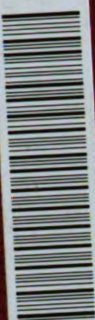


ALVIN L. FARNSWORTH



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AN ORIGINAL DESIGN OF A
RAPID SAND FILTER

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

Alvin L. Farnsworth

1947

An Original Design of a
Rapid Sand Filter
A Thesis Submitted to
The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE
By

Alvin L. Farnsworth

Candidate for the Degree of
Bachelor of Science

December 1947

THESIS

A C K N O W L E D G E M E N T

It is the desire of the author to hereby gratefully acknowledge the help of Wesley Bintz, Consultant Civil Engineer of Lansing, Michigan. Mr. Bintz made available information which allowed a practical approach to this problem and consequently made this thesis of more value to the author and possibly of more value to those who may choose to read it.

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OUTLINE OF PROBLEM

For the purpose of this thesis we shall assume that the author has been approached by someone who desires a filter plant to filter the water in a swimming pool of capacity 62,200 gallons. The filter plant will be operated 16 hours each day and it is desired to have a complete turnover of the water each day. A pump room must be provided to house the pump and the piping for the filters.

The following is a solution for the above problem. More complete details will be worked out as individual problems but this general solution will tend to give an overall picture of the design. Since we must filter a pool of water in 16 hours, the rate per minute will be: $62,200/16$ or 64.5 GPM. The rate at which the water will pass through the filters is about 3 GPM per square foot of filter area. However, the filters must be washed and the washing rate is about 15 GPM per square foot of filter area. We will divide the filter into three cells so that it may be washed part at a time, thus minimizing the size of pump required. If we now divide the total rate per minute by 3 we get the rate per cell per minute. This will be 21.5 GPM. If we now divide this rate per cell by the rate of filtering per square foot, we will have the required number of square feet per cell. This is 7.2 square feet.

Rather than use graded gravel in the cells, we will use porous underdrain plates to hold the filter sand. An

arrangement of this kind facilitates cleaning and repair of filters without the expense of re-grading or replacing the graded gravel. These plates are about 1 foot square and $1\frac{1}{4}$ inches thick. Since each of the plates gives a filter area of 1 square foot we will need 8 plates in each cell to meet the requirements set forth in the preceeding paragraph. Thus, we will build three filter cells each 2 feet by 4 feet. Also we will build a similar cell for use as a mixing and settling chamber.

The pool for which the filter is to be used is of the sunken type and our filters and pump room will also, therefore, be sunken with the floor a continuation of the pool floor. (The filters being placed at deep end of pool.) With this condition it will be necessary for pump room door to open into the pump room. This will require about 3 feet. The pump and the filter piping will require about 4 feet. The pump room, then, will be about 8 feet wide if we leave a little extra space for chemical containers. The length of the room will be the same as the length of the filters, or about 10 feet. This is assuming the small dimensions of the filter cells and mixing chamber to run parallel with the length of the room and the partition walls between filter cells to be about 8 inches thick.

Our problem now becomes that of computing the details for four 2' by 4' cells which must be water tight, a pump room 8' by 10' and the proper system of piping to

circulate the water through the filters and back into the pool.

DESIGN OF ROOF SLAB

The roof is to be built of reinforced concrete and constructed such that the span will be as shown in Sketch 1. Since the roof will be used for sun bathing we will design for a live load of 100# per square foot. Weight of concrete 150# per cubic foot.

Assuming a 6 inch slab we have:

live load		100#
dead load	150/2	<u>75</u>
Total		175# per sq. ft.

Assuming a simply supported slab:

$$M = Wl^2/8 = 175 \times (10.67)^2/8 = 2505 \text{ ft. lb.}$$

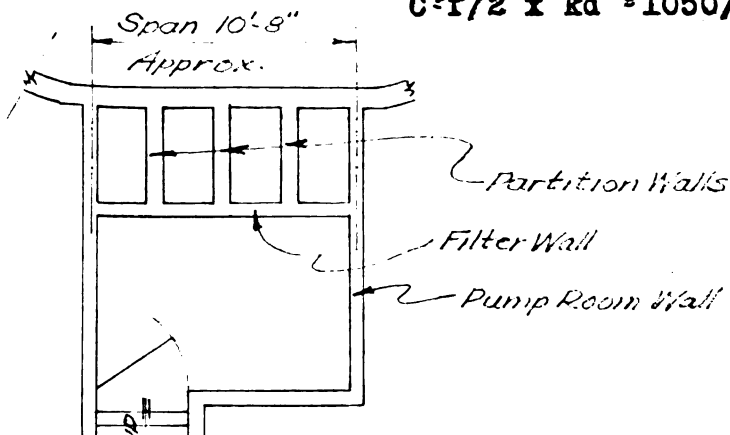
In keeping with the design of the pool to be constructed at the same time as the filter plant, we will assume $f_c = 20,000\#/sq. \text{ in.}$, $f_t = 1050\#/sq. \text{ in.}$, and $f'_c = 3000\#/sq. \text{ in.}$

Then:

$$k = .344 \text{ and } j = .885$$

$$M = Cjd = C(d \times kd/3)$$

$$C = f/2 \times kd = 1050/2 \times .344d = 181d$$



SKETCH 1

$$M = 181d(d - .344d/3) = 181d(d - .115d) \\ = 160d^2$$

$$d^2 = M/160 = 2505/160 = 15.65$$

$$d = \sqrt{15.65} = \underline{3.96} \text{ inches}$$

Use effective depth of 4" with 2" cover making a 6" slab.

Steel Required

$$M = Tjd = A_s f_s j d \quad \text{or} \quad A_s = M / f_s j d$$

$$f_s = 20,000 \# / \text{sq. in.}$$

$$d = 4"$$

$$j = .885$$

$$A_s = 2505 / 20,000 \times .885 \times 4 = .0354 \text{ sq. in. per inch}$$

$$\frac{1}{2}" \phi @ 5\frac{1}{2}" = .1963 / 5.5 = .0356 \text{ sq. in. per inch}$$

Steel: Use $\frac{1}{2}" \phi @ 5\frac{1}{2}"$ c.c. Also use $\frac{1}{2}" \phi @ 18"$ c.c.

in opposite direction for temperature stresses and to tie the slab together.

See detail drawing 2.

Check for Shear:

Using method outlined in references 1 and 3

$$\Sigma_v = 8000V / 7ud$$

$$\Sigma_v = 3.4 \text{ for } \frac{1}{2}" \phi @ 5\frac{1}{2}" \text{ c.c.}$$

$$V = 175 \times 1067 / 2 = 932.5 \# = .93 \text{ kips}$$

$$d = 4"$$

$$\text{Allowable } u = .05f' = .05 \times 3000 = 150 \# / \text{sq. in.}$$

Therefore, no hooks are required on bars.

$$\text{Allowable } v \text{ in this case} = .02 \times f' = 60 \# / \text{sq. in.}$$

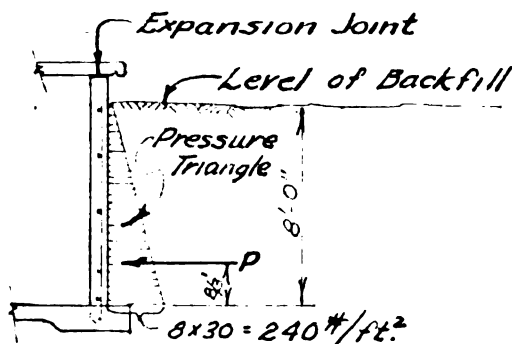
$$v_e \text{ developed} = 932.5/12 \times 4 = 19.4\#/sq. \text{ in.}$$

DESIGN OF WALLS

In designing walls we have three separate situations: the pump room walls, the filter wall, and the partition walls. The maximum stress in the pump room wall will occur after the backfill is placed and before the filters are filled for operation. Maximum stress in the filter wall will occur when all filter cells are in operation. In a partition wall the maximum stress will occur when the cell on one side is completely empty and the cell on the opposite side is in operation.

Pump Room Wall

For purposes of computing backfill pressures against the wall horizontally, we will assume the backfill to be a liquid weighing 30#/ cubic foot. From the Sketch 2 we will see that the wall can be designed either as a curtain wall with the other walls as counterforts or as a canilever retaining wall. (Note that the joint at the top of the wall must be a slip joint so that the roof slab is simply supported. This makes the wall a canilever as shown in section A-A.)



SKETCH 2

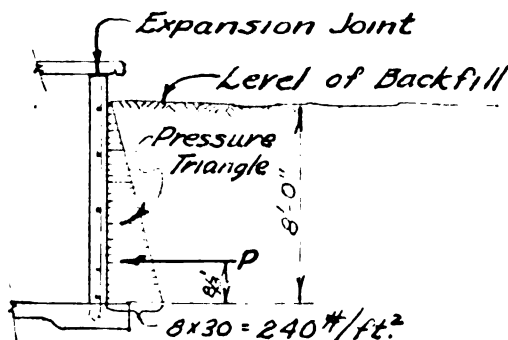
$$v_c \text{ developed} = 932.5/12 \times 4 = 19.4\#/sq. \text{ in.}$$

DESIGN OF WALLS

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SKETCH 2

In order to conserve materials and save the necessity of making a thick wall we will use a combination of the two above mentioned possibilities, designing for $5/8$ of the stresses to be carried each way, thus allowing a safety factor to take care of the possibility that both sets of reinforcement might not come into action simultaneously.

(Note: For wall design, reference 1 will be used instead of the long method used in the roof design.)

Canilever Steel

At base of wall:

$$P = 240/2 \times 8 = 960\# \quad (\text{See Sketch 2})$$

$$M = 960 \times 8/3 = 2840 \text{ ft.lb. or } 2.56 \text{ kip ft.}$$

$$2.56 \times 5/8 = 1.60 \text{ kip ft.}$$

From table 2 or reference 1: Req'd. $d = 3\frac{1}{2}"$

Wall thickness $3\frac{1}{2}"$ plus 3" cover = $6\frac{1}{2}"$

(See "Negative Steel")

(Maximum moment for the counterfort part of the design will occur at the bottom foot of the wall where the average pressure per running foot will be $7.5/8 \times 240 = 225\#$ Then:

$$M = wL^2/10(\text{end span}) = 225 \times (8.5)/10 = 1625 \text{ ft. lb.}$$

From this we see that the moment developed in the canilever part of the design is greater and the wall thickness established in that part of the design will govern.)

At point 2' above base of wall:

$$M = 6 \times 30/2 \times 6 \times 2 = 1080 \text{ ft.lb.}$$

$$1.08 \text{ kips ft.} \times 5/8 = .675 \text{ kip ft.}$$

At point 4' above base of wall:

$$M = 4 \times 30/2 \times 4 \times 4/3 = 320 \text{ ft. lb.}$$

$$.32 \text{ kip ft.} \times 5/8 = .20 \text{ kip ft.}$$

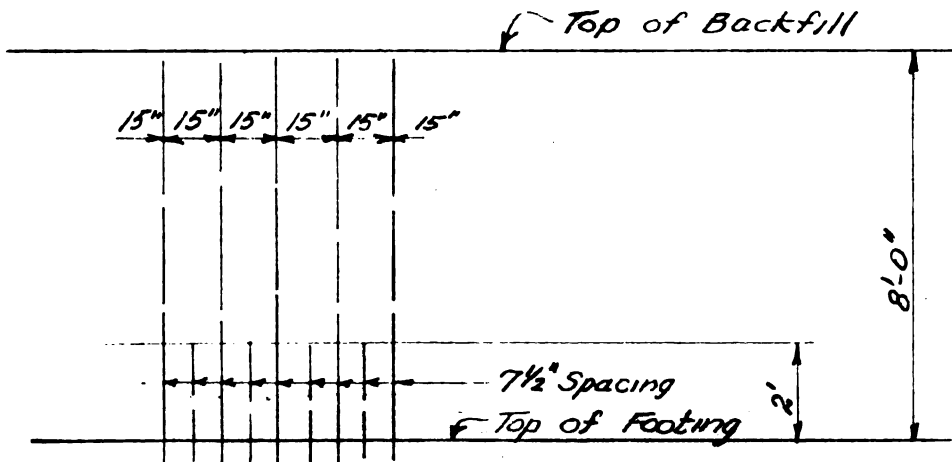
At point 6' above base of wall:

$$M = 2 \times 30/2 \times 2 \times 2/3 = 40 \text{ ft. lb.}$$

$$.04 \text{ kip ft.} \times 5/8 = .025 \text{ kip ft.}$$

Height above footing	Moment kip ft.	$A_s = M/ad$	Steel Table 3 Ref. 1
0	1.60	.318	$\frac{1}{2}" \phi @ 7\frac{1}{2}" \text{ o.c.}$
2	.68	.134	$\frac{1}{2}" \phi @ 15" \text{ o.c.}$

Since we don't want a spacing greater than 18" we will go no higher than the 15" spacing shown for 2' above footing. See Sketch 3.



SKETCH 3

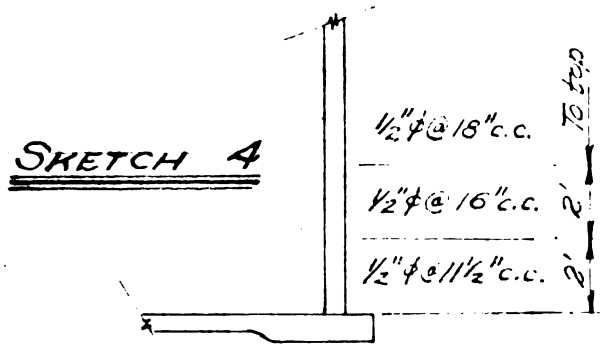
Horizontal Steel

For the following computation "l" will be taken as 8'-6" which is the longest span. Not as much steel would be required in the shorter span but we will keep the wall uniform regardless.

Height of horizontal

1-foot strip above footing	$M = wl^2/10$ $\times 5/8$	$A_s = M/ad$	Steel Table 3 Ref. 1
0 to 1	1.015	.21	$\frac{1}{2}" \phi @ 11\frac{1}{2}"$ c.c.
2 to 3	.745	.15	$\frac{1}{2}" \phi @ 16"$ c.c.
4 to 5	.467	.09	$\frac{1}{2}" \phi @ 18"$ c.c.

All steel above 4' point to be 18" c.c.



Negative Steel

The canilever steel already required that the wall be $6\frac{1}{2}"$ thick in order to give 3" cover of the canilever steel on the backfill side. By increasing the wall thickness to 7" we can place our steel in the center of the wall and have it serve both as negative and positive steel.

Pump room wall to be 7" thick.

Bond

A $\frac{1}{2}" \phi$ fully stressed at 20,000#/sq. in. will carry $20,000 \times .1963 = 3920\#$. The bond between the concrete and the bar will carry: $3.1416 \times \frac{1}{2} \times 150 = 236\#$. Thus, $3920/236 = 16.6$ inches will be required for proper bond. Make bars extend 18" beyond corners or points of lapping.

Filter Wall

Since the partition walls provide us supports at 2'-6" centers it will no doubt be most economical to design the filter wall as a curtain wall.

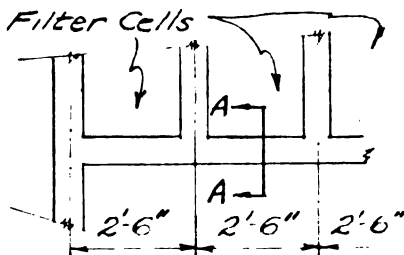
Pressure at bottom of wall is $8 \times 62.4 = 499\#/ft.$

The average pressure on the bottom 1-foot strip of wall is:

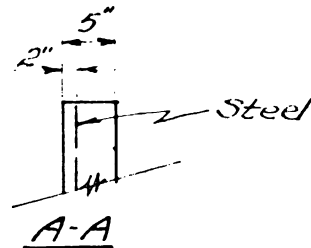
$$7.5/8 \times 499 = 467\#/ft.$$

$$M = wl^2/10 = 467 \times (215)^2/10 = 292 \text{ ft.lb. or } .292 \text{ kip ft.}$$

From table 2 of Reference 1, the depth required is less than 2". Since the wall will be open into the pump room 2" cover will be enough on the pump room side. As in the case of the pump room walls we will make the same steel act as positive and negative steel. We will want 3" cover on the side toward the filter cells and the wall thickness then becomes: 2" plus 3" or 5".



SKETCH 5



SKETCH 6

Anchorage in the partition walls will have to be checked after the partition walls are designed. At corners continue steel for 18" after bending around the corner.

Steel Required

$$M/ad = A_s = .292/1.44 \times 2 = .102 \text{ sq. in./ft.}$$

From table 3 of reference 1, use $\frac{1}{2}" \phi @ 18" \text{ c.c.}$ horizontally. Use same amount of steel also vertically for temperature stresses. (Theoretically, less steel could be used higher up on the wall but we don't want spacing greater than 18" c.c.)

Partition Walls

For the partition walls we have the same maximum pressures as for the filter wall but "l" will be 4'-6".

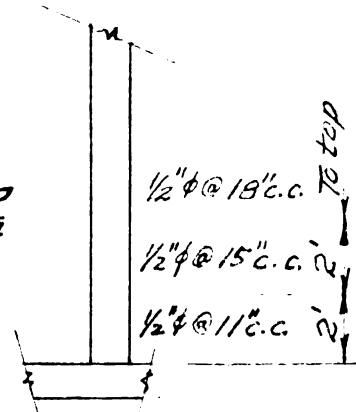
$$M = wl^2/10 = 467 \times (4.5)^2/10 = 945 \text{ ft. lb.}$$

Required "d" is $2\frac{1}{2}"$. However, since the walls come in contact with water on both sides we will want 3" cover of the steel on each side and the wall will, therefore, be 6" thick. The steel will be placed in the center of the wall and will act both as negative and positive as required.

Steel Required

Height of horizontal 1-foot strip above footing	$M = wl^2/10$	$A_s = M/ad$	Steel
0 to 1	.945	.219	$\frac{1}{2}" \phi @ 11" \text{ c.c.}$
2 to 3	.695	.160	$\frac{1}{2}" \phi @ 15" \text{ c.c.}$
4 to 5	.441	.102	$\frac{1}{2}" \phi @ 18" \text{ c.c.}$

All steel above 4' to be 18" c.c.

SKETCH 7

Check for Anchorage of Filter Wall

The steel in the partition walls will also serve as tie steel to tie the filter wall to the partition walls. The bottom 1-foot strip of the filter wall has an average pressure of 225#/sq. ft. The shear at the partition wall connection would be $225 \times 2.5 = 563\#$. At least there will be one $\frac{1}{2}"\phi$ at this point which will carry $20,000 \times .1963 = 3930\#$. Thus, the steel in the partition walls will be sufficient to tie the filter wall to the partition walls.

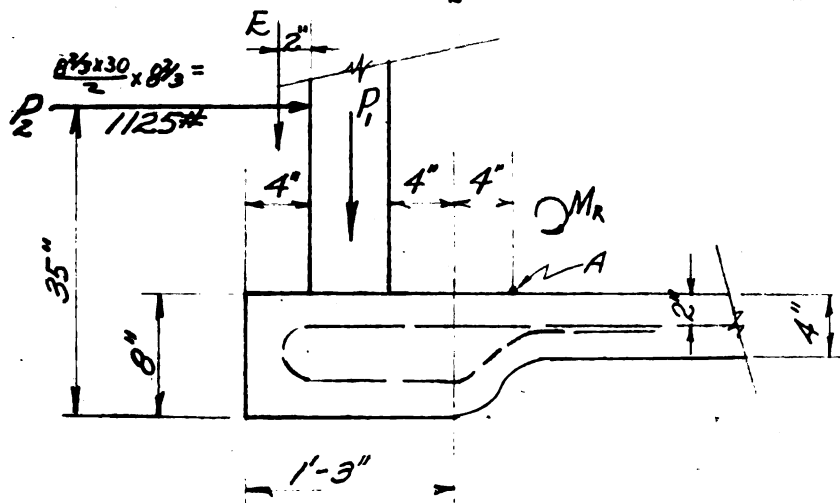
FOOTINGS

The footing under the swimming pool walls will be continued to serve the filter plant also. See drawings of filter walls for footing details.

The following is an investigation to determine if the footings as used for the pool wall are sufficient for our purposes.

In Sketch 8 " P_1 " equals weight of roof slab, plus weight of wall, plus weight of footing. (Considering a 1-foot length of structure.) " E " is the weight of backfill

over footing. " P_2 " equals the side pressure of the backfill.



SKETCH 8

$$\text{Roof slab } \frac{1}{2} \times 6 \times 150 = 450$$

$$\text{Wall } \frac{7}{12} \times 9 \times 150 = 787$$

$$\text{Footing } \frac{8}{12} \times 1 \times 150 = \underline{100}$$

$$\text{Total } P_1 = 1337\#$$

$$E = \frac{4}{12} \times 8 \times 100 = 266\#$$

M_R equals resisting moment of floor at critical section.

$$M_R = A_s / ad \quad A_s = .20$$

$$d = 2"$$

$$a = 1.44$$

$$M = 2 \times 1.44 \times .2 = .576 \text{ kip ft.} = 576 \text{ ft. lb.}$$

The moment produced at the critical section by the system shown in sketch 8 (at left of critical section):

$$M = (1125 \times 27) - (1337 \times 11.5) - (266 \times 17) = 844 \text{ ft. lb.}$$

From this we see that the resisting moment of 576 ft. lb. produced by the slab at the critical section isn't enough to resist the 844 ft. lb. moment set up by the external

forces. Therefore, we will widen the footing. Making the footing 1'-6" wide by adding 3" on the inside of the wall the externally caused moment now becomes:

$$M = (1125 \times 27) - (1337 \times 14.5) - (266 \times 20) = 477 \text{ ft. lb.}$$

Our footing will thus become 8" x 1'-6". See detail drawings.

FILTER PIPING

In reference 4 we find the following recommendations:

Hydraulics:

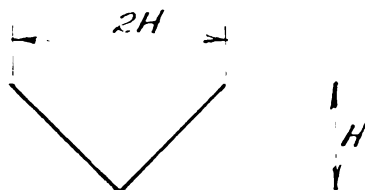
Piping:

Inlet	Max. Velocity	4 fps
Outlet	" "	4 fps
Waste	" "	4 fps
Backwash	" "	10 fps @
20 GPM/ sq. ft. filter area		
Controllers etc.		6 fps

Washwater Trough

While water is being filtered it runs down the trough from the mixing chamber and overflows the sides of the trough into the filter cells. No particular size of trough would be required for this part of the operation. However, when backwashing we wash one cell at a time and we want the water to come up through the filter and run out the trough into the mixing chamber without overflowing into the other two clean

cells. Since the water can only escape through one end of the trough this one end acts as a wier. It will be a 90° V-notch wier as shown in sketch 9. It has been found that the V-notch trough works nicely in this type of set-up because it allows the filter to be evenly washed since the washwater that comes up directly under the trough can easily get into the trough.



SKETCH 9

When specifying the pump we will assume a back-wash rate of 15 GPM/ sq. ft. of filter area. However, in designing the piping we will assume a rate of wash of 20 GPM/ sq. ft. of filter area.

Our trough must handle the water from one cell or 8 sq. ft. of filter area or $8 \times 20 = 160$ GPM.

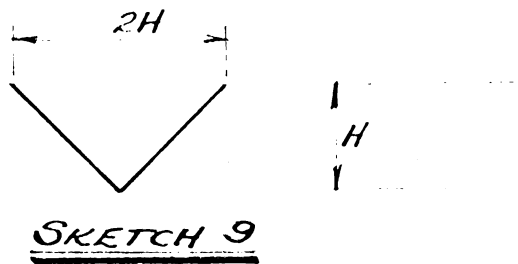
From page 87 of reference 5, we get the formula $Q = 2.52H^{2.47}$. From table 37 on page 110 of reference 5, we find that for $Q = .356 \text{ cfs}$, $H = .453$ ft. or 5.45 inches.

Use $H = 7"$ to allow some freeboard.

Filter Cell Outlets, Risers, and Mixing Chamber Outlet

The sizes of these pipes will all depend on the washwater flow since the maximum requirement will be while washing. Since we wash one filter at a time, the maximum flow through these pipes will be:

cells. Since the water can only escape through one end of the trough this one end acts as a wier. It will be a 90° V-notch wier as shown in sketch 9. It has been found that the V-notch trough works nicely in this type of set-up because it allows the filter to be evenly washed since the washwater that comes up directly under the trough can easily get into the trough.



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8 sq. ft. x 20 GPM/sq. ft. filter area = 160 GPM.

Converting this to cubic feet per second we have:

$$160/60 \times 7.48 = .357 \text{ cfs}$$

For computing pipe sizes we will use the simple formula $Q = AV$ where:

Q = quantity in cubic feet per second

A = area (inside cross-section) of pipe in sq. ft.

V = velocity of water in feet per second

Recommended V during backwash is 10 fps.

$$A = Q/V = .357/10 = .0357 \text{ sq. ft. or } 5.13 \text{ sq. in.}$$

Use 3" pipe.

Since the flow out of the mixing chamber is by gravity, we must check to see if the flow will equal the 10 fps rate upon which we have based the design of the pipe size.

$$v = C \sqrt{2gh} \text{ where:}$$

v = velocity of flow in feet per second

C = coefficient of discharge

g = gravity constant

h = head in feet

$$v = .82 \sqrt{2 \times 32.2 \times 4.75} = 14.4 \text{ fps}$$

From this we see that the water would flow even faster than the 10 fps rate assumed and the design is on the conservative side.

Headers, Pool Inlet, and Mixing Chamber Inlet:

These pipes handle the filtered water from all three cells at once. At a filter rate of 3 GPM per square foot of

filter area this will be: $3 \times 8 \times 3 = 72$ GPM. Velocity will be assumed as 4 fps as recommended in reference 4.

$$A = 72 \times 144/60 \times 7.48 \times 4 = 5.77 \text{ sq. in.}$$

Use 3" pipe.

In order to better distribute the clean water, the pool inlet will be divided into two $1\frac{1}{2}$ " pipes as shown on "Isometric" of filter piping.

Pool Outlet:

The size of the pool outlet is now based on the filter plant operation. It will be 6" in the case of this size pool, the size being determined by the pool designer. This 6" pipe is larger than would be required to operate the filters, but such a size is desirable in order to facilitate the quick drainage of the entire pool. See "Isometric" of filter piping.

PUMP AND MOTOR

Our pump has two jobs to perform. It must wash the filters and also return clean water to the pool when filters are filtering. (These operations cannot, obviously, be performed at the same time.) We must find the head loss (total) in each case.

Losses During Washing

We must supply water for washing at the rate of 160 GPM or .356 cubic feet per second. Velocity in the 6" pipe will be:

$$V = 144 \times .356 / 28.891 = 1.77 \text{ fps.}$$

Velocity in the 3" pipe will be:

$$V = 144 \times .356 / 7.393 = 6.95 \text{ fps.}$$

Losses (References 4, 5, and 6)

Entrance $KV/2g = .04 \times (1.77)/2 \times 32.2$	Negligible
50' of 6" pipe $\frac{1}{2} \times .38 =$	.19 ft.
Tee in 6" pipe $.3 \times .38 =$	.11
Contraction to 3" =	.28
2 Tees & 1 Ell in 3" pipe $10.5 \times 50/100 =$	5.25
12' of 3" pipe $10.5 \times 12/100 =$	1.26
Porous plates & filter media =	<u>2.00</u>
Total	9.09 ft.

Water after washing is at a level in the trough 2'-6" below pool water level. Therefore, we subtract this from the 9.09 ft. leaving 6.59 feet.

Losses During Filtering

The filters will be operated at 3 GPM per square foot of filter area. Each filter produces $3 \times 8 = 24$ GPM.

Velocity in the cell outlets will be:

$$V = 144 \times 24 / 7.48 \times 60 \times 7.393 = 1.05 \text{ fps.}$$

Since the pool inlet is the same size as the cell outlets but carries the water from all three cells at the same time the velocity in the pool inlet will be:

$$V = 3 \times 1.05 = 3.15 \text{ fps.}$$

Velocity in the $1\frac{1}{2}$ " pipes will be:

$$V = 144 \times 36 / 7.48 \times 60 \times 2.04 = 5.67 \text{ fps.}$$

Suction Lift (References 4,5,& 6)

Height from floor to pump	2.00 ft.
Entrance	Negligible
12' of 3", 1 Ell, & 3 Tees .38 x 87/100=	.33 (@ 1.05 fps)
9' of 3", 1 Tee & 1 Ell 2.57 x 43/100=	<u>1.11</u> (@ 3.15 fps)
Total	3.44 ft.

See reference 4, #12-S-1660.

PUMP ROOM EQUIPMENT (When required by health authorities or
by Owner.)

Disinfector

This shall be a chlorinator similar to that manufactured by the Everson Filter Co., 627 W. Lake Street, Chicago, Illinois. Use size recommended by manufacturer.

Pressure Gauge

Attach to influent side of pump a gauge that will show pressure or vacuum. Relative readings will indicate when washing of filters is necessary.

Flow Indicator

Attach rate of flow indicator to discharge side of pump to indicate filtering and washing rates.

Coagulating Device

An automatic device for feeding of lump crystal Potash Alum or Ammonia Alum to the water will be connected to the supply piping of the filters.

Alkalinity Device

Connect this device to venturi tube of the coagulating device.

Hair Strainer (or Catcher)

Connect this item into riser pipe below entrance into mixing chamber.

UNIT PRICES FOR ESTIMATING

Concrete (1:1½:3) Per Cubic Yard

Materials

Cement	1.85 Bbls @	3.60	\$ 6.66
Sand	.42 CuYd @	1.75	.74
Gravel	1.84 CuYd @	2.75	2.31
Lime	.13 Bbls @	2.60	<u>.34</u>
Total Materials			\$10.05

Labor (Mixing in small batch mixer and
placing with buggies or wheelborrows)

Common

labor	3.75 Hrs. @	1.00	\$ 3.75
Mixer	.38 Hrs. @	2.00	.76
Foreman	.30 Hrs. @	1.50	<u>.34</u>
Total Labor			\$ 4.96

Total per Cu.Yd. concrete in place \$15.01

Formwork (100 sq.ft. contact area)

Materials

Lumber	225 BdFt @	100.00	\$22.50
Nails	.5 lbs. @	.07	.04
Wire	2.5 lbs. @	.08	<u>.20</u>
Total Materials			\$22.74

Labor (Erection and Wrecking)

Carpenter

5.85 Hrs @ 2.00 \$11.70

Formwork (continued)

Helper	5.10 Hrs.	③	1.50	7.65
Foreman	.60 Hrs.	③	2.25	<u>1.35</u>
Total Labor				\$20.70
Total Cost Formwork per 100 sq. ft.				
	contact area			\$43.44
Cost Formwork per sq. ft.				
	contact area			.43

Excavation (Per Cubic Yard)

Hand Excavation

Common

labor	1.50 Hrs.	③	1.00	\$ 1.50
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Total Cost Hand Excavation per

Cubic Yard	\$ 1.50
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Power Equipment Excavation

Operator	.06 Hrs.	③	2.25	\$.14
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Equipment	.06 Hrs.	③	9.00	<u>.54</u>
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Total Cost per Cu.Yd. for power equipment

Excavation (no haul)	\$.68
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ESTIMATE OF COSTEarthwork (Assuming level ground at water level in pool)

Excavation

Filter room	80.0	CuYd		
Access stairs	<u>15.0</u>	"		
	95.0	CuYd	@ \$1.20	\$114.00

Gravel Sub-drainage

Under floor	2.34	CuYd		
Around Walls	4.45	"		
Under Stairs	<u>2.63</u>	"		
	9.40	CuYd	@ \$2.75	\$ 25.85

Backfill

Around filter room	21.0	CuYd	@ \$1.00	<u>\$ 21.00</u>
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Total Earthwork. \$160.85

Concrete

Floor, Footings, Pump Pad,

and Pedestal 3.76 CuYd @ \$20.00 \$ 75.20

Con. Fl. & Scum Gutter .96 " @ 35.00 33.60

Roof Slab 2.84 " @ 45.00 127.80

Walls 7.86 " @ 70.00 550.20

Stairs 1.34 " @ 25.00 33.50

Trough .27 " @ 110.00 29.70

Total Concrete. \$850.00

Reinforcing Steel $\frac{1}{2}$ "Lin. Ft.

Roof 400

Floor and Footings 418

ESTIMATE OF COSTReinforcing Steel (Continued)Lin. Ft.

Partition Walls	160
Filter Wall	133
Pump Room Wall	685
Stairs	170
Trough	113
Miscellaneous	<u>30</u>
Total	2,109 Lin.Ft.

Weight 2,109 x .668/2,000

.705 Tons

 $\frac{1}{2}$ "

.705 Tons @ \$120.00 \$84.50

Labor

.705 Tons @ 40.00 28.17

Total Reinforcing Steel. \$112.67

Woodwork

Door & Frame with Hardware	1	@ \$30.00	\$30.00
Window Frames & Lights	2	@ 5.00	<u>10.00</u>
Total Woodwork.			\$40.00

Underground

Drain Tile	40	Lin.Ft. @ \$.64	<u>\$25.60</u>
Total Underground.			\$25.60

Painting

Woodwork	60	Sq. Ft. @ \$.10	\$ 6.00
Pumproom & Stairway	350	Sq. Ft. @ .08	<u>28.00</u>
Total Painting.			\$34.00

ESTIMATE OF COSTPlastering

Filter Cell Walls	25	SqYd @ \$	.84	<u>\$21.00</u>
Total Plastering.				<u>.\$21.00</u>

Electrical

Fixtures	2	@ \$30.00	\$60.00
Wall Plug	1	@ 10.00	10.00
Switch	1	@ 12.00	12.00
Connection to Pump	1	@ 40.00	<u>40.00</u>
Total Materials			\$122.00
Overhead & Incidentals	30%		<u>36.60</u>
Total Electrical.			<u>\$158.60</u>

Plumbing

Water Service to Pool

Pipe 2"	30	L.F. @ \$	.26	\$ 7.80
Valve 2"	1	@	7.74	7.74
Tee 2"	1	@	1.43	1.43
Plug 2"	1	@	.30	.30
Ells 2"	3	@	.74	2.22

Outlet Piping from Pool

Tee 6" x 3" x 6"	1	⊙ \$14.16	\$14.16
Pipe 2"	30	L.F. ⊙ .53	15.90
Valve 3"	3	⊙ 13.54	40.62
Ell 3"	2	⊙ 2.27	4.54
Tee 3"	2	⊙ 2.45	4.90

ESTIMATE OF COSTPlumbing (continued)

Filter Outlets and Backwash Line

Pipe 3"	35	L.F. @ \$.53	\$18.55
Tee 3"	7	@ 2.45	17.15
Valves 3"	4	@ 13.54	64.16
Ell 3"	2	@ 2.27	4.45
Plugs 3"	3	@ .45	1.35

Mixing Chamber Outlet

Pipe 3"	3	L.F. @ \$.53	\$ 1.59
Valve 3"	1	@ 13.54	13.54
Ell 3"	1	@ 2.27	2.27

Pump Discharge Inlets

Pipe 3"	90	L.F. @ \$.54	\$47.70
Pipe 1½"	20	" @ .19	3.80
Valve 3"	2	@ 13.54	27.08
Ell 3"	7	@ 2.27	15.89
Tee 3"	3	@ 2.45	7.35
Bushings 3" to 1½"	4	@ .58	2.32

Filter Media

Porous Plates	24	SqFt	
Sand-special	1.8	CuYd	

\$90.00

Miscellaneous

Caulking lead	10	Lbs. @ \$.20	\$ 2.00
Caulking Oakum	5	" @ .15	.75

ESTIMATE OF COSTPlumbing (continued)

Special Equipment

Pump and Motor	1	@ \$250.00	\$250.00
Alkalinity Pot	1	@ These	
Coagulent Pot	1	@	
Chlorinator	1	@	Items
Flow Indicator	1	@	<u>Optional</u>
Total Materials			\$669.65
Labor and Incidentals 100%			<u>669.65</u>
Total Plumbing.			.\$1,339.30

Miscellaneous

Wood baffles, mixing chamber	67	BdFt	@ \$.15	\$ 10.05
Fine Grading	300	SqFt	@ .20	60.00
Manhole Rings and Covers	2	Each	@ 15.00	<u>30.00</u>
Total Miscellaneous.				.\$100.05

RESUME OF COSTS

Earthwork	\$ 160.85
Concrete	850.00
Reinforcing Steel	112.67
Woodwork & Sash	40.00
Underground	25.60
Painting	34.00
Plastering	21.00
Electrical	158.60
Plumbing	1,339.30
Miscellaneous	<u>100.05</u>
Total	\$2,842.07
Misc. and Incidentals	
(Overhead) 5%	<u>142.10</u>
Total	\$2,984.17
Contractors Profit 10%	<u>298.42</u>
Grand Total.	\$3,282.59
Cost per square foot of Filter.	\$.136.77

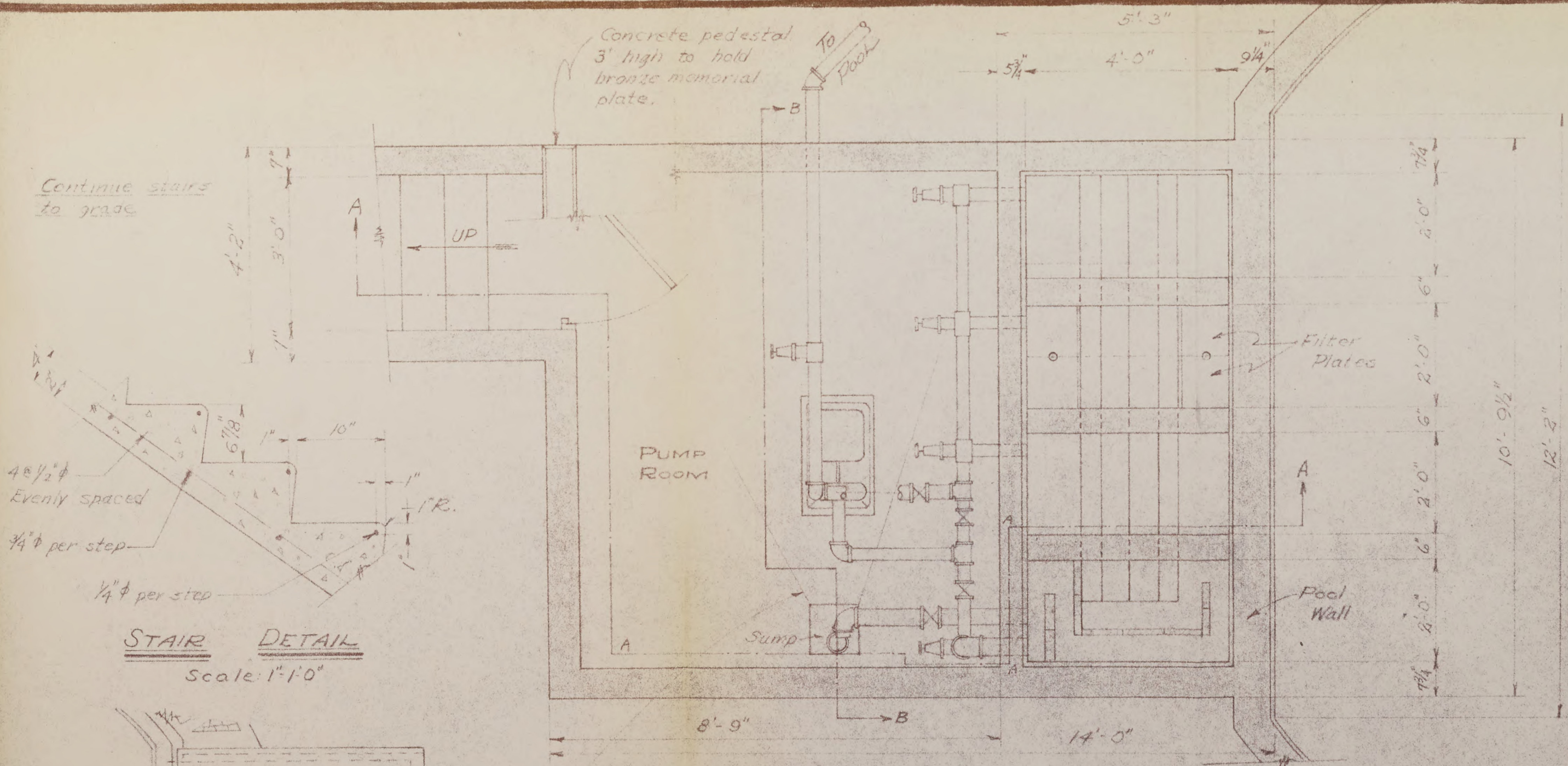
It might be well to note in conclusion that the prices used here are those for central Michigan in August 1947 as near as could be determined.

A swimming pool of the size for which this filter plant is designed would cost approximately \$3,000.00 or, in other words, only as much as the filter plant itself. When we get into larger sizes of pools, we find that the filtering equipment

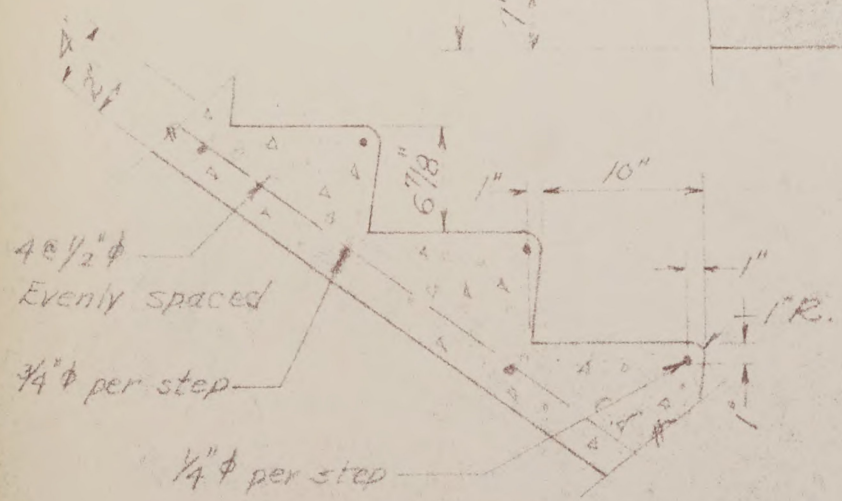
becomes a lesser percentage of the total cost. However, even in large jobs of this kind (swimming pool with recirculation system) the filtering arrangement remains one of the largest items and demands much attention.

R E F E R E N C E S

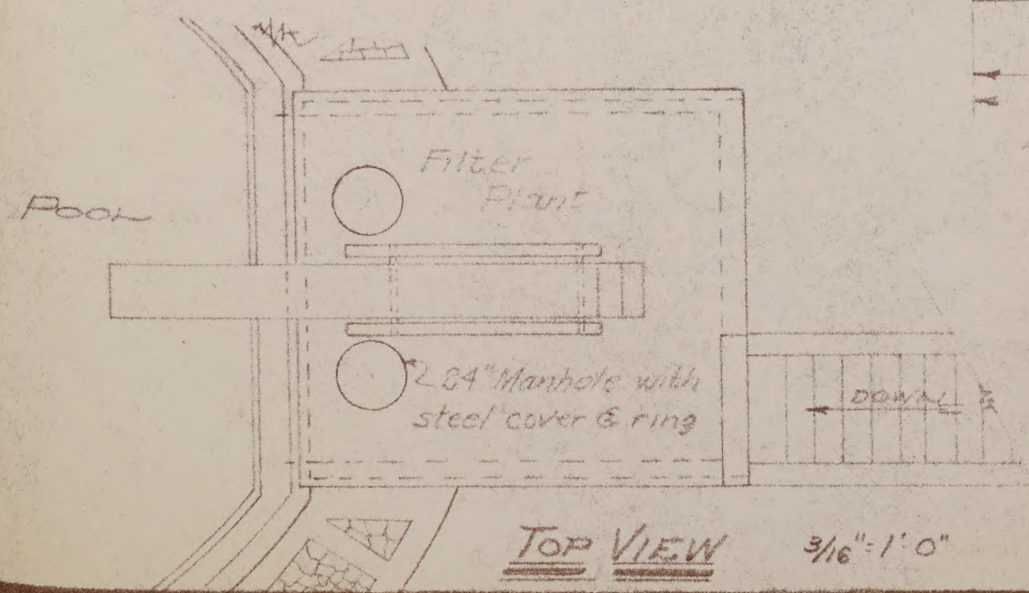
1. "Reinforced Concrete Design Handbook" of the American Concrete Institute.
2. "Reinforced Concrete Design" by Sutherland & Reese.
3. "Report of Joint Committee" of the American Concrete Institute.
4. "Camp Porous Bottoms for Rapid Sand Filters", Bulletin 12 S 12 & 12 S 1660 of Walker Process Equipment, Inc.
5. "Handbook of Hydraulics" by King.
6. "Gardner-Denver" Centrifugal Pumps Types B & C A-101.



Continue stairs
to grade



STAIR DETAIL
Scale: 1" = 1'-0"



TOP VIEW 3/16" = 1'-0"

Pump room floor to be pitched
toward sump, as shown, at
about 1/8" per foot.

PLAN VIEW
Scale: 1/2" = 1'-0"

PLAN

RAPID SAND FILTER

DESIGN & DETAILS By

ALVIN L. FARNSWORTH

MICHIGAN STATE COLLEGE

SCALE: As Noted

1 of 6

Sheet and detail

10'-9 1/2"

1/2" ϕ @ 18" o.c.

1/2" ϕ @ 5 1/2" o.c.

3'-0"
2'-0"
1/2" ϕ @ 12" c.c.

Dowels
4 @ 1/2" ϕ
Evenly spaced

1/2" ϕ @ 18" c.c.

1/2" ϕ @ 3 1/2" c.c.

2-24" Manholes with steel covers & rings.

Note! Water service to be piped in over scum gutter at most convenient point. Pitch pipe from valve toward pool to allow complete drainage.

Not less than 2"

1x3 light steel sash 8"x18". One each side pump room

Not less than 2"

2 @ 3 1/2 x 3 1/2 x 1/4" Lintel over door

See sheet 3 for wall detail

9'-7"

See sheet 1 for stair detail

2x4 key

To Sewer

Pool Outlet

Thicken floor to 8" under pump

SECTION 'B-B'

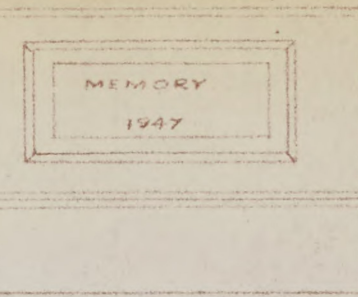
SECTION 'A-A'

ELEVATIONS

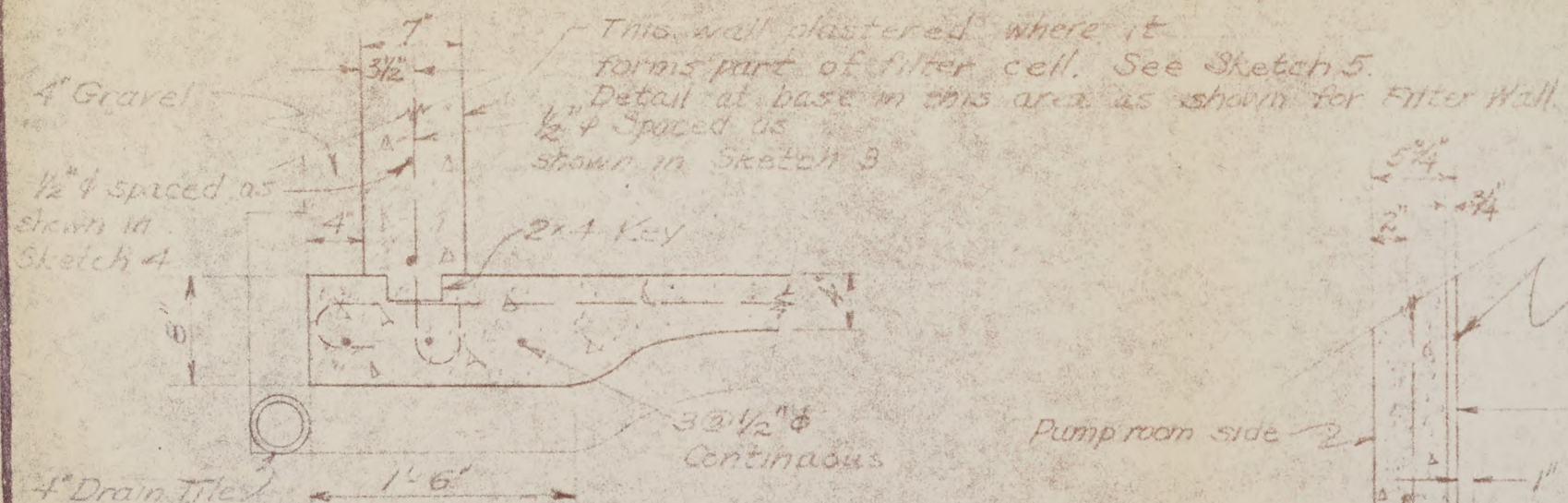
SECTIONAL ELEVATIONS
RAPID SAND FILTER
DESIGN & DETAILS BY
ALVIN L. FARNSWORTH
MICHIGAN STATE COLLEGE

SCALE: 1/2"=1'-0"

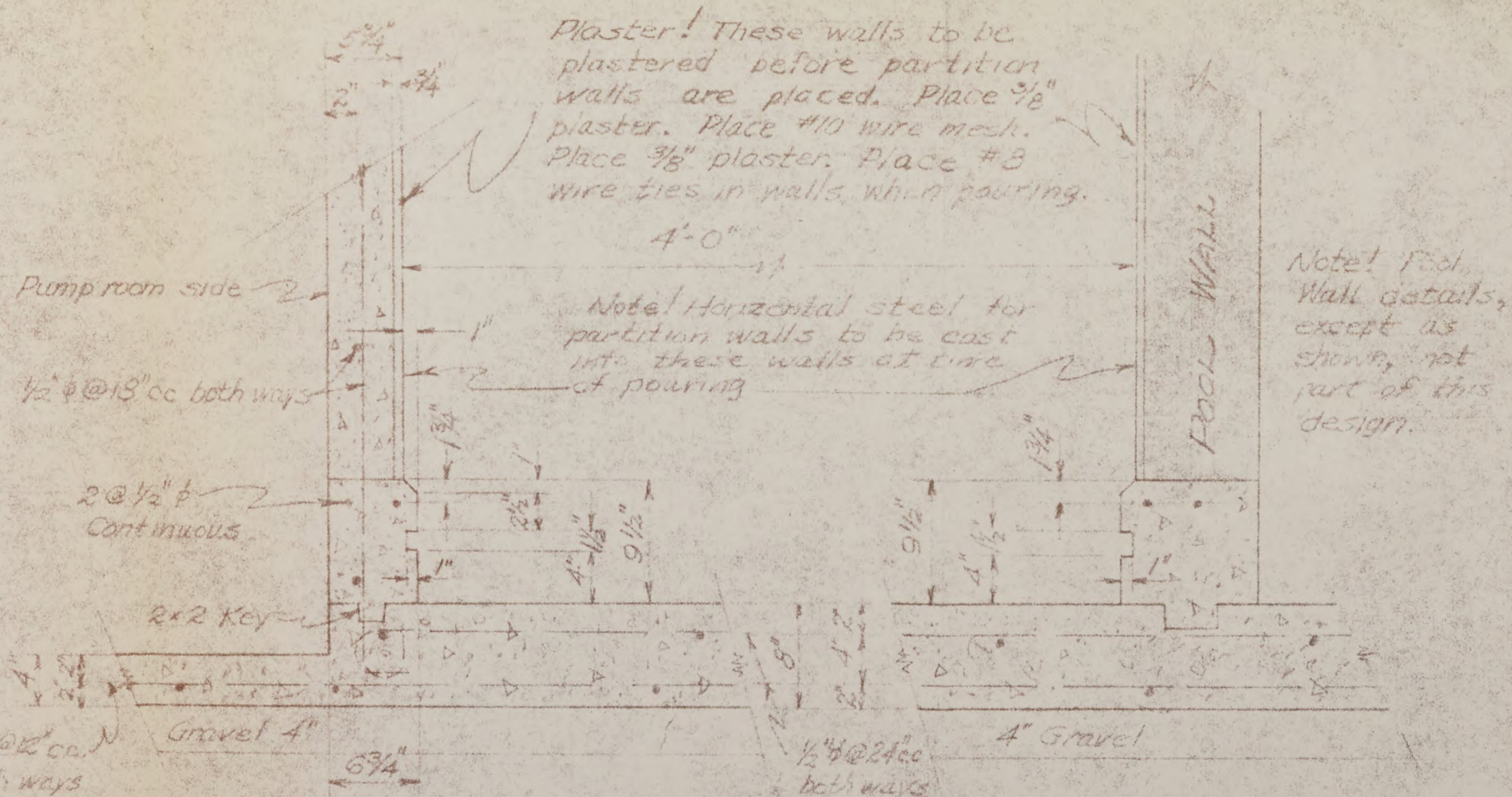
2 of 5





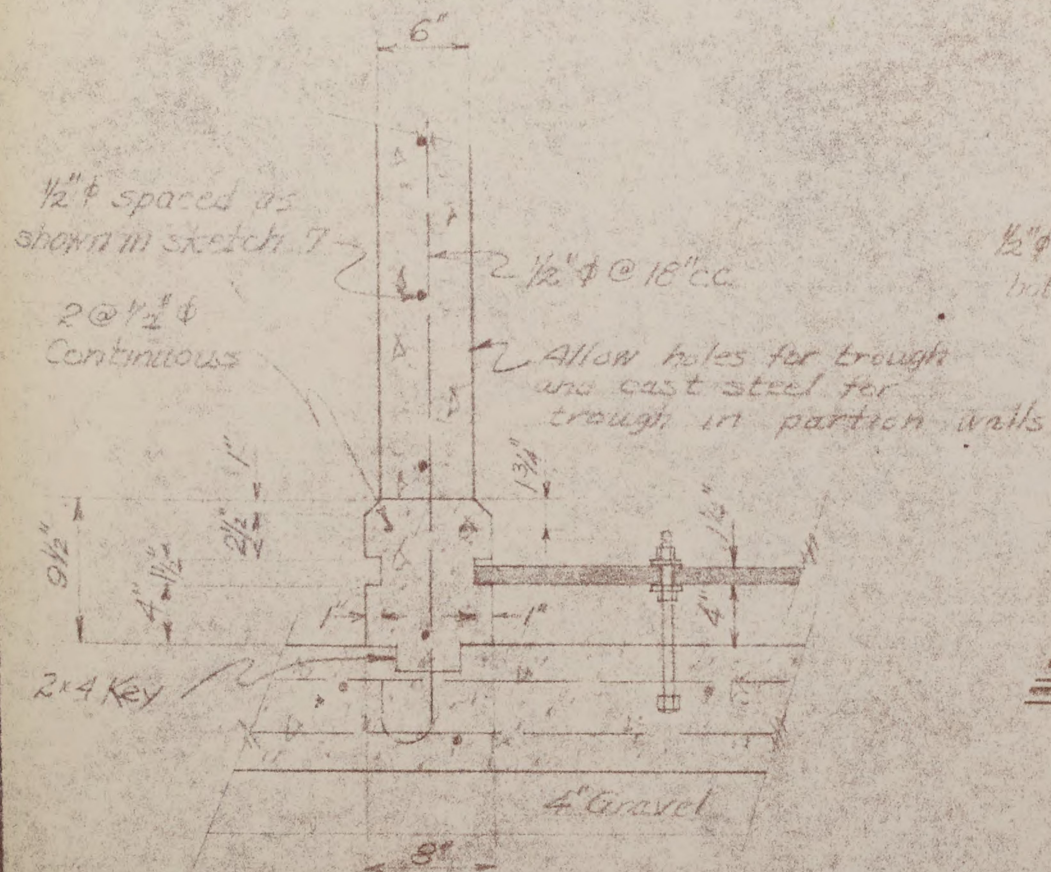


PUMP ROOM WALLS



FILTER WALLS

POOL WALL



PARTITION WALLS

FILTER WALL DETAILS

FILTER WALL DETAILS

RAPID SAND FILTER

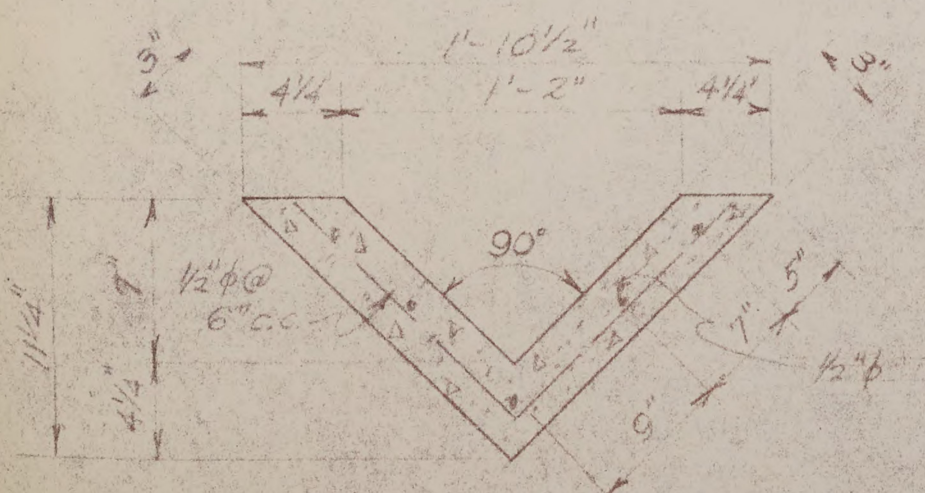
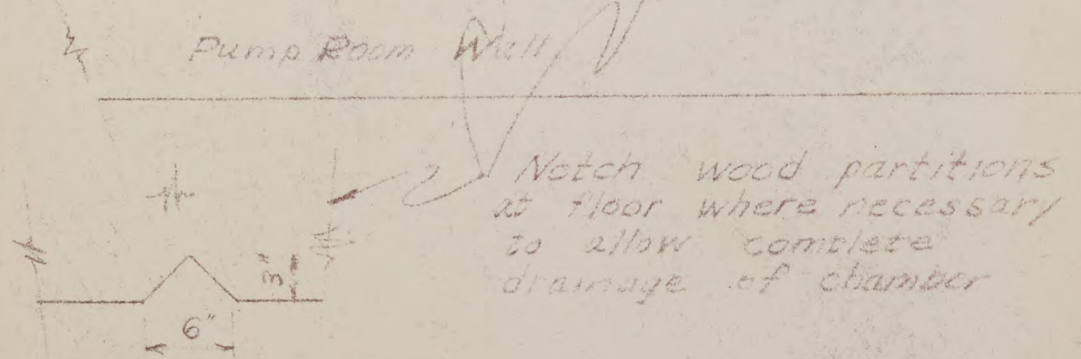
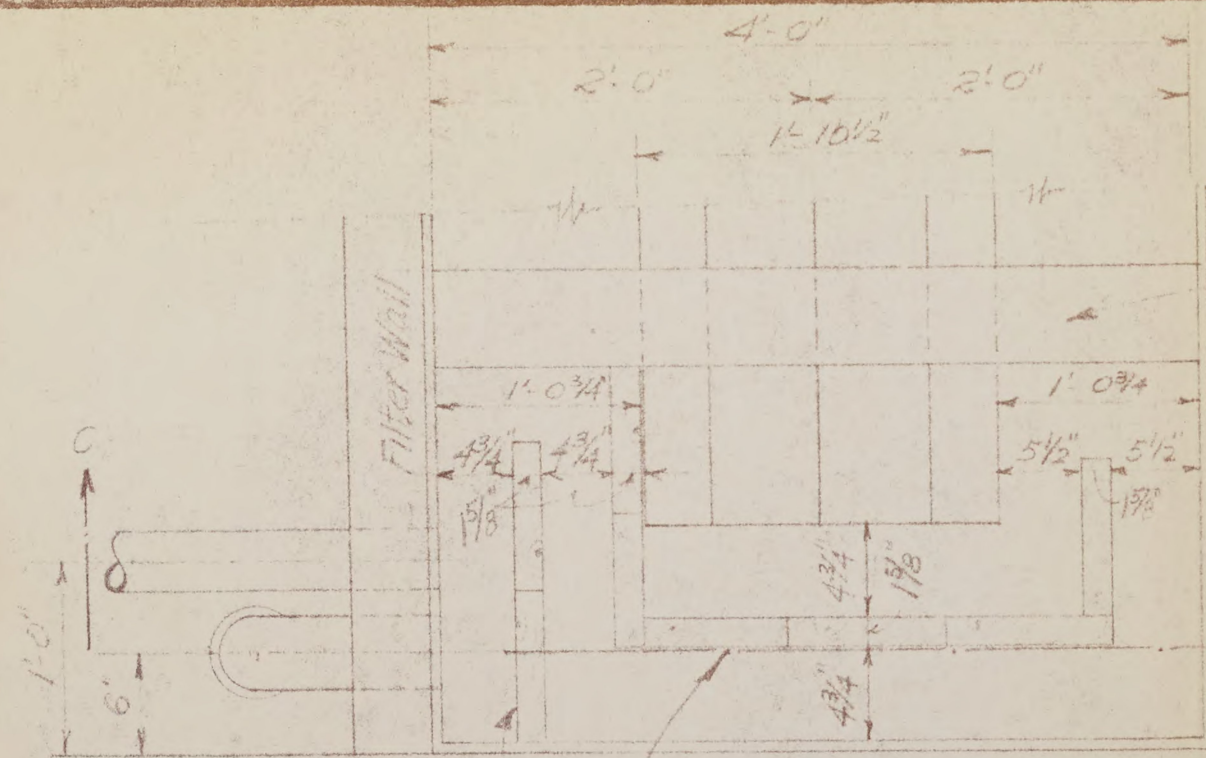
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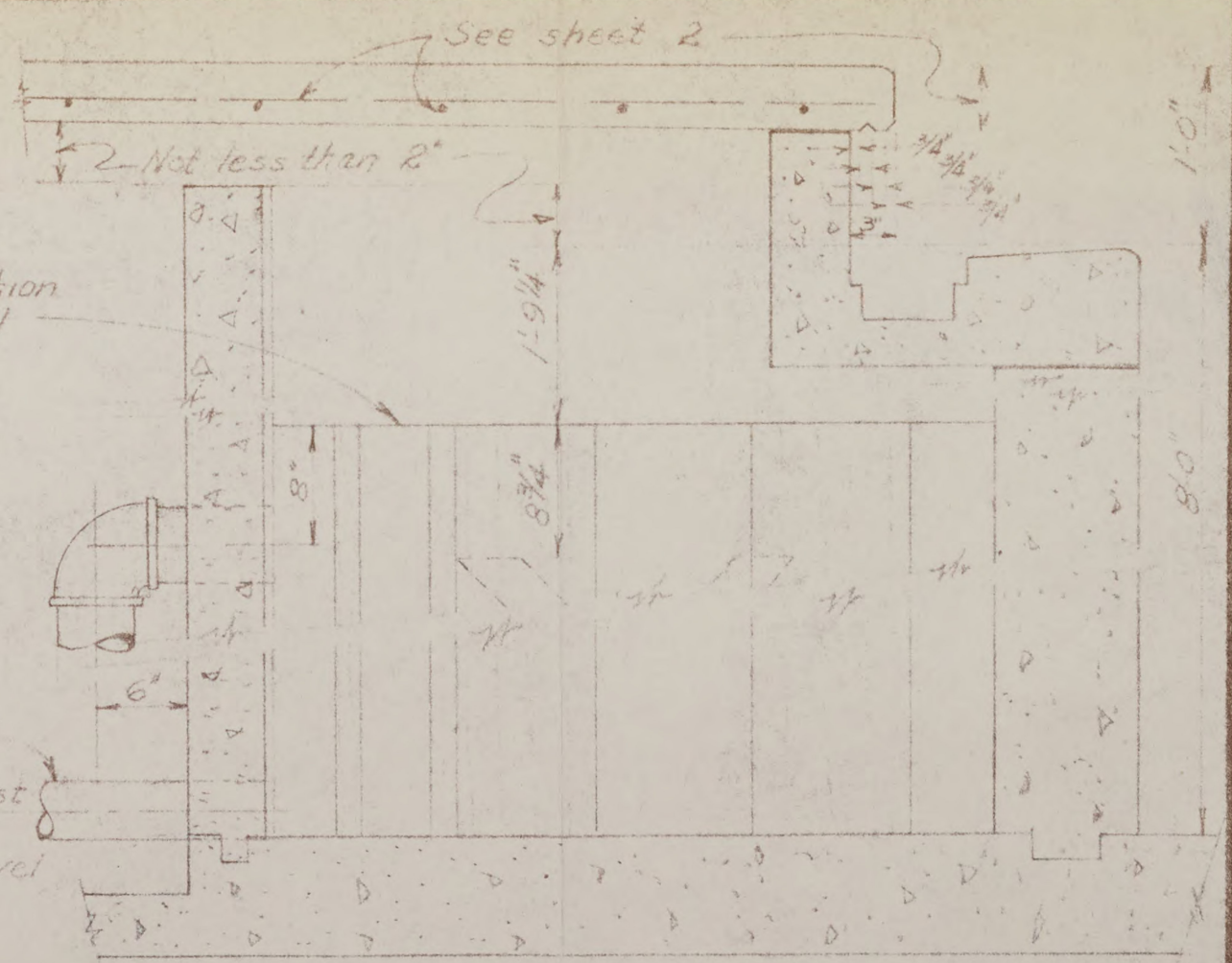
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SCALE: 3/4" = 1'-0"

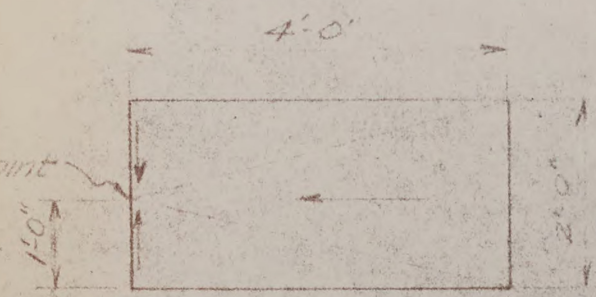
3 of 6



DISTRIBUTION TROUGH 1 1/2" x 1'-0"



MIXING CHAMBER 1'-1'-0"

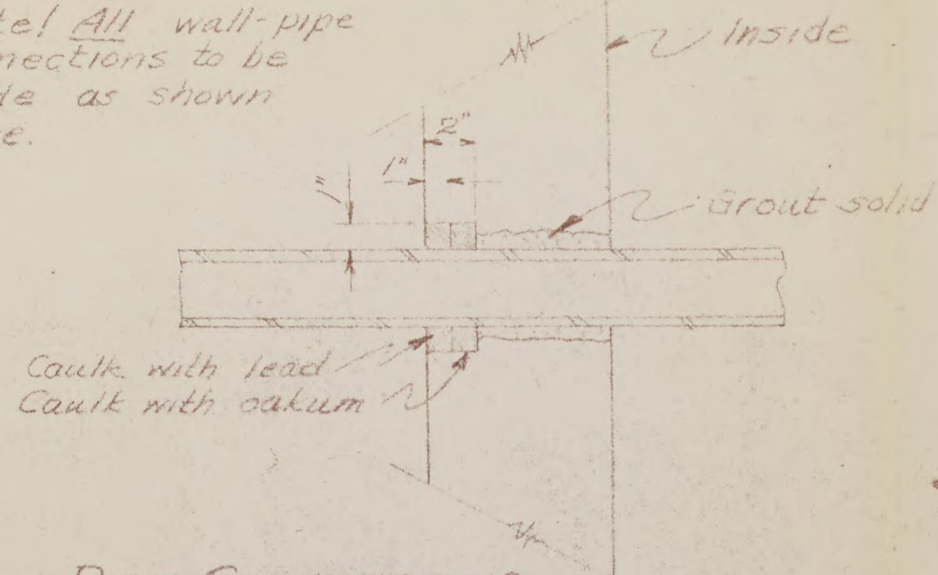


MIXING CHAMBER FLOOR 1/2" x 1'-0"

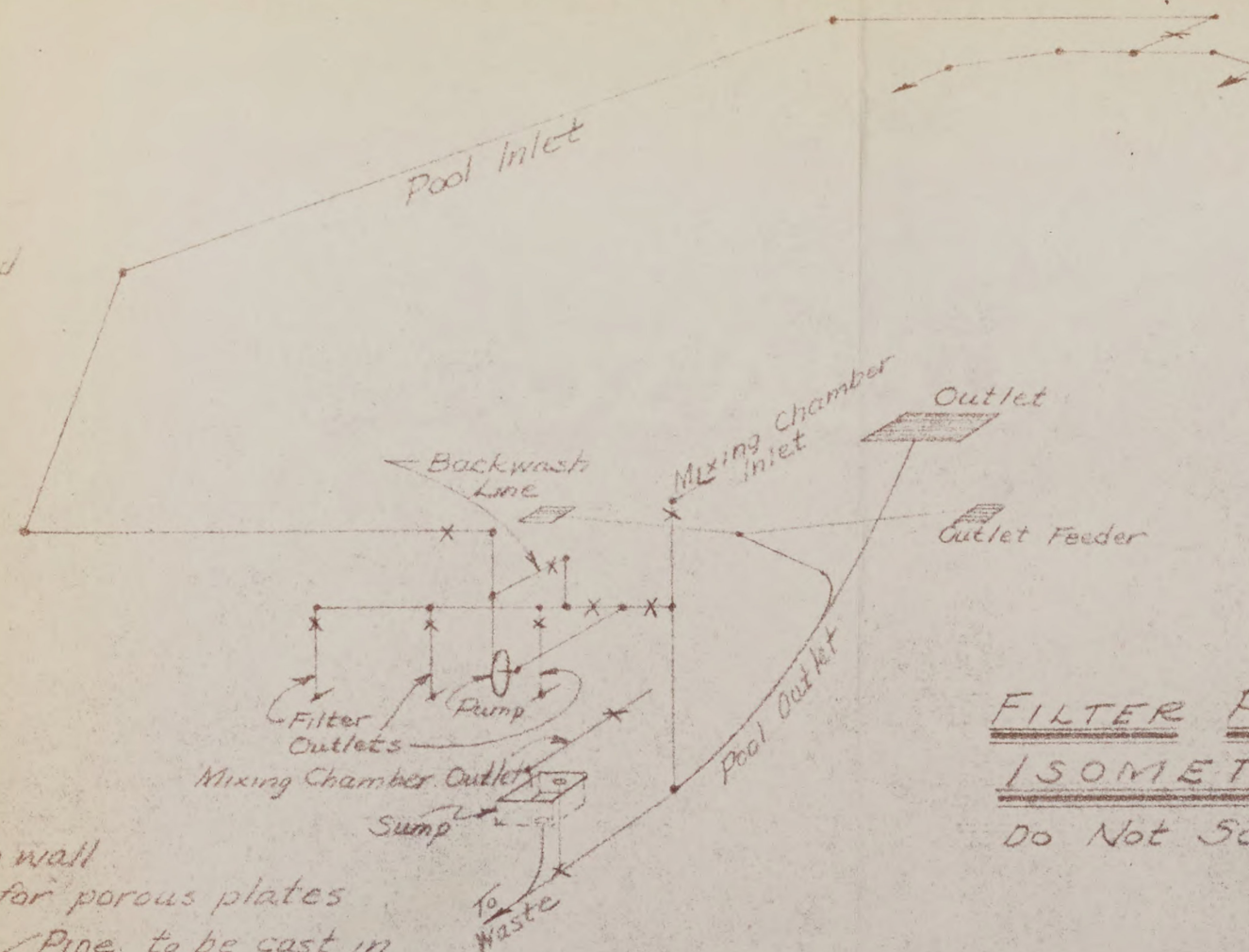
C-C
See sheet 3 for wall & floor details not shown here.

MIXING CHAMBER DETAILS
RAPID SAND FILTER
 DESIGN & DETAILS BY
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 SCALE: As Noted 4 of 6

Note! All wall-pipe connections to be made as shown here.



WALL-PIPE CONNECTIONS



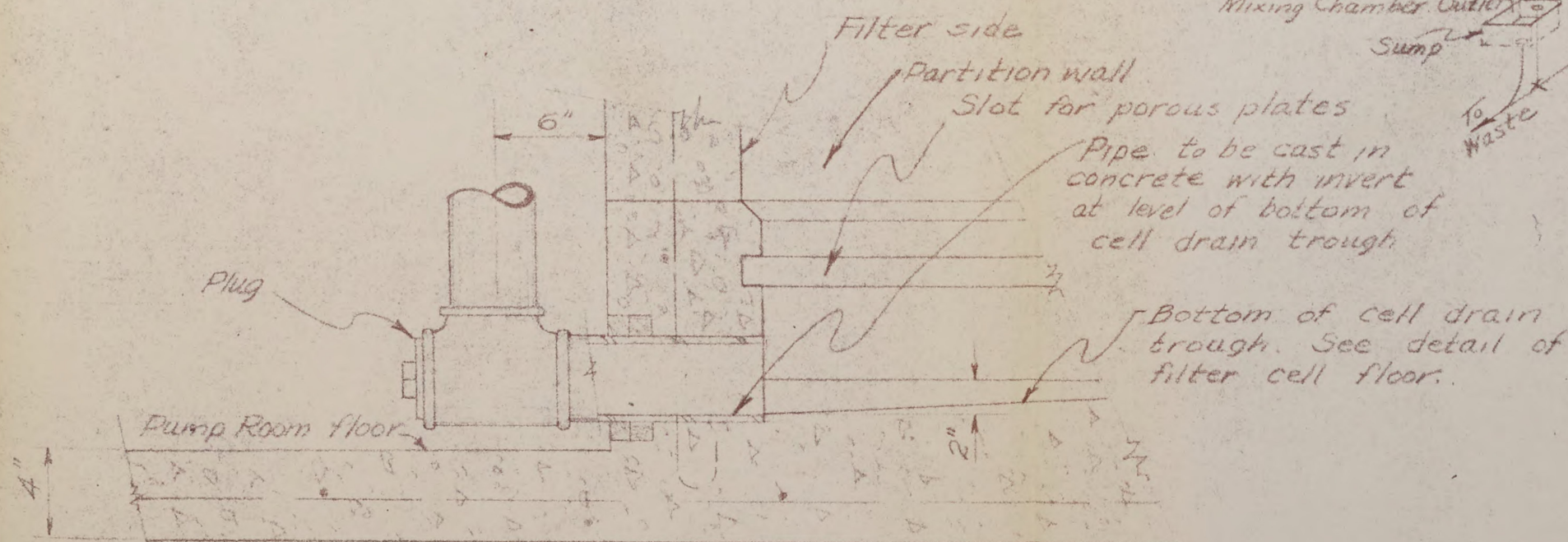
LEGEND

- + Cross
- ┤ Tee
- └ Ell
- x Valve
- └ "Y"

FILTER PIPING

ISOMETRIC

Do Not Scale



FILTER CELL OUTLET

FILTER PIPING

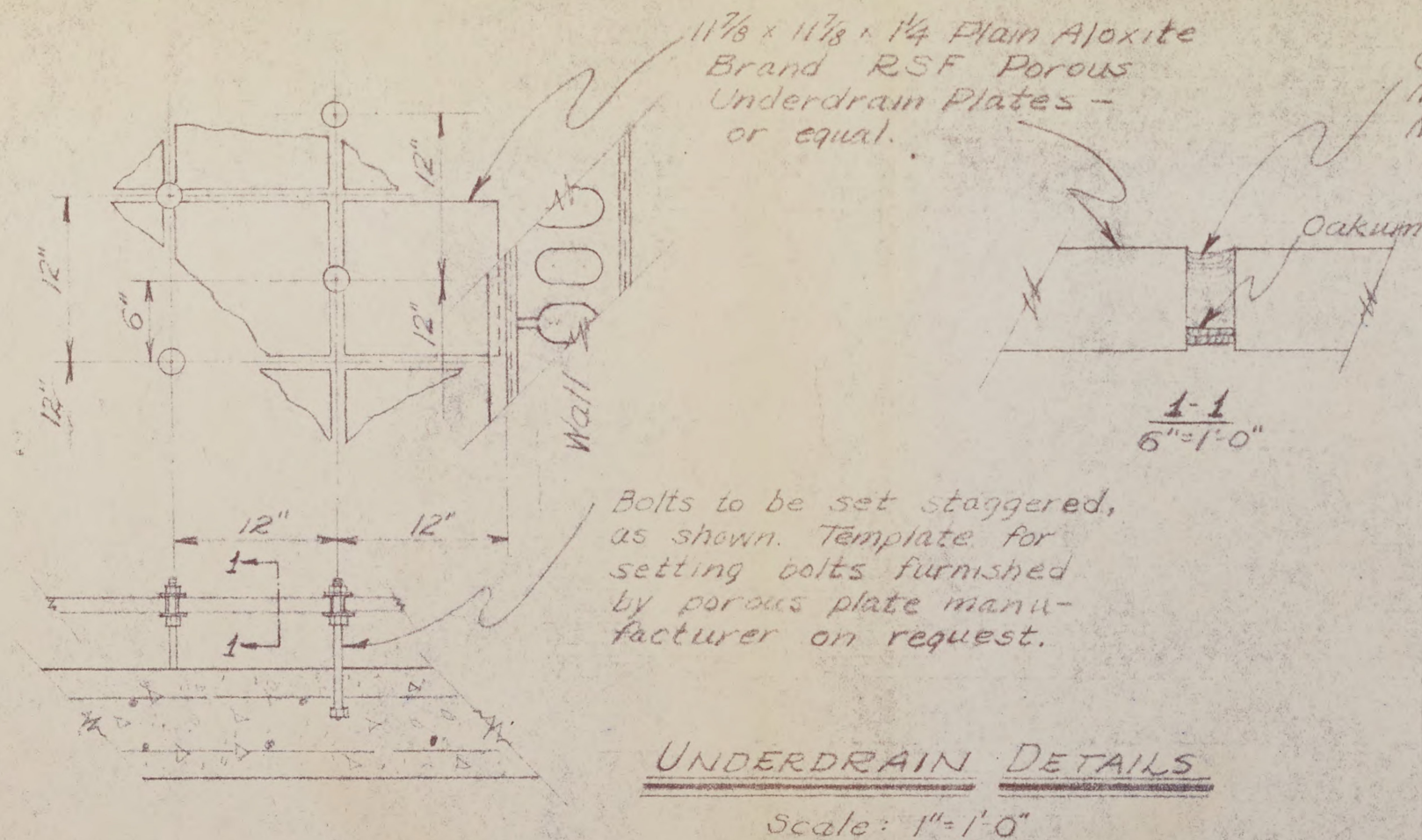
RAPID SAND FILTER

DESIGN & DETAILS By

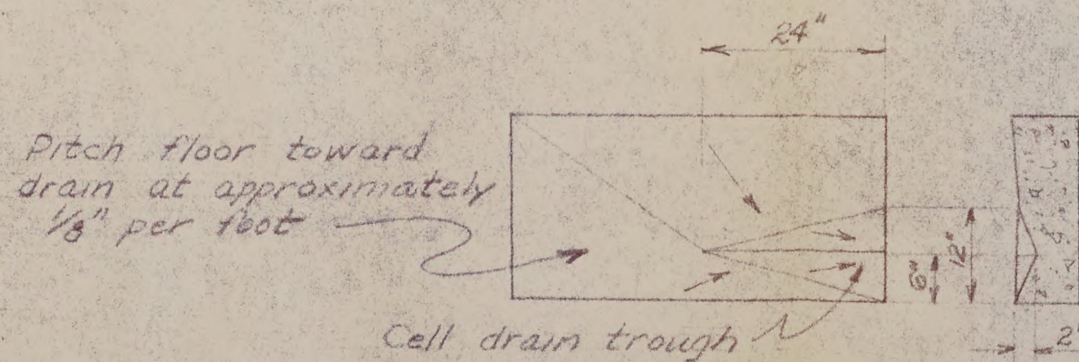
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SCALE: $1\frac{1}{2}" = 1'-0"$

5 of 6



Note! Use 24" of sand on
top of porous plates.
Effective size = .35 mm.
Unit Coef. = 1.75



FILTER UNDERDRAIN

FILTER UNDERDRAIN RAPID SAND FILTER

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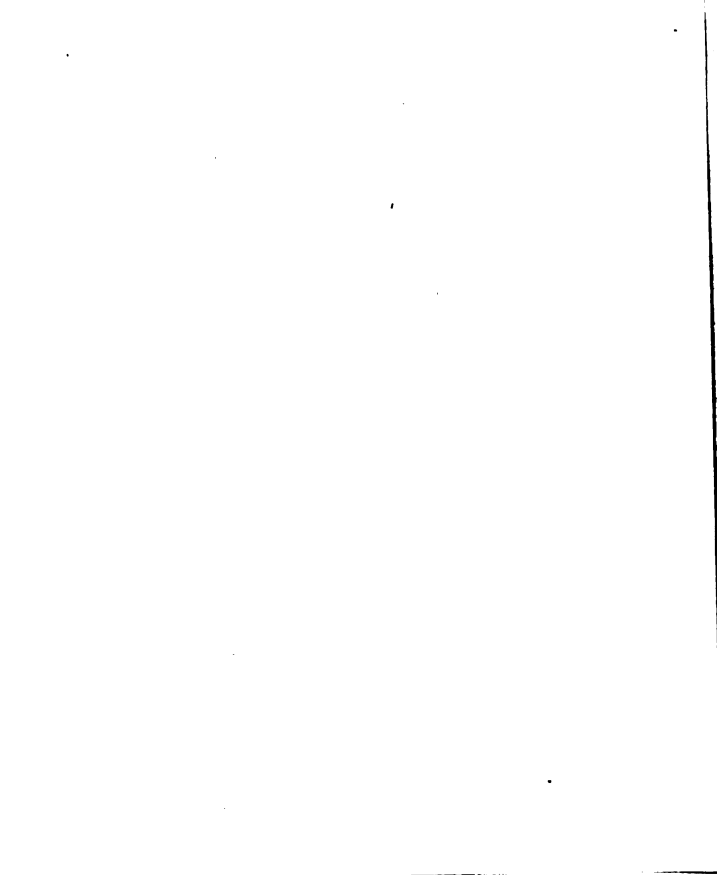
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SCALE: As Noted

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ROOM USE ONLY

ROOM USE ONLY



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