REPORT OF AN INVESTIGATION

OF A

PLAN OF ELIMINATION OF GRADE CROSSINGS

ON THE A.T.&.S.F. RY.

IN THE CITY OF PASADENA, CALIFORNIA.

Submitted by

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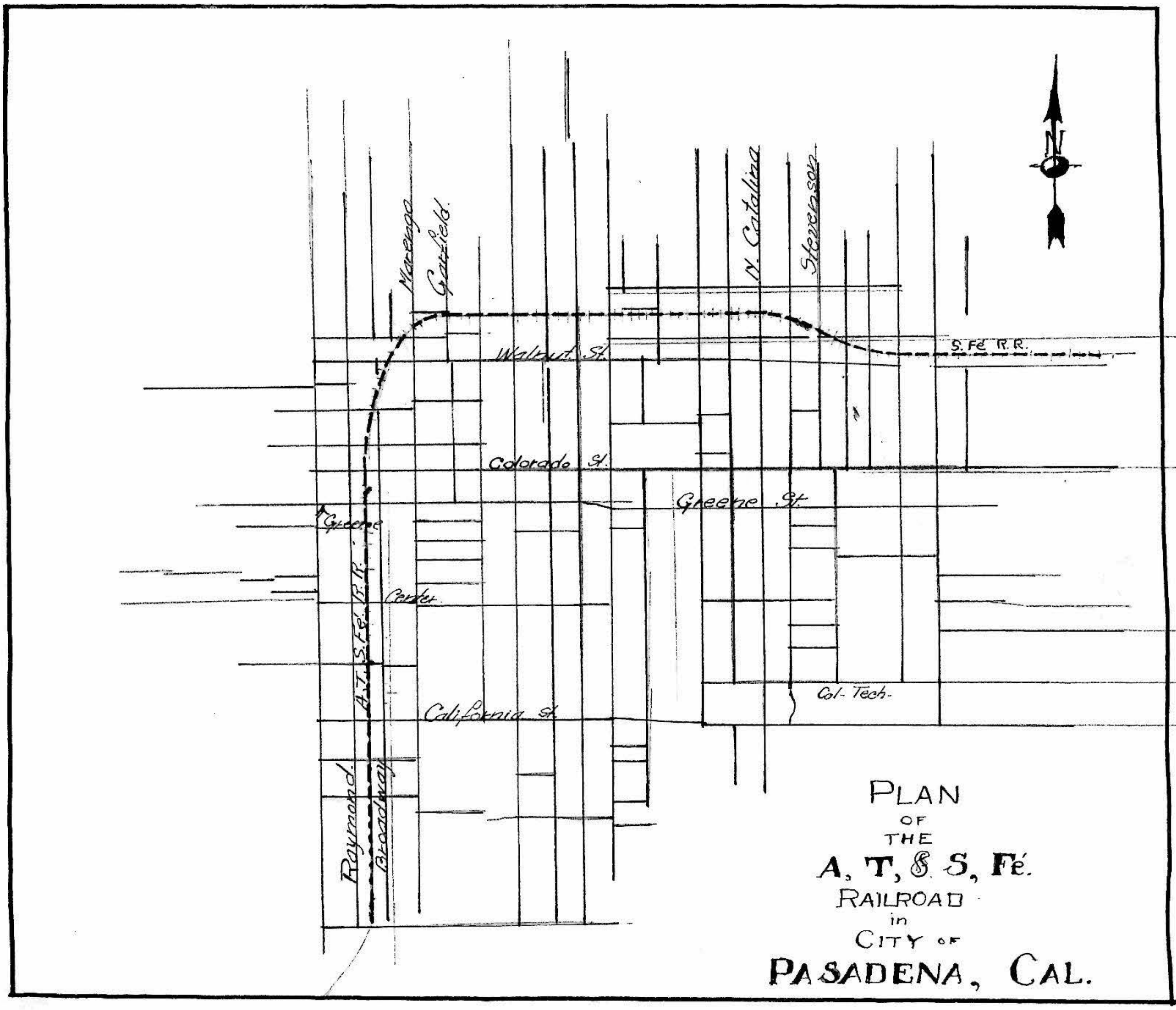
Marengo
Garfield
N. Catalina
Stevenson
N
Walnut St.
S. Fé R.R.
Colorado St.
Greene St.
Greene
Carter
A.T.S.Fé. R.R.
Col-Tech
California St.
Raymond
Broadway
PLAN
OF
THE
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in
CITY OF
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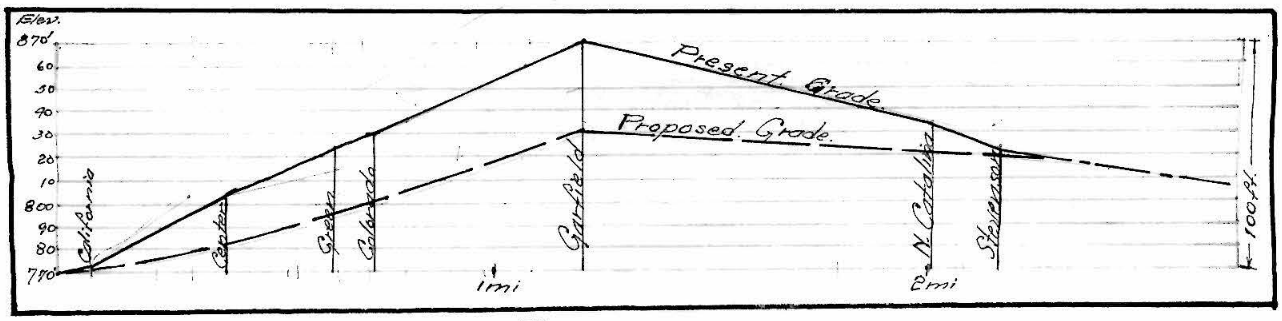

Elev.
870'
60
50
40
30
20
10
800
90
80
770'
California
Carter
Green
Colorado
Garfield
N. Catalina
Stevenson
Present Grade
Proposed Grade
1 mi
2 mi
100 ft.

PROFILE

SANTA FE GRADE CROSSING ELIMINATION IN PASADENA.

I. Present Conditions and The Plan in General:

The problem of the Atchison, Topeka, and Santa Fe railroad in Pasadena is a very dynamic one, as is readily recognized by engineers, city officials, and laymen. The route of the railroad was first laid out in the eighties and because of certain liberal concessions granted by the City of Pasadena, the right-of-way was located through Pasadena, despite the fact that the grade coming into the city either from Los Angeles or San Bernardino was enormous. Some years later, other transcontinental routes of the Santa Fe out of Los Angeles were sought, and a right-of-way was obtained by way of Fullerton and Riverside to San Bernardino, where this route joins the one from Los Angeles through Pasadena. This route, however, is ten miles longer than the one through Pasadena, which means a considerable loss of time in a short division of approximately only sixty miles in length.

At the present time, all transcontinental freight trains from Los Angeles over the Santa Fe are sent out by way of Fullerton and Riverside, while twelve of the sixteen daily passenger trains are routed through Pasadena. The reason for this is obvious, for speed is essential to passenger trains while a low grade is best for freight trains. The chief difficulty of the Pasadena route is the heavy grade through the city, as well as the great number of grade crossings, which reduces materially the speed of the passenger trains, which is the main object of routing passenger trains through Pasadena. Under the proposed plan the ruling grade on the division between Los Angeles and San Bernardino would not be changed. The present ruling grade, east bound, is a rise of 114.9 feet per mile (2.175%) between Los Angeles and Highland station, which would not be changed. The present rise of 114 feet per mile (2.16%), eastbound from Usado station to Pasadena would, however be materially reduced. Westbound, the present ruling grade on the division is 79.9 ft. per mile (1.51%) between Wilton station and Pasadena, which would be materially reduced, but this is still a grade of 77.9 ft. per mile (1.475%) between Arcadia and Santa Anita stations which would not be altered by the project. Hence under the proposed plan no change in arrangement of freight and passenger routing would be possible.

Various solutions have been suggested and surveys have been made for the purpose of relocating the right-of-way through Pasadena, but these have usually had only one object in view-the reduction of the grade. Most of these proposals necessitate the purchase of land for a new right-of-way diagonally through the south-central part of the city, from approximately the southern city-limits at Fair Oaks Avenue, to Lamanda Park, or to Arcadia. These proposals would certainly reduce the grade of the railroad, but the cost of buying a right-of-way through some high-class sections of the city, as well as not providing for grade-crossing elimination, practically make these ideas out of the question. Furthermore, a transcontinental route through the center of a city of 60,000 population is of no small value to both the city and the railroad, and if these proposals went through, this loss would be considerable. The abandonment of the present right-of-way would mean material loss to many manufacturers and warehouse concerns of the city which are now dependent on the railroad, and which own industrial and side track property along the right-of-way.

The situation, then, since an enormous loss would be incurred by both property owners and the railroad by a relocation, narrows down to the question of what could be done with the present right-of-way to reduce the grade and eliminate grade-crossings. This specifically, is our problem, and the matter which we intend to take up in some detail.

Grade-crossings may be eliminated in two ways- - by raising the grade of the railroad so as to cross over the highway, and by lowering the grade of the railroad so as to allow the highway to pass over the track. The former method is a very expensive one, for in the design of structures, very heavy loads must be provided for, while in the latter plan, the cost of structures is materially less because only comparatively light loads are imposed. An elevation of the alignment, or track, would be out of the question, then, for two reasons, namely (1) it would make an enormously expensive, probably unsightly, structure in the center of the city, and (2) it would raise the grade, which is now at approximately the maximum allowable, to still a larger grade.

This brings us definitely to the plan of lowering the grade of the railroad by means of a cut through the heart of the city which will provide for grade-crossing elimination through the city and will also considerably lower the grade on the alignment. The cut, as estimated by a preliminary survey, should start at about California Street, at which the alignment would be lowered about four feet to conform with the present grade of the street. Going north on the right-of-way, the cut would be made deeper and deeper and by the time Bellevue Street is reached, the grade of the track will be low enough to permit an overhead crossing, at approximately the present grade of the street. From there north, through the center of Pasadena, the cut will probably be made still a little deeper, making a maximum cut of approximately thirty feet at the summit, which is near the intersection of Marengo Avenue. Then the cut will begin to decrease, but keeping sufficient depth to provide for the required clearance of twenty-one feet, until Wilson Avenue is reached. The situation at this end of the cut is fairly favorable to the plan, for at Michigan Avenue, the present railroad grade is 2.5 feet above that of the intersecting street, while at Stevenson Avenue, one block West, the natural grade of the street is one foot higher than that of the track. By lowering the track, an overhead bridge can be provided at Stevenson Avenue, while the grades will be equated at Michigan Avenue, providing a crossing no more unsafe than at present. At Michigan, Chester, and Holliston Avenues, much safer grade crossings will be had than at present, as shown by accompaning profiles. At present, these grade crossings are rather unsafe, for the grade of the railroad is from three to five feet above the natural grade of the streets, but under the proposed plan, there is no difference in the grade of the railroad and the natural grade of the street. The cut as thus planned will be about 14,000 feet long of which 10,000 feet will be in a cut of 20 feet or more.

Structures will have to be provided at each street intersection beginning at Bellevue Drive (one block north of California Street) and continuing to and including Stevenson Avenue. These structures, artisticly designed so as to conform with modern improvements in the district, might be all of one design, except the more important crossings at Colorado Street and Lake Avenue. Constructing similar structures would save a considerable amount in the cost. The spans at

Colorado Street and Lake Avenue will probably be of a separate design because of the necessarily heavy loads imposed by Pacific Electric cars. None of these structures should cause any difficulty, for the span in no case will exceed fifty feet.

The problem of the economics of the cut is a phase of considerable importance and requires some study. The question lies in determining at various sections along the right-of-way the minimum cost of making the cut. If the property is very valuable, as is the case from California Street to about Holly Street, it would be entirely too expensive to buy property adjoining the right-of-way to obtain sufficient width to provide for the necessary slope of $1\frac{1}{3}$ to 1. It would be much more economical to erect a retaining wall in this case. On the other hand, through the residential districts, as from Walnut Street to Stevenson Avenue, where adjoining property is much cheaper, it would probably be preferable to buy the property than to erect a retaining wall. The cut, in any case, would be beautified to conform with other modern improvements, for on the side slopes, plants and shrubs would help hold the slopes in place as well as furnish aesthetic features. The present right-of-way is unsightly as well as being a menace at street intersections and also a menace to trespassers. In a cut, the trespassers could be kept out, the right-of-way beautified, and safe crossings provided at street intersections.

The problem of side tracks also is to be considered, for one of the points in favor of this plan is that the industrial district of the city will remain where it now is located. It will be necessary to provide sufficient length of each switch track so some elevation can be gained for unloading at the warehouses or at the freight depot. It would, of course, not be necessary to elevate them up to their present grade, but, for instance, where the cut is twenty-five feet, it would be well if the switch track could be brought up within five or ten feet of the ground level to facilitate handling of freight. Typical sidings are designed and are submitted, herewith.

In some sections of the city, the present sewer system would be an interference to such a cut as is proposed. The depth of sewers at some intersections is from five to ten feet under the surface. It will be necessary in such cases to run a lateral sewer, parallel to the right-of-way to a point where the pipe may be put under the track without too great a loss of elevation to provide for the minimum slope between the cut and the first sewer main below the cut. This plan is the one proposed and provides for a lateral intercepting sewer running parallel to the right of way from Euclid to Michigan Avenues, and results in the least adjustment of the present sanitary sewer system. No storm sewers are located in the district and so it is unnecessary to provide for this matter.

In all cases of the design, plans must be provided for a growth of the city of Pasadena, as well as for a growth of transportational demands. This would be particularly noticeable in the design of the width of structures provided at street intersections, and also in railroad-yard and switching space. A new passenger and a new freight depot are quite desirable to conform with even the present size of Pasadena, and these should be provided for in the proposed plan. We would suggest that the present location of each is quite satisfactory, and we believe new buildings should be erected on the present sites, so as to be in harmony with the general plan of the project. As the railroad in the proposed plan will be in a cut of about 28 feet below the level of the present track, the passenger depot could be designed to be built over the track. Suitably graded approaches could be designed for the discharge of passengers. This problem, however, is one for the architects and will not be taken up in this thesis.

The cost of the project will be quite significant, and, in all probability, will determine the feasibility of the plan. The gross cost of about $2,000,000 would, of course, include excavation, erection of retaining walls where necessary, purchase of additional right-of-way, erection of twenty-one structures at street intersections, and sanitary sewer and paving adjustments. This estimate does not include the erection of new passenger and freight depots as have been discussed. The capitalized saving to be subtracted from this cost will include present costs of operation that will be reduced, such as capitalized saving of reduction of grade and running time, cost of watchmen and flagmen, and the operating cost and upkeep of crossing signals. The saving due to reduction of grade and running time will be a small amount per train, but will result in a considerable annual saving. Ten flagmen could be dispensed with by the project, as well as an electrician who keeps the crossing signals in order. The actual saving, however, cannot be determined, for the elimination of a grade-crossing is an enormous saving to the railroad company, but such saving cannot be capitalized. The apparent net cost, then, will be considerably in excess of the actual cost of the project.

The cost of the project is, we believe, the only drawback, but this would be balanced by an elimination of the grade-crossings and death-traps to trespassers in the heart of the city, a small, though by no means unimportant reduction of grade, an improvement in the beautification of the right-of-way, and the saving incurred by keeping the industrial district in its present location.

II. SPECIFIC CONSIDERATIONS.

A. ECONOMIC DEPTH OF CUT, GRADE, AND NUMBER OF TRACKS.

In the proposed profile of the railroad, these matters were taken into consideration :

1. The economic crossings of the streets should be as near the natural surface of the ground as is possible.
2. The necessary clearance for locomotives is 22'-0" from the top of rail to bottom of overhead structure.
3. The cost of the project increases approximately in proportion to the square of the depth of cut. As the cut depth is increased, besides the added cost of excavation, the cost of either (1) a higher retaining wall, or (2) additional right-of-way and also more side-slope excavation is added.
4. The grade of the railroad should be cut down as much as possible below the present excessive grades.
5. The grade should be small, comparatively, in front of the passenger depot in order to facilitate the starting of east-bound trains.

The reduction of the present grade was begun at station 2697+56.83 (about 800 feet south of California Street) because at that point there is a decided change in grade for trains north and eastbound, from 0.7% to 1.474%. The proposed change to a grade of 1.02% accomplishes the result of reducing the grade of the railroad from 3 feet above the natural grade of California Street to the natural grade. From California Street to Bellevue Street, the grade is cut from 2.16% to .413% so that a 20 foot cut below the present grade at Bellevue Street is obtained. A deeper cut would increase the cost of excavation as well as necessitate a steeper grade farther up the hill. From Bellevue Street northward, the grade is cut from 1.857% to 1.447% so that a 25 foot cut results just north of the present freight depot. A deeper cut would materially increase the cost of excavation. The cut at Center Street is 24 feet below the present grade.

The grade from in front of the freight depot to Colorado Street is taken as 1.00% so as to assist north and east-bound trains in starting, after a stop at the passenger station. This makes a cut of 29 feet below the present grade at Colorado Street. From Colorado Street to the summit between Marengo and Garfield Avenues, a constant grade of 1.525% is proposed to replace an average grade of 1.60%. The proposed grade is in an average cut of 29.5 feet, with a maximum cut of 30 feet. The cut is not made any deeper because of increasing costs at deeper cuts.

Starting at Hill Ave. at the East end of the project the present grade changes from 0.4% to 1.4%, west-bound. Under the proposed plan, the grade of 1.4% is cut to 0.77%

lowering the crossing at Hill Avenue 1 foot. At Holliston Avenue the present crossing is 1.6 feet above the natural grade of the street. The proposed cut will put the railroad 2.4 feet below the natural grade of the street, which is not at all objectional. At Chester Ave. the present grade is 3 feet above the natural grade of the street. The proposed cut puts the railroad 3.0 feet below the natural grade. A culvert is located between Holliston and Chester Avenues at station 2564+08.30. The elevation of the top of the east side of the culvert is 802.60. The present grade crosses this culvert on a trestle bridge at a height of top of rail of 809.2, while the proposed grade will cross at an elevation of top of rail of 804.60. If the new grade is put lower, there will not be sufficient room for a structure over this culvert.

At Michigan Avenue the present grade crosses the street 2.6 feet above the natural grade while the proposed grade makes this crossing at 6.4 feet below the natural surface. This feature is rather objectionable but it is necessary to get down in a cut so that when Stevenson Avenue, only 400 feet west, is reached there will be sufficient depth to provide for an overhead structure without excessive rise. From Michigan Avenue to Wilson Avenue the proposed grade of the railroad is on the level so that sufficient depth is obtained at Stevenson and Wilson Avenues to provide for crossings with a minimum of changes in the grade of these streets. At Stevenson Avenue the present grade of the railroad is 0.6 feet below the natural surface of the street, while the proposed grade provides a clearance of 16 feet from the top of rail to the natural surface of the ground. Allowing 22 feet clearance and 3 feet for the crown thickness of the structure, there will be a necessary rise of 9 feet above the natural surface of the ground. As shown by profile of Stevenson Avenue, this rise is easily taken care of by a maximum grade of 4.2% on the south approach. At Wilson Avenue the proposed grade is 20.5 feet below the natural grade of the street, making a necessary rise of 4.5 feet.

From Wilson Avenue to Madison Avenue, the proposed grade is 0.608% reducing the present grade of 0.74% and making crossings at Catalina, Mentor, Lake, Elm, El Molino, and Madison Avenues at an average depth of 24.5 feet with a minimum of 23.5 feet at Elm Avenue. The cut is kept at this depth in order to provide sufficient room for structures. The cost would be excessive if the cut was made deeper. From Madison Avenue the present grade of 1.28% as far as Euclid Avenue is cut to 0.955% in order to reduce the rise at the summit. This makes crossings at Galena Avenue 26 feet, and at Los Robles 28 feet below the present grade. From Euclid Avenue to the present summit between Garfield and Marengo Avenues, the proposed grade is level, replacing the present grade of 0.2%. This cuts down the rise and fall, making a depth of cut of 29.5 feet at Garfield Avenue. A deeper cut, reducing the grade still more will probably be uneconomical.

The question of providing a double track throughout the project was considered and it is the opinion of the writers that such would require an expenditure of too large a sum of money to be worth-while. An additional 12 feet of right-of-way would have to be provided, and would necessarily be purchased for the entire length of cut of 14000 feet, regardless of the price of the land. Furthermore, the main line of the A.T.&.S.F. is but single track from Pasadena to Los Angeles and there would be no particular advantage in this additional expenditure. A double track is provided in the proposed plan at the passenger depot. This double track strip, however, is narrowed into a single track at a point 200 feet south of Colorado Street to prevent a large expenditure on Colorado Street frontage.

B. ECONOMIC DESIGN OF WALL.

1. - Assumptions .

$\theta = 36^\circ - 53' = \tan^{-1} \frac{1}{1.333}$.

Slope of surcharge = 1.333 : 1
(Recommended by Merriman -
C.E. Handbook, for soil,
also gravel, sand, and clay-
earth.)

$\phi = 45^\circ$.

Natural slope = 1 : 1 .
(See E.P. Goodrich - Trans.ASCE.,
vol. 53, p. 301, quoted from
B. Baker.)

W = Weight of earth = 100 pounds per cu.Ft.

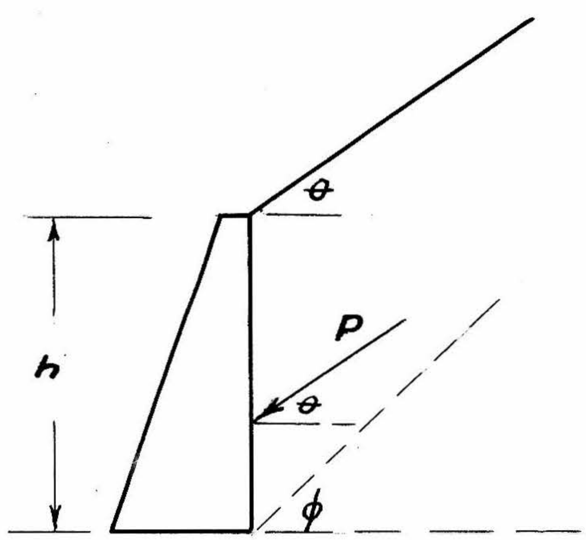
P = Pressure of earth on a vertical plane =

$.29 \frac{W h^2}{2}$. (From Diagram 1, Hool, Concrete Eng. Handbook. p.517.)

P= Pressure of earth on a vertical plane =

$30 \frac{h^2}{2}$. (Building Ordinance, City of Pasadena)

This value of P will be used hereafter.



2. Reinforced Wall.

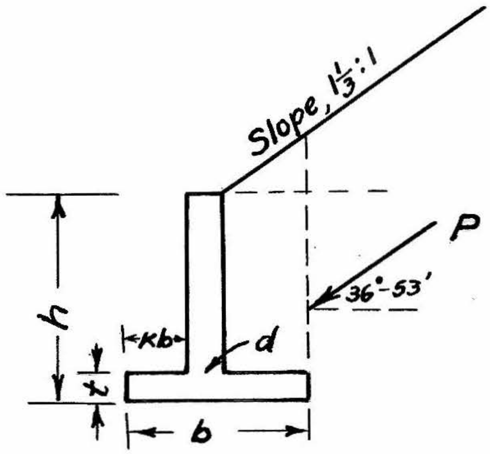
(a) Thickness of stem = " d_1 ".

From Hool, page 589, $d_1 = .408\ h^{3/2}\sqrt{\frac{w}{k}\cos\theta}$.

or $d_1 = .408\ h^{3/2}\sqrt{\frac{30}{k}\ .8}$.

For n= 15, f_s = 16,000 , f_c = 650, then k= 107.

Hence $d_1 = .408 \times .474\ h^{3/2} = .194\ h^{3/2}$ inches.



(b) Necessary Thickness of Toe Slab. (see Hool, p.596)

When $k = \frac{1}{3}$ and allowable shearing stress = 40#,

$$t = 0.095\ R_v\ k\ \frac{(2-k)}{V} = \frac{1.667 \times .333 \times .095}{40}\ R_v =$$

$$= .00132\ R_v$$

(R_v= Vertical component of reaction on base.)

$$\text{But } R_v = \frac{2}{3}\ b\ 110\ h + \frac{110}{6}\ b^2 + 9\ (\ h + \frac{b}{2}\ )^2 =$$

$$= 9\ h^2 + 82.5\ bh + \frac{249}{12}\ b^2\ .$$

b = .381 h (Proof follows later).

$$\text{Hence } t = .00132\ h^2\ (\ 9 + 31.4 + 3.01\ ) =$$

$$.0573\ h^2 \text{ inches.}$$

3. Necessary Width of Base.

Assume the weight of wall the same as the weight of earth - Average combined weight = 110 #/cu.ft.

Disregard weight of the toe.

For resultant at $\frac{1}{3}$ point, (Moments at that point=0)

$$\left[\frac{2}{3} b \cdot 110 h \cdot \frac{1}{3} b\right] + \left[\left(\frac{2}{3}b\right)^2 \cdot \frac{3}{4} \cdot \frac{1}{2} \left(\frac{2}{3} b - \frac{2}{9} b \right)\right]$$

$$+ \left[.6b \cdot \frac{2}{3} \cdot \frac{30}{2} \cdot \left(h + \frac{b}{2} \right)^2\right] - \left[\frac{30}{2} \cdot \frac{1}{3} \cdot .8 \cdot \left(h + \frac{b}{2}\right)^3\right] = 0$$

Solving :

$$4\left(\frac{h}{b}\right)^3 - 27.22 \left(\frac{h}{b}\right) - 1.07 = 0$$

Solution by trial, $\frac{h}{b} = 2.63$ or

$$\frac{b}{h} = 0.381 = \frac{8}{21} .$$

4. Economic Heighth of Wall.

$b = \frac{8h}{21}$. d' = depth of cut.

Assume t= thickness of toe slab = $\frac{h}{12}$.

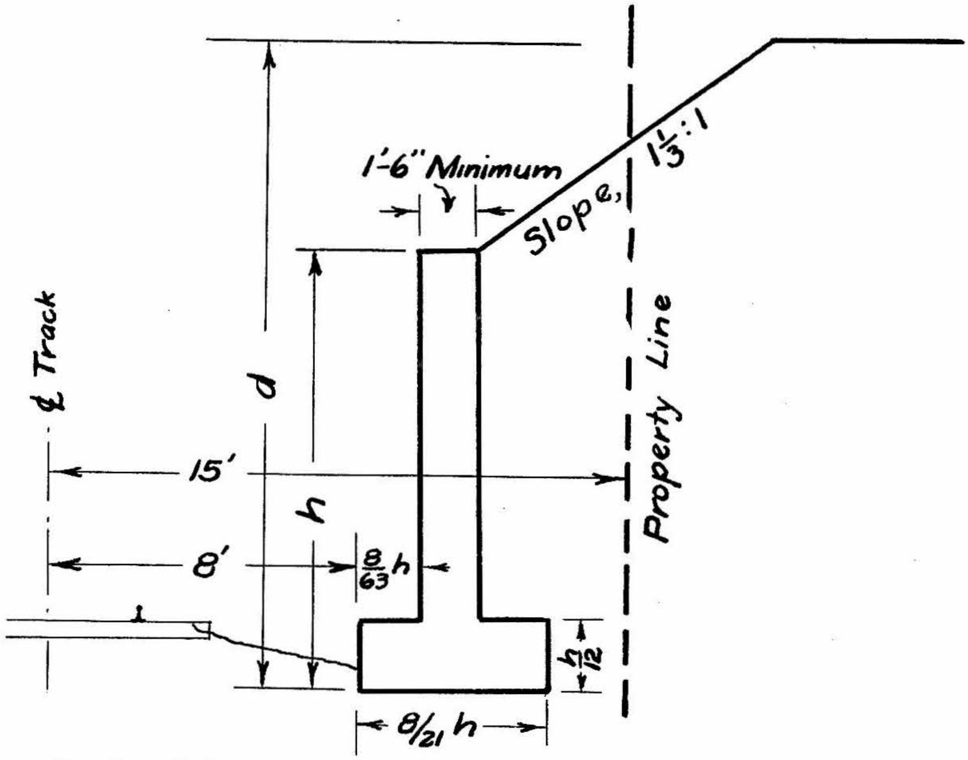
Let

D = Cost of land for additional right-of-way, per square foot of land.

E = Cost of excavation per cu. ft.

F = Cost of reinforced concrete in place, per cubic foot.

Assume cost of obtaining easement, where necessary, as negligible.



Cost of land :

$$\left[\frac{4(d-h)}{3} + 1.5 + \frac{8h}{63} - 7\right] D.$$

Cost of excavation :

$$\left[\frac{8h}{21} + 8 + \frac{d}{8}\right] d\,E.$$

Cost of Concrete :

$$\left[1.5\,h + \left(\frac{8h}{21} - 1.5\right)\cdot\frac{h}{12}\right] F.$$

Total Cost :

$$\frac{4\,d\,D}{3} - \frac{76\,h\,D}{63} - 5.5\,D + \frac{8\,d\,h\,E}{21} + 8\,d\,E + \frac{d^2E}{8}$$

$$+ \frac{2\,h^2F}{63} + \frac{11\,h\,F}{8}.$$

To find the minimum cost, differentiate this expression for cost and equate the differential in each case to zero.

(1) $$\frac{\text{Differential Cost}}{\text{Differential } h} = -\frac{76\,D}{63} + \frac{8\,d\,E}{21} + \frac{4\,F\,h}{63} + \frac{11\,F}{8} = 0$$

$$\frac{\text{Differential Cost}}{\text{Differential } d} = \frac{4\,D}{3} + \frac{8\,h\,E}{21} + 8\,E + \frac{d\,E}{4} = 0$$

From (2), $d = -\dfrac{112\,D + 4\,E\,(8\,h + 168)}{21\,E}$

From (1), $h = -\dfrac{192\,d\,E + 693\,F - 608\,D}{32\,F}$

Substituting" d" in "h" ,

(3) $$h = \frac{11424\,D - 4851\,F + 43008\,E}{224\,F - 2048\,E}$$

This value of "h" represents the economic heighth of wall in terms of cost of land, cost of excavation,and cost of concrete.

From cost data, E, cost of excavation = \$.02 per cu.ft.

F, cost of concrete = \$25. per cu. yd., or say \$1. per cu. ft.

D, cost of land per sq.ft., varies from values of \$.30 to \$11.00

Hence, substituting in formula (3), above, the economic heighth of wall is obtained :

Cost of land per sq.ft.	Economic heighth of wall, in feet.
\$0.30	none
\$0.50	9.5
\$0.75	25.0
\$1.00	40.0

For higher values of land, the economic heighth of wall will be still higher, which is larger than the maximum cut of 30 feet.

5. Design of Reinforced Concrete Retaining Walls.

Four general types of walls have been designed on the basis of aforementioned principles and assumptions :

Type "A" - a 10 foot wall in a 25 foot cut.

Type "B" - a wall of sufficient heighth in a 25 foot cut so that no additional right-of-way is required to be purchased, outside of the present 30 foot right-of-way.

Type "C" - similar to type "B", except for a 30 foot cut.

Type "D" - a wall for supporting a side-track adjacent to and about 20 feet above the main-line track. The wall is designed to support the equivalent of a locomotive loading.

Sketches of these four typical walls are submitted.

6. Maximum cut allowed without providing a wall, and without purchasing additional right-of-way :

$$\frac{4}{3}(d-h)+\frac{.381\,h}{3}+1=8$$

$$h = 0 \quad , \text{so}$$

$$\frac{4}{3}\,d = 7 \text{ ft.} \qquad \text{or} \qquad d = 5.25 \text{ ft.}$$

7. Type of wall for each particular property.

The retaining wall will be run full heighth of cut from 100 feet north of California Street to Walnut

Street, since the depth of cut at 100 feet north of California Street is 5 feet (see preceeding calculation for maximum depth of cut without using retaining wall). Referring to cost data of land, the price of land per square foot exceeds $0.50 from California Street to Walnut Street. From Walnut Street as far east as Elm Ave., the value of property is less than $0.50 per square foot, and so type "A" retaining wall will be used in this section. From Elm Ave. to 200 feet East of Lake Ave., the value of property exceeds $0.50 per square foot, so type "B" wall will be used. From this point east, to 100 feet east of Stevenson Ave. where the depth of cut is only 5 feet, type "A" wall will again be most economical.

Where side-tracks are necessary, type "D" wall will replace the wall used on adjacent property.

COST OF REINFORCED CONCRETE RETAINING WALLS

Type "A" :

Volume per lineal foot: 0.73 cu. yds.

Cost at $25 per cu.yd.: ....$18.30per ft.

Type "B" :

Volume per linear foot: 2.62 cu. yds.

Cost: .... $65.60 " "

Type "C" :

Volume per liner foot: 3.70 cu.yds.

Cost per linear foot: ....$92.50 " "

Type "D" :

Volume per linear foot: 2.39 cu.yds.

Cost per linear foot: ....$60.00 " "

TOTAL COST OF RETAINING WALLS

Type "A" :

Total length: 10,240 ft.

Cost: $187,392

Type "B" :

Total length 2,600 ft.

Cost: $170,560

Type "C" :

Total length: 3,570 ft.

Cost: $330,225

Cost of Retaining Walls Cont.-

Type "D" :

Total length: 3,450 ft.

Cost: $200,700

TOTAL COST OF WALLS $888,877

TOTAL LAND PURCHASED ALONG RAILROAD

RIGHT OF WAY

At $0.25 per sq. ft. :

Total Area: 5,450 sq. ft.

Cost: $1,362.60

At $0.30 per sq. ft. :

Total Area: 12,032 sq. ft.

Cost: $3,609.60

At $0.50 per sq. ft. :

Total Area: 94,359 sq. ft.

Cost: $47,179.50

At $1.50 per sq. ft. :

Total Area: 4,500 sq. ft.

Cost: $6,750.00

Land Purchased continued:-

At $1.80 per sq. ft. :

Total Area: 5,980 sq. ft.

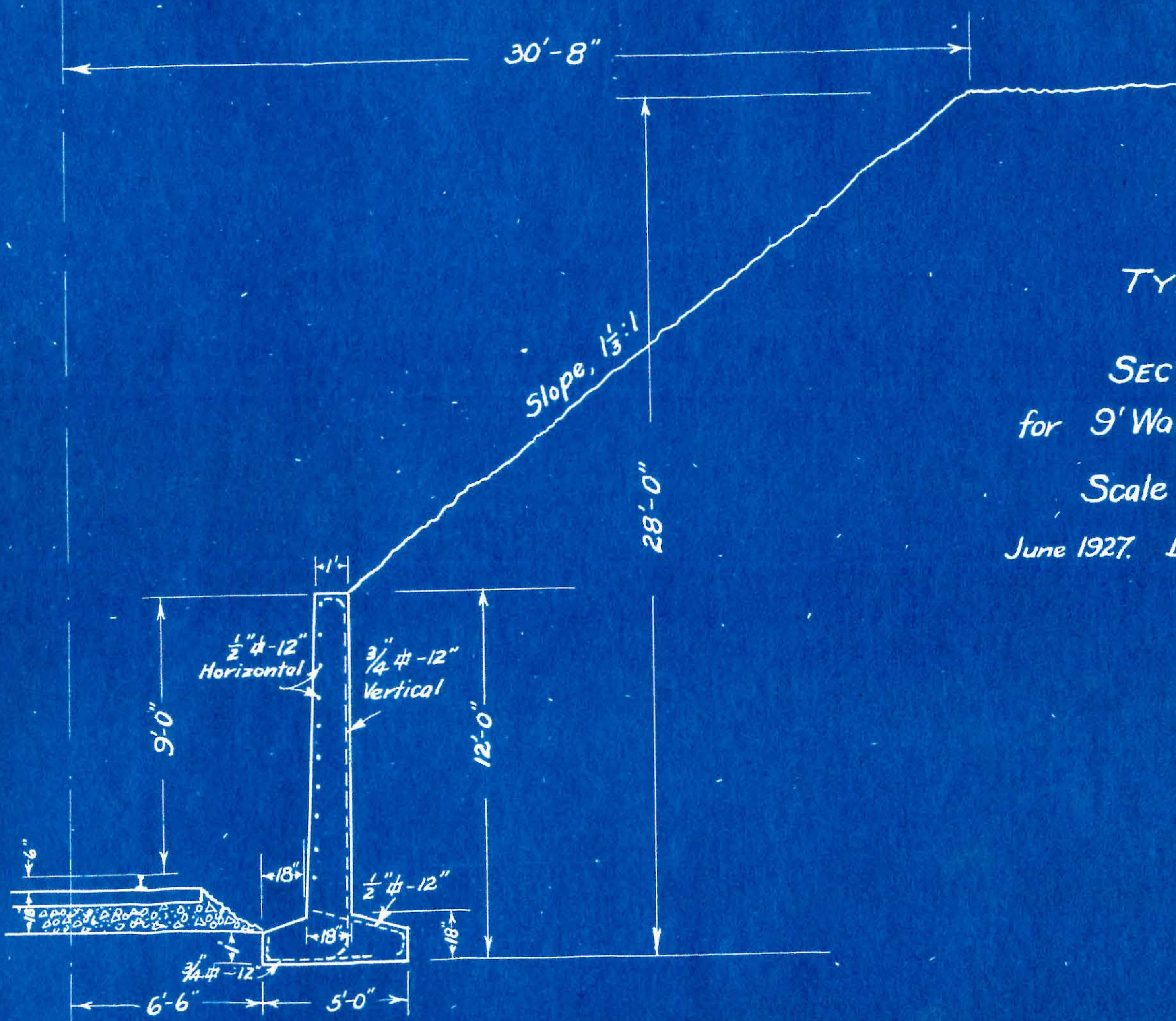
Cost: $10,764.00

At $3.55 per sq. ft. :

Total Area: 3,600 sq. ft.

Cost:......................... $12,780.00

TOTAL COST OF LAND: $82,445.70



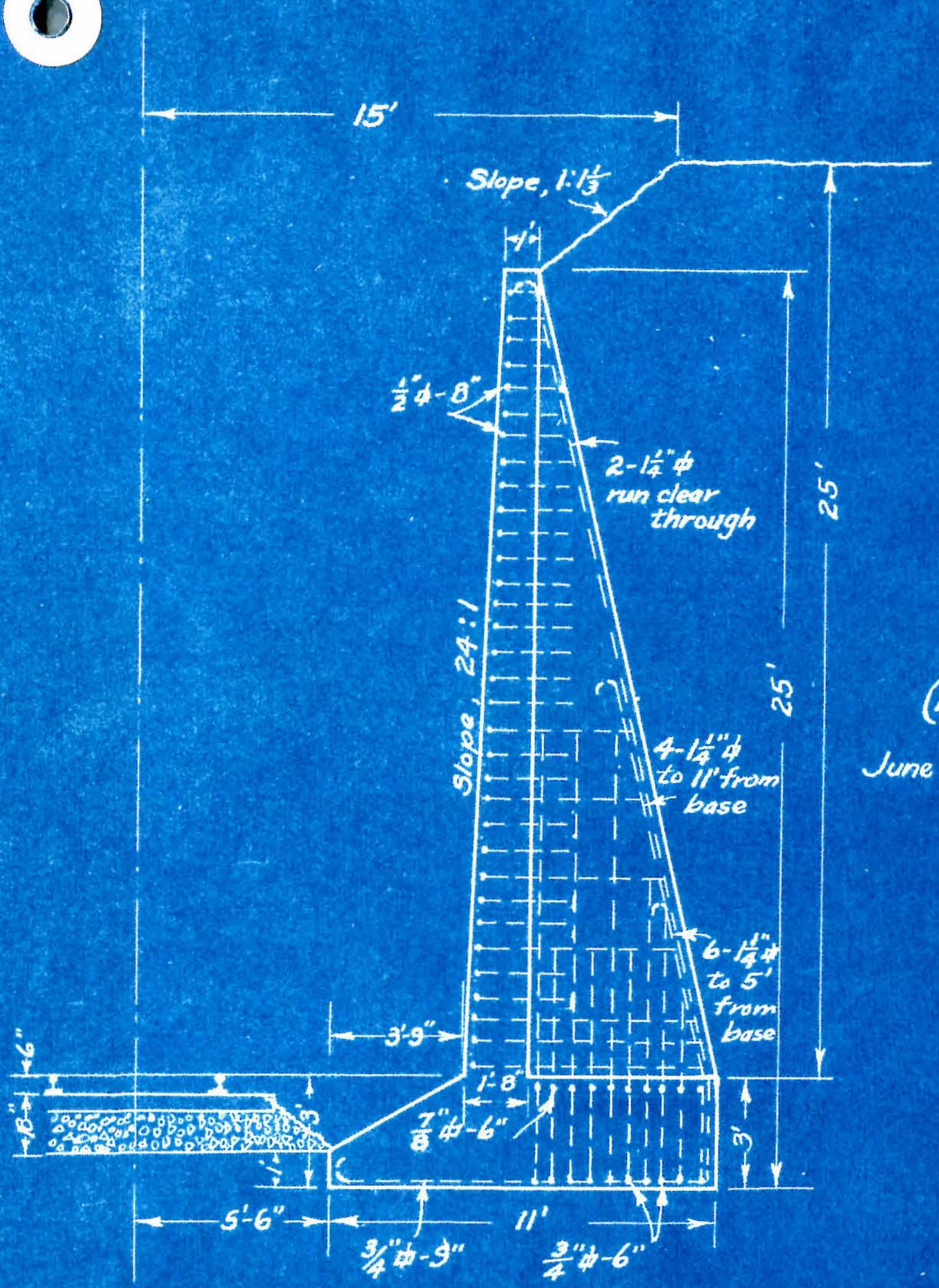
TYPE A.

SECTION

for 9' Wall in 25' Cut.

Scale, 1" = 5'.

June 1927. Designed by E. Browder.



TYPE B.

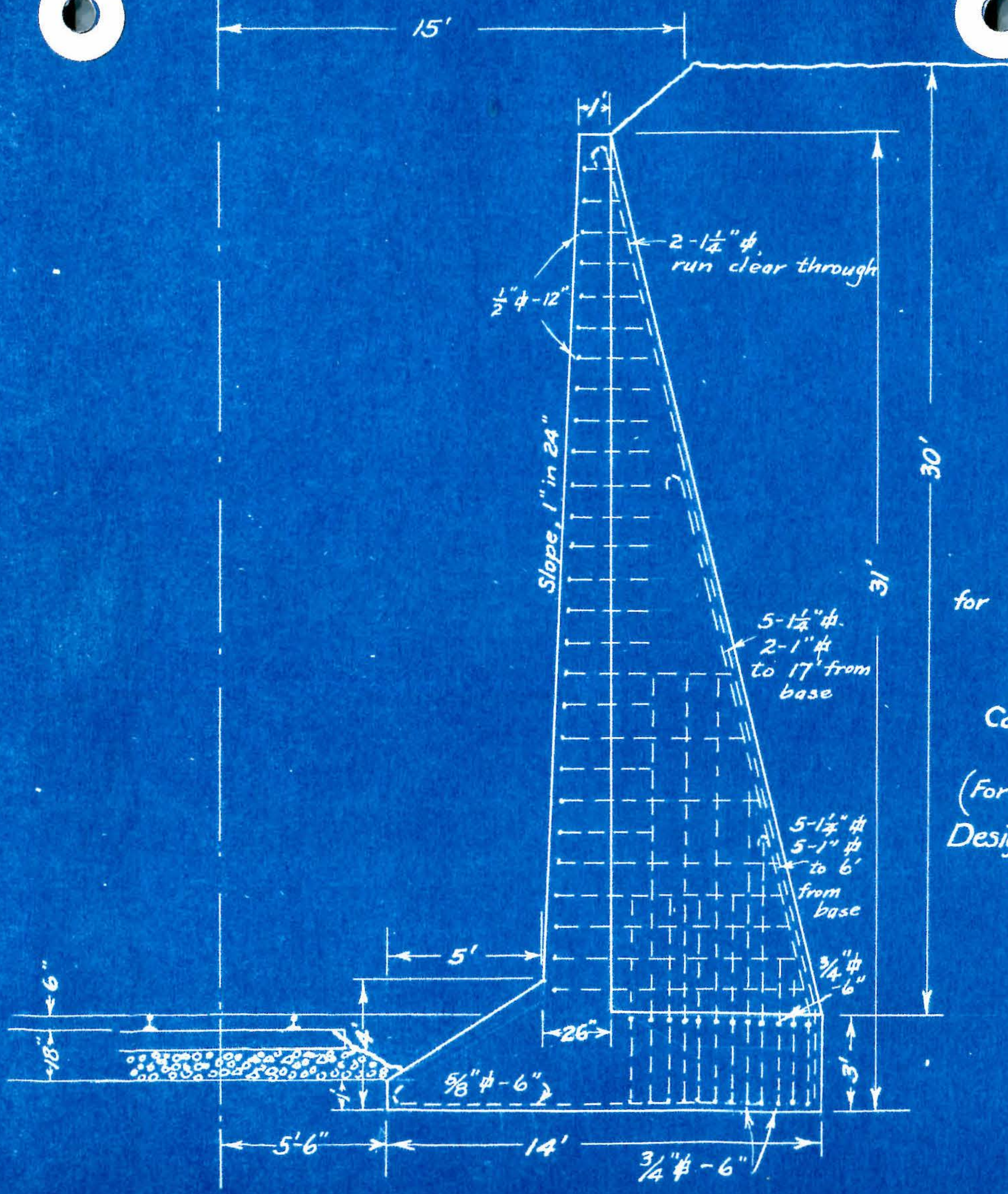
SECTION
for 25 Foot Cut.

Scale, 1" = 5'

Counterforts - 8' c. to c.
18" wide.

(For 30' Right of Way)

June 1927. Designed by E. Browder.



TYPE C.

SECTION
for 30 Foot Cut.

Scale, 1" = 5'.

Counterforts - 8' c. to c., 18" wide
(For 30' Right of Way)

Designed by E. Browder.
June, 1927.

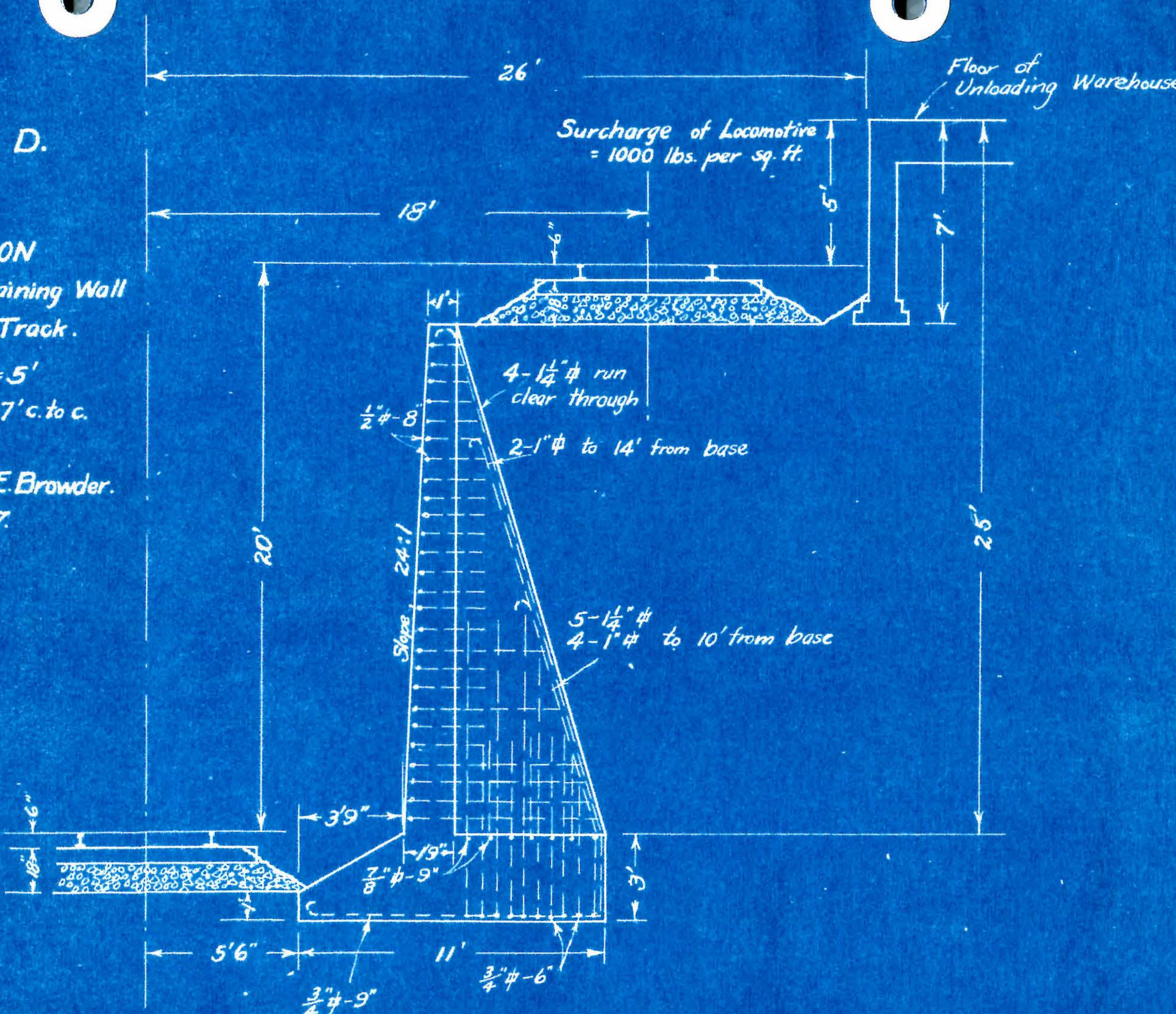
TYPE D.

SECTION
showing Retaining Wall
for Side Track.

Scale, 1" = 5'

Counterforts - 7' c. to c.
18" wide.

Designed by E. Browder.
June 1927.



C. NEW PLAN OF CITY SEWER SYSTEM.

As much of the present sanitary sewer system will be left intact, as is possible. The present system which is cut by the proposed project must be taken care of by an intercepting sewer run parallel to the railroad. New manholes are required below the railroad in each case of an intersection. Details of revisions and also a map showing these revisions follow.

NECESSARY REVISIONS IN

THE SANITARY SEWER SYSTEM .

. . . .

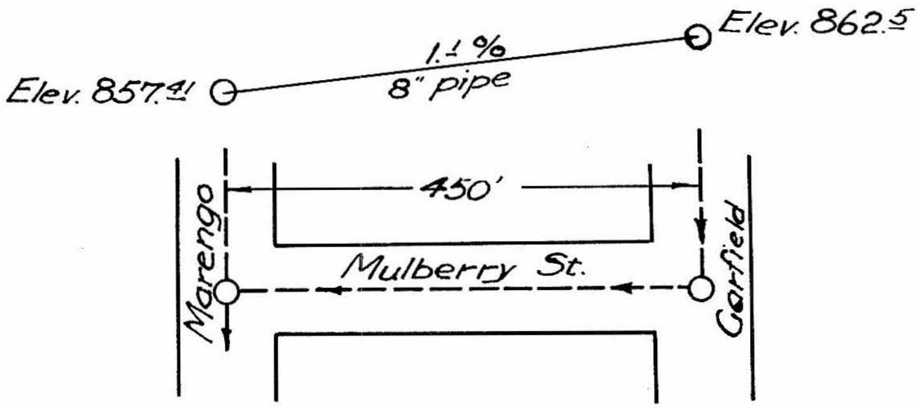
Garfield Avenue:

Plug up sewer across railroad tracks

Install new manhole south of tracks.

Mulberry Avenue:

Tear up, and reverse slope of drainage.



Marengo Avenue:

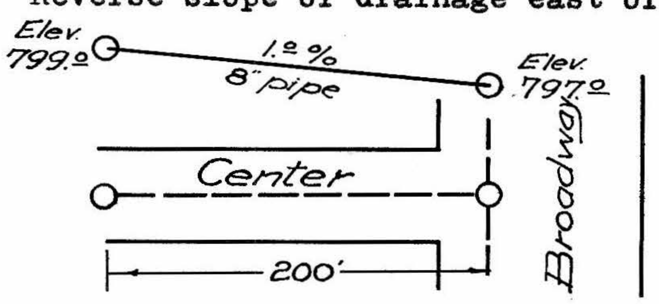
New manhole just above railway

" " " below "

Center Street:

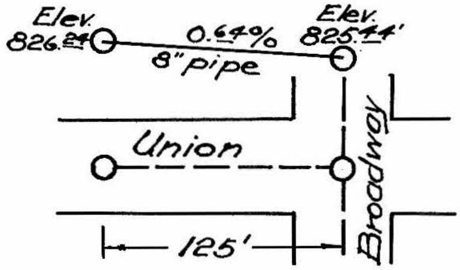
Install two new manholes.

Reverse slope of drainage east of tracks.



Union Street - east of railway:

Run a new sewer from M.H. just east of tracks to M.H. at corner of Broadway and Union.



Union Street - west of railway:

Install new M.H. just west of tracks.

Crescent Drive:

Install new M.H. at Crescent and Marengo Ave.

M.H. invert elevation: 856.58 ft.

Construct new 8" sewer on Cresent Drive to Chestnut St. on a 0.7% grade

Necessary Chestnut St. M.H. invert elev.:

Elev.: 854.66 Ft.

Chestnut Street:

New M.H. just east of railway.

" " " west " " at Crescent Drive.

(Elevation given immediately above)

Sewer from west will run into M.H. 1.17 ft. above invert. No change in the present system therefore necessary.

Walnut Street:

No change necessary to east of railway.

Walnut Street continued:

Install new M.H. just west of railway.

Elevation of invert: 846.45 ft.

Construct an 8" sewer line between Chestnut and Walnut. Fall: 854.66-846.45 = 8.21 ft.

Slope: 2.34%. Distance: 350 ft.

Construct an 8" sewer line between Walnut and Holly. Fall: 846.45-830.81 = 15.64 ft.

Slope: 2.08%. Distance: 750 ft.

Holly Street:

Tear out old sewer.

Construct new 8" sewer.

Slope: 0.8%. Distance: 200 ft.

Elev. of invert at Holly and just west of railway: 829.21 + 0.8 x 200 = 830.81 ft.

Colorado Street:

West of railway - install new M.H.

East " " " " " and reverse drainage slope.

Construct 8" sewer connecting old M.H. on Colorado St. and old M.H. on entrance to Broadway. Slope: 2.58%. Distance: 165 ft.

Old M.H. elevations, respectively:

820.85 ft., and 816.52 ft.

REVISIONS OF SANITARY SEWER EAST OF EUCLID AVE.

Euclid Avenue:

Install new M.H.'s just north and south of tracks

On north side of railway construct a new8"

sewer westward to Los Robles Ave.

M.H. invert elevation: 860.00 ft.

Slope: 0.82%. Distance: 458 ft.

Los Robles Avenue:

Install new M.H.'s just N. and S. of tracks.

Continue 8" sewer to Galena.

M.H. invert Elev.: 856.25 ft.

Slope: 1.36%. Distance: 458 ft.

Galena Avenue:

Install new M.H.'s just N.and S. of tracks.

Continue 8" sewer to Madison Ave.

M.H. invert elev.: 850.5 ft.

Slope: 1.15%. Distance: 458 ft.

Discharge, Galena to Madison: 1.00 c.f.s.

Madison Avenue:

Install new M.H.'s just N.and S. of tracks.

Continue with 10" sewer to El Molino Ave.

M.H. invert elev.: 845.2 ft.

Slope: 0.84%. Distance 442 ft.

El Molino Avenue:

Install new M.H.'s N. and S. of tracks.

Continue 10" sewer to Elm Ave.

M.H. invert elev.: 841.5 ft.

Slope: 0.925%. Distance: 650 ft.

Elm Avenue:

Install ne M.H.'s N. and S. of tracks.

Continue 10" sewer to Lake Ave.

M.H. invert elev.: 835.3 ft.

Slope: 0.84%. Distance: 673 ft.

Lake Avenue:

Install new M.H.'s N. and S. of tracks.

Continue 10" sewer to Mentor Ave.

M.H. invert elev.: 829.84 ft.

Slope: 0.84%. Distance: 440 ft.

Mentor Avenue:

Install new M.H.'s N. and S. of tracks.

Continue 12" sewer to Catalina Ave.

M.H. invert elev.: 826.14 ft.

Slope: 0.843%. Distance: 415 ft.

Catalina Avenue:

Install new M.H.'s N. and S. of tracks.

Continue 12" sewer to Stevenson Ave.

M.H. invert elev.: 822.64 ft.

Slope: 0.84%. Distance 806 ft.

Stevenson Avenue:

Install new M.H.'s on N. and S. of tracks.

Continue 12" sewer to Michigan Ave.

M.H. invert elev.: 816.00 ft.

Slope: 0.84%. Distance: 410 ft.

Michigan Avenue:

Install new M.H. Elev. invert: 812.56 ft.

Continue 12" sewer southward under tracks to Walnut Street. Leave present sytem intact. Elev. of rail: 819.00 ft.

Slope: 0.878%. Distance: 330 ft.

Walnut Street:

Install new M.H. Elev. of invert: 809.66 ft.

Continue 12" sewer eastward on Walnut to Sierra Bonita.

Install manholes every 310 ft.

Slope: 1.00%. Distance: 2480 ft.

Sierra Bonita Street:

Install new M.H. Elev. of invert: 784.86 ft.

Continue 12" sewer southward on Sierra Bonita to Colorado Street. where present elevation of sewer: 764.37 ft.

Slope: 1.665%. Distance: 1230 ft.

Colorado Street:

Eastward to Allen and southward on Allen utilize present system.

SUMMARY

Streets	Feet of Pipe			No. of M.H.
Garfield Ave.	0	8"	pipe	1
Mulberry Ave.	450'	"	"	0
Marengo Ave.	0	"	"	2
Center Street	200'	"	"	2
Union Street	125'	"	"	1
Crescent Drive	275'	"	"	2
Chestnut St. to Walnut St.	350'	"	"	1
Walnut St. to Holly	750'	"	"	2
Holly St.	200'	"	"	0
Colorado St.	145'	"	"	2
Colorado St. to Broadway	165'	"	"	0
Euclid Ave. to Madison Ave.	1340'	"	"	8
Madison Ave. to El Molino Ave.	450'	10"	pipe	2
El Molino to Elm Ave.	660'	"	"	2
Elm Ave. to Lake Ave.	670'	"	"	2
Lake to Mentor Ave.	460'	"	"	1
Mentor to Michigan Ave.	1580'	12"	"	10
Michigan Ave.	330'	"	"	1
Walnut St, Michigan to Sierra Bonita	2480'	"	"	12
Sierra Bonita	1230'	"	"	3

SUMMARY continued:

Totals:	4000'	8"	pipe
	2240'	10"	"
	5620'	12"	"

55 New manholes

Costs:

Average cost as quoted by the Engineer's Office of the City of Pasadena is $2.00 per lineal foot of laid sewer. This includes manholes as well.

Estimated cost:

11,860 x 2 = $23,720

D. DESIGN OF TYPICAL STRUCTURE.

The structure suggested is simply adapted from a standard 40-foot highway bridge of the Missouri Highway Department. No attempt was made to select the most economical type, but it is thought that the one suggested will give an approximate idea of the probable structure, as well as give a general idea of the cost. The design submitted herewith would be satisfactory at all street intersections except Colorado Street and Lake Avenue where another design would be required due to street-car loadings imposed thereon.

COST OF VIADUCT CONSTRUCTION

Concrete in Structure:

Total: 386 cubic yards

Cost per cubic yard in place: $25.00

Total Cost: $9,630

Pavement:

Allow 20' on each side for repaving.

Total: (40 + 60)x 40 = 4000 sq. ft.

Cost per sq.ft. of 7" concrete = $0.22

Total Cost: ....$ 880

Sidewalks:

Consider curb and gutter to be included and cost covered by the per foot cost.

Total sq. ft.: 1000 sq. ft.

Cost per sq. ft.: $0.38

Total Cost: $380

Earth Fill:

Total cu.yd.: 48.5 cu.yds.

Cost per cu. yd.: $0.25

Total Cost: $13

Total cost of Viaduct:

Concrete:	$9,630	
Pavement:	880	
Sidewalks:	380	
Earth Fill:	13	
Total		$10903

E. PLAN FOR SIDE TRACKS.

Approaches must be provided for the side tracks to bring the freight near the surface. Typical plans of proposed sidings from Walnut to Holly Streets and from Green to Center Streets are submitted herewith. One other siding would be necessary from El Molino Ave. to Elm Ave. but it would be very similar to the one proposed between Walnut and Holly Streets.

F. DRAINAGE IN THE CUT.

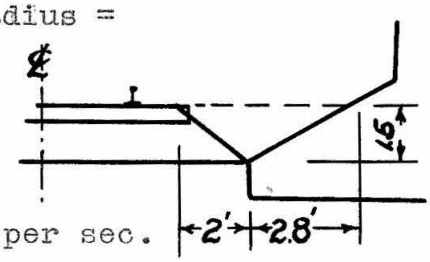
1. Required capacity.

Assuming 4 inches per hour = maximum rate of rainfall. Then the necessary capacity of the drain at Stevenson Ave. due to the maximum rate of rainfall falling on a strip 50 feet wide and 6000 feet long (approximately the distance from Stevenson Ave. to the summit at Garfield Ave.) = $\frac{50 \times 6000}{60 \times 60} \times \frac{4}{12} \times \frac{1}{2}$ = 14 sec.ft. in each of two drains.

2. Necessary Area of Drain.

Using Kutter's formula, and assuming n= .02 with an average slope of .7% , with drain as shown flowing 1.5 feet deep, the hydraulic radius =

$$\frac{.75 \times 4.8}{2.5 \quad 3.18} = .64$$



Velocity of flow = $c\sqrt{rs}$ =

$100 \times .62 \sqrt{.64 \times .007}$ = 4.15 ft.per sec.

Quantity this drain can handle =

.75 x 4.8 x 4.15 = 15 sec.ft.

Hence this drain would be satisfactory.

The maximum depth of water in the drain would be 1.5 feet. The values taken are rather conservative as the rainfall of 4 inches per hour would be very exceptional.

G. MAINTENANCE OF TRAFFIC DURING CONSTRUCTION.

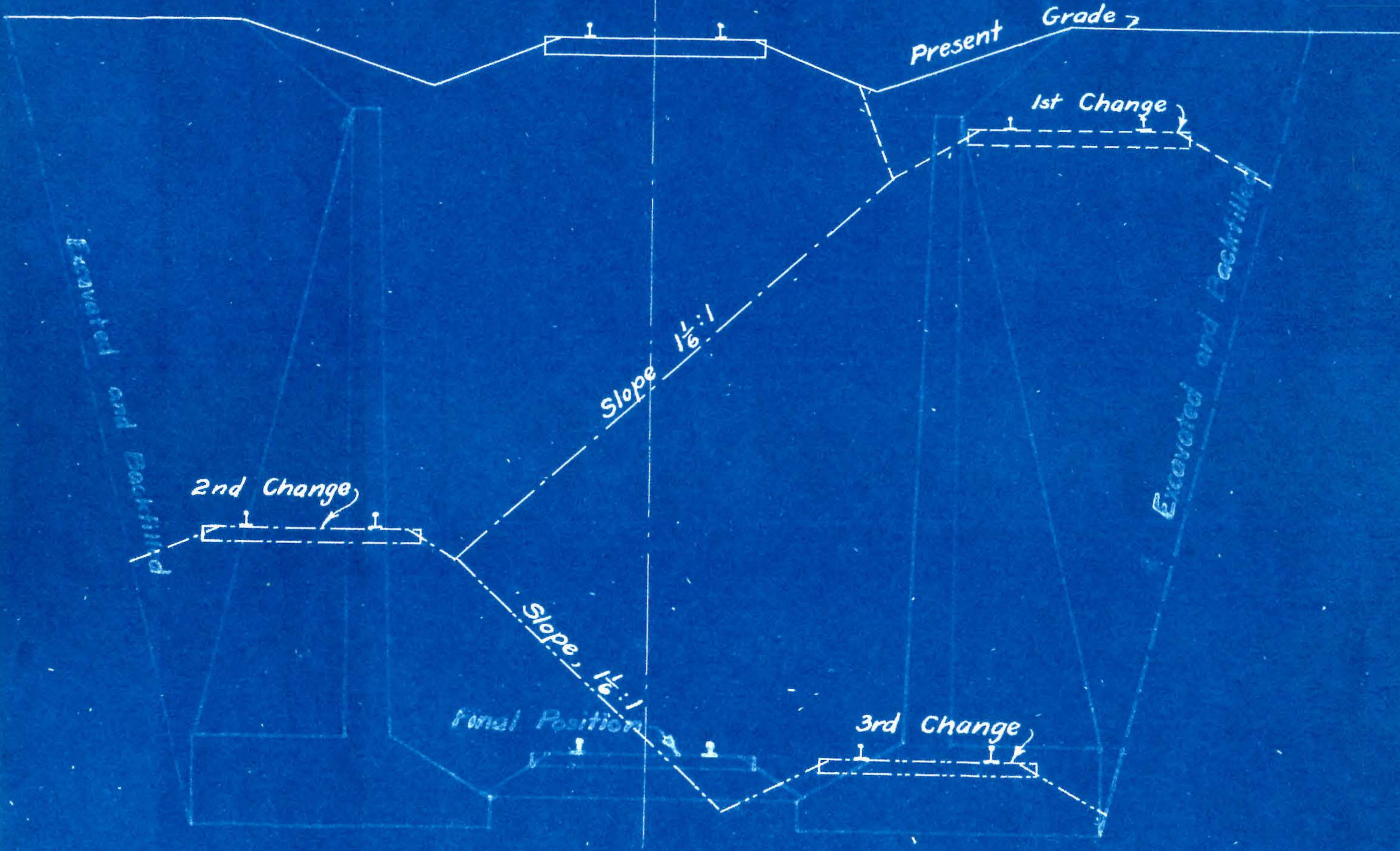
Cost of maintenance of traffic for lowering 1 foot of track 1 foot in depth = $0.25

Number of feet of track lowered 1 foot by the project

= 331,386.

Total cost = 331,386 x $0.25 = $82,846.

The method of maintaining traffic under construction is shown rather clearly in the following sketch.



SKETCH SHOWING METHOD OF CONSTRUCTION TO MAINTAIN TRAFFIC.
Scale, 1" = 5'.

H. a. COMPUTATION OF ESTIMATED TOTAL COST.

Excavation - 476,228 cu.yds.@$0.50	=	$238,114.
Retaining Walls, total	=	$888,877.
Additional Right-of-way, total	=	$ 82,446.
Structures at intersections, 21 @ $10,903	=	$228,963.
Adjustment of Sanitary Sewer System, total	=	$ 23,720.
Maintenance of traffic during construction, total	=	$ 82,846.
Sum	=	$1,544,966.
Adding 25% for Engineering and Overhead expenses,	=	$ 386,241
GRAND TOTAL OF ESTIMATED COST	=	$1,931,207.

B. CAPITALIZED SAVING INCURRED.

Considering 6 passenger and 2 freight trains passing through Pasadena each way daily, and the cost of a train-mile of $3.60, the annual saving of 30 feet of reduction of class "C" rise and fall which the project affords, would be

365 x 30 x 2 x (6+2) x 3.60 x $.0082 = $5,170.

($.0082 = cost of one foot of class "C" rise and fall per $1.00 cost of the train-mile, considering an average grade reduction of .50%, which the project affords.

see Raymond, Railroad Engineering, p.254)

Ten flagmen, now employed would be unnecessary as well as one electrician.

10 flagmen @ $900 annually		=	$9,000.
1 electrician @ $1800	"	=	$1,800.
Total annual saving		=	$15,970.

This annual saving of $15970 Capitalized @ 5%

= TOTAL CAPITALIZED SAVING OF $319,000.

CONCLUSIONS.

In the foregoing study it was assumed that the location of the Santa Fe in regard to grade crossings in Pasadena is not as desirable as it might be. It is thought by the writers that the most economical solution of the problem, if the railway is to stay in Pasadena, is by means of lowering the track in an open cut, thus eliminating grade-crossings, reducing the rise and fall on the division, and reducing the objectionable dirt and noises of the railroad in the city. Further, it is the belief of the writers that the location of the main line of the Santa Fe through the heart of Pasadena will be an advantage both to the city and to the railroad. The Southern Pacific and Union Pacific railroads run branch lines into Pasadena, but the Santa Fe is the only direct transcontinental route. Industrially, this is a big advantage in the matter of time saving and convenience.

Furthermore, the writers believe that the time is now ripe for such a project as is proposed. Pressure is being made in state, county, and city legislations for the removal of grade crossings. The two notable grade separations in Pasadena on the Santa Fe at Fair Oaks Avenue and at Columbia Street have proven a success. Property valuations in Pasadena at the present time are not as large as they will be in the future. So, for the foregoing reasons, the writers would recommend the plan for further consideration by railroad engineers and municipal authorities.

III.- DATA. -

A.- COST DATA

Furnished by City Engineer, Pasadena, California

Sanitary Sewer, average size, laid: $2.00 per foot

This includes manholes.

Excavation:

$0.50 per cu. yd.

Reinforced Concrete, in place, includes form work:

$25.00 per cubic yard.

Concrete Curb:

$0.55 per linear foot.

Concrete Gutter:

$0.32 per square foot.

Concrete Sidewalk:

$0.21 Per square foot.

Concrete Pavement, 6" thick:

$0.20 per Square foot.

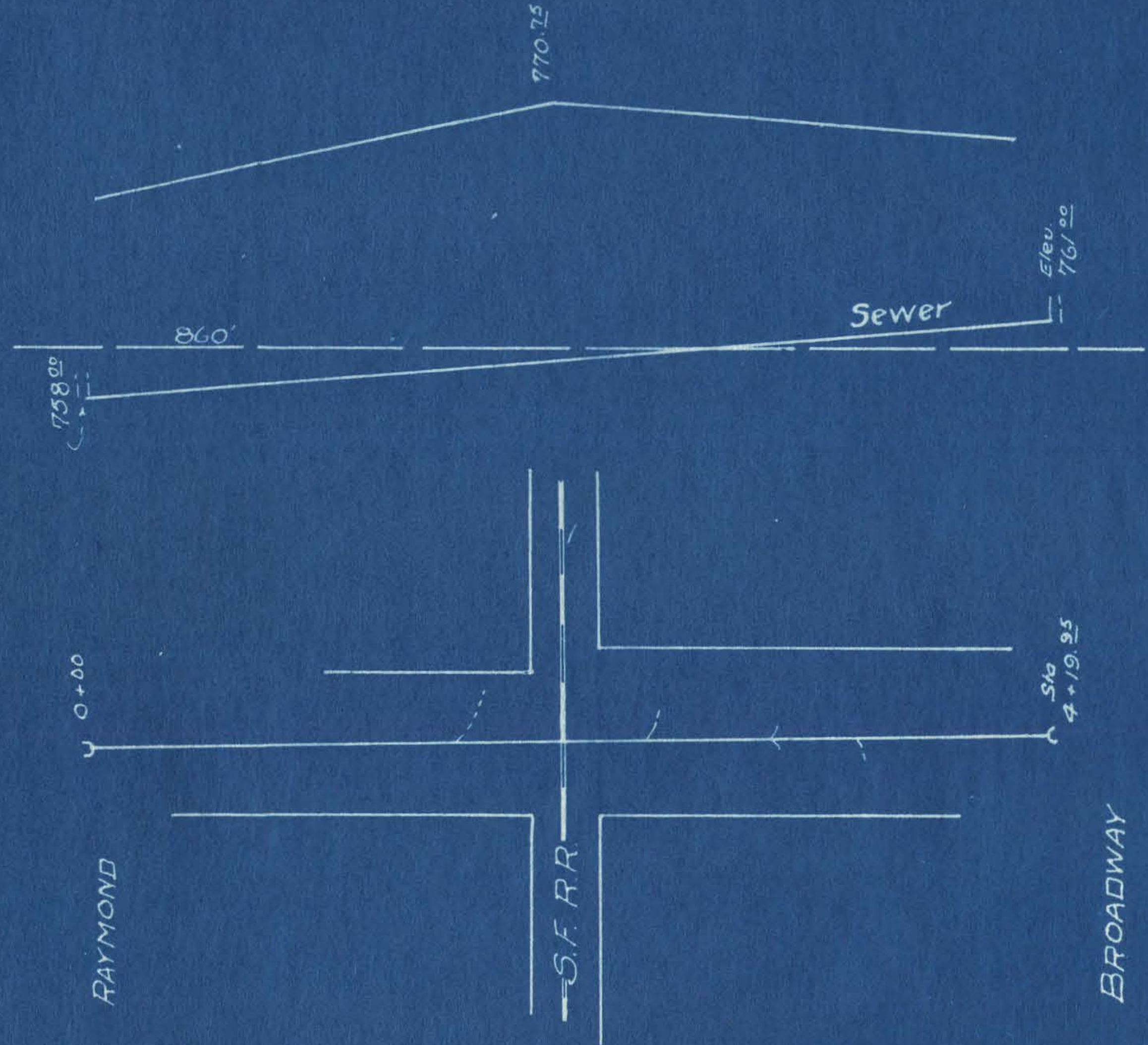
Concrete Pavement, 7" thick:

$0.22 per square foot.

B.- ESTIMATES OF PROPERTY VALUES

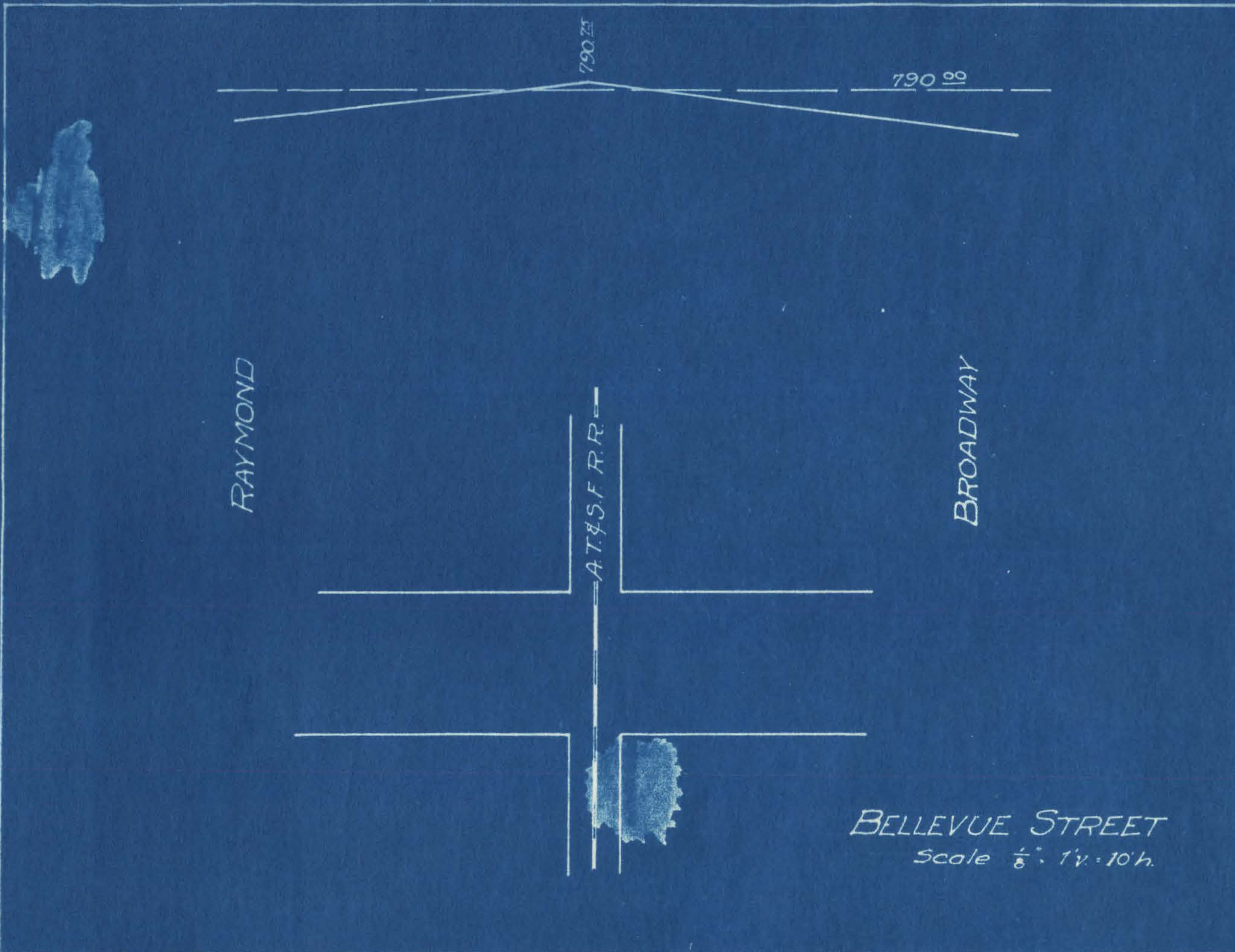
along Railroad right-of-way as given by Mr. Curtis with Mr. B.O. Kendall - 67 N. Raymond Ave, and compared with computed estimates from the City's Assessor's Office. Computed estimate taken as equal to 3/2 the assessed value.

From Street	To Street	Cost of front ft.	Depth of Lot	Costs Est.	Costs Comp.
California	Center	$250	167'	$1.48	$1.25
Center	Green	300	"	1.78	1.76
Green	Colorado	600	"	3.55	
Colorado	Union	1000	117	8.55	13.36
Union	Holly	100000 entire blk.	20400 sq.ft	$4.90	
Walnut	Marengo	60	130	0.46	0.475
Marengo	1/2 btw. Euclid-Los Robles	75	192'	0.39	0.46
Los Robles frontage		100	195'	o.51	0.525
1/2 btw. Los Robles--Galena	150 East El Molino	75	192'	0.39	0.33
El Molino	Elm	35		0.33	0.30
Elm	1/2 way Lake	250	310	0.80	0.59
1/2 way Lake-Lake		500	295	1.67	
East side Lake		250	185	1.35	
1/2 way Lake - Mentor-Catalina		60	200	0.30	
Catalina	Eastward	50	200	0.25	

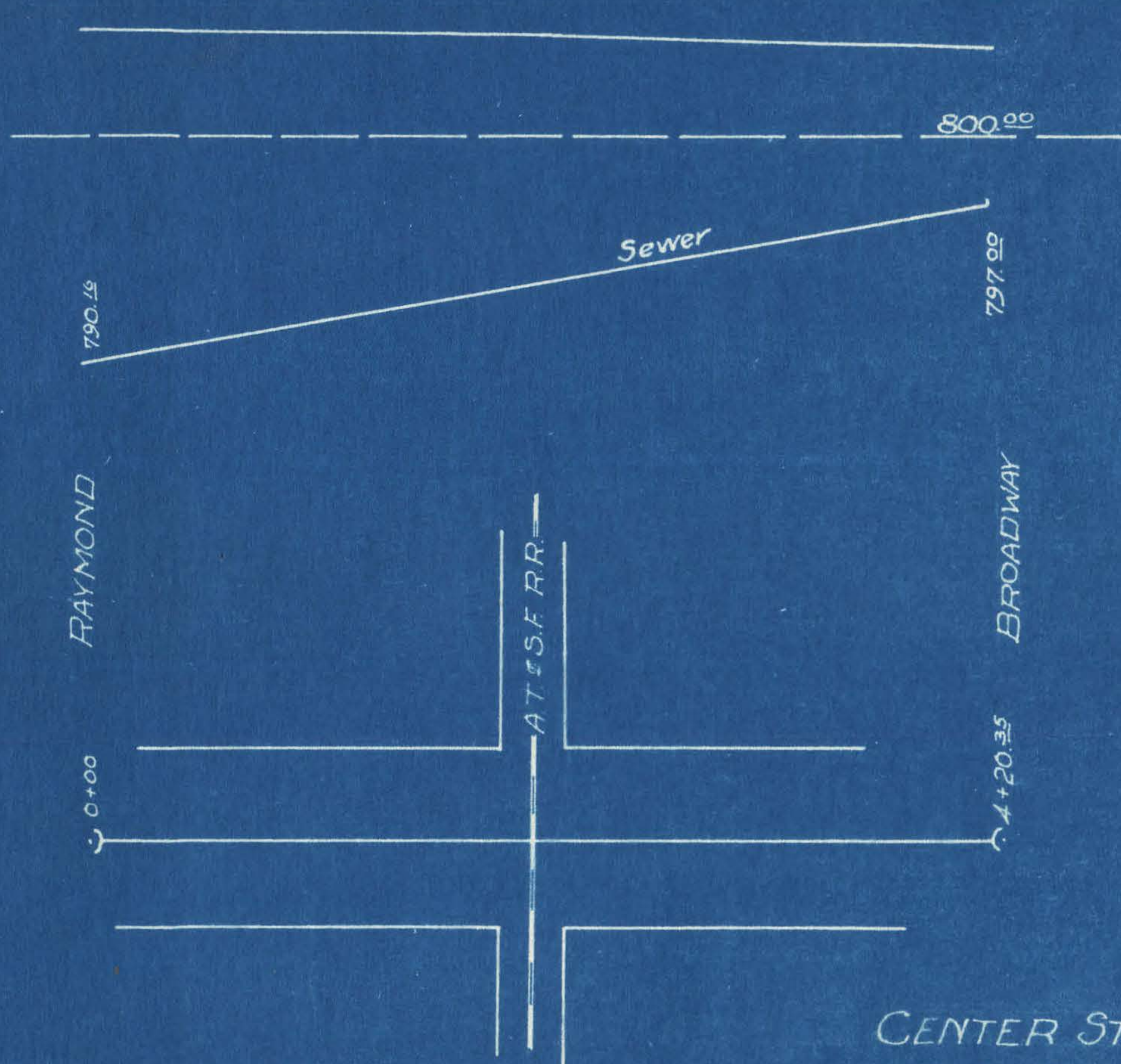


CALIFORNIA STREET PROFILE

Scale $\frac{1}{8}''$ = 1' vert; = 10' horiz.

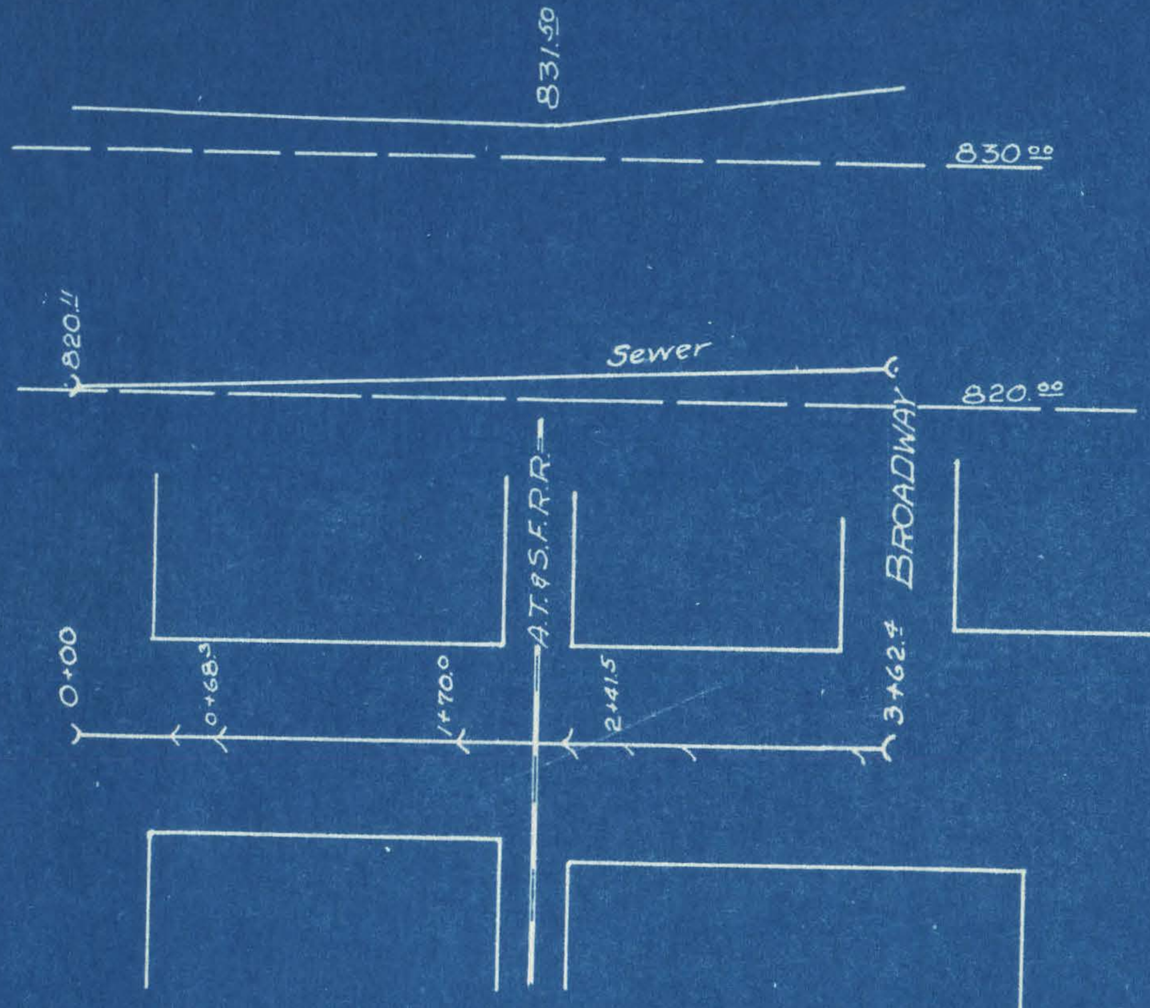


BELLEVUE STREET
Scale 1/8" : 1'v. = 10'h.



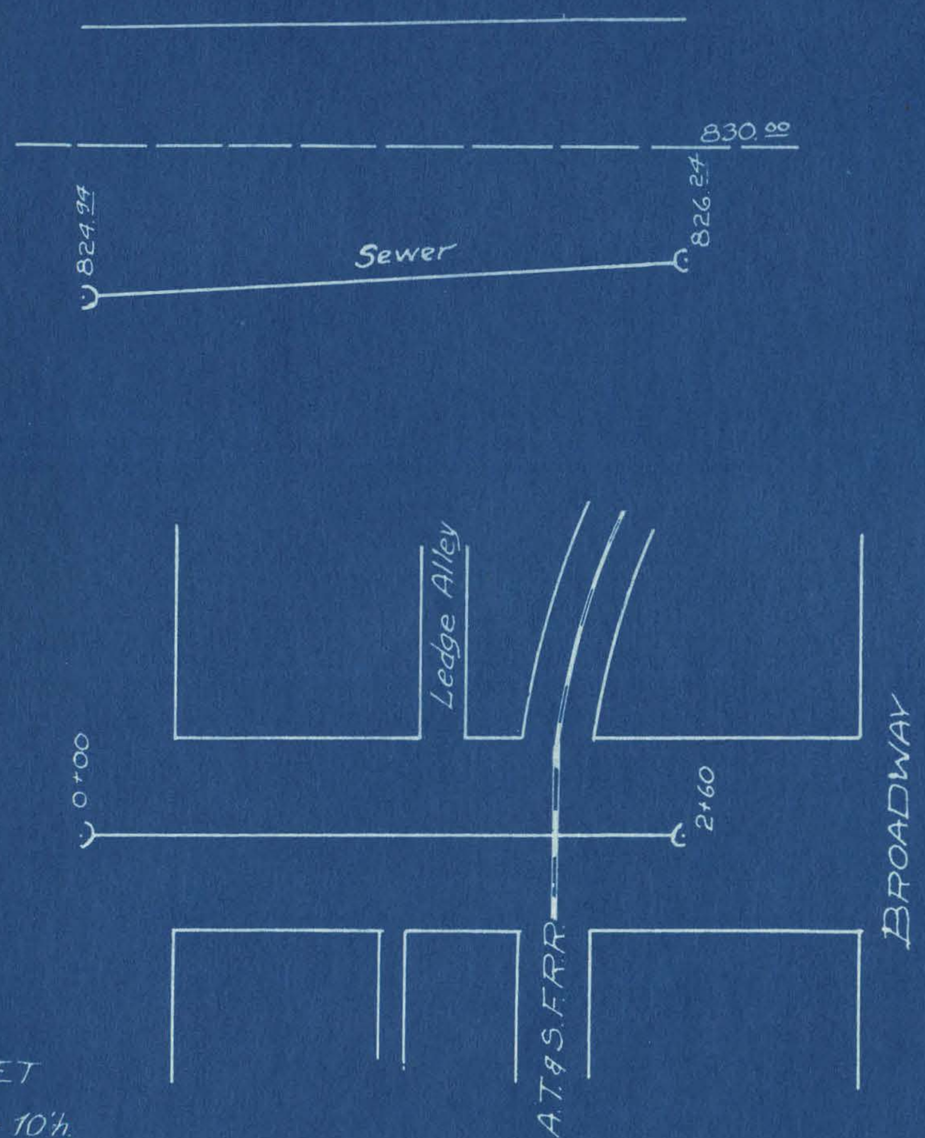
CENTER STREET

Scale: 1/8" = 1' v. = 10' h.



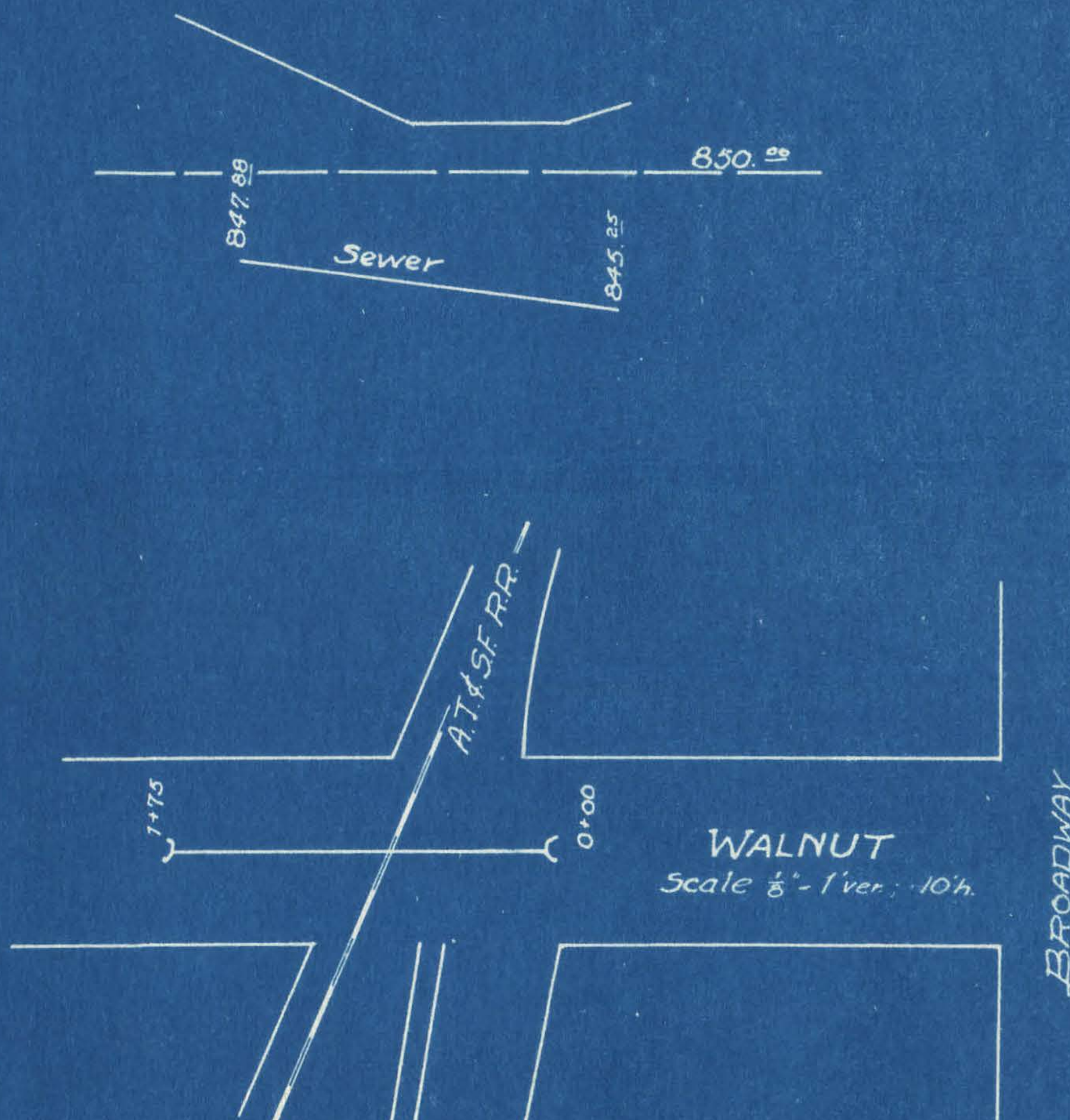
COLORADO STREET

Scale $\frac{1}{8}$" = 1' ver. = 10' h.

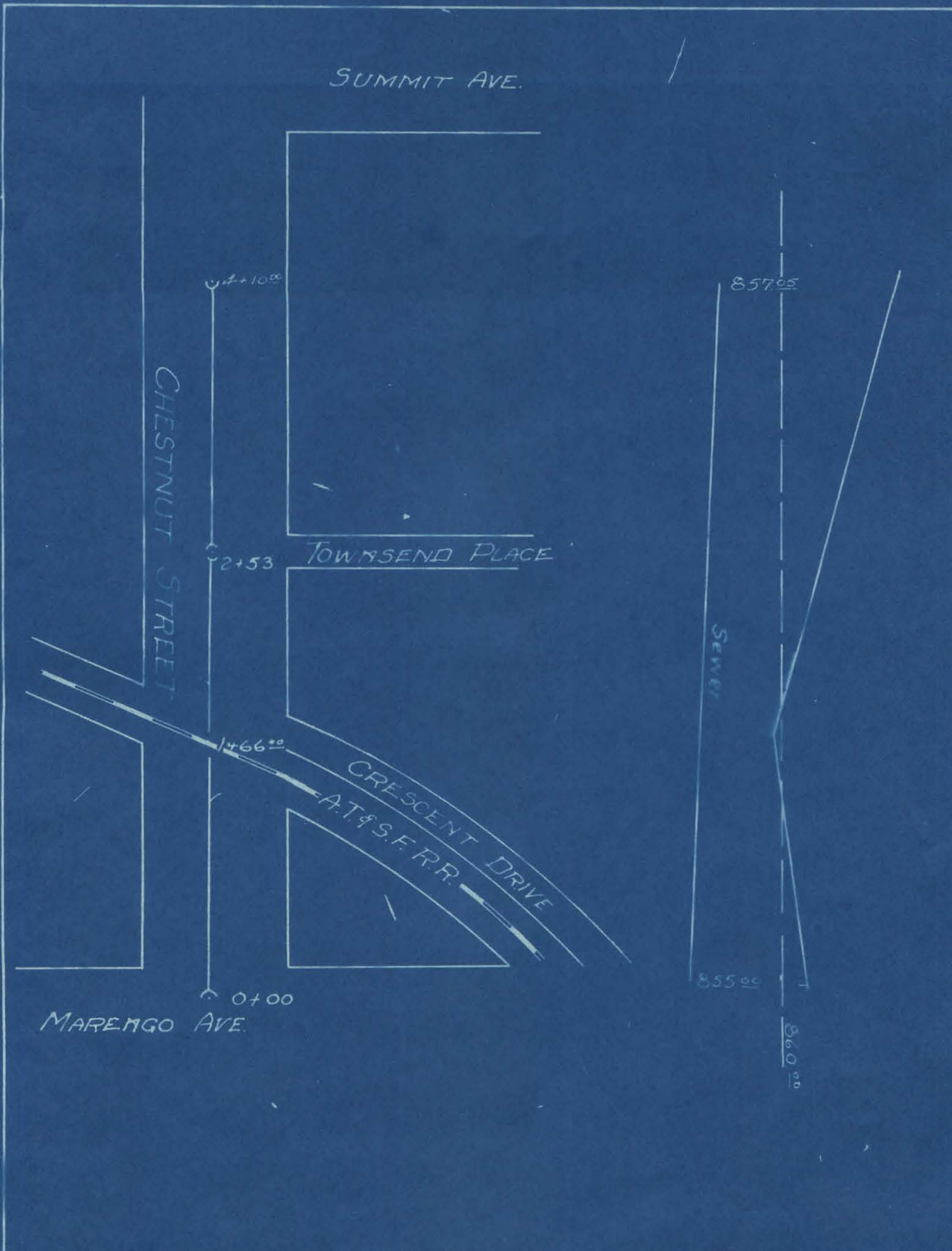


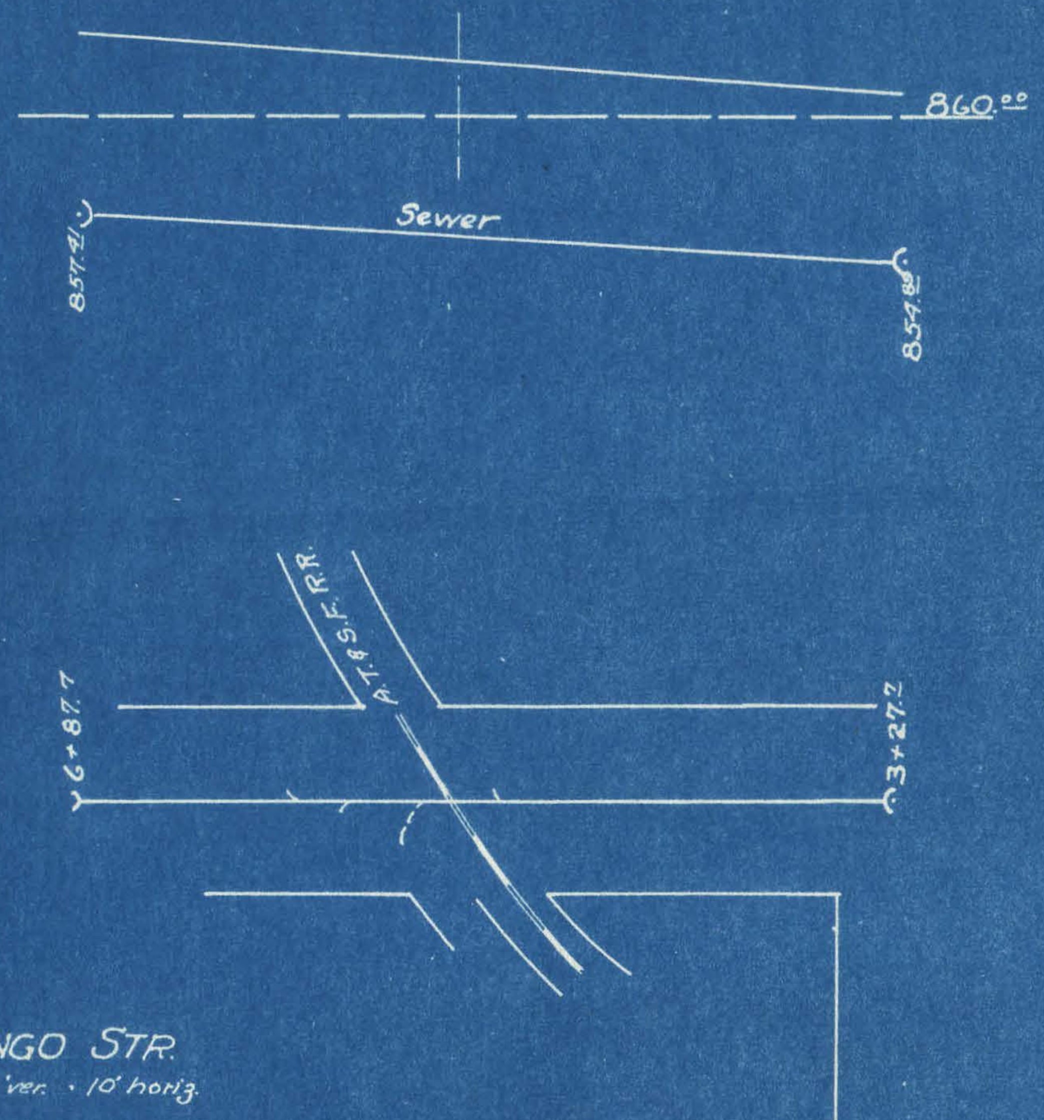
UNION STREET

Scale $\frac{1}{8}$" = 1' ver. = 10' h.

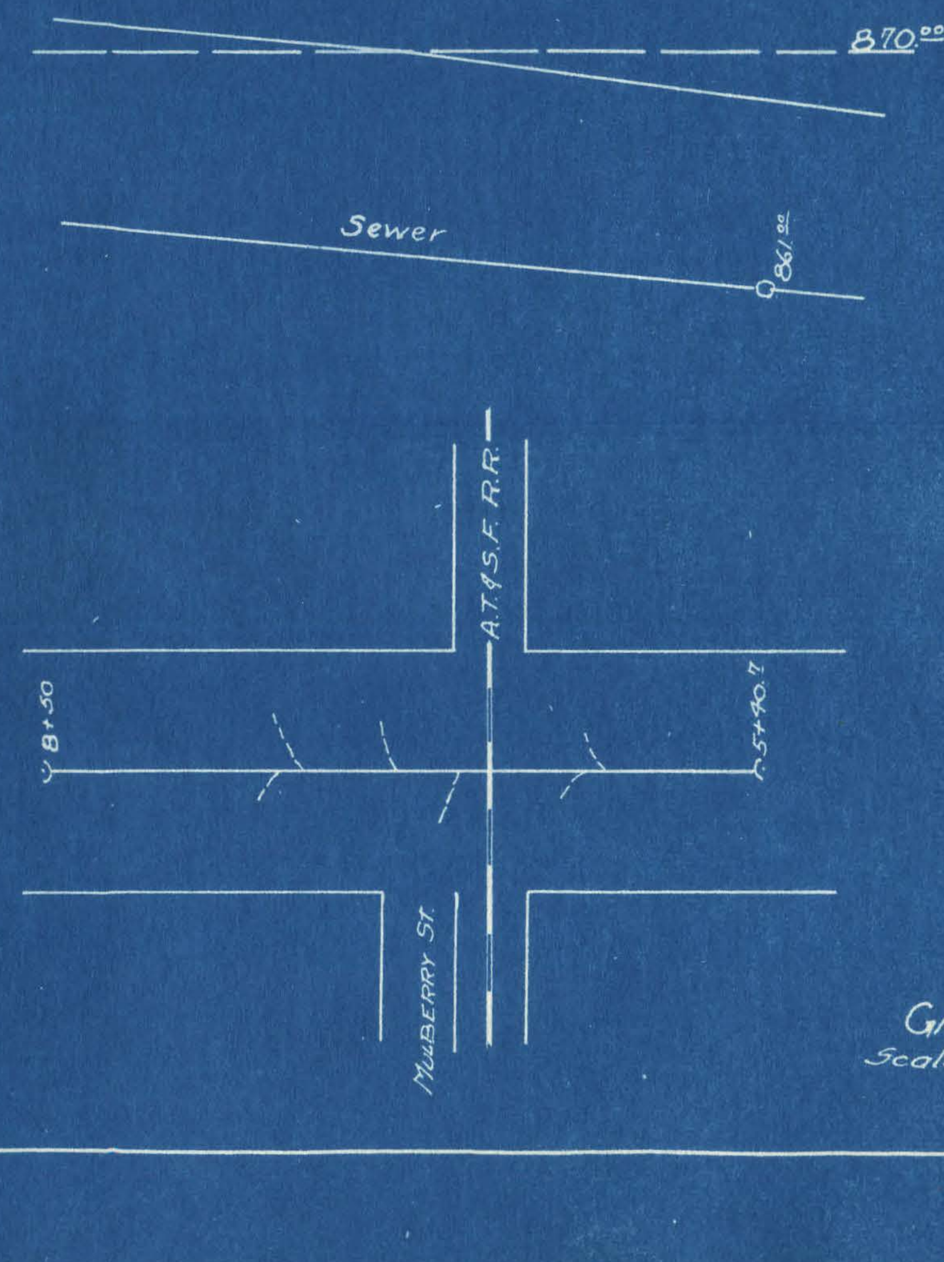


850.00
847.88
Sewer
845.25
A.T.&S.F. R.R.
1+75
0+00
WALNUT
Scale 1/8" - 1' ver.; 10' h.
BROADWAY

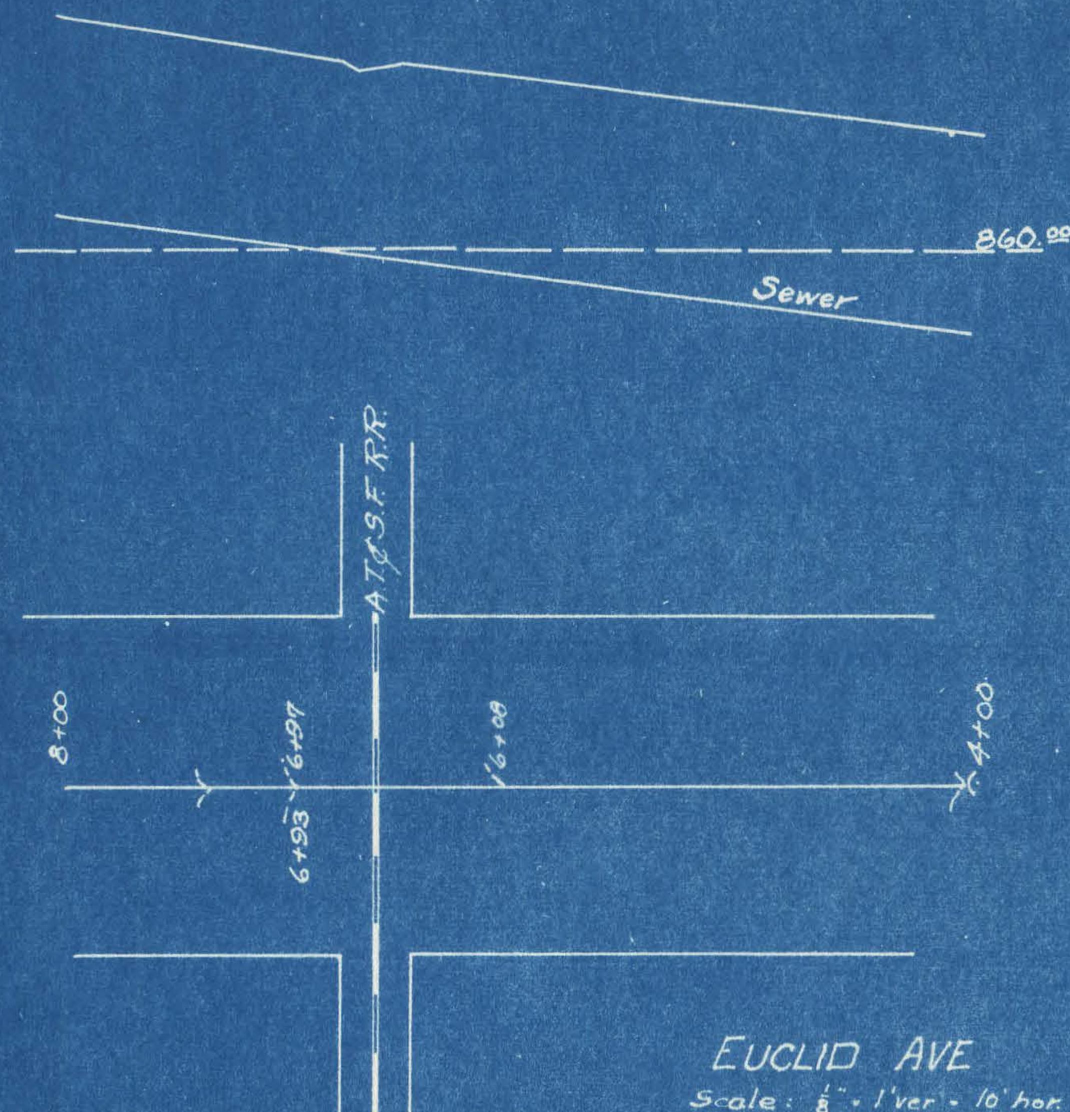

SUMMIT AVE.
4+10.00
857.05
CHESTNUT STREET
2+53
TOWNSEND PLACE
Sewer
1+66.00
CRESCENT DRIVE
A.T.&S.F.R.R.
855.00
0+00
MARENGO AVE.
860.00



MARENGO STR.
Scale 1/8" - 1' ver. - 10' horiz.

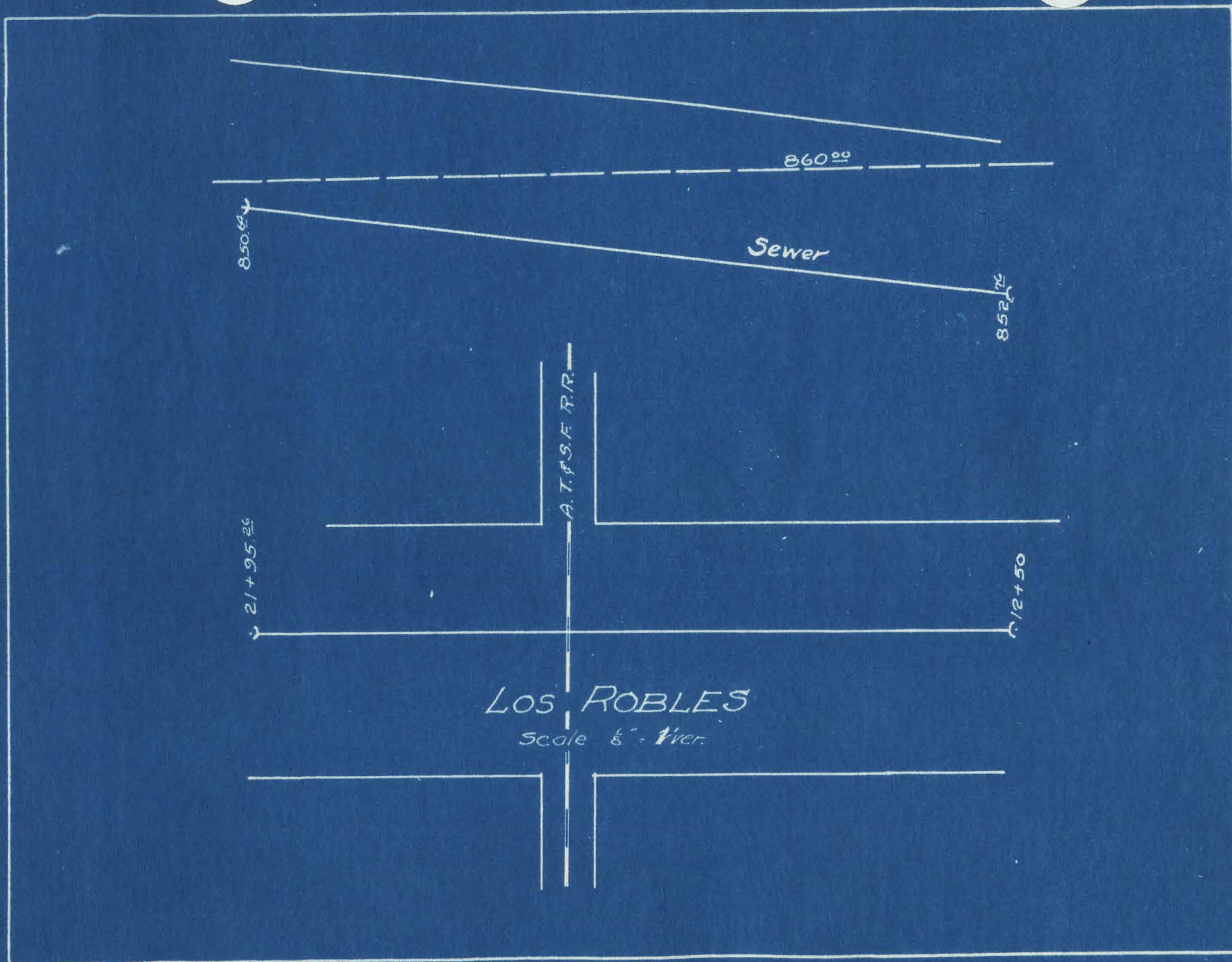


GARFIELD AVE.
Scale 1/8": 1' ver. 10' horiz.

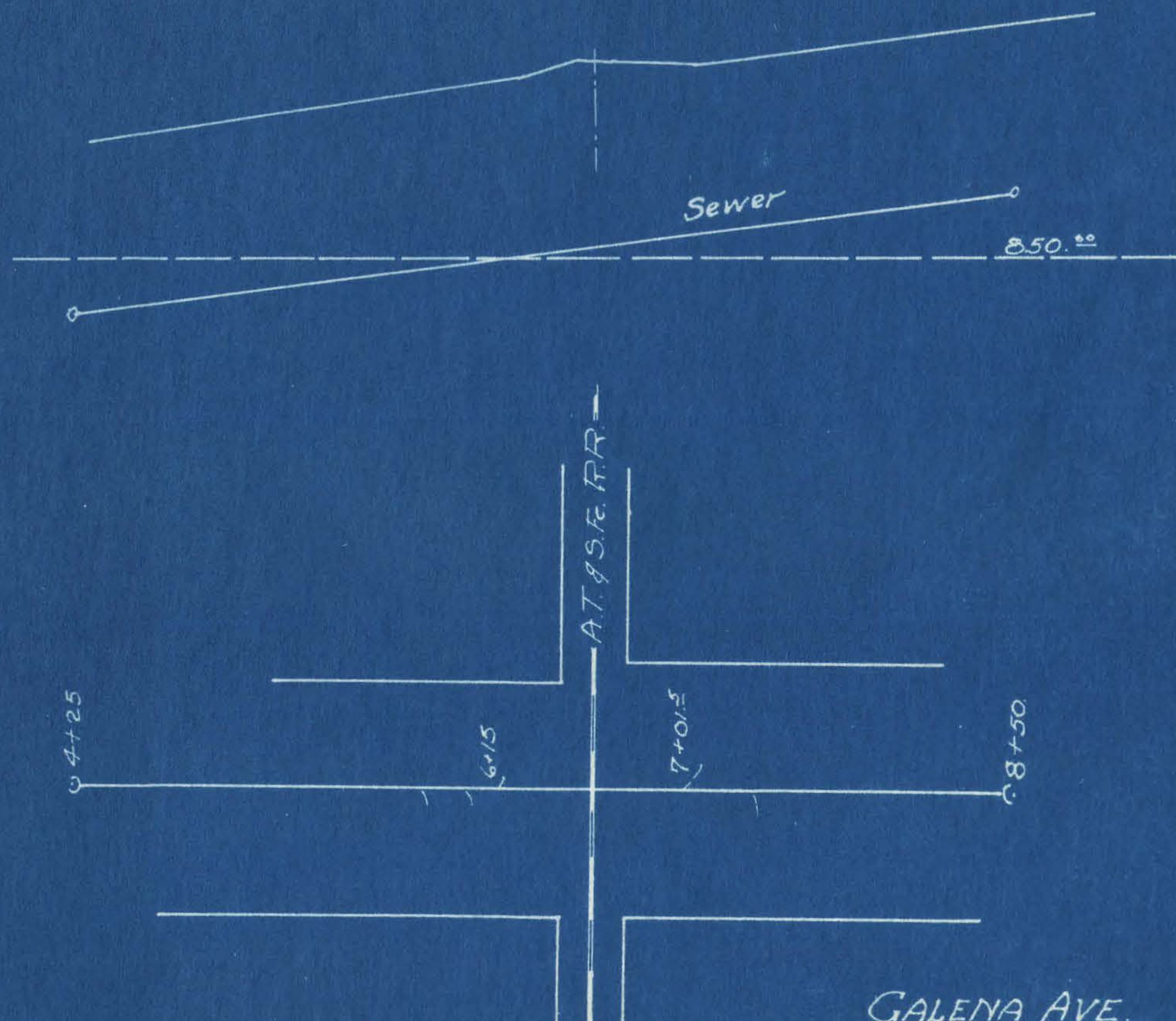


EUCLID AVE

Scale: 1/8" = 1' ver. = 10' hor.

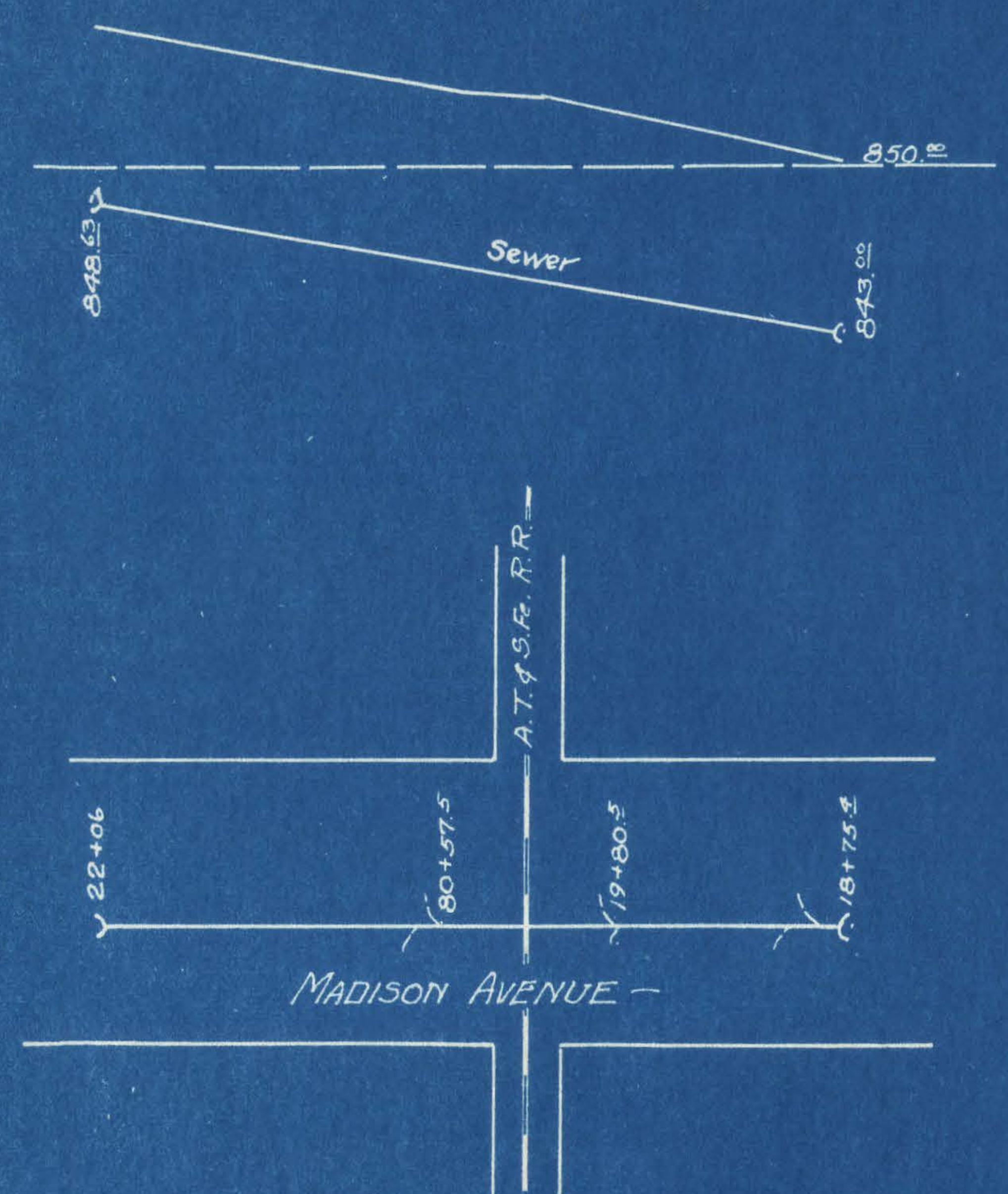


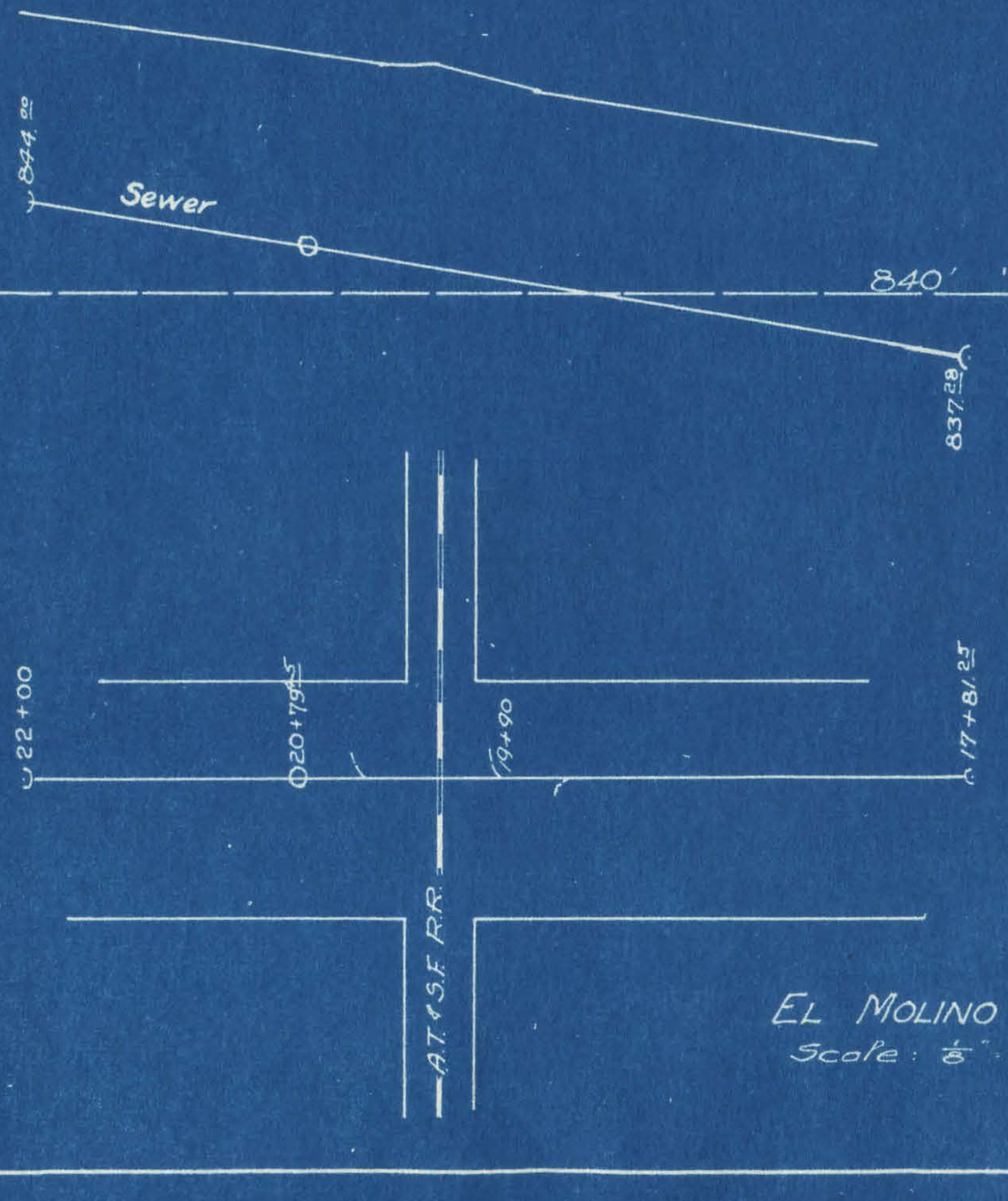
860.00
Sewer
850.64
852.76
A.T.&S.F. R.R.
21+95.26
12+50
LOS ROBLES
Scale 1/8" = 1' ver.



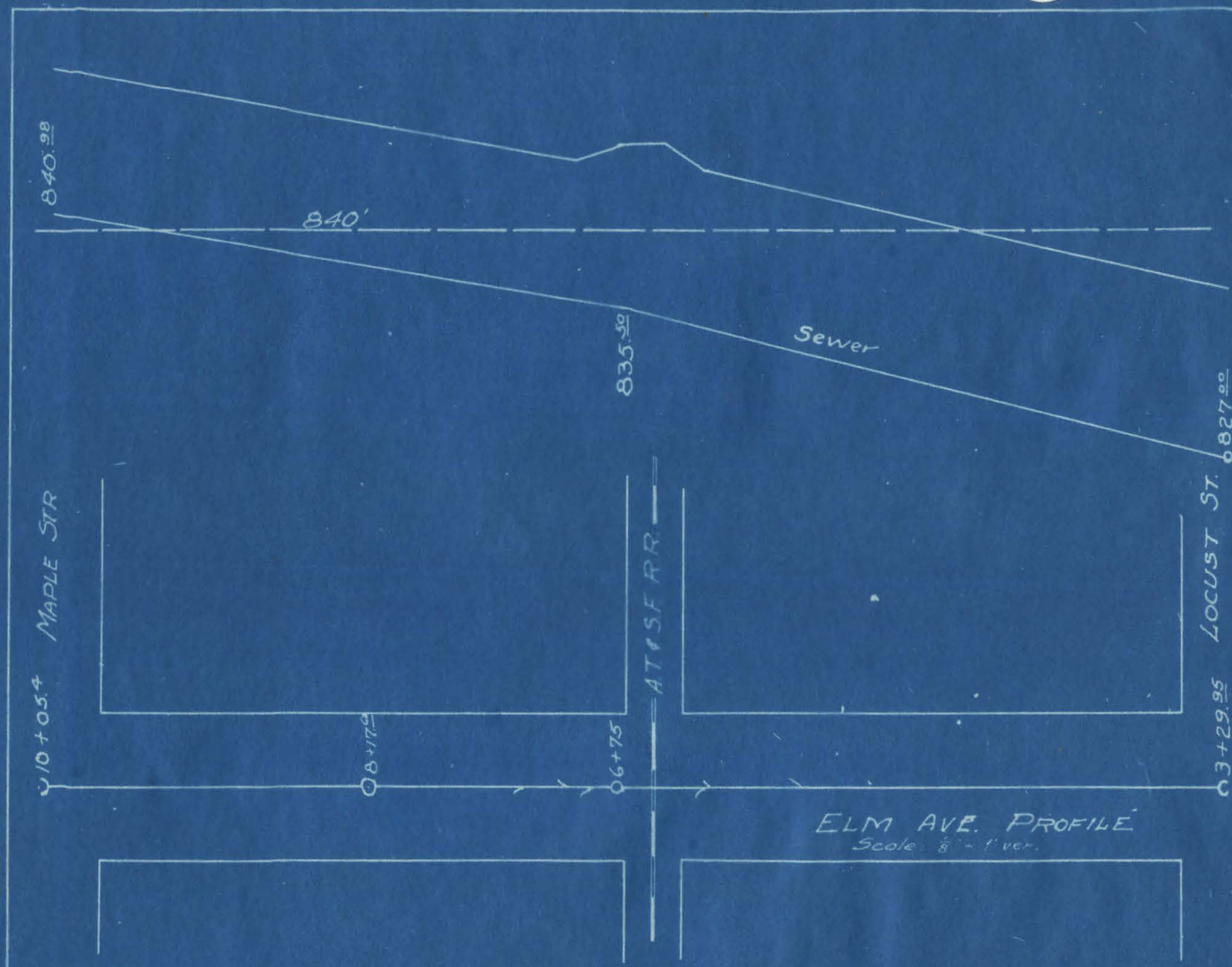
GALENA AVE.

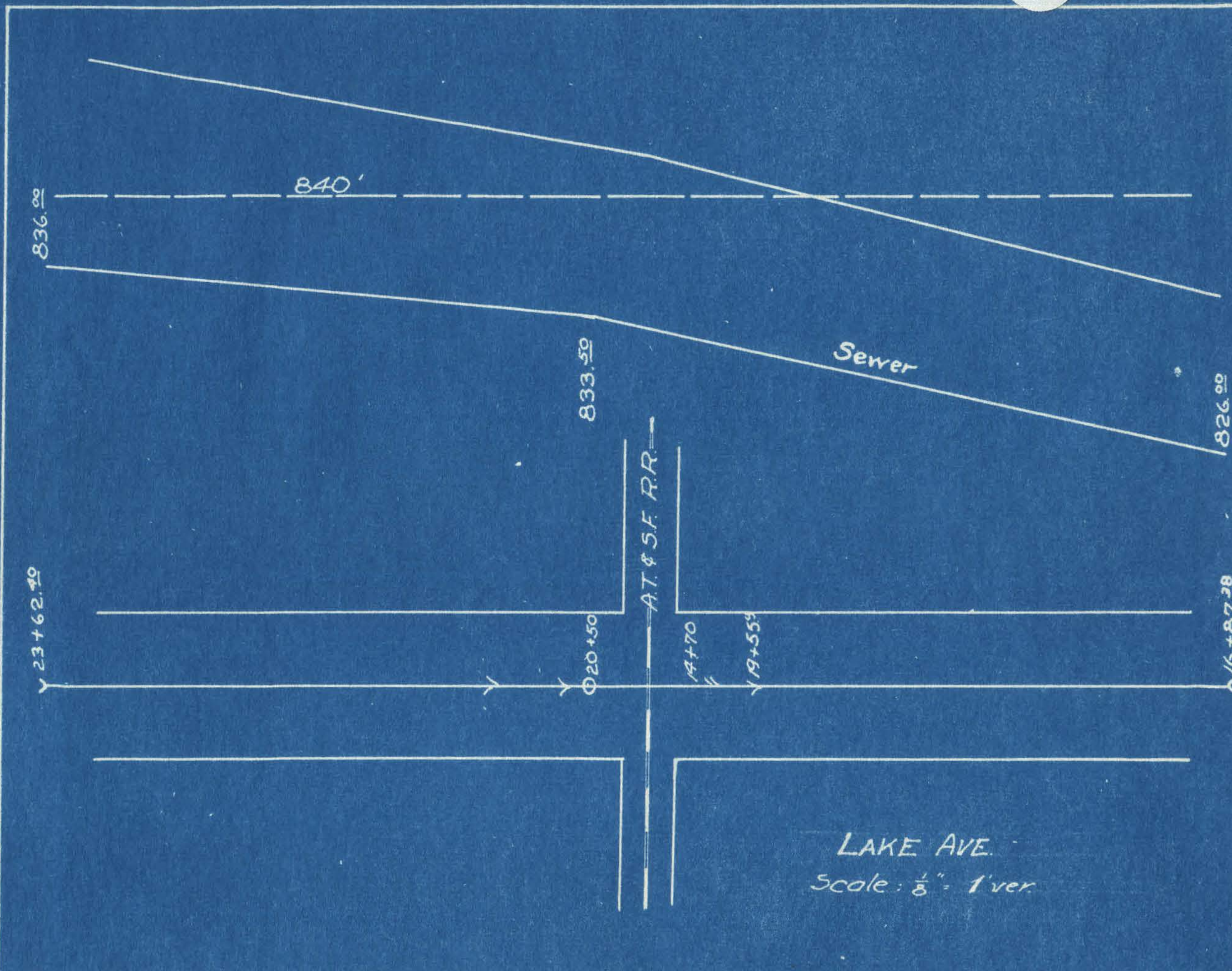
Scale: 1/8" = 1' vert.

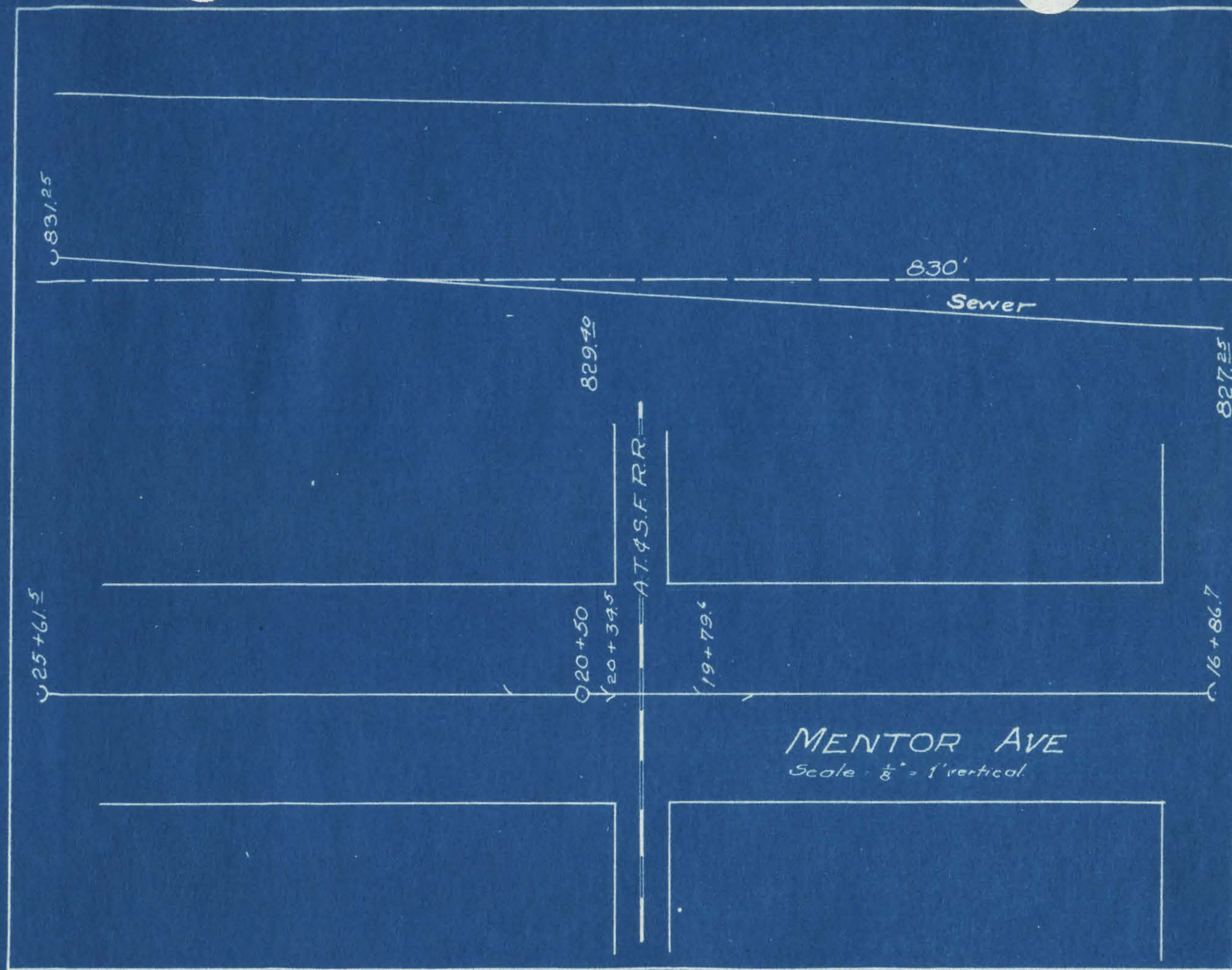

850.00
848.63
Sewer
843.00
A.T.&S.Fe. R.R.
22+06
80+57.5
19+80.5
18+75.4
MADISON AVENUE



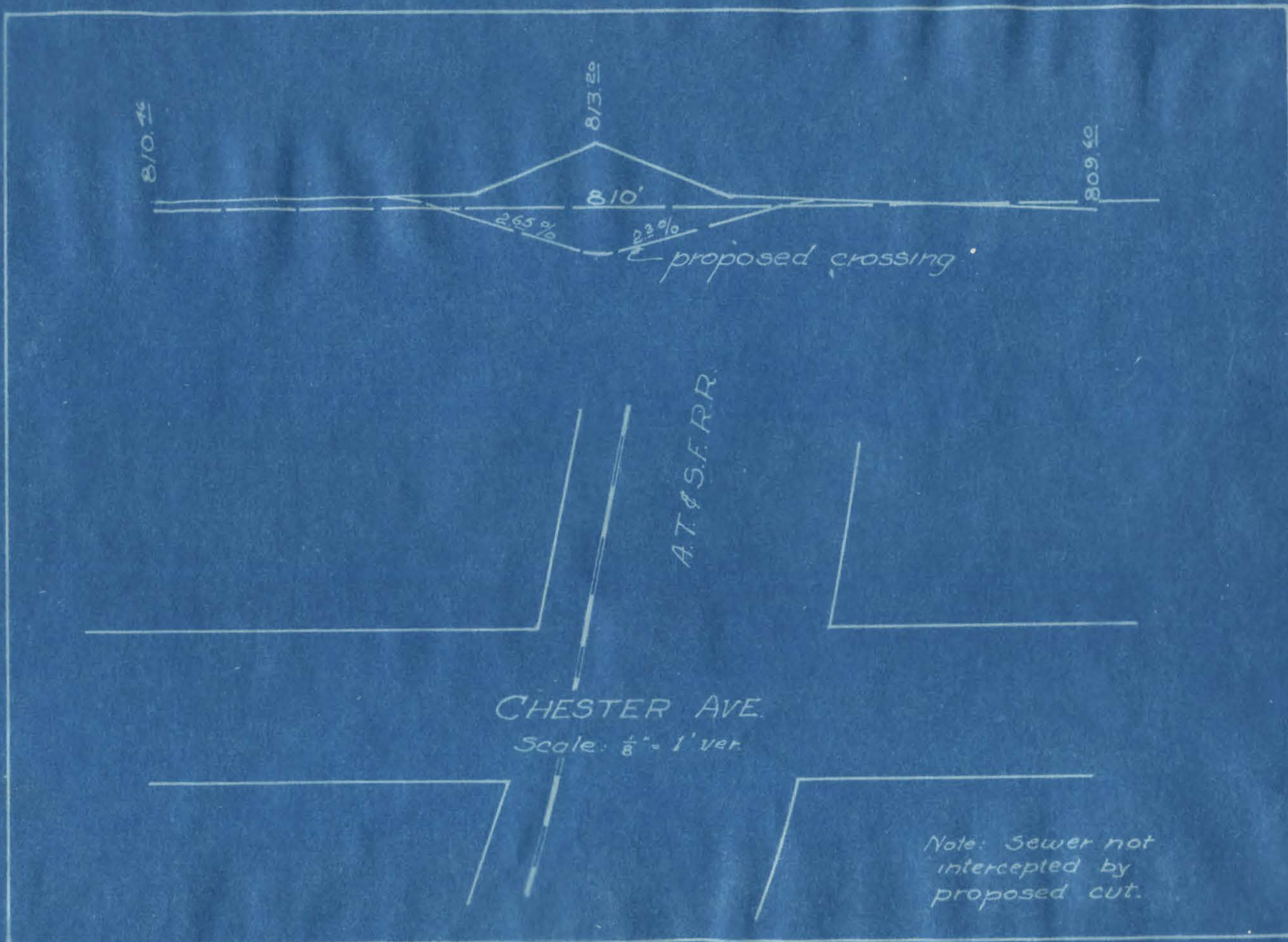
EL MOLINO AVE.
Scale: 1/8" : 1' ver.


840.98
840'
835.50
Sewer
827.00
MAPLE STR
A.T.&S.F. R.R.
LOCUST ST.
10+05.4
8+17.9
6+75
3+29.95
ELM AVE. PROFILE
Scale 1/8" = 1' ver.

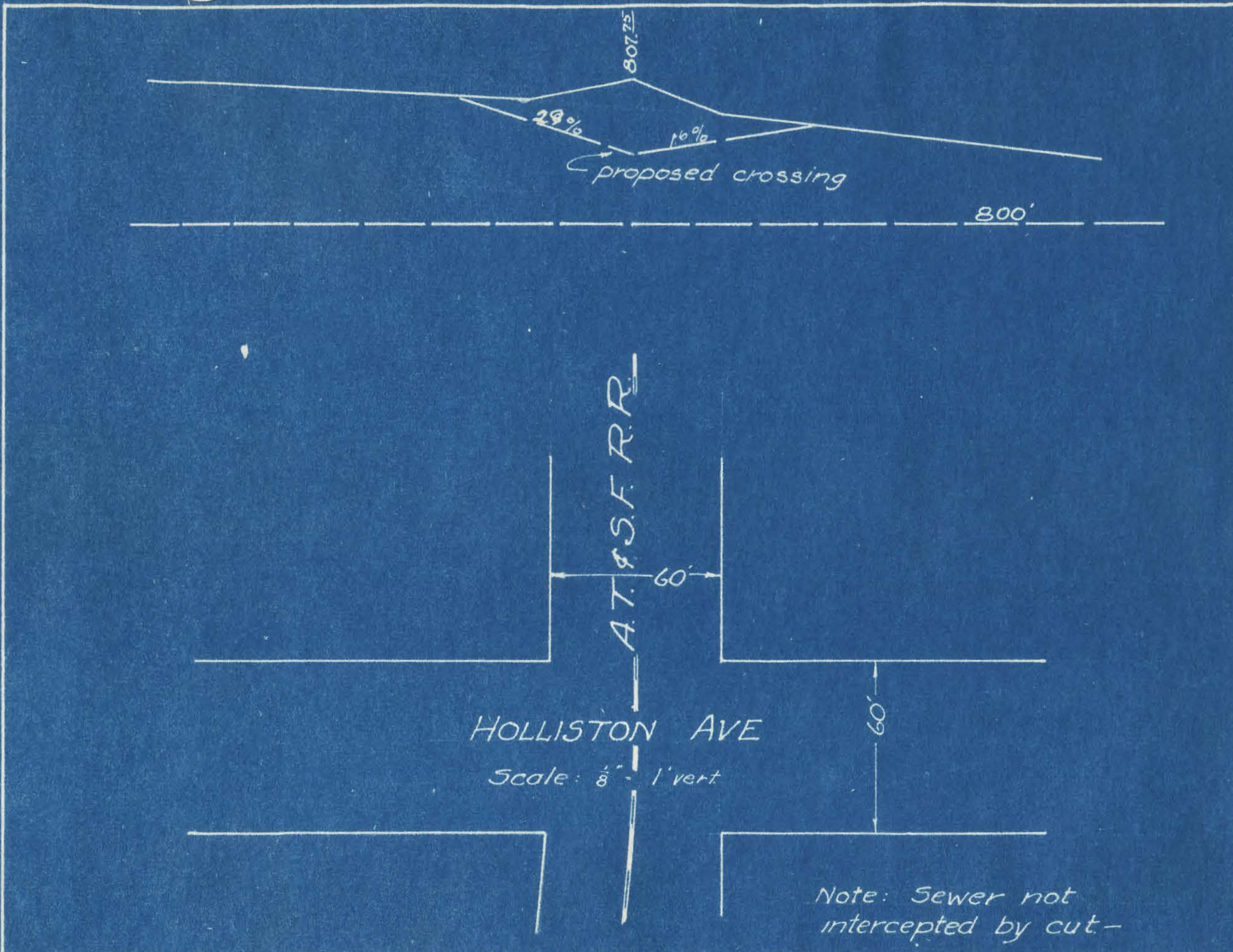

840'
836.00
833.50
Sewer
826.00
A.T.&S.F. R.R.
23+62.40
20+50
14+70
19+55
16+87.38
LAKE AVE.
Scale: 1/8" = 1' ver.



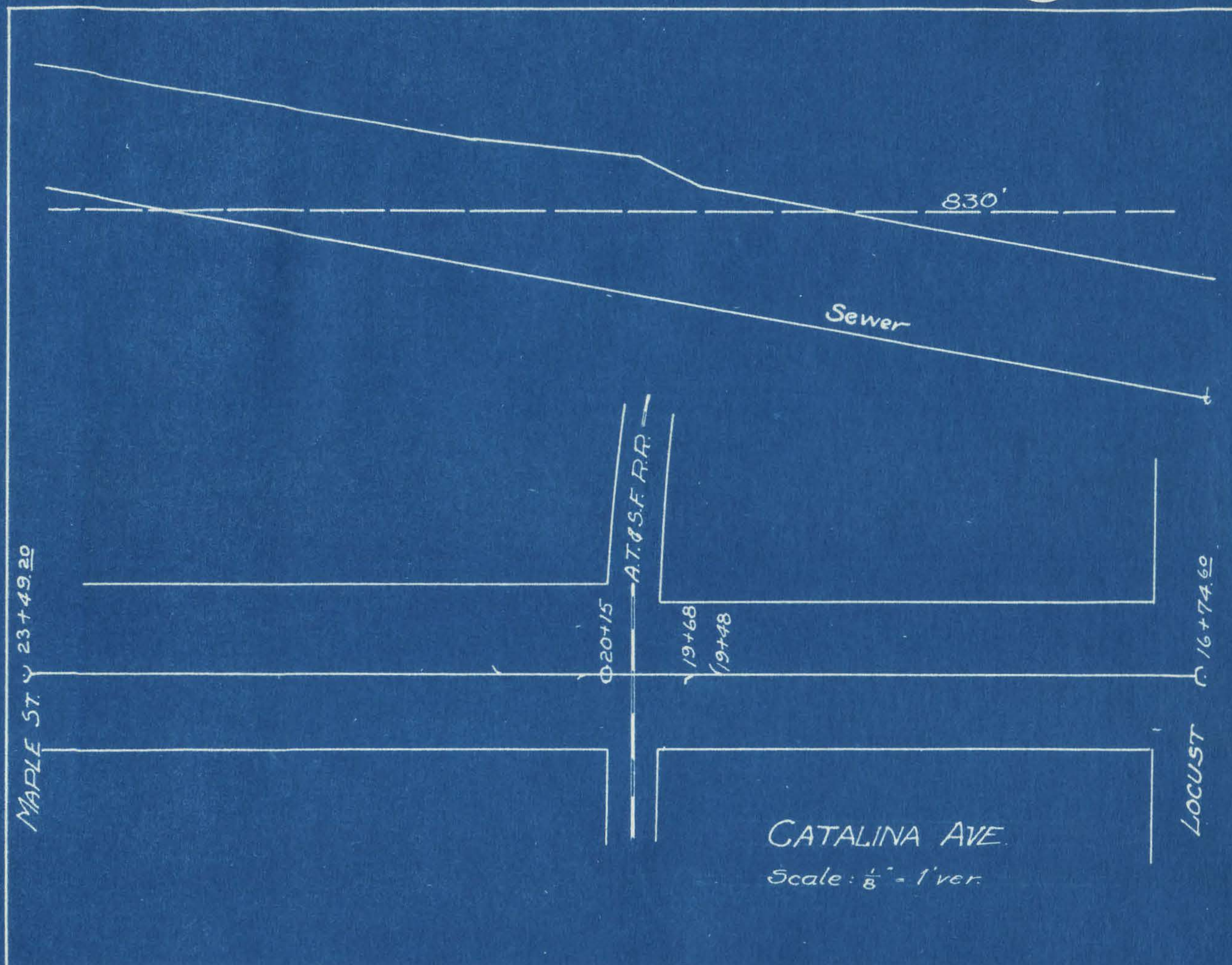
831.25
830'
Sewer
829.40
827.25
A.T.&S.F. R.R.
25+61.5
20+50
20+34.5
19+79.6
16+86.7
MENTOR AVE
Scale: 1/8" = 1' vertical

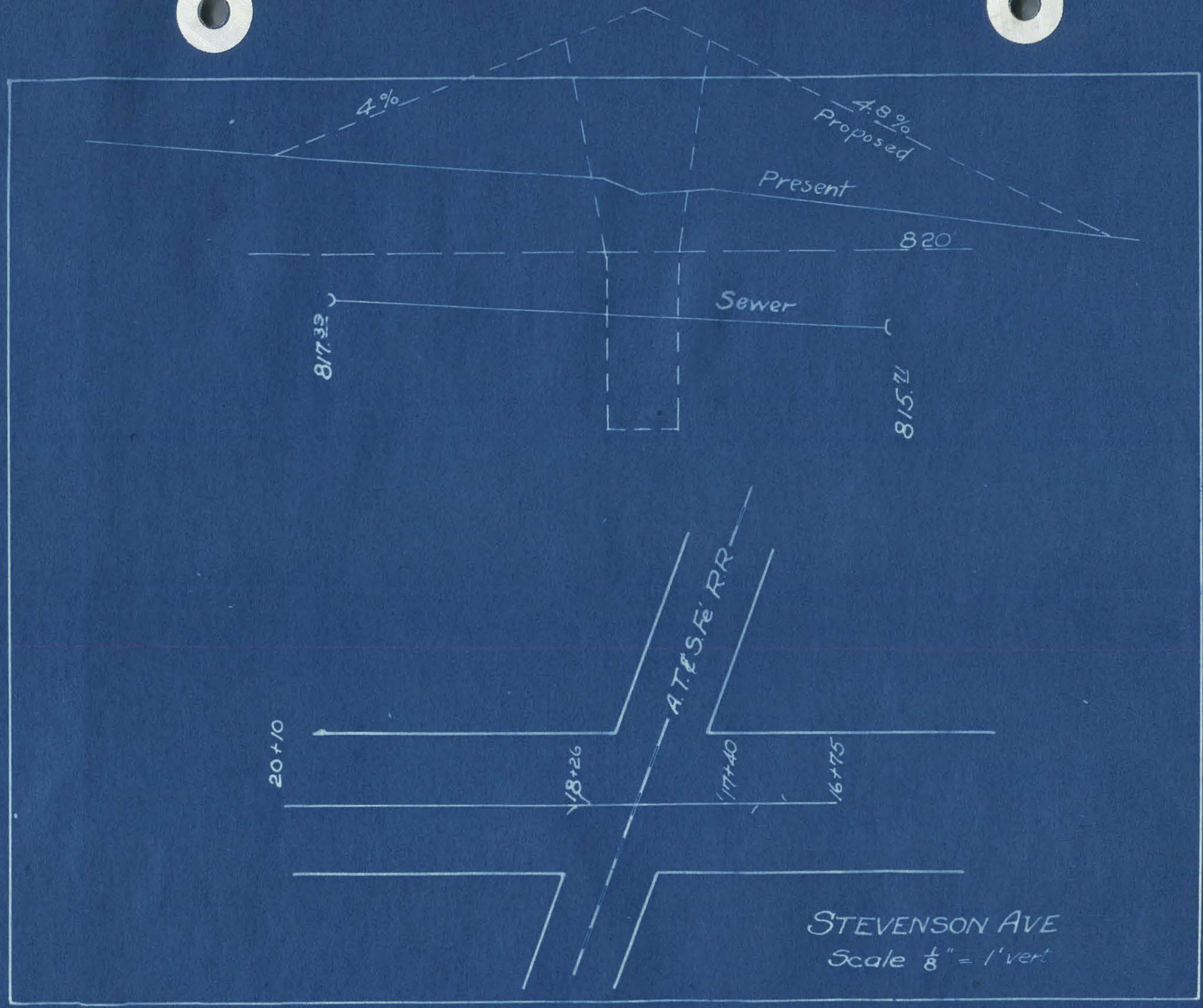


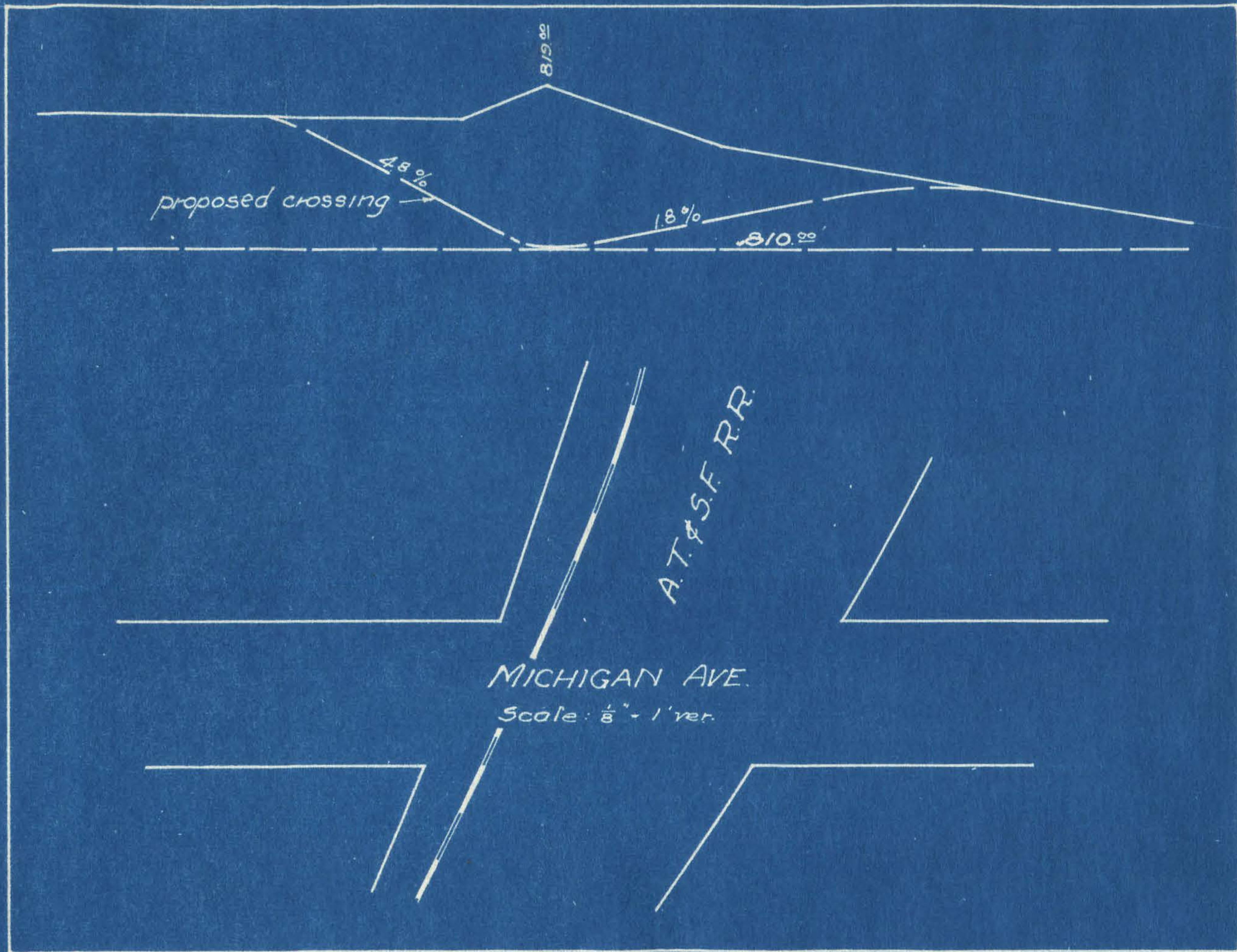
810.46
813.20
809.40
810'
2.65%
2.3%
℄ proposed crossing
A.T.&S.F.R.R.
CHESTER AVE.
Scale: 1/8" = 1' ver.
Note: Sewer not intercepted by proposed cut.

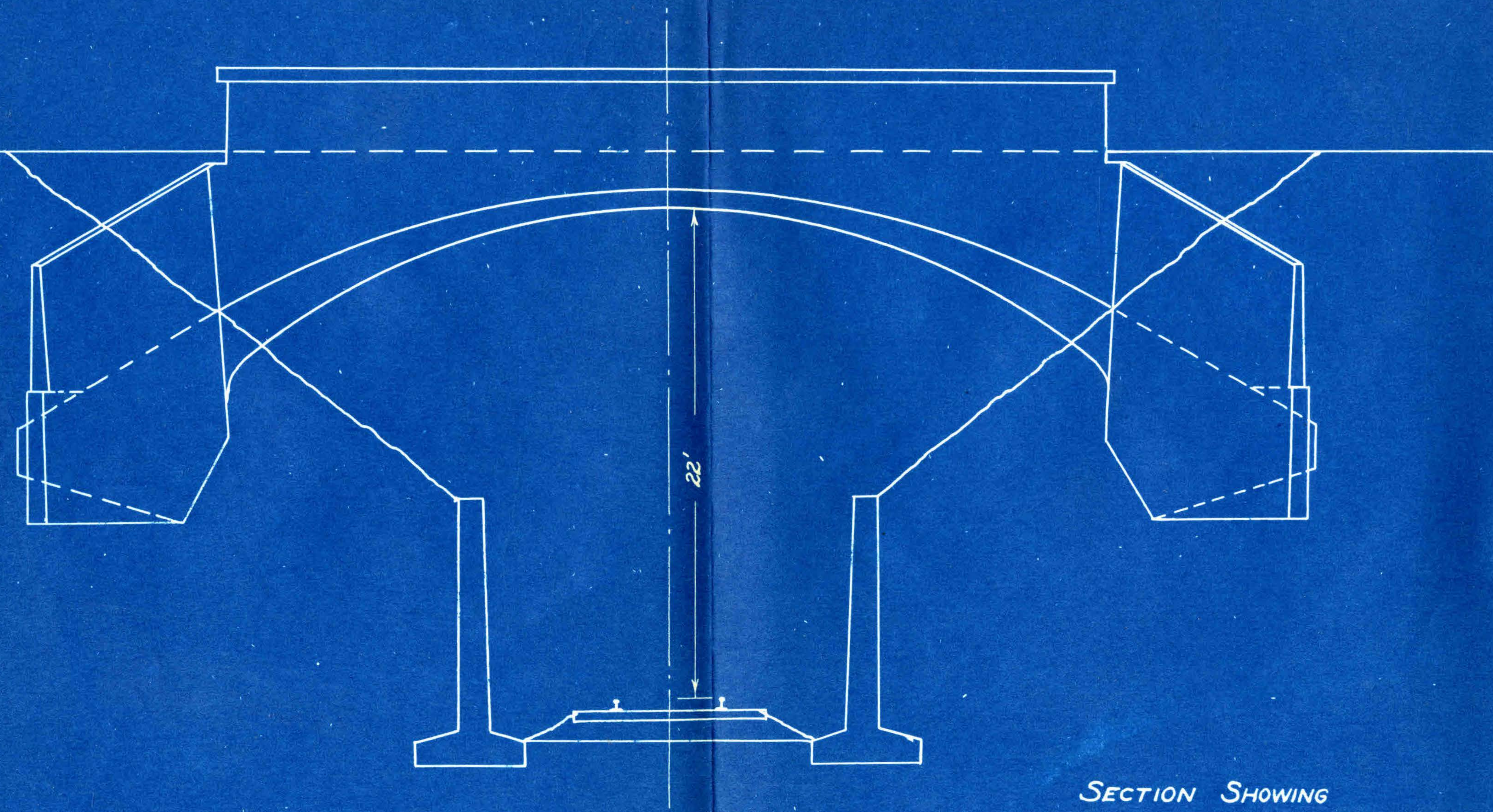


807.75
29%
6%
proposed crossing
800'
A.T.&S.F. R.R.
60'
60'
HOLLISTON AVE
Scale: 1/8" - 1' vert.
Note: Sewer not intercepted by cut-

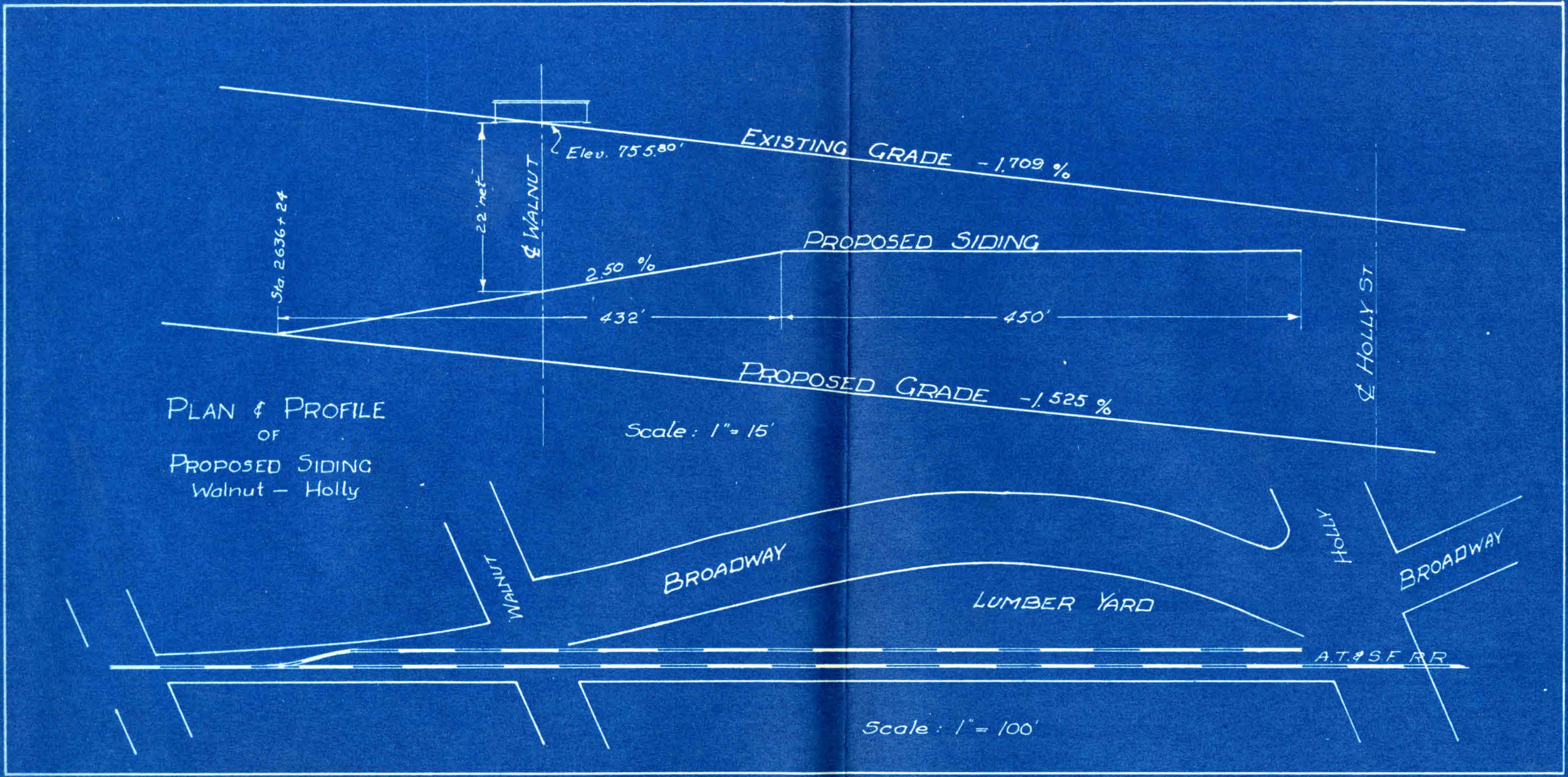

830'
Sewer
A.T.&S.F. R.R.
MAPLE ST.
23+49.20
20+15
19+68
19+48
16+74.60
LOCUST
CATALINA AVE
Scale: 1/8" = 1' ver.


4%
4.8%
Proposed
Present
820'
Sewer
817.33
815.71
A.T.&S.Fe R.R.
20+10
18+26
17+40
16+75
STEVENSON AVE
Scale 1/8" = 1' vert


819.00
4.8 %
proposed crossing
1.8 %
810.00
A.T.&S.F. R.R.
MICHIGAN AVE.
Scale: 1/8" - 1' ver.



SECTION SHOWING
TYPICAL CUT AT INTERSECTION.
Scale, 1"=5' Drawn by Ed. Browder.


PLAN & PROFILE
OF
PROPOSED SIDING
Walnut – Holly
EXISTING GRADE -1.709 %
Elev. 755.80'
22' net
℄ WALNUT
Sta. 2636+24
2.50 %
PROPOSED SIDING
432'
450'
℄ HOLLY ST.
PROPOSED GRADE -1.525 %
Scale: 1" = 15'
WALNUT
BROADWAY
HOLLY
BROADWAY
LUMBER YARD
A.T.& S.F. R.R.
Scale: 1" = 100'