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THE DESIGN OF A WATER SUPPLY
DISTRIBUTION SYSTEM FOR
VERMONTVILLE, MICHIGAN

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE

G. R. Smith

1946

THESIS

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The Design of a Water Supply
Distribution System
for
Vermontville, Michigan

A Thesis Submitted to

The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE
by

G. R. Smith
Candidate for the Degree of
Bachelor of Science

July 1946

THESIS

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FOREWORD

This design of a water supply distribution system is for the village of Vermontville in Eaton County in the State of Michigan.

Vermontville is located in hilly country with no previous water distribution and with no sewerage. It is a small farming community with no industry and no prospects of growth. Neither is Vermontville a wealthy village, a factor which has largely influenced the design of its proposed water supply system.

The entire cost of the project is to be raised by a bond issue to be retired over a long period. The indebtedness of the village will be rather large, so throughout the discussion and design, costs have been kept to a minimum. It is the only way Vermontville can afford a water supply for the public.

The source of water is to be from wells driven in the central part of the village. From the wells the water will be pumped to an elevated storage tank and thence by gravity throughout the distribution system to the consumer.

There is no water treatment plant.

The features of the design included in this thesis are:

1. Design of the pipe system.
2. Location of valves and hydrants.
3. Design of the elevated storage tank in respect to height and capacity.
4. A cost estimate of the system excluding the wells and pumps.

PART I

POPULATION AND CONSUMPTION STUDY

Population and Estimated Growth

The village of Vermontville is a typical farm center with no industry and with no reason for it to grow. It has had an almost constant population for the past twenty-five years with a maximum of 585 in 1920 and a minimum of 564 in 1940.

A comparison with other villages of the same type, population, and lack of industry, shows no probability of increasing growth.

None of the standard methods of estimating the future population apply to this village as can readily be seen by looking at the graphic representation of its growth in Fig. 1.

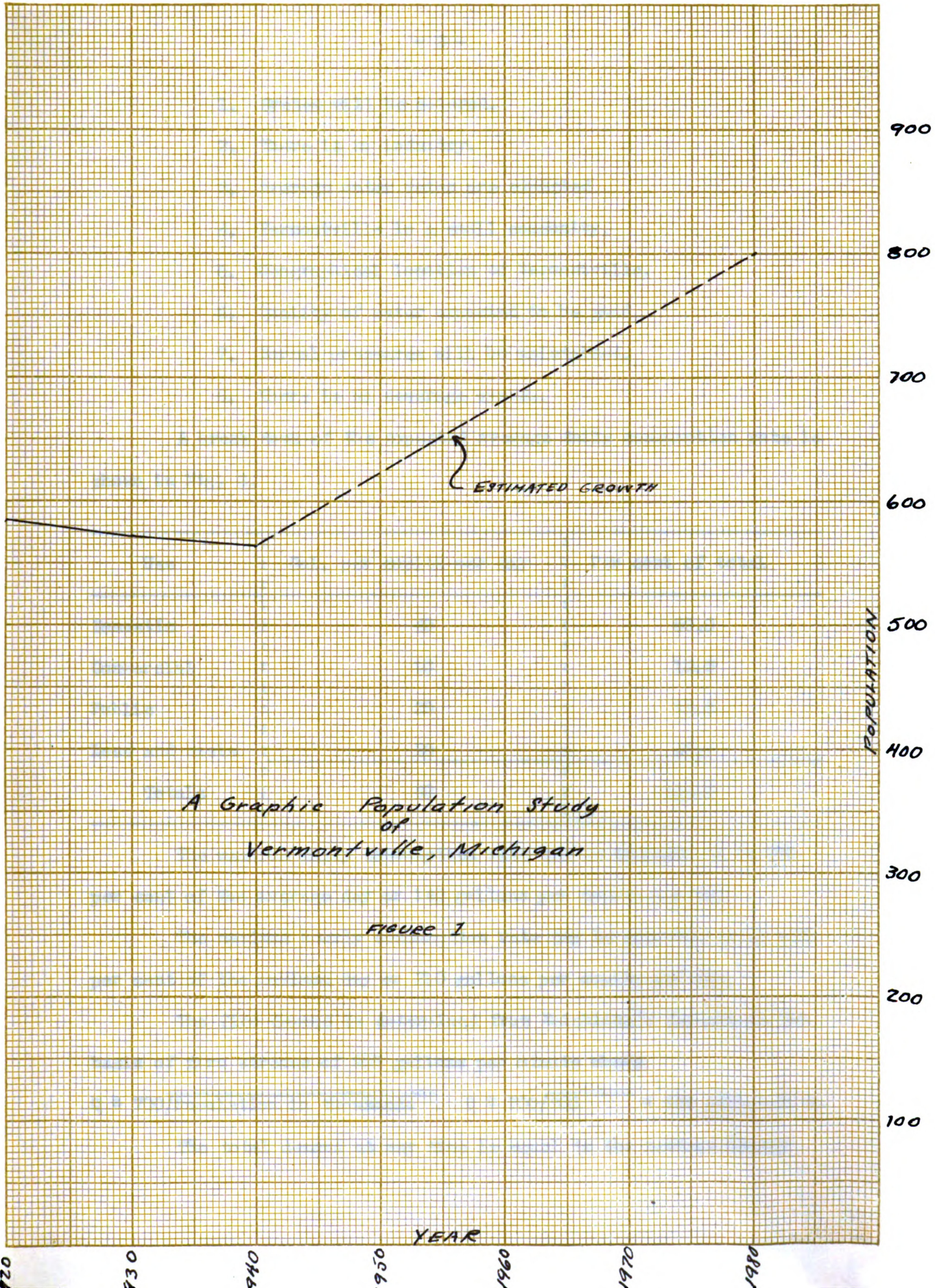
However, some allowance must be made for the possibility of growth however small that possibility is.

After considering all probabilities, 50 per cent was added to the present population as a possible increase during the life of the system. This gives a working figure for design of 800 persons to be supplied with water.

Consumption rates

On comparison with other towns of the same population, and considering the following items, a figure of 80 gallons per capita per day was decided on as an average daily consumption to be expected.

Factors affecting consumption rates are:



1. System will be metered.
2. There is no industry.
3. Average water rates are expected.
4. Vermontville is a small community.
5. Geographical location of Vermontville.
6. Quality of water expected to be good.
7. Normal pressures will be maintained.
8. There is no sewerage system.

A break down of the expected average daily consumption rate is shown in Fig. 2.

Use	Gal. per capita per day	Per cent of total
Domestic	40	50.0
Commercial	10	12.5
Public	20	12.5
Loss and waste	20	25.0
Totals	80	100.0

The maximum daily consumption rate can be expected to be 125 per cent of the average day or 140 gallons per capita per day.

The maximum hourly consumption rate can be expected to be 150 per cent of the maximum day or 210 gallons per capita per day.

The fire demand is determined from Krichling's formula on the basis of fire streams of 250 gallons per minute where

$$Q = 700 / \sqrt{\text{Population in thousands}} \quad Q = 700 / \sqrt{600} = 625 \text{ gallons/min.}$$

The total demand at any time is equal to the maximum hourly

rate plus the fire demand or 210 gal/capita/day = 115 gal/min

+ 625 gal/min

Total = 740 gal/min

or 43,400 gal/hr.

PART II

WATER DISTRIBUTION SYSTEM

The water distribution system includes the pipes and fittings, valves, hydrants, meters, and overhead storage necessary in controlling the water from the pumping station to the consumer.

Distribution Pipes

Location

All water pipes shown on the maps are placed as near the prospective consumers as possible. A few dwellings desirous of water are neglected due to their isolation which makes the price of service too great.

The centers of streets were reserved for possible future sewer installation, and the water pipes are to be placed between the street edge and curbs at a minimum depth of $4\frac{1}{2}$ feet. Since these are design and not construction maps, the exact locations of mains are not shown. The pipes are shown on the side of street containing the greater number of prospective consumers in order to conserve expenditures in service pipe installations.

Cross connections are as close together as economically practical. The dead ends although not good design, were unavoidable due to street layout and extra expense involved in closing them in. All dead ends are fitted with risers for flushing if a hydrant is not on the end.

Size

Trial and error has proven the best method of designing the sizes of the pipes in a distribution system.

Since the system is of the gravity flow type, the writer first secured elevations of all street intersections and of the prospective site of elevated storage. He found the bulk of the town fairly level except for the end of South Main Street which was 100 feet below the ground level of the storage tank site.

The governing features of design are the desired fire flow and pressure at the most distant points from the elevated storage, and a minimum desirable size of six inch pipe as recommended by the National Board of Fire Underwriters for satisfactory hydrant supply. Five hundred gallons per minute at a minimum of 20 pounds per square inch pressure is recommended by the National Board of Fire Underwriters, and these figures were used to determine the satisfactory size pipe lines. These were determined by the head losses in the cast iron pipe from storage to outlying points of the system, using the Hazen-Williams formula and designing for 20 to 30 years hence.

The different head losses for trials of different size pipe were compared with necessary height of elevated storage until the discharges at the control points of the system were as shown in Fig. 3. The discharges shown are from a 100 ft. storage tank through the size pipes shown on the maps.

The total water consumption for other than fire does not enter into the design of pipe size because it has such a slow rate in comparison to fire demand.

Fig. 3

Location	Distance from elevated storage	Equivalent pipe size	Loss of hydraulic head in ft. at 20 ⁴ / ₁₁ "	Head loss/ 1000'	Discharge in gals. per min.
End of N. Main	3450'	6.4"	65.3	18.95'	660
" " S. "	3900	5.0	173.8	44.5	530
" " E. "	4110	6.5	72.3	12.3	610
" " W. "	2010	6.3	87.4	33.1	845

Valves and Fittings

Valves are located in the system in such a manner that no more than two blocks and not more than a thousand feet of pipe need be isolated in event of a bad leak. They are so arranged that not more than two or three valves need be closed to do this.

Crosses or tees were placed at all points where streets may be developed in the future requiring additions to the system.

All valves are gate valves that can be opened and closed from the surface of the ground.

Hydrants

Hydrants are located on corners throughout the system wherever possible with 600 ft. as the minimum distance between. Exceptions are found in cases of isolated groups of homes which resulted in a considerable savings.

Hydrants are all on the same side of the street as the pipe which saves the additional cost of crossing streets and reduces head loss in the branch pipes.

With hydrants arranged as shown on the map, there can be at least four streams available on any building.

The hydrants are to be six inch, upright, with two outlets. A gate valve is placed in the branch pipe near the hydrant.

Pressure

With the determined 100 ft. storage tank, the available head is 115 to 120 feet. Other than the case of fire, this head will maintain a pressure of 45 to 50 pounds per square inch throughout the system. This is an entirely satisfactory figure, for there are no buildings of over three stories in the village. It is also the recommended pressure for cast iron pipe systems.

Elevated Storage

Purpose

The elevated storage tank will serve numerous needs of the system. They are:

1. Insurance against power failure or break down of pumps by the storage of one or more days supply of water.
2. The equalization of hourly and daily fluctuations of demand.
3. The equalizing of pressure for domestic service and for fire fighting.
4. The maintenance of nearly uniform head and discharge for pumps, thereby reducing operating costs.

5. Improvement of pressures at distant points from the storage during maximum demand.
6. It will avoid 24 hour pumping operation in this installation and permit pumps of smaller capacity, thereby reducing costs.

Type

The type storage tank will be of steel construction and built entirely above the ground. It was previously determined in the study of pipe sizes to make the height of the tank 100 ft.

Capacity

The capacity of the tank is designed in respect to the purpose it is intended to serve as well as safety and economical operation cost.

In this case, the capacity is based on the storage necessary to equalize the pumping rate plus storage of fire flow for a minimum of two hours. The storage necessary for equalizing the pumping rate is figured at 25 per cent of the maximum day consumption. Storage computations are shown below:

$$25 \% \text{ max. day} = 210 \times 300 \times 0.25 = 42,000 \text{ gal.}$$

$$2 \text{ hr. fire flow @ } 500 \text{ gal/min} = 500 \times 60 \times 2 = \underline{60,000 \text{ "}}$$

$$\text{Total storage needed} = 102,000 \text{ "}$$

Use a 100,000 gallon tank.

Location of overhead storage

The selected location of the tank is shown on map 1. It is located on the same property with the proposed site of the two wells.

This point is centrally located to the distributing system. Being a tree type system, its location insures equal fire flow to all extreme points.

The tank is on ground of relative high elevation which gives the system an added natural head.

Using the same ground for storage and wells results in a saving of real estate expenditure.

Service pipes and meters

The cost of service pipes from the main to the residence will be borne by the resident. This service pipe consists of a corporation cock tapped into the main, connected by a lead goose neck to a galvanized iron service pipe which ends in a shut off valve at the curb stop. The shut off valve is of the type that has a telescopic riser enabling the valve to be controlled from the surface of the ground.

The resident will also extend the service into his building where the village will install a meter.

There are 200 services in the system and likewise 200 meters to be installed.

PART III

ESTIMATED COST OF THE SYSTEM

The following cost estimate is not a figure of total cost to the village for a complete waterworks system. The figures shown refer only to the cost, in place, of the storage tank, all pipes including fittings, valves in the system, meters, and fire hydrants.

All prices used in these computations are derived from current engineering lists and from recently awarded contracts for waterworks construction of a similar size and location.

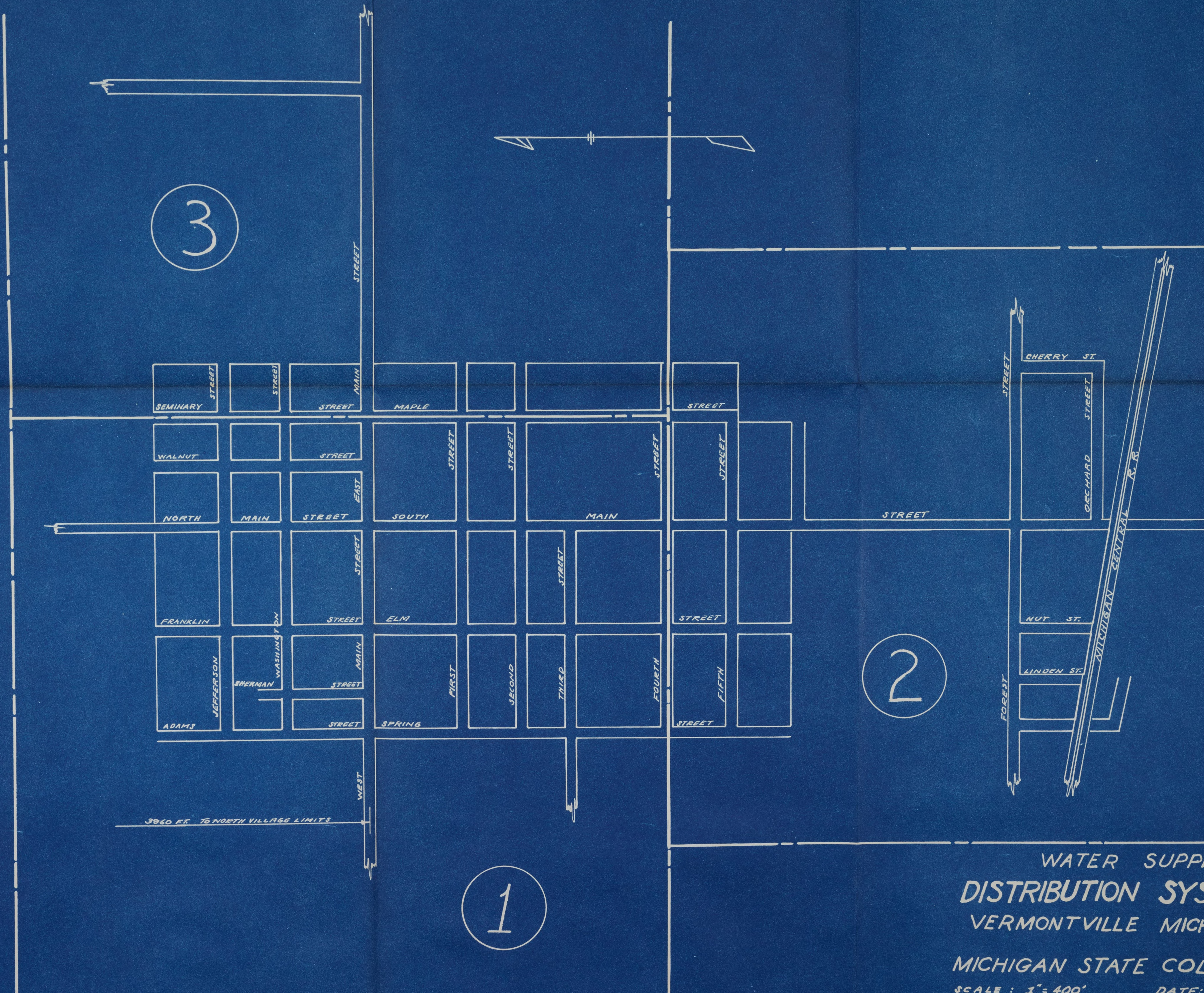
The cost of the meters applies only to the 200 resident and mercantile establishments that have indicated their desire for water service.

Cost of elevated storage tank in place - 100 ft. structure of 100,000 gal. capacity.....	\$16,000.00
36 valves installed @ \$50.00.....	1,800.00
200 meters installed @ \$15.00.....	3,000.00
35 6" 2-way hydrants installed, including connection to pipe and gate valve between @ \$150.00.....	5,250.00
Pipe installation including costs of pipe and fittings:	
1,210 ft. 8" pipe @ \$3.25/ft.....	3,935.00
18,540 ft. 6" pipe @ \$2.75/ft.....	51,000.00
1,900 ft. 4" pipe @ \$2.25/ft.....	4,275.00
Total.....	\$35,260.00

LIST OF REFERENCES

Water Supply Engineering. Babbitt & Doland. 1931 McGraw Hill Book Co.
Water Supply & Sewerage. Steel. 1938 McGraw Hill Book Co.

APPENDIX X



WATER SUPPLY
DISTRIBUTION SYSTEM
 VERMONTVILLE MICHIGAN
 MICHIGAN STATE COLLEGE
 SCALE : 1" = 400' DATE: 7-1-46
 G. R. SMITH

LEGEND

- RESIDENCES
- MERCANTILE
- DESIRE SERVICE
- HYDRANTS
- VALVES

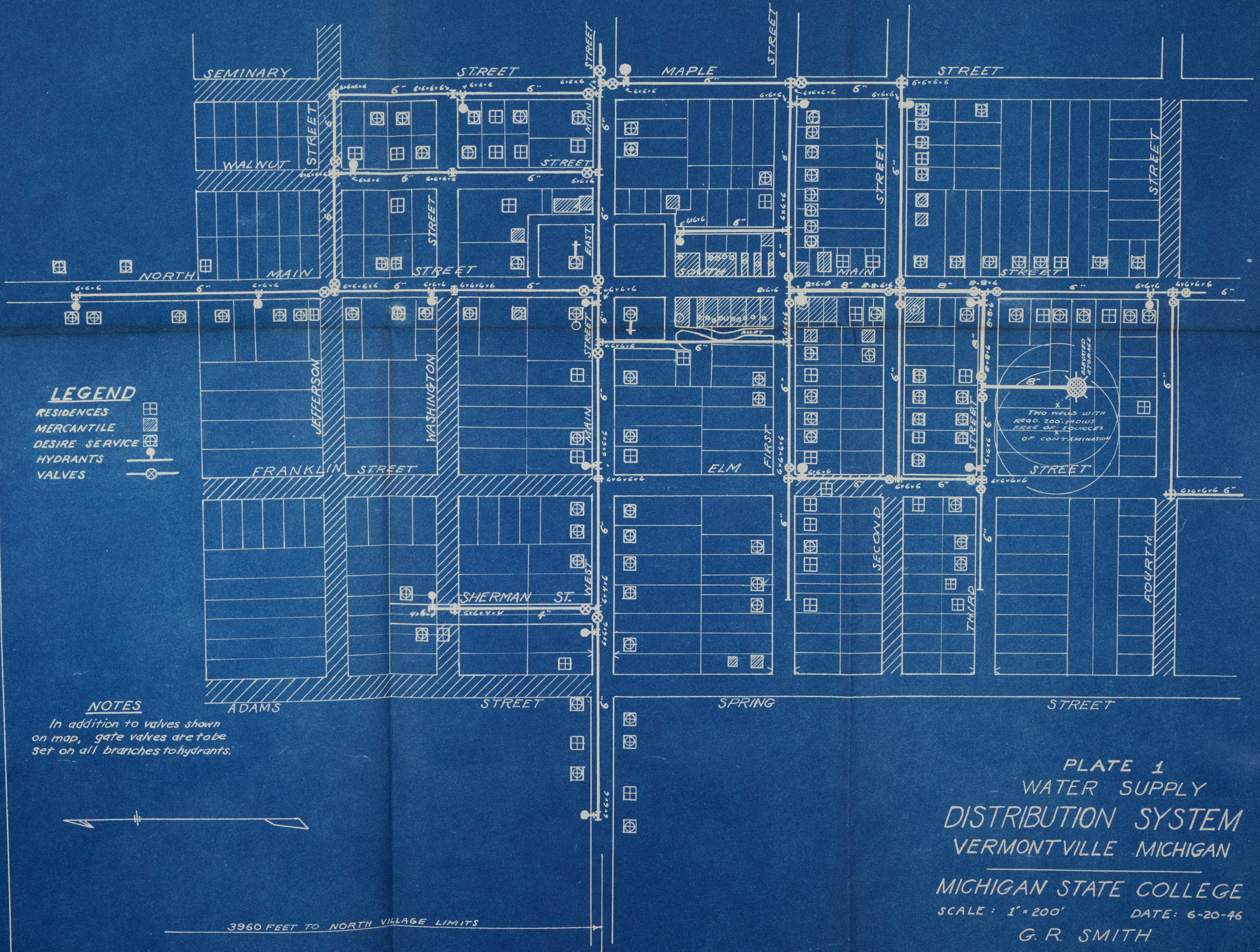
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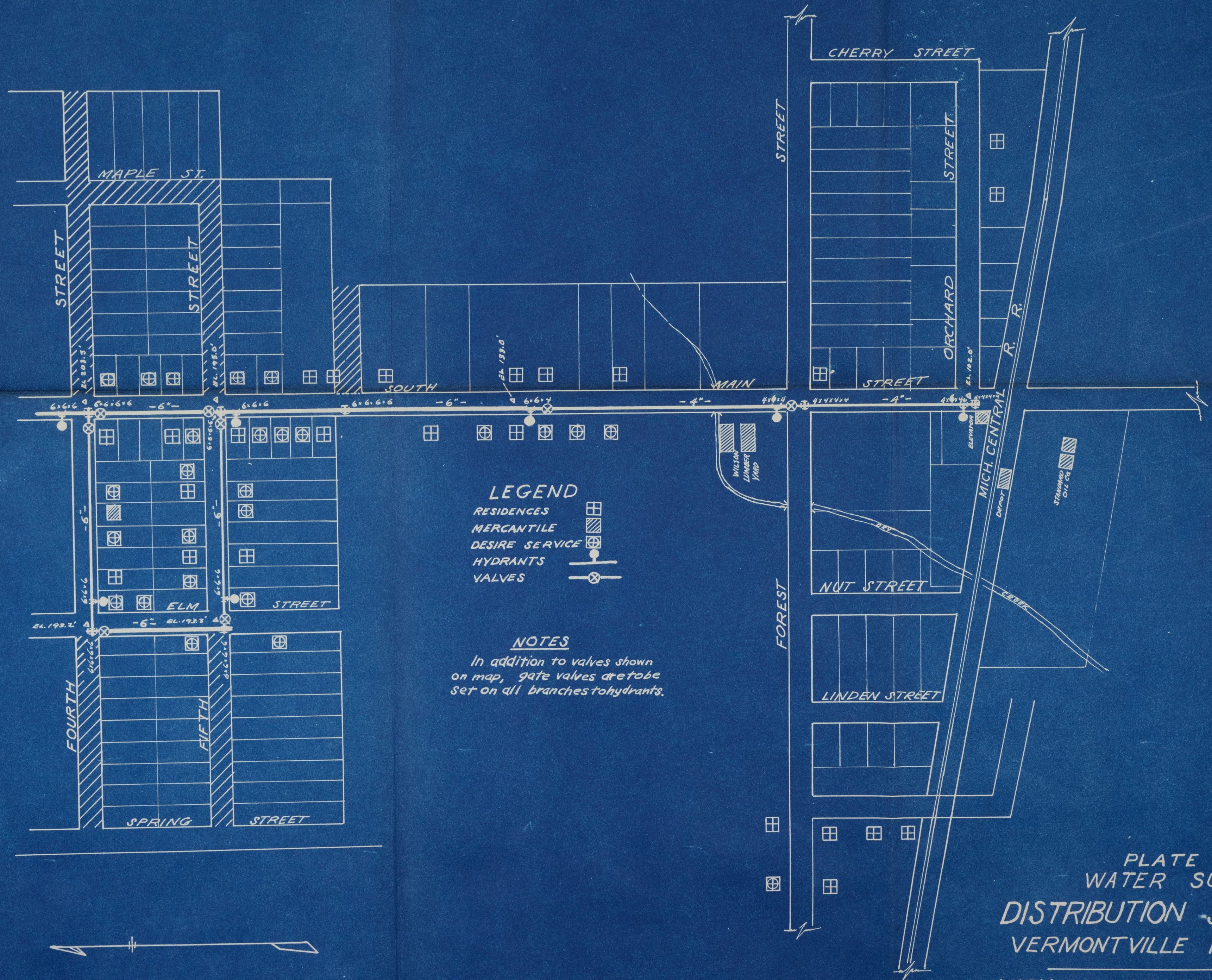
In addition to valves shown on map, gate valves are to be set on all branches to hydrants.



3960 FEET TO NORTH VILLAGE LIMITS

PLATE 1
WATER SUPPLY
DISTRIBUTION SYSTEM
VERMONTVILLE MICHIGAN
MICHIGAN STATE COLLEGE
SCALE: 1"=200' DATE: 6-20-46
G. R. SMITH





LEGEND

- RESIDENCES 
- MERCANTILE 
- DESIRE SERVICE 
- HYDRANTS 
- VALVES 

NOTES

In addition to valves shown on map, gate valves are to be set on all branches to hydrants.

PLATE 2.
WATER SUPPLY
DISTRIBUTION SYSTEM
VERMONTVILLE MICHIGAN

MICHIGAN STATE COLLEGE

SCALE : 1" = 200'

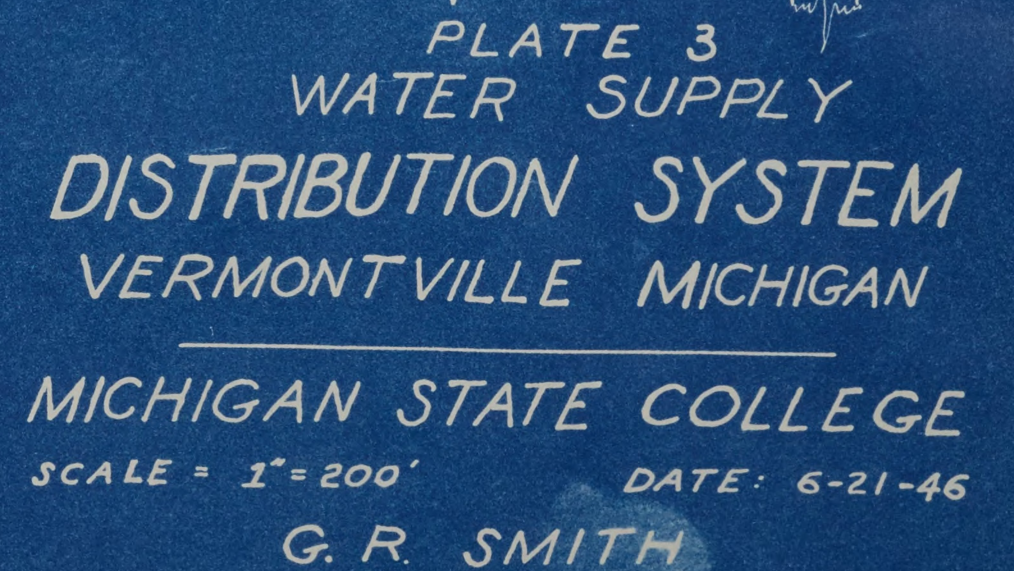
DATE: 6-21-46

G. R. SMITH



RESIDENCES 
MERCANTILE 
DESIRE SERVICE 
HYDRANTS 
VALVES 

In addition to valves shown on map, gate valves are to be set on all branches to hydrants.



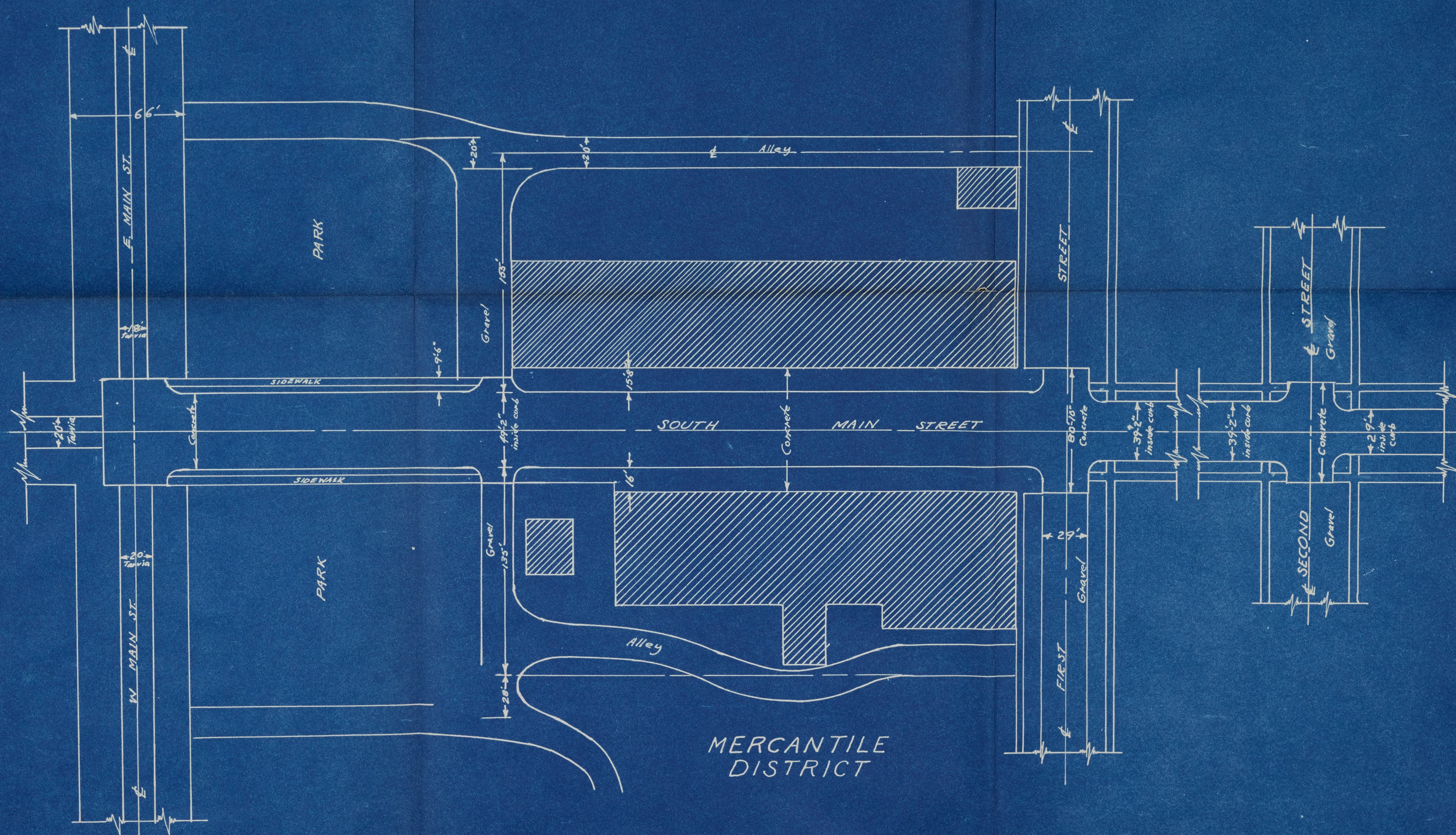


PLATE 4
WATER SUPPLY
DISTRIBUTION SYSTEM
VERMONTVILLE MICHIGAN

MICHIGAN STATE COLLEGE

SCALE: 1" = 50'

DATE: 6-22-46

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