of the cross section x the porosity. By averaging the depth of porous stratum from the driller's reports the depth was taken as ten feet, From the contour map the width was taken to be 8000 feet, The porosity of the soil as 25 percent. Then Q = 10 x 8000 x 10 x .25   Q = 200,000 cubic feet per day.
200,000 x 7.481 = 1,496,200 gallons per day.

From investigations of the supply of Owosso made in 1917 by Mr. Chaupe, a Toledo engineer, the following information was obtained. Water from the gravity wells amounts to 6,200 gallons per day. The spring supplies approximately 410,000 gallons per da y The air driven wells appear to have a total output of from 800,000 to 900,000 gallons. This makes a total of less than 1¼ million gallons per day. In the report Mr. Chaupe states that gravity wells have fallen from 700,000 gallons to 62,000 gallons in less than a year.

The city of Owosso in the year of 1917 pumped 303,905,700 gallons of water or an average of 830,000 gallons per day. From a series of diagrams (Public Water Supply, page 27) and tables it is concluded that the maximum monthly rate is about 115 percent of the average monthly rate. The diagram further shows that excessive consumption is likely to continue for two or three consecutive months. Using the above figures as a basis we find that Owosso will use an average of 1 million gallons per day of water during the maximum period. This means that the supply is not enough to warrant any great increase of population. For the present popu-

Yield Continued:

lation it is adequate but for any proportional increase new water bearing areas will have to be looked for.

Purity:

In examining this water , as to its suitability for public use, three different kinds of tests have been applied. These are as follows:

Physical Examinations

Chemical Examination

Bacterial Examination

The water to be perfectly satisfactory as to its physical requirements should be colorless, free from any turbity, undesirable odor or taste an of sufficiently low temterature to be refreshing.

The water at Owosso is colorless, pleasing to the eye, and entirely suited for public usages.

A sample of water was taken and allowed to stand in a test tube for a period of two weeks. At the end of that time, the bottom of the tube was examinied. and several small particles were found on the bottom but not enough to discolor the water and make it turbid.

A sample of the water was taken and warmed to about 60°F. the bottle being tightly corked during the heating. The cork was removed and the nose placed at the top of the bottle. No odor was detected. The taste is normal, not particularly pleasant but not disagreeable.

The temperature of the water was taken a fountain near the city hall, at a watering trough and from a free running hydrant. The temperature was found to average 50°F. which makes the water suitable for domestic use.

This analysis of the physical properties shows that the

Purity Continued:

water of Owosso is all that specifications require.

A chemical analysis of the Owosso water proves it to be a hard water. One pound of chlorine is used per million gallons as a softener. A chemical analysis of a sample taken in the Ann Arbor Railroad freight yard by Dr.R.M.Olin of the Michigan Department of Health is as follows:

Report on Chemical Examination of Water April 16,1920.

Chemical Analysis	Parts per Million Gals.	Grains per Gal.
Solids, total	363	21.16
SiO_2	14.6	.85
$FeO_3 + Al_2O_3$	trace	
Ca	77.5	4.52
Mg	26.6	1.55
Na + K	3	.17
Cl	10 .	.58
(SO_4)	43.4	2.53
$H(CO_3)$	306	17.84

Lime $Ca(OH)_2$
to soften 1000 gals. 2.2 lbs.

Soda Ash Na_2CO_3
to soften 1000 gals. .46 lbs.

The bacterial examination of water is one which sanitary engineer must make. Several analyses follow which the author will not attempt to discuss.

Report on Bacteriological Examination of Water Samples.

Michigan Department of Health

Date March 25, 1920
Soruce Tap at J.Bower's Meat Market

Bacteria per cubic centimeter.

Agar at 37°-- 24hours-----7,000

Gelatine at 20°--48 hours

Purity Continued:

No. of Positive Fermentations

In 5 --10 cc Samples.....4

In 1 -- 1 cc " 0

In .1-- .1cc " 0

Endo's Media........Positive

Refermentation...... "

Coli Group.......... "

Potability.......... Does not conform to standard.

Date October 29, 1919.

Source Taken on Discharge Side of pumps in station

Bacteria per cubic centimeter

Agar at 37°---24 hours---17

Gelatine at 20°--48 hours---

No. of Positive Fermentations

In 5 10 cc Samples....1 .

In 5 1 cc " ....none

Endo's Media........Positive

Refermentation...... "

Coli Group.......... "

Potability.......... Safe

Date March 25, 1920

Source Tap at Sprague's Drug Store

Bacteria per cubic centimeter

Agar at 37°---24 hours---- 15,000

Gelatine at 20°--48 hours-

No. of Positive Fermentations

In 5 10 cc Samples......5

In 5 1 cc " 1

Purity Continued:

Endo's Media........Positive

Refermentation....... "

Coli Group.......... Does not conform to standard

From the table and typhoid curve which follows, a high typhoid rate is noticeable in the years 1902, 1908, 1909, and 1910.

Typhoid Table of Owosso, Michigan.

by the Michigan Board of Health.

Year	Population	Number of Cases	Rate per 100,000
1900	8,696	3	34.5
1901	8,808	2	22.7
1902	8,921	4	44.8
1903	9,033	1	11.1
1904	9,145	0	0.0
1905	9,257	2	21.6
1906	9,370	0	0.0
1907	9,482	1	10.5
1908	9,594	3	31.3
1909	9,707	3	30.9
1910	9,739	3	31.1
1911	9,721	1	10.3
1912	9,804	1	10.2
1913	9,886	1	10.1
1914	9,969	0	0.0
1915	10,050	1	9.9
1916	10,136	3	29.6
1917	10,222	1	9.8

Purity Continued:

The rate during these years is not alarming for in 1902 there were only 4 cases in Owosso while in the same year 9 cases were reported in the County of Shiawassee. Reports of the Bureau of Public Health state that the water of Owosso was not contaminated at this time but cases were brought into the city by infected patients. In 1908,1909, and 1910 the same conditions existed.

The typhoid rate is the best indication of contamination and is taken as such by the Board of Health. A water supply which which shows a low typhoid rate is considered a very good asset to a municipality. Owosso is fortunate in this respect.

Pumping Plant:

The pumping plant of the Owosso Water Works is located in the south eastern part of the city on the south bank of the Shiawassee River. The main station building is built of brick and appears to be in good repair, It is ninety-four feet long, forty-two feet wide, and twenty-eight feet high. A steel and frame truss with slate roofing covers the main part of the building and the e end wings.

The equipment consists of the following machinery and material: (1) Two Gordon Compound Duplex Force Pumps with a displacement of ten by twelve inches, capable of pumping 735 gallons each per minute, at a speed of forty-five revolutions per minute. These engines were installed in 1889 , thirty years ago, and have been completely worn out since that time. In the valuation report which accompanies this thesis they are rated as scrap.; (2) One Snow Compound Duplex Force Pump, Crank and Fly Wheel Type with a displacement of ten by eighteen inches., at the rated speed of fifty-six revolutions per minute, this engine will pump 1370

Pumping Plant Continued:

gallons per minute. The cylinders have been rebored to a diameter of 11¼ inches which gives a capacity , at the rated speed, of 1600 gallons per minute. This engine is in fair repair. ;

(3) Two Loos Scotch Marine Type Boilers , each 200 horse power, 9 feet 6 inches in diameter by 12 feet 8 inches long and containing 108 @ 3½ inch fire tubes.;

(4) One small storage reservoir with brick walls covered with a conical wooden roof, 20 feet in diameter by 27 feet deep, with a capacity of 25,000 gallons.;

(5) One large storage reservoir built with brick walls, concrete bottom and a concrete slab roof on steel I beams. Capacity 412,000 gallons.;

(6) One Laidlaw -Dun Gordon Cross Compound Duplex Air Compresso with a capacity of 850 cubic feet of free air at 60 to 70 lbs. pressure per minute. Rated speed -133 revolutions per minute.;

(7) Three Boiler feed pumps, together with the innumerable small accessories that are found in any plant of similar nature. A summation of these can be found in the valuation report accompanying this thesis.

At present the plant is giving fair service at a high rate of cost. Mr.H.E.Riggs of the University of Michigan in a report submitted to the City Council of Owosso in 1919 revealed this fact and summarized his findings as follows: the average daily consumption has not increased , the fuel cost has increased 100 percent, the total pumping cost 84 percent, and the cost of coal 800 percent. The accompanying statistics bring out more forcefully these facts.

Pumping Station Continued:

Pumping Statistics and Fuel Cost

Year	Gals. pumped in 1000 gals.	Average per day	No. Services	Av. gals. pumped per service per day
1910	176,635	483,932	1,364	354
1911	233,939	640,929	1,518	422
1912	246,177	672,616	1,675	423
1913	217,565	596,000	1,735	355
1914	263,067	720,706	1,830	415
1915	255,731	700,607	1,898	383
1916	274,923	751,390	2,059	395
1917	332,551	911,100	2,104	432
1918	349,801	955,620	3,163	454
1919	301,067	824,840	2,174	381

The above statistics show that the average number of gallons pumped per service per day has consistently averaged about 400.

Analysis of Cost

Year	Coal used Lbs.	Average Lbs. Coal per day	Lbs. Coal per 1,000,000 gals.	Coal Cost 1,000,000 gals.	Total Cost mill gals.
1910	1,993,000	5,463	11,288	15,99	55,90
1911	2,741,100	7,510	11,717	19.76	48.70
1912	2,668,400	7,290	10,840	19.24	57.30
1913	2,308,500	6,325	10,610	18.22	56.40
1914	3,065,800	8,399	11,654	.....	......
1915	2,903,700	7,952	11,351	16.33	57.20
1916	2,709,200	7,405	9,855	17.23	54.10
1917	3,429,100	9,395	lo,312	......	.....
1918	3,542,600	9,705	10,157	25.89	48.80
1919	3,012,800	8,254	10,000	32,15	103.00

Pumping Plant Continued:

Coal cost per million gallons in 1910 was $16.00, in 1919, $33.15, or an increase of 100 percent.

Operating Expenses

Year	Salaries	Fuel	
1893	$ 2,151.00	$ 1,164.00	
1894	2,323.00	1,195.00	
1896	2,542.00	1,377.00	
1897	2,542.00	1,201.00	
1898	2,543.00	1,440.00	
1901	2,543.00	1,034.00	
1902	2,760.00	1,270.00	
1905	3,300.00	1,744.00	
1906	3,300.00	2,050.00	
1907	3,300.00	1,721.00	
1908	3,300.00	2,806.00	Air lift began
1909	3,300.00	2,509.00	
1910	3,566.00	2,824.00	
1911	4,590.00	4,623.00	
1912	3,064.00	4,737.00	
1913	3,300000	3,964.00	
1915	3,510.00	4,173.00	
1916	3,769.00	4,737.00	
1918	3,700.00	9,032.00	
1919	9,486.00	9,680.00	

The fuel cost in 1893 was $ 1,164.00 , in 1919, $ 9,680.00, showing an increase of 800 percent. The report further shows that the air lift doubled the consumption of coal. Authority states that t e air lift is applied to raising water from bore holes, not to be used in permanent plants, because of its inefficiency. Due to its simplicity and ease of mobility the air lift is used for temporary work.

Pumping Plant Continued:

The two Gordon Compound Duplex Force Pumps are considesed as scrap but are still in use. At any time these pumps should f fail , Owosso would face a water shortage which might mean a considerable loss to the city.

Owosso under the existing circumstances must realize that the life of its plant is fulfilled. Its equipment is obsolete , expensive and inadequate. Modern machinery which will be efficient in fuel and labor costs must be installed .

Household Consumption:

The service mains of the city of Owosso are equiped with meters of the positive displacement type; that is in which a definite quantity of water passes at each complete movement of a disk.

To receive a service, the property owner is required to p oay the city a sum of money which in all cases is equal to the cost of the service.

The service used is a 3/4 inch lead pipe connected to the main with a corporation cock. The pipe is laid at a depth of 5 to 6 feet, the length averaging 25 feet on a 66 foot street and 50 feet on a 90 foot street. At the present time there are 3170 services , all of which are metered. In 1919 approximately 175,000,000 gallons of water were delivered to customers, an average of 40 gallons p r customer per day. O f this amount, approximately 25 were for domestic consumption and 15 for commercial usages. This is the normal consumption for domestic and commercial requirements. (Public Water Supply, page 27)

The water rates of Owosso compare favorably with the

Household Consumption Continued:

rate of other cities nearby, being about normal. The comparative water rates of Owosso ,East Lansing, and Lansing were made. The respective rates being as follows:

Water Rates of Owosso.

For the first 900 cubic feet used during any one quarter of the year , seventeen cents ($ .17) per hundred cubic feet.

For the next 12,000 cubic feet used during the same quarter of the year, ten cents ($ .10) per hundred cubic feet .

All water used over and above 12,000 cubic feet during the same quarter of the year, as above set forth, a charge at the rate of six and one-half cents ($ .06½) per hundred cubic feet.

Minimum Charges for Services.

For a service using a 5/8 inch meter, a minimum charge of $1.50 per quarter.

For a service using a 3/4 inch meter a minimum charge of $2.25 per quarter.

For a service using a 1 inch meter , a minimum charge of $3.50 per quarter.

For a service using a 1¼ inch meter, a minimum charge $4.50 per quarter.

For a service using 2 inch meter , a minimum charge of $8.00 per quarter.

For a service using a 3 inch meter, a minimum charge of $12.00 per quarter.

For a service using a 4 inch meter, a minimum charge of $25.00 per quarter.

For a service using a 6 inch meter, a minimum charge of $60.00 per quarter.

Household Consumption Continued:

Water Rates of East Lansing.

For the first 3,000 gallons used during any one quarter of the year , fifty cents ($ .50)

For each additional thousand gallons during any one quarter of the year, twenty cents ($.20) .

Minimum Charges for Water Services

For all services , the minimum charge of $1.50 per quarter.

Water Rate of Lansing.

For the first 2,000 cubic feet during any one quarter of the year, nine cents ($ .09) per hundred cubic feet.

For the next 3,000 cubic feet used during the same quarter of the year, eight cents ($ .08) per hundred cubic feet.

For the next 5,000 cubic feet used during the same quarter of the year, seven cents ($ .07) per hundred cubic feet.

For the next 25,000 cubic feet used during the same quarter of the year, six cents ($ .06) per hundred cubic feet.

For the next 300,000 cubic fett used during the same quarter of the year, five cents ($ .05) per hundred cubic feet.

All water used over and above 335,000 cubic feet used during the same quarter of the year as above set forth , a charge at the rate of 4½ cents per hundred cubic feet.

Minimum Charges for Water Services.

For a service using a 5/8 inch meter, a minimum charge of $ .45 per month.

For a service using a 3/4 inch meter, a minimum charge of $ .60 per month.

For a service using a 1 inch meter, a minimum charge of $1.00 per month.

For a service using a 1¼ inch meter, a minimum charge of [illegible]

Household Consumption Continued:

For a service using a 2 inch meter, aminimum charge of $2.00 per month.

For a service using a 3 inch meter, a minimum charge of $4.00 p r month.

For a service using a 4 inch meter, a minimum charge of $8.00 per month.

For a service using a 6 inch meter, a minimum charge of $12.00 per month.

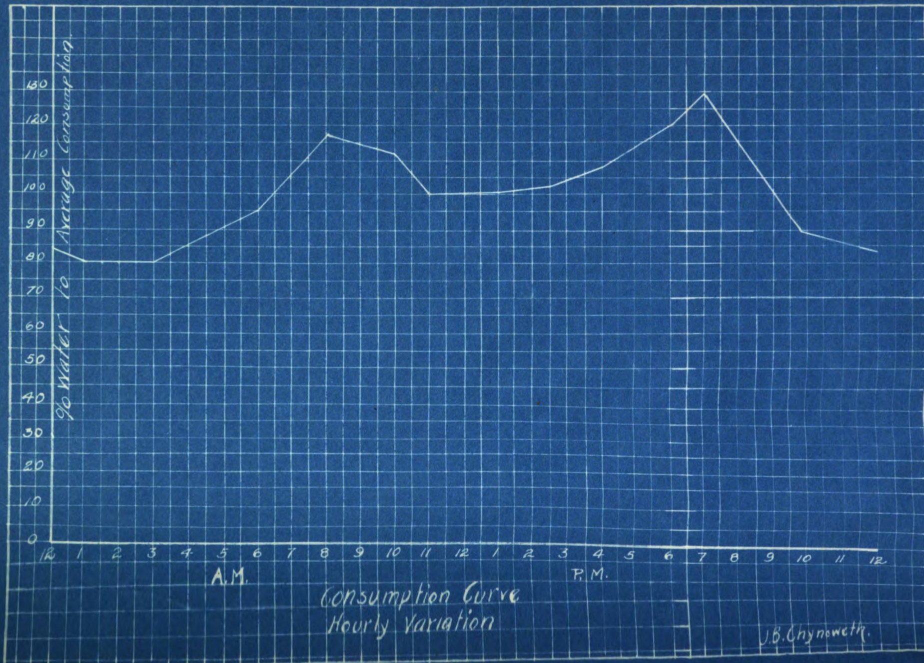
For a service using a 8 inch meter, a minimum charge of $20.00 per month.

Comparative Water Rates--------- Quarterly

No. Cubic Feet	Lansing	Owosso	East Lansing
3,000	$ 2.06	$ 3.63	$ 5.98
10,000	7.70	10.63	15.86
20,000	13.70	18.15	40.82
40,000	25.20	31.13	60.74
60,000	35.20	44.13	90.66
100,000	65.20	70.05	150.50
500,000	257.20	329.53	748.04

The comparison with Lansing and East Lansing is hardly a fair test but shows that the water rate lies somewhere between the rate of a larger city and that of a smaller one.

Lansing is a city with a population of 60,000 . A maintenance department is efficiently operated and conducted by skilled workmen . There is constantly work to be done in; the installation of new services , the removing of obsolete mains and the relaying of new ones, placine hydrants and so forth to keep separate gangs employed for each kind of work. The practice developes experts, in the particular phase of work in which they



Consumption Curve
Hourly Variation

Household Consumption Continued:

are engaged, thereby decreasing the cost of operation.

Owosso is a city with a population of 12,000. The main tenance department is hardly to be compared with that of Lansing. Whereas in that city, the work is divided, one gang does all the maintenance work in Owosso. This practice results in less economy and increased cost of operation.

East Lansing has a population of about 3,000. Its maintenance department consists of a foreman who hires unskilled labor when work is to be done. In addition , the plant at East Lansing is comparatively new with a heavy debt to struggle under. As a consequence the water rates are slightly higher than those in Owosso or Lansing.

Fire Service:

For fire purposes the pressure required in the mains depends upon whether it is intended that fire streams shall be furnished directly from the hydrants or whether steam engines shall be used. In the case of small cities and towns it is of greater advantage to supply fire streams without the use of engines, and in most places this method is adopted.

Owosso is one of the cities that follow in this class. Consequently fire s are fought from hydrant pressure alone.

If hydrant fire pressure is to be supplied, it may be said that in general the pressure in the mains should be such and the hydrants so placed that a large proportion of the fire streams required in a business district should be of a 240 to 250 gallon capacity, and in a residence district of 175 to 200 gallon capacoty. Authority states that a hydrant pressure lower than 60 pounds

Fire Service Continued:

for residence districts and 70 pounds for business districts is undesirable. However, such pressures are common. In Owosso the pressure at the pumping station is 65 pounds. From the above it can readily be seen that the city has less than 65 pounds to rely on for fire protection. The working pressure at the hydrants in the business district will not average over 60 pounds, which according tp previous statement s, is inadequate.

From calculations which follow the pressure of 60 pounds is a reasonable one at which to figure the pressure int the business district.

3 pumps deliver 3070 gals per min. over 2 12 inch mains.
3 " " 1035 " " " " 1 12 " "

3096 feet =,the distance from the pump house to the business district.

From a diagram for calculating C.I. pipes (Public Water Supply page 242), the loss in head in pounds for 1035 gals. per 1000 feet through a 12 inch main = 2.2

2.2 x 3.1 = 6 , no. pounds loss in 3096 feet.
65 - 6 = 59 pounds , the pressure at the hydrant.

Some water is drawn from the 12-inch main before it reaches the business district. This reduction in quantity will decrease the loss of head from 6 to 5 pounds. The head loss per 1000 feet for ~~5000~~ five 250 gallon streams is 1.9 pounds or 5.7 pounds for 3000 feet. (Public Water Supply Table 98) Assuming a 60 pound pressure at the hydrant the following fire streams can be obtained

Example: (Hughes and Safford's Hydraulics, p. 182)

The pressure at a fire hydrant is 60 pounds per square inch. To the hydrant is attached 300 feet of the best quality b rubber lined 2½-inch rubber hose. What is the pressure at the base of the nozzle with a 1-inch smooth nozzle?

Fire Service Continued:

$$p = \frac{P}{\frac{LFd^4}{6822} + 1}$$

p = effective pressure at base of play pipe
P = pressure at hydrant in pounds per sq. in.
L = length of hose in feet
d = diameter of nozzle orifice in inches
F = loss of head in feet

Using 300 feet of hose p = 40 lbs. effective pressure at base of play pipe.

Using 400 feet of hose p = 34 lbs. effective pressure at the base of the play pipe.

With the above nozzle pressures , the following fire streams can be obtained:

1 40 lbs. nozzle pressure, 300 feet good quality rubber-lined hose, 2½ inches in diameter, 1 inch smooth nozzle.

Vertical Jet
Average highest drop, still air = 83 feet
Highest good fire stream = 64 feet

Horizontal Distance, jet elevated 30° to 45°
Average extreme drops , level of nozzle still air = 133 ft.
Limit of good effective fire stream = 55 "

Gallons per minute = 186

2 34 lbs. nozzle pressure, 400 feet good quality rubber lined hose, 2½ inches diameter, 1 inch smooth nozzle.

Vertical Jet
Average highest drop, still air = 70 feet
Highest good fire stream = 55 "

Horizontal Distance, jet elevated 30° to 45°
Average extreme drops, level of nozzle, still air = 115 ft.
Limit of good effective fire stream = 49 "

Gallons discharged per minute = 168.

The above fire streams have a low discharge which is hazardous in the business district. They discharge an average of 175 gallons per minute, sufficient protection for a residential area but not so for a business district. From 240 to 250 gals. per minute is the normal fire stream discharge required in such an area.

Fire Service Continued:

To remedy this deficiency would necessitate a greater hydrant pressure. Using 80 pounds per sq.in. at the hydrant, the following fire stream should be obtained:

1 80 lbs. hydrant pressure, 300 feet good quality rubber lined hose, 2½ inches diameter, 1 inch smooth nozzle.

Vertical Jet.
Average highest drop still air = 100 ft.
Highest good fire stream = 71 "

Horizontal Distance, jet elevated 30° to 45°.
Average extreme drops, level of nozzle, still air = 150 ft.
Limit of good effective fire stream = 61 "

Gals. discharged per minute = 200

2 80 lbs. hydrant pressure, 400 ft. good quality rubber lined hose, 2½ inches diameter, 1 inch nozzle

Vertical Jet
Average highest drop, still air = 94 ft.
Highest good fire stream = 69 "

Horizontal Distance, jet elevated 30° to 45°
Average extreme drops, level of nozzle = 143 ft.
Limit of good effective fire stream, still air =59 ft.

Gals. pre minute discharged = 196.

The above fire streams discharge only a average of 200 gallons per minute., but do so using 300 and 400 feet of hose. For 200 feet the discharge will be about 250 gallons.

A map , of the city of Owosso, showing the distribution system, impresses one with the number of 4-inch cross mains, many of whi h supply hydrants . The loss of haed, per 1000 feet, in a 4-inch main is 12 pounds. There are numerous hydrants located more than 2000 feet from a feeder and are connected with a 4-inch main. This meains that 24 pounds of pressure, for 175 gallon stream is lost before the water reaches the hose. A low pressure in the residential results from this condition.

Fire Streams:

The number of fire streams available in any town, should be equal to $2.8\sqrt{x}$, where x represents the population in thousands. This formula is given by Mr. Kuichling and is accepted by engineers as standard. Owosso has a population of 12,000, requiring from the preceding formula nine fire streams of 250 gallons each. This would require a pumping capacity of 2,250 gallons per minute in addition to the other uses. Authority (Public Water Supply) states that 2/3 of this estimate should be capable of being concentrated upon any one square in the compact valuable part of the city, or upon one extremely large building of special hazard. Investigating fire protection from this angle the following computations are made:

A 500 ft. radius fire circle in the business district cuts ; 4----8 inch pipes, 4----4 inch pipes, and 1----6 inch pipe. It is required that five firestreams , of 250 gallons each , be available in accordance with the above estimate.

1----8 inch pipe will discharge 6½ times as much as a 4 inch with the same loss of head.

1----6 inch pipe will discharge 3 times as much as a 4 inch with the same loss of head.

5 fire streams at 250 gallons = 1,250

Reducing all pipes to the relative capacity of 4 inch pipes

4----8 inch pipes = 6½ x 4 = 26

1----6 inch pipe = 3 x 1 = 3

4---- 4inch pipes = 4 x 1 = 4

33

1,250 ÷ 33 = 38 gallons, capacity of each 4-inch pipe.

4----8 inch pipes will carry 38 x 6.5 x 4 = 988 gallons.

1----6 inch pipe will carry 38 x 3 x 1 = 108 "

4----4 inch pipes will carry 38 x 4 x 1 = 152 "

1250

Fire Streams Continued:

Loss of head in 4-inch pipes per thousand feet for 38 gallons = 2 pounds.

Loss of head in 6-inch pipes per thousand feet for 104 gallons = .6 pounds.

Loss of head in 8-inch pipps per thousand feet for 347 gallons = .8 pounds.

Four hydrant s are available , two of which are two-way hydrants, capable of furnishing six fire streams. The loss of head is not high enough to warrant any change in the cross mains of this particular fire circle.

In the residential districts , there are several localities in which it would require more than 500 feet of hose to fight a fire. However, there are only a few houses in the neighborhood and not a great deal of protection is needed.

Accounting:

The functions performed b a water works are as follows: (1) To furnish water for private use; (2) To furnich water for public on the stseets , sewers, fountains, and public buildings; (3) To furnish fire protection to property. (1) and (2) the cost of service may be considered approximately proportional to the quantity of water supplied but in (3) it is out of all proportion to the amount of water used for ahile the cost of construction is greatly affected, the total amount of water consumed is slight. The extra cost involved in furnishing adequate fir protection is due largely to increased pumping capacity , increased size of mains, reservoirs, cost of hydrants and increased cost of maintenance. Estimates of careful observers place the proportion of interest , depreciation and maintenance expenses shargeable to fire protection as one-third to one-half the entire cost. (Public Water Supply)

The sources of revenue are the water rates and the funds received by general taxation. The former are paid by those who use the water, and in proportion to the amount used. The latter are paid by assessment on all taxable property. If the revenue be so raised that each interest served be charged according to the cost of the service, the cost of furnishing water to private customres should be paid byn the water rates. The cost of supplying water for public purposes should be paid by taxation and according to the amount used; and the cost of fire protection should also be met by taxation, since the individual is benefitted by reason of the protection afforded to property.(Public Water Supply)

Mr. Chaupe, a Toledo engineer, estimated in 1917 the number of gallons delivered to the mains at the Owosso Pumping Station, as 303,905,700 for that year and proportioned

Accounting Comtinued:

the water usage to the following accounts; Water delivered to customers meters 158,298,300 gallons; water used at nine fires 113,000 gallons; water used for street sprinkling 3,780,000 gallons; water used for street flushing 58,000 gallons; water used for fountains 2,000,000 gallons; water used for horse troughs 2,000,000 gallons ; water used for drinking fountains 230,000 gallons; water used fr sewer flushing 65,800,000 gallons.

At the present time, the operatinf expenses of the Owosso water works system are borne by the private customers, the water rate being figured high enough to cover most of the expenses. A deficiency is met by a fund drawn from general taxation.

Mr.Chaupe further states that 145,607,400 gallons of water were not paid for in 1917., and has worked out the following table in a report submitted by him to the city council.

Loss of Water Pumped in 1917.

Total gallons pumped estimated from revolution =	337,673,000
Less estimated slippage	33,767,300
Total estimated waterdelivered to mains	303,905,700
water delivered through customers meters	158,298,300
Total loss	145,607,400

The above loss is not the number of gallons of water lost through leakage but the number of gallons pumped and not paid for. This amou nt will include leakage, together with city and public usages.

From what the auther could learn of past accounting, the city at one time paid a part of theoperating expenses in proportion to the amount of water used, but the practice has been

Accounting Continued:

discontinued in favor of the method now in use.

It is hardly fair to the private consumer to be expected to pay for water that the public as a whole benefits by. Therefore, it is of the opinion of the writer that a new system of proportioning water rates should be worked out, whereby general taxation , as well as the private consumer will share proportionatelyof the operating expenses.

Depreciation:

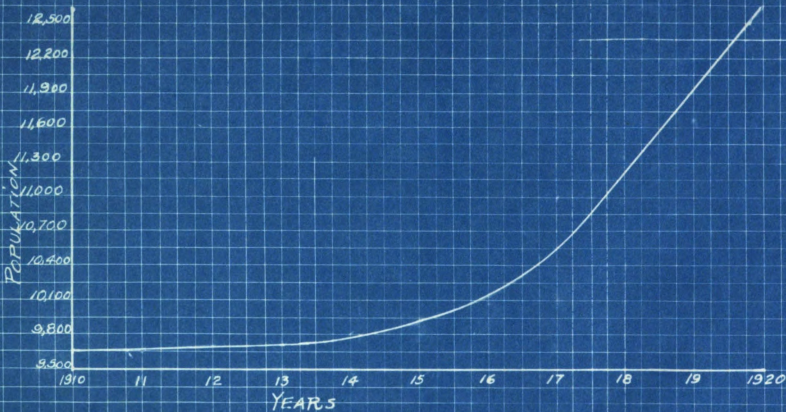
There is a large loss of value in every plant which is due to age , inadequacy and obsolescenee. (Uniform Accounts for Water Works, published by New England Water Works Association)

Age, or the wearing out of parts due to use, or the rusting out , due to the action of the elements, is an active cause of loss of value in almost every plant.

Inadequacy , or the fact that due to the growth of the city and the increasing usage of water , certain pipe lines a d machines which were amply large, now do not meet requirements. These parts will have to be replaced.

Obsolescence, or the fact that machines have become obsolete and out of date on account of a recent development of better and more economical machines.

A financial statement found in the city clerk's office of the city of Owosso, revealed the fact that no funds were set aside for depreciation. This statemant was for the years 1916 to 1919 and is as follows:



Water Investigation of Owosso, Mich
June 1920.

J. B. Chynoweth.

Population Curve
City of Owosso. Mich

Depreciation Continued:

Financial Statement

	1916	1917	1918	1919
Gross income from operations	21,852.73		$ 27,483.88	$ 30,892.82
Operating Expenses	14,490.83		17,053.82	31,033.58
Net Earnings	6,961.90		10,431.06	140.76
Interest on bond	4,794.56		4,650.39	4,724.00
Gain or loss on operations	2,167.32m		5,780.67	4,864.76

The above account shows nothing for depreciation. At some time in the near future equipment that was installed thirty years ago will have to be replaced. If ther is no fund for this replacement new bonds will have to issued and the water rates proportionately raised. At the present time, two of the pumps are considered as scrap, and will have to be replaced.

An appraisal should be made of the depreciable property, which includes work structures , equipment, wells, and the distribution system. The value , life, and the remaining life of each piece of depreciable equipment should be estimated, whereby a yearly amount could be set aside for that purpose.

Suggestions for Improvement:

The population curve of Owosso shows that the city is growing. An indication of further growth, is the fact that recently several automobile factories have located there. Lansing and Flint, two nearby cities, have doubled their population over night because of this industry. Shipping facilities of Owosso are good , the city being entered by connecting lines

Suggestions for,Improvement Continued:

of the Grand Trunk, Michigan Central and the Ann Arbor Railroads. As a consequence,its location is fertile teritory for the manufacturing industry.

It has been pointed out in a preceding article, entitled "Fire Service",that the city has just enough fire protection. The distribution system has reached its maximum ability to give the city that protection. A further increase of population, especially in the residential section, would be in danger through fire risk. The four-inch mains, to which hydrants are connected, are inadequate because of pressure lost due to friction. In addition the system contains a number of dead ends which are objectionable on account of the stagnation which exists in the pipes and the deterioratiom of the water which is likely to ensue.

It is a general principle , when laying out a distribution system, to arrange mains so that the smaller cross mains may be fed from both ends, since a pipe so fed is equivalent to two pipes. This system is known as the gridiron system.

It is proposed that the principle of this system be carried out in the following manner:

Lay a twelve inch mainon Hickory Street , connecting the present twelve-inch main on Corunna Avenue, thence around the city (See map) and reconnecting a twelve-inch main, of the

present system at the intersection of Dewey and East Streets. Such a pipe would feed the cross mains from both ends, eliminate a number of dead ends, provide the residential areas with additional fire protection and serve as a feeder for any additional cross mains the city cared to put in.

To provide such a main would require an expenditure of approximately $ 64,800.00. This amount being based on the following estimate:

20,000 feet 12 inch C/I. pipe in place at $3.00	=$ 60,000.00
1 River crossing	500.00
300 Services changed at $5.00	1,500.00
Removing 6000 feet of 4-inch at $.20	1,200.00
Removing 8000 feet of 6-inch at $ .20	1,600.00
Total	64,800.00

An increase of population will also affect the present consumption of water. From a previous discussion of the power plant , it is evident that the plant is obsolete and inadequate. At the present time , the pumps are working to their full capacity , endangering the city if the accident should happen to either pump. The situation has become so acute that the insurance companies are alarmed. This fact is substantiated from the following article published May tenth, 1930 in the Owosso daily paper.

Owosso must spend over $ 75,000.00 on her water works at once or the Michigan Inspection Bureau, maintained by the insurance companies operating in the State, and which fixes the insurance class in which a city is placed, will cause insurance rates to be raised here. As a result the city commission has decided to adopt the plan recommended by Professor Hoad of the Engineering firm of Hoad and Decker of Ann Arbor, to install

a huge reservoir with a capacity of 1,800,000 gallons, and a new centrifugal pump , electrically driven . The reservoir will

Suggestions for Improvement Continued:

be built at an estimated cost of $ 75,000.000 and the pumps installed at a cost of about $ 3,500.00.

It is not proposed by the author to recommend a relief for the situation because of his inexperience and the lack of available data on present day machinery. However, it is of his opinion that an electrically driven centrifugal pump could be installed which would require very little attention. The financial statemant(See Pumping Plant) shows that the big item os expense, for the present pumps , are fuel and labor..A pump which will reduce these factors is the pump to be investigated.

Appendix.

Large Storage Reservoir.

Small Storage Reservoir

City Pumping Station

Air Lift Near Pump House
Well.

Wells S. of Plant.

Valuation

of

Owosso Waterworks

Report Compiled by

H. E. Riggs.

Present Value of Owosso Water works.

	Cost of Reproduction	Present Value.
Land	$11,407	$11,407
Works and Structures	16,740	9,754
Equipment	61,270	41,801
Wells	7,675	2,543
Distribution	209,831	141,032
	$306,923	$206,537
Contingencies @ 5%	15,346	10,327
Engineering @ 5%	15,346	10,327
Legal and Administration @ 1%	3,069	2,065
	$340,684	$229,256
Interest during Construction 3%	10,220	10,220
Total	$350,904	$239,476

Land Cost of Reproduction

Part of N.W. 1/4 and part of N.E. 1/4 Section 19, T.7 N.R. 3 E, commencing at a point on E Corporation line, City of Owosso (as in 1874) where the N. boundary line of land owned and occupied by the Ann Arbor Railroad intersects said corporation line; thence N. along said city to the left bank of the Shiawassee River at low water mark; thence W. along down the left bank of said river to a point in line with the N. line of Oakwood St. in the J.L. Wright Addition; thence S. on same course of N. line of said street to N. line of Railroads Companys ground; thence easterly on the N. line of said railroad land to beginning. Also part N.E. 1/4 commencing at S.E. corner of above land: thence N. 78-50 E., 306 feet; thence N.

parallel to city line to the left bank of river; thence

Land	Cost of Reproduction
Southwesterly down and on said river	$1,547
bank to aforesaid city line; thence	
S. on city line to beginning.	
Orginal purchase made in 1889	
3.867 acres @ $400	
Orginal cost $445	
Lots 24-46 BLK. 5	
Lots 1-46 " 6	
All in Aubrey's Addition	
Orginal purchase in 1892	
Cost $1,900	
8.6 acres @ $350	3,010
Lots 1-21 Inclusive	
Blk. 36 Aubrey's	
Addition. Purchased in 1911	
Price $675	
The whole of Blks. 37,38	
Lots 9-42 Blk. 40	
" 33-37 " 41	
Purchased in 1915.	
19.5 acres @ $3,000	5,820

Land	Cost of Reproduction.
Lot 19 Blk. 27	
Original plat of City of Owosso.	
Purchased in 1918	2,000
Total	$11,407

Work Structures.	Cost of Reproduction	% of Condition	Present Value.
Main Station Bld. 94x42x28 feet high. Original building built in 1889	$13,000	50	$6,500
Coal sheds 18x150x10 feet high. Built in 1915. Cost $2,222	2,240	85	1,904
Brick workshop on Comstock Ave. 25x65x30 feet high.	1,500	90	1,350
	$16,740		$9,745

Pump Station Equipment.			
2- Loos Scotch Marine Boilers.	$7,500	70	$5,250
1- Cold water feed pump Burnham Pump Co.	150	50	75
1-Cold water feed pump Fairbanks Morse.	30	50	15
1- Hot water feed pump Union Pump Co.	250	50	125
1- Stillwell open feed heater	225	50	112

Pump Station Equipment.	Cost of Reproduction	% of Condition	Present Value.
1-Closed feed water heater. Purchased 1919. Price $200	$225	50	$112
1- Pressure tank for feed water	50	75	38
Steam gages ect.	120	75	90
1- Laidlaw-Dunn Gordon Cross COmpound Duplex Air Compressor.	3,600	75	2,700
2- Gordon Compound Duplex Force Pumps. Installed in 1889. Scrap	5,000	Scrap	400
1- Snow Compound Duplex Force Pump.	9,000	60	5,400
1- Small storage reservoir. Constructed 1889	2,500	60	1,500
2- Large Storage reservoirs. Installed 1895.	10,000	90	9,000
1- Circular Emergency reservoir. Connected to river.	1,000	75	750
1- Square Emergency reservoir. Connected with river.	750	50	375

Pumping Station Equipment.	Cost of Reproduction.	% of Condition.	Present Value.
Coal shed from A. A. Railroad to coal shed.	$800	90	$720
1- Industeral tank	165	80	132
1- Fairbanks Merse Scale	200	80	160
1- Cast iron turn table	15	80	12
2- Coal cars	40	75	30
5- Harris air lift pumps 2- Sullivan air lifts 6- : boosters	2,075	75	1,556
Furniture of plant and shop.	50	50	25
Tools, jacks eet.	600	75	450
Stock of supplies, lead pipe, cast iron pipe eet.	500	100	500
	$61,270		$41,801

Wells.

2- 6 inch free flowing wells, near pump house.	400	75	300
5- 6 inch free flowing wells abandoned	1,000	No value.	
1- 10 inch air lift Near pump house	400	75	300
1- spring S. plant.	400	50	200
5-6 inch rock wells East of plant. Drilled in 1915 Cost $275 each.	1,375	75	1,031
1-6 inch rock well Not in use . E. of plant	350	No. Value.	

Wells.	Cost of Reproduction.	% of Condition.	Present Value.
1- 6 inch air lift S. of plant.	$700	75	$525
4-6 inch wells Abandoned due to mineral qualities of the water.	2,800	No value.	
5- Brick well housings	250	75	187
	$7,675		$2,547

Mains.

Feet	Size	Kind	Unit Price	C.of Rep.	Est, Life	% of Cond.	Present Value.
9,267	12	C.I.	7.05	18,997	80	65	$12,348
3,698	10	:	1.65	6,102	70	59	3,600
14 ,210	8	:	1.27	18,147	60	60	10,888
71, 987	6	:	.92	66,210	60	74	48,995
67,747	4	:	.75	50,810	50	60	30,486
1,134	2	:	.44	499	40	80	1,339
				$160,665			$108,508
4- River crossings @ $400				1,600	70		1,120

Hydrants.

9- Engine hydrants 405 80 324

238 regular hydrants 2-2/ 1/2 hose connections 7,854 50 3,927

1- hydrant 4-2 1/2 hose connection. 35 50 17

249 Connections from mains to hydrants. 2,490 70 1,743

10,784 6,011

Meters.

Number	Kind	Price	Cost of Rep.	Present Value.
2,089	5/8	$7.50	$15.668	
28	3/4	11.00	308	
18	1	14.00	252	
12	1 1/2	26.00	312	
13	2	41.50	546	
2	3	70.00	140	
Installation on 2,163 meters @ $2.00			4,326	
			$21,526	@ 75¢ $16,172

Meter Equipment.	Cost of Rep.	Present Value.
6- Brick wells @ $30	$180	
1- Wood meter well	20	
25-Meter boxes of 18 inch tile.	250	
318 Meter boxes of 24 inch tile.	3,816	
1,110 Meter boxes of 6 inch tile.	3,300	
116- Meter boxes of 18 inch concrete tile.	1,160	
	$8,750	@ 75¢ $6,567

Gates.

Number	Size	Cost	Cost Rep.	Present Value.
9	12	$45.00	$405	
6	10	35.00	210	
18	8	27.00	486	
102	6	19.50	1.989	
115	4	13.50	1,552	
			4,642 @	70¢ 3,249

58- Brick wells @ $20 for gate valves	1,189	
189- C.I. gate valve wells.	$ 662	
ry	$209,831	
	1,822	@ 70 $145,029

Total to Summary

Pocket Contains
1 Map of Owosso.

Pocket empty as of 10/8/09