A DESIGN FOR A SEWAGE TREATMENT PLANT FOR THE TOWN OF ELK RAPIDS, MICHIGAN

Thesis for the Degree of B. S.

MICHIGAN STATE COLLEGE

Paul T. Spelman—Raymond J. Kostecke

1949

SUPPLEMENTARY MATERIAL IN BACK OF BOOK

A Design for a Sewage Treatment Plant for the Town of Elk Rapids, Michigan

A Thesis Submitted to

The Faculty of

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of

AGRICULTURE AND APPLIED SCIENCE

by

Paul T. Spelman   Raymond J. Kostecke

Candidates for the Degree of

Bachelor of Science

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The authors wish to express their appreciation for the helpful advice and assistance of; Professor Frank R. Theroux and Professor Alfred Harle Leigh.

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Illustrations found in folder on back cover.

INTRODUCTION

The village of Elk Rapids Michigan, located in Antrim county in the north east section of the lower peninsula, has been in need of a sewage treatment plant for many years. The present wastes emptying into the east arm of Grand Traverse Bay contaminate over 2 miles of public sandy beach. This condition has forced the village health authorities to abandon the beautiful beach in front of the village pa rk. The public bathing beach had to be located well over a mile up the bay.

The village is adverse to letting any industry, small or large, operate there. They would rather depend on tourist business for their livelihood than rely on other means. The existance of a desire for their type of business and an existence of a contaminated public beach is an inconsistancy. The petty jealousy and strong desire to block progress on the part of the younger inhabitants tends to prevent the development of any industries. Therefore, to exist they need the tourists and to keep the tourists they need adequate sewage treatment.

With this in mind we decided to undertake the design of a treatment plant. The winter population is but 700. Knowing the attitude of the town, we do not expect this number to grow, more probably it will decrease. The summer population is 1500. This number has been increasing ever since 1920. This increase has not been uniform. There was a big spurt in 1929 and again in 1946. We estimate the probable maximum population for the next 20 years at 2500 in the summer months.

In arriving at our design constants we looked into the water supply records. There is an average of 127,000 g.p.d. for the winter months. This would give about 180 gallons per capita per day. The piping in the system is old, so considering the high wastage and leakage the figure isn't too far out of line. The summer water records are of no value. With lawn sprinkling, cemetary sprinkling and 200,000 gallons per day to the cannery we could arrive at no definite amount that would enter the sewage system. A value was assumed of 100 gallons per capita per day, or 250,000 gal. per day.

To obtain B.O.D. values, samples taken from the present line would be of no value. The lines serve but 500 and the rate of infiltration more than equals the volume of the sewage. (Town Engineer's statement). Since the remaining lines will be new we expect very little infiltration. We took an average value of B.O.D. from 70 cities having a system and whose lines were less than 5 years old. The value of 200 p.p.m. B.O.D. was reached in this manner. A value of 200 p.p.m. was taken.

Allowance was made for the eventual introduction of a line from the eastern section of the village. The depth of the wet well will allow a drop of 6 ft. from the east side to the plant. Transite pipe will be used to maintain a good velocity flow to the plant.

Manholes and Interceptor Lines

The total sewage coming into our plant will be 250,000 gallons per day (G.P.D.). The west side of the village has 75% of the existing population. We do not believe this will change. The west side will therefore contribute 75% of the sewage or .75 x 250,000 = 187,000 G.P.D..

The maximum flow expected will be 175% of the average because there are storm drains connected to the present system and during canning season the cherry pit wastes will enter the plant. 1.75 x 187,000 = 328,000 G.P.D. maximum. 328,000 ÷ 24 x 60 x 60 x 7.5 = .508 cu. ft. per sec. at max. flow.

Refering to the map, we numbered the existing lines (1) to (3). No.one (1) being the westermost line and number three (3) being the line coming from the block in front of the plant. The old line running from the cannery is to remain undisturbed. The cannery has ceased operating and will be removed soon.

Line # 1 will carry 20% of the west side total flow, or .20 x .508 = .102 cu. ft. per sec.. Line # 2 will carry 75% of total west side flow or, .75 x .508 = .38 cu. ft. per sec.. Line # 3 will carry 5% of total flow or, .05 x .508 = .025 cu. ft. per sec.. These figures are based on assumed No. of people to be served.

At the present time all three lines empty directly into the river so special intercepter lines had to be installed to carry the sewer to the treatment plant.

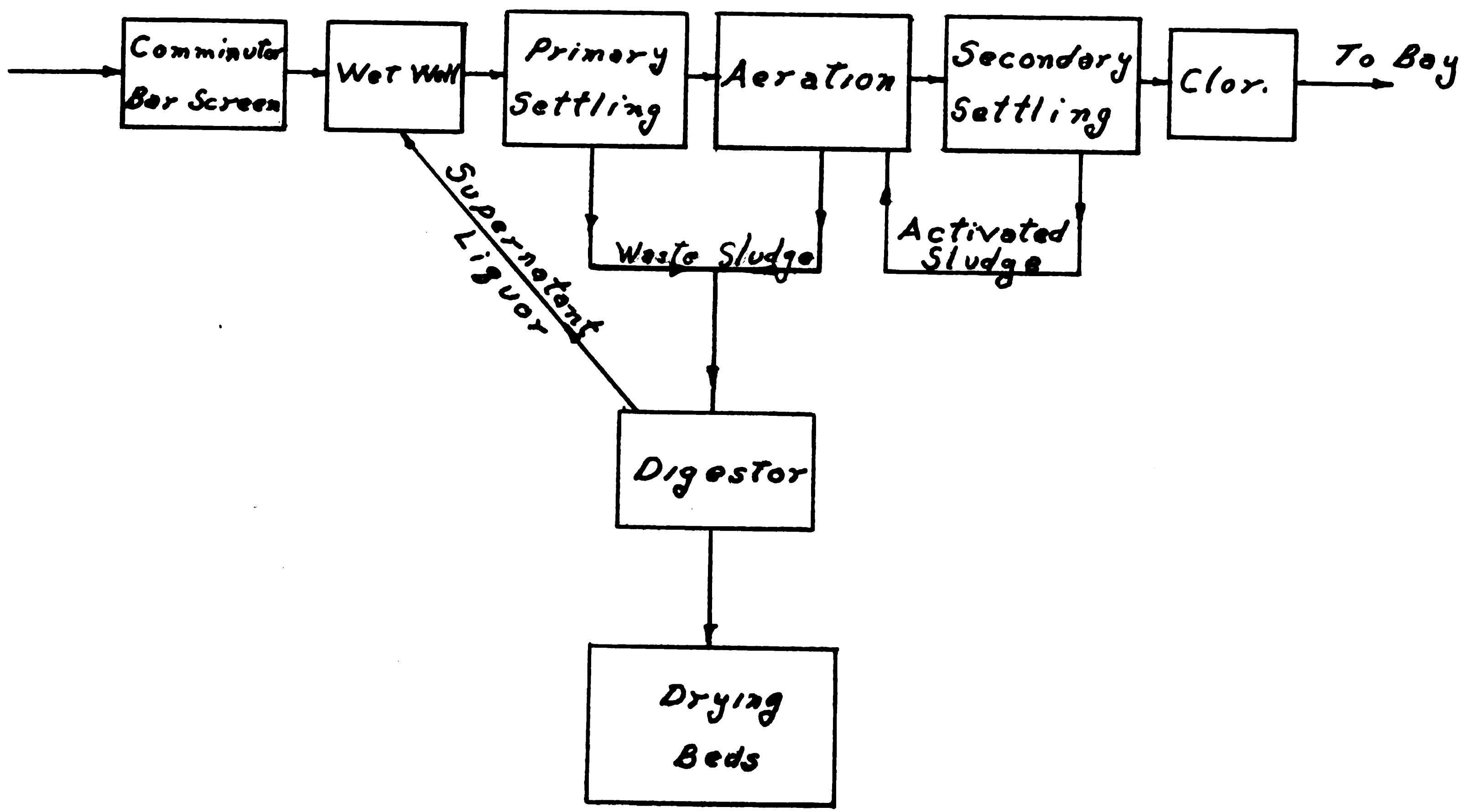
Intercept line one (1) 200 ft. southwest of its outlet. The invert elevation of the intersection will be 585 ft. The lead off pipe leaving manhole # 2 and going toward manhole # 3 will be an 8 inch pipe. The velocity when flowing full at a slope of .006 will be 2.6 ft. per sec.. The vol. when full is .9 cu. ft. per sec.. At .102 cu. ft. per sec. the velocity is 1.3 ft. per sec.. Distance to line # 2 is 315 ft. and the invert drop is 1.88 ft. Bearing from manhole # 2 to manhole # 3 is 77° 30' NE.

The 8 inch pipe enters manhole # 3 at an invert elevation of 583.11 ft.. The exit elevation of a 10 inch pipe is 583.01 ft.. The 10 inch pipe will have a slope of .008, a capacity of 1.9 cu. ft. per sec., velocity of 3.7 ft. per sec.. With a flow of .38 cu. ft. per sec., the velocity will be 2.75 ft. per sec.. Invert drop to diversion manhole is 3.2 ft. Distance to manhole # 4 is 400 ft.. Bearing is N 52° 15' E. Manhole # 4, entering invert 579.81 ft. and exit invert 579.81ft.

A special shut-off valve will be employed in manhole # 4 to divert the flow into the bay in case of a break down at the disposal plant.

Distance from manhole # 4 to wet well is 230 ft.. A 10-inch pipe will be used with a slope of .008. The vel. of a .815 cu. ft. per sec. flow is 2.8 ft. per sec. Invert at comminutor is 576.76 ft. A Chicago pump comminutor and by-pass bar screen is to be used before wet well. (See drawing of flow diagram on following page).

FLOW DIAGRAM



sludge. Figuring a draw off of twice a day we have 25 gal. of raw sludge. 25 gal. @ 95 % water = 500 gal.. 500 ÷ 7.5 = 66.7 cu. ft.

Area of sludge hoppers (detailed in primary section) is 84.5 cu. ft.. This will allow twice a day draw off during summer and once a day during the winter months.

Secondary Settling

Secondary settling is accomplished in the aeration tank. The accompanying bulleten of the Chicago Pump Co goes into detail concerning their features.

Aeration Tank

After checking various types of aeration tanks we decided to use a Chicago Combination Aerator-Clarifier. This combination has been proven to be the most economical and efficient, with B.O.D. reductions as high as 98 %. This efficiency was of prime concern because the effluent from the clarifier is emptied into the bay on which is located a public bathing beach.

Two concrete tanks 25 ft. wide by 25 ft. long by 13 ft. 6 inches deep will be used as specified in "Bulletin 128-kl Chicago Pump Co." (Copy of the bulletin is attached) The maximum allowable flow rate through each clarifier in one day is 235,000 gal.

Clorination Tank

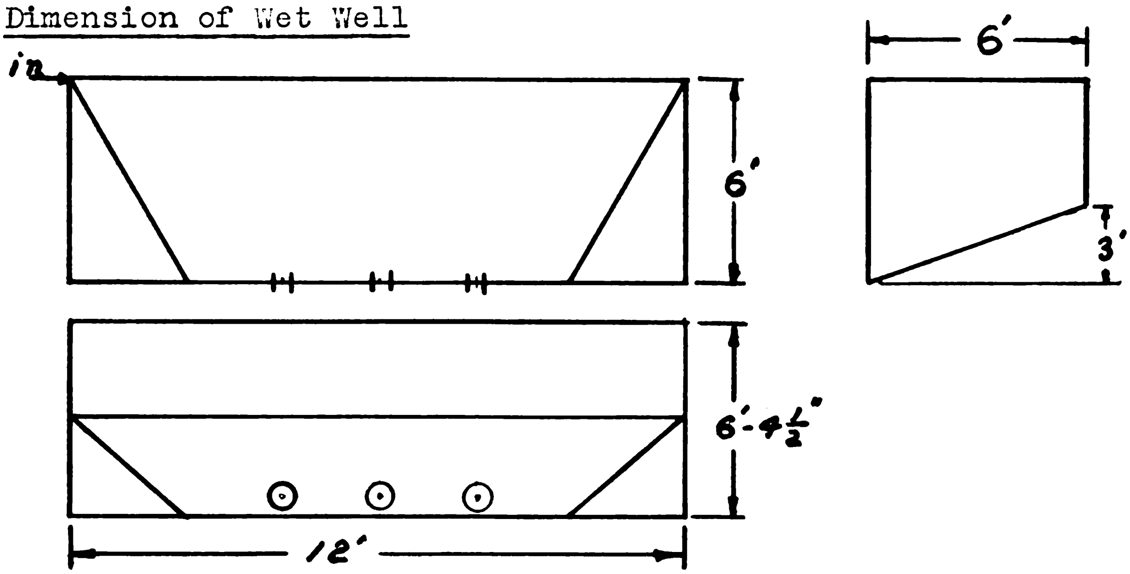
The volume of the clorination tank was found by a 20 minute detention period; V = .508 x 60 x 20 = 666 cu. ft. A tank 10 ft. long by 7 ft. wide by 11 ft. 9 inches deep.

Wet Well

Average flow = 10,400 gal. per hr.. Max. = 18,250 gal. per hr.. 8 min. flow = 18,250 x 8 ÷ 7.5 x 60 = 324 cu. ft.. The wet well will be pumped every 8 min. at a maximum flow. The volume of the wet well will be 18,250 x 8 ÷ 7.5 x 60 = 324 cu. ft..

The pumps are to pump for 10 min. and will pump a total of 730 cu. ft., or 73 cu. ft. per min., or 550 gal. per min. against a head of 17 ft.. Two Yeomans 6MS4 @ 5 H.P. each will be used alternately to pump the sewer from the wet well. Six-inch cast iron pipes may be used to primary amd 4-inch pipes for the rest of the system.

Dimension of Wet Well



Primary Settling Tank

Suspended solids = 200 P.P.M. Detention period of 1.5 hours for average daily flow. 250,000 x 1.5 ÷ 24 x 7.5 = 2080 cu. ft.. Tank size = 19 ft. long x 10 ft. wide x 11 ft. deep = 2090 cu. ft.. Detention time for maximum flow = .86 hours. Volume of raw sludge @ 200 P.P.M. = 50 gal. raw

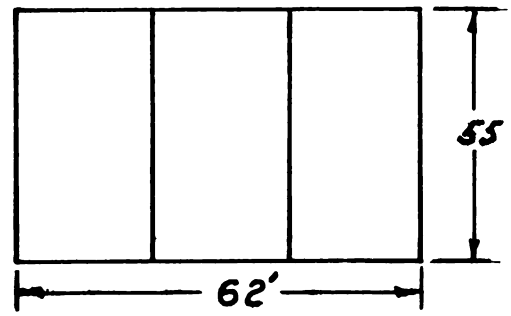
Digestor

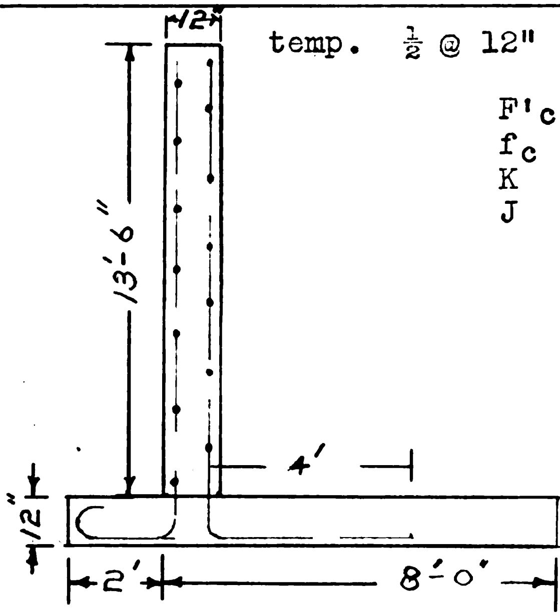
To make the appearance of the sewer treatment plant symetrical, and to utilize the west side of the digestor as one wall of the proposed fire house, we decided to design a rectangular shaped digestor. Many problems were encountered in the design of the digester tank walls. However, after experimenting with various methods of design, we decided that the most economical would be to design the walls as cantilever walls. The tank was designed for capacity of 6 cu. ft. per capita. The tanks size is 26 ft. long by 25 ft. wide by 23 ft. deep giving a total volume of 15,000 cu. ft.. This is exactly what is needed to supply 6 cu. ft. per capita. 2500 x 6 = 15,000 cu. ft..

Sludge Drying Beds

The minimum area required per person for the sludge drying beds is about .5 sq. ft. per capita. (Water Supply and Sewage by Steel) We decided to be on the safe side and use an area of 1.3 sq. ft. per capita. The area needed will be, 2500 x 1.3 = 3300 sq. ft.. The size of the drying beds will be 55 ft. by 62 ft. giving us a total area of 3420 sq. ft..

Dimension of Sludge Drying Beds





temp. ½ @ 12"

F'_c = 3000 psi.
f_c = 1800 psi.
K = 359
J = .842

Temp. Steel ½" ϕ @ 12"

Internal Pressure

$$\frac{13.5 \times 62.4}{2} \times 13.5 = 5{,}700 \ \#$$

$$M = 5{,}700 \times \frac{13.5}{3} \times 12 = 306{,}000 \text{ in-lbs.}$$

$$d = \frac{306{,}000}{359 \times 12} = 8.4\text{ " say } 9\text{ "}$$

$$A_s = \frac{306{,}000}{20{,}000 \times .842 \times 9} = 2.02 \text{ sq. in.}$$

Use 1" ϕ @ 4" c/c A_s = 2.37 = 9.4 in. 1" ϕ @ 4" c/c

$$v = \frac{5{,}700}{12 \times .842 \times 9} = 62.5 > 60$$

but o.k.

$$u = \frac{5{,}700}{9.4 \times 9 \times .842} = 80 < 150 \quad \text{o.k.}$$

Reduce to 1" ϕ @ 8" c/c 6' from top

Check u 10' from top. S_s = 3120 #

$$u = \frac{3120}{4.7 \times 9 \times .842} = 88 < 150 \quad \text{o.k.}$$

Check u 8' from the top S_s = 1950 #

$$u = \frac{1950}{2.35 \times 9 \times .842} = 110 < 150 \quad \text{o.k.}$$

Reduce to 1" ϕ @ 16" 4' from top

External Steel

$P' = \frac{13.5 \times 100}{2} \times .28 \times 13.5 = 2560$ #

$P'' = 62.4 \times \frac{5}{2} \times 5 = 780$ #

Sheer = 3,340 #

M = (3,340 x 13.5 + 780 x 1.67) 12

= 195,600 in. lbs.

$A_s = \frac{195,600}{20,000 \times 9 \times .842} = 1.29$ sq. in.

Use 3/4" o @ 4" c/c $A_s = 1.32$ $\Sigma_o = 7.1$ — 3/4" ø 4" c/c

$u = \frac{195,600}{7.1 \times 9 \times .842} = 37 < 150$ o.k.

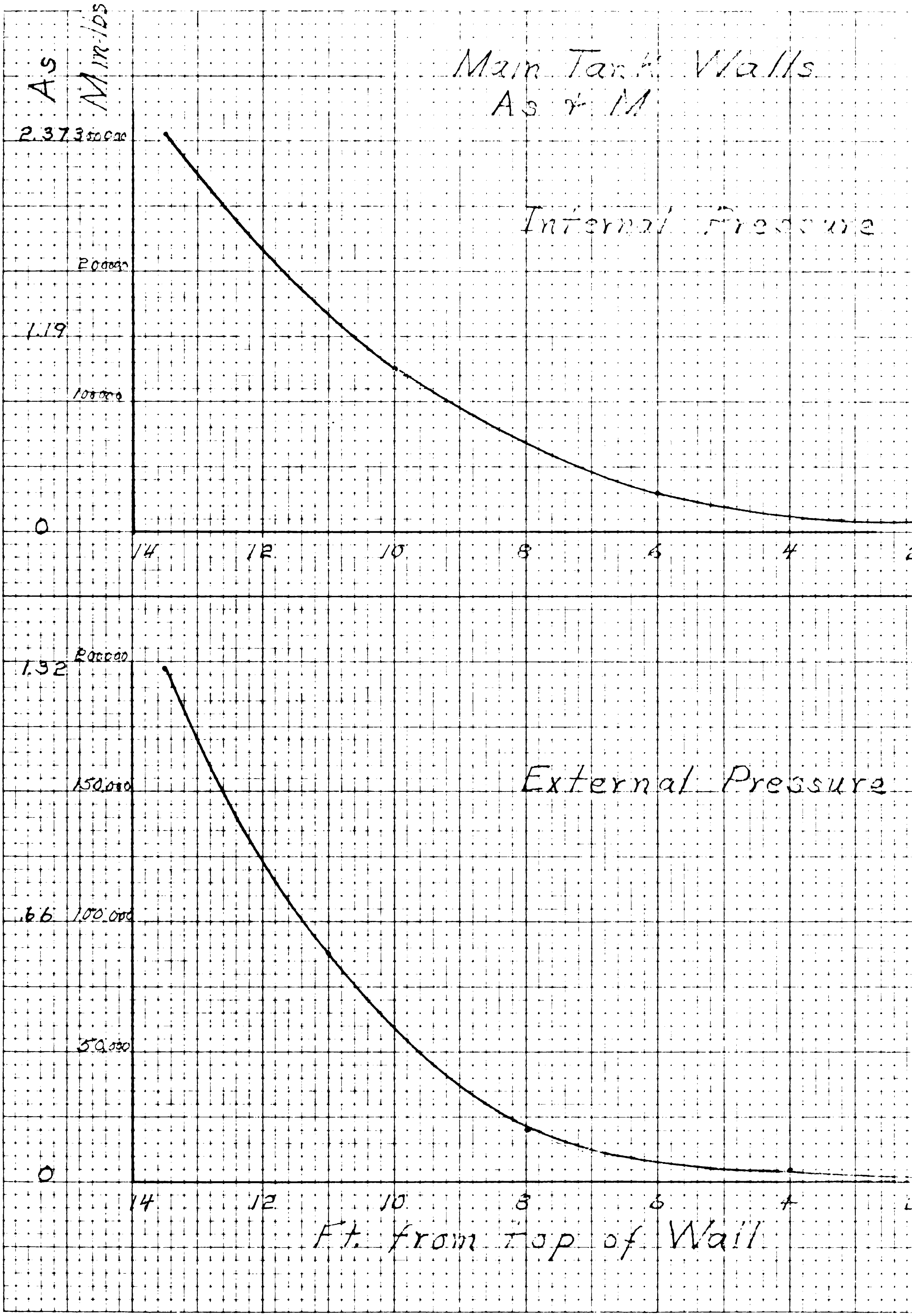
Check u 11 ft. from the top.

$u = \frac{1895}{3.6 \times 9 \times .842} = 70$ o.k. — Reduce to 3/4" @ 8" 8' from top

Check u 9 ft. from the top.

$u = \frac{1140}{1.8 \times 9 \times .842} = 84$ o.k. — Reduce to 3/4" @ 16" 6' from top

Walls having water on each side will have internal reinforcement on each side.



Main Tank Walls
As + M
As
M in-lbs
Internal Pressure
2.373
300000
200000
1.19
100000
0
14
12
10
8
6
4
2
External Pressure
1.32
200000
150000
.66
100000
50000
0
14
12
10
8
6
4
2
Ft. from Top of Wall

Complete drawing of the primary tank will be found on seperate sheet in folder in back of book.

Effluent, influent, scum troughs and sludge hopper sketches will be found on the following sheets.

Base to be 9" thick with a 3/4" ø @ 6" mesh located midway in slab. Hook into sidewalls, extend up into wall by waste sludge pit and bend down under wall by clorination chamber.

Walls to have steel the same as all main walls. This steel is used to resist internal and external pressure.

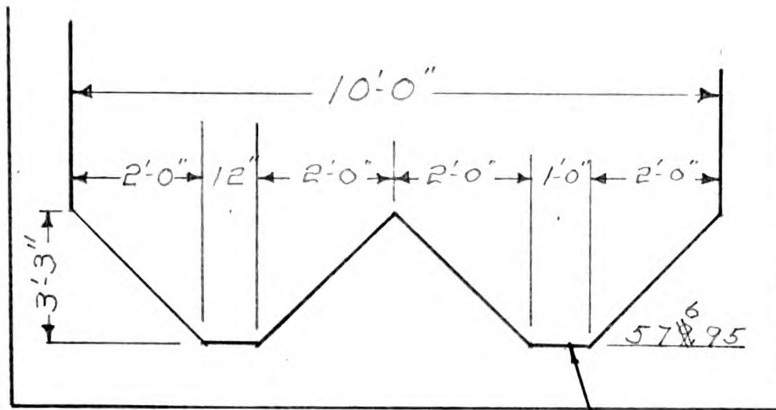
Provide sludge and scum removing mechanism.

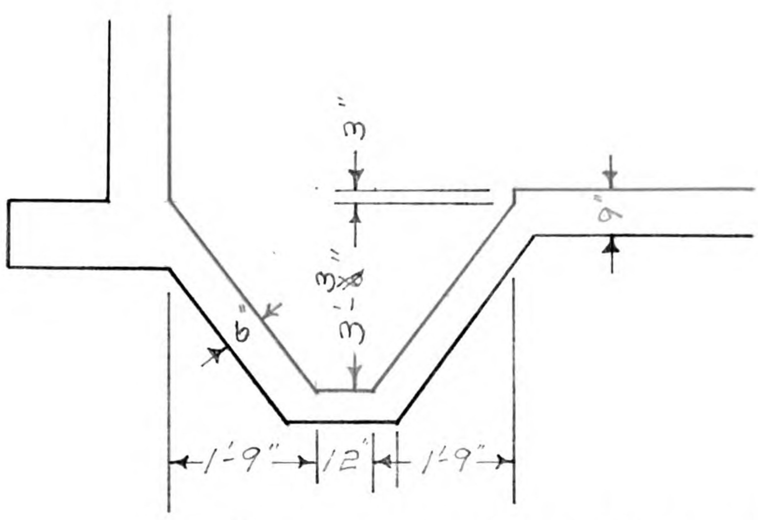
Provide pop off valve set to let go 300 lbs. per sq. ft..

Detention period of 1.5 hrs. of average daily flow.

$$\frac{250,000}{24} \times \frac{1.5}{7.5} = 2080 \text{ cu. ft.}$$

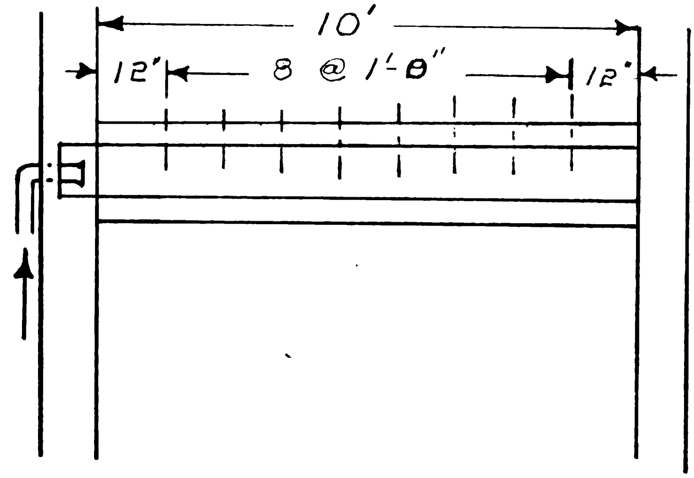
Tank size: 19 ft. long by 10 ft. wide by 11 ft. deep = 2090 cu. ft. o.k.

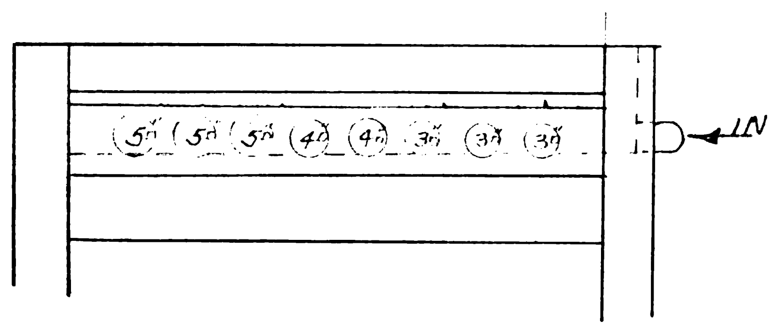


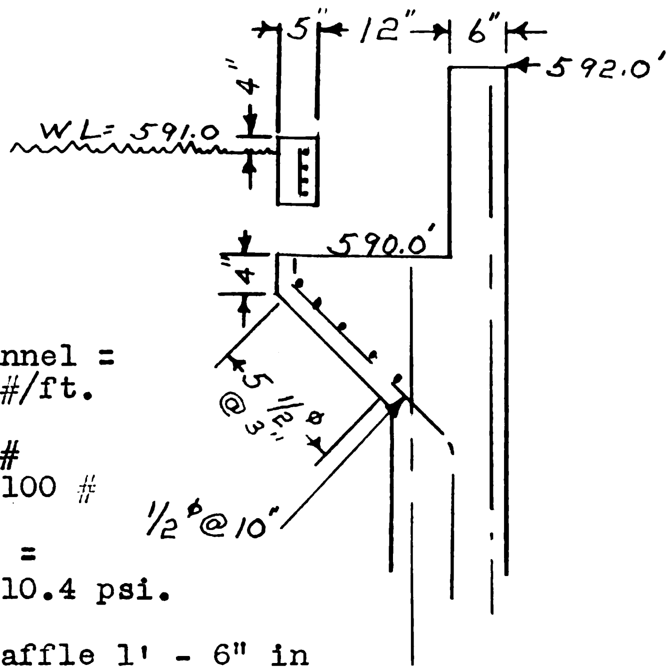


Sludge Hopper - Draw off to be regulated by operator.

PRIMARY INFLUENT CHANNEL — Sheet W-1







Total wt. of channel =
161 x 150 = 350 #/ft.

350 x 12 = 4200 #
Wt. per wall = 2100 #

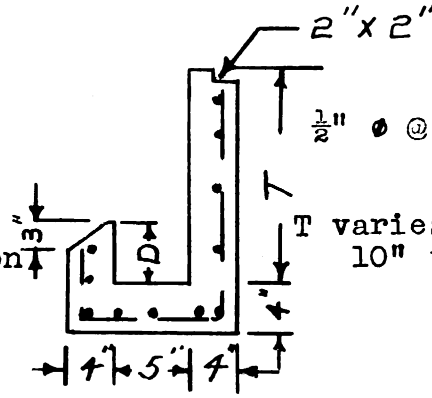
Unit wt. at wall =
2100 ÷ 12 x17 = 10.4 psi.

Provide wooden baffle 1' - 6" in front of openings.

Data

place 5 3/4" ϕ @ 4"c/c in each wall opp trough to take care of mom. place on side away from trough bent 3' into trough

Data



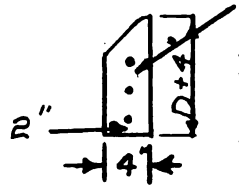
$\frac{1}{2}$" ø @ 12".

Increase "D" from 2" to 6" in flow direction

T varies from 10" to 14"

Design as 3 different beams:

Beam "A"



3-$\frac{1}{2}$" @ 1$\frac{1}{2}$" c/c/

$M = 1/8\ WL^2 = \frac{30}{8} \times 144 \times 12 = 6500$ in.#

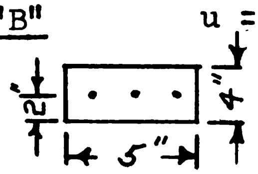
$A_s = \frac{6500}{20{,}000 \times .866 \times 5} = .065$ sq. in.

$v = 360 \div 4 \times .866 \times 5 = 15$ o.k.

Data: 3 $\frac{1}{2}$" ø @ 1$\frac{1}{2}$" c/c

Beam "B"

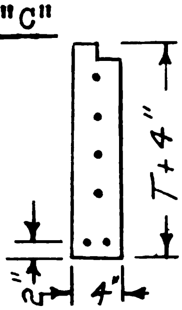
$u = 360 \div 1.6 \times 5 \times .866 = 36$ o.k.



$M = 1/8\ WL^2 = \frac{30}{8} \times 144 \times 12 = 6500$ in.#

$A_s = \frac{6500}{20{,}000 \times .866 \times 2.5} = 1.5$ sq. in.

Beam "C"



$M = 1/8\ WL^2 = \frac{280}{8} \times 144 \times 12 = 48{,}300$ in. #

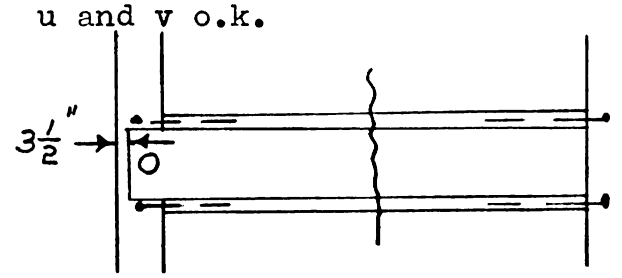
$A_s = \frac{48{,}300}{20{,}000 \times .866 \times 12} = .232$ sq. in.

Use 3/4" ø @ 2 3/4" c/c

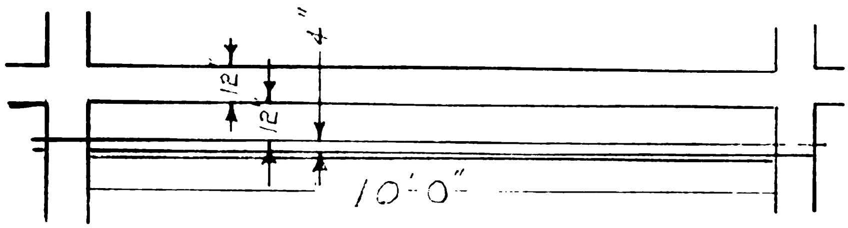
Data: 3 $\frac{1}{2}$" ø @ 1$\frac{1}{2}$" c/c

u and v o.k.

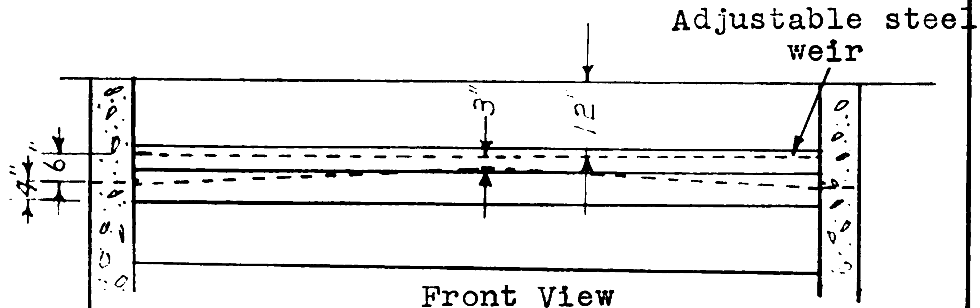
Data: 2 3/4" ø @ 5" in wall opp trough for mpm bend in to trough 3 ft.



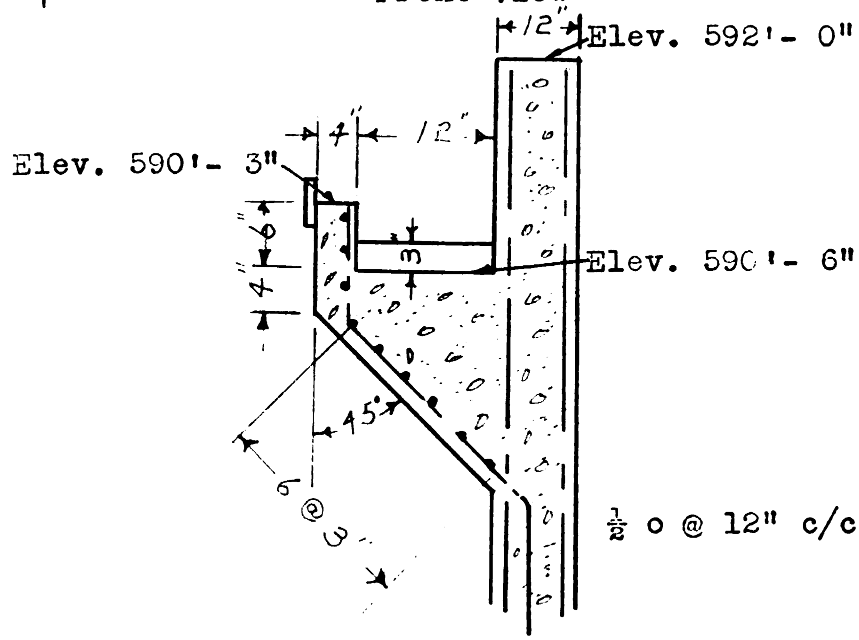
PRIMARY EFFLUENT CHANNEL Sheet W-1



Top View



Front View



Side View

u and v o.k.

Provide 2' anchorage in wall for all ½" ø bars.

½" øas noted

4-3/4" ø @ 4"c/c in wall away from the trough bend 3' into trough

AERATOR AND CLARIFIER	Sheet W-1

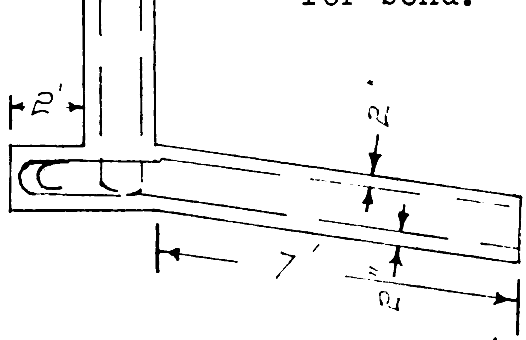
	Data

Interior size = 25' x 25'

Dimension to follow specifications of manufacturer (Chicago Pump).

Walls - 1 ft. thick. Steel as prescribed in "Wall Steel" on sheets preceeding.

Base - 6" slab 3/8" x 4" mesh- add 3/4" ⌀ @ 6" to 5' sq. center. Extend 3' for bond.



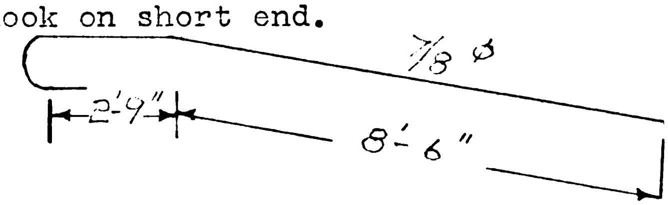
Bendup every 3/4" ⌀ as shown.

3/4" ⌀ @ 6"c/c

7/8" ⌀ 9" c/c

To top of base slab add 7/8" ⌀ @ 9" c/c.

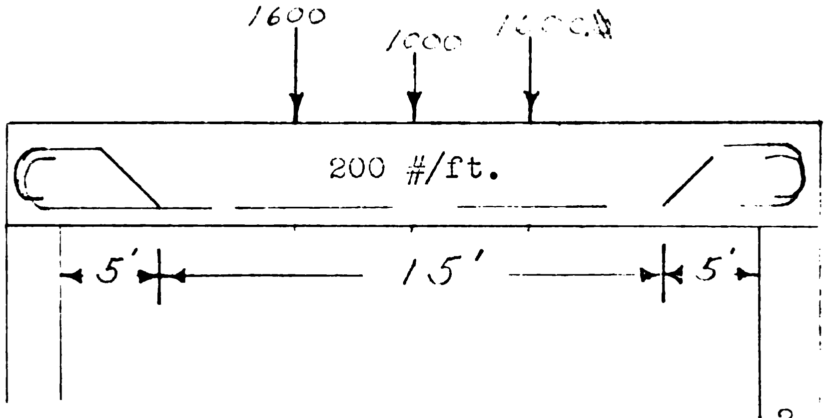
Extend 3'-6" beyond deflection point and hook on short end.



To bottom of base slab extend steel resisting external pressure 3' beyond deflection point or 8' from wall.

Provide releif valve to go @ 300 p.s.f.

AERATOR SUPPORT BEAM Sheet W-1



$M = 13.5 \times 4800 - 4 \times 1600 - 200 \times \frac{13.5^2}{2} \times 12$

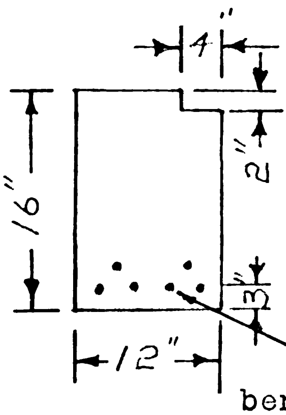
$= 482,400$ in. lbs.

Assume b = 12 $d = (482,400 \div 236 \times 12)^{\frac{1}{2}}$
$= 13"$

$v = 4800 \div 13 \times 12 \times .866 = 36$ o.k.

$A_s = \frac{482,400}{20,000 \times 13 \times .866} = 2.14$ sq. in. Use 6-3/4" ⌀ A_s = 2.14

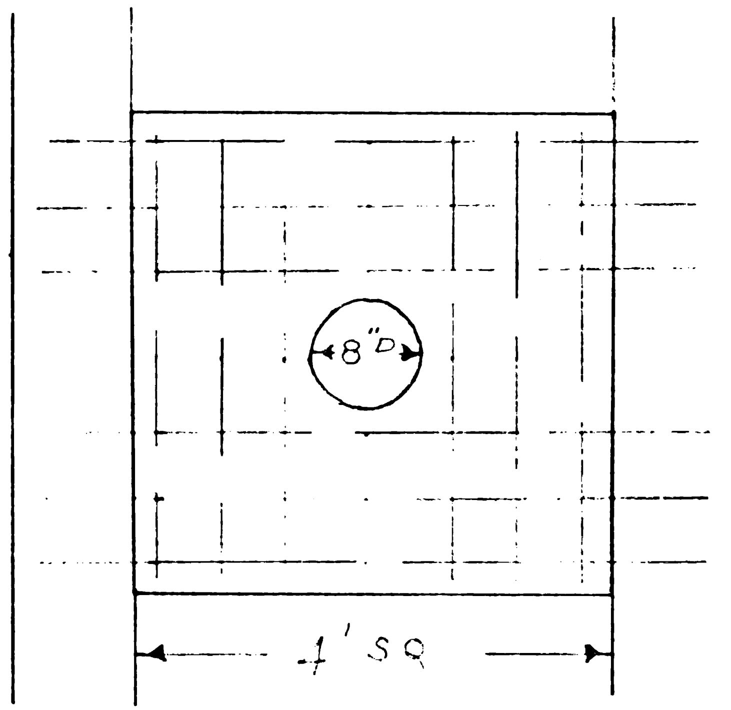
$u = \frac{4800}{14.1 \times 13 \times .866} = 30$ o.k.



6-3/4" ⌀ bars
bend up top 2 5' from wall.
carry over and hook over
support wall

Data
6-3/4" ⌀
6-3/4" ⌀ bars
4-3" c/c
2-6" c/c

Data



Concret slab in center to support a load of 1000 lbs.

$M = 1000 \times 2 + 300 \times \frac{16}{8} = 2600$ ft. lbs.

$d = (2600 \times 12 \div 236 \times 40)^{\frac{1}{2}} = 2.1$ say 4"

$A_s = \frac{26,000 \times 12}{20,000 \times .866 \times 4} = .45$ sq. in.

Use ½" φ bars spaced at 6" c/c from each end. 2-rows both ways.

$v = \frac{800}{40 \times .866 \times 4} = 8$ psi. o.k.

$u = \frac{800}{9.6 \times .866 \times 4} = 33$ psi. o.k.

Bearing Pressure on walls caused by the

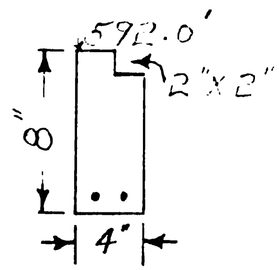
two beams $= \frac{4800}{12 \times 12} = 33$ psi. o.k.

6-½" φ bars 3 each side of hole hook those going into beam

Effluent weir to be the same as in primary tank. The exit opening will be in the center of the back wall. Trough will slope from sedes to center.

5" down at end drop 3" per side to 16" flat

Beam to support grating use 4 x 8" beam.



Dead wt.	=	34 lbs.
Grate	=	175 "
L.L.	=	50 "
Total	=	159 lbs./ft.

liqid elev 590.0'

$$M = 1/8\ WL^2 = \frac{159 \times 12^2 \times 12}{8} = 34{,}400 \text{ in. \#}$$

$$A_s = \frac{34{,}400}{20{,}000 \times .866 \times 6} = .33 \text{ sq. in.}$$

2-½" ∅ bars @ 1½" c/c

$$v = \frac{1910}{.866 \times 6 \times 42} = 46 \text{ psi. o.k.}$$

$$u = \frac{1910}{2 \times .866 \times 6 \times 3.1} = 59 \text{ psi. o.k.}$$

Final effluent shall drop into a 16" x 16" well. The sides of the well will have steel plates projecting 7" out apaced at 16". The well walls shall be concrete blocks. Anchors will be provided in concrete wall.

The clorination by pass shall consist of 2 pipes the same size as the clarifier effluent pipe. Both shall lead directly to the effluent well and shall be connected to the clarifier effluent pipe by a B.F. Goodrich flexible rubber connector.

The pipes in the clorination tank shall be coated with a acid resistant material.

The clorination tank was designed for a 20 min detention.

The size of the tank is:

$$\frac{250,000}{24} \times \frac{.33}{7.5} \times 1.35 = 620 \text{ cu. ft.}$$

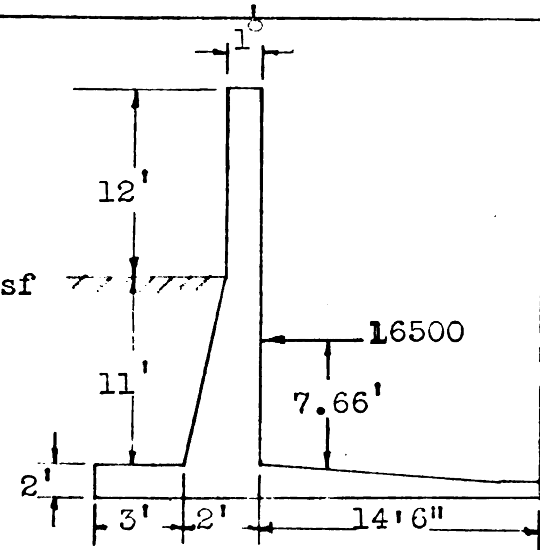
Make the tank 12' wide x 9' long x 11' deep.

In all walls use main wall steel. All walls are 12" thick.

Base is 12" thick. Place steel same as aerator clarifier except keep the 3/4" ø 6" c/c , 3" from top of slab. The steel is to run all the way across. Take steel resisting external pressure and run half way across tank to steel from opposite wall. Add sufficient steel to resist wall moments in top and bottom of slab.

3/4" o @ 6" c/c bend down every other bar

Design data		Data
f'_c = 3000 psi		
f_c = 1350 psi		
v_c = 60 psi		
f_s = 18,000 psi		
u = 150 psi		
K = 248		
Soil P. = 5000 psf		



Tank Full

$P = 62.4 \times \frac{23^2}{2} = 16500$ lbs.

$M_{23} = 16500 \times 7.66 \times 12 = 1,516,000$ in.#

$d = \left(\frac{1,516,000}{248 \times 12}\right)^{\frac{1}{2}} = 22.6$ in. say 24 in.

$v = \frac{16500}{12 \times .875 \times 24} = 65$ psi o.k.

$A_s = \frac{1,516,000}{18,000 \times .875 \times 24} = 4.0$ sq. in/ft. — 1 sq in, 3 in c/c

$M_{17} = 62.4 \times \frac{17^3}{6} \times 12 = 613,000$ in #

$A_s = \frac{613,000}{18,000 \times .875 \times 18} = 2.16$ sq. in/ft. — 7/8 ϕ 3 in. c/c

$M_{12} = 62.4 \times \frac{12^3}{6} \times 12 = 216,000$ in. #

$A_s = \frac{216,000}{18,000 \times .875 \times 12} = 1.14$ sq. in/ft. — 5/8 ϕ 3 in. c/c

$M_6 = 62.4 \times 6^2 \times 12 = 27,000$ in. #

$A_s = \frac{27,000}{18,000 \times .875 \times 12} = .143$ sq. in/ft. — 1/4 ϕ 3 in. c/c

$u = \frac{16,500}{16 \times .875 \times 24} = 50$ o.k.

DESIGN OF WALLS FOR DIGESTOR TANK — Sheet W-II

TANK EMPTY:

Data: p_1 = Earth Pressure (Rankine)

p_2 = Water Pressure(External)

$$P_1 = .28 \times 100 \times \frac{10^2}{2} = 1400\ \#$$

$$P_2 = 62.4 \times \frac{5^2}{2} = 780\ \#$$

M_1 = 1400 x 3.33 x 12 = 56,000 in. lbs.

M_2 = 780 x 1.67 x 12 = 15,600 "

Total = 71,600 in lbs.

$$A_s = \frac{71,600}{18,000 \times .866 \times 24} = .190 \text{ sq in/ft.}$$ — ½ ø @ 10" c/c

$$v = \frac{2180}{12 \times .866 \times 24} = 10 \text{ psi. o.k.}$$

$$u = \frac{2180}{1.9 \times .866 \times 24} = 52 \text{ psi. o.k.}$$

Embedment: $L = \frac{18,000}{4 \times 150} = 30$ in. (Hook Bottom & Top)

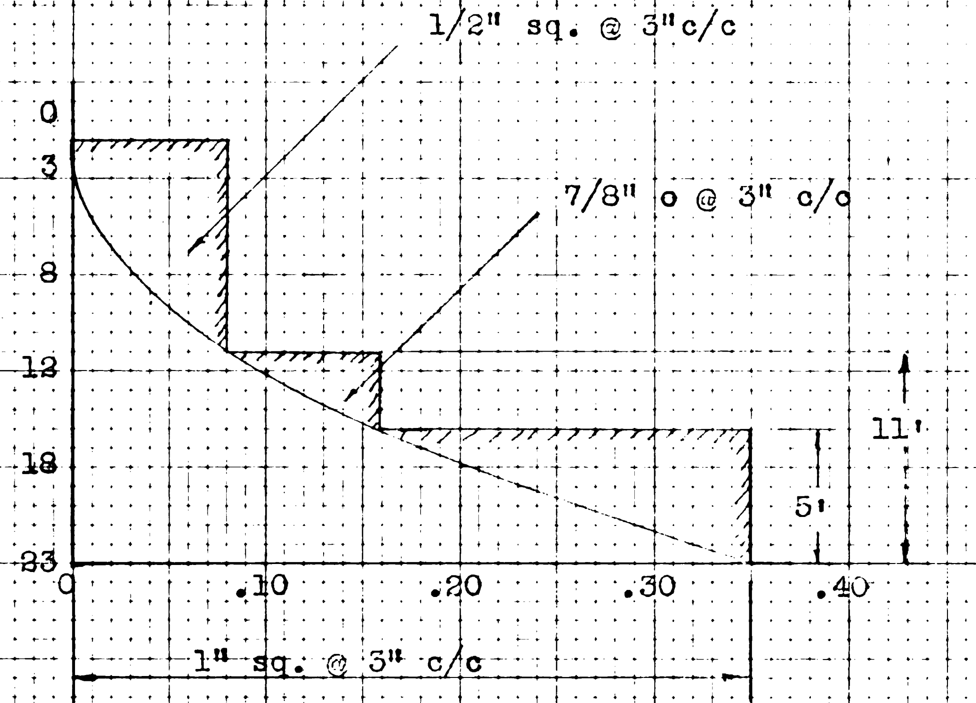
Temperature Steel:
.002 x 12 x 18 = .44 sq. in.

Front: ½ ø @ 9" c/c = .27 sq. in.

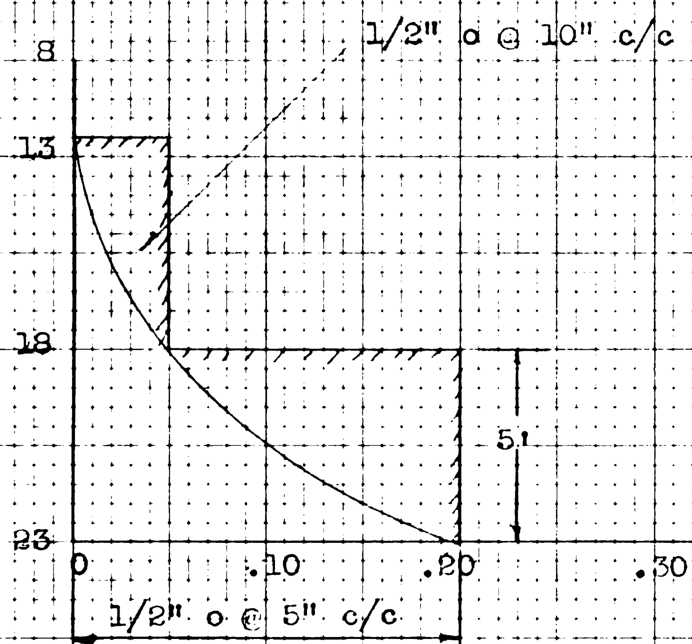
Back : ½ o @ 12" c/c = .20 sq. in.
Total = .47 sq. in. o.k.

Cut off steel as shown on sheets W- III and W- IV.

Steel Data for Digestor Tank:

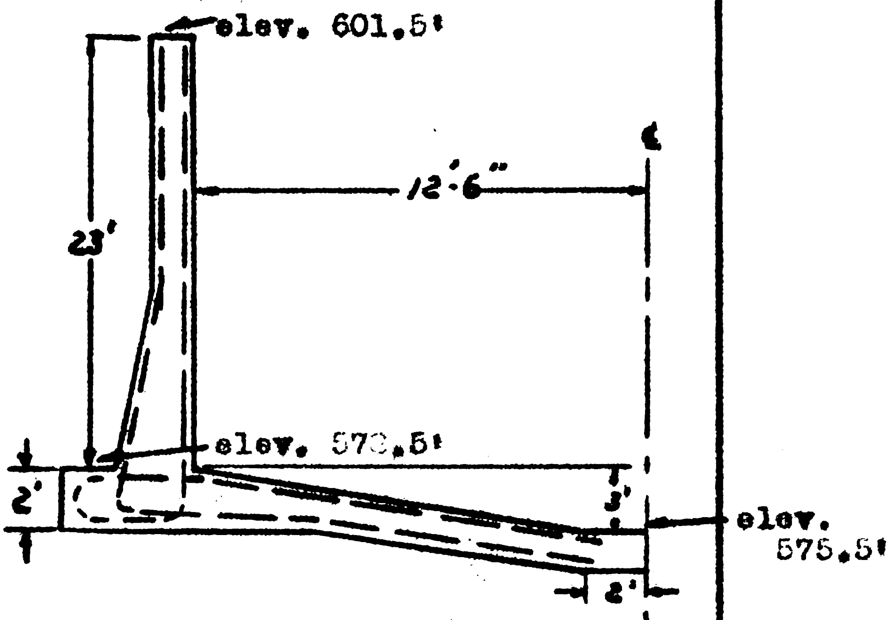


Cutting off Steel For Inside Wall



Cutting off Steel For Outside Wall

Design of Base for Digestor Tank | Sheet W-1



Base steel: Use 1" sq. bars 3" c/c 3" from top of slab. Cut steel to 1" sq. bars 6" c/c 6 ft. from each corner.

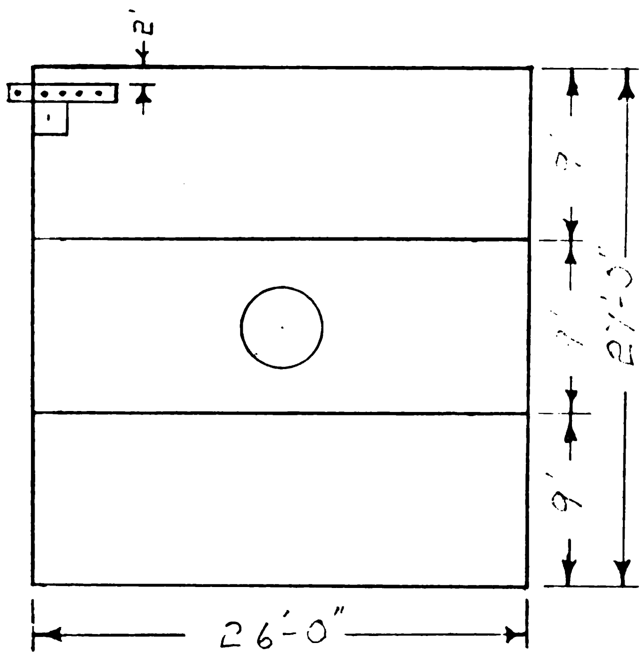
Base is to be 2 ft. thick at the corners, and will taper off to 1 ft., 3 ft. from the corners.

Hook steel as shown.

3" from bottom of base use ½" ø bars @ 10" c/c.

1" sq. @ 3" c/c Reduse to 1" sq. @ 6" c/c 6' from each corner.

Data



Slab 5"	=	62.5	#/sq. ft.
Snow	=	25	"
L.L.	=	50	"
total		137.5	"

Moments using 4" slab.

End span:

Negative = D.L. = 62.5 x 81 x .04 = 202
L.L = 75 x 81 x .04 = 243
M = 445
M = 445 x 12 = 5330 in. lbs.

Positive: D.L. = 62.5 x 81 x .085 = 430
L.L. = 75 x 81 x .105 = 638
M = 1068 x 12 = 12,800 in. lbs.

Mid span:
1st. support: D.L.= 62.5 x 81 x.10 = 505
L.L.= 75 x 81 x .120 = 730

Neg. M = 1235 x 12 = 14,800 in. lbs.

Positive Moment Mid-span:

D.L. = 62.5 x 81 x .03 = 152

L.L. = 75 x 81 x .08 = 485

M = 637 x 12 = 7650 in. lbs.

Steel Slab B:

$$A_s = \frac{7650}{20{,}000 \times .866 \times 2.5} = .177 \text{ sq. in.}$$

$$-A_s = \frac{14{,}800}{20{,}000 \times .866 \times 2.5} = .342 \text{ sq. in.}$$

$$v = \frac{617}{12 \times 2.5 \times .866} = 24 \text{ psi. o.k.}$$

$$u = \frac{617}{2.5 \times .866 \times 31} = 92 \text{ psi. o.k.}$$

Slab A and C:

$$A_s = \frac{12{,}000}{20{,}000 \times .866 \times 2.5} = .295 \text{ sq. in.}$$

$$-A_s = \frac{5330}{20{,}000 \times .866 \times 2.5} = .123 \text{ sq. in.}$$

v o.k.

$$u = \frac{617}{2.5 \times .866 \times 3.1} = 92 \text{ o.k.}$$

Data

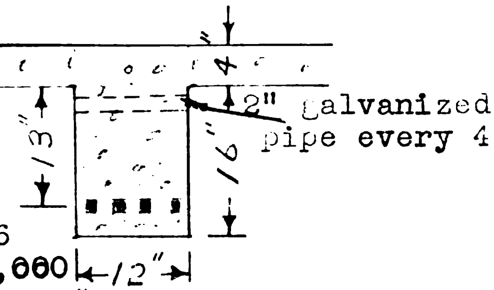
Slab B: ½" ø @ 8" bend up every other 1'-10" from support. carry neg. mom. 2' beyond deflection pt.

½" ø @ 16" over support

Slab A and C: ½" ø @ 8" c/c

½" ø @ 16" c/c bend up every other 1'-10" from the support hook all end bars

T - Beams to support roof.

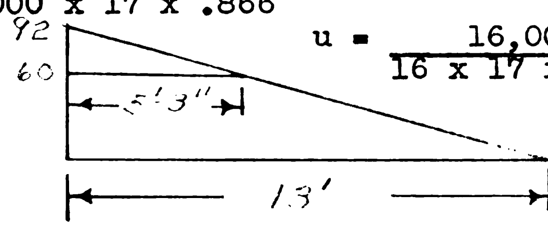


Sheer = 137.5 x 9 x 13 = 16,000 #

M = 137.5 x 9 x 26 x 26 x $\frac{12}{8}$ = 1,260,000 in. #

d = $\frac{16,000}{12 \times .866 \times 90}$ = 17" use stirrups for 30 psi. in v.

A_s = $\frac{1,260,000}{20,000 \times 17 \times .866}$ = 4.30 sq. in.



u = $\frac{16,000}{16 \times 17 \times .866}$ = 68 psi. o.k.

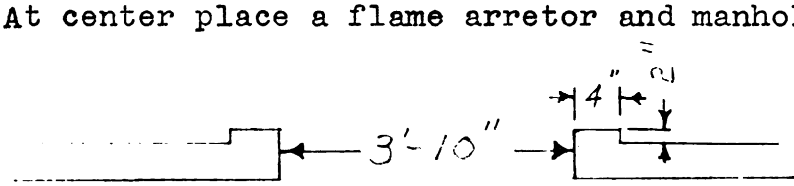
Sheer taken by stirrups:

v = 32 x 14 x 22 x .866 = 8520 lbs.

Usē ½" round stirrups taking 6200 lbs.

Space 6 @ 11 inches. Hook main bars.

At center place a flame arretor and manhole.



Add ½" ø @ 6" c/c 2' either side of hole perpendicular to beams. Place ½" ø @ 4" c/c 8' long parallel to beam either side of hole.

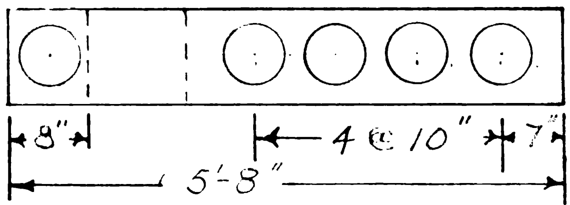
4-1" ◘ @ 3" c/c

bend up 2 bars 6' from wall.
Add 2-1" ◘ hooked over wall extend 10' from wall.

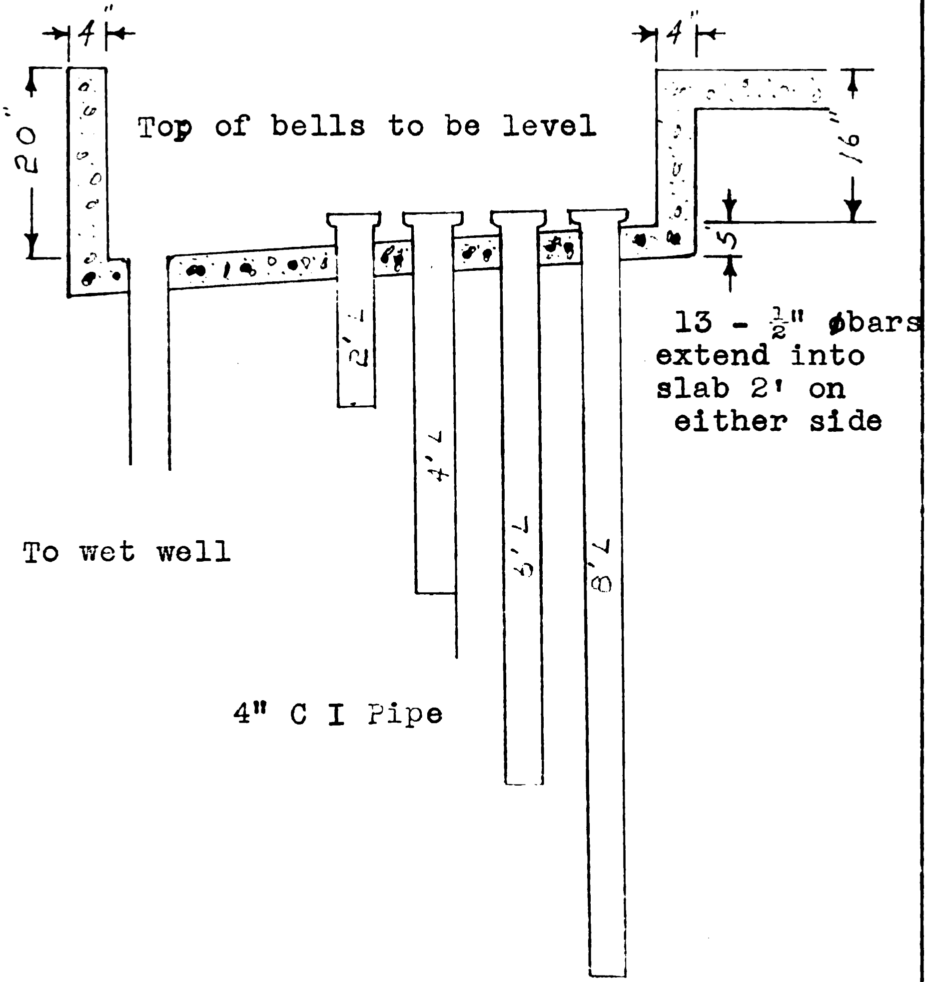
6-½" ø stirrup @ 10"

Data

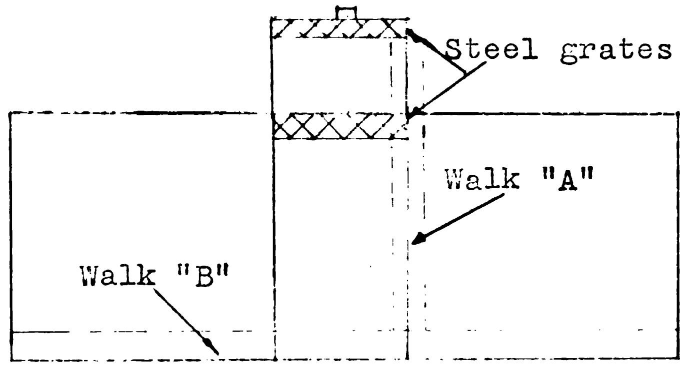
Supernatant overflow box:

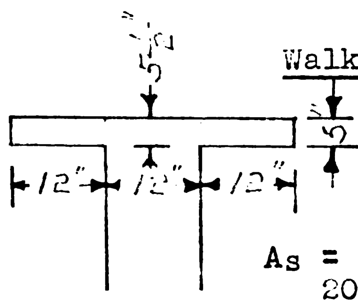


Bend bars up end and carry 2'-6" into slab on each side.



Data





$$M = 12 \times 200 + 63 \times 6 = 2778 \text{ in. lbs.}$$

$$A_s = \frac{2778}{20{,}000 \times .866 \times 2.5} = .065 \text{sq.}''$$

$\frac{1}{2}$" ø @ 6" c/c 2' 10" long

$$v = \frac{263}{12 \times .866 \times 2.5} = 16 \text{ psi. o.k.}$$

$$u = \frac{263}{3.1 \times .866 \times 2.5} = 39 \text{ psi.}$$

u is kept low because necessary embedment not available.

Data

R¹		R²		R³	R⁴
-132	+132	-24.6	+24.6	-132	+132
+132	+ 66			- 66	-132
0	- 45	-128	- 64		0
		+87.5	+175	+61.6	
	-22.8	-64.7	-32.4		
		+12.0	+24	+8.4	
	-3.1	-8.9	-4.9		
		+1.8	+3.6	+1.3	
	-.5	-1.3	-.7		
		+.3	+.5	+.2	
	-.1	-.2			
	+126.5	-126.7	+126.7	-126.5	

$$R^1 \times 30 \times 12 - 146 \times 30 \times 15 = 126{,}500$$

$$R^1 = 2920 = R^4$$

$$R^2 \times 13 \times 12 - 2530 \times 43 \times 12 - 146 \times \frac{43^2 \times 12}{2}$$

$$R^2 = 2920 = R^3$$

$$A_s = \frac{126{,}500}{20{,}000 \times .866 \times 4} = 1.82 \text{ sq. in.}$$

7/8" ϕ @ 4"

7/8 ϕ @ 4" c/c both poss and neg.

$$v = \frac{2530}{12 \times 4 \times .866} = 60 \text{ psi.} \quad \text{o.k.}$$

$$u = \frac{2530}{8.3 \times 4 \times .866} = 88 \text{ pse.} \quad \text{o.k.}$$

Provide hooks in bars @ R^1 and R^2.

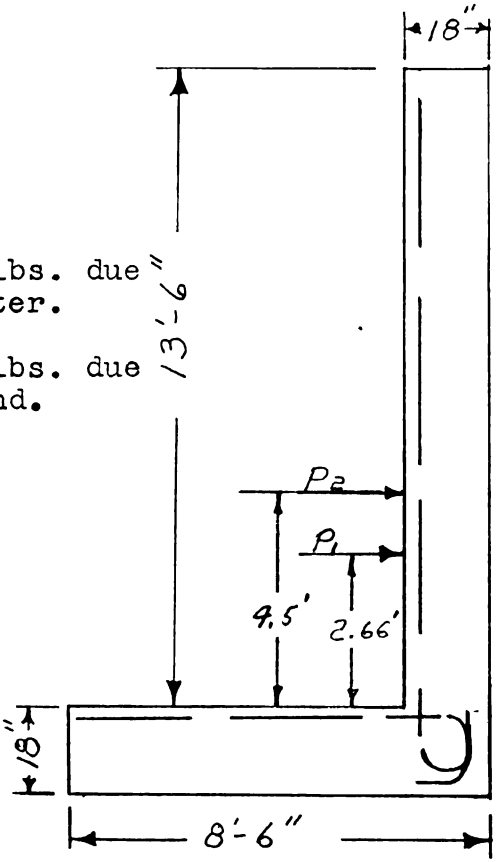
Bend up every otherb bar, extend 3 ft. 6 in. beyond inflection point.

CANTILEVER WALL FOR WET WELL AND COMMINUTOR   Sheet W-1

Data

P_1 = 1950 lbs. due to water.

P_2 = 2590 lbs. due to sand.



Sum of Moments Overturning:

4.16 x 1950 + 2590 x 6 = 24,000 ft. lbs.

Sum of Moments Riding:

3040 x .75 + 1900 x 4.25 + 14,000 x 5 = 80,000 ft. #

x = 18,940 ÷ into 56,830 = 3

e = 4.25 - 3 = 1.25 inches.

$p = \frac{18,940}{8.5} \left(1 \pm 6 \times \frac{1.25}{8.5} \right) = 4190 \ \& \ 270$

M = 203,300 in. lbs.

$A_s = \frac{203,300}{20,000 \times .866 \times 15} = .78$ sq. in.

u and v o.k.

Base use 3/4" ø @ 5" c/c Hook under column

3/4" ø @ 5" c/c reduce to 3/4" ø @ 10" c/c 5' from top

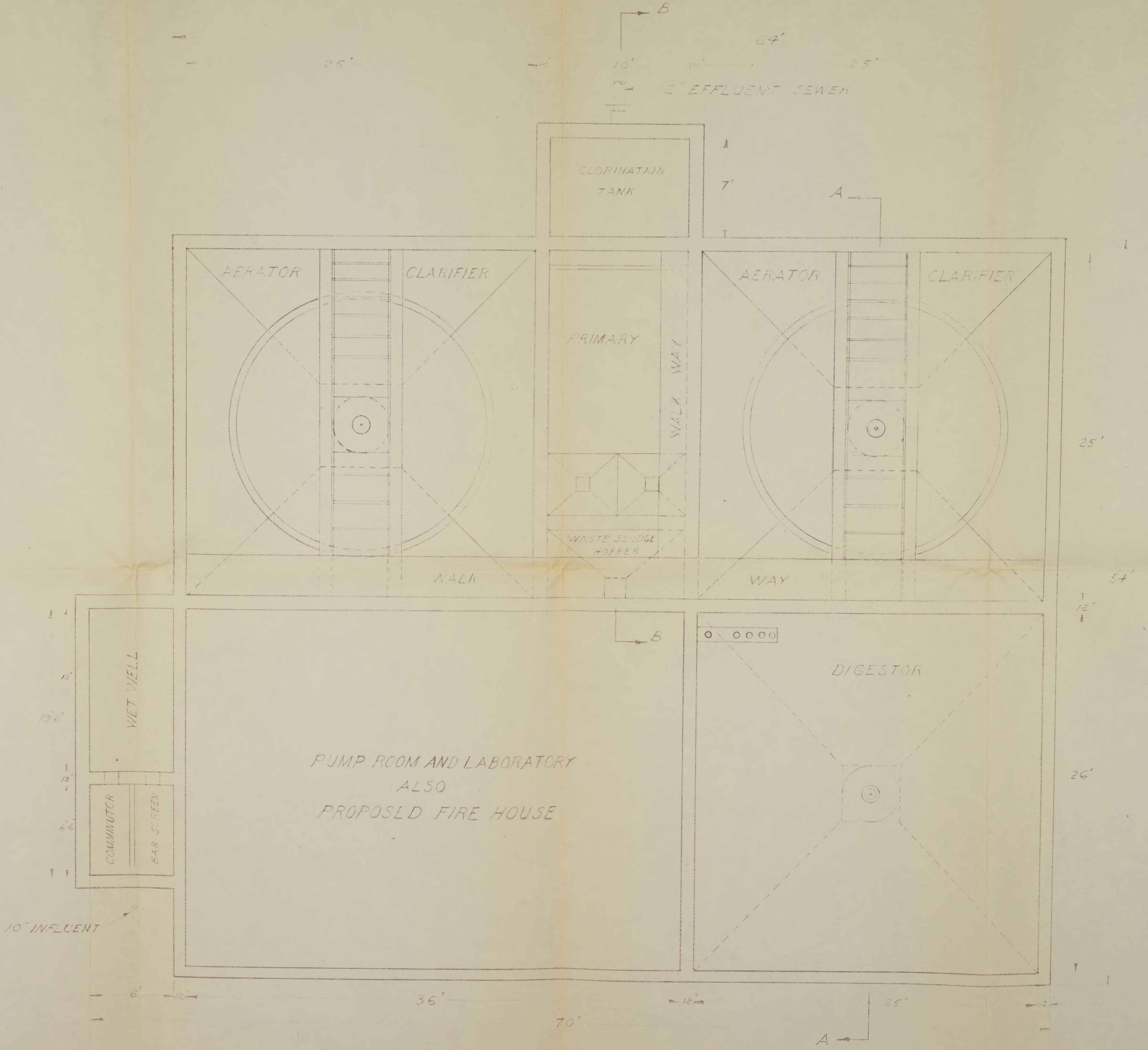
CONCLUSION

This thesis is not completely finished. The ardh-itectural drawings and fire house design are not completed. We had the fire house design finished along with the rest of the plant by the first of May. We then received a letter from the Chicago Pump Company saying the clarifier units we had designed for were carrying too heavy a load. Their latest findings had rerated the loadings downward. This threw out most of our work and consequently in the 3 weeks left we had to redo our entire thesis. There is enough work left in this paper to complete another senior civil engineering thesis. The firehouse design, cost estimate and complete drawings will take more time than our short six week time will allow.

This thesis, while it adds nothing to the worlds store of knowledge, had increased the sum total of our knowledge immeasurably. These design sheets are short but behind each is a series of trials and errors too. Each design was tried in numerous different ways untill we finally evolved the easiest and the most economical to build. Building codes and convention hampered us to some degree, but we do believe our design to be of the best.

12 Jun 59
[redacted]

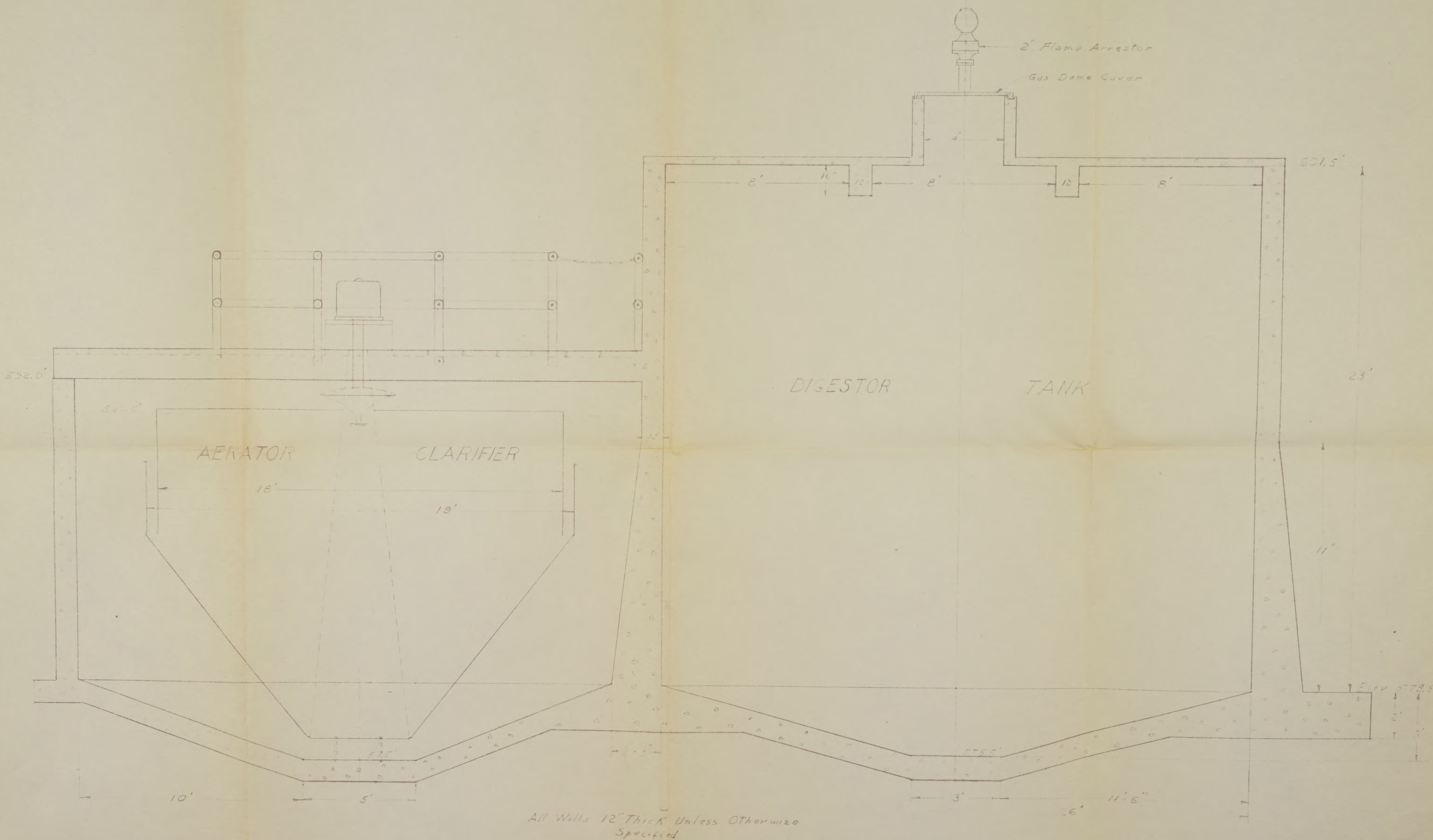
[redacted]



TOP VIEW OF PROPOSED SEWER TREATMENT PLANT FOR VILLAGE OF ELK RAPIDS

Scale 1" = 5'

SHEET No 1

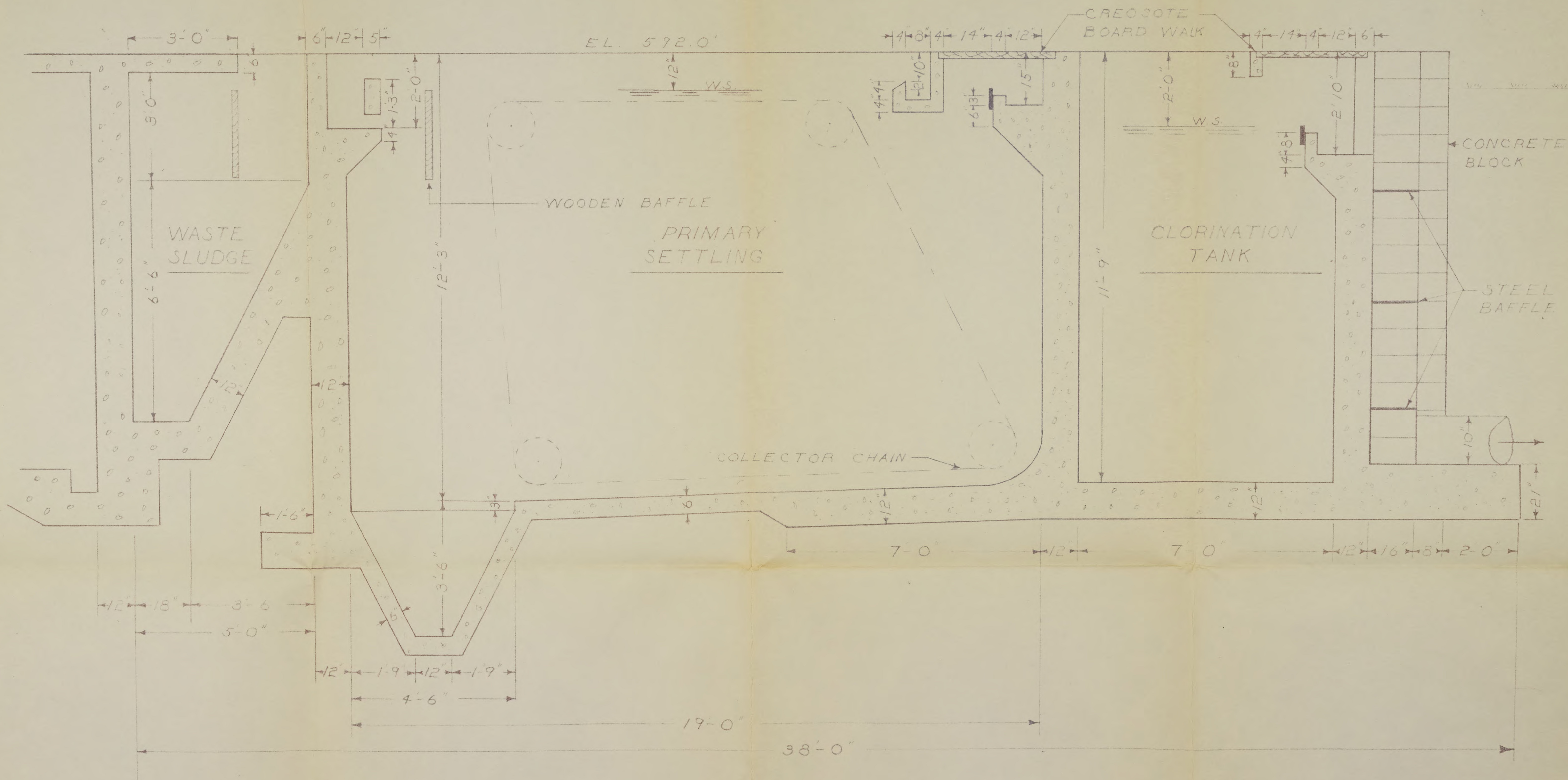


SECTION - AA

SHEET No. 1

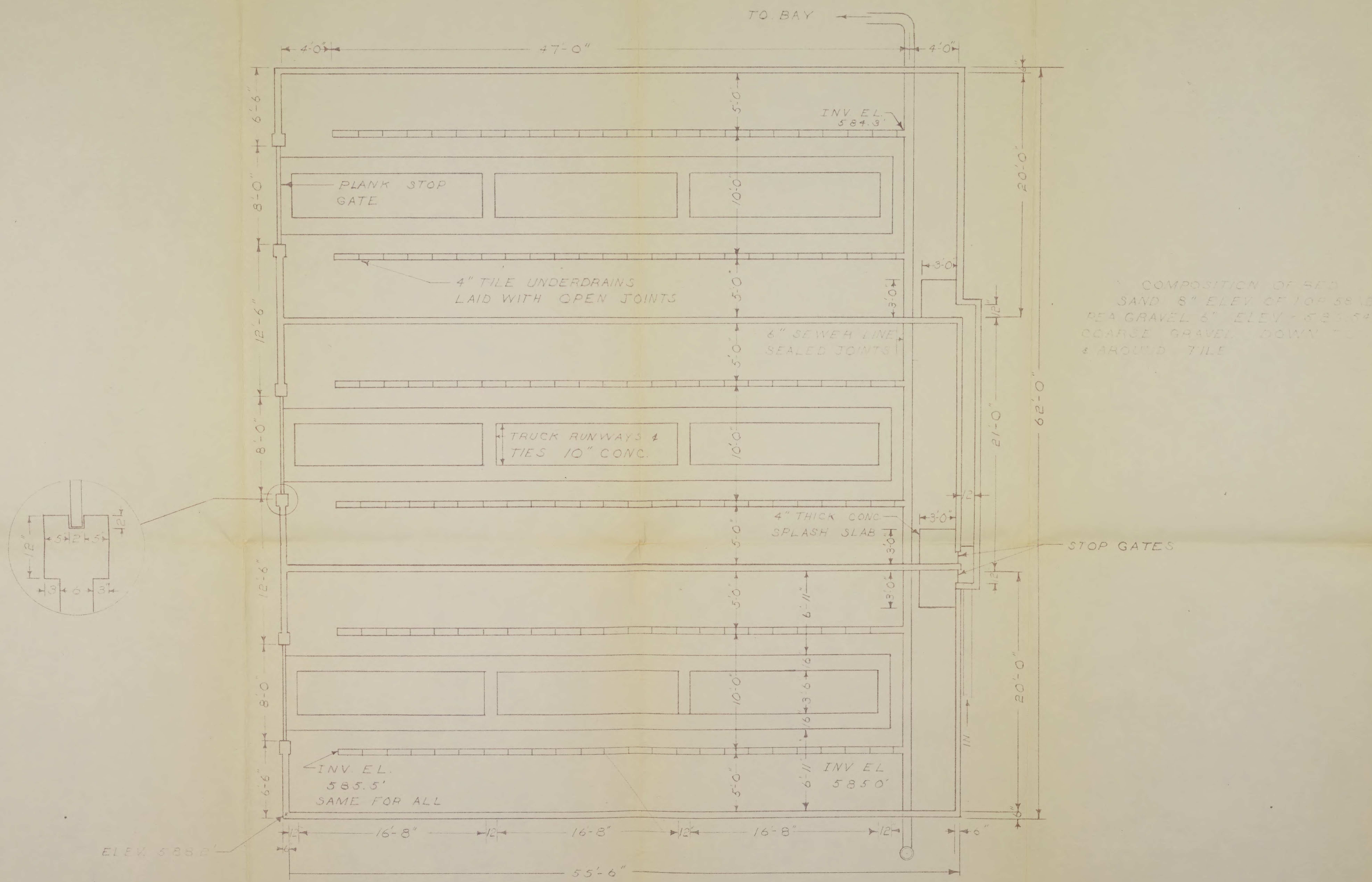
SCALE 1"-3'


GRAND
TRAVERSE
BAY
PRIVATE ISLAND
ELK
RIVER
STREET
STREET
NOBLE
Line #3
M.H. #4
Drying Beds
Treatment Plant
STREET
STREE
BRIDGE
VILLAGE
PARK
Line #1
M.H. #3
M.H. #2
Court
Courts
RIVER
Line #2
M.H. #1
CEDAR
SECTION OF ELK RAPIDS
MICHIGAN
SCALE 1" = 100'
PROPOSED SEWER
TREATMENT PLANT



SECTION "BB"
ELK RAPIDS DISPOSAL PLANT
SCALE ½" = 1'   SHEET 4 of 5

PTS



PLAN OF SLUDGE BEDS
ELK RAPIDS DISPOSAL PLANT
SCALE $\frac{3}{16}$" = 1'   SHEET 5 of 5