A Report Of An Investigation Of A Portion Of
Strouble's Creek, Near Blacksburg,
Montgomery County, Virginia.

By

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A report of an investigation of a portion of "Strouble's Creek, near Blacksburg, Montgomery County, Virginia...

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Blacksburg, Virginia

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BY

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To Robert H. Houston, C.E., Professor of Civil Engineering.

Approved: R.H. Houston,
Acting Professor Civil Eng.
6/9/13.

W.N.C. 6-26-'35

I hereby certify, on my honour, thaf, in presenting this thesis, I am presenting only work which has been done by me in person, with the exception thac I was assisted in the field work by Messrs. T.H.Olinger, W.A.Callaway, P.P.Phillips, C.Metcalfe and W.G.Warwick.

B.H.Rowe, Jr.

(16)

A report of an investigation of a portion of Strouble's Creek, near Blacksburg, Montgomery County, Virginia, for the purpose of locating a reservoir to serve as a source of ice supply for the Virginia Polytechnic Institute, as a skating pond for the cadets of the Institute and as a possible source of water supply for the Tuberculosis Barns of the Virginia Agricultural Experiment Station, located nearby.

This report will include a study of the topography of the portion of Strouble's Creek Valley involved, of the water flow conditions of this stream, of complete designs for a Hollow Deck and Buttress Type of Reinforced Concrete Dam, and cost estimates on the proposition.

This report will be accompanied by a complete topographic map of the area involved, the field notes, and complete plans for the Hollow Deck and Buttress Type of Dam decided on, save that the 36" pipe and control valve for the drainage of the reservoir are not shown.

THE METHOD OF PROCEEDURE.

RECONNAISSANCE. A careful reconnaissance survey of the approximate location desired was made, without the use of instruments. This investigation was made for the purpose of locating the most satisfactory site for the dam, both from a constructional point of view and with the desire to avoid any unnecessary damage to the land. It was decided that the most economical location would be at a point about fifty feet above the upper edge of the present pond and with the dam at right angles to the bed of the stream. This location, it was seen, would give a very satisfactory body of water, would flood as small an area as would be flooded by any other location and would cause the least damage to adjacent property. Here there occurs a fine outcrop of nearly flat-lying dolomitic limestone, and it was found that at no point across the valley was this stone more than four feet under the surface of the overlying soil. This limestone will give a most satisfactory foundation on which to place the dam.

LOCATION AND TOPOGRAPHIC SURVEY.

The next step was the location and topographic survey. The intersection of the dam and the line of the bed of the stream was taken at a point 60' above the point of entrance of the stream into the present pond. A point 6.00 to the south east of the bank of the stream was chosen as Sta. 0+00 of a traverse line, run by transit 1400 ft to a point in the field in the rear of Dr. Davidson's property and owned by the Virginia Agricultural Experiment Station. This travers was run with a chain and taking the deflection angles at turning points. (This traverse was originally run 1700', but on the final location only 1400' of it was used. Similarly, in taking the topography contours were run out up to the 416' contour, but only those up to the 410' contour were used. In plotting the topographic map only these latter limits were used.) With a wye level a profile was taken at 400' intervals over this traverse line, and the elevations thus obtained on which to base the topography. With the wye level and a cloth- wire tape the points for two foot contours were obtained, running at approximated right angles to the traverse line. These contours were referred to that of ~~Stat~~ Station 0+00, the elevation of which was assumed at 400' merely for convenience. There were no buildings on this land, nor any other peculiar topographic features of any importance. It might be noted, however, that although it is not so indicated on the map, the limestone quarry from which the stone for the concrete is to be obtained will be flooded. This quarry is but a small affair, is not of any great financial value, and was consequently ignored in making both the survey and cost estimates.

The next step was the taking of borings through the soil along the line of the longitudinal dimension of the dam to find the depth of the solid rock under the ~~s~~ surface. This was done by driving a steel rod with a sledge af the points found for each of the contour intervals. Next were taken the necessary stream measurements. This was done with a rectangular wier, and a wye level and rod to determine the hieght of water on the wier. The wier was made of a 2" white pine material. It was made of three 12" widths, making its total depth 36". It was made of such length thaf the ends projected well into the banks of the stream when the wier was in place. The notch was made rectangular, with sharp edges, and width, 12". The water face of the wier was carefully covered with oil-cloth, which was also allowed to run in a continuous piece upstream for four feet; this to ensure as small an amount of leakage as possible. There was practically no leakage through or under the wier board. A shot was taken with the ~~lev~~ level on the bottom of the notch, reading on the rod 6.83. A reading was then taken on the surface of the water af a point 6' atove the wier board. This last reading was taken a number of times, and an average of the readings then used for determining the height of wafer on the wier. This last average reading was 7.50, giving the height of water, h== 0.67'. This completed all of the necessary field work.

DETERMINATION OF PROPER HEIGHT OF DAM.

The field notes were next plotted up, this giving a means of making ~~som~~ some computations which would enable a decision as to the advantageous height of dam to be made. The plotting was done on a scale of 1"=100'. This map was carefully inspected, and the determination made thaf a dam with its crest at an elevafion of 410', with respect to the ground elevetion at Station 0+00 would give the most satisfactory results. A dam of this height will give a fully sufficient volume of water for the purposes desired, and will give an area of surface of water of approximately 10 Acres. This will under the ordinary winter temperature conditions prevailing in this locality give a plentiful supply of ice if the proper care is taken in cutting it.

DETERMINATION OF TYPE OF DAM.

It having been found thaf there was a small dolomitic limestone quarry near the site of the dam, examination of the rock was made and this showed thaf the stone was of an excellent character to use for the rock aggregate in a concrete. It was found thaf an excellent sand could be secured for a very reasonable price. It was, therefore, decided thaf a hollow Deck and Buttress Type of Reinforced Concret dam would not be unreasonably expensive, as compared to some form of timber dam, and would be much less expensive than a masonry or massive concrete dam. This type was, therefore, decided on.

DESIGN OF THE DAM...

Although not really a part of the design of the dam the necessary excavation and preparation of the foundation will be considered at this point. The overlying soil is to be entirely removed from all portions of the rock surface covered by the dam, and then well cleaned by washing with the flow from a hose. The trenches are to be then excarated and finished to as nead plane surfaces as possible, and the resting places for the buttresses are to be made and finished to plane surfaces. This is to be done to avoid as much as possible the tensile stresses which will result in the bottom part of the concrete in these trenches if there are any pronounced irregularities. See note at bottom of page 67

The dam is to consist of two slabs resting on buttresses and massive concrete placed in trenches cut into the stone foundation as described in the preceding paragraph. The slab forming the wafer face is to have a sfraight line profile. That forming the overflow face is to hare a curved face, consisting of a parabolic curve at the top and running to a point 5'- 6" below the top, there to be joined by a tangent which connects it with a cycloidal curve(radius of generating circle = 2.83) which continues to the base. This is shown in the accompanying plans. This profile for the spillway will give the best results in removing the water rapidly and in avoiding scour af the base. The cycloid is to commence af a point 5.00ft from the base. The dimensions of the buttresses and of the trenches are shown on the plans. The buttresses are to be spaced 14' c. to c. The dimensions given on the plans are those at the point where the dam has its greafesf height, and the dimensions af any other point afe to be obtained by considering that the base is at the elevation corresponding to this point, and taking the dimensions occuring above a line drawn through the proper elevation pn the plans as given.

The Back Slab.

Pressures.

Assume thaf fhe wafer exerts a uniform pressure on the whole face of 100 #/ sq. in., which will be a safe maximum for assumption.

Assume, for concrete, w= 150 #/ cu.ft.

Assume the back slab as haring a uniform thickness of 6", which is nearly true.

Then; Pressure due to concrefe = 1×1×150 × 1/2 = 75 #/ sq.ft.

***** Then, Total unit pressuee = 100 + 75 = 175 #/ sq.ft.

$M = 1/8\ wl^2 = 1/8 \times 14^2 \times 12 \times 175 = 51,450$ i-p.

Assume; $f_c = 600$; $f_s = 15,000$; n= 15; d=6"; b = 12".

*****

Taking a lamina 12" wide and 14' long.

Since the slab is ~~rectangular~~ square (practically) the reinforvement will be put in both longitudinally and transversely.

∴ for the strip, M = 1/2 × 51,450 = 25,725 i-p.

For the above assumed values of f_c, f_s, n the diagram given on page 277 of Turneaure and Maurer's "Principles of Reinforced Concrete Construction" itis found thaf, j= 0.86; k = 0.42 and p = 0.0075.

Then A = pbd = 0.0075 × 12 × 6 = 0.27 sq. in. of steel

$$f_c = \frac{2M}{b\,k\,j\,d^2} = \frac{2 \times 25725}{12 \times 0.42 \times 0.86 \times 6^2} = 329 \text{ \#/ sq. in.}$$

This is a very low value for f_c, but it would be inadvisable to make d less than 6" because in some places it will be decidedly greafer than this. Also it must be understood thar if desired in order to reduce the expense a low mix of concrefe could be used, say a 1:3:6 mix.

The front slab will, then, be made of a slab reinforced with 3/8 " round rods spaced 6" cc. with a straight line inner profile and with a profile on the outside formed as described previously. The reinforcement will be placed both longitudinally and tramsversely. The transverse rods are to be 24" over-le length. This is to permit of their being buried for 12" in the massive concrefe of the base and bent back intothe top of the dam atthe crest.

The water face slab.
Design of the lower 1/3 of the slab.

Pressures.

Max water pressure at base = 875 #/ sq.ft.
Max wafer pressure af top = 582.6 #/ sq- ft.
Average pressure = 728.8 #/ sq.ft.

Considering w for concrete = 150 #/ cu.ft., and taking the average thickness of the slab as being = 9"; for concrete w = 9/12 × 150 = 113 #/ft^2

:. Total unit pressure on the section = 728.8 + 113 = 841.8 #/sq.ft.

Taking a lamina 12" wide and 14 ft. long,

$$M = 1/8\, wl^2 = \frac{841.8 \times 14^2 \times 12}{8} = 259{,}989 \text{ i-p.}$$

Since the slat is square the reinforcement will be put in both longitudinally and transeversely,

:. Use M = 1/2 × 259989 = 129,995 i-p.

Assume f_c = 600; f_s = 15,000; and n = 15.

Then from diagram on p. 277; j = 0.86; k = 0.42; p = 0.0075.

And, A = 1/2 p b d = 1/2 × 0.0075 × 12 × 9 = 0.48 say =0.50 sq in of stee

$$f_c = \frac{2M}{b\,k\,j\,d^2} = \frac{2 \times 129995}{12 \times 0.42 \times 0.86 \times 9^2} = 738 \text{ \#/sq.in.}$$

This value of f_c is right high, but is within the permissible limit of 750 #/ /sq.in. There will be no impact stresses on this structure, hence this may be considered as safe. It will be necessady to use a good, rich mix of concrete for this part of the work, say a carefully made 1:2:4 mix, and full ~~car~~ care must be taken in placing it.

The lower 1/3 section is, then, to be composed of a slab 10" thick at ~~th~~ the bottomand 8" at the top, here to be joined by the middle 1/3 slab which ~~i~~ is 8" thick af its bottom. The slab is to be made of 1:2:4 concrete well mixed and carefully placed; and with reinforcement consisting of 9/16" round bars, which, longitudinally, are to be bent up over the buttresses to care for the negafive bending moments which will occur af these points and for the diagonal tension stresses; and the transverse rods are to be 24" over length, 12" of which is to project over into each of the parts above and below the ~~se~~ section. All bars are to be spaced 6" cc.

Design of the middle 1/3 of the slab.

Pressures.

Max water pressure at bottom = 582.6 #/sq.ft.

Max water pressure at top = 291.7 #/sq.ft.

Average pressure = 437.2 #/ sq.ft.

Considering w for concrete as = 150 #/cu.ft., and taking the arerage thicknes of the slab as = 7", w = 7/12 × 150 = 87.5 #/sq.ft

∴ Total unit pressure on the section = 437.2 + 87.5 = 524.7 #/sq.ft.

Taking a lamina 12" wide and 14' long,

$$M = 1/8\, wl^2 = 1/8 \times 524.7 \times 14^2 \times 12 = 154{,}262 \text{ i-p.}$$

Since the slab is squarethe reinforcement will be placed both longitudinally and transversely, hence, take M = 1/2 × 154262 = 77,131 i-p.

Assume $f_c = 600$; $f_s = 15{,}000$; and $n = 15$.

Then, from diagram on p.277, ; j = 0.86; k = 0.42 and p = 0.0075.

A = 1/2 p b d = 1/2 × 0.0075 × 12 × 7 = 0.315 say = 0.32 sq in of ~~ste~~ steel.

$$f_c = \frac{2M}{b\,k\,j\,d^2} = \frac{2 \times 77131}{12 \times 0.42 \times 0.86 \times 7^2} = 726 \text{ \#/sq.in.}$$

This value of f_c is high, but is within the limit of 750 #/sq.in. The s same mix of conceete and the same care ade to be taken in the case of this ~~se~~ section as for the one previously described.

The middle 1/3 section is, then, to consist of a slab 8" thick at the bottom and 6" af the top, here to be joined by the upper 1/3 section which is 6" thick. This section is to be made of the same concrete as the other slab parts, with the same precautions, and with reinforcement to consist of 7/16" round rodswhich, longitudinally, are to be bent up over the buttresses as described before, and the transverse rods ade to be 24" over length as before. All rods are to be spaced 6" cc.

Design of the upper 1/3 of the slab.

Pressures.

Max water pressure at the bottom = 291.6 #/sq.ft.

Max wafer pressure at the top = 000.00 #/sq.ft.

Average pressure = 145.8 #/sq.ft.

Considering w for concrete = 159 #/cu.ft., and taking the thickness of the slab at 6" over all w = 1/2 × 150 = 75 #/sq.ft.

Thdn, Total unit pressure = 145.8 + 75 = 220.8 #/sq.ft.

Taking a lamina 12" wide and 14' long,

$$M = 1/8\ wl^2 = 1/8 \times 220.8 \times 14^2 \times 12 = 64{,}915 \text{ i-p.}$$

Since the slab is squade the reinforcement is to be placed both longitudinally and transversely, hence take M = 1/2 × 64915 = 32,458 i-p.

Assume $f_c = 600$; $f_s = 15{,}000$; and n = 15.

Then, from diagram on p. 277; j = 0.86; k = 0.42 and p = 0.0075.

Then, A = 1/2 p b d = 1/2 × 0.0075 × 12 × 6 = 0.27, say = 0.30 sq.in o pf steel.

$$f_c = \frac{2\ M}{p\ b\ k\ j\ d^2} = \frac{2 \times 32458}{12 \times 0.42 \times 0.86 \times 6^2} = 416 \text{ \#/sq.in.}$$

This value of f_c is rather low, and is especially so considering the relatively high values used in the two lower 1/3 sections of the slag. This discrepaancy can be over looked, or can be readily corrected by increasing the thickness of the lower parts 1" at all points. Care is to be taken as before in the mixind and placing of the concrete in securing a compact homogeneous mass.

The upper 1/3 section is, then, to consist of a slab 6" thick from top to bottom. This section is to be made of the same concrefe and with the same precautions, and with reinforcement to consist of 7/16" round rods, which, longitudinally, are to be bent up over the buttresses as described before, and, transversely the rods are to be 24" over length as in the case of the two lower sections. All rods are to be spaced 6" cc.

NOTE:- In the bottom of the trenches there is to be placed 1/2" round rods, spaced 12" cc. These ade to care for the tensile stresses which will be produced by irregularities in the trench surface.

The note at the end of the first paragraph on page (4) has reference to these rods. They are mentioned here because they may properly be considered under that part devoted to the reinforced work. The cost of these rods will be approximately $200.00

PROTECTIVE COVERING FOR THE OVERFLOW SURFACE.

From a line three feet below the crest of the dam to and over the crest and on the overflow side to a line three feet below the crest there is to be plaeed over the surface a 1/4" covering of neat cement of a consistency represented by 27% of water, to the whole mass of the cement. This is to protect the surface from abrasion due to the flow of the water and small articles in suspension. This will be at a cost of atout $0.50 per sq yd. There will be about 265 sq.yds. to be so covered, making the total cost of this part of the work = 265 sq.yds @ $0.50 = $135.00 (about)

SPECIFICATIONS.

The Materials.

The Cement. The cement shall be that made by the Atlas Portland Cement Company of New York, shall be supplied in paper bags, shall be inspected on arrival, andshall then be entirely free from any damaging effects due to moisture or other causes. The cement shall be stored in an entirely moisture proof room, and removed only as it may be needed for use.

The Sand. The sand shall be a clean, sharp quartz sand of a size retained on a 1/16" mesh and passed by a 1/4" mesh. The sand shall be entirely free from all matter of a vegetable, clay or calcareous nature.

The Stone. The stone shall be that obtained from the dolomitic limestone quarry near the site of the dam. It shall be well crushed and only that accepted which will pass a 2 1/2" mesh and will be retained on a 1/2 " mesh revolving screen, at the crusher. In the case of the unreinforced concrete in the trenches and in the buttresses it may be permitted to use stones not greater than 3 1/2 " in any diameter. Byt care shall be taken to see that not more than approximately 10% of stones of this size are allowed in the aggregate.

TheConcrete. For the reinforced parts of the work the mix shall be a 1:2:4, and for the unreinforced a 1:3:5. The cement and sand shall be thoroughly mixed, dry, and the stone then added. The whole will then be mixed wet. Care shall be taken that a thoroughly homogeneous mass is obtained. No more shall be mixed in one batch than can be placed within twenty minutes after the mixing is completed. No concrete shall be mixed in the absence of the Inspector.

The Steel. The sfeel shall be tha« supplied by the Cambria Steel Company, of Johnstown, Pennsylvania; shall be "Structural Steel", capable of taking an allowable unit tensile stress of 16,000 #/ sq.in.

The Lumber for the Forms. The lumber for the forms shall be a medium grade of pine. Scrap material from the mills may be used provided it meets all requirements. Care shall be taken that no lumber is used which shall have such an excessive number of knots, knot holes or other weaknesses as might cause the forms to be in any danger of giving way under the reasonable strains due to the placing of the concrete.

No work shall be done in the absence of the Inspector, and the contractor is to assume full liability in case any such work is done and is then rejected by the Inspector or Engineer in charge of the work.

THE WORKMANSHIP. The Inspector will at all times insist on the most careful work on all parts of the structure, with particular reference to the building of forms, the reuse of old lumber in forms, the mixing and the placing of the concrete. The Inspector will see that great care is taken in the placing of the reinforced work, especially with reference to the placing around the rods.

THE WATER CONDITIONS IN THE RESERVOIR.

These calculations are approximations, partly because of methods used and partly because of assumptions made. It is assumed that the land surface falls more than 2' below the 2' contour interval limit below the 400' contour. This is approximately correct. The area within any contour line was found by the use of a polar planimeter. This gives but approximately correct results for the areas. The volume within any two contours was found by multiplying the average of their areas by the contour interval of 2'.

The following results were obtained by ths methods and assumptions stared above:--

Area within	400' contour	=	18112	sq.ft.
" "	402	"	=	84032	" "
" "	404	"	=	159912	" "
" "	406	"	=	248704	" "
" "	408	"	=	314816	" "
" "	410	"	=	394560	" "

Volume when water is at 400' contour = 9056 cu.ft.
" " " " " 402 " = 111200 " "
" " " " "404 " = 346144 " "
" " " " " 406 " 745760 "" "
" " " " " 408 " = 1309280 " "
" " " " " 410 " = 2018656 " "

1 cu.ft. = 7.481 U.S. Gallons. Hence,--

Max capacity of the reservoir = 7.481 × 2018656 = 14,910,578 gallons.

With a rectangular wier, fully contracted, l = 12", 2" thick, as previously stated, the average value of h was found = 0.'67.
Using Bazin's Formula # 3, as given on page 549 of Trautwine's Handbook, and with the constant, m = 0.41, found in table on p. 554;

$$Q = m\,l\,h\sqrt{2gh}$$

$$= 0.41 \times 1 \times 0.67\sqrt{2 \times 32.2 \times 0.67}$$

$$Q = 1.8 \text{ cu.ft./ sec-}$$

At this rate, of 1.8 cu. ft./ sec., it will take to fill the reservoir to t

400' Contour;		0 da.	1 hr.	33 min.
402	"	0 "	17 "	10 "
404	"	2 "	5 "	24 "
406	"	4 "	19 "	10 "
408	"	8 "	9 "	59 "
410	"	12 "	23 "	31 "

Approximately, it will take 13 days to fill the reservoir from the flow of Strouble's Creek. From information given by residents of the neighbourhood it is known that the flow at the time the measurements were taken represents about the normal flow conditions of this stream.

Using Fanning's Formula, as given on page 27 of Vol. VII of the Cyclopedia of Civil Engineering issued by the American School of Correspondence, under flood conditions there will be a flow of 152.9 cu.ft./ sec-
This is gotten from,

$$Q = \frac{200}{\sqrt[6]{M}} = \frac{200}{\sqrt[6]{5}} = 152.9$$

In this formula, Q = cu.ft. / sec. flowing; M= Drainage area in square miles.

No calculations were made to show times for filling at this rate of flow, it will be the exception rather than the rule that the reservoir will be filled by flood flow.

Emptying of Reservoir.

Forthe purpose of emptying the reservoir there is to be built into the base, in a trench excavated in the rock foundation, and filled in around with concrete, a 24" cast iron pipe, with a suitable control valve.

With ths pipe open for full flow it will take about 5 1/2 days to empty the reservoir. This is an approximation, the irregular shape making it impossible to calculate this time exactly.

Thispipe is to be placed ar that point found to be most convenient acter the foundafion is prepared, and will of course be placed af the lowesf point.

THE COST ESTIMATE.

The elements entering into the cost of such an undertaking as this are of such a nature as to make any other than approximations impossible. The main elements of cost are the following:--

1. Excavation and preparation of the foundation.
2. Concrete work
   a. Unreinforced.
   b. Reinforced.
3. Protective covering for the overflow surface.
4. Drainage pipe and control valve.
5. Engineering and Inspection.
6. Land.
7. Interest and depreciation.

Each of these elements will now be taken up in some detail, and it will be shown how the estimate of cost is arrived at.

1. With out making a much more elaborate survey than the circumstan-seemed to warrant it will be impossible to hare exact values as to the amount of excavation to be done. It is however estimated that the excacation and preparation of the foundation will not cost more than $ 800.00

2. The cost of the concrete work is found by taking average cost figures on old jobs and appliing them to the case in hand. From figures given in Trautwine's Civil Engineer's Pocketbook it is estimated that the average cost of unreinforced concrete, in place, is $ 6.00 per cu. yd, There are 350 cu.yds. of unreinforced work on this job, @ $ 6.00 / cu.yd. this gives the cost of this part of the work as $ 2800.00 From the same book it is found that the average cost for reinforced work is $8.00 per cu.yd, in place, and inchiding the cost of forms, labour, materials,etc. There are 375 cu. yds. of reinforced work, and this @ $ 8.00 / cu. yd. gives a cost of $ 3750.0

This makes the total cosf of the concrete $ 6550.00.

3. The estimate forthe cost of this has already been made on page (8), and is there shown to be $ 135.00

4. The pipe and valve for draining the reservoir will cost, including the materials and the labour of installation not over $ 50.00

5. The expenses coming under this head are entirely indeterminate, but it is estimated that they will not exceed $ 1000.00

6. The land affected by this reservoir has an area of approximafely 10 A. This land is worth atout $30.00 per acre. This makes the land cosf $3000

7. The estimafe as to the interest on firsf cost and depreciation will be approximafed at $1500.00

These figures will give a value which is not improbafly a little too high, but they are not far from the true figures.

Estimated thusly the cost will be:-

Excavation and preparation of foundation..........	$ 800.00
Concrete work....................................	6550.00
Protective covering for overflow surface..........	135.00
Drainage pipe and valve...........................	50.00
Engineering and inspection........................	1000.00
Land..	3000.00
Interest and depreciation.........................	1500.00
Total cost...........................	$12035.00

The dam and reservoir, complete, will, then, cost about $ 12000.00.

Field Notes on Survey
of
Strouble's Creek
for the
Location of a
Dam and Reservoir.

Traverse up Strouble's Creek for Dam.

Sta.	Angle
0	
+50	
1	
+50	
2	
+50	
3	
+50	
4	
+40	16°39'L
+50	
5	
+50	
6	
+50	
7	
+50	
8	
+50	
9	
+50	
10	
+50	
11	
+50	

Mar. 25, 1913. Fowle, - Inst. Collaway - Book Olinger - Rod Phillips Warwick } Chain Metcalfe - Stake

60' above pond and 6.35 S.E. of bank.

Hub.

12	18°57' R
+50	
13 ~~+0~~	
+50	
14	

Hub.

Stake in field. 6.57 to left of bank.

This makes the total cost of the concrete

Levels and topography for Dam.

Sta.	B.S.	H.I.	F.S.	Elev.	
0+00	6.4	406.4	6.4	400.00	Assumed.
+50			6.4	400.00	
1			6.3	400.10	
+50			6.28	400.12	
2			7.30	399.10	
+50			6.94	399.46	
3			5.53	400.87	
+50			5.32	401.08	
4			5.12	401.38	
+50			3.55	402.85	
5			3.53	402.87	
+50			3.61	402.79	
6			2.40	404.00	
+50			2.22	404.18	
7			2.40	404.00	
+50			3.10	403.30	
8			1.50	404.90	
+50			1.08	405.32	
9			0.30	406.10	
T.P.			0.94	405.36	
	7.58	413.04			
9+50			6.40	406.64	
10			6.24	406.80	
+50			5.32	407.72	
11			4.96	408.08	

Mar. 28 – Apr. 3 – 1913.

Fowle - Inst
Olinger, Callaway } Rod & Tape

$\frac{168}{410}$ $\frac{136}{408}$ $\frac{118}{406}$ $\frac{104}{404}$ $\frac{86}{402}$ $\frac{60}{400}$ 400.0 $\frac{117}{402}$ $\frac{137}{404}$ $\frac{160}{406}$ $\frac{180}{408}$ $\frac{198}{410}$

$\frac{195}{410}$ $\frac{156}{408}$ $\frac{132}{406}$ $\frac{117}{404}$ $\frac{102}{402}$ $\frac{72}{400}$ 400.1 $\frac{68}{400}$ $\frac{162}{402}$ $\frac{195}{404}$ $\frac{215}{406}$ $\frac{233}{408}$ $\frac{245}{410}$

$\frac{177}{410}$ $\frac{142}{408}$ $\frac{121}{406}$ $\frac{92}{404}$ $\frac{38}{402}$ $\frac{8}{400}$ 399.1 $\frac{3}{400}$ $\frac{121}{402}$ $\frac{168}{404}$ $\frac{208}{406}$ $\frac{250}{408}$ $\frac{275}{410}$

$\frac{105}{410}$ $\frac{90}{408}$ $\frac{77}{406}$ $\frac{66}{404}$ $\frac{55}{402}$ $\frac{3}{400}$ 400.9 $\frac{108}{402}$ $\frac{182}{404}$ $\frac{208}{406}$ $\frac{225}{408}$ $\frac{246}{410}$

$\frac{124}{412}$ $\frac{114}{410}$ $\frac{106}{408}$ $\frac{95}{406}$ $\frac{80}{404}$ $\frac{56}{402}$ $\frac{16}{402}$ 401.4 $\frac{4}{402}$ $\frac{150}{404}$ $\frac{212}{406}$ $\frac{228}{408}$ $\frac{254}{410}$

$\frac{131}{410}$ $\frac{124}{408}$ $\frac{116}{406}$ $\frac{95}{404}$ $\frac{77}{402}$ $\frac{17}{400}$ $\frac{3}{400}$ 402.9 $\frac{124}{404}$ $\frac{166}{406}$ $\frac{195}{408}$ $\frac{226}{410}$ $\frac{}{412}$

$\frac{136}{410}$ $\frac{128}{408}$ $\frac{108}{406}$ $\frac{74}{404}$ $\frac{19}{402}$ $\frac{13}{402}$ 404.0 $\frac{67}{406}$ $\frac{67}{\text{Edge Quarry}}$

404.2 $\frac{8}{406}$ $\frac{29}{408}$ $\frac{48}{410}$ $\frac{74}{407.7}$ $\frac{74}{\text{Edge Quarry}}$

$\frac{150}{412}$ $\frac{114}{410}$ $\frac{100}{408}$ $\frac{90}{406}$ $\frac{22}{404}$ 404.0 $\frac{10}{406}$ $\frac{76}{407.2}$ $\frac{76}{\text{End Quarry}}$ $\frac{105}{410}$

$\frac{133}{410}$ $\frac{109}{408}$ $\frac{90}{406}$ $\frac{22}{404}$ 404.9 $\frac{80}{406}$ $\frac{100}{408}$ $\frac{120}{410}$

$\frac{137}{410}$ $\frac{124}{408}$ $\frac{92}{406}$ 406.1 $\frac{107}{406}$ $\frac{130}{408}$ $\frac{139}{410}$

Top of stake at Sta. 8+00.

$\frac{145}{410}$ $\frac{133}{408}$ N. edge qr. $\frac{28}{406}$ 406.8 $\frac{87}{408}$ $\frac{116}{410}$ $\frac{133}{412}$

$\frac{135}{410}$ $\frac{38}{408}$ edge qr. $\frac{25}{405.3}$ 408.1 edge qr. $\frac{38}{410}$ $\frac{140}{412}$

Sta.	B.S.	H.I.	F.S.	Elev.
11+50		413.04	3.87	409.17
12			4.50	408.54
+50			3.66	409.38
13			3.45	409.59
+50			3.20	409.84
14			2.63	410.41
14			2.19	410.85

$\frac{163}{412}$	$\frac{125}{410}$	408.1	$\frac{36}{410}$	$\frac{73}{412}$
$\frac{190}{412}$	$\frac{15}{410}$	409.5	$\frac{32}{410}$	$\frac{90}{412}$
	$\frac{129}{412}$	410.8	$\frac{87}{412}$	

Top of stake.