THESIS
OF
LEO EARL WILT
CLASS 1905.

DESIGN OF A FILTER PLANT

F o r

CITY OF EASTON

LEO EARL WILT

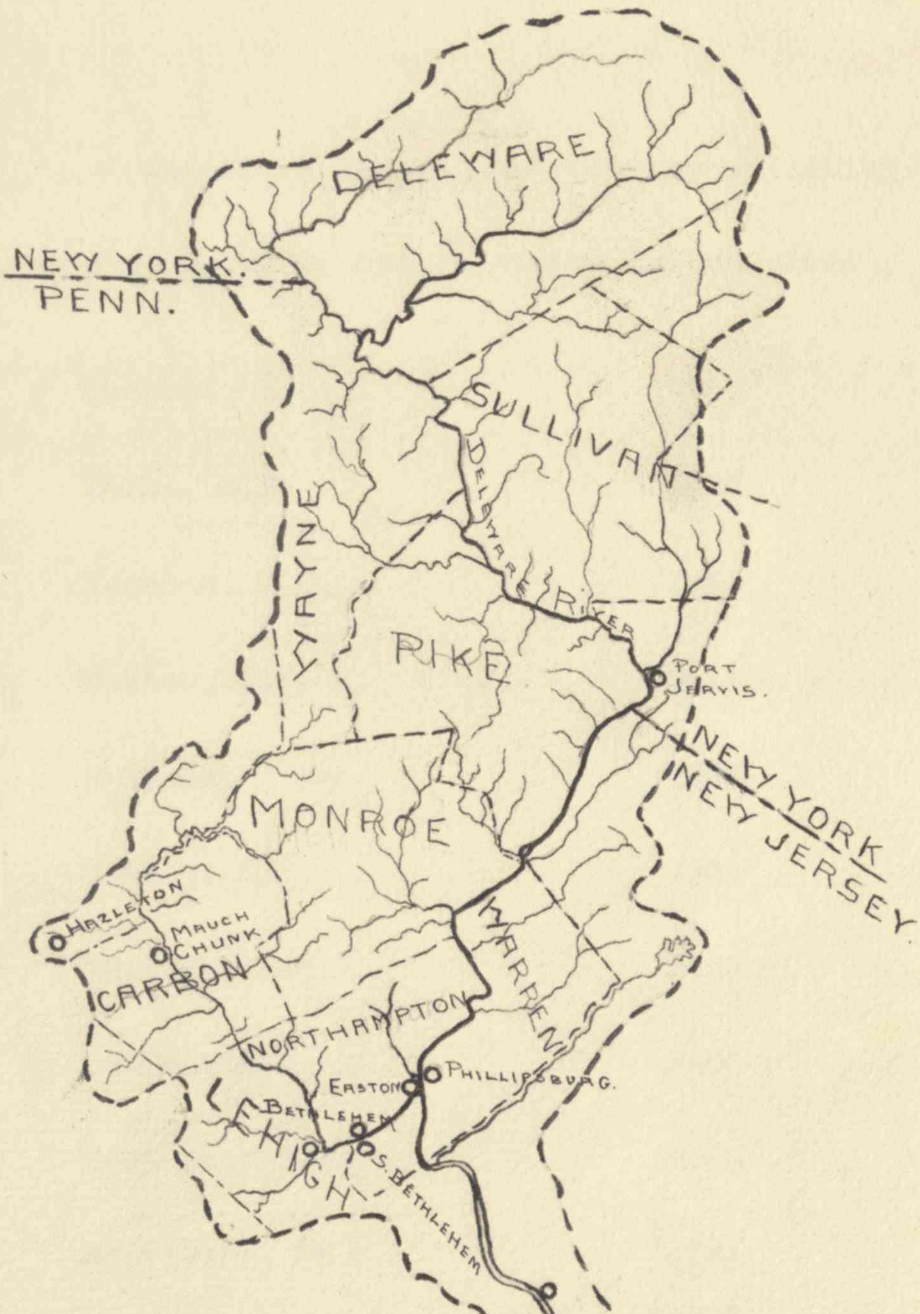
LAFAYETTE COLLEGE

Class of 1905.

June 19, 1905.

The Delaware drainage area comprises parts of the States of New York, New Jersey and Pennsylvania and contains six thousand eight hundred fifty-five square miles. The main river of the Delaware system rises in New York State, in a county bordering the western part of the Catskills. Elevation at that point is said to be about ninteen hundred (1900) feet. It flows in an irregular course, its general course being southward, and empties into the Delaware Bay.

The drainage basin of the Delaware is a very important one, prosperous and thickly settled. Several investigations show the water to be very much polluted by sewage and industrial refuse. But most of this contamination takes place below Easton.



DELEWARE DRAINAGE AREA.

Towns above Easton contributing polluting substances to Delaware and their population are:-

Deposit, N.Y.	2051
Delhi, N.Y.	2078
Hancock, N.Y.	1883
Walton, N.Y.	2811
Honesdale, Pa.	2864
Hawley, N.Y.	1925
Port Jervis, N.Y.	9385
Stroudsburg, Pa.	3450
East Stroudsburg, Pa.	2648
Belvidere, Pa.	1784
	30,879

Ten of these towns have sewage systems, but they all indirectly contribute sewage to the Delaware. However, they are all at a considerable distance from Easton; the nearest being Belvidere fourteen (14) miles above and farthest Delhi, two hundred forty-five (245) miles. The river for most of this distance flows through mountains and as a rule is shallow having many rapids which tend to purify the water. Analyses made on different days during the summer of '89 gave following result:

DATE	TUR-BIDITY	COLOR	NITROGEN AS				CHLORINE	TOTAL RESIDUE	HARDNESS		IRON. —
			ALBUM AMM	NITRITE	NITRATES	FREE AMM			ALK	NON HAR	
APR 16	3	.15	.060	.000	260	.004	1.7	44.5	23.	6.	.30
JUNE 29	650	.18	.350	.004	.160	.040	1.6	48.0	27.	8.	11.80
JULY 6	1	.12	.088	.003	.320	.042	2.2	93.0	42	9.5	11.80
JULY 27	480	.12	.226	.004	.160	.086	2.0	273.	27.	9.5	8.00
AUG. 17	3	.11	.102	.006	.160	.018	2.8	116.	57.	7.5	.20
SEPT. 13	8	.08	.116	.004	.160	.024	3.0	103.	57.	14	.30

Analyses made by Instructor Turrentine of Lafayette College on May 25, '04 and June 1, '04 gave following results:

DATE.	CO_2	Cl.	FREE AMM.	ALB. AMM.	HARDNESS	NITRATES	TOTAL SOLIDS	IRON.
MAY 25.	5	4.4	.06	.30	33.	.132	60.2	TRACE
JUNE 1.	4	3.2	.12	.24	32.5	.11	63.0	.2
		PARTS PER MILLION						

From these it is seen that the water is much better than most river supplies. It is somewhat harder than most river waters but this is due to its flowing through a limestone country. During the greater part of the year the water is unusually clear, and it is only during the Spring freshets that turbidity gives any trouble. Then the matter in suspension is coarse sand and clay which settles in a short time.

Examination for bacteria made by students in the Biological Lab. of Lafayette College during May of 1904 and 1905, show from 400 to 800 bacteria per c.c. While this does not represent the amount the year around, it is no doubt at a time when the water is polluted the most. During the season of high water more bacteria and other impurities may be carried into the water but as the volume of water is greater the pollution is not so great. Now the river furnishes a good quality of water for Easton and while there seems to be no great need of filtration at present, yet there is no doubt that conditions in the near future will demand it.

At present there is no attempt made at

purification. There are sand filters in the intake opposite the pumping station but it is very doubtful whether they do any good. The current no doubt washes away the sand and fills the crib with clay and gravel.

Water is taken from the river through the crib in mid stream, flows to a Corliss and a Worthington pump each of a capacity of two million gallons daily. The water is then forced through a 20" rising main to a reservoir on the side of Chestnut Hill. The reservoir is trapezoidal in shape, 340' in length; 194' wide at one end and 182' at the other. Its capacity is about eight million gallons.

In June 1903, a series of investigations on the water consumption in Easton were made by

Messrs. F. K. Day and H. Gordon. They found the average daily consumption to be one million nine hundred thousand gallons or an average consumption per capita of 97 gallons. Deducting for loss by leakage and waste gives 75 gallons per consumer or 51 gallons per capita. The waste per day was found to be 80% of the daily consumption and 64% of amount pumped. With all house connections metered the daily consumption could no doubt be easily kept below one million gallons.

Since that time the consumption has increased, and now averages somewhat more than two million gallons, with a maximum of at least three million gallons per day.

There are three methods of purification used in this country. Plain sedimentation, sand filtration and mechanical filtration.

Sedimentration is the simplest method. It requires large settling basins where the water can be stored for some time to allow the matter in suspension to settle. This requires large areas in basins as there must be duplicate basins for the consumption. Sedimentation has been but little used in the East where conditions do not demand it. In the West especially along the Ohio and Mississippi it has been quite extensively used. Here the matter in suspension is so extremely fine that weeks and sometimes even months are required to clear the water.

As the suspended matter settles it entangles and carries down with it much of the organic matter and bacteria. There are few data upon how much of this is removed by standing but it is clear that the amount will be dependent upon the amount of suspended matter present.

There would be only about a month out of the year when the water of the Delaware would be turbid enough to require sedimentation. During the remainder of the year it is doubtful whether sedimentation would remove many of the bacteria. Not only this but the great cost would preclude its use here.

Sand filtration has been used more than any other method. It is a slow filtration through sand. Water is run upon a bed of sand from two to five feet thick and passes through at a rate of one to three million gallons per acre per day. The latest American practice consists in building covered filters, having the floor and roof made of ground arches, supported by pillars. Upon the floor are placed the drains, embedded in clay or concrete. Over these are placed layers of gravel, each successive layer being smaller in size. Upon the gravel is a layer of sand generally about four feet in thickness. It is the sand alone which performs the work of purification as the gravel is only to keep the sand from being washed into the drains.

The bacteria in the water exist upon dead organic matter and the result of this action is the production of a thin semi-gelatinous film over and around the grains of sand in the top layers of a bed. This forms a thin film over the whole top of the filter and it is this which retains the bacteria and organic matter. Finally this Schmutzdecke, as it is called, becomes so dense and clogged that a high head is required to force water through when it becomes necessary to remove the top layer of one-quarter to one and a half inch.

The bacterial efficiency of the sand filters is high. At Albany, N.Y. the efficiency has never fallen below 97% since the plant was put in operation in '99. London, for three years, removed an average of 97.6%. All properly conducted plants remove at least 96.5% of bacteria present in the raw water..

The mechanical or American filter is a new method which is rapidly growing in favor. It is essentially a rapid filtration through sand aided by a coagulant. The coagulant most generally used is sulphate of alumina. The alumina is added to the water before filtration and is at once decomposed into its component parts, sulphuric acid and alumina. The first combines with lime or other base in the water; while the alum forms a hydrate of alumina which settles through the water in a gelitinous mass, entangling with it bacteria and organic matter. This forms a film on the surface of the filter similar to the Schmutzdecke, in the slow sand filters.

At frequent intervals a reverse current of water is sent through the sand which washes out all the accumulated impurities. These filters are operated at rates of 100,000,000 gallons to 150,000,000 gallons per acre daily.

There are many advantages and many objections to slow sand and mechanical filtration. The former would require more filtering area. A slow sand filter plant with a capacity of two million gallons daily would require about one and a half acres, while a mechanical plant would only need 1/4 acre. It is claimed that the first produces a more satisfactory effluent. Again the mechanical maintains a higher efficiency the whole year around. A sand filter requires less attention than a mechanical and consequently there is less danger of an interruption in the flow. Success with the mechanical plant requires a constant supply of the right amount of coagulant, and any interruption of this supply either by carelessness of attendants or failure of apparatus may do a great deal of harm.

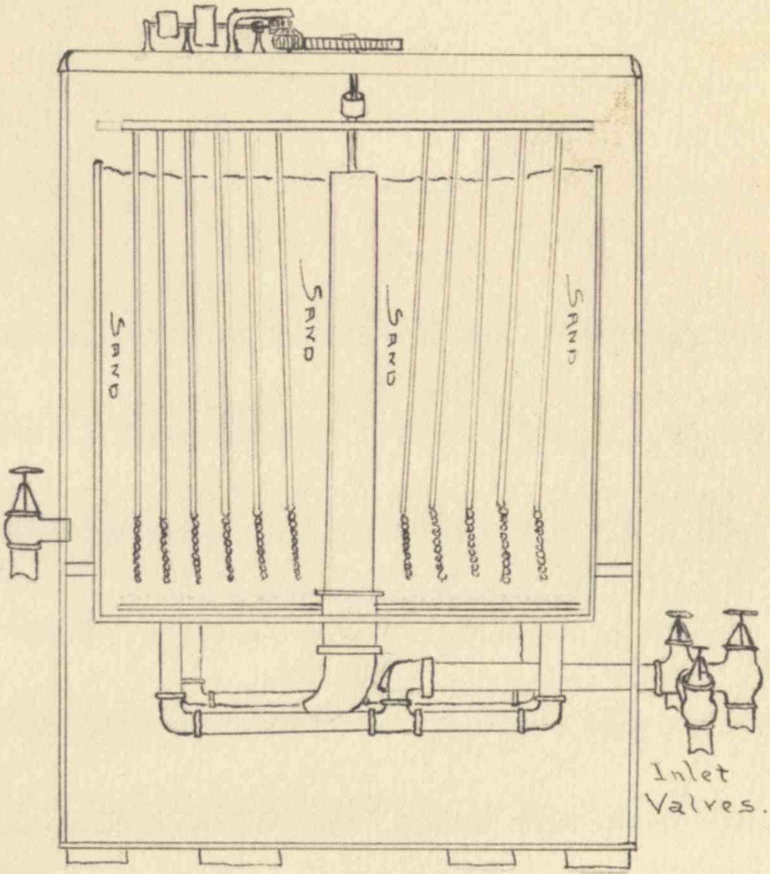
In regard to the cost. In the first cost of erecting a mechanical plant would be much cheaper and more easily constructed. Cost of operation depends a great deal upon the men in charge. Some sand filters are maintained for a very low sum while others have an extremely high rate. For example, the slow filters at Lawrence, Massachusetts, cost yearly per milliom gallons, seven Dollars and seventy cents; while those at Albany, N.Y. cost only one dollar and ninety-five cents. At Elmira, N.Y. a mechanical plant costs yearly per million gallons including interest and depreciation three dollars and fifty cents. At Quincy, Ill. only two dollars and eighty cents and at Lorain, Ohio, four dollars and twenty-five cents per million gallons. There is not the wide range that one sees in cost of sand filters.

After looking over the merits and defects of both methods, it seems as though a mechanical plant will better serve the people of Easton, cost less to construct and less to operate than a sand.

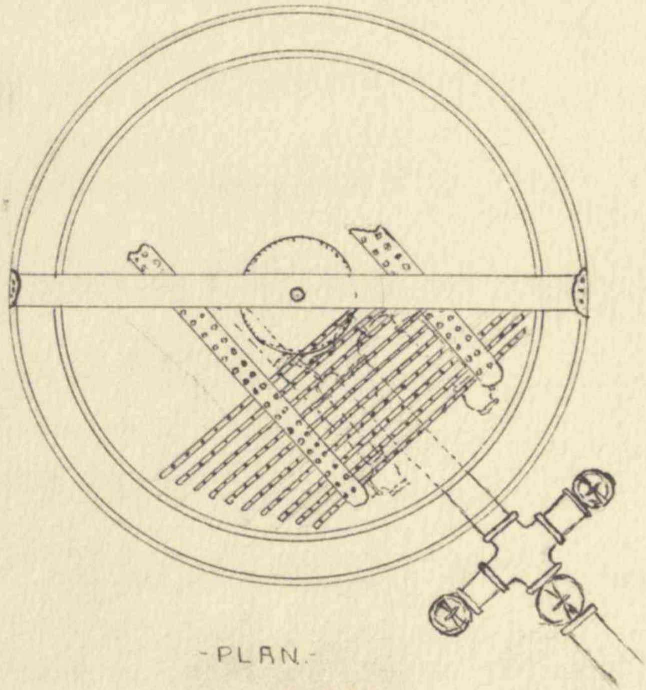
In designing a filter plant provision must be made for the future as well as the present. Easton in 1900 had a population of 26,000. It is safe to say that in twenty-five years there will be at least 35,000. At present the daily consumption is nearly two million gallons daily. In twenty-five years this may reach four million or even more. But a mechanical plant can be enlarged by adding more units, so it is sufficient for the present to have only enough filtering area for immediate use, leaving space for additional filters.

The plant will be designed for a daily capacity of two million five hundred gallons. It can be divided into three parts, filter house, power plant and clear water reservoir.

The filter building proposed would be a brick structure on stone foundations 175' by 52', with wooden roof trusses on 15' centers. It contains eight circular filters, 12' in diameter and 16' in



VERTICAL CROSS SECTION.



-PLAN-

SCALE 4'=1"

FILTER.

height, constructed of 2-1/2" dressed cypress timber and bound with iron hoops. The filters rest upon concrete foundations, and the floor is concrete. Down the center between the filters is an open concrete trough to carry off the filtered water. An operating platform 3' below top of filters extends the length of the building. From this all valves are operated.

The power room is in a wing 50' by 30'. Power is furnished by a HP motor direct current. Plenty of room will be left in case this power should become inadequate.

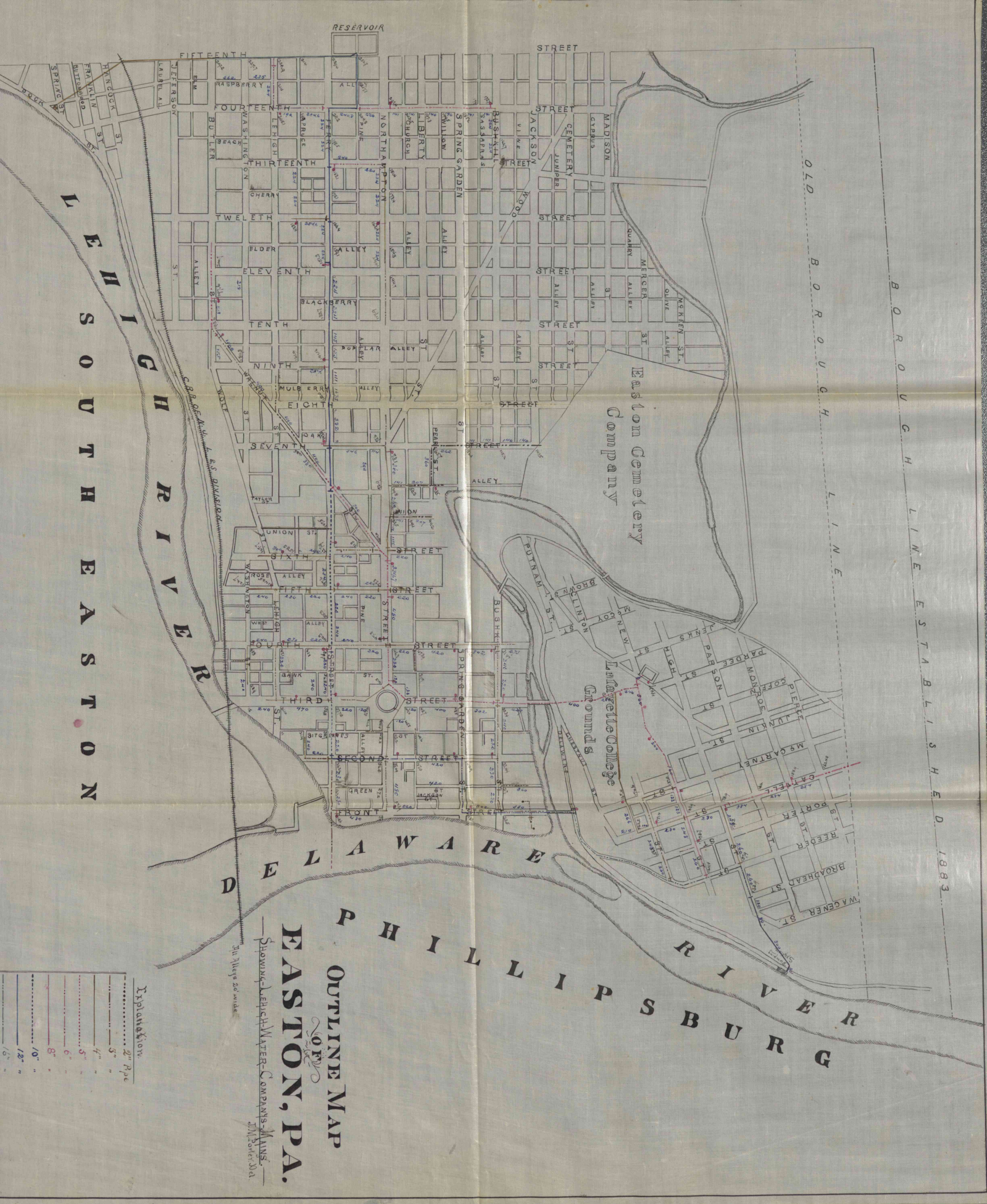
The mixing of coagulant will be done in a seperate structure, built of brick, two stories in height ' X ' The first floor to contain labratory for chemical and bacteriological examinations. On second floor is an iron tank 8' in diameter and 10' deep, to contain coagulating solution from which it is fed to settling tank, the flow being regulated by a valve. The alumina is dissolved in a small iron tank elevated above other tank and its flow is so regulated that the larger tank always contains same amount of solution.

Water upon being pumped from river is allowed to flow into a concrete tank 20' in diameter and ten feet deep which is built beside the mixing house. Here it receives the coagulant and then flows to filters by gravity. In clearing filters, filtered water is pumped from clear reservoir by a small pump in power room run by the motor.

The only suitable location for the plant is at the present reservoir on the side of Chestnut Hill. The filter building could be built on level space at north side of reservoir and on a bank above which will give a head for flow to filters. The present reservoir can be used as a clear water reservoir.

The total cost of the entire plant will be approximately seven thousand ($7,000) Dollars per million gallons. For a plant of three million gallons capacity the cost would be twenty-one thousand ($21,000) Dollars. However the cost would no doubt be nearer thirty thousand ($30,000) Dollars which would include cost of clearing reservoir and changes in force main. Cost of Maintenance would be about three dollars and fifty cents per million gallons.

Coagulant costs twenty-five ($25) Dollars per ton.


OUTLINE MAP OF EASTON, PA.
—Showing Lehigh Water Company's Mains—
J. M. Porter Del.
All Alleys 20' wide
Explanation
2" Pipe
3" "
4" "
5" "
6" "
8" "
10" "
12" "
16" "
RESERVOIR
FIFTEENTH STREET
FOURTEENTH STREET
THIRTEENTH STREET
TWELETH STREET
ELEVENTH STREET
TENTH STREET
NINTH STREET
EIGHTH STREET
SEVENTH STREET
SIXTH STREET
FIFTH STREET
FOURTH STREET
THIRD STREET
SECOND STREET
FRONT STREET
NORTHAMPTON
SPRING GARDEN
BUSHKILL
JACKSON
CEMETERY
MADISON
LEHIGH RIVER
SOUTH EASTON
DELAWARE RIVER
PHILLIPSBURG
Easton Cemetery Company
Lafayette College Grounds
OLD BOROUGH LINE
BOROUGH LINE ESTABLISHED 1883
C. R. R. OF N. J. L. & S. DIVISION