THESIS

DESIGN OF A WATER PIPE SYSTEM TO CREATE IMPROVED PRESSURES IN LEXINGTON, VIRGINIA

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AND

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B I B L I O G R A P H Y

A Design of A Water Works System----W. T. Lyle.

Cast Iron Handbook--Cast Iron Manufactures Assn.

Water Supply Engineering-----Babbitt and Doland.

Public Water Supplies-----Turneaure and Russell.

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Part 1.

INTRODUCTION

The need for a new design for the water pipes and mains in the town of Lexington is evident. There are no existing maps showing the plan of the system, nor is there any knowledge of the location of mains, hydrants, gate, blow off or waste valves, other than common knowledge of those men who have been connected with the water department of the town for a great many years. There is no engineer in charge of the water department, rather the head of the department is a man who is in his position because of his general knowledge of the existing system.

Upon investigation it has been found that the present system consists of a great number of dead ends, and that there is not proper pressure at the curb to supply some of the taller buildings in town. A map in the Supertendents of Water Work's office shows pressures at

several points in the town to be less than twenty (20) pounds.

The two educational institutions located in the town do not have proper pressures and supply in case of fire and this points to a great need for improvement.

There are three new developments in the town that have been added to the corporate limits of town since the present system of pipes and mains have been in existance. These, Davidson Park, owned by Washington and Lee University, and the other two, Morningside Heights, and Monroe Park, both located on a high level, do not receive the proper pressures. Some attempt should be made to take care of them.

With the present system of fire protection, Volunteer, there should be sufficient pressure at the curb and at the hydrants so that the efficiency of the fire department could be brought to a higher standard. There were two cases of fire losses this past year, when two fraternity houses burned beyond repair, because the water pressure was not great enough for sufficient fire streams.

The fire department would be far more efficient if the water supply were better. They are to be commended for the manner in which they fight fires under the present exixting conditions.

It is assumed by the writers that the present income of the town will not take care of this added expenditure. Therefor, the only method possible to raise the required funds would be by bond issues.

The State Of Virginia limits the amount of bond issues of a city or town. The only way that the town could raise the limit of their bond issue would be to annex new territory to the town. This would have to be accomplished in the following manner. A committee of public spirited citizens would take it upon themselves to go to Richmond, to attend the sessions of the legislature, and try to lobby a bill through the house and senate for a new bonding district. It is advisable for the local civic clubs to back these individiuals to their fullest extent.

It is not the purpose of this thesis to show how the moneys are to be raised for the improvements, but to give a plan for a new water supply system that will benefit the town in giving better pressures at the curb.

CONSUMPTION AND DISTRIBUTION.

Per Capita.

The town has a partial metered system, and by data obtained it is found that the consumption is as follows:

For domestic purposes	30 gallons per capita per day.
For public purposes Flushing, fire extinquishment, etc	5 gallons per capita per day.
For leakage,	5 gallons per capita per day.
For Commericial purposes	10 gallons per capita per day.
TOTAL CONSUMPTION:	50 gallons per capita per day.

The total consumption is assumed to increase 50% in the next thirty years, thus amounting to 75 gallons per capita per day.

The maxium daily rate is 150% of the average, thus amounting to 112.5 gallons per capita per day. The maximum hourly rate is 50% of this or 168.25 gallons per capita per day.

However it is safe to assume a lower rate, say, 150% of the monthly maximum, which is 125% of the average. This maximum hourly rate is 75 gallons x 1.25 x 1.50 , which equals 140 gallons per capita per day.

This is assumed as the maximum ordinary consumption.

Total.

The consumption per capita is assumed to be uniform throughout the town, therefore, the total maximum consumption.

thirty years hence will be 140 times the population as determined. In determining the size of mains and small pipes the densities of population in the different districts of distribution must be considered.

Fire rate.

The consumption for fire extinguishment amounts to very little in the course of a year, but will determine the size of the distributing pipes. The total number of fire streams required at one time is determined Kuitchling's formula; $Y = 2.8\sqrt{X}$; or $Y = 2.8 \times 2.4 = 7$ streams

where Y = the number of streams.
and X = the population in thousands.

Two thirds of this number are needed in the business districts. For the residential districts, from one fourth to one third of this number are required.

Streams of two hundred and fifty gallons are to be used in the business districts, and streams of one hundred and seventy five gallons in the residential districts.

Pressure:

Ordinary Service; The maxium pressure at the curb is thirty pounds in the residential districts and forty pounds in the business districts. The necessary pressure at hydrants for fire conditions should be one hundred pounds, but since the fire department is equipped with pumpers and it is impossible to obtain such pressures with the existing reservoir it will not be possible to maintain this pressure at hydrants. It will be necessary

however, to maintain a pressure of forty (40) pounds at the hydrants., For a two hundredand fixty gallon stream, with a nozzel pressure of fourty five pounds, and a loss of head of eighteen pounds in each hundred feetdof hose, the maxium length of the hose is three hundred feet. For a hundred and seventy five gallon stream, with a nozzle pressure of thirty five pounds, the loss of head nine pounds per hundred feet of hose, the maximum length of hose is seven hundred feet

Source of Supply.

The source of supply is obtained from an impounding reservoir a distance fourteen miles from Lexington, at Adcocks Knob. The water is then brought to the distributing reservoir, located one mile southwest of the town. The elevation at low water is two hundred and ninety two and seven tenths (292.7) feet above an assumed datum plane. Its capacity is about one million and a half gallons

Distribution Districts.

Mains shall be laid in the bounding streets of each district, and the district filled with a network of smaller distributing pipes, in order to provide good circulation, and avoid dead ends. The distributing pipes shall be laid on the north side of east and west streets, the same distance form the curb, and on the east side of north and south streets. The depth of the covering shall be

four feet, to prevent freezing. The size of the distributing pipes will be determined principally by the fire demand. The town is divided into districts depending upon whether they are business or residential districts. The distributing disricts are adopted as follows, indicated by bounding streets:

No. 1. Main Street, Campbell Lane, Lewis Street, Massey Street, and Parry Lane.

No. 2. V. M. I. Road, Main Street, College Lane, and Letcher Ave.

No. 3. College Lane, Washington and Lee Road, Washington Street, Jefferson Street, and Main Street.

No. 4. Massey Street, Lewis Street, Preston Street, and Randolph Street.

No. 5. Randolph Street, Parry Lane, Main Street, and McDowell Street.

No 6. Jefferson Street, Washington Street, McLaughton Street, White Street, and Main Street.

No 7. White Street, Main Street, Sellers Ave., Ross Road, and Woods Creek.

No. 8. Main Street, Houston Street, Taylor Street, and Wallace Street.

No. 9. Ross Road, Stonewall Street and Lane.

No. 10. White Street, Jefferson Street, and Main Street.

Part 3.

HYDRANTS AND MAINS.

Hydrants.

The number and location of hydrants is determined by the number of streams in each district, which are as follows:

No. 1.	1/4	the	total	number	of	streams,	2.
No. 2.	2/3	"	"	"	"	"	4.
No. 3.	2/3	"	"	"	"	"	4.
No. 4.	1/3	"	"	"	"	"	2.
No. 5.	1/3	"	"	"	"	"	2.
No. 6.	1/3	"	"	"	"	"	2.
No. 7.	1/3	"	"	"	"	"	2.
No. 8.	1/3	"	"	"	"	"	2.
No. 9.	1/3	"	"	"	"	"	2.
No. 10.	1/3	"	"	"	"	"	2.

The drips of all hydrants shall drain into the sewers. The bottom of all hydrants are to be set four feet below the surface of the ground to provide against frost.

Mains.

The size of the mains shall be made economical for the ordinary supply unless the loss of head be prohibited at times of fire. The pressures at the curb should not exceed one hundred and thirty pounds. The draught of the main bounding a district is assumed to be proportional to the number of small pipes in the districts which lead to the main in question.

Part 4.

ANALYSIS.

The following analysis shows the amount of water carried by each main. The principle artery is brought from the distributing reservoir, across Woods Creek, into Washington Street, Around Washington and Lee and V. M. I. roads, to Main Street, thence to Sellers Ave., to Jackson Avenue, and Dwn White Street and Main Street.

Analysis:

Line around Washington and Lee Campus, from Washington Street to Letcher Ave.,
3/5 #3, all No. 2.

Line around V. M. I. Road, College Lane to Main Street.
All of #2, minus Letcher Ave.,

Line in front of V. M. I. Commisary.
All of line from intersection of two V.M.I. roads to intersection of road with Main street.

Line in Main Street, Campbell Ave., from interection of V. M. I. road and Main Street to Lewis Street.
3/13 #1,

Line on Washington Street, from Reservoir inlet, to Jefferson Street.
2/5 #3, all #1, 1/8 #6, 2/10 #10.

Line on Jefferson Street, from Washington Street to Main Street.
2/5 #3, 2/10 #10, all #1.

Line on Lower Main Street, from Flatiorn to V.M.I. Road.
3/13 #1.

Line on Parry Lane, and Massey Street, from Main to Lewis.
1/2 #1, 2/9 #4.

Line on Lewis Street, from Massey Street to Campbell Lane.
4/13 #1,

Line from Reservoir Line to foot of Jordan Street.
All #7, all #8, all #9, all #5, 7/8 #6, 8/10 #10
7/9 #4,

Line along Woods Creek, from Jordan to White Street.
7/8 #6, all #5, 4/6 #7, 8/10 #10, 7/9 #4.

Line along White Street and Main Street, from Woods Creek to Main and McDowell.
7/8 #6, all #5, 4/7 #7, 8/10 #10, 7/9 #4,

Line along Main Street, from Flatiorn to McDowell.
1/2 #10, 1/2 #5.

Line from McDowell and Main to Preston and Randolph, along McDowell and Randolph.
1/2 #5, 7/9 #4.

Line along Preston Street, from Randolph to Lewis.
4/9 #4.

Line along Randolph, from Preston to Massey.
1/2 #5, 3/9 #4.

Line along Woods Creek, south from Jordan to Ross Road.
All No.9, all #8, 3/7 #7.

Line Along Ross Road, Stonewall to Jackson Ave.,
All #8, 3/7 #7.

Line From Jackson and Ross Road to Sellers and Main, along Sellers and Jackson Ave.
All #8, 2/7 #7.

Line along Main Street, Sellers to White Street.
1/8 #8, 2/7 #7.

Line along Wallace and Taylor Street.
1/2 # 8.

Line along Houston Street, Main to Taylor.
1/4 #8.

Line Along Ross Road, via Lane to Stonewall Street.
1/2 #9.

Line along Ross Road, from Ross Road to Lane.
1/2 #9.

Line from Nelson and McLaughton, to White Street.
3/8 #6.

The above anaylsis is recommended for use, but by no means is the only one that can be used. There are many ways that it can be drawn up, but underconsideration of the topgraphy of the town it has been decided that this is best to use. A linewas taken from the reservoir line to the foot of Jordan street, and it is assumed that by adding this additional line pressures in the south partnof town can be improved. The smallest pipe used in the bounding districts were taken as six inch, and those in the district were taken as four inch. The economic size of mains are obtained from the formula: (T & R, page 165)

$$S_1 : S_2 :: 1 : n^4$$

Where S = the loss of head in the main.
and S = the loss of head in the small pipes
and n = the number of small pipes.

The mains will be laid in the same location as the distributing pipes, but the depths of the ditch will not exceed three (3) feet. The covering is less than required for distributing pipes, which is proper, since the danger of freezing is much less in the larger pipes.

Part 5.

FIRE STREAMS

The number of fire streams have already been determined and is equal to seven. The fire streams by districts are as follows:

District No. 1.

1/4 x 1500 = 375 gallons per minute.
Therefor, one 250 gallon stream and one 175 gallon stream shall be used.

District #2.

2/3 x 1500 = 1,000 gallons per minute.
Therefore, two 250 gallon streams and three 175 gallon streams shall be used.

District #3.

Same as #2.

District #4.

1/3 x 1,500 = 500 gallons per minute.
Therefore, use three 175 gallon streams.

District #5.

Same as #4.

District #6.

Same as #4.

District #7.

Same as #4

District #8.

Same as #4.

District #9.

Same as #4

Disrtict #10.

Same as #4.

INVESTAGATION FOR ALLOWABLE LOST HEAD.

Investagation for ruling grade. (Worst condition at Corner of Taylor and Houston Street)

Surface Elevation at corner of Houston and Taylor	294.7
Pressure head at curb line, 2.304 x 40	92.16
Piezometric level at this point	286.86
Low water level in reservoir	292.7
Piezometric level at this point	286.86
Drop in Piezometric level	16.8
Distance in Thousand feet	10.0
Lost head per thousand	1.68

To find the lost head in feet per thousand for mains leading to each district.

District #8.

Distance to Taylor and Wallace	8,000ft.
Surface elevation at Taylor and Wallace	193.8
Pressure head at the curb, 2.304 x 40	92.16
Piezometric level at this point	285.96
Lost head in feet per thousand 6.73/8	.84
Level of low water at reservoir	292.7
Piezometric level at this point	285.96
Drop in piezometric level	6.73

District #7.

Distance to White and Main Streets.	6,875 ft.
Surface elevation at White and Main	200.1
Pressure head at the curb, 38 x 2.304	87.55
Piezometric level at this point	287.65

Elevation of low water in reservoir	292.7
Piezometric level at this point	287.65
Drop in piezometric level	5.1
Lost head in feet per thousand 5.1/6.8	.73

District #6.

Surface elevation, Jordan and White	184.3
Pressure head at the curb, 40 x 2.304	92.16
Piezometric level at this point	276.46
Elevation of low water in reservior	292.7
Piezometric level at this point	272.46
Drop in piezometric level	16.24
Distance 5,360 ft.	
Lost head feet per thousand 16.24/5336	3.04

District #10.

Distance	6,380
Elevation corner Main and White Streets	200.54
Piezometric level at this point, 2.304 x 38	87.55
Piezometric level at this point	288.09
Water elevation at reservoir	292.7
Piezometric level at this point	288.09
Drop in Piezometric level	4.61
Lost head in feet per thousand 4.61/6.38	.72

District #5.

Distance	6,340
Elevation at corner Randolph and McDowell	181.3
Piezometric level at this point, 2.304 x 40	92.16
Piezometic level at this point	273.46
Elevation of low water at reservoir	292.7
Piezomteric level at this point	273.5
Drop, in piezometric level	19.2

Lost head per thousand feet 19.2/6.3	3.04

District #4

Distance	9,500 ft
Surface elevation at Lewis and Massey	175.7
Pressure head at curb, 2.304 x 40	92.16
Piezometric level at this point	267.86
Elevation of low water at reservior	292.7
Piezometric level at this point	267.86
Drop in piezometric level	24.9
Lost head in feet per one thousand, 24.9/9.5	2.6

District #3.

Distance	6,110 feet
Surface elevation on W.L.U. road	150.7
Pressure at curb, 2.304 x 40	92.2
Piezometric level at this point	242.9
Elevation of low water at reservoir	292.7
Piezometric level at this point	242.9
Drop in piezometric level	49.8
Loss head in feet per thousand, 49.8/6.11	8.1

District #2

Distance	8,104 feet
Surface elevation at V.M.I. Lane	144.3
Pressure head at the curb, 40 x 2.304	92.2
Piezometric elevation at this point	236.5
Elevation of water in reservior	292.7
Piezometric level at this point	236.5
Drop in piezomtric level	56.2
Loss head in feet per thousand 56.2/8.1	6.9

District #1.

Distance	9,560 Feet
Surface elevation at Lewis and Massey	175.7
Pressure head at this point, 2.304 x 40	92.2
Piezometric level at this point	267.9
Elevation of low water at reservior	292.7
Piezomteric level at this point	267.9
Drop in piezometric level	24.8
Lost head in feet per thousand, 24.8/9.56	2.6

Population by Districts.

Number 1.	700
Number 2.	1,300
Number 3.	560
Number 4.	610
Number 5.	1,305
Number 6.	690
Number 7.	1,055
Number 8.	400
Number 9.	50
Number 10.....	1,085.
Total population	7,695

Part 7.

DESIGN OF MAINS.

LEWIS STREET, MASSEY ST TO CAMPBELL AVE.,

Analysis: 4/13 #1 $\frac{140}{1440} = .0972.$

4/13 x 700 x.0972 — 20.9 g.p.m.
Size of pipe — 6 inch

MASSEY STREET, MAIN TO LEWIS.

Analysis: 1/2 #1, 2/9 #4.

1/2 x 700 x .0972 — 34.0
2/9 x 610 x .0972 — 13.1
47.1
Size of pipe — 6 inch

MAIN STREET, FROM LEWIS STREET TO V.M.I. ROAD.

Analysis: 3/13 #1,

3/13 x 700 x .0972 — 15.6
Size of pipe — 6 inch

LOWER MAIN STREET, FLATIRON TO V.M.I. ROAD.

Analysis: 3/13 #1.

Same as one above, use 6 inch pipe.

LINE AROUND V.M.I.

Analysis; All #2, minus Letcher Ave.

(1,300 - 175) 0972 — 109.35
Size of pipe — 6 inch

LINE AROUND WASHINGTON AND LEE CAMPUS.

Analysis: 3/5 #3, all #2

3/5 x 500 x .0972 + 1300 x .0972 — 154.1
Size of pipe — 6 inch

PRESTON STREET, RANDOLPH TO LEWIS.

Analysis: 4/9 #4,

4/9 x 610 x .0972	26.3
Size of pipe	6 inch

RANDOLPH, PRESTON TO MASSEY.

Analysis: 1/2 #5, 3/9 #4,

1/5 x 1305 x .0972	63.4
3/9 x 610 x .0972	19.7
	83.1
Size of pipe	6 inch

McDOWELL ST, MAIN STREET TO PRESTON STREET.

Analysis: 1/2 #5, 7/9 #4.

1/2x1305 x .0972	63.4
7/9 x 610 x .0972	4.6
	68.0
Size of pipe	6 inch

MAIN STREET, FALT IORN TO MCDOWELL STREET.

Analysis; 1/2 #10, 1/2 #5.

1/2 x 1085 x .0972	52.1
1/2 x 1305 x .0972	63.4
	115.5
Size of pipe	8 inch pipe

JEFFERSON STREET, WASHINGTON TO MAIN STREET

Analysis: 2/5 #3, 2/10 #10, all #1.

2/5 x 500 x .0972	19.4
1/5 x 1085 x .0972	21.09
700 x .0972	68.04
	108.5
Size of pipe	_ inch

WASHINGTON STREET, RESERVOIR INLET TO JEFFERSON STREET

Analysis: 2/5 #2, all #1, 1/8 #6, 2/10 #10.

2/5 x 5500 x .0972	19.4
1/5 x 1085 x .0972	21.1
1/8 x 690 x .0972	8.39
700 x .0972	68.4
	116.8
Size of pipe	8 inch

McLAUGHTON, NELSON STREET TO WHITE STREET.

Analysis: 3/8 #6.

3/8 x 690 x .0972	24.5
Size of pipe	6 inch

WHITE STREET, WOODS CREEK TO MAIN STREET.

Analysis: 7/8 #6, all #5, 4/7 #7, 8/10 #10, 7/9 #4.

7/8 x 690 x .0972	58.7
7/9 x 610 x .0972	46.1
8/10 x 1085 x .0972	84.4
690 x .0972	67.0
1305 x .0972	127.0
150 x .0972	4.8
400 x .0972	38.9
1055 x .0972	107.9
	924.8

Use 16 inch pipe

WOODS CREEK, JORDAN STREET TO ROSS ROAD

Analysis: All #9, all #8, 3/7 #7,

3/7 x 1055 x .0972	44.0
400 x .0972	38.9
50 x .0972	4.8
	87.7

Use eight inch pipe.

ROSS ROAD, STONEWALL STREET TO JACKSON AVE.

Analysis: All #8, 3/7 #7.

3/7 x 1055 x .0972	44.0
400 x .0972	38.9
	82.9

Use 6 inch pipe.

SELLERS AVENUE, FROM JACKSON AND ROSS ROAD

Analysis: All #8, 2/7 #7.

2/7 x 1055 x .0972 400 x .0972	68.2

Use six inch pipe

MAIN STREET, SELLERS TO WHITE.

Analysis: 1/8 # 8, 2/7 #7.

1/8 x 400 x .0972	4.8
2/7 x 1055 x .0972	29.3
	34.1

Use six inch pipe.

ROSS ROAD, LANE TO STONEWALL STREET.

Analysis: 1/9 #9.

1/2 x 50 x .0972	2.4

Use six inch pipe.

ROSS ROAD, TO LANE

SAME AS ABOVE------USE SIX INCH PIPE.

Part 8.

DESIGN OF RESERVOIR LINES.

LINE FROM RESERVOIR TO FIRST BRANCH.

Total number gallons perday	1,077,300
Total gallons per minute	741
Lost head on flattest grade	.72
Size of pipe	16"

LINE FROM FIRST BRANCH TO SECOND BRANCH.

Total number gallons per day	404,640
Total number gallons per minute	281
Lost head on flattest grade	2.6
Size of pipe	10"

LINE FROM RESERVOIR LINE TO FOOT OF JORDAN STREET.

Total number gallons per day	662,400
Total number gallons per minute	460
Lost head on flattest grade	.72
Size of pipe	12"

Part 9.

INVESTAGATION FOR MAXIMUM PRESSURES IN THE MIDDLE OF EACH DISTRICT FOR MAXIUM ORDINARY CONSUMPTION.

District #3.

Distance, Distributing Reservoir to corner W. L. U. road and Washington Street	5,535 feet	
Lost head per one thousand feet	.32	
Lost head for 5,535 feet		1.76
Distance on Washington St., from W.L.U. Road to Jefferson Street.	725 feet	
Lost head in one thousand feet	.55	
Lost head in 725 feet		.39
Distance from Washington St. to Flatiron on Jefferson Street	975 feet	
Lost head per one thousand feet	1.9	
Lost head in 975 feet		1.85
Distance into district	200 feet	
Lost head per one thousand feet	1.5	
Lost head in two hundred feet		.3
Total lost head		4.33
Elevation of low water in reservoir	292.7	
Total lost head	4.33	
Elevation of hydraulic grade line at this point	288.4	
Elevation of ground here	95.0	
Piezometric difference	193.4	
Pressure at this point	84 #s	

District #2.

Lost head from Reservoir to W. L. U. Road		1.76
Distance from Washington St and W.L.U. Road to College lane	1,950 feet	
Lost head per one thousand feet	3.9	
Lost head in 1,950 feet		7.41

Lost Lost head from College Lane into district 3.63

Total lost head 12.80

Elevation of low water in reservoir 292.7
Total loss of head 12.80

Elevation of hydraulic grade line 279.9
Ground elevation at this point 137.5

Piezometric elevation at this point 142.4

Pressure at this point, 142.4 x .434 62 pounds.

District #1.

Total lost head from Reservoir to Flatiron 4.03

Distance along Parry lane and Lewis Street 2,130'

Lost head per one thousand feet .45
Lost head for 2,130 feet .96

Distance from Massey to Diamond on Lewis 1050feet
Lost head per one thousand feet .30
Lost head for 1,050 feet .31

Distance into Curruthers and Dorman lanes, 1500 feet
Lost head per one thousand feet 2.5
Lost head for 1,500 feet 3.80

Total lost head 9.70

Elevation of low water at reservoir 292.7
Total lost head 9.7

Elevation of hydraulic grade line 283.0
Eleveation of surface 134.0

Piezometric elevation here 149.0

Pressure at this point, 149.0 x .434 64.5 pounds

District #6.

Total lost head from Reservior to Washington Street and W. L. U Road 1.76

Distance from Reservoir line to McDowell Street 1,950 feet

Lost per per one thousand feet .3
Lost head for 1,950 feet 5.585

Distance from McLaughin Street into to Jackosn Ave and Preston Street, 1,000 feet		
Lost head per one thousand		2.0
Total lost head		4.34
Elevation of low water at reservoir	292.7	
Total lost head	4.34	
Elevation of hydraulic grade line	288.4	
Elevation of surface here	167.0	
Piezometric elevation at this point	121.4	
Pressure at this point, 121.4 x .434		52.69 pounds

District #10.

Lost head from Reservior to W.L.U. Road and Washington Street		1.76
Lost head from reservoir line to Washington and Jefferson Street		2.15
Lost head from Washington and Jefferson Streets to Flatiorn		1.85
Distance from Flatiorn to Nelson Street, 1,320		
Lost head per one thousand feet	.60	
Lost head for 1,320 feet		.78
Distance in district, 1,000 feet		
Lost head per one thousand feet		.15
Total lost head		6.69
Elevation at reservoir at low water	292.7	
Total lost head	6.69	
Elevation of Hydraulic grade line	286.0	
Elevation of surface here	169.1	
Piezometric elevation at this point	116.9	
Pressure at this point, 116.9 x .434	50.73pounds	

District # 5.

Total lost head		6.69
Elevaton of Reservoir at low water	292.7	
Total lost head	6.69	
Elevation of hydraulic grade line	286.0	
Elevation of surface	134.0	
Piezometric elevation	152.0	

Pressure at this point 65.96 pounds.

District #4

Total lost head to Massey and Lewis Streets		4.99
Distance on Lewis Street, from Massey to Washington Street, 750 Feet.		
Lost head per thousand feet	.35	
Lost head for 750 feet		.1
Distance into district, 750 feet		
Lost head for one thousand feet	2.0	
Lost head for 750 feet		1.5
Total lost head		6.59

Elevation of low water at reservoir	292.7
Total lost head	6.59
Elevation of hydraulic grade line	226.1
Elevation of surface	134.0
Piezometric eleatiation at this point	152.1

Pressure at this point, 152.1 x .434 .66 pounds

District #7.

Distance from Reservoir line to foot of Jordan Street 705 feet

Lost head per one thousand feet	.48	
Lost head for 705 feet		.33
Distance from Reservior to Reservior line, 3,500 ft.		
Lost head per one thousand feet	.14	
Lost head for 3,500 feet		.49
Distance along Woods Creek, 975 feet		
Lost head per 1,000 feet	.34	
Lost head for 975 feet		.33
Distance along Ross Road, from Jackson Ave to Stonewall Street, 525 feet		
Lost head for one thousand feet	.1.5	
Lost head for 525 feet		.75
Distance from Ross road to Main and Sellers, 1370feet		
Lost head per one thousand feet	1.4	
Lost head for 1,370 feet		1.91
Dstance on Main from Sellers to Edmundson, 380 feet		
Lost head for one thousand feet	3.5	
Lost head for 380feet,		1.33
Distance up Edmundson to West Side Court, 855 feet		
Lost head per one thousand feet	2.0	
Lost head for 855 feet		1.7
Total lost head		5.31

Elevation of low water at Reservoir		292.7
Toal lost head		5.3
Elevation of hydraulic grade line		287.4
Eleation of surface at this point		161.2
Piezometric elevation at this point		126.2
Pressure at this point, 126.2 x .434		54.6 lbs.

District #8.

Lost head to Corner Sellers and Main		2.28
Distance from Sellers and Main to Taylor and Wallace, 1,770 feet		
Loss of head per one thousand feet	.3	
Loss of head for 1,770 feet		.53
Loss of head (Total)		2.81
Elevation of low water at reservoir,		297.2
Total lost head		2.8
Elevation of hydraulic Grade line		294.4
Elevation of surface at this point		194.0
Elevation of piezometric level		100.0
Pressure at this point, 100 x .434		43.4 pounds.

District #9.

Loss head to Ross Road		1.15
Distance along Ross Road, 1650 feet		
Lost head per one thousand feet	.8	
Lost head for 1,650 feet		1.3
Total lost head		2.45
Elevation of low water at low water		292.7
Total lost head		2.5
Elevation of hydraulic grade line		290.2
Surface elevation at this point		184.3
Piezometric level at this point		105.9
Pressure at this point 105.9 x .434		46 pounds

Part 10.

VALVES.

Gate Valves.

Gate valves are necessary in case of breaks in the line, and so that sections of districts, or districts can be cut off from the remainder of the town in case of needed repairs within that section. There should be as few gate valves as possible, to cut the expense of the plan. In case of a break, not more than four lines must be exposed, or less than three. This condition is set down for districts five and ten, which are business districts. In the remainder of the town, not more than five lines should be exposed, or less than three.

There are exceptions to this rule however, when less valves can be used where there remains more than five lines exposed. This exception is left to the judgement of the writers in cases where the lines are short, and the draught on them are not excessive.

Waste Valves.

Three waste valves are to be used in the town, and are to be connected with the nearest sewer. The purpose of these valves are to drain the area in which there is a break, so that repairs can be made. These valves are also used for blow off valves.

Blow Off Valves:

Whereever there is a depression in the topography

of the town, or where the velosity in the pipes might be low, deposits of mud are apt to collect. Blow off valves are placed throughout the town to care for this need. In this case, the blow off valves and the waste valves were used interchangabely. In this manner less valves are needed, and expense cut.

Part 11.

FIRE INVESTAGATION.

District #2.

Assume fires in number 2 and three.

Fire in #2, in middle of district.

Line around W.L.U.
Analysis: For fire, all #2, 3/5 #3.
For M.O.C.all #2, 3/5 #3.

For fire consumption.	
3/5 x 1,000	600 g.p.m.
All #2	1,000 g.p.m.
For M.O.C.	154 g.p.m.
Total draught on line at times of fire	1,754 g.p.m
Lost head in feet per thousand, (8" pipe)	65 feet
Lost head to middle of this district	51 feet

Line to middle of V.M.I.
Analysis: For fire consumption

All #2,	1,000 g.p.m.
For M.O.C.	109.4 g.p.m.
Lost head in feet per thousand	26 feet
Lost head to middle of district	39 feet
Distance 1,500 feet	
Lost head in ths distance (Total) 39 + 51	91 feet
Piezometric elevation at V.M.I. Road	227.2 feet
Total lost head	90.0
Piezometric difference	136.2
Pressure at this point 136.2 x .434	59 pounds.

District #3.

Assume fires in #2 and #3.

Fire in middle of District #3.

Line from Letcher Ave to middle of V.M.I. Road.
Analysis: 1/2 fire daraght, and 1/2 M.O.C.

Total draught -- 1/2 x 109.4 & 1/2 x 1,600	854.7
Lost head in feet per thousand	60 feet
Distance 1200 feet	
Lost head in this distance	75 feet
Piezometric elevation at center of W.L.U. Road	271.5 feet
Total lost head to this point	75.0 feet
Difference in elevation at this point	196.5
Pressure at this point	64 pounds.

District #1.

Assume fires in Districts 1 and 4.

Fire in District #1, corner Maury and Diamond.

Line on WashingtonbStreet, rrom W.L.U. Road to Jefferson Street (8inch pipe)

Analysis:

For M.O.C. 2/5 #2, all #1, 1/8 #6, 2/10 # 10	116.8 g.p.m
Fire , for #1 and #4 375 & 500	875.0 g.p.m.
Total draught	991.8 g.p.m
Loss per onethousand feet	25 feet
loss along Washington to Jefferson	18.7 feet

Jefferson Street, Washington Street to Main Street

Analysis:

For M.O.C., 2/5 #3, 2/10 #10, all #1	108.5 g.p.m.
Fire Number 1 and 4	875 g.p.m.
Total fire draught	983.5 g.p.m.
Loss in line on Jefferson to Main Street	
Try 8 inch pipe	
Loss head per one thousand feet	25 feet
Loss in this distance	22.5 feet

Line along Massey Street, Parry Lane to Lewis Street.
Total Distance 1,800 feet

Analysis: M.O.C. 1/2 #1, 2/9 #4.	47.1 g.p.m
Fire, #4 and #1	875.0 g.p.m
Total draught	922.1 g.p.m

Lost head per one thousand feet	23 feet
Lost head in this distance	41.4 feet
Line along Lewis and Diamond Streets	
Total distance, 1050 feet	
Analysis: M.O.C. 1/2 #1	34.0 g.p.m.
Fire all #1	375.0 g.p.m.
Total draught	409 g.p.m.
Lost head per one thousand feet	22 feet
Lost head in this distance	22 feet
Line along Diamond Street, Lewis to Massey.	
Total distance 900 feet	
Analysis: M.O.C. 3/13 #1	113 feet
Total loss of head	104.6 feet
Piezometric elevation	241.5
Total lost head to the point in question	104.6
Loss in head	136.9
Surface elevation at this pojnt	120.0
Pressure at this point	6.94 feet

District #4.

Assume fires in Districts #4 and #1.

Fire at intersection of Fuller and Washington Streets

Loss head to Massey and Lewis	72.6
Line along Lewis, to Washington Street 600 feet	
Analysis: M.O.C. 1/2 #1, 2/9 #4.	47.1 g.p.m.
Fire,	500 g.p.m.
Total draught	547.1 g.p.m.
Lost head per one thousand feet	30 feet
Lost head for 600 feet	18 feet

Line along Washington Street, from Lewis to Fuller:
Distance, 600 feet

Analysis: M.O.C. 1/9 #4	24 g.p.m.
Fire,	500 g.p.m.
Total draught	524 g.p.m.
Lost head in this distance	18 feet
Total lost head to the point in question	108 feet
Piezometric elevation at WLU Road and Washington St.	241.5 feet
Total lost head	108.0 feet
Difference in Piezometric elevation	133.5 feet
Pressure at this point	9.2 pounds

Since there is only one line pulling from this line sure this pressure need only be enough for the pumper and is sufficient.

District #10.

Assume fires in Districts #5 and 10.

Fire on Nelson Street, between Jefferson and Main Streets, in the middle of the block.

Piezometric elevation foot of Jordan Street 292.7

Line along White Street, from Woods Creek to Main Street,
Analysis: M.O.C. 7/8 #6, all #5, 4/7 #7, 8/10 #10, 7/9 #4.

	924.8 g.p.m.
Fire draught	1,000 g.p.m.
Total draught	1,924.8 g.p.m.

Assume a twelve inch pipe
Loss per one thousand feet 14 feet
Loss to main Street 22.4 feet

Line along Main Street, White to Nelosn Street
Assume an eight inch pipe.

Anaylsis: M.O.C. 1/2 #8, 1/2 #5.	115.5 g.p.m.
Fire	1,000.0 g.p.m
Total draught	1,115.5 g.p.m

Lost head in feet per thousand	32 feet
Distance	1,600 feet
Lost head in this distance	51 feet

Dine into center of district, four inch pipe Lost head	10 feet
Total lost head to the point in question	83.5 feet
Piezometric elevation at foot of Jordan Street	292.7 feet
Surface elevation	155.0 feet
	137.7 feet
Total lost head	83.5 feet
Piezometric Difference	54.2 feet
Pressure at this point	22 pounds.

###Which is sufficient because fire peessure draws on only one line.

District #5.

Assume fires in District #5 and #10

Fire in #5 on Nelson Street, between Randolph and Main.

Loss to Main and Nelson	73.5 feet
Loss to fire	10.0 feet
Total lost heas	83.5 feet
Piezometric elevation at foot of Jordan Street	292.7 feet
Surface elevation at point in question	150.0 feet
Elevation of hydraulic grade line	142.7 feet
Lost head to this point	83.5 feet
Piezometric difference	59.2 feet
Pressure at this point	26 pounds

District #6.

Assume fires at Preston and Jackson

Lost head to Jackson and White Street per one thousand	14 feet
Distance, 1350 feet	
Total lost head for this distance	19 feet

Lost head in 4" pipe to Preston Street	23.3 feet
Total lost head	42.3 feet
Piezometric elevation at foot Jordan Street	292.7
Surface elevation	165.2
	127.5
Pressure at this point	55 pounds

District #8.

Assume fires in Districts #7 and #8.

Loss to Main and White	22.4 feet
Line from Main and White to Houston and Taylor Streets	
Analysis: M.O.C.	38.9 g.p.m.
Fire	500.0 g.p.m.
Total draught	538.9 g.p.m.
Lost head per one thousand feet	32 feet
Lost head for 1000 feet	32 feet
Total lost head	54.4 feet
Piezometric elevation at foot of Jordan Street	292.7
Total lost head	54.4
	238.3
Surface elevation	194.7
Difference in piezometric elevation	43.6
Pressure,	20 pounds.

District #7.

Assume fires in 7 & 9.

Reservior line to Ross Road

Max. Ordinary Consumption	87.7 g.p.m.
Fire draught	1,000.0 g.p.m
Total fire draught	1,087.7
Assume eight inch line, 900 feet long	
Lost head per one thousand feet	26.0
Lost head in this distance	23.4

Line on Ross Road, Stonewall Street to Jackson Ave.
Distance, 500 feet

Draught: For M.O.C.	82.9 g.p.m.
For fire	500 g.p.m.
Total Draught	582.9 g.p.m.
Lost head per one thousand feet	40.0 feet
Lost head for 500 feet	20 feet
Lost head in 4"pipe, into district	26 feet
Total lost head	69.4 feet
Piezometric elevation at foot of Jordan Street	292.7 feet
Surface elevation	156.1 feet
Elevation of hydraulic grade line	136.6 feet
Total lost head	69.4 feet
Difference in piezometric elevation	77.2 feet
Pressure at this point	32 pounds.

District # 9.

Assume fires in 7 and 9.

Lost head to Ross road	23.4 feet
Lost head to center of district	
Distance 1300 feet	
Draught: M.O.C.	4.8 g.p.m.
Fire	500.0 g.p.m
Total draught	504.8 g.p.m.
Lost head into district	15.6 feet
Total lost head to point in question	39 feet
Piezometric elevation at foot of Jordan Street	292.7
Surface elevation	165.0
Elevation of hydraulic grade line	127.7
Total lost head	39.0
Difference in Piezometric elevation	88.7 feet
Pressure at this point	39 pounds.