March 24, 1933

Accompanying report of even date to Hydraulic Engineer on soil samples El Capitan Dam.

Laboratory Sample No.	19550	19551	19552	19553	19554	19555	19556	19557	19558
Job No.	256	257	258	259	260	261	262	263	264
Percentages Passing									
Screen 1/4"						100.0			
Sieve #10						99.5			
20				100.0		97.9			100.0
30	100.0	100.0	100.0	99.0	100.0	92.9			99.3
40	96.4	99.0	99.0	96.0	98.4	87.9	100.0	100.0	97.3
50	92.4	95.6	96.4	91.0	93.8	81.4	99.2	98.6	92.3
100	75.6	76.6	80.4	68.6	73.4	63.4	84.0	86.0	69.8
200	55.6	54.0	61.0	44.0	52.8	43.6	57.4	63.6	35.2

J. Y. Jewett,
Testing Engineer

5-15-33
copy/p

April 7, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Soil Samples, 4th series, hydraulic fill, El Capitan Dam.

Nine samples from hydraulic fill, El Capitan Dam, constituting the fourth series taken, were received on April 4th. These were taken on that date, and are Job Nos. 265-73; Lab. Nos. 19586-94. Locations from which taken are as follows:

Sample	Elevation Water surface	Elevation sampled	Coordinates N.	E.
265	607.5	598	3840	4950
266	"	587.5	3840	5000
267	"	596.5	3840	5075
268	"	592.5	3650	5050
269	"	591.5	3650	5000
270	"	593.5	3650	4960
271	"	590.5	3400	4960
272	"	589.5	3400	5000
273	"	591.5	3400	5050

As in previous reports, these samples are combined in two groups in statement of results below. One, marked "Center Group" includes sample taken above line of concrete core wall. The other, marked "Outside Group" includes those taken at the given distances from this line. The table below shows percentage of moisture content, and the usual gradation of solids; with columns added for specific gravity and percent of voids, determination of which has been made on each sample, instead of on composites as previously. Per cent of voids is computed according to formula in Hatch's paper as noted in last report (of Mar. 24th) which is based on assuming that the volume occupied by the moisture content represents the voids space, which is correct, provided the material itself is considered as non-absorbent.

April 7, 1933

Accompanying report of even date to Hydraulic Engineer on soil samples El Capitan Dam.

Percentages passing Sieve No.	Laboratory Sample No.	19586	19587	19588	19589	19590	19591	19592	19593	19594
	Job No.	265	266	267	268	269	270	271	272	273
10		100.0		100.0						
20		98.0		99.0			100.0			100.0
30		91.6	100.0	96.8	100.0	100.0	99.0		100.0	98.0
40		83.6	99.0	92.4	98.8	98.8	96.2		98.8	95.0
50		74.2	98.0	84.4	97.6	94.6	91.4	100.0	96.0	90.6
100		57.2	86.6	65.6	88.2	78.2	78.4	90.0	82.2	76.6
200		42.0	63.0	46.6	66.6	56.2	60.8	70.0	60.6	51.4

J. Y. Jewett

Testing Engineer

Center Group

Lab. No.	Rob. No.	Moisture Content	Gradation of Solids Sand	Silt	Clay	Specific Gravity	% of Voids
19587	266	37.0	37.0	34.9	28.1	2.74	61.7
19590	269	37.0	43.8	38.0	18.2	2.72	61.5
19593	272	37.0	39.4	35.5	25.1	2.76	61.9
Average		37.0	40.1	36.1	23.8	2.74	61.7

Outside Group

Lab. No.	Rob. No.	Moisture Content	Sand	Silt	Clay	Specific Gravity	% of Voids
19586	265	33.3	58.0	26.9	15.1	2.76	58.0
19588	267	37.5	53.4	26.5	20.1	2.72	62.0
19589	268	38.9	33.4	39.8	26.8	2.70	63.2
19591	270	29.6	39.2	34.0	26.8	2.75	53.6
19592	271	45.0	30.0	40.2	29.8	2.73	69.1
19594	273	33.3	48.6	29.6	21.8	2.72	57.6
Average		36.3	43.8	32.8	23.4	2.73	60.6

Grading in detail giving the sand separation on the several sieves, is shown on the attached report form.

Mica Content:

Mica content, on a composite of all the samples, determined in same manner as previously, shows 3.0 per cent, as representing approximately the flaky portion going off in suspension in wash water, and caught on No. 200 sieve.

Beach Samples:

It is again suggested that the obtaining of beach samples, of undisturbed material, in the manner referred to in last paragraph of report of March 24th, might be desirable.

J. Y. Jewett

225 Copy 4-7-33
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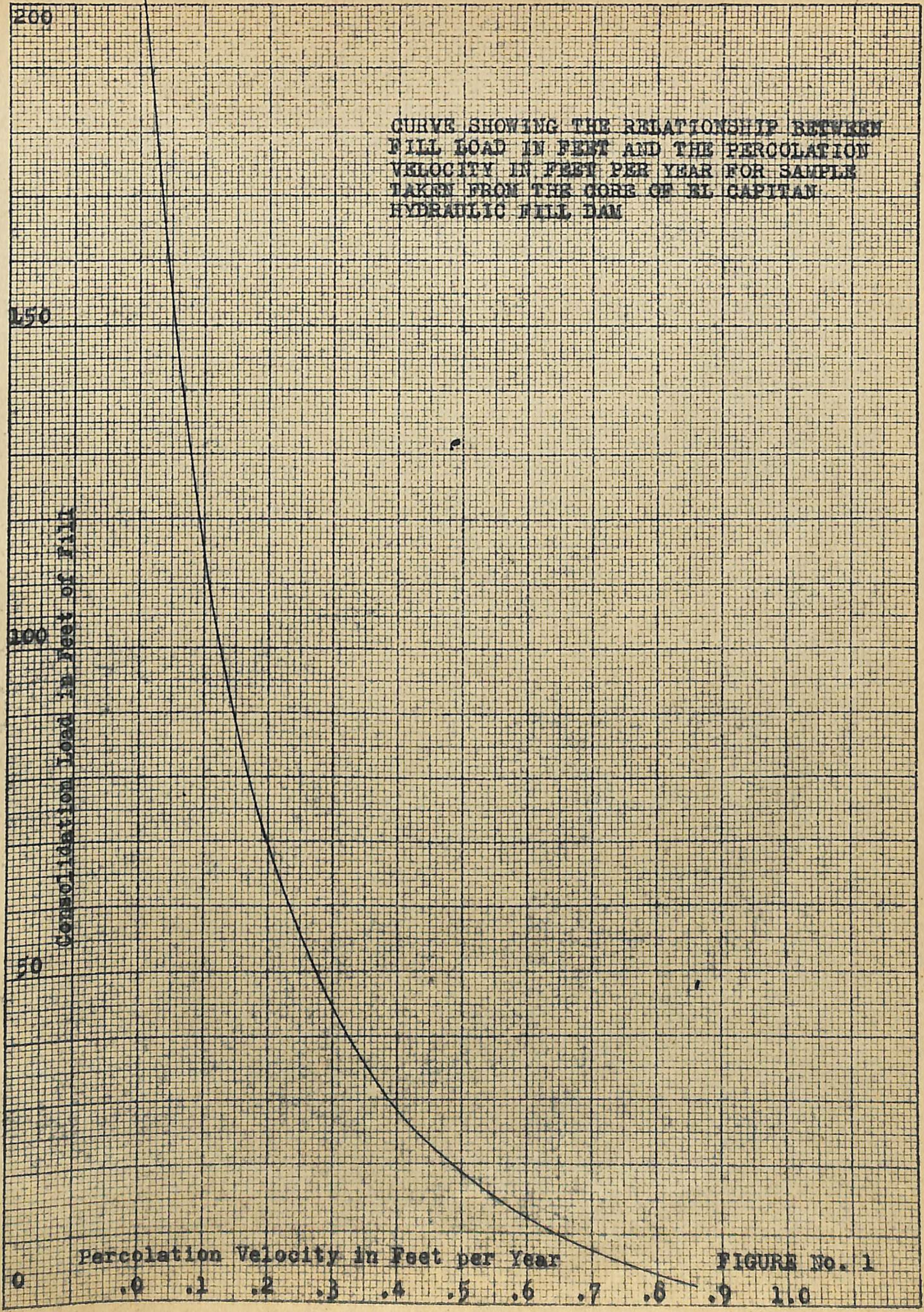

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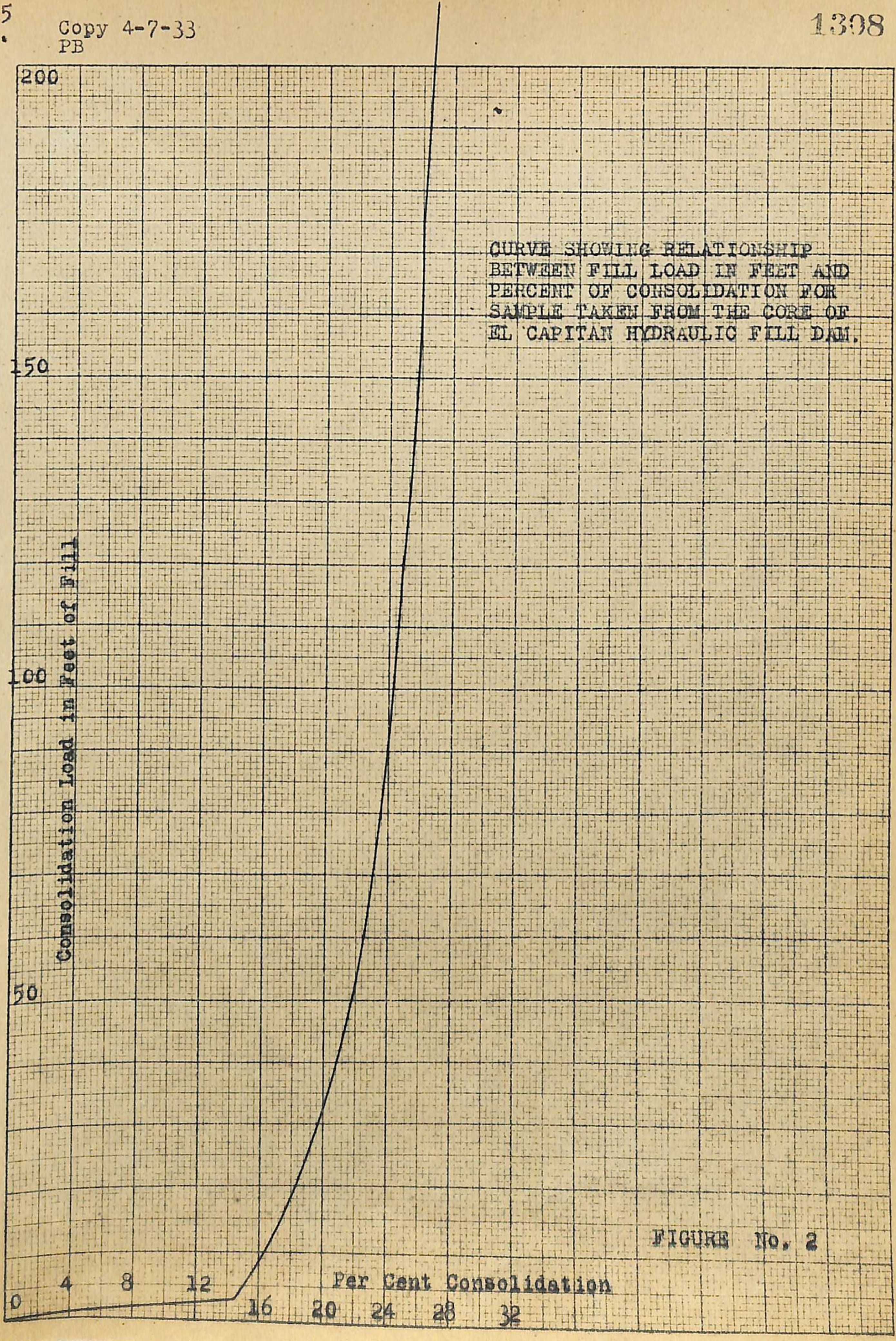


FIGURE No. 2

5-15-33
copy/p

April 14, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Soil sample Hydraulic fill, El Capitan Dam

Soil sample from hydraulic fill, El Capitan Dam, taken from beach at elevation 616, two feet above water surface of the pool, at coordinates N 3600-E5100, was received on April 13. This is Job No. 277: Lab. No. 19610.

Moisture content was 12.2%.

Gradation of solids is as follows:

Gravel	2.0%
Sand	76.5
Silt	18.8
Clay	2.7
	100.0

Detailed grading of the sand and gravel portions on the several sieves, is shown on the attached report form.

Specific gravity 2.76. Per cent of voids based on specific gravity, and moisture content, 27.7.

Percentage of flaky mica in sand portion, 2.0.

J. Y. Jewett

JYJ/b

5-15-33
copy/p

CITY OF SAN DIEGO, CALIFORNIA

Division of Engineering

Laboratory Report April 14, 1933

Accompanying letter of even date to Hydraulic Engineer on soil sample, El Capitan Dam.

Percentages passing	Laboratory Sample No.
Screen No.	19610
1/2 inch	100.0
1/4 "	98.0
Sieve No.	
10	96.9
20	91.8
30	78.9
40	67.7
50	55.3
100	34.2
200	21.5

J. Y. Jewett
Testing Engineer

5-15-33
copy/p

April 24, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Soil Sample, Hydraulic Fill, El Capitan Dam.

Soil sample from hydraulic fill, El Capitan Dam, taken April 21st, was received on the 22nd. This is reported as taken on center line of the core, at coordinates N 3450: E 5000, at elevation 590.6, with elevation of water surface in the pool at 614.6. This is Job No. 278; Lab. No. 19642.

Moisture content is 27.3% by weight. Specific gravity (of solid portion) 2.75. Per cent of voids based on these factors, 50.8.

Wt. per cu. ft. of the material, in condition as received, based on weight of the sample, and the volume occupied in the container, was 115 lbs. Per cent of voids computed from this weight, and said specific gravity, checks with above.

Gradation of solids is as follows:

Sand..........	39.6%
Silt..........	37.4
Clay..........	23.0
	100.0

Percentage of flaky mica in sand portion, 2.0.

It was thought from observation, that the clay content might run somewhat higher than the above; but it is noted by referring to report of Apr. 7, on 4th series of core samples, that this gradation corresponds very closely to the average shown in that report for the samples of the center group, which were taken at approximately the same elevation as this sample.

Grading in detail giving the same separation on the several sieves, is shown on the attached report form.

J. Y. Jewett

JYJ/b

5-15-33
copy/p

CITY OF SAN DIEGO, CALIFORNIA

Division of Engineering

LABORATORY REPORT April 24, 1933

Accompanying report of even date to Hydraulic Engineer on soil sample, El Capitan Dam.

Percentages passing	Laboratory Sample No.
	19642
Sieve No. 20	100.0
30	99.0
40	97.0
50	93.8
100	80.4
200	60.4

J. Y. Jewett

Testing Engineer

RESULTS OF LABORATORY TESTS OF CORE MATERIAL FROM EL CAPITAN HYDRAULIC FILL DAM, SAN DIEGO, CALIFORNIA.

A sample of the core material from El Capitan Dam was received from Mr. H. Y. Jewett at the Field Engineering Laboratory on March 14, 1933, and tests commenced under his diredtion on same date. The moisture content of the sample as received was 37.8%, determined as described later.

The consistency of the sample was so wet that it was impossible to obtain a plasticity needle reading.

CONSOLIDATION-PERCOLATION TESTS

The sample was thoroughly mixed to insure uniformity of moisture content throughout and to eliminate any possible segregation of the fine and coarse materials. This mixing was accomplished by pouring the soil from one container to another until the material was mixed uniformly. A porous disc was placed at the bottom of an eight inch diameter standard consolidation cylinder and covered with filter paper to prevent any possible loss of fine material. A layer of the core material, four and one-quarter inches thick, was placed and its upper surface carefully smoothed to a plane normal to the axis of the cylinder. A filter paper was placed on top of this layer of soil followed by another porous disc upon which the piston was set.

The consolidating load was applied by means of a hydraulic jack and a heavy spring. The load is expressed in "feet of fill". A fill load of ten feet, for example, would be a total force equal to the weight of a column of soil eight inches in diameter and ten feet high, the weight of the soil being assumed at 125 pounds per cubic foot.

The first load applied was equivalent to three feet of fill. This load was left unchanged for eighteen hours at which time the rate of consolidation was less than 0.001 of an inch per hour.

Upon completion of the consolidation a percolation test was started. Water under pressure was applied to the specimen through the plrous disc at the bottom. A head of sixty inches on the four and one-quarter inch layer of soil was used, giving a hydraulic gradient of 14:1. The amount of water passing through the specimen was determined by measuring the quantity necessary to maintain the pressure head. The percolation rate is expressed as a velocity in terms of feet per year under a unit hydraulic gradient, in this case, the flow through the specimen at a gradient of one is assumed to be one fourteenth of that found in the test. The percolation rate thus expressed is the depth of water in the percolation cylinder, above the specimen, if the test were carried on for one year, keeping the applied pressure head above the water in the cylinder by an amount equal to the thickness of the soil layer, assuming that there was no loss from evaporation on the water surface.

The consolidation was measured to the nearest thousandth of an inch. The percentage of consolidation is based on the original height of the soil column. The consolidation for the first fill load amounted to 0.637 inches giving a value of 15.0% for the percent of consolidation.

The test was continued by obtaining the per cent of consolidation and the percolation rate for the several fill loads as shown in the accompanying table. The dry weight per cubic foot and the moisture content are calculated from conditions at removal and from the consolidation percentages. The soil density is expressed as the dry weight of the soil per cubic foot. The dry weight of soil contained in a saturated soil sample is calculated from the specific gravity and the moisture content. The moisture content is based on the dry weight of soil and is equal to the number of grams of water combined with each 100 grams of dry soil. In this case the entire mass of the sample is occupied either by soil particles or moisture.

A summary of test results is shown in the table and on Figures No. 1 and No. 2.

Date	Hour	Feet Fill	Vel. Ft/Yr	Percent Cons.	Percent Voids Vol.	Lb/c.f. Dry Wt.	Moist. % saturated
3-14	3:47 PM	0	-	-	50.6	86.9	36.3
3-15	10:10AM	3	0.870	15.0	41.9	102.2	25.6
3-15	1:45PM	13	0.620	16.9	40.6	104.6	24.1
8-16	9:40AM	33	0.370	20.2	38.1	108.9	21.8
3-17	8:53AM	75	0.210	23.4	35.6	113.4	19.5
3-20	2L50PM	150	0.049	26.0	33.3	117.4	17.7
3-22	1:00PM	225	o.018	27.1	32.3	119.2	16.9
3-22	3L00PM	0	-	26.1	33.2	117.6	17.6

The above computations are based upon a Specific Gravity of 2.82. The date and hour shown correspond to the completion of the consolidation of the sample for each consolidation load.

SPECIFIC GRAVITY AND MOISTURE CONTENT

The specific gravity of the material was determined by the standard procedure of the Field Engineering Laboratory. Two 100-gram samples of the soil are selected. They are dried at an oven temperature of approximately 250° Fahrenheit until no further loss in weight occures. The sample is then weighed and the average loss in weight determined. The ratio of the weight of the lost moisture to the oven dried weight of soil is used to express the moisture content. Fifty grams of the oven dried soil is then weighed and placed in a 125-cc. Erlenmeyer flask. About 60 cc.'s of water is then placed in the flask and it is placed under a vacuum of 4 cm. absolute pressure until no further loss of air can be observed upon tapping the sides of the flask. The flask is then filled with water to a pre-determined level representing a know volume and weighed. The factors thus obtained permit the calculation of the average Specific Gravity of the soil, eliminating any error caused by small amounts of air trapped in the irregularities of the soil particles. The average of three determinations is 2.81.

The specific gravity subsequent to consolidation was found to be 2.82 corresponding to a weight of 176.0 pounds per cubic foot of solid material.

MECHANICAL ANALYSIS

The per cent of material passing the No. 200 sieve was found to be 35.1 per cent.

2-19-35
copy/p

June 24, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Soil Samples hydraulic fill, El Capitan Dam

Four samples from core section hydraulic fill El Capitan dam, taken June 20th, were received on the 22nd. These are Job Nos. 315-18; Lab. Nos. 19705-8. It is reported that these were taken by process giving samples of the material in place, uncontaminated with outside water. It is understood that the main purpose in taking these was to obtain information as to the condition of the material in the top layers of the fill, before resuming full sluicing operations following the period during which this feature has been suspended. Locations from which the samples were taken are as follows:

Sample No.	Elevation Water surface	Elevation Sampled	Coordinates N	Coordinates E
315	616.5	603	3850	5000
316	"	604.5	3850	5000
317	"	606	3850	5000
318	"	605	3860	4990

Depth of water in pool 9 feet.

The table below shows percentage of moisture and specific gravity of the solids with percentage of voids as computed therefrom and with weight per cubic foot as further computed from this latter factor and said specific gravity. The usual gradation of the solids is given, and the detailed grading of the sand portion is shown as usual on separate report form.

Lab. No.	Job No.	Per cent Moisture	Specific gravity of solids	Per cent voids	Wt. per cu. ft. lbs.	Gradation of Solids percentage Sand	Silt	Clay
19705	315	33.3	2.76	57.9	109	45	27	28
6	316	29.4	2.74	53.3	113	52	27	21
7	317	42.8	2.72	67.1	98	24	45	31
8	318	28.6	2.76	52.5	114	41	50	9

Determination of flaky mica in the sand portion gives the following percentages:

315	1.9
316	1.6
317	2.3
318	4.3

A main feature of the above results lies in their variability. Nos. 315 and 316 are marked by unusual coarseness of the sand portion; although in percentage terms this portion is not abnormal in amount.

No. 317, in contrast, shows a relatively fine-grained, light-weight material, such as might be expected at this location. No. 318 is a low-clay, high-silt material, with sand content not abnormal in amount but shown as containing an unusually high mica content.

The Resident Engineer, in conversation regarding these samples, spoke of encountering hard compact layers of material, difficult to penetrate with the sampling instrument when taking thes samples, and raised the question as to whether this might be due to large mica content. To the writer it seems probable that this is due rather to the magnetic iron content, which has been referred to in previous communications as a marked feature of the sand portion of the material going into this fill. Observation of the behavior of sands of this type during past years shows that when wet they have a tendency to settle into a dense, compact mass and when used in concrete or mortar, produce a harsh-working, non-plastic mixture which tends to settle and pack in a similar manner.

Detailed grading of sand portion

Lab. No.	Job No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200(silt and clay)
19705	315	100	99	97	92	87	82	70	55
6	6	100	99	97	93	88	82	67	48
7	7					100	99	92	76
8	8				100	99	98	90	59

J. Y. Jewett
Testing Engineer

JYJ/b

2-28-35
Copy/m

August 11, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow Pit Samples, Hydraulic Fill Material, El Capitan Dam.

1. Seven samples from Borrow Pit A, hydraulic fill material, El Capitan Dam, brought in July 26, are listed as Job Nos. 348-54; Lab. Nos. 19752-58. Locations from which taken, are reported as follows:

Number	Location	Coordinates
348	Near Top of cut	N. 2740 E.11, 300
349	Center of cut	ditto
350	Bottom of cut	"
351	Near Top of cut	N. 3040 E.11, 200
352	Center of cut	ditto
353	Bottom of cut	"
354	Center of cut	N. 2100 E.10, 150

2. Gradation (in percentages) is shown in the following table, with detailed gradings of the sand portion shown on the attached report form

Lab. No.	Job. No.	Gravel	Sand	Silt	Clay
19752	348	--	66	22	12
53	349	--	66	19	15
54	350	3	55	28	14
55	351	--	69	19	12
56	352	--	73	16	11
57	353	--	69	18	13
58	354	--	73	22	5

Flaky mica in composite sample, going off in suspension in wash water, held on No. 200 sieve, is approximately 2%. Specific gravity on sample sample - 2.76. Sample No. 350 contained numerous small roots, and apparently has a higher organic content than usual in this material.

J. Y. Jewett.

JYJ/b
cc - 4 encl.

2-27-35
Copy/m

Aug. 21,1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Grading of Decomposed Granite from Spillway, El Capitan Dam

1. Six samples of decomposed granite from spillway excavation, El Capitan Dam, taken on Aug. 16th, were received at the laboratory on the 17th. These are listed As Job Nos. 397-402; Lab. Nos. 19792-97. Locations from which taken are reported as follows:

Sample Number	Elevation Sample	Coordinates N.	E.
397	740	4420	5500
398	735	4400	5380
399	730	4350	5300
400	725	4330	5250
401	745	4200	5050
402	775	4500	5050

2. On advice of Mr. Pyle, in order to simulate in some degree the effect on a material of this kind, unstable in particle size, of the sluicing and washing process under which it is placed in the Dam (in the beach section) the samples were treated by a washing process similar to that used in the examination of concrete sands. This consists of stirring and agitating in an excess of water, and of pouring off the silt and clay portion, going into suspension under this procedure. The process is repeated until the water runs practically clear. In the record on the attached report form, detailed gradings are shown on the samples as received; and, for comparison, after being treated with said washing process.

JYJ/b
cc - 4 encl.

J. Y. Jewett.

October 3, 1933

From : Resident Engineer

To : Hydraulic Engineer

Subject : San Diego River Project, El Capitan Feature
Hydraulic fill material, clay

1. As requested on September 18, 1933 by the Hydraulic Engineer, the Resident Engineer accompanied by D. W. Albert on September 19 spent about one hour in the vicinity of Viejas Valley, DeLong Ranch looking for possible clay deposits which might be better than the clay in borrow pits areas designated in the El Capitan Dam contract.

2. The result of this visit to the valley disclosed that there was apparently no clay of better quality than that existing in borrow pits A and B. This country is entirely within the deep weathered granite zones and the residual soils are similar to those within the reservoir basin.

3. On September 22 the Resident Engineer visited the Myer Ranch two miles northwest from Lakeside and there found the Montezuma clays which are formed in the low ground below the ancient gravel deposits. Samples of this material were taken and delivered to the testing laboratory and Mr. J.Y. Jewett has reported on them. These deposits of Montezuma clay occupy an area about 20 acres in extent lying north and northeast of the Myer home and within easy access from existing roads.

4. Investigation indicates that they might be a depth of three feet over this area which would indicate that there is about 100,000 cubic yards at least available.

5. On October 2 the Resident Engineer went to the head of Harbison Canyon to investigate the possibility of clay deposits in that vicinity. This search was prompted by specimens of rock shown the Resident Engineer by Mr. J. W. Wiley which were reported to have come from this vicinity, which specimens of rock are not usually associated with granites. Investigation at the head of Harbison Canyon disclosed nothing but decomposed granite soils with apparent clay content similar to that within the reservoir basin.

6. Engineer Fred D. Pyle reported that Fletcher Hills adjoining what is known as Fletcher Boulevard between El Cajon and San Diego, contained deposits of Montezuma clay adobe and samples were submitted to the testing laboratory and results reported by Mr. J. Y. Jewett of these tests.

7. From observations made in various visits within the granite soils of this vicinity it is quite apparent that the weathering does not produce clays of much better quality than that already present and outlined for use in borrow pits A, B and C.

Harold Wood

HW/p

2-27-35
Copy/m

Oct. 12, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Prospective Borrow Pit Materials, El Capitan Dam, for Clay Content.

Detailed grading of the sand portion is shown on the attached report forms.

2. Experience in handling this material in the laboratory, and reducing it from the lumpy form in which it was received, to size suitable for operation in the grading test procedure, indicates that it might be more difficult material to reduce and pulverize under the action of the sluicing stream in the hydraulic process of placement in the dam, than the material from the present borrow pit source of supply. If it is contemplated using this material, it might be well to get a few loads in advance, for trial as to its action in this respect.

J. Y. Jewett

JYJ/b
cc - 4 encl.

2-27-35
Copy/m

October 12, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Prospective Borrow Pit Materials, El Capitan Dam, Clay Content.

1. The following samples of prospective borrow pit materials for increase of clay content, El Capitan Dam, were received at the laboratory on October 9th. Listing of these samples; with grading as obtained in the laboratory, is as follows:

Lab. No.	Job. No.	Field No.	Depth (Ft.)	Sand (Percentage)	Silt (Percentage)	Clay (Percentage)
			Meeyer's Ranch - W. Area			
19921	465	1 W	2	42	17	41
22	66	2 W	2	49	19	32
23	67	3 W	1.5	45	25	30
24	68	4 W	1	51	19	30
25	69	5 W	4	25	24	51
26	70	6 "	1.5	20	28	52
			Meyer's Ranch - Lot 59			
19927	456	2	2.5	32	20	48
28	7	3	2	44	14	42
29	8	4	3.5	39	15	46
30	9	5	2.5	38	32	30
31	60	6	2	20	18	62
32	1	7	4	22	17	61
33	2	8	1.5	20	20	60
34	3	9	2	23	21	56
35	4	10	2.5	40	19	41
			Fletcher Hills Dist.- S. of Blvd.			
19936	471	1	3.5	34	15	51
37	2	4	2.5	45	19	36
38	3	6	5	35	19	46
39	4	7	5	29	23	48
40	5	8 & 9	6	45	21	34
41	6	10	3	44	20	36
42	7	11	4.5	36	20	44
43	8	16	5.5	22	17	61
44	9	18	4	33	21	46
45	80	20	*3.5	41	20	39
46	1	21	x4	34	18	48

*South on Hillside
x North " "

2-18-35
copy/p

October 14, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Beach and borrow pit samples hydraulic fill El Capitan Dam

Seventeen samples as listed below were received at the laboratory on October 12 and 13. Lab. Nos. applying are 19986-92 on Job Nos. 502 and 509-14, received 12th, and Nos. 19993-20002 on Job Nos. 498-501 and 503-8 received 13th.

Sample No.	Kind	Elevation beach	Elevation beach	Coordinate N	Coordinate E
498	Puddle core beadh	684.5	677.5	3420	4890
499	" " "	684.5	677.5	3620	4890
500	" " "	684.5	677.5	3860	4890
501	Test pit olive orchard 6 feet below surface				
502	" " " " 10 " " "				
503	Northeast end borrow pit "A" at natural ground surface				
504	" " " " " " midpoint(7' below surface)				
505	" " " " " " pit floor (15' " ")				
506	North central portion" " " natural ground surface				
507	" " " " " " midpoint(9' below surface)				
508	" " " " " " pit floor(18' " ")				
509	Southerly end at " " " " ground surface				
510	" " " " " " " midpoint				
511	" " " " " " " pit floor				
512	Central portion " " B " ground surface				
513	" " " " " midpoint				
514	" " " " " pit floor				

Gradation of these samples shows results as stated below with detailed grading of the sand portion shown on the attached report forms.

Lab. No.	Job No.	Sand	Silt	Clay
		Percentage		
19986	502	71	20	9
87	509	84	13	3
88	510	61	24	15
89	511	49	26	25
90	512	70	193	11
91	513	75	17	8
92	514	57	25	18
93	498	78	20	2
94	499	81	15	4
95	500	85	13	2
96	501	76	22	2
97	503	76	22	2
98	504	78	17	5
99	505	70	19	11
20000	506	75	17	8
1	507	75	17	8
2	508	77	20	3

Detailed grading of sand portion

Lab. No.	Job No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200(silt & clay)
19986	502	100	98	95	86	78	69	47	29
87	509	100	95	86	71	61	51	30	16
88	510	100	99	97	90	83	75	57	39
89	511		100	99	95	91	85	67	51
19990	512	100	99	97	87	77	68	46	30
91	513	100	99	96	84	74	63	40	25
92	514		100	99	94	87	79	59	43
93	498	100	99	95	84	75	64	39	22
94	499	100	99	96	84	73	61	35	19
95	500	100	99	94	81	70	57	31	15
96	501	100	99	95	84	75	65	42	24
97	503	100	99	96	84	74	63	40	24
98	504	100	99	94	80	69	58	37	22
99	505	100	99	95	83	74	65	45	30
20000	506		100	96	84	74	63	41	25
1	507	100	99	96	83	73	63	41	25
2	508		100	96	83	72	61	39	23

J. Y. Jewett
Testing Engineer

JYJ/b

Oct. 17, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Prospective Borrow Pit Materials, El Capitan Dam.

1. Results as stated below, have been obtained from grading determinations on the following samples, brought in for that purpose, with reference to clay content.

Lab. No.	Job. No.	Field No.	Description
			South of Santee
19947	481-a	K-1	-- Sample lost
48	482	K-2	
49	83	K-3	
19958	484	1-P	Depth 7.5, feet
59	85	2-P	8.5 "
60	86	3-P	9.5 "
61	87	4-P	6.0 "
62	88	5-P	4.0 "

19950	---	---	Los Coches Creek, Tunnel No. 2, near Outlet end.

Old Olive Orchard in Basin

19963	489	1 - Basin Depth 4.5 ft.	- D.G. No change.
64	90	2 - " " 3.5 "	" " "
65	91	3 - " " 9.0 "	Soil -- Same mat. at limit of hole
66	92	4 " " 10.0 "	Good soil - same mat. at limit of hole.

20004 - Pyle's No. 1 - ¼ mi. N.E. of Meyers Ranch, 2 ft. below surface.
5 " " 2 - Across River from W. end, El Monte Park, surface.
6 " " 3 - Same, bottom of plow furrows.
7 " " 4 - " side of wash, 3 ft. below surface.

2-19-35
copy/p

October 17, 1933

MEMORANDUM

Subject: San Diego River Project, El Capitan Feature
Hydraulic fill, gradation tests

In order to determine the amount of fines - clay and silt - remaining on the beaches as compared with the fines in the borrow pit material, four tests were made of material as deposited on the inner slopes of the rock embankment for hydraulicking into the hydraulic fill and of material as found in the middle ov the beaches. These tests were as follows:

Job No.	Source	Per cent Sand	Silt	Clay
	October 3, 1933. Each sample composite (12).			
449	Midway east beach; depth one foot	68	20	12
450	Midway west beach; depth one foot	77	21	2
451	West embankment before sluicing	72	17	11
	October 7, 1933. Each sample composite (12)			
452	West embankment before sluicing	68	21	11
453	Midway west beach, depth one foot	79	19	2
454	East embankment before sluicing	70	20	10
455	Midway east beach, depth one foot	82	17	1
	October 10, 1933. Each sample composite (7)			
493	Midway west beach, depth one foot	84	14	2
494	Midway west beach, depth three feet	75	22	3
	October 12, 1933			
498	Midway west beach, depth 7 feet N3420 E4890	78	20	2
499	Midway west beach " " " N3620 E4890	81	15	4
500	Midway west beach " " " N3860 E4890	85	13	2

Details of the gradation tests are shown on the attached exhibits.

Fred D. Pyle
Engineer

FDP/c

2-19-35
copy/p

October 18, 1933

M E M O R A N D U M

Subject: San Diego River Project, El Capitan Feature
Hydraulic fill, gradation tests.

Tests made of puddle core, beach and borrow pit materials at El Capitan Dam show the following average results:

	Clay	Silt	Sand	
Puddle core material (a)	24	38	38	Period 6 mos. last
Beach material (b)	3	18	79	10/6/33
Borrow pit (on embankment dry)(c)	10.7	19.3	70	10/6/33
Borrow pit (borrow pit) (d)	10	20	70	
Borrow pit (prior to construction) (e)	10.2	13.5	76.3	

Possible sources of clay and silt		10/18/33		
Meyers, east	9 samples	49.5	19.5	31
Meyers, west	6 "	39.5	22	38.5
Fletcher Hills	11 "	44.5	21	34.5
SW of Santee	7 "	34	24.5	41.5
Opposite El Monte Park (f)	3 "	25.7	32	42.3

(a) Samples taken from the puddle core area on the axis of the El Capitan Dam in ten series, each series consisting of three samples.

(b) Samples taken on 700 foot reach of beach midway between summit pool and rock embankment at depths of 1, 3 and 7 feet.

(c) Samples taken from dry borrow pit material on inner edge of rock embankments ready for sluicing at same dates as beach samples indicated above.

(d) Samples from borrow pits A and B at depths averaging from surface to 18 feet, taken October 12 and 13, 1933. Tests indicate that other samples of material in the vicinity of areas A, B and C have about the same clay and silt contents as areas A, B and C.

(e) Composite samples from boring of areas A, B and C before construction undertaken.

(f) Two samples from opposite El Monte Park from surface and one from depth of 3 feet in bank of ravine.

Fred D. Pyle
Engineer

FDP/c

2-27-35
Copy/m

Oct. 19, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Prospective Borrow Pit Materials, El Capitan Dam.

1. Results as stated below, have been obtained from grading determinations on five samples brought in for that purpose. These are Job Nos. 517-21; Lab. Nos. 20026-30. Samples were taken October 18th, and have the following listing as furnished by the El Capitan office.

Sample No.	Kind		Depth of: Sample :	Coordinate
517	Clay material Pit	#1	1.0	Easterly end of field
518	ditto	#3	6.0	Southerly " " "
519	"	#4	1.0	" " " "
520	"	#4	5.0	" " " "
521	"	#4	8.0	" " " "

Samples from field across river and north of El Monte Park.
Sample #518 from bottom of arroya.
Samples 519, 520, 521 old basement excavation.

Lab. No.	Job. No.	Percentage Gravel	Sand	Silt	Clay
20026	517	24	27	22	27
27	18	28	36	17	19
28	19	12	44	27	17
29	20	1	37	30	32
30	21	--	66	26	8

Detailed grading of the sand portion is shown on the attached report form.

J. Y. Jewett.

JYJ/b
cc - 4 encl.

2-26-35
Copy/m

October 25, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow Pit Materials, El Capitan Dam.

1. Results as stated below have been obtained from grading determinations on eleven samples brought in for that purpose. These are Job Nos. 529-39; Lab. Nos. 20038-46. Samples were taken October 19th, and have the following listing as furnished by the El Capitan office.

Sample No.	Kind	Depth of hole	Depth of sample	Location
529	Clay	4'	3'	Pit 1 South of Area B
30	"	4½	3'	" 2 " " " "
31	"	10'	1'	" 1 West of Chocolate Crk.
32	"	"	5'	" 1 " " " "
33	"	"	10'	" 1 " " " "
34	"	8'	1'	" 2 " " " "
35	"	"	4'	" 2 " " " "
36	"	"	8'	" 2 " " " "
37	"	10	1'	" 3 " " " "
38	"	"	5'	" 3 " " " "
39	"	"	10'	" 3 " " " "

Lab. No.	Job. No.	Percentage Sand	Silt	Clay
20036	529	54	35	11
37	30	63	25	12
38	31	71	20	9
39	32	62	34	4
40	33	77	22	1
41	34	71	20	9
42	35	76	18	6
43	36	68	22	10
44	37	69	22	9
45	38	71	23	6
46	39	63	23	14

Detailed grading of the sand portion is shown on the attached report forms.

J. Y. Jewett.

JYJ/b
cc - 4 encl.
State Engineer
Senior Engineer Dam Inspection
Fred D. Pyle
Resident Engineer

2-26-35
Copy/m

Oct. 26, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow Pit Materials, El Capitan Dam.

Results as stated below have been obtained from grading determinations on six samples brought in for that purpose. These are Job Nos. 544-49; Lab. Nos. 20062-67. Samples were taken October 24th, and have the following listing as furnished by the El Capitan office.

Sample No.	Pit No.	Sample Depth	Pit Depth	Location
544	1	Surface	10'	Near old flume crossing west of Chocolate Crk.
545	1	5'	10'	Ditto
546	1	10'	10'	"
547	2	Surface	10'	"
548	2	5'	10'	"
549	2	10'	10'	"

Lab. No.	Job. No.	Percentage		
		Sand	Silt	Clay
20062	544	69	20	11
63	5	65	19	16
64	6	76	15	9
65	7	58	28	14
66	8	56	28	16
67	9	68	31	1

Detailed grading of the sand portion is shown on the attached report form.

J. Y. Jewett

JYJ/b
cc - 4 encl.
State Engineer
Senior Inspector of Dams
Resident Engineer
F. D. Pyle

LABORATORY CERTIFICATE

SMITH-EMERY COMPANY
Chemical Engineers and Chemists
Metallurgical and Testing Engineers
920 Santee Street
Los Angeles

LABORATORY

No. P19199 Date November 3, 1933.

Sample Soil

Received 10-20-33 Marked El Capitan Dam (see below)

Submitted by Rohl Connolly Company
4351 Alhambra Avenue
Los Angeles, California

REPORT

Samples were taken at El Capitan Dam by our engineer, F. L. Howard, on October 18th, 19th and 20th, 1933. Samples were taken of the soil in the beaches and core of the dam, also from the borrow pits, the locations as indicated in the following report.

The beach samples were taken by digging a hole with a shovel approximately 3 ft. deep. This appeared to be below any surface condition that was not representative of the soil in place.

The core samples were taken with a sampler as built by the Resident Engineer of the City of San Diego. It was necessary, however, to revamp the sampler in order to obtain a representative sample of the soil in place, inasmuch as the sampler was not provided with any means of escape of the air in the sample chamber. It was found that a part of this air was displaced with water in lowering the sampler in place and the air and water probably washed a portion of the clay and fines from the sample as it was entering the chamber. This condition, however, was corrected by providing an escape for the air and water through the handle of the sampler, after which it appeared to give us a representative sample of the soil in place.

Samples as taken from the borrow pits were obtained by taking a uniform cut from the floor of the pit to the top of the bank. This soil was placed on a canvas and thoroughly mixed and a representative sample taken.

The analyses of the fines are based on percentages of dry weight and separated into gravel, sand, silt, and clay portions. The screening analyses were made on Tyler standard sieves. The gravel is that portion retained on a 1/4 mesh sieve. That portion passing through a 1/4 mesh and retained on a 200 mesh sieve is reported as sand. The percentage of clay is determined by the hydrometer method, and the portion by difference passing the 200 mesh sieve is reported as silt.

The log of the samples and results are as follows:

BEACHES: Sampled October 18, 1933.

Elevation of water = 680.9 ft.

Sample Number	Elevation of beach	Elevation of sample	Coordinates
Upstream side of dam:			
1	682.7 ft.	679.7 ft.	E5065-N3330
2	684.0	681.0	E5095-N3330
3	682.0	679.0	E5059-N3503
4	682.5	679.5	E5078-N3500
5	682.5	679.5	E5055-N3755
6	682.9	679.9	E5078-N3755
7	682.3	679.3	E5054-N3905
8	683.2	680.2	E5076-N3905
Downstream side of dam:			
9	682.2	679.2	E4948-N3582
10	683.3	680.3	E4922-N3583
11	685.0	682.0	E4890-N3583
12	682.9	679.9	E4935-N3305
13	683.7	680.7	E4910-N3305
14	684.7	681.7	E4890-N3305
15	682.1	679.1	E4955-N3770
16	683.4	680.4	E4925-N3772
17	684.7	682.6	E4887-N3780

CORE: Sampled October 19, 1933

Elevation of water = 680.9 ft.

	Sample Number	Depth below water level: Water	Depth below water level: Sample	Elevation of sample	Coordinates
Upstream	37	6.8 ft.	12.3 ft.	668.6 ft.	E5030-N3900
Downstream	38	5.8	10.2	670.7	E4980-N3900
Center line	39	8.2	13.8	667.1	E5000-N3900
Center line	40	10.7	16.0	664.9	E5000-N3600
Upstream	41	9.3	13.4	667.5	E5030-N3600
Downstream	42	9.2	15.0	665.9	E4980-N3600
Center line	43	13.9	19.0	661.9	E5000-N3300
Upstream	44	10.9	13.2	667.7	E5030-N3300
Downstream	45	12.2	16.0	664.9	E4980-N3300

- continued -

BORROW PIT "A" As shown on City of San Diego Map, File #2435 D2, W-D 351. Sampled October 19 & 20.

Sample Number	Profile	Elevation from floor of pit	Location
18	J	13.7 ft.	120 ft. S.E. of Center line
19	I	19.0	350 " " " " "
20	H	20.5	510 " " " " "
21	G	25.5	630 " " " " "
22	F	27.5	590 " " " " "
23	E	17.0	190 " " " " "
24	E	15.3	85 " N.W. " " "
46	E	18.0	365 " " " " "
47	D	15.0	410 " " " " "
48	B	10.3	390 " " " " "
25	C	11.0	130 " " " " "
26	C	12.5	615 " S.E. " " "
27	B	7.0	670 " " " " "
28	A	9.0	300 " " " " "
29	A	9.0	50 " " " " "
30	(120 ft. N.W. Profile A)	18.0	275 " S.W. " " "
31	(105' N.W. Profile B)	16.0	410 " " " " "

DECOMPOSED GRANITE: Sampled October 20, 1933.

Sample Number	Location
32	Approximately 600 ft. from Spillway Streams
33	" 800 " " " "
34	" 1000 " " " "
35	End of dump from material as truck dumped

ANALYSIS OF SAMPLES

	Sample Number 1	Gravel 1.77%	Sand	Silt	Clay	Apparent Specific Gravity	Voids	Organic
	1	1.77%	75.78%	15.45%	7.00%	2.63	50.0%	
	2	0.80	84.20	10.00	5.00	2.66	46.8	
	3	0.80	74.80	18.60	5.80	2.74	53.2	
	4	1.00	87.00	6.00	6.00	2.70	45.3	
	5	3.11	76.21	12.88	7.80	2.71	50.2	
	6	1.40	85.60	6.80	6.20	2.74	48.9	
	7	0.75	83.50	9.55	6.20	2.77	51.7	
Beaches	8	1.00	85.40	5.40	9.20	2.73	49.1	
	9	2.00	82.60	8.60	6.80	2.73	50.0	
	10	1.00	82.25	12.15	4.60	2.73	50.8	
	11	0.75	90.50	3.95	4.80	2.73	48.5	
	12	1.00	57.50	30.70	10.80	2.75	58.2	
	13	1.00	76.00	17.20	5.80	2.97	56.9	
	14	1.50	84.25	9.45	4.80	2.76	50.0	
	15	2.75	81.25	12.00	4.00	2.74	51.9	
	16	1.00	87.75	7.25	4.00	2.70	49.0	

ANALYSIS OF SAMPLES

	Sample Number	Gravel	Sand	Silt	Clay	Apparent Specific Gravity	Voids	Organic
Borrow Pit "A"	18	3.25	76.00	10.95	9.80	2.70	52.1	
	19	0.75	80.50	10.95	7.80	2.71	46.3	
	20	1.25	76.25	12.50	10.00	2.75	54.0	
	21	0.50	75.50	13.00	11.00	2.74	56.3	
	22	5.00	80.25	12.95	4.80	2.75	49.8	
	23	3.00	77.50	10.70	8.80	2.66	55.3	
	24	0.50	78.50	15.20	5.80	2.74	52.9	
	25	0.75	81.50	10.35	7.40	2.71	54.2	
	26	-	65.50	20.10	14.40	2.64	56.6	
	27	2.75	79.25	11.60	6.40	2.74	55.1	
	28	1.00	70.75	16.45	11.80	2.77	55.6	
	29	0.50	81.25	4.25	14.00	2.79	53.9	
	30	1.75	69.00	21.25	8.00	2.78	57.0	
	31	1.50	74.75	11.75	12.00	2.76	54.9	
	46	0.75	86.50	6.75	6.00	2.76	55.7	
	47	9.00	73.25	7.75	10.00	2.75	53.6	
	48	4.75	86.25	5.00	4.00	2.86	60.1	
Core	37	-	16.50	51.50	32.00	2.70	70.5	
	38	-	57.00	27.80	15.20	2.69	58.1	
	39	-	14.00	58.60	27.40	3.04	74.0	Color #1
	40	-	31.00	42.80	26.20	2.78	76.8	Color #1
	41	-	16.00	48.40	35.60	2.66	70.5	
	42	-	41.00	34.80	24.20	2.80	67.7	
	43	-	12.00	51.20	36.80	2.95	68.8	Color #1
	44	-	23.00	44.20	32.80	2.83	72.6	
	45	-	6.00	55.40	38.60	2.83	72.6	
Decomposed Granite	32	4.25	88.25	7.50				
	33	13.75	81.00	5.25				
	34	11.25	81.25	7.50				
	35	9.75	85.25	5.00				

Percent retained on

Sample No.	1	2	3	4	5	6	7
Screen 1/4"	1.77	0.80	0.80	1.00	3.11	1.40	0.75
Sieve #10	5.11	5.40	4.00	5.50	9.11	6.40	2.50
20	11.77	15.20	10.20	16.50	19.55	14.80	6.50
30	17.33	25.40	15.60	27.00	27.55	22.80	11.50
40	28.22	42.20	26.00	44.00	40.21	37.20	23.50
50	37.77	53.40	34.20	56.00	49.55	50.00	37.50
100	59.99	74.40	56.60	77.50	66.66	73.80	67.00
200	77.55	85.00	75.60	88.00	79.32	87.00	84.25

- continued -

Per Cent Retained on

Sample No.	8	9	10	11	12	13	14
Screen 1/4"	1.00	2.00	1.00	0.75	1.00	1.00	1.50
Sieve #10	5.80	5.20	7.25	6.75	4.25	6.00	6.50
" 20	16.60	10.80	16.25	17.25	8.75	14.00	15.50
" 30	26.80	16.20	23.25	27.00	12.25	21.75	24.25
" 40	44.20	28.40	36.25	45.75	17.50	35.25	40.00
" 50	56.60	41.20	47.50	60.75	22.50	46.25	53.50
" 100	76.60	68.80	69.50	81.75	37.75	66.00	75.00
" 200	86.40	84.60	83.25	91.25	58.50	77.00	85.75

Sample No.	15	16	17	18	19	20	21
Screen 1/4"	2.75	1.00	1.50	3.25	0.75	1.25	0.50
Sieve #10	8.75	10.50	8.75	14.25	6.25	6.25	6.50
" 20	19.25	24.25	23.00	27.00	19.75	16.25	19.25
" 30	29.00	34.25	38.50	36.00	33.25	26.00	32.25
" 40	38.00	50.25	51.00	48.50	43.75	41.00	41.75
" 50	49.25	62.50	64.25	56.50	54.00	50.75	50.75
" 100	68.75	79.50	82.25	70.25	70.00	67.25	65.00
" 200	84.00	88.75	91.50	79.25	81.25	77.50	76.00

Sample No.	22	23	24	25	26	27	28
Screen 1/4"	5.00	3.00	0.50	0.75	--	2.75	1.00
Sieve #10	17.75	20.00	10.50	7.00	4.00	8.75	6.25
" 20	31.75	39.75	24.50	19.25	11.00	19.50	13.75
" 30	40.75	50.50	33.00	30.75	17.25	29.00	21.50
" 40	53.75	57.00	45.00	40.50	28.00	37.50	33.75
" 50	62.50	63.00	54.00	51.25	37.00	47.75	43.50
" 100	76.75	72.75	70.00	69.75	54.00	68.00	60.50
" 200	85.25	80.50	79.00	82.25	65.50	82.00	71.75

Sample No.	29	30	31	46	47	48	37
Screen 1/4"	0.50	1.75	1.50	0.75	9.00	4.75	-
Sieve #10	5.50	8.00	10.75	15.50	23.25	13.75	½
" 20	17.00	16.00	23.00	38.00	35.00	29.00	0.5
" 30	29.25	22.75	34.00	51.25	42.00	42.75	1.0
" 40	39.25	34.25	42.00	59.00	51.75	52.50	1.5
" 50	50.25	44.00	51.25	66.25	58.75	63.25	2.0
" 100	69.50	59.50	66.25	78.75	72.50	80.75	5.0
" 200	81.75	70.75	76.25	87.25	82.25	91.00	16.5

- continued -

Per Cent Retained On

Sample No.	38	39	40	41	42	43	44
Screen 1/4"	-	-	-	-	-	-	-
Sieve #10	-	-	-	-	-	-	-
" 20	2.0	0.5	-	-	2.0	-	-
" 30	8.0	0.5	-	-	6.0	-	-
" 40	13.5	0.5	0.5	0.5	11.0	-	1.0
" 50	21.5	1.0	1.5	1.5	15.0	0.5	3.0
" 100	41.5	2.5	10.0	6.0	27.0	2.0	10.0
" 200	57.0	14.0	31.0	16.0	41.0	12.0	23.0

Sample No.	45	32	33	34	35
Screen 1/4"	-	4.25	13.75	11.25	9.75
Sieve #10	-	22.75	31.75	26.75	27.50
" 20	-	39.75	47.00	44.00	45.25
" 30	-	47.50	56.25	55.25	55.25
" 40	-	61.50	69.25	54.75	70.00
" 50	1.0	70.75	77.00	72.50	79.25
" 100	2.0	85.00	89.00	85.00	90.50
" 200	6.0	92.50	94.75	92.50	95.00

Respectfully submitted,

Smith-Emery Co. (Signature)

(SEAL) INSPECTING & TESTING ENGINEERS

Lab. No. P19199

Percentage Finer

Sample No.	37	38	39	40	41	42	43	44	45
Sieve #10	100.0	100.0	100.0	-	-	100.0	-	-	-
" 20	99.5	98.0	99.5	-	-	98.0	-	-	-
" 30	99.0	92.0	99.5	100.0	100.0	94.0	-	100.0	-
" 40	98.5	86.5	99.5	99.5	99.5	89.0	100.0	99.0	100.0
" 50	98.0	78.5	99.0	98.5	98.5	85.0	99.5	97.0	99.0
" 100	95.0	58.5	97.5	90.0	93.0	73.0	98.0	90.0	98.0
" 200	83.5	43.0	86.8	69.0	84.0	59.0	88.0	77.0	94.0
Clay, 1 min. (0.0467 mm.)	53.0	26.2	47.4	39.0	54.6	38.2	57.8	49.8	59.6
Clay 5 min. (0.023 mm.)	41.0	19.2	33.4	30.0	41.6	29.2	43.8	41.8	45.6
Clay, 15 min. (0.0148mm.)	31.0	15.2	27.4	26.2	35.6	24.2	36.8	32.8	38.6
Clay, 30 min. (0.0097mm.)	28.0	13.2	24.4	24.2	31.6	21.2	32.8	28.8	34.6
Apparent Specific Gravity	2.70	2.69	3.04	2.78	2.66	2.80	2.95	2.83	2.83
Voids	70.5	58.1	74.0	76.8	70.5	67.7	68.8	72.6	72.6
Organic			#1	#1			#1		

Remarks: The particle sizes for 1, 5, 15 and 30 minute hydrometer reading are those given by Harry H. Hatch in Proceedings of the American Society of Civil Engineers, Vol. 58, No. 8, October issue of 1932. The Organic Determinations were made in accordance with the A.S.T.M. Serial Designation C 40-22.

2-19-35
copy/p

November 23, 1933

From : Resident Engineer

To : Hydraulic Engineer

Subject : San Diego River Project, El Capitan Feature
Hydraulic fill - puddle core sounding weight

1. For sounding the depth of water in the summit pool at El Capitan dam, a steel weight having the following dimensions and weight was used on the lower end of a standard Lufkin metallic tape.

Material	Cold rolled steel shafting
Diameter	3-5/8 inches
Length	2 inches
Shape	Square top and bottom
Tape attachment	1/2 inch eye bolt screwed into the top of the disk
Weight	6 pounds

2. Considerable variation in depth readings are obtainable depending on rapidity of descent of the weight. The weight was lowered gently for all soundings reported in the City of San Diego's records.

3. The use of this weight was adopted so that the same weight could be used by both the City and the contractor so the records could be comparable.

Harold Wood
Resident Engineer

HW/p

LABORATORY CERTIFICATE

SMITH-EMERY COMPANY
Chemical Engineers and Chemists
Metallurgical and Testing Engineers

920 Santee Street
Los Angeles

LABORATORY

No. P19599 Date December 13, 1933

Sample Soil

Received 12-7-33 Marked El Capitan Dam

Submitted by Rohl Connolly Company
El Capitan Dam via Lakeside
San Diego County, California

REPORT

Samples were taken at El Capitan Dam by our Mr. G. L. Cheney on December 6th, 1933. The samples were taken from the Beaches, Core and Borrow Pit dump by the spillway. The locations are as indicated in the following report.

The Beach samples were taken by digging a hole with a shovel and the sample taken approximately one foot below the level of the beach. This sample should represent material placed after our sampling of October 18th, 1933.

The Core samples were taken with the sampler belonging to the Resident Engineer of the City of San Diego in the same manner as used by us in our previous sampling.

The Borrow Pit samples were taken at twenty foot intervals along the dump at the edge of the spillway, sample No. 16 being at the westerly end. The samples were taken approximately one foot below the surface of the dump.

The samples from the pit north of the quarry road were taken a few inches into the face of the bank at the east and west sides of the workings, respectively.

The analyses of the fines are based on percentages of dry weight and separated into gravel, sand, silt, and clay portions. The screening analyses were made on Tyler standard sieves. The gravel is that portion retained on a 1/4 mesh sieve. That portion passing through a 1/4 mesh and retained on a 200 mesh sieve is reported as sand. The percentage of clay is determined by the hydrometer method, and the portion by difference passing the 200 mesh sieve is reported as silt.

The log of the samples and results are as follows:

BEACHES: Sampled December 6, 1933.
Elevation of water = 683.4 ft.

Sample Number	Elevation of Beach	Elevation of Sample	Coordinates
Upstream side of Dam:			
1	684.5	683.5	E5080-N3620
2	684.3	683.3	E5060-N3620
3	685.0	684.0	E5087-N3455
4	683.5	682.5	E5062-N3455
5	684.9	683.9	E5095-N3200
6	683.7	682.7	E5062-N3200
Downstream side of Dam:			
7	685.5	684.5	E4890-N3307
8	684.5	683.5	E4911-N3307
9	683.5	682.5	E4932-N3307
10	683.7	682.7	E4954-N3585
11	685.6	684.6	E4926-N3585
12	687.1	686.1	E4890-N3585
13	683.4	682.4	E4940-N3770
14	684.7	683.7	E4925-N3770
15	686.2	685.2	E4890-N3770

CORE: Elevation of water = 683.4 ft.

Sample Number	Depth Below Water Level		Coordinates
	Water Depth	Sample Depth	
22	4'0"	6'0"	E4960-N3220
23	7'8"	9'8"	E4980-N3220
24	6'7"	8'7"	E5000-N3220
25	6'5"	9'5"	E5020-N3220
26	5'8"	7'8"	E5040-N3220
27	7'8"	9'8"	E5040-N3300
28	7'7"	9'7"	E5020-N3300
29	7'4"	10'4"	E5000-N3300
30	7'10"	8'10"	E4980-N3300
31	5'8"	6'8"	E4960-N3300
32	3'9"	4'9"	E5040-N3620
33	5'8"	7'8"	E5020-N3620
34	6'4"	8'4"	E5000-N3620
35	6'0"	8'0"	E5000-N3620

BORROW PIT: At Spillway Dump.

Sample No.	Location
16-21	Taken at 20 ft. intervals from west line, of Dump.
E	East side of borrow pit north of quarry road.
W	West " " " " " " " "

- continued -

ANALYSIS OF SAMPLES

	Sample Number	Gravel	Sand	Silt	Clay	Apparent Specific Gravity	Voids
Beaches	1	None	95.0%	1.7%	3.3%	2.73	#
	2	"	88.1	6.9	5.0	2.78	47.0%
	3	"	83.7	13.0	3.3	2.75	#
	4	"	84.6	10.4	5.0	2.74	46.2
	5	"	91.5	3.6	4.9	2.78	49.3
	6	"	81.5	14.0	4.5	2.78	45.3
	7	"	87.6	9.0	3.4	2.79	45.9
	8	"	82.1	13.7	4.2	2.78	45.7
	9	"	81.1	15.2	3.7	2.76	46.7
	10	"	79.0	16.4	4.6	2.73	40.3
	11	"	78.6	16.8	4.6	2.75	44.7
	12	"	81.4	14.6	4.0	2.75	45.1
	13	"	83.0	13.6	3.4	2.75	45.5
	14	"	83.7	12.7	3.6	2.76	44.9
	15	0.2	80.9	14.3	4.8	2.75	43.6
Pit	16	None	66.7	25.7	7.6	2.75	45.5
	17	"	65.3	23.7	11.0	2.73	42.8
	18	"	75.7	17.7	6.6	2.73	43.6
	19	"	66.3	23.7	10.0	2.74	48.1
	20	"	80.6	8.0	11.4	2.74	44.5
	21	"	64.4	23.2	12.4	2.73	43.6
	E	"	62.5	25.5	12.0	2.73	48.3
	W	"	48.9	32.9	18.2	2.70	43.7
Core	22	"	52.8	34.8	12.4	2.75	41.8
	23	"	32.6	45.8	21.6	2.78	61.5
	24	"	45.7	37.3	17.0	2.78	62.4
	25	"	20.1	48.9	31.0	2.78	60.5
	26	"	12.2	71.4	16.4	2.79	63.8
	27	"	13.4	47.2	39.4	2.76	68.9
	28	"	9.1	51.5	39.4	2.76	69.2
	29	"	9.2	62.4	28.4	2.76	63.8
	30	"	14.3	50.1	35.6	2.71	65.6
	31	"	48.6	32.8	18.6	2.71	51.0
	32	"	73.4	17.6	9.0	2.71	45.0
	33	"	61.5	28.7	9.8	2.82	55.0
	34	"	38.1	41.1	20.8	2.75	62.5
	35	"	70.4	20.6	9.0	2.79	50.2

Note: # Not sufficient sample for voids determination

- continued -

Per Cent Passing

Sample No.	1	2	3	4	5	6	7	8
4 mesh	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sieve #10	97.3	98.1	98.8	99.5	99.7	99.6	99.7	99.8
" 20	81.7	91.1	95.3	95.8	98.1	95.5	95.6	95.5
" 30	66.6	80.3	87.3	86.3	92.6	86.3	86.5	86.2
" 40	44.1	57.6	68.2	64.8	75.9	66.3	63.5	66.9
" 50	31.3	42.4	52.5	49.8	50.9	52.9	47.1	53.2
" 100	13.6	20.9	27.8	27.4	22.9	30.0	22.9	29.2
" 200	5.0	11.9	16.3	15.4	8.5	18.5	12.4	17.9

Sample No.	9	10	11	12	13	14	15	16
4 mesh	100.0	100.0	100.0	100.0	100.0	100.0	99.8	-
Sieve #10	99.7	99.6	99.7	99.5	99.6	99.6	98.5	100.0
" 20	97.3	95.5	95.4	95.3	94.0	95.3	91.6	96.5
" 30	90.1	87.7	86.1	87.2	85.2	89.1	80.7	89.5
" 40	71.8	72.2	66.1	68.4	68.1	74.0	61.6	79.7
" 50	56.5	60.5	52.8	54.4	55.0	60.2	49.4	68.5
" 100	31.0	37.2	32.4	29.9	30.5	31.7	29.9	47.5
" 200	18.9	21.0	21.4	18.6	17.0	16.3	19.1	33.3

Sample No.	17	18	19	20	21	E	W	22
4 mesh	100.0	100.0	-	100.0	100.0	100.0	-	100.0
Sieve #10	99.9	98.2	100.0	96.2	98.8	99.9	100.0	99.8
" 20	97.9	93.2	99.0	83.0	95.3	99.7	99.8	99.5
" 30	93.1	85.7	95.1	74.3	89.5	95.7	99.4	96.3
" 40	81.0	70.2	83.6	60.1	77.9	81.6	90.3	80.3
" 50	70.8	58.3	73.1	50.4	68.2	70.3	82.0	73.0
" 100	50.5	37.5	50.7	31.6	49.6	50.7	64.3	58.2
" 200	34.7	24.3	33.7	19.4	35.6	37.5	51.1	47.2

Sample No.	23	24	25	26	27	28	29	30
4 mesh	-	-	100.0	-	-	-	-	-
Sieve #10	100.0	-	99.8	100.0	-	-	-	-
" 20	99.9	100.0	99.8	99.9	-	-	100.0	-
" 30	99.7	99.9	99.5	99.8	100.0	100.0	99.9	100.0
" 40	99.5	99.1	99.2	99.7	99.8	99.9	99.7	99.8
" 50	99.0	98.0	98.8	99.6	99.0	99.7	99.5	99.5
" 100	92.2	84.3	94.4	96.3	94.9	97.8	97.1	97.2
" 200	67.4	54.3	79.9	87.8	86.6	90.9	90.8	85.7

Sample No.	31	32	33	34	35
4 mesh	-	-	100.0	-	-
Sieve #10	100.0	100.0	99.9	-	-
" 20	99.7	95.1	99.7	100.0	100.0
" 30	97.2	85.6	99.5	99.9	99.8
" 40	84.7	70.1	99.2	99.7	96.4
" 50	75.4	59.1	95.9	99.1	88.1
" 100	60.6	38.8	63.3	84.1	55.1
" 200	51.4	26.6	38.5	61.9	29.6

- continued -

Percentage Finer

Sample No.	22	23	24	25	26	27	28
Sieve #10	99.8	100.0	-	99.8	100.0	-	-
" 20	99.5	99.9	100.0	99.8	99.9	-	-
" 30	96.3	99.7	99.9	99.5	99.8	100.0	100.0
" 40	80.3	99.5	99.1	99.2	99.7	99.8	99.9
" 50	73.0	99.0	98.0	98.8	99.6	99.0	99.7
" 100	58.2	92.2	84.3	94.4	96.3	94.9	97.8
" 200	47.2	67.4	54.3	79.9	87.8	86.6	90.9
Clay, 1 min. (0.0467mm.)	23.4	29.6	28.8	43.0	25.4	51.4	50.4
Clay, 5 min. (0.023 mm.)	19.4	24.6	21.8	35.0	19.4	45.4	43.4
Clay 15 min.) (0.0148mm.)	12.4	21.6	17.0	31.0	16.4	39.4	39.4
Clay, 30min. (0.0097mm.)	9.4	19.6	16.0	27.0	15.4	36.4	37.4

Sample No.	29	30	31	32	33	34	35
Sieve #10	-	-	100.0	100.0	99.9	-	-
" 20	100.0	-	99.7	95.1	99.7	100.0	100.0
" 30	99.9	100.0	97.2	85.6	99.5	99.9	99.8
" 40	99.7	99.8	84.7	70.1	99.2	99.7	96.4
" 50	99.5	99.5	75.4	59.1	95.9	99.1	88.1
" 100	97.1	97.2	60.6	38.8	63.3	84.1	55.1
" 200	90.8	85.7	51.4	26.6	38.5	61.9	29.6
Clay, 1 min. (0.0467mm.)	41.4	44.6	25.6	13.0	10.8	30.8	13.0
Clay, 5 min. (0.023 mm.)	34.4	41.6	20.6	11.0	9.8	25.8	11.0
Clay,15 min. (0.0148mm.)	28.4	35.6	18.6	9.0	9.8	20.8	9.0
Clay,30 min. (0.0097mm.)	26.4	33.6	16.6	7.0	7.8	17.8	8.0

Remarks: The particle sizes for 1, 5, 15 and 30 minute hydrometer reading are those given by Harry H. Hatch in Proceedings of the American Society of Civil Engineers, Vol.58,No. 8, October issue of 1932.

Respectfully submitted,

Smith-Emery Co. (Signature)

(SEAL) INSPECTING & TESTING ENGINEERS

2-18-35
copy/p

Dec. 13, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Composition of material in puddle core El Capitan Dam

With reference to your request when at your office on the 11th, I am summarizing herewith my views on the character of the material going into the hydraulic fill, El Capitan Dam, as expressed from time to time in letters and reports to your office, regarding these materials.

The clay content of the borrow pit material, I have considered to be a relatively coarse grained clay, judging from the readiness with which it settles when shaken in an excess of water, as compared with the extremely slow and gradual settlement of some types of clay. The main characteristic of the intermediate silt content between the clay and the sand is that it is of grain size to pass the No. 200 mesh sieve and to go into settlement in the clay determination process. Under a magnifying glass this portion has a granular, not an amorphous appearnace. The sand portion is a relatively heavy sand, of high specific gravity, due in part to its magnetic iron content, and in part to the composition of the rock from which it is derived. While it may be classed in general as a granitic sand, it is composed in part of rock of a higher specific gravity than ordinary granite. This feature was even more pronounced in the material examined for concrete aggregates, in the river bar, adjacent to the borrow pit area. Another feature of the sand portion is a large mica content, amounting to from two to three per cent by weight of flaky mica going off in suspension in wash water and held on the No.200 sieve. These two features of mica and magnetic iron content, are characteristic of San Diego River sands in general.

With regard to the effect of these features on the consolidation of the core fill, I have judged that the high specific gravity of the material as a whole, and the relative coarseness of grain of the clay portion, are favorable factors to that end. The mica content judging from experiemts on record on sand-mica mixtures, may be considered as in effect adding slightly to the clay content. Sands of the type described have the property, when saturated with water, of settling into a dense, compact mass giving off free water at the surface. This is also the case when used in mortar in a concrete mixture with production of a non-plastic, harsh-working mix.

With regard to desirable percentages of the several portions, a summary made, following the completion of tests on the 10th series of core samples (date of report on 10th series, Sept. 9, 1933) comprising some ninety odd samples, showed a total average in percentages Clay, 21; silt, 31; sand, 45.

The records on these core sample series were kept in two groups, one comprising the samples taken along the center line (coordinate E 5000) and the other including the samples taken at varying distances from this line. There was very little difference between the separate averages on these two groups, indicating a fairly uniform distribution of the material over the whole core area. The samples of the core series taken since, however, have shown a much wider range of variation, some running remarkably high in clay, and others being of a sandy nature with a few of coarse sand similar to the beach material. (This refers to samples taken between the 10th series, and the special series now under way) indicating a much less uniform distribution of the material under later operations.

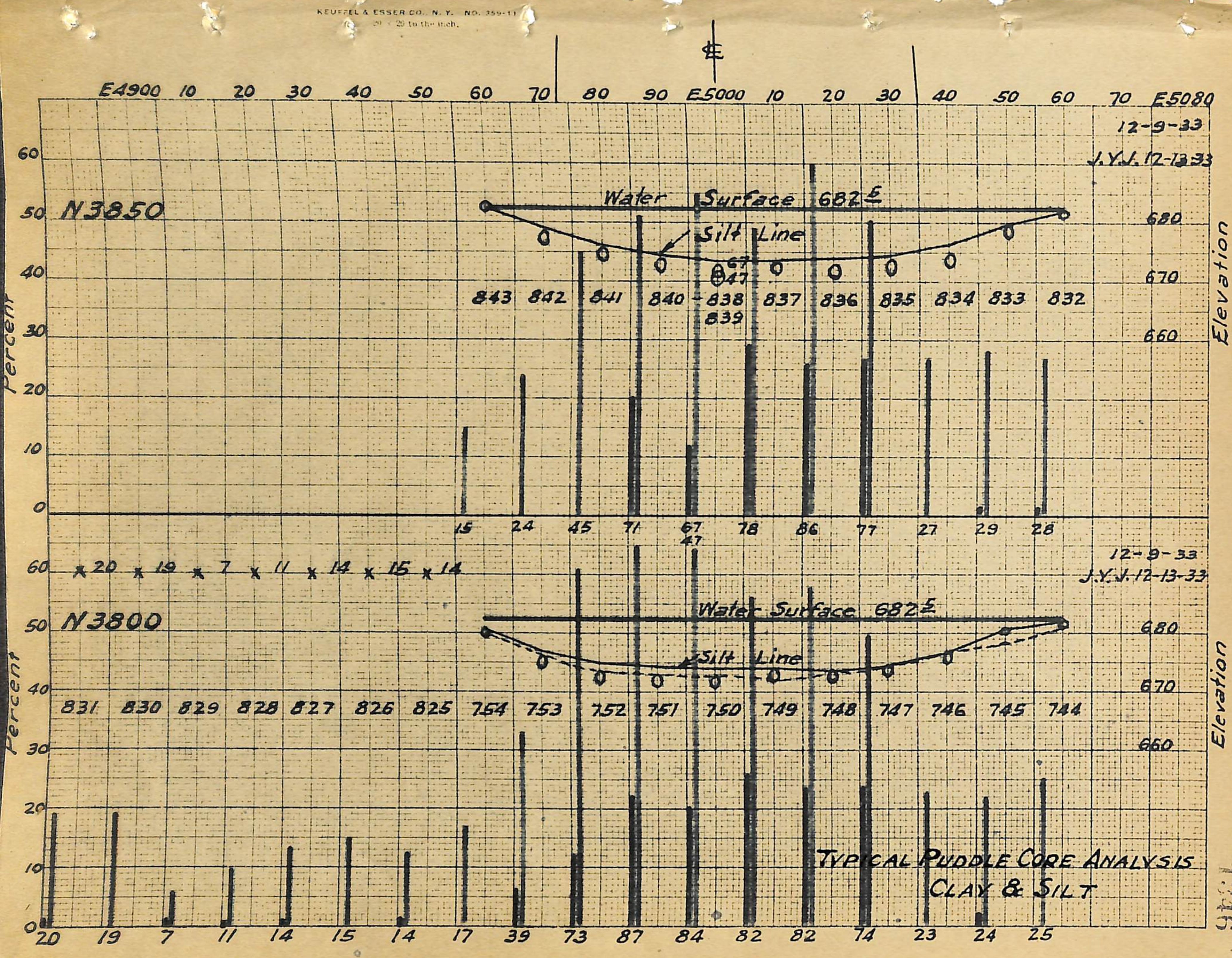
Results of the consolidation and percolation tests on material represented by the above general average, show a very slight and practically negligible rate of percolation. On the other hand, material from the border line between the puddle core and the beach, having a composition of clay, 4; silt, 26; sand, 68; pea gravel, 2; and a sample of borrow pit materials of similar composition, show a high rate of percolation; while a sample of fine sand, screened out to pass a No. 50 sieve and held on No. 200, shows even a much higher rate than these.

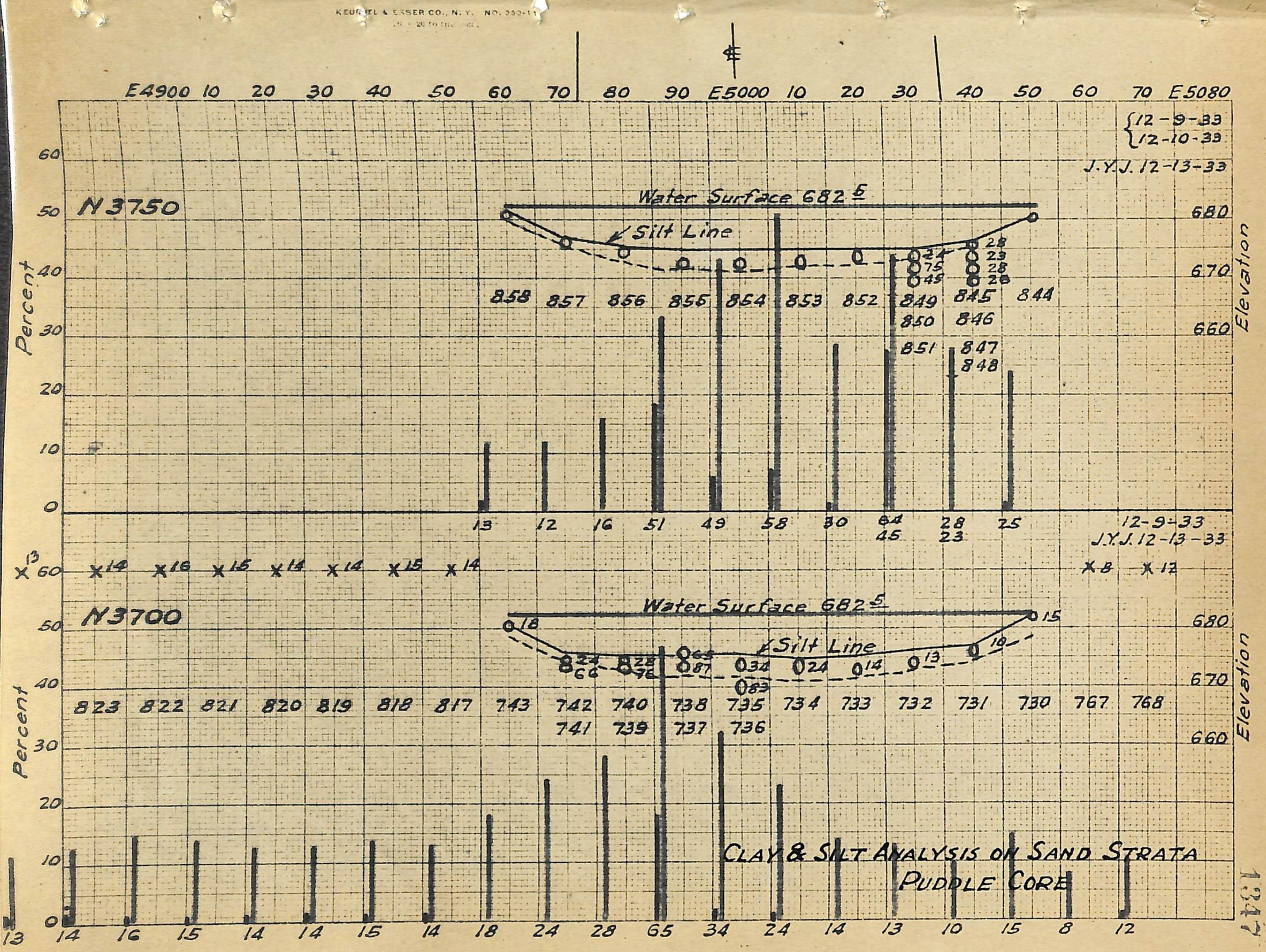
The material of these coarse samples when removed from the apparatus after test, is friable and easily crumbled in the hand; while that with the higher percentage of "fines" dries into a dense, compact structure somewhat similar to, and perhaps even harder than a clay brick before burning. Specimens from these tests are on exhibition at your office, and in the laboratory.

In my judgment, the percentages of the three portions as stated in the above general average at the end of the 10th series, represents a good combination of the materials as to gradation of grain size, all the way through. It avoids an excess of a plastic fine-grained, semi-liquid, clayey deposit such as has given trouble in some previous dams of this type; but has sufficient fine material for suitable compaction and water-tightness. I do not believe however, that the percentage of fines should be reduced much lower than shown in this average, unless percolation tests in advance show that such reduction is permissible.

Exploration of prospective borrow pit materials in the vicinity of Lindo Lake near Lakeside, shows a heavy clay content of apparently a somewhat finer grained composition than the present El Capitan material, and somewhat lighter in specific gravity. It has appealed to me, that a mixture of this clay, for increase in clay content; with the fine sand and silt of the present borrow pit for compaction purposes, would make an ideal combination for further operations, if such a mixture is practicable to obtain.

JYJ/b J. Y. Jewett


KEUFFEL & ESSER CO. N.Y. NO. 359-11
20 × 20 to the inch.
E4900 10 20 30 40 50 60 70 80 90 E5000 10 20 30 40 50 60 70 E5080
12-9-33
J.Y.J. 12-13-33
N3850
Water Surface 682±
Silt Line
843 842 841 840 838 837 836 835 834 833 832
839
Percent
Elevation
680 670 660
15 24 45 71 67 78 86 77 27 29 28
47
x 20 x 19 x 7 x 11 x 14 x 15 x 14
N3800
Water Surface 682±
Silt Line
831 830 829 828 827 826 825 754 753 752 751 750 749 748 747 746 745 744
20 19 7 11 14 15 14 17 39 73 87 84 82 82 74 23 24 25
Typical Puddle Core Analysis
Clay & Silt


CLAY & SILT ANALYSIS ON SAND STRATA
PUDDLE CORE
N3750
N3700
Water Surface 682±
Silt Line
Percent
Elevation
E4900 10 20 30 40 50 60 70 80 90 E5000 10 20 30 40 50 60 70 E5080
12-9-33
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J.Y.J. 12-13-33
858 857 856 855 854 853 852 849 850 851 845 846 847 848 844
13 12 16 51 49 58 30 64 45 28 23 25
823 822 821 820 819 818 817 743 742 741 740 739 738 737 735 736 734 733 732 731 730 767 768
14 16 15 14 14 15 14 18 24 28 65 34 24 14 13 10 15 8 12
KEUFFEL & ESSER CO., N.Y. NO. 359-11

2-21-35
Copy/m

Dec. 21,1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow Pit Samples, El Capitan Dam.

Six samples from Borrow Pit A, El Capitan hydraulic fill material, are listed as Job Nos. 1216-21; Lab. Nos. 20881-86. Twenty-four samples from Borrow Pit C are listed as Job Nos. 1369-91 (incl. 1386A); Lab. Nos. 21013-36.
Locations from which taken, as furnished by the El Capitan Office; and gradation as determined in the laboratory, are as shown in the following table.
Detailed gradings of the sand portion are shown in separate table on attached sheet.

Lab. No.	Job No.	Coordinates N.	Coordinates E.	Depth of Sample (Ft.)	Percentage Sand	Percentage Silt	Percentage Clay
20881	1216	3140	11,450	1	73	19	8
82	17	"	"	9	75	25	0
83	18	"	"	18	69	30	1
84	19	3300	11,470	1	72	21	7
85	20	"	"	7	72	28	0
86	21	"	"	14	62	30	8
21013	1369	5077	3371	1	71	19	10
14	70	"	"	3.5	71	27	2
15	71	"	"	8	64	22	14
16	72	5007	3312	1	60	21	19
17	73	"	"	2	57	18	25
18	74	"	"	4	70	28	2
19	75	4955	3273	1	54	27	19
20	76	"	"	2.5	51	23	26
21	77	"	"	3.5	55	22	23
22	78	4877	3209	1	65	22	13
23	79	"	"	2	63	22	15
24	80	"	"	4	60	18	22
25	81	4986	3150	1	63	22	15
26	82	"	"	3	54	22	24
27	83	"	"	6	82	15	3
28	84	5037	3213	1	68	24	8
29	85	"	"	3	73	20	7
30	86	"	"	4.5	83	17	0
31	86A	5098	3269	1	66	23	11
32	87	"	"	6	74	25	1
33	88	"	"	3.5	53	19	28
34	89	5153	3319	1	67	23	10
35	90	"	"	3.5	60	21	19
36	91	"	"	7	75	18	7

2-26-35
Copy/m

Dec. 21, 1933

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow Pit Samples, El Capitan Dam

Nine additional samples from Borrow Pit C, listed as Job. Nos. 1419-27; Lab. Nos. 21037-45, are included in the following addition to the above tabulation.

Lab. No.	Job. No.	Coordinates N.	Coordinates E.	Depth of Sample (Ft.)	Percentage Sand	Percentage Silt	Percentage Clay
21037	1419	4597	3405	1	68	20	12
38	20	"	"	4	13	64	23
39	21	"	"	6	58	24	18
40	22	4493	3487	1	73	18	9
41	23	"	"	4	80	12	8
42	24	"	"	8	78	15	7
43	25	4358	3444	1	75	17	8
44	26	"	"	4	75	22	3
45	27	"	"	8	70	29	1

J. Y. Jewett

JYJ/b
cc- 4 encl.

2-26-35
Copy/m

December 21, 1933

From

To

Subject Accompanying report of even date to :Hydraulic Engineer, on Borrow Pit Samples, El Capitan Dam.

Job No.	Percentages Passing Sieve No. ¼"	10	20	30	40	50	100	200 (Silt & Clay
1216		100	98	88	78	65	44	27
17		100	99	90	80	68	42	25
18		100	98	88	80	69	49	31
19		100	97	86	77	66	45	28
20		100	98	87	77	66	44	28
21		100	98	89	82	73	54	38
.....		...	..	..	..	..	..	..
1369	100	99	98	89	79	67	45	29
70	100	99	97	85	77	65	44	29
71	100	99	97	88	78	69	50	36
72	100	99	97	90	82	73	56	40
73	100	99	97	89	80	72	56	43
74	100	98	91	81	72	63	44	30
75		100	99	94	87	78	60	46
76	100	99	98	93	87	79	62	49
77	100	99	97	91	84	75	58	45
78	100	99	97	88	80	70	50	35
79	100	98	95	87	79	69	51	37
80	100	98	96	88	79	72	54	40
81	100	99	98	92	83	73	52	37
82		100	99	93	86	76	58	46
83	100	97	91	77	65	51	30	18
84	100	99	97	88	78	66	45	32
85	100	97	92	80	70	60	40	27
86	100	96	87	70	59	47	28	17
86A	100	99	98	90	80	70	49	34
87	100	99	95	81	70	58	38	26
88		100	98	91	83	74	59	47
89		100	98	90	80	69	48	33
90		100	98	91	82	71	52	40
91	100	98	94	80	69	58	40	25

Dec. 21, 1933

From :

To :

Subject : Accompanying report of even date to Hydraulic Engineer, on Borrow Pit Samples, El Capitan Dam.

Job. No.	Percentages Passing Sieve No. ¼"	10	20	30	40	50	100	200 (Silt & Clay)
1419		100	98	90	81	70	49	32
20			100	99	98	96	92	87
21	100	99	96	88	82	74	56	42
22	100	99	95	82	72	62	41	27
23	100	99	92	77	65	53	33	20
24	100	99	92	77	65	52	33	22
25	100	98	92	80	69	58	38	25
26	100	98	93	81	71	59	39	25
27	100	99	95	83	74	64	44	30

J. Y. Jewett

JYJ/b
cc - 4 encl.

State Engineer
Senior Inspector of Dams
Resident Engineer
E.D. Pyle

2-19-35
copy/p

1-30-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Core samples hydraulic fill, El Capitan Dam

Lab. No.	Job No.	Elevation sample		Depth of water	Coordinates N	Coordinates E	Gradation Sand	Gradation Silt	Gradation Clay
21626	1883	674.5	670.5	7.0	3750	4973	39	49	12
27	84	672.5	668.5	9.0	3750	4980	49	47	4
28	85	671.5	667.5	10.0	3750	5000	54	41	5
29	86	673	669	8.5	3750	5020	53	45	2
21630	87	674	673	6.5	3750	5035	77	21	2
31	88	673	669	8.0	3750	5027	63	33	4
32	89	674.5	670.5	7.0	3725	4973	48	50	2
33	1890	673.5	669.5	8.0	3725	4980	56	43	1
34	91	669.5	665.5	12.0	3225	5000	56	40	4
35	92	668.5	664.5	13.0	3725	5020	59	39	2
36	93	673.5	669.5	8.0	3725	5035	66	32	2
37	94	669.5	665.5	12.0	3700	5035	54	43	3
38	95	667.5	663.5	14.0	3700	5020	54	25	21
39	96	669.5	665.5	12.0	3700	5000	25	49	26
21640	97	675	671	6.5	3700	4980	44	36	20
41	98	676	672	5.5	3700	4973	42	57	1
42	99	672	668	9.5	3675	4973	39	27	34
43	1900	670.5	666.5	11.0	3675	4980	44	53	3
	1	667	663	14.5	3675	5000			
	2	670.5	666.5	11.0	3675	5020			
	3	673.5	671	8.0	3675	5035			
	4	670.5	666.5	11.0	3675	5028			

J. Y. Jewett
Testing Engineer

JYJ/p

2-9-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow pit samples; El Capitan Dam

Eight samples of material from borrow pit "A" taken this date, are Job Nos. 2101-8; Lab. Nos. 21826-33. Gradation of these samples is shown in the following table; with locations from which taken, as furnished by the El Capitan office. Detailed gradings of the sand portion are shown in separate table beyond.

Lab. No.	Job No.	Coordinates N.	Coordinates E.	Depth of sample (Ft.)	Percentage Sand	Percentage Silt	Percentage Clay
21826	2101	2480	10460	2	47	26	27
27	2	"	"	4	41	24	35
28	3	"	"	5.5	47	36	17
29	4	2480	10400	2	64	21	15
21830	5	"	"	4	60	33	7
31	6	"	"	7	65	22	13
32	7	2560	10520	1	53	25	22
33	8	2480	10370	1	62	24	14

Job No.	Percentages passing Sieve No. ¼"	10	20	30	40	50	100	200 (Silt & Clay)
2101		100	99	97	94	88	70	53
2			100	98	95	91	75	59
3			100	98	95	91	72	53
4	100	99	96	88	81	71	51	36
5	100	99	99	97	92	83	60	40
6		100	99	95	90	80	55	35
7		100	99	97	93	86	65	47
8		100	99	94	88	78	56	38

J. Y. Jewett

JYJ/p
cc-4 encl.

2-15-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow pit samples, El Capitan Dam

Nine samples of material from new borrow pit, west side of river, about one-half mile upstream of pit "A", are listed as Job Nos. 2083-91; Lab. Nos. 21846-54. Gradation of these samples is shown in the following table, with locations as furnished by the El Capitan office. Detailed gradins of the sand portions are shown in separate table beyond.

Lab. No.	Job No.	Kind	Depth of sample	Location	Percentages Sand	Silt	Clay
21846	2083	clay	1 ft.	South end Pit K	67	22	11
47	84	"	6 "	" " " "	59	31	10
48	85	"	12 "	" " " "	47	41	12
49	86	"	1 "	Center " "	66	20	14
50	87	"	9 "	" " "	58	30	12
51	88	"	18 "	" " "	72	15	13
52	89	"	1 "	North end " "	58	40	2
53	90	"	8 "	" " " "	61	22	17
54	91	"	15 "	" " " "	67	26	7

Detailed grading of sand portion

Job. No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200 (silt & clay)
2083	100	99	95	87	81	74	56	33
84	100	99	97	89	83	75	57	41
85		100	99	96	93	89	78	53
86	100	98	92	82	75	67	50	34
87		100	99	93	87	79	60	42
88	100	99	95	85	75	65	44	28
89		100	98	94	92	86	66	42
90	100	99	97	89	82	74	55	39
91	100	99	96	87	79	71	51	33

J. Y. Jewett

JYJ/p
cc - 4 encl.

2-21-35
copy/m

Feb. 19, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow Pit Material, El Capitan Dam.

Three samples of material from new borrow pit ("K") upstream from Borrow Pit A, are listed as Job Nos. 2120-22; Lab. Nos. 21858-60. These are composites, taken from the material as dumped at the mixing box.

These give gradation percentages as follows, with detailed grading of the sand portion, as shown on the attached form.

	Sand	Silt	Clay
No. 2120	64	27	9
21	65	25	10
22	61	27	12

A portion of this material is intended for use in a consolidation and percolation test, as carrying a total of silt and clay content of approximately 35 per cent.

J. Y. Jewett

JYJ/b
cc - 4 encl.

2-18-35
copy/p

Feb. 21, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : Sand samples from beach excavation, El Capitan

Six sand samples taken February 18 from material excavated from the beach of the puddle core and deposited on the face of the upstream rock embankment, are listed as Job Nos. 2133-38; Lab. Nos. 21878-83. These are reported as taken commencing at the north abutment at about equidistant intervals along the embankment to the south abutment. Gradation of these samples is shown in the following table with detailed grading of the sand portion on the attached report form.

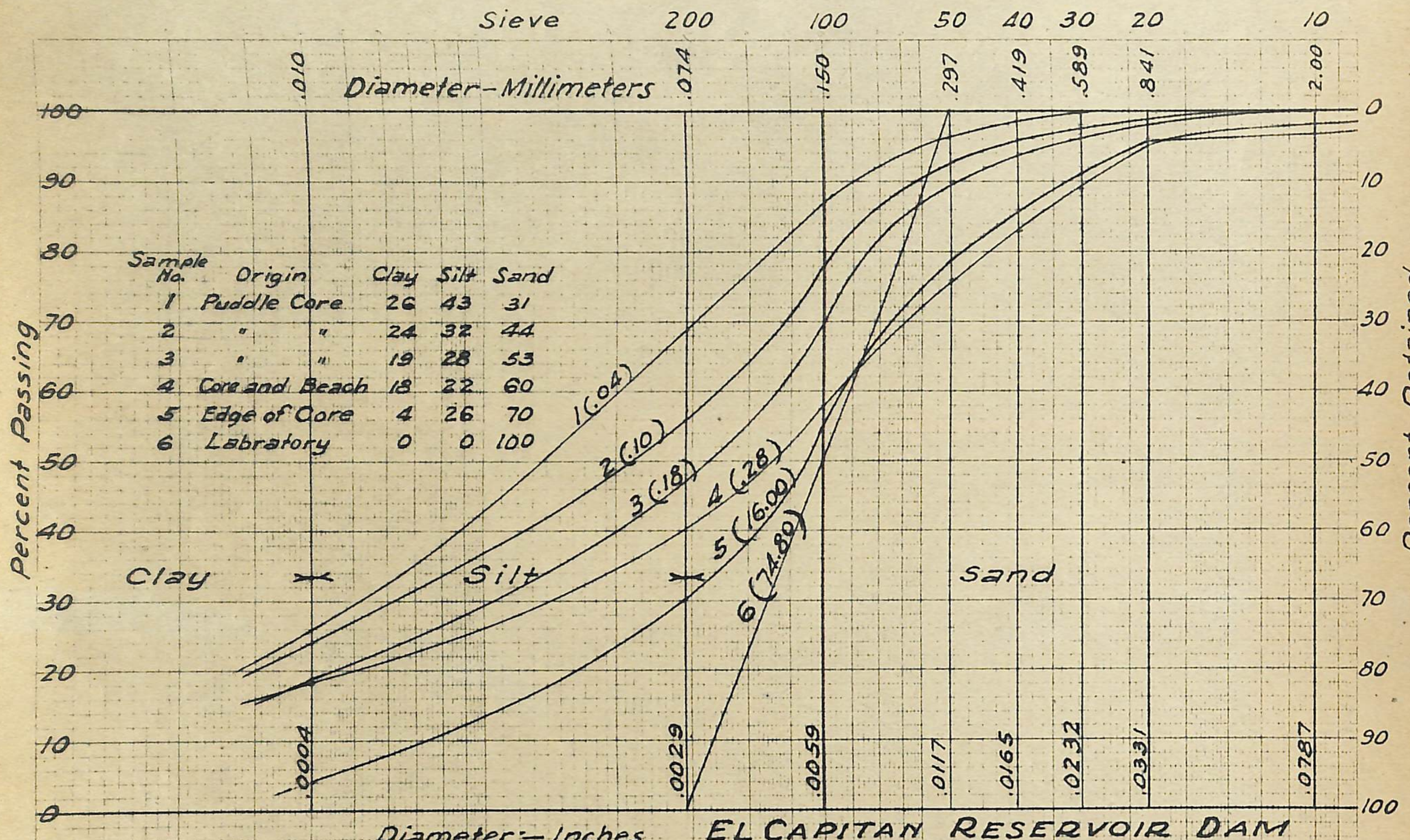
Lab. No.	Job No.	Gradation percentage Sand	Silt	Clay
21878	2133	76	20	4
79	34	79	16	5
80	35	77	20	3
81	36	73	23	4
82	37	78	19	3
83	38	83	14	3

Detailed grading of sand portion

Lab. No.	Job No.	Percentages passing sieve No. 1/4"	10	20	30	40	50	100	200(silt & clay)
21878	2133		100	98	91	83	72	44	24
79	34					100	98	67	21
80	35	100	99	96	85	76	65	42	23
81	36		100	96	83	73	61	41	27
82	37	100	98	94	83	74	63	39	22
83	38	100	99	94	79	68	56	32	17

J. Y. Jewett

JYJ/b



EL CAPITAN RESERVOIR DAM

PERCOLATION & CONSOLIDATION TESTS

GRADATION ANALYSIS

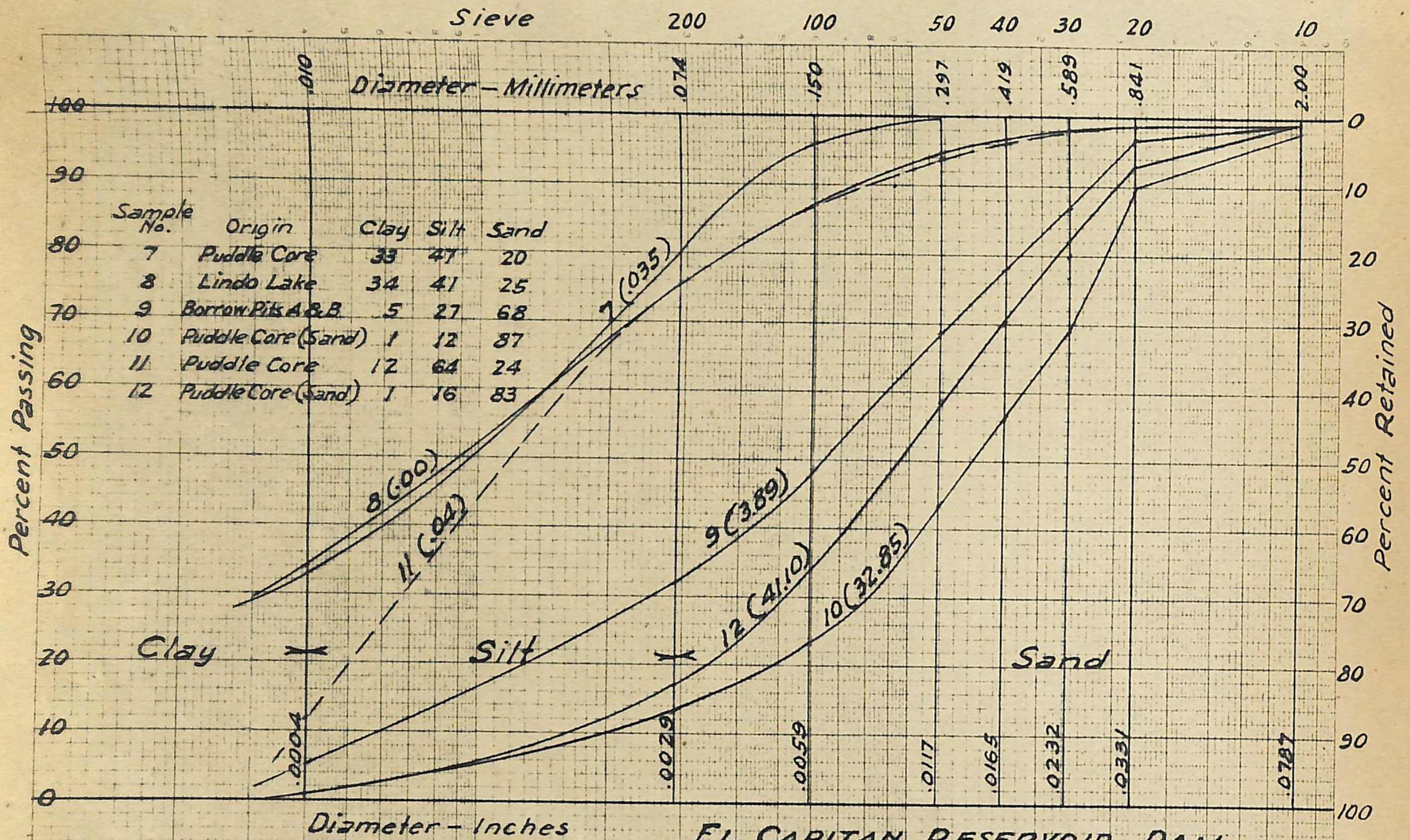
April 1934

(.04) = Percolation Velocity in feet per year on Ratio of Unity—Pressure 75 feet of fill.

H. N. Savage [signature]
Hydraulic Engineer

Sheet 1

Dr. by N.C. 4/4/34 [initials]



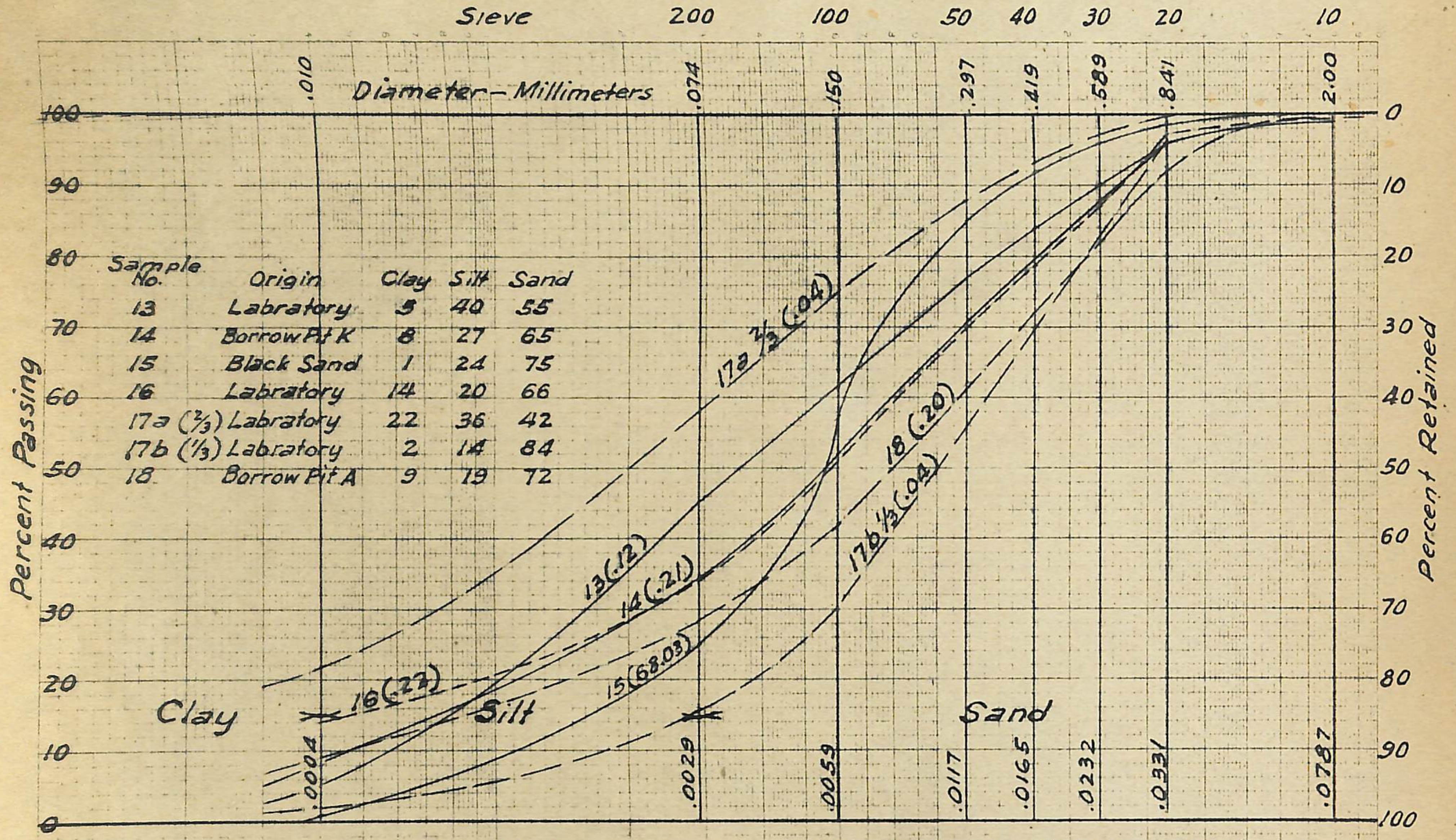
(.035) = Percolation Velocity in feet per year on Ratio of Unity – Pressure 75 feet of fill.

EL CAPITAN RESERVOIR DAM
PERCOLATION & CONSOLIDATION TESTS
GRADATION ANALYSIS
April 1934

H. M. Savage ℓ F.D.O.
Hydraulic Engineer.

Sheet 2

Dr. by N.C. 4/4/34 F.D.O.



Diameter—Inches

(.04) = Percolation Velocity in feet per year on Ratio of Unity – Pressure 75 feet of fill.

Sample 17 – Top and bottom thirds of Sample 17a, middle third of 17b. Material from outside did not appear to pass into middle.

Dr. by N.C. 4/4/34 – [initials]

Sheet 3

EL CAPITAN RESERVOIR DAM
PERCOLATION & CONSOLIDATION TESTS
GRADATION ANALYSIS
April 1934

H. N. Savage [signature]
Hydraulic Engineer

May 11, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : San Diego River Project, El Capitan Feature
Hydraulic fill, laboratory work

In accordance with letter from your office of May 8 on the above subject, the following statement is submitted, as furnishing the information requested therein.

Identification of Samples:

The samples as received from the El Capitan office carry job sample numbers in a consecutive series, these numbers for identification purposes being marked on the containers in which the samples are delivered. A record sheet also accompanies each lot delivered, giving sample numbers and description of location from which each was obtained. In the case of samples from the puddle core this involves location by coordinates and depth at which the sample was taken.

On arrival at the laboratory sample numbers in the laboratory series are assigned and in the report on results, both sets of numbers are recorded. While the making of the tests is under way the several receptacles in which the samples are placed during the process are accompanied by a marked tag carrying the sample number, thus making the identification complete during the entire process. The surplus material, if any, remaining after the amount required for tests is removed, is placed in a marked container and set aside for further use if required.

Tests for Gradation:

In the tests for gradation of size of particles the sample is first spread out in a shallow pan and dried in an oven to remove the moisture. In case the percentage of moisture is required, the sample is weighed both before and after drying, to determine this; but ordinarily this is not required.

The process of determining the gradation of the solids gives a classification, in terms of percentage by weight, of sand, silt and clay portions, the sum of these percentages of course totaling one hundred. In terms of classification, the sand portion is that held on a sieve of No. 200 mesh. The clay, or colloidal portion, is that determined by a hydrometer process as described below. The silt content is an intermediate portion passing the No. 200 sieve, but of coarser grain size than the clay, and going into settlement during the operation of the hydrometer process.

The clay determination comes first and is made by placing a weighed portion of the dried sample in the cup of a stirring apparatus, with a little potassium hydroxide to serve as a deflocculent, and with water nearly filling the cup. Operation of this apparatus for a stated period brings about a so-called dispersion of the sample; which, in effect, means the breaking down and separation of the material into its unit particle sizes, a condition which it is impracticable to reach by the ordinary process of working with a trowel, as might be done in the case of a clear sand sample. The sample is then transferred, with additional water to a graduated glass cylinder in which a hydrometer of the Bouyoucos type is inserted, and after standing for a defined period, the reading of a scale on the stem of this instrument gives the clay content in terms of grams per liter, from which the percentage is computed. A thermometer reading is also taken, as this instrument is standardized at a temperaturs of 67°F., and a specified correction is applied for temperatures above or below that mark.

For determination of the sand percentage, the contents of the cylinder are washed out into a shallow pan, the wash water being passed through a No. 200 sieve to avoid loss of any sand particles, and dried in an oven, then weighed to obtain said percentage. In addie tion, the gradation of the sand portion can be determined, if desired, in terms of percentage passing each of a set of standard sieves, ranging from 1/4" mesh to No. 200.

Apparatus Used:

The stirring machine mentioned above is of the type used for mixing purposes at soda fountains, but the cup used for soil samples is of a special design for this purpose, containing a set of baffle wires, and the lower end of the stirring rod has a special form of button attached, which is replaced as it wears out.

The hydrometer process was developed by Geo. J. Bouyoucos, Research Professor in Soils at Michigan State College. It is in use by the Bureau of Public Roads, U. S. Department of Agriculture, in study of highway subgrade soils; and by other investigators of soil problems, as being the most suitable method yet devided for determination of colloidal content; and as superseding other methods used, or proposed for use, from time to time.

The standard sieves used for sand analysis conform with requirements of the American Society for Testing Materials for this purpose, and each sieve is stamped with its rating as to size of mesh, and diameter of wire, in both millimeters and inches.

Consolidation and Percolation Test:

This test is carried out with equipment similar in principle to apparatus devised by investigators at Mass. Institute of Technology, as described in a paper on Soils Mechanics Research by Glennon Gilboy, in Proceedings, American Society of Civil Engineers, October 1931. The type in use here is patterned after a modification of said apparatus, as adopted by the Bureau of Water Works of the Department of Water & Power, City of Los Angeles, in its study of materials for Bouquet Canyon Dam. Its distinguishing features are a simplification of operating parts, and provision for the use of a sample of larger and more adequate size.

The container in which the sample is placed is a metal cylinder, eight inches in diameter, nine inches deep. The sample as placed in the cylinder is in a water saturated state, the water content in puddle core samples being as received from the work, and in other samples being that required to produce a state of plasticity similar thereto. The bottom plate of the cylinder is provided with a water valve and inlet pipe, for percolation purposes. The sample is placed in the cylinder to a depth of four inches, with a porous plate of the Filtros type below and above. On top of the upper plate is placed a metal piston head, with perforations for the passage of water. Compression is applied to the specimen through use of the testing machine, Olsen Universal type, 200,000 lbs. capacity, with which the laboratory is equipped. In applying the pressure a car spring is introduced, as an equalizer, between the bearing head of the testing machine and the piston above mentioned.

The test is carried out by applying pressure in several stages, corresponding in amounts to the weight of a column of earth of the same diameter as the cylinder, and of the height specified for each stage, said weight being based on an assumed weight per cubic foot of such earth column. Reference bars attached to the piston head at points of semicircumference and matching similar bars attached to the outside of the cylinder, give a means for reading the amount of change in depth of the specimen, due to the consolidation produced by the pressure applied. These readings are made by means of an Ames micrometer dial, of one inch capacity, reading to thousandths of an inch. The results are reported in percentage terms of reduction in volume, based on the reduction in depth of specimen as shown by these readings, for the several stages at which pressure is applied.

Between these periods of application of pressure, and when the change in volume for each has reached its end point, percolation rates are obtained, by turning on a flow of water at the valve previously mentioned, and measuring the rate of flow, in cc. per hour, under two heads of pressure, of 56 and 80 inches, corresponding to hydraulic gradients of 1:14 and 1:20 respectively.

General:

Auxiliary to the consolidation and percolation test, and included in the reports on this test, in addition to the record of volume change and rate of water flow as above noted; is determination of specific gravity of the material, and results of computation of moisture content, percentage by weight, of correcponding voids, in percentage by volume, and of corresponding weight per cubic foot for each of the several stages included in the process.

Two special features of the borrow pit material used in the hydraulic fill, are a high mica content; and a high content of magnetic iron particles, present in the finer grades of the sand portion. The probable effect of these factors has been commented on from time to time in reports to your office. The effect of the relatively high specific gravity of the sand portion as a whole, has also been commented on in these reports.

J. Y. Jewett

JYJ/b

2-18-35
copy/p

May 28, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : San Diego River Project, El Capitan Feature
Hydraulic fill, percolation and consolidation tests

In response to request in your letter of May 25, on the above subject, the following discussion is submitted on the five points on which questions are raised by you therein.

(a) The imperviousness of puddle core in a dam of the type of El Capitan is dependent primarily on the property possessed by a compact mass of soil particles, of extremely fine grain size, of resisting the passage of water through the mass, even when under a considerable head of pressure. The sum total of voids in such a mass may be as great or greater than in a mass of coarser composition, but their extremely small size, and lack of continuity, serves to retard, and reduce to a minimum the water flow.

As relating to actual construction practice in a dam of this type, the term "soil" as used above should be broadened to include a range of material of grain size classified more specifically as "sand" "silt" and "clay". As defining these three classes, the sand portion is rated as that passing a sieve of 1/4" mesh, and held on one of No. 200 mesh (equivalent to 40,000 meshes per sq.in.) The silt and clay portions are of fineness passing this latter mesh; the clay or colloidal content, as separate from that of the silt, being determined by a hydrometer process.

As extreme limits, experience in past construction has shown that the finer portions represented by the silt and clay content should not be in such excess as to remain in an unconsolidated, semi-liquid condition, that will break through confines, and slump out, under increase of pressure, as the core is built up. At the other extreme is a sand content so deficient in fines as to allow an unduly large flow through the mass, under the conditions of water pressure to which the structure is subjected. Between these two extremes, is a wide range of possible combinations, which will give a satisfactory degree of imperviousness in the structure.

While the gradation of the materials as to grain size is the main factor in building an impervious core, there are beyond this, variations in the facility with which materials of the same gradation may settle and consolidate into a compact mass.

For instance, as has been brought out in previous correspondence, the sand in the borrow pit materials at El Capitan has a relatively high specific gravity due in part to the nature of the rock from which it was derived, and in part to the inclusion in its finer portions of a magnetic iron content, prevalent in the sands of the San Diego River valley. This sand is therefore a class of material, which, when combined with a suitable amount of silt and clay tends to settle and compact readily into a dense, impervious mass.

(b) A reasonable requirement for puddle core material, to comply with the contract specifications, is the condition just named, of a sand content combined with a sufficient amount of the finer grades to produce a dense impervious mass.

In further discussion of the properties of the El Capitan materials, it may be noted that the portion classed as clay is of a relatively coarse grained nature as clays go, judging by the rate of settlement when shaken in an excess of water. As a result of this feature, the clay and silt portions merge into one another, without a very distinct line of demarcation, and for this reason it is more desirable to use the sum of the silt and clay contents in considering their part in the total combination, than would be the case if the clay portion, by itself, were of higher percentage and of finer grained quality. It is therefore evident that this material does not run toward the extreme of fineness mentioned under (a) and as it is found by experience on the work, that the material as a whole contains an excess of coarse sand, the question as a matter of practical operation, becomes one of limiting the sand content, and of determining as nearly as practicable, what may be the minimum amount of the finer materials required in combination therewith.

(c) Do not know of any way in which a factor of safety in numerical terms, such as 1, 2, 4, etc. can be applied to the results of the percolation tests to which reference is made. This is a relatively new form of test as applied to materials entering into a structure of this type; and, while, through the accumulation of data, standards are being built up, correlation of the test results with field conditions, is, at present, mainly a matter of judgment on the part of the engineer in charge.

(d) Ten series of puddle core samples, comprising a total of 93 samples, taken during period of Feb. 28 to Sept. 5, 1933, show, as stated in previous reports, a general average of:- Sand 45%; Silt 34%; Clay 21%. Also, as between the several series, and the individual samples thereof, a fair degree of uniformity is shown. Two additional series, taken Oct. 3 and Nov. 8, 1933, show a much higher average silt and clay content; but also a much wider range of variation among the individual samples. Beyond this, the core samples, not classed in series, and taken in much larger quantities numerically, show a continued wide range of variation in percentage content, and reflect the presence of sand strata.

Percolation tests on composite samples, representing the materials comprising the above named series, show a slight, and for practical purposes, a negligible rate of flow. It is also understood that observation in the field shows a good degree of consolidation and compaction in the core itself during the period covered by these tests. The writer concurs in the opinion of the engineers on the work, that the condition of the core up to this time, may be considered as satisfactory.

Other percolation tests on samples ranging down to as low as 30% silt and clay content, show also a low, and practically negligible rate of flow; but when 25% is reached, a marked increase is shown.

Also, an increase in friability of the samples after coming out of the test (with which is combined a compression test for consolidation of the material under pressure) is markedly in evidence, as the percentage of silt and clay decreases. Moreover, this low flow while predominating, has not been universal among all the 30% samples, indicating that other factors than gradation percentage, may enter into the result.

The percolation tests are run on a sample of volume of 200 cu.in. and of uniform composition. If it were possible to place material in the puddle core so that every 200 cu.in. thereof would uniformly contain a 30% silt and clay content, and no less it would seem, from the tests thus far made that this might reasonably be adopted as a limiting percentage.

Since this is not possible, and since the general average for ten sample series, as cited above, has been accepted as indicating satisfactory performance for the portion of the fill thus far placed, it would not seem unreasonable to consider this as a guide for future performance. It may further be noted, that in said ten series, only ten individual samples show a sand content higher than 60%, with a maximum of 68%, and that five of these occur in the first series, at the start of the work.

RECOMMENDATION: It is my recommendation therefore, that in future work, the puddle core samples should be required to show a general averagein the vicinity of 50% silt and clay content; and that individual samples should not fall below a low limit of 35%. It is believed that this will provide a sufficient "factor of safety" to ensure the durability of the structure.

(e) The above applies both to new work and to the rectifying operations referred to under (e)

JYJ/b J. Y. Jewett

2-21-35
Copy/m

June 10, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : Prospective borrow pit material; El Capitan Dam

Eighteen samples of prospective borrow pit material from tract in the vicinity of Lakeside, were received at the laboratory on the afternoon of June 8.

Sketch map of this area, furnished with the samples, shows its location in Lot 46 of El Cajon Land & Water Company; north of Laurel Street, and between Beech on the east and Ash on the west. Dimensions are 600 feet along Laurel, and 200 northerly along Beech and Ash. Samples were taken in four rows starting northerly from Laurel, and running east to west, with the following listing: 1st row, A 1-6; 2nd row B 1-3; 3rd row, C 1-3; 4th row, D 1-6. All samples were reported as representing material at a depth of one foot to seven with the top foot wasted, except the first (A1) which showed a depth of one to six feet only. Corresponding laboratory sample numbers are 22648-65.

Results for gradation have been obtained, as shown in the following table:

Lab.	Field	Percentage of			Percentages passing Sieve							
No.	No.	Sand	Silt	Clay	No. 1/4	10	20	30	40	50	100	200 (x)
22648	A1	54	28	18	100	99	97	94	90	85	68	46
49	2	26	38	36		100	98	95	92	90	83	74
50	3	20	48	32					100	99	96	80
51	4	38	50	12					100	99	88	62
52	5	43	37	20				100	99	98	84	57
53	6	40	40	20			100	99	98	95	80	60
54	B1	34	41	25			100	99	98	95	86	66
55	2	24	58	18						100	96	76
56	3	38	45	17				100	99	97	84	62
57	C1	33	39	28			100	99	98	97	89	67
58	2	38	59	3					100	99	89	62
59	3	37	41	22			100	99	97	94	83	63
22660	D1	4	77	19						100	99	96
1	2	40	42	18				100	99	98	90	60
2	3	50	36	14			100	99	98	95	72	50
3	4	43	51	6				100	98	95	80	57
4	5	47	32	21			100	99	96	92	76	53
5	6	38	39	23			100	99	97	95	85	62
	Average	36	44	20								

Among the characteristics of this material are a relatively high silt content; and fineness of the sand portion. Many of the samples from observation might be classed as a "silty sand." The clay portion, judging from its rate of settlement in water, is finer grained, as a clay, than that of the present borrowpit material at El Capitan.

The first two of these factors, taken by themselves, making for a uniformity of grading in the coarser portions of the material, might tend toward a higher percolation rate, judging from results obtained on some of the percolation samples. In combination however, with a fine grained clay, this tendency probably would be offset.

As was noted in connection with previous samples from the Lakeside region, it would seem that the material from that source might be mixed to good advantage with the material from the present borrow pits at El Capitan.

J. Y. Jewett.

JYJ/p
cc-4 encl.
State Engineer
Asst. Deputy State Engineer
Resident Engineer
Hydraulic Engineer

7/16/34
copy/f

COPY

June 18, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject: Settlement of suspended clay by chemical action.

In report of June 10, on prospective borrow pit material for El Capitan Dam, from vicinity of Lakeside; it was noted that the clayey portion of this material is evidently of a finer grained structure than that of the present borrow pit material, judging from its slower rate of settlement under suspension in water.

With reference to the use of chemical means for producing more rapid settlement, as brought up by Mr. Pyle a few trials were made, results of which were reported to him verbally, and are summarized below.

These trials were made on a composite sample (Lab.No.22681) comprising the samples covered in said report of June 10, having a higher clay content than 20%. Three chemicals were used in the first trial:- sodium chloride (common salt), lime and alum. Addition was in amount of 5% of each, i.e. 5 grams of the chemical were added to 100 grams of the dry sample, and shaken vigorously in an excess of water, in the glass cylinders used for the hydrometer clay determination. The amount of water used was approximately one liter, and when set aside for settlement stood at a depth of 15 inches in the cylinder. The portion containing the salt cleared slowly, but came down practically clear over night. That containing the lime settled in a very few minutes, leaving the water as clear as drinking water. The portion in which powdered alum was used settled almost as quickly as the lime, but did not leave the water quite as clear. This addition of alum developed gas, causing pressure on the rubber stopper with which the mouth of the cylinder was closed, while shaking.

There are other chemicals that might be experimented with, but from this trial it appeared that lime would be the most practical material to use for the purpose. In the quantities that would be required on the work, it would be presumably much lower in cost than alum or of any other chemical that might be used. Therefore, as a follow up, trial was made with lower percentages of the lime alone. One per cent brought settlement in ten minutes, but left the water somewhat cloudy. One half per cent was much slower in action, but brought settlement over night, though with considerable cloudiness left in the water. Smaller fractions of a per cent were practically without effect.

The lime used is rated as a "High Calcium" hydrated lime, "Sierra" brand, product of U.S.Lime Products Corporation of San Francisco, at Sonora, Calif. plant. Another sample of lime, which gave similar results in the one per cent quantity, is listed as a

"Chemical" lime (in distinction from the hydrated product) "Shell" brand, product of Calif. Chemical Corporation of San Francisco, at Newark plant. This latter product is rated as having a fineness of 98.5% through a 325 mesh sieve. The hydrated lime of the other sample is also an extremely fine powder, but leaves a slight residue on the 200 mesh sieve, when washed through.

In distinction from the above rating as a "High Calcium" product, it may be noted that some of the hydrated limes on the market carry considerable quantities of magnesia, in combination with the lime; being produced from impure limestones of a lime-magnesia composition. The American Society for Testing Materials has several specifications on lime and lime products for various purposes, and if it comes to a matter of purchase for use at El Capitan, it would be well to specify the type of lime best suited for the purpose, considering both cost and effectiveness.

J. Y. Jewett

JYJ/b

2-20-35
Copy/m

June 19, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : Borrow Pit Samples; El Capitan Dam; Lakeside Pit.

CITY ENGINEER

Results for gradation have been obtained as shown in the tables below, on samples from new Lakeside Pit; taken June 16, by D.W. Albert and L. H. Hill. Locations from which taken, as reported by the El Capitan office, are also shown in the first of the tables below. Said report lists these as "silt" samples.

Lab. No.	Job. No.	Location	Percentage Sand	Silt	Clay
22682	2834	S.W. end of hogbox	32	50	18
83	35	S.E. " " "	30	50	20
84	36	N.E. " " "	32	50	18
85	37	N.W. " " "	31	63	6
86	38	West end of pit	46	41	13
87	39	1/4 point of pit	54	44	2
88	40	3/4 " " "	37	45	18
89	41	East end of pit	58	28	14

Job. No.	Percentage Passing Sieve No. ¼"	10	20	30	40	50	100	200 (Silt & Clay)
2834				100	99	99	95	68
35			100	99	99	98	94	70
36			100	99	99	98	94	68
37			100	99	98	97	89	69
38			100	99	98	97	85	54
39		100	99	98	97	94	74	46
40			100	99	99	98	87	63
41		100	99	94	89	82	62	42

J. Y. Jewett

JYJ/b
cc-4 encl.

7-24-34
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ENGINEERING OFFICES

J. B. Lippincott

Los Angeles, California

June 20th, 1934.

Messrs. H. W. Rohl & T. E. Connolly,
4351 Alhambra Avenue,
Los Angeles, Calif.

Gentlemen:-

Numerous dams built by the hydraulic fill process have either failed or have experienced trouble during the construction period due to the sliding or sloughing of the toes of the dam from the pressure exerted by the semi-liquid or plastic core material. Notable examples are the Calaveras Dam of a projected height of 210 feet which failed in 1918, the Necaxa Dam #2 of a projected height of 185 feet which failed in 1908, the Linville Dam to be 168 feet in height which failed in 1919 and the Alexander Dam in the Hawaiian Islands, 125 feet ultimate height which failed in 1930.

An analysis has been made to determine the stability of the El Capitan Dam from failure due to this cause during the construction period. A study was made of the section of the dam as contained in the contract drawings and specifications. It is self evident from the drawings that the weakest portion of the dam insofar as stability during construction is concerned, is the upstream half and our analysis has therefore been confined to that part only. The study was also limited to that portion of the upstream toe above elevation 660 which is about 30 feet below the present elevation of water in the summit pool.

Drawing No. 1 shows a section of this portion of the dam with dimensions for each 10 feet increase in elevation. The plans of the dam as shown on the drawings accompanying the specifications show that the puddle core material on the upstream side intersects the outside limits of the dam at about elevation 756. The dam cannot be constructed by hydraulic methods as shown on the plans above this elevation as there is no provision for any material to carry and restrain the horizontal pressure of the core material. Some change in the plan of the dam near the top must be made if it is to be built to the height shown on the specification drawings. In making our analysis we have therefore only determined the weights and loads to be carried to elevation 756.

In making this study three factors must be determined. First, the weight of the materials in the outer flanks of the dam which restrain and confine the semi-liquid puddle core material; second, the "coefficient of friction" of these materials to determine the resistance to sliding, and third, the horizontal pressure exerted by the puddle core.

The first of these factors can be determined within reasonable limits of accuracy. The last two, however, vary through wide limits. No tests or experiments have been made at the El Capitan Dam to determine the "coefficient of friction" of the various materials of which it has been constructed and no tests have been made to determine the lateral pressure exerted by the puddle core material. We must therefore depend upon tests made at other dams or from experiments on similar materials in selecting proper values to use for the last two factors mentioned above.

Pressure of Core Material.

Drawing No. 2 is a diagram showing the lateral and vertical pressure of the core material at dams heretofore constructed by this method where actual determinations were made. In this analysis we are concerned particularly with the lateral or horizontal pressure exerted by the semi-liquid core. Based on the data shown on this drawing we have assumed for the purpose of this study that the lateral pressure of the core material at the El Capitan Dam will be equivalent to the liquid pressure of water weighing 62-1/2 lbs. per cubic foot.

Weight of Stable Materials.

In this analysis we have estimated that the rock embankment on the outside of the dam will weigh 110 lbs. per cubic foot and that the sandy beach material lying between the rock embankment and the puddle core will weigh 110 lbs. per cubic foot. These estimated weights are based upon the specific gravity of the materials used at the El Capitan Dam and the percentage of voids as determined at this location or at dams constructed of similar materials.

Coefficient of Friction.

The pressure exerted by the semi-liquid core material is resisted by the weight of the materials making up the stability section of the dam. In the El Capitan Dam the stability section consists of the sandy beaches adjacent to the core and the rock embankment on the outside. As these materials have little or no bond or cohesion their tendency to slide under lateral pressure depends on their weight and the internal friction of the materials. This resistance to sliding is expressed as the "coefficient of friction". It varies with the size of the particles making up the mass. If the materials making up the stability section of the dam are coarse, the resistance to sliding from lateral pressure of core material will be greater than for a mass having the same weight but finer in texture. The coefficient of friction is computed by dividing the total horizontal pressure that will start movement by the weight of the mass moved lying vertically over the plane of sliding. A coefficient of 0.5 therefore means that material having this coefficient will start to slide when the total lateral pressure is half the total weight of the material overlying the sliding plane.

Table No. 1 attached hereto is a compilation from recognized authorities or from actual tests showing the coefficient of friction of various materials. The values range from 1.0 for large heavy stone to 0 for liquid puddle core. Where no cohesion exists as in a loose rock-fill the coefficient of friction is approximately equal to the tangent of the angle of repose of the material. Based on the angle of repose of the rock forming the rock embankment section of the El Capitan Dam we have assumed a coefficient of friction for this material of 0.85.

The most uncertain factor in this entire study is the selection of the proper value of the coefficient of friction for the beach material. A study of Table No. 1 shows that it might vary through wide limits. The use of such data calls for sound judgment based on broad experience. It is the writer's opinion that for beach material such as that placed in the El Capitan Dam by the semi-hydraulic fill method it would not be safe to assume a value greater than 0.45 in computing the resistance to sliding of the material overlying the beach areas. No resisting strength should be allowed for any material overlying the puddle core area as the coefficient of friction of that material would be practically nil.

Combining the above factors an analysis of the upstream toe of the El Capitan Dam for each 10 feet increase in elevation shows the following "factors of safety", i.e., the ratio of the ultimate resisting strength of the stability section to the total core pressure as a liquid equivalent to water.

Elevation of Sliding Plane	Factor of Safety when completed to elevation 756
660	1.65
670	1.64
680	1.60
690	1.59
700	1.55
710	1.63
720	1.70
730	1.85
740	2.07
750	2.80

The above tabulation indicates the weakest point to be at elevation 700 when the factor of safety would be but 1.55.

The proper factor of safety to obtain in the design of engineering structures depends upon the uncertainties involved in the construction such as the changes in the character of the materials used, control over such materials and the magnitude of the project. Certainly for a dam such as the El Capitan, which when completed will cost nearly $3,000,000 and with all the uncertainties incident to construction by the hydraulic fill process, the factor of safety should be conservative and large. Analyses similar to this which have been made for other dams constructed by this process show factors of safety of 2 or greater; more generally it has been at least 2.5. This study shows that the completion of the El Capitan Dam in accordance with the contract plans by the present methods is certainly a hazardous enterprise and every precaution should be used to prevent failure.

As has been stated, the most uncertain factor in this study is the coefficient of friction of the beach material. In this analysis we have used a value of 0.45. In order to determine the minimum value that could obtain in the beach section of the dam without failure assuming the coefficient of friction of the rock embankment and the lateral pressure of the core as previously estimated, a study has been made with the following results:

Elevation of Sliding Plane	Minimum Value of Coefficient of Friction of beach material to prevent failure
660	0.21
670	0.21
680	0.23
690	0.24
700	0.26
710	0.24
720	0.22
730	0.19
740	0.15
750	0.12

It has been previously stated and Table No. 1 shows that the coefficient of friction varies with the fineness of the material. It is therefore important that the beaches at the El Capitan Dam should be as coarse as is possible to obtain from the materials available and that only those materials should be used which will produce the required amount of puddle core and yield a coarse beach. The methods utilized in the construction should be such as to remove as much of the fine material from the beaches as possible. The proposal to import hydraulic fill material made up almost entirely of fines to be deposited in the dam by running the same through hydraulic equipment over the beach areas should not be permitted. The beaches that would be built of this material would be much finer than those heretofore constructed and would have a much lower coefficient of friction than the values used in this study as indicated by data contained in Table No.1. It is the writer's opinion that if such a program were carried out the structure would be in danger.

The study further demonstrates the advisability of changing the contract plans for that part remaining to be built either by changing to a rolled fill construction or narrowing the puddle core section and topping off at a higher elevation with a rolled fill.

Narrowing the puddle core will permit the use of coarser borrow pit material and will increase the stability due to the greater volume and weight of beach material and the use of coarser material will result in creating beaches having a higher coefficient of friction.

Very truly yours,

EAR:w

Table No. 1
Compiled Data on
Coefficient of Friction of Clay, Sand and Earth
for computing sliding factors of earth dams

Materials	Authority	Coefficient from shearing tests	Angle of internal friction Ø	Coefficient of internal friction Tan Ø	Cohesion lbs. per sq. ft.	Angle of Repose a	Tan a
Very soft puddle clay	1		0°	0°	400		
Soft puddle clay	1		3°	0.05	600		
Moderately firm clay	1		5°	0.09	1000		
Stiff clay	1		7°	0.12	1400		
Very stiff boulder clay	1		16°	0.29	3200		
Dry sand	1			0.70	1.47		
Wet sand	1			0.85	8.28		
Very wet sand	1			1.70	6.36		
Damp fresh earth	1			1.63	18.45		
Dry sand	1					20°-35°	0.38-0.72
Moist sand	1					30°-45°	0.59-0.86
Wet sand	1					20°-40°	0.38-0.86
Ordinary dry earth	1					20°-45°	0.38-1.00
Ordinary moist earth	1					25°-45°	0.48-1.00
Ordinary wet earth	1					25°-30°	0.48-0.59
Gravel round and angular	1					30°-48°	0.59-1.11
Gravel sand and clay	1					20°-37°	0.58-0.77
Soft flowing mud	1					0	0
Soft rotten rock	1					37°	0.75
Hard rotten rock	1					45°	1.00
Rip rap	1					45°	1.00
Wet puddle clay	2		0°-2½°	0.04	400-900		
Stiff puddle clay	2		2°	0.035	1200		
Wet sandy clay	2		2½°	0.04	1200		
Stiff sandy clay	2		10°	0.18	1000		
Moderately firm boulder clay	2		6½°	0.11	1400		
Very stiff boulder clay fairly dry	2		16°	0.29	3800		
Clean sand	3&2					33°-41'	0.67
Sand and clay	3&2					36°-53'	0.75
Dry clay	3&2					29 -44	0.57
Damp plastic clay	3&2					18°-24'	0.33
Clean gravel	3&2					36°-53'	0.75
Gravel and clay	3&2					36°-53'	0.75
Gravel sand and clay	3&2					36°-53'	0.75
Soil	3&2					33°-41'	0.67

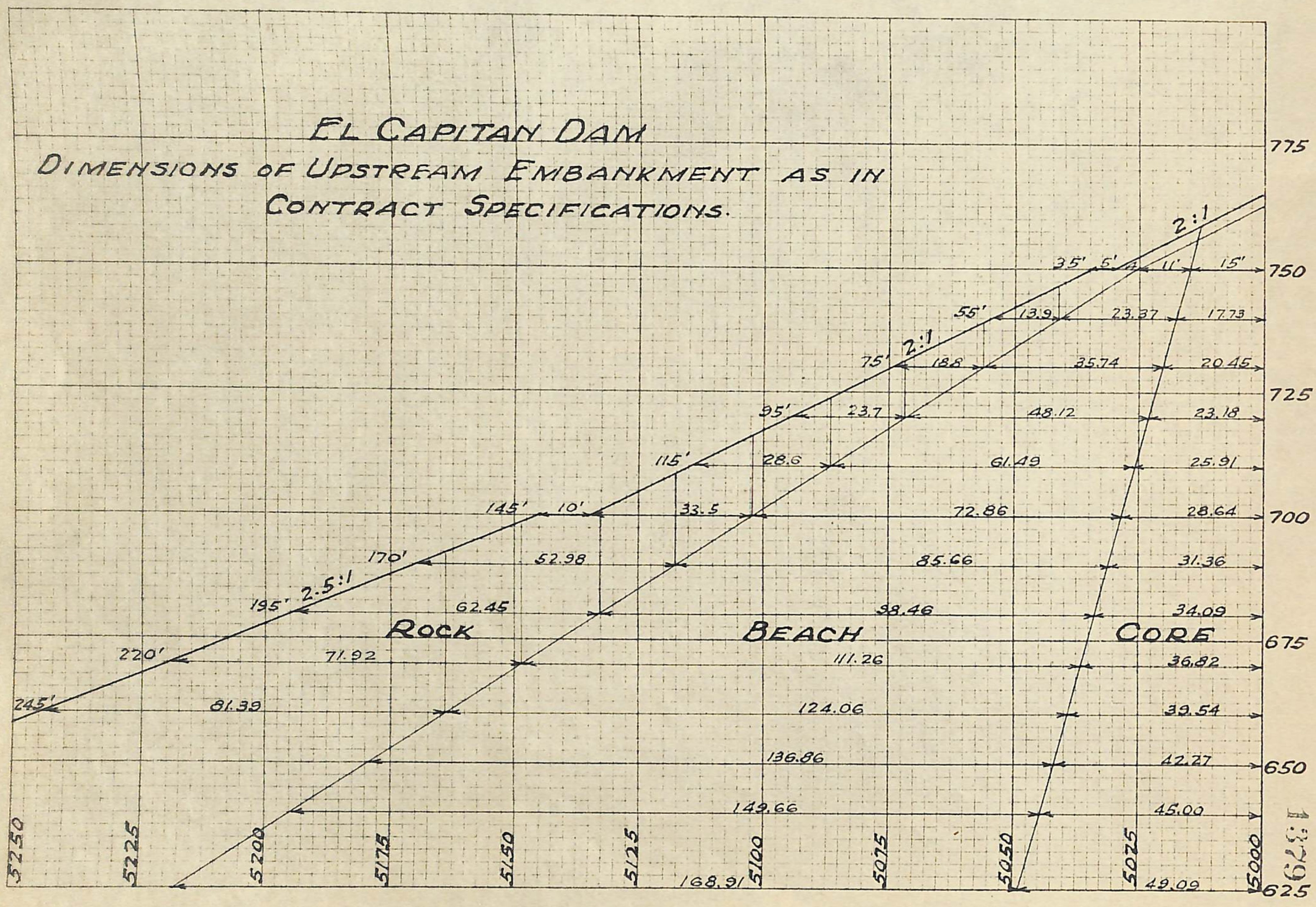
Materials	Authority	Coefficient from shearing tests	Angle of internal friction ϕ	Coefficient of internal friction Tan ϕ	Cohesion lbs. per sq. ft.	Angle of Repose a	Tan a
Soft rotten rock	3&2					36°-53'	0.75
Hard rotten rock	3&2					45°	1.00
Sand below core wall Tieton Dam	4	0.51					
Sand and gravel core wall Tieton Dam	4	0.60					
Beach material from San Pablo Dam, moist Orindian Blue Shale	5	0.45-					
Monterey brown shale	5	0.49-					
Worn brown shale, sand & small stones from dam	5	0.54					
Note: Above results are average values with vertical pressure corresponding to more than 100' depth of fill.							
Colloidal mud	6	.23-.28					
Fat clay	6	.25-.40					
Sandy clay	6	.40-.50					
Friction tests at Cobble Mt. Dam, see accompanying diagram "f" below tests of moist material under vertical load of 100# per sq. in.							
Crushed trap rock	7	0.97					
Cobble mountain dam beach material	7	0.78					
Coarse bank sand	7	0.68					
Ottawa sand	7	0.54					
50%-3/4" to 1-1/4 stone screened from bank gravel & 50% coarse bank sand	7	0.86					
40%-3/4" to 1 1/4 stone screened from bank gravel & 60% coarse bank sand	7	0.74					
3/4" to 1 1/4" stones screened from bank gravel	7	0.88					
1/4" to 3/8" stones screened from bank gravel	7	0.74					
White clay, fine grained wet	8			0.40			
do	8			0.42			
do	8			0.28			
do	8			0.25			
do	8			0.34			
			average	0.34			
White clay, fine grained moist	8			0.47			
do	8			0.45			
do	8			0.42			
do	8			0.35			
do	8			0.39			
			average	[illegible]			

40 1/3

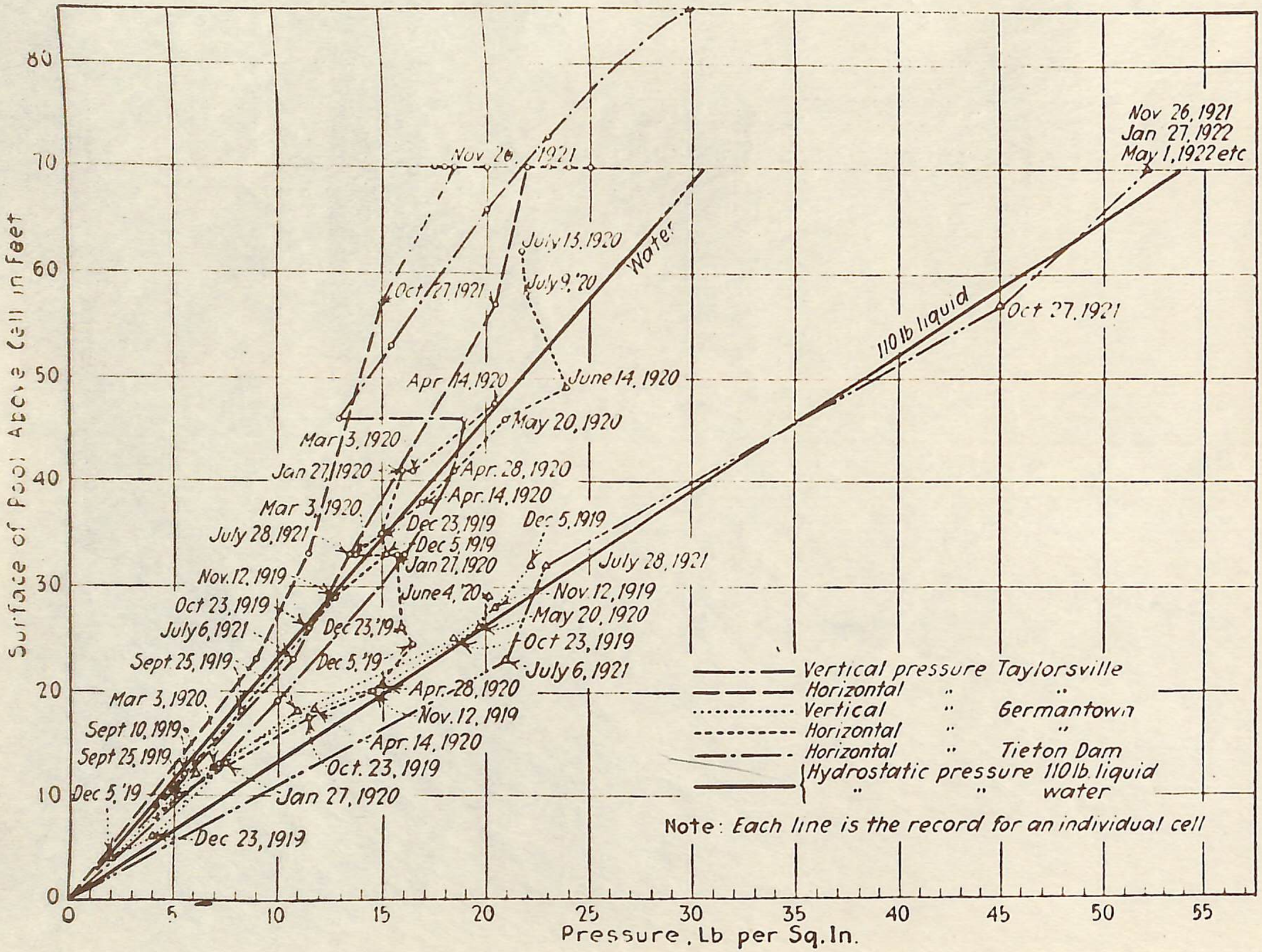
Materials	Authority	Coefficient from shearing tests	Angle of internal friction ϕ	Coefficient of internal friction Tan ϕ	Cohesion lbs.per sq.ft.	Angle of Repose a	Tan a
Yellow clay, containing some grit fairly wet	8			0.80			
	8			0.80			
	8			0.71			
	8			0.76			
	8			0.58			
	8			0.52			
	8			0.48			
	8			0.77			
	8			0.71			
	8			0.71			
			Average	0.68			
Black gumbo moist	8			0.77			
" " "	8			0.86			
			"	0.82			
Black gumbo wet	8			0.50			
" " "	8			0.89			
" " "	8			0.73			
			"	0.71			
Black loam moist	8			0.77			
" " "	8			0.67			
" " "	8			0.79			
			"	0.74			
Black loam wet	8			0.67			
" " "	8			0.78			
			"	0.72			
Yellow clay moist	8			0.84			
" " "	8			0.84			
" " "	8			0.81			
			"	0.83			
Yellow clay very wet	8			0.53			
" " "	8			0.47			
			"	0.50			

(1) Cain's, "Earth Pressure, Walls & Bins" - 1916
(2) "American Civil Engineers Hand Book"-Merriman & Wiggin-1930
(3) "Kidder's Architects' and Builders' Pocket Book"-1916 (4) Engineering News Record Vol.97 p.547
(5) Hazen-Trans.A.S.C.E.-Vol.LXXXIII (6) Experiments by Dr.Chas.Terzaghi-Engineering News-Record Vol.95 page 1026-Dec.24, 1925. (7) Proceedings A.S.C.E.-Vol.58 Number 8.
(8) "Results of Tests of Frictional Resistance of Foundation Soil at Stnme River Dam Site" Scheidenhelm in Trans. A.S.C.E. Vol. 81 page 950.

Drawing No. 1


EL CAPITAN DAM
DIMENSIONS OF UPSTREAM EMBANKMENT AS IN CONTRACT SPECIFICATIONS.
ROCK
BEACH
CORE
2:1
2:1
2.5:1
775
750
725
700
675
650
625
5250
5225
5200
5175
5150
5125
5100
5075
5050
5025
5000
3.5'
5'
4
11'
15'
55'
13.9
23.37
17.73
75'
18.8
35.74
20.45
95'
23.7
48.12
23.18
115'
28.6
61.49
25.91
145'
10'
33.5
72.86
28.64
170'
52.98
85.66
31.36
195'
62.45
98.46
34.09
220'
71.92
111.26
36.82
245'
81.39
124.06
39.54
136.86
42.27
149.66
45.00
168.91
49.09

Drawing No. 2



Recorded pressures in hydraulic-fill dam cores

Reproduced from Fig. 1 of an article on the core material at Germantown dam, published in *ENR*, Dec. 18, 1930, p. 954.

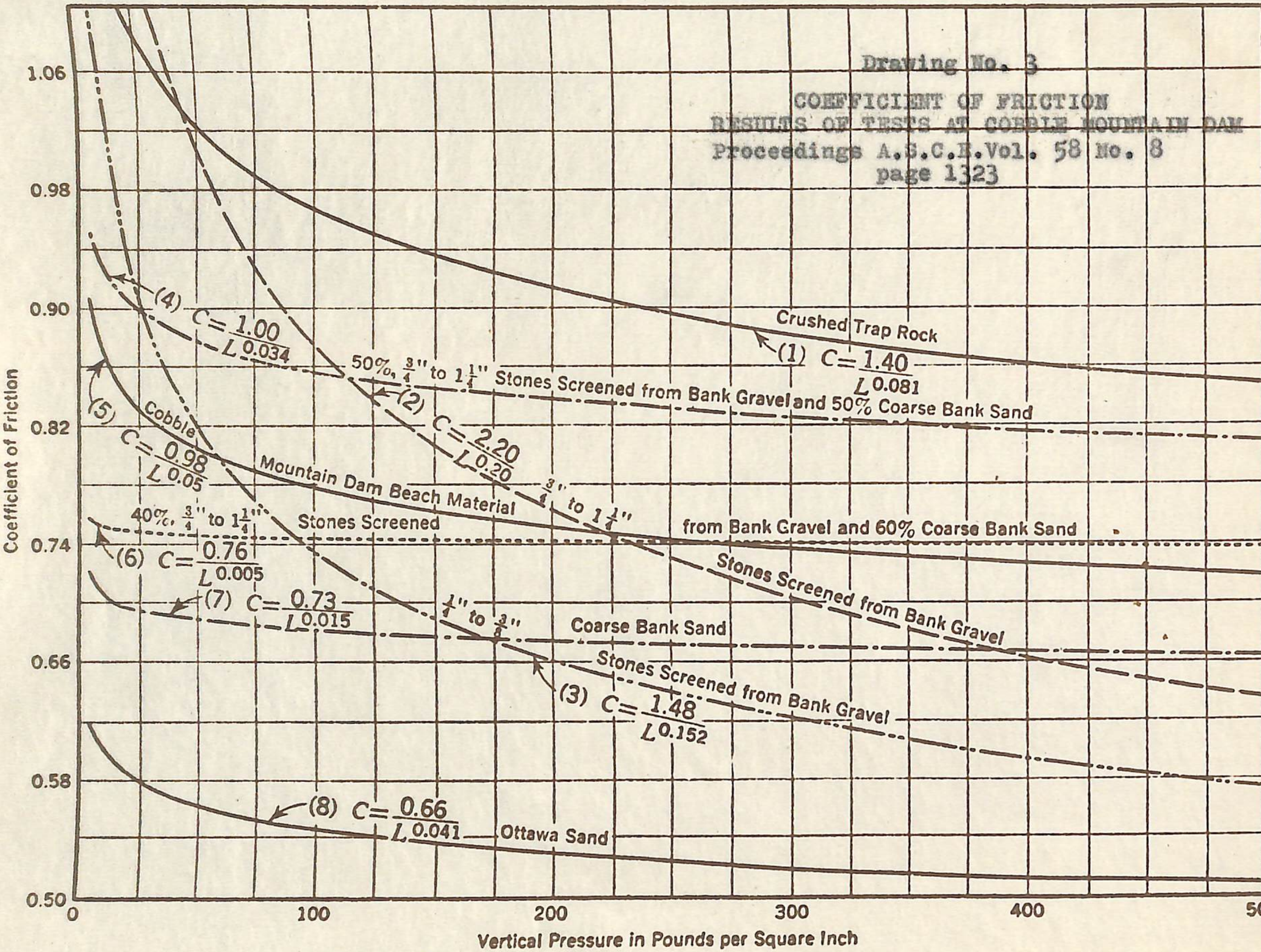
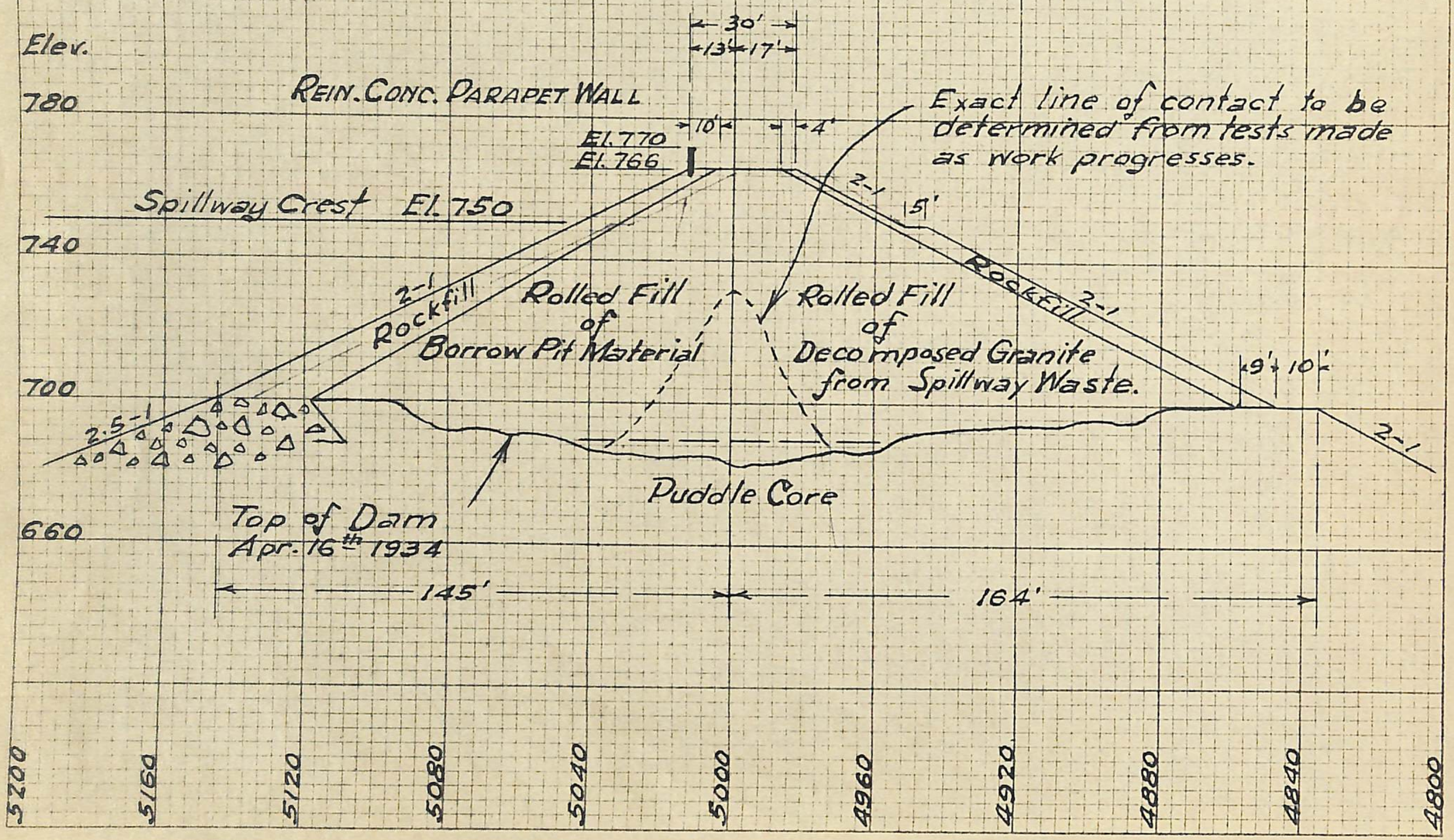


FIG. 10.—COEFFICIENT-OF-FRICTION CURVES FOR VARIOUS MATERIALS.

El Capitan Dam

Section Showing

Suggested Method of Completing Dam Above Present Elev.



8/6/34
copy /f

July 14, 1934

Messrs. H. W. Rohl & T. E. Connolly S-117
Contractors El Capitan Dam
4351 Alhambra Avenue
Los Angeles, California.

Subject: San Diego River Project, El Capitan Feature, Hydraulic Fill, Settlement of Suspended Matter by Chemical Action.

Gentlemen:

Enclosed for your information is copy of report dated June 18, 1934 of a few trials made by City Testing Engineer J. Y. Jewett to determine the effect of certain chemicals on settlement of suspended matter, especially that originating in your Lakeside borrow pit and being placed in the El Capitan reservoir dam.

Very truly yours,

Fred D. Pyle
Hydraulic Engineer.

FDP/f
Encl.

2-19-35
copy/p

7-27-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Core samples, El Capitan Dam

Twenty-two samples from puddle core, El Capitan Dam, taken July 25, by D. W. Albert, G. W. Converse, W. H. Simpson, and L. H. Hill were received at the laboratory on the 26th. Locations from which taken, as furnished by the El Capitan office are shown in the following table, with elevation of water surface given as 709.5. Gradation percentages, as obtained in the laboratory, are shown in the table; with detailed gradings of the sand portions in separate table beyond.

Lab. No.	Job No.	Elevation sample		Depth water	Coordinates N	Coordinates E	Percentages of Sand	Silt	Clay
22922	2970	697.5	691.5	7.0	3900	4985	35	57	8
23	71	697	691.5	9.0	3900	5015	48	34	18
24	72	696.5	691.5	7.0	3800	4985	54	39	7
25	73	696.5	691.5	6.0	3800	5015	39	57	4
26	74	695.5	691.5	6.0	3700	5015	26	62	12
27	75	696.5	692.5	5.5	3700	4985	57	38	5
28	76	699	691.5	7.5	3700	5000	34	62	4
29	77	695.5	691.5	6.0	3600	4985	54	39	7
22930	78	695.5	691.5	8.5	3600	5015	17	73	10
31	79	695.5	691.5	6.0	3500	5015	13	69	18
32	2980	697.5	693.5	7.0	3500	4985	38	55	7
33	81	693.5	691.5	9.5	3400	4985	70	27	3
34	82	695.5	691.5	8.0	3400	5000	11	78	11
35	83	695.5	691.5	6.5	3400	5015	48	32	20
36	84	695.5	693.0	8.0	3300	5015	66	30	4
37	85	695.5	691.5	7.0	3300	5000	55	39	6
38	86	695.5	691.5	7.5	3300	4985	48	48	4
39	87	695.5	691.5	10.0	3200	4985	26	64	10
22940	88	696.0	692.0	6.5	3200	5015	65	31	4
41	89	693.5	691.5	7.0	3200	5000	59	38	3
42	2990	700.5	698.5	7.0	3200	5000	4	63	33
43	91	702.5	700.5	7.0	3200	5000	9	71	20

Detailed gradings of sand portion

Job No.	Percentages passing sieve No. 1/4"	10	20	30	40	50	100	200(silt and clay)
2970	100	99	98	95	92	87	76	65
71	100	99	98	93	88	82	67	52
72	100	99	97	92	88	82	66	46
73			100	99	97	93	79	61
74					100	99	93	74
75		100	99	97	93	86	66	43
76		100	99	98	97	94	84	66
77	100	99	98	93	88	81	63	46
78				100	99	99	96	93
79				100	99	99	97	87
2980			100	99	98	96	85	62
81	100	98	93	82	74	64	45	30
82	100	99	99	99	99	98	96	89
83	100	99	97	92	86	80	68	52
84	100	99	96	89	83	73	52	34
85		100	98	93	87	79	60	45
86			100	99	98	95	77	52
87			100	99	98	97	91	74
88	100	98	96	89	82	72	52	35
89	100	98	94	88	82	75	59	41
2990						100	99	96
91					100	99	98	91

Samples 2990 and 91 are noted on El Capitan location sheet as taken at special request of F. D. Pyle.

J. Y. Jewett
Testing Engineer

JYJ/p

2-19-35
copy/p

8-3-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Puddle core samples, El Capitan Dam

Twenty three samples from puddle core, El Capitan Dam, taken July 30 by D. W. Albert, G. W. Converse, M. D. Elliott and L. H. Hill were received at the laboratory on the 31st. Locations from which taken, as furnished by the El Capitan office, are shown in the following table, with elevation of water surface given as 711. Gradation percentages, as obtained in the laboratory, are shown in the table, and also percentage of moisture content, as requested in your letter of July 28. Detailed gradings of the sand portions are shown in separate table beyond.

Lab.	Job	Elevation		Depth	Coordinates		Moisture	Percentage		
No.	No.	sample		water	N	E	percent	Sand	Silt	Clay
22966	3010	701.5	693	9.0	3150	4985	15.6	57	36	7
67	11	697	693	10.0	3150	5000	23.8	56	35	9
68	12	700	696	7.0	3150	5015	18.2	55	30	15
69	13	697	693	7.0	3250	5015	30.8	21	60	19
22970	14	697	693	7.0	3250	4985	21.4	55	35	10
71	15	700	696	8.0	3350	4985	15.4	74	15	11
72	16	697	693	8.5	3350	5000	32.0	24	53	23
73	17	697	693	5.0	3350	5015	21.2	54	34	12
74	18	697	693	7.5	3450	5015	33.3	17	54	29
75	19	702	694	6.0	3450	4985	23.4	46	49	5
76	3020	701.5	694.5	3.0	3550	4985	17.1	58	32	10
77	21	697	693	4.0	3550	5015	28.6	29	37	34
78	22	698	694	9.0	3650	5015	19.1	70	24	6
79	23	699	695	5.0	3650	4985	25.0	44	30	26
22980	24	697.5	693.5	6.5	3750	4985	26.9	46	39	15
81	25	697.5	693.5	7.0	3750	5015	20.0	66	28	6
82	26	697.5	693.5	6.0	3750	5000	29.2	36	52	12
83	27	697	693	9.5	3850	5015	26.1	38	49	13
84	28	702	698	4.0	3850	4985	19.4	64	31	5
85	29	698	694	4.0	3850	4985	27.3	39	54	7
86	3030	697	693	9.0	3950	5015	1[illegible].7	74	20	6
87	31	697	693	8.5	3950	5000	16.7	61	33	6
88	32	697	693	6.5	3950	4985	22.2	46	46	8

Detailed gradings of sand portion

Job No.	Percentages passing sieve No. 1/4	10	20	30	40	50	100	200 (silt and clay)
3010	100	98	94	86	80	72	58	43
11			100	99	98	93	72	44
12	100	99	98	93	89	83	61	45
13					100	99	95	79
14		100	98	94	90	85	68	45
15	100	99	95	87	80	70	41	26
16					100	98	92	76
17		100	98	94	90	84	65	46
18					100	99	96	83
19		100	98	96	94	92	78	54
30 20		100	99	97	95	91	64	42
21					100	99	92	71
22	100	99	96	88	80	70	44	30
23					100	98	85	56
24			100	96	94	90	77	54
25	100	97	93	85	79	71	50	34
26	100	99	98	97	96	94	76	64
27			100	99	98	96	83	62
28	100	98	93	86	79	70	50	36
29				100	97	93	80	61
3030	100	97	90	78	69	59	36	26
31	100	99	98	97	91	82	49	39
32	100	99	98	96	94	90	74	54

J. Y. Jewett

JYJ/p

2-19-35
copy/p

8-13-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Puddle core samples; El Capitan Dam

Twenty-four samples from puddle core, El Capitan Dam, taken August 9 by D. W. Albert, G. W. Converse, F. Osborne and L. H. Hill, were received at the laboratory at noon of the 10th. Locations from which taken, as furnished by the El Capitan office, are shown in the following table; with elevation of water surface given as 716.5. Moisture percentage and gradation percentages, as obtained in the laboratory, are shown in the table, with detailed gradings of the sand portions in separate table beyond.

Lab. No.	Job No.	Elevation sample		Depth water	Coordinates N	Coordinates E	Percentage of Moisture	Sand	Silt	Clay
23012	3041	703.5	699.5	5.0	3900	4985	31.8	37	60	3
13	42	700.5	698.5	5.0	3900	5015	25.0	67	30	3
14	43	702.5	698.5	6.0	3900	5000	25.0	35	62	3
15	44	702.5	698.5	4.5	3800	4985	23.8	34	58	8
16	45	702.5	700.0	5.0	3800	5015	16.7	60	35	5
17	46	702.5	698.5	4.0	3700	5015	19.3	60	28	12
18	47	699.5	695.0	10.5	3700	6000	22.2	47	50	3
19	48	707.5	700.5	3.5	3700	4985	18.6	45	51	4
23020	49	706.5	699.5	3.5	3600	4985	25.0	63	29	8
21	3050	702.5	698.5	6.5	3600	5000	22.2	60	38	2
22	51	702.5	699.5	5.0	3600	5015	16.7	63	34	3
23	52	702.5	698.5	5.5	3500	5015	31.5	29	55	16
24	53	706.5	698.5	4.0	3500	4985	32.2	46	52	2
25	54	706.5	698.5	3.0	3400	4985	18.2	57	34	9
36	55	701.5	698.5	5.5	3400	5000	20.8	50	33	17
27	56	702.5	698.5	4.5	3400	5015	25.0	59	32	9
28	57	702.5	698.5	3.0	3300	5015	21.4	53	45	2
29	58	702.5	698.5	3.0	3300	4985	26.6	45	52	3
23030	59	702.5	701.0	6.5	3200	4985x	18.2	46	51	3
31	3060	704.5	701.5	5.5	3200	5000xx	26.7	36	63	1
32	61	702.5	698.5	6.0	3200	5015xxx	18.2	76	20	4
33	62	706.5	702.5	6.0	3100	5015	18.8	58	32	10
34	63	706.5	702.5	7.0	3100	5000	19.2	56	40	4
35	64	706.5	703.5	4.0	3100	4985	25.0	55	40	5

x Impenetrable below 701.0

xx " " 701.5

xxx " " 698.5

2-19-35
copy/p

Detailed grading of sand portion

Job	Percentages passing sieve No.							
No.	1/4	10	20	30	40	50	100	200(silt and clay)
3041		100	99	98	95	90	78	63
42	100	95	87	76	70	62	47	33
43			100	97	94	90	78	65
44			100	99	98	97	81	66
45	100	98	91	81	75	68	54	40
46	100	99	96	90	84	75	55	40
47			100	97	94	89	72	53
48				100	99	97	79	55
49	100	98	96	85	77	69	54	37
3050		100	98	93	88	80	59	40
51			100	97	94	88	66	37
52				100	99	98	92	71
53			100	96	93	88	74	54
54	100	98	96	91	87	82	65	43
55		100	99	95	91	85	69	50
56	100	99	96	89	83	76	57	41
57			100	94	90	84	67	47
58	100	99	98	94	91	87	73	55
59			100	96	92	87	74	54
3060				100	96	93	83	64
61	100	99	95	82	73	63	39	24
62	100	98	95	89	84	78	61	42
63			100	95	91	83	55	44
64			100	94	92	87	70	45

A noticeable feature of the above results lies in the relatively low clay percentages and relatively high silt percentages as compared with recent previous series; but without any marked difference in the average sum total of the two. When taken together, this serves to maintain the general average of approximately 50 per cent sand content, and 50 per cent sum of silt and clay, which is being aimed at as a suitable combination for the core material.

J. Y. Jewett
Testing Engineer

JYJ/p

2-19-35
copy/P

August 27, 1934

From : Hydraulic Engineer

To : Resident Engineer

Subject : San Diego River Project, El Capitan Feature
Hydraulic fill, puddle core tests

Samples for determining the moisture content and gradation analysis of the puddle core material of the hydraulic fill section of the El Capitan Dam should be furnished the City Testing Engineer from time to time.

The samples should be taken from four sections about equally spaced across the dam, and from five locations on each section, that is, on the axis of the dam, 10 feet each side and 20 feet each side, and at such elevations as the Hydraulic Fill Engineer deems proper.

Fred D. Pyle
Hydraulic Engineer

FDP/f
cc-City Testing Engineer

2-19-35
copy/p

August 30, 1934

Testing Engineer

Hydraulic Engineer

Samples from puddle core pool; El Capitan Dam.

These samples were taken on August 17 by D. W. Albert and L. H. Hill, and were delivered at the laboratory on the 25th.

The samples, as shown by the listing in the table below, were taken near the surface of the pool and the material, as per your note on El Capitan listing sheet, is known as "slimes". The table shows moisture content, and gradation, as determined in the laboratory, with detailed grading of sand portion on attached report form.

Lab. No.	Job No.	Elevation Water Surface	Elevation Sample	Coordinate North	Per cent moisture	Gradation Percentages Sand	Silt	Clay
23072	3071	718	718	3200	43.6	17	75	8
73	72	718	716.5	3200	40.4	12	84	4
74	73	718	718	3800	50.0	19	74	7
75	74	718	716.5	3800	34.5	31	64	5

The unexpected and surprising feature of the above results is the low clay and high silt content in the solid portion. Separation and settlement of the silt, in the hydrometer cylinder, was clear cut and evident on observation during the period in which the clay reading was under determination. The appearance of the material, which suggests the use of the term "slimes" as descriptive, is probably due to the mica content, in combination with the fine silty particles which predominate. A similar appearance in which the mica particles are plainly visible, is shown on the mesh of the No. 200 sieve through which the water from the hydrometer cylinder is passed, when removing the sand portion for drying.

Detailed grading of sand portion

Job No.	Percentage passing sieve No. 40	50	100	200 (silt & clay)
3071	100	99	97	83
72	100	99	96	88
73	100	99	92	95
74	100	99	95	69

J. Y. Jewett
Testing Engineer

JYJ/b

2-19-35
copy/p

9-1-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Puddle core samples, El Capitan Dam

Twenty samples from puddle core, El Capitan Dam, taken August 29 by Messrs. Albert, Von Seggern, Osborne, Remmen and Converse, were received at the laboratory on the morning of the 31st.

Locations from which taken, as furnished by the El Capitan office are shown in the following table, with elevation of water surface given as 724. Moisture percentage and gradation percentages, as obtained in the laboratory, are shown in the table, with detailed gradings of the sand portion in separate table beyond.

Lab. No.	Job No.	Elevation sample		Depth water	Coordinates N	E	Per cent moisture	Gradation Sand	Silt	Clay
23090	3097	722	716	0	3200	4986	17.0	67	30	3
91	98	722	718	1	3200	4990	40	13	68	19
92	99	722	718	1.5	3200	5000	43.6	12	48	40
93	3100	716	712	2	3200	5010	16.3	24	73	3
94	1	722	716	0	3200	5017	28.1	32	64	4
95	2	722	716	0	3400	4986	17.6	64	32	4
96	3	721	717	1	3400	4990	37	14	76	10
97	4	721	717	2	3400	5000	40.8	19	71	10
98	5	714	710	2	3400	6010	20	22	69	9
99	6	722	716	0	3400	5017	16.7	63	35	2
23100	7	722	716	0	3600	4986	19.2	66	31	3
1	8	720	716	1	3600	4990	17.9	54	43	3
2	9	720	716	2	3600	5000	43.7	18	73	9
3	3110	716	712	2	3600	5010	(x)	62	34	4
4	11	722	716	0	3600	5017	17.5	58	40	2
5	12	722	716	0	3800	4986	17.3	52	43	5
6	13	715	711	1	3800	4990	32.7	21	73	6
7	14	714	710	2	3800	5000	35.7	17	70	13
8	15	716	712	2	3800	5010	34.6	14	76	10
9	16	722	716	0	3800	5017	16	52	44	4

(x) Sample jar broken - water had escaped.

Predomina ting feature of the gradation percentages, as in the case of the last previous series, report of August 13, is in the high silt percentage, relative to that of the clay content which, taken in combination with the latter, serves to maintain the desired percentage of fines, whereas if dependence were placed on the clay content alone, this would run short

Detailed gradings of sand portion

Job No.	1/4"	10	20	30	40	50	100	200 (silt and clay)
	Percentages passing sieve No.							
3097	100	99	94	83	75	66	49	33
98				100	99	99	96	87
99						100	97	88
3100			100	99	98	97	92	76
1		100	98	97	96	94	86	68
2	100	99	96	86	79	70	52	36
3				100	99	99	96	86
4					100	99	96	81
5				100	99	98	94	78
6	100	99	96	87	80	72	55	37
7	100	99	96	86	77	68	49	34
8		100	98	94	90	85	69	46
9			100	99	98	98	93	82
3110	100	99	96	87	80	72	54	38
11	100	99	97	92	87	80	62	42
12	100	99	96	90	85	79	66	48
13	100	98	97	96	95	94	90	79
14				100	99	99	95	83
15					100	99	96	86
16	100	99	96	90	85	78	63	48

J. Y. Jewett
Testing Engineer

JYJ/p

2-18-35
copy/p

9-11-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Core samples; El Capitan Dam; Well No. 1

Nine samples from Well No. 1, puddle core, El Capitan Dam are reported by El Capitan office as taken September 8 (Job Nos. 3110-15, elevation of water surface 732) and September 9 (Job Nos. 3116-18, elevation of water surface 733) by H. L. Harper and reported by L. H. Hill. Location of well is listed as co-ordinate N 3160 E 5008. Elevation of sample is shown in the table below with results for moisture percentage and gradation analysis as obtained in the laboratory. Detailed grading of the sand portion is shown in separate table beyond.

Lab. No.	Job No.	Elevation sample	Per cent moisture	Gradation percentage sand	silt	clay
23142	3110	720	32.1	53	43	4
43	11	708	32.0	18	70	12
44	12	706	25.4	28	44	28
45	13	702	26.2	18	63	19
46	14	700	23.3	35	54	11
47	15	698	19.7	50	31	19
48	16	697	30.1	37	56	7
49	17	695	20.0	53	32	15
23150	18	693	25.4	25	45	30

	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	x200(silt & clay)
3110	100	99	95	89	84	78	63	47
11			100	99	98	97	92	82
12			100	99	98	97	87	72
13			100	99	98	97	93	82
14		100	99	97	94	90	79	65
15	100	99	97	92	86	78	63	50
16			100	99	98	95	83	63
17	100	99	96	91	88	83	68	47
18				100	99	98	93	75

x Sum of silt and clay

J. Y. Jewett

JYJ/p

2-18-35
copy/p

9-13-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Core samples; El Capitan Dam; Well No. 2

Nine samples from puddle core, El Capitan Dam, Well No. 2, were taken on September 11. Report from El Capitan office shows location of this well at coordinates N 3700 E 5000, elevation of water surface 735; elevation of sample as shown in table below. Well casing found crystalized and broke when last samples taken. 8 feet of water in well following morning. Well abandoned and new well undertaken. Results for moisture percentage, and gradation of solids, as obtained in the laboratory, are shown in the table; with detailed grading of the sand portion in separate table beyond.

Lab. No.	Job No.	Elevation sample	Per cent moisture	Gradation percentage Sand	Silt	Clay
23152	3128	727.0	20.6	54	29	17
53	29	722.6	22.2	54	41	5
54	3130	720.0	24.5	38	61	1
55	31	717.0	16.7	49	29	22
56	32	715.0	31.2	35	41	24
57	33	714.0	11.1	49	44	7
58	34	712.5	15.4	56	41	3
59	35	710.0	26.2	28	69	3
23160	36	707.5	31.1	14	66	20

The following note appears on El Capitan report sheet:

"Well casing fractured at El. 705, admitting moisture from higher levels and contaminating further samples. This well was therefore abandoned at Sample No. 3136-El. 707.5, and additional samples will be furnished from another test well to be sunk alongside of Well No. 2."

Sand Grading

Job No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200 (silt and clay)
3128	100	99	96	89	84	77	62	46
29		100	99	95	91	85	68	46
3130	100	99	98	98	97	95	81	62
31	100	99	97	92	88	83	71	51
32	100	99	98	96	95	92	84	65
33	100	99	96	89	84	78	65	51
34	100	99	96	88	81	73	57	44
35	100	99	99	99	98	97	91	72
36					100	98	96	86

JYJ/p

J. Y. Jewett

2-18-35
copy/p

9-15-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Core samples; El Capitan Dam; Well No. 2-A

These samples are reported as taken September 13 from Test Well No. 2-A, supplementing Well No. 2, which was lost at elevation 705; and as located at the same coordinates N3700 E5000. Elevation of water surface is given as 736.5; and elevation of sample as shown in the table below. Results for moisture percentage, and gradation of solids, as obtained in the laboratory are shown in the table with detailed grading of the sand portion in separate table beyond.

Lab. No.	Job No.	Elevation sample	Per cent moisture	Gradation percentage Sand	Silt	Clay
23164	3139	724.0	27.8	40	54	6
65	40	721.5	24.1	42	54	4
66	41	719.5	20.0	44	53	3
67	42	717.0	20.5	48	33	19
68	43	714.5	18.2	48	42	10
69	44	712.0	22.2	48	49	3
23170	45	709.5	27.4	23	71	6
71	46	707.0	28.8	23	68	9
72	47	704.5	25.8	18	69	13
73	48	702.0	22.8	28	51	11
74	49	699.5	19.6	47	46	7
75	3150	697.0	24.0	15	67	18

Sand Grading	Percentages passing sieve No. 1/4"	10	20	30	40	50	100	200(silt & clay)
3139		100	99	98	96	93	80	60
40		100	99	97	95	92	78	58
41		100	99	96	92	86	73	56
42			100	99	98	96	88	75
43	100	99	96	90	85	78	64	52
44			100	98	96	91	74	52
45		100	99	98	98	97	92	77
46					100	99	94	77
47					100	99	96	82
48					100	99	92	72
49	100	99	98	93	89	84	71	53
3150			100	99	99	99	96	85

Well 2-A was 1.25 feet from Well 2 at the surface. The following comparison has been made of the percentage of moisture and the gradation analysis for the two wells.

Well No.	Job No.	Elevation sample	Per cent moisture	Gradation percentage Sand	Silt	Clay
2	3130	720.0	24.5	38	61	1
2-A	3141	719.5	20.0	44	53	3
2	3131	717.0	16.7	49	29	22
2-A	3142	717.0	20.5	48	33	19
2	3132	715.0	31.2	35	41	24
2-A	3143	714.5	18.2	48	42	10
2	3133	714.0	11.1	49	44	7
2	3134	712.5	15.4	56	41	3
2-A	3144	712.0	22.2	48	49	3
2	3135	710.0	26.2	28	69	3
2-A	3145	709.5	27.4	23	71	6
2	3136	707.5	31.1	14	66	20
2-A	3146	707.0	28.8	23	68	9
2 average (7)			21.5	39	50	11
2-A " (6)			23.7	39	53	8

J. Y. Jewett

JYJ/p

2-18-35
copy/p

9-18-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Core samples; El Capitan Dam; Test Wells Nos. 3 & 4

Report from El Capitan office shows samples from these wells taken September 14-16. Location of No.3 is given as coordinates N 3500 E 5017; of No. 4 N 3500 E 5025. Elevation of water surface is given as follows: Sample Nos. 3171-85, 737.5; 3186-90, 738.5; 3191-3203 739.5; 3186-90, 742.0 elev. flank; 3191-3203, 743.0 elev. flank.

Elevation of sample is shown in the following table together with moisture and gradation percentages as obtained in the laboratory, and with detailed sand grading in separate table beyond.

Lab. No.	Job No.	Elevation sample	Per cent moisture	Gradation percentage Sand	Silt	Clay
			Well No. 3			
23177	3171	737.5	11.5	58	29	13
78	72	735.0	15.1	62	33	5
79	73	732.5	7.3	59	37	4
23180	74	730.0	12.2	57	28	15
81	75	727.5	15.6	58	37	5
82	76	725.0	10.7	63	31	6
83	77	722.5(x)	11.7	61	35	4
84	78	720.0	10.0	57	38	5
85	79	717.5	9.1	59	35	6
86	3180	716.0	14.0	58	37	5
87	81	715.0	18.8	58	36	6
88	82	714.0	18.4	67	29	4
89	83	712.5(xx)	20.3	62	33	5
23190	84	710.0	22.6	39	53	8
91	85	708.0	20.4	30	65	5
			Well No. 4			
92	86	737.0	10.5	62	26	12
93	87	734.5	6.3	72	24	4
94	88	732.0	11.1	61	32	7
95	89	729.5	5.9	65	30	5
96	3190	727.0	11.5	63	33	4
97	91	724.5	14.3	65	31	4
98	92	722.0	10.4	63	33	4
99	93	719.5	11.5	76	20	4
23200	94	717.0	6.1	64	32	4
1	95	714.5	17.6	80	16	4
2	96	712.0	21.6	40	45	15
3	97	709.5	21.9	62	34	4
4	98	707.5	17.9	36	57	7
5	99	706.0	21.0	45	51	4
6	3200	702.5	26.0	28	58	14
7	1	700.0	20.0	40	48	12
8	2	697.5	28.8	24	63	13
9	3	695.0	25.4	32	58	10

Sand Grading

Job No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200 (silt and clay)
				Well No. 3				
3171		100	98	90	83	75	57	42
72	100	99	94	85	77	70	53	38
73	100	98	96	90	84	76	58	41
74	100	99	97	90	84	76	59	43
75	100	99	97	91	85	77	59	42
76	100	99	96	87	80	71	53	37
77	100	99	96	88	81	73	55	39
78	100	99	95	86	80	73	58	43
79	100	99	96	87	81	73	57	41
3180		100	98	91	85	77	60	42
81		100	97	91	85	77	60	42
82	100	99	94	83	74	65	48	33
83	100	95	87	79	74	68	53	38
84			100	99	98	97	86	61
85			100	99	99	97	90	70
				Well No. 4				
86	100	98	94	86	78	69	52	38
87	100	96	88	77	70	61	48	28
88		100	97	89	82	74	56	39
89	100	99	94	84	76	68	55	35
3190	100	99	95	87	80	71	53	37
91	100	97	94	85	76	68	50	35
92	100	98	93	83	76	68	51	37
93	100	99	95	84	76	65	44	24
94	100	99	96	87	80	70	52	36
95	100	96	88	77	69	60	41	20
96	100	98	97	96	95	94	81	60
97	100	99	98	96	93	86	61	38
98					100	98	86	64
99		100	99	98	97	92	71	55
3200	100	99	98	98	97	95	88	72
1		100	99	97	94	90	78	60
2				100	98	97	92	76
3		100	99	97	96	91	80	68

(x) Samples 3171 to 3177 inclusive taken with post hole auger in uncased hole. Samples 3178 to 3185 inclusive taken with sand pump in cased hole.

(xx) Due to sudden increase of moisture in sample 3183, casing was examined and found to be admitting no seepage from any point above elevation of sample which was at bottom of casing.

J. Y. Jewett

JYJ/p

2-18-35
copy/p

9-18-34

From : Testing Engineer
To : Hydraulic Engineer
Subject : Core samples; El Capitan Dam; Test Well No. 5

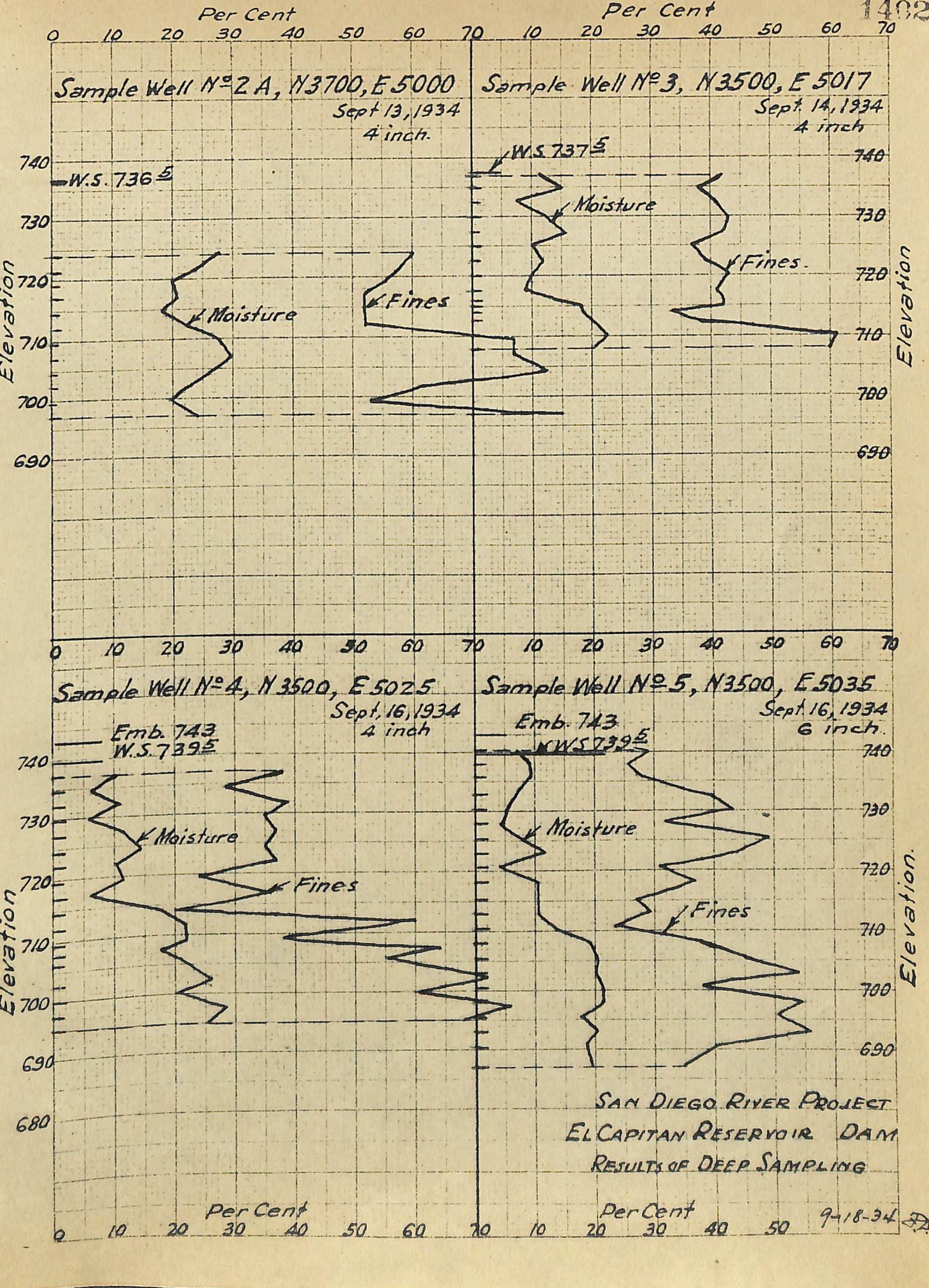
These samples are reported by El Capitan office as taken September 16. Location is given as coordinates N 3500 E 5035. Elevation of water surface is given as 739.5 and of flank as 743. Sample elevation is shown in the following table; with moisture and gradation percentages as obtained in the laboratory. Detailed sand grading is given in separate table beyond.

Lab. No.	Job No.	Elevation sample	Per cent moisture	Gradation percentage Sand	Silt	Clay
23210	3204	740.5	7.0	71	17	12
11	5	738.0	9.1	74	22	4
12	6	736.0	9.1	73	23	4
13	7	733.0	6.8	61	29	10
14	8	730.5	4.8	57	29	14
15	9	728.0	4.4	68	28	4
16	3210	725.5	8.3	51	25	24
17	11	723.0	11.9	56	39	5
18	12	720.5	4.0	69	27	4
19	13	718.0	10.4	63	32	5
23220	14	715.5	10.2	73	23	4
21	15	713.0	10.6	71	25	4
22	16	710.5	13.8	77	20	3
23	17	708.0	19.1	62	34	4
24	18	705.5	20.3	55	40	5
25	19	703.0	20.0	46	49	5
26	3220	700.5	21.4	62	33	5
27	21	698.0	21.1	46	31	23
28	22	695.5	17.4	50	42	8
29	23	693.0	20.4	44	53	3
23230	24	690.5	18.6	60	32	8
31	25	687.0	19.1	65	28	7

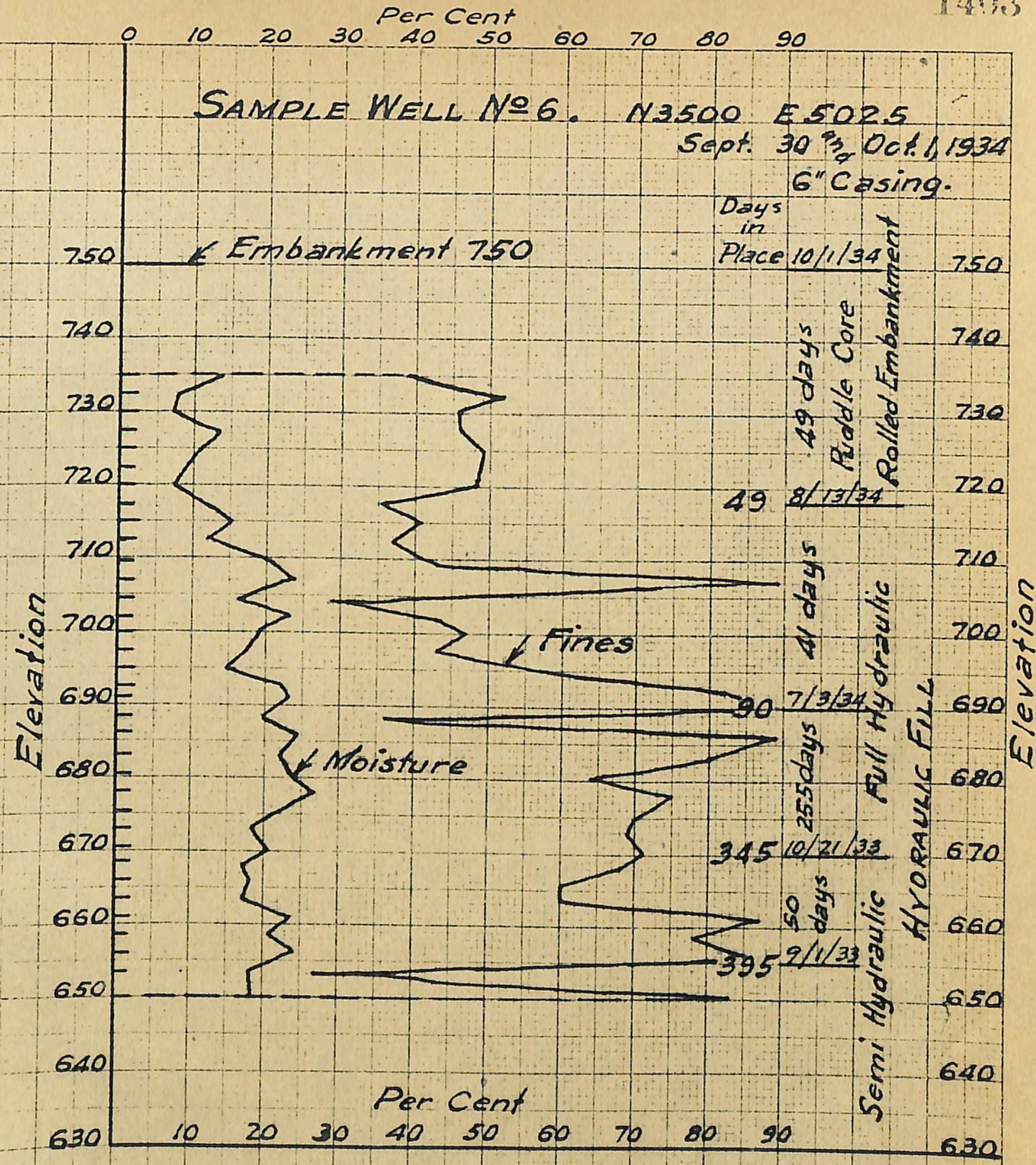
Sand grading Job No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200(silt and clay)
3204	100	95	88	78	71	62	43	29
5	100	96	88	78	70	60	40	26
6	100	97	89	78	70	61	42	27
7	100	98	95	86	79	71	54	39
8	100	99	97	90	85	77	60	43
9	100	99	95	85	78	70	52	32
3210	100	99	97	91	87	80	65	49
11	100	99	97	89	83	75	59	44
12	100	99	96	86	78	68	48	31
13	100	99	97	89	82	73	54	37
14	100	97	90	80	73	64	44	27
15	100	98	93	81	72	63	44	29
16	100	99	96	87	78	66	41	23
17	100	99	96	88	82	73	53	38
18		100	99	99	96	91	68	45
19	100	99	98	96	94	90	74	54
3220		100	99	98	95	89	65	38
21	100	99	98	94	91	86	72	54
22		100	99	98	96	90	70	50
23	100	99	98	98	97	94	80	56
24	100	99	96	92	88	81	60	40
25	100	99	97	93	87	78	54	35

JYJ/p

J. Y. Jewett



SAN DIEGO RIVER PROJECT
EL CAPITAN RESERVOIR DAM
RESULTS OF DEEP SAMPLING



SAN DIEGO RIVER PROJECT
EL CAPITAN RESERVOIR DAM
RESULTS OF DEEP SAMPLING

Dr. by P.D.P.
Tr. by H.C. 10/3/34

2-19-35
copy/p

9-19-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Puddle core samples; El Capitan Dam

Samples from puddle core El Capitan Dam, taken September 15 by D. W. Albert, H. L. Harper and L. H. Hill, are reported as having the listing by location as shown in the table below. Elevation of water surface is reported as 740.5, and of all samples as 736. Results for moisture and gradation percentages, as obtained in the laboratory, are shown in the table, with detailed sand grading given in separate table beyond.

Lab. No.	Job No.	Coordinates N	E	Per cent moisture	Gradation percentage Sand	Silt	Clay
23232	3161	3100	5000	28.1	43	54	3
33	62	3200	"	35.1	23	65	12
34	63	3300	"	19.5	64	32	4
35	64	3400	"	25.7	45	54	1
36	65	3500	"	26.7	53	43	4
37	66	3600	"	24.4	48	49	3
38	67	3700	"	30.0	49	48	3
39	68	3800	"	29.5	51	45	4
23240	69	3900	"	28.9	50	46	4
41	3170	4000	"	21.7	58	38	4

Sand gradation

Job No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200 (silt & clay)
3161	100	97	97	96	95	93	80	57
62	100	99	99	97	96	94	87	77
63	100	96	92	84	78	70	52	36
64	100	97	96	93	91	87	74	55
65	100	99	97	93	90	84	67	47
66	100	99	98	94	91	85	70	52
67	100	99	98	95	92	87	71	51
68	100	99	97	93	89	83	69	49
69	100	99	98	95	90	83	67	50
3170	100	99	97	90	84	76	58	42

Composition of these samples shows the same predominating feature of high silt content, noted in connection with recent previous sets of core samples (i.e. exclusive of test well samples).

J. Y. Jewett

JYJ/p

2-18-35
copy/p

10-2-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Core samples; El Capitan Dam; Test Well No. 6

These samples are reported by El Capitan office as taken September 30 and October 1. Location is given as coordinate N 3500 E 5025. Elevation of embankment surface at well is given as 750. Sample elevation is shown in the following table; with moisture and gradation percentages as obtained in the laboratory. Detailed sand grading is shown in separate table beyond.

Lab. No.	Job No.	Elevation sample	Per cent moisture	Gradation percentage Sand	Silt	Clay
23283	3263	735	13.8	61	32	7
84	64	732.5	7.9	48	28	24
85	65	730	7.4	54	32	14
86	66	727.5	13.3	54	42	4
87	67	725	11.1	51	33	16
88	68	720	7.5	52	44	4
89	69	717.5	12.1	65	31	4
23290	3270	715	15.1	59	36	5
91	71	712.5	12.0	63	32	5
92	72	709.5	20.9	57	39	4
93	73	707	23.6	11	82	7
94	74	704.5	16.1	71	26	3
95	75	702	23.0	57	39	4
96	76	700	19.4	53	39	8
97	77	697.5	17.6	57	31	12
98	78	695	14.8	43	37	20
99	79	692.5	22.4	18	75	7
23300	3280	691	23.0	10	73	17
1	81	688.5	19.8	64	33	3
2	82	686	24.2	11	67	22
3	83	683	22.0	20	55	25
4	84	680.5	23.3	36	42	22
5	85	678	26.8	25	47	28
6	86	675.5	22.0	30	46	24
7	87	673	18.5	31	53	16
8	88	670.5	20.3	29	50	21
9	89	668.5	17.2	32	60	8
23310	3290	666	18.2	40	56	4
11	91	663.5	17.2	40	56	4
12	92	661	23.7	13	64	23
13	93	658.5	20.8	22	69	9
14	94	656	23.8	14	69	17
15	95	653.5	18.2	73	25	2
16	96	650	18.4	17	56	27

Sand Grading

Job No.	Percentage passing sieve No. 1/4"	10	20	30	40	50	100	200(silt and clay)
3263	100	99	94	87	80	72	54	39
64		100	99	94	89	83	67	52
65	100	99	95	89	83	78	61	46
66	100	99	95	88	83	76	61	46
67	100	99	97	92	87	81	65	49
68	100	99	97	90	84	77	62	48
69	100	99	96	88	81	71	51	35
3270	100	98	96	89	82	74	57	41
71	100	99	97	89	82	73	54	37
72	100	99	95	88	82	75	59	43
73						100	99	89
74			100	98	91	78	49	29
75			100	99	96	87	63	43
76		100	99	97	92	84	64	47
77			100	99	97	89	64	43
78	100	99	99	98	97	94	80	57
79						100	95	82
3280		100	99	99	99	99	98	90
81	100	99	98	94	88	77	52	36
82						100	98	89
83					100	99	91	80
84	100	99	99	99	99	98	91	64
85						100	95	75
86					100	99	93	70
87			100	99	96	94	84	69
88				100	99	97	89	71
89			100	98	96	93	83	68
3290			100	99	95	91	76	60
91		100	99	94	90	84	73	60
92						100	96	87
93						100	95	78
94					100	99	96	86
95		100	98	86	74	61	40	27
96					100	99	96	83

J. Y. Jewett

JYJ/p

3-13-35
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SAN DIEGO RIVER PROJECT, EL CAPITAN FEATURE
Hydraulic Fill, Summary of Analysis
Borrow pit materials before letting of contract

Area	Sample No.	Analysis percent of Clay	Silt	Total Fines	Sand	Remarks
A	4	20.0	26.0	46.0	54.0	November 2, 1931, Harold Wood and J. Y. Jewett
	5	3.1	10.2	13.3	86.7	" " " " " "
	6	20.0	17.6	37.6	62.4	" " " " " "
	61	9.7	11.1	20.8	79.2	(composite of 108 secured by (P.O.Gottschling when survey (of borrow pit areas were (made during summer and fall (of 1931
	62	10.3	15.8	26.1	73.9	
	63	8.3	15.2	23.5	76.5	
B	64	11.4	15.2	26.6	73.4	Composite of 64 specimens
C	1	20.0	14.0	34.0	66.0	November 2, 1931, Harold Wood and J. Y. Jewett
	2	16.0	18.0	34.0	66.0	" " " " "
	3	6.8	8.0	14.8	85.2	" " " " "
	65	11.4	9.9	21.3	78.7	Composite of 10 specimens

Note: Clay and silt passing 200 mesh screen.

Hydraulic fill, Summary of Analysis
Borrow pit materials after letting of contract

Area Number	Number of Samples	Average analysis percent of Clay	Silt	Total Fines	Sand
A	27	10.5	21.7	32.2	67.8
B	10	10.8	21.8	22.6	67.4
C	37	12.3	22.5	34.8	65.2
Olive orchard	12	10.0	22.0	32.0	68.0
Lower Chocolate Creek	9	8.0	22.0	30.0	70.0
Upper Chocolate Creek	6	11.0	24.0	35.0	65.0
K	9	11.0	27.0	38.0	62.0
Disintegrated granite from spillway-Regular	6			2.0	98.0
Washed	6			5.0	95.0

Hydraulic fill, Summary of Analysis
Materials investigated for puddle core up-building

Northwest El Monte Park	9	21.0	26.0	47.0	53.0
Meyers Ranch Lot 59	9	50.0	19.0	69.0	31.0
Meyers Ranch West Area	6	39.0	22.0	61.0	39.0
Fletcher Hills	11	45.0	19.0	64.0	36.0
Southwest Santee	7	34.0	25.0	59.0	41.0
Lindo Lake	11	33.2	48.0	81.2	18.8

3-15-35
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Hydraulic Fill

Beach Material

Number of Samples	Date	Analysis percent of: Clay	Silt	Total Fines	Sand	Remarks
2	1933 3-8	4	17	21	79	
1	4-13	2	19	21	79	
12	5-27	undivided		2x	98	
2#	10-3	7	20	27	73	Midway of beaches
2#	10-7	1.5	18	19.5	80.4	" " "
1°	10-10	2	14	16	84	At depth of one foot
1°	10-10	3	22	25	75	At depth of three feet
3	10-12	3	16	19	81	At depth of seven feet
138	11-17	1	20	21	79	Semi hydraulic
22	12-6	1	13	14	86	Full hydraulic
65	12-9	1	13	14	86	Full hydraulic
3	1934 2-14	2	18	20	80	Material removed
6	2-18	3	22	25	75	Material removed
9	3-10	1	14	15	85	Upstream beach
18	3-15	2	15	17	83	Downstream beach
48	3-28	3	18	21	79	Depth 1 foot
8	6-18	2.5	15.5	18	82	Depth 1 foot
16	7-5	3	13	16	84	Downstream beach full hydraulic
14	7-5	4	16	20	80	Upstream beach semi-hydraulic
8	7-18	3	14	17	83	Downstream beach full hydraulic
9	7-18	3	16	19	81	Upstream beach semi-hydraulic
8	7-26	3	15	18	82	Downstream beach full hydraulic
10	7-26	4	11	15	85	Upstream beach full Hydraulic

(x) These samples very unusual and were probably taken at a time when beaches were being built up by use of downstream spoil bank materials consisting of streambed excavation

(#) Each sample composite of 12
(°) Each sample composite of 7

3-15-35
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Hydraulic Fill
Puddle core samples on axis of dam

Series	Date	Number of Samples	Average Elevation	Average analysis percent of Clay	Silt	Total Fines	Sand
1	2-25-33	6x	553	16	27	43	57
2	3-8-33	3	565	22	34	56	44
3	3-23-33	3	577	33	24	57	43
4	4-4-33	3	590	24	36	60	40
5	5-27-33	3	604	24	37	61	39
6	7-1-33	3	608	26	41	67	33
7	7-11-33	3	620	23	38	61	39
8	8-1-33	3	627	21	37	58	42
9	8-11-33	3	637	20	36	56	44
10	9-5-33	3	650	21	49	70	30
11	10-3-33	2	653	30	34	64	36
12	11-8-33	3	667	41	48	89	11
13	11-29-33	3	664	20	62	82	18
14	12-5-33	4	674	11	44	55	45
15	7-9-34	8	685	11	41	52	48
16	7-13-34	10	687	14	42	56	44
17	7-25-34	6	694	13	58	71	29
18	8-3-34	4	696	13	43	56	44
19	8-9-34	6	701	5	48	53	47
20	8-29-34	4	717	18	65	83	17
21	9-15-34	10	---	4	47	51	49

(x) 3 - 10 feet east of axis, 3 - 10 feet west of axis, remainder on axis of dam. Samples also taken near outer boundary of theoretical puddle core section where results variable because of the occasional intrusion of transition section.

(xx)The analysis of about 1000 samples taken between December 6 and 22 indicated sand strata in about 85 percent of the puddle core area placed between November 27 and December 5, 1933.

Hydraulic Fill

Sand Strata in Puddle Core Area

Gradation analyses were made of 882 samples taken from the puddle core area after full hydraulic placing discontinued December 6, 1933, and before work of eliminating sand strata was undertaken. The following tabulation shows the general results of the analyses arranged according to the variation in the percentage of fines.

Percent of fines	Number of samples	Percent	Percent of fines	Number of samples	Percent
0 to 5	0	0	51 to 55	17	1.9
6 10	11	1.2	56 60	20	2.3
11 15	82	9.3	61 65	25	2.8
16 20	118	13.4	66 70	22	2.5
21 25	84	9.5	71 75	34	3.9
26 30	55	6.3	76 80	52	5.9
31 35	24	2.7	81 85	86	9.8
36 40	21	2.4	86 90	127	14.4
41 45	18	2.0	91 95	66	7.5
46 50	18	2.0	96 100	2	0.2
Total	431	48.8		451	51.2

The sand strata formed on the steep under-water beaches and slid or moved into the imperviour puddle core material when the core lagged too far behind the beaches. An average of all the above samples would form an excellent impervious puddle core.

Between January 5 and February 5, 1934 the Contractor eliminated the sand strata in the puddle core area by removing the sand strata material to the beaches and rewashing it. Some of this material was wasted over the sides of the rock embankment or removed entirely from the dam. During this time 389 samples were taken and analysed. A gradual improvement was noticed.

Between February 9 and March 21, 1934 the Contractor placed material by full hydraulic methods. Sand strata gradually formed and hydraulic operations were discontinued. During this period 250 samples were taken and analyzed.

The Contractor corrected the sand strata condition in the puddle core by the operation of a rotating core mixing machine. This work was intermittent and was not completed until June 15, 1934. 319 samples were taken and analyzed during this period.

When hydraulic operations were resumed, material rich in fines was secured from vicinity of Lakeside, and was placed either directly in the summit pool, or by hydraulic operations, to bring up the lagging summit pool. This method overcame the conditions which had contributed to the formation of sand strata in the puddle core.

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Hydraulic Fill

Consolidation and Percolation Tests

Tests made in 18" diameter cylinder with sample 4" deep before pressure applied

Test No.	Analysis percent of: Clay	Silt	Total Fines	Sand	Origin	Pressure equal to 35 foot fill: Consolidation	Voids Volume	Weight cubic foot	80" head cc. per hour H.G.20-1	Theoretical Velocity Feet per year, Pressure 75 feet of fill: Basis Unity	Head 75' Core 60'	Gallons per day # (Pressure 75 feet of fill): Head 75' Core 60'
Los Angeles					Puddle core	20.2	38.1	108.9	5.8	.21	.26	780
1	26	43	69	31	Puddle core	20.8	48.0	118	1.6	.04	.05	150
2	24	32	56	44	Composite of 31	33.3	39.4	128	8.2	.10	.12	360
3	19	28	47	53	Composite of 12	22.0	37.8	129	10.1	.18	.22	660
4	18	22	40	60	one-half core and beach	20.2	35.7	132	15.0	.28	.35	1,050
5	4	26	30	70	Edge of core	10.1	38.0	130	510.0	16.0	20.0	60,000
6	0	0	0	100x	Laboratory	15.5	46.9	122	2,352.0	74.8	93.5	280,000
7	33	47	80	20	Axis, composite of 8	32.2	32.8	133	2.8	.035	.04	120
8	34	41	75	25	Lakdside	20.0	44.3	121	0.0	0.0	0.0	0
9	5	27	32	68	A and B composite	7.2	29.2	141	124.0	3.89	4.8	14,400
10	1	12	13	87	Sand strata	2.9	35.6	134	1,174.0	33.2	41.5	125,000
11	12	64	76	24	Puddle core composite	17.1	42.1	125	1.7	.04	.05	150
12	1	16	17	83	Excavated from core #1924	12.5	34.7	134	958.0	41.1	51.6	155,000
13	5	40	45	55	Wasted from puddle core	13.2	34.6	133	7.6	0.12	0.15	450
14	8	27	35	65	Composite of 3 from pit K	11.6	32.4	137	7.6	0.21	0.26	780
15	1	24	25	75	Puddle core	6.9	45.5	125	2,055.0	68.08	85.10	255,300
16	14	20	34	66	Upstream beach N3700	11.3	33.6	135	8.6	0.22	0.27	825
17	2	14	16	84	Composite puddle core-beach	12.7	30.6	140	2.4	0.04	0.05	150
18	9	19	28	72	Borrow pit A	9.1	34.5	134	7.1	0.20	0.25	750
19	20	46	66	34	Composite puddle core	21.1	40.4	125	0.0	0.0	0.0	0
20	3	22	25	75	Laboratory samples comp.	8.2	34.0	137	330.0	10.05	12.56	37,680
21	7	23	30	70	Laboratory samples comp.	10.3	31.7	137	15.0	0.37	0.37	1,110
22	10	21	31	69	Laboratory samples comp.	10.2	34.7	131	47.0	1.45	1.81	5,430
23	4	25	29	71	Puddle core	9.3	41.0	126	32.0	0.79	0.98	2,961
24	5	32	37	63	Beach	10.5	40.0	128	54.0	1.68	2.10	630
25	5	13	18	82	Beach	7.0	32.2	138	2,050.0	73.10	91.40	274/200
26	3	13	16	84	Beach	5.9	34.2	135	4,600.0	141.90	177.40	532,200
27	23	26	49	51	Borrow pit B	14.9	33.7	133	1.4	0.02	0.025	75
28	11.6	33.8	45.4	54.6	Composite 2 Borrow pit B	9.4	29.7	137	5.5	0.13	0.16	480
29	3	29	32	68	Borrow pit A	9.3	28.2	142	44.0	1.27	1.59	4,770
30	3	10	13	87	Spillway waste	3.7	37.7	129	2,540.0	88.89	111.11	333,330
31	3	36	39	61	Composite Lakeside-Pit A	13.6	30.1	137	19.0	0.41	0.51	1,530
32	4	39	43	57	Borrow pit B	9.3	27.6	137	80.0	2.00	2.50	7,500
33(xx)	20	36	56	44	Puddle core	18.0	37.3	130	4.7	0.74	0.92	2,815

(x) 50% passed 100 mesh screen and retained on 200 mesh screen
50% passed 50 mesh screen and retained on 100 mesh screen

(xx) Composite of all puddle core samples of regular series, taken during construction of dam; does not include special series taken during removal of the sand strata

(#) Assumed area of puddle core subject to percolation 146,000 square feet. Velocity of 1 foot per year equals 146,000 cubic feet per year equals 400 cubic feet per day equals 3000 gallons per day. Assumed average head 75 feet, average thickness of core 60 feet.

MATERIALS - SAMPLING AND TESTING

ROLLED FILL

2-18-35
copy/p

July 25, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject : San Diego River Project, El Capitan Feature
Rolled fill

On July 23, 1934 the Resident Engineer and L. H. Hill secured four samples, listed in detail below, from the local borrow pit areas at the El Capitan Dam.

Sample No.	Source	Depth feet	Coordinates N	E	Description
2959	Borrow pit B NE corner	4	1400	11000	Top soil material to a depth of 4 feet
2960	" "	4 & 10	"	"	
2961	Borrow pit A	12	3000	11300	
2962	West spoil bank				Spillway excavation material

Sample 2959 was a reddish clay, rather lumpy, probably containing about 40 per cent fines.

Sample 2960 was iron stained decomposed granite which crumbled and broke down readily and which occurs immediately below the top soil.

Sample 2961 was of more sandy material occurring in the east side of the large pit "A" and is what we commonly call a "sandy material".

Sample 2962 was typical of the decomposed granite that is being excavated for the spillway.

These four samples were taken by the Resident Engineer on July 23 directly to the laboratory of the Los Angeles Department of Water & Power located at Second and Rose Streets, Los Angeles. He arrived with the samples at 4:30 P.M. and learned that Mr. R.R. Proctor, who has charge of the laboratory work, was on vacation and was referred to his assistant field engineer Mr. Nelson.

Arrangements were made with Mr. Nelson by telephone for the materials in the four samples to be run through the standard tests to determine the maximum density for percentage of moisture for the purpose of making rolled fill.

An appointment was made to meet with Mr. Nelson at the laboratory at 9 A.M. on July 24 at which time Mr. Nelson and a staff of four other assistants was made available and began immediately on the making of the necessary tests.

Material from samples 2959 and 2960 were combined to make one test by combining them in the proportion of 2/5 of sample 2959 and 3/5 of sample 2960 as this is about the proportion this material will occur in the local borrow pits.

It was also requested that a test be run on the straight material of sample 2959 as it was considered that this might be almost too much clay to use alone.

A report will be available probably in the mail not later than July 26 which will cover these four tests. The report will show by curves the moisture in percent dry weight, to the dry weight of the material as compacted. It will also show the plasticity needle penetration resistance.

The Resident Engineer secured a copy of the standard form (letter size) on which are recorded soil characteristics, as it is thought that this form might be used to advantage for reporting similar tests if made in the City of San Diego's laboratory.

The Resident Engineer remained at the Los Angeles laboratory until 2:10 P.M. at which time the samples were being dried in the oven and no further work could be done until the following forenoon.

During the time that he was at the laboratory he secured the following information relative to Blackhawk hydraulic jacks. This is a standard type of hydraulic jack used in testing large work and is obtainable through the Commercial Motor Parts Company, 1205 Santa Fe Avenue, Los Angeles, telephone Trin.1986. The 12-ton jack equipped with pressure gauge, being 16-3/4 inches high, can be purchased for $54.00. The jack alone without the gauge can be purchased for $28.60.

Mr. Nelson stated that the information on the tests would be mailed directly to this office and that the proper billing would be forthcoming.

Harold Wood
Resident Engineer

HW/p

2-16-35
copy/p

DEPARTMENT
of
WATER and POWER

City of Los Angeles

BUREAU OF WATER WORKS & SUPPLY

July 30, 1934

Mr. Fred Pyle, Chief Engineer
Bureau of Water Development
City of San Diego
524 F Street, San Diego, California

Dear Sir:

The accompanying curves are the results of compaction tests made on soil samples from El Capitan dam. These samples were brought to the field engineering laboratory by Mr. Wood on July 24, 1934. The materials on which tests were performed are as follows:

No. 2959 - Brown sandy clay

No. 2959 / 2960 - 2/5 sandy clay; 3/5 decomposed granite.

No. 2961 - Brown sandy loam

No. 2962 - Gray decomposed granite.

These tests were conducted according to the methods as outlined in a series of four articles on "The Design and Construction of Rolled Earth Dams" by R. R. Proctor, which appeared during August and September, 1933 in the Engineering News-Record.

Very truly yours,

H. A. Van Norman
Chief Engineer &
General Manager.

2-16-35
copy/p

SUMMARY OF COMPACTION TESTS

Rolled Embankment

Date 1934	Sample No.	Location North	Location East	Elevation	Compacted in place	Weight dry	Moisture % dry	Origin of mat'l	Remarks taken by
8-31	3088	3300	5030	725	139	129	7.4		OVS
28	3091	3400	5050	725	135	123	9.5	Pit A	"
28	3092	3800	5060	725	132	121	9.0	"	"
28	3093	3600	4960	726	139	124	12.0	D.G.	"
29	3094	3620	4965	727	138			" gray	HIW
29	3095	3620	5040	727	151			" red and clay	"
29	3096	3620	5050	727	133			" " "	"
30	3097	3600	5060	727.5	127	117	8.0	Pit A	OVS
30	3098	3600	5050	727.5	144	132	8.0	" "	"
30	3099	3600	4965	727.5	145	134	7.5	D.G.	"
31	3100	3620	4978.5	724			18.5		8'from puddle
9-4	3101	3600	5060	730	137	130	5.2	mixed GD	OVS
4	3102	3600	5030	730	143	132	8.1	Pit A	"
4	3103	3600	4960	730	155	147	5.2	DG	"
7	3119(L)	3600	5060		140	133	5.3	upstream flank	"
7	3119(2)	3600	5030		112	104	8.1	" " "	"
7	3119(3)	3600	4965		146	135	8.1	Downstream	
14	3155	3600	5040	740	148	133	11.2	DG	OVS-LHH
14	3156	3700	4970	740	122	114	6.7	Borrow pit	"
14	3157	3700	4940	740	138	131	5.3	DG	"
18	3226	3750	5030	742.5	144	133	8.1	Pit L	DWA-LHH
18	3227	3750	5050	742.5	121	106	14.3	DG	"
18	3228	3150	5045	742.5	154	141	9.6	DG	"
24	3248	3600	4960	747	144	133	8.1	DG	"
24	3249	3600	4980	747	127	117	8.1	Pit L	"
24	3250	4075	5035	747	152	142	6.7	DG	"
24	3251	4050	5020	747	122	116	5.0	Pit L	"

2-18-35
copy/p

8-16-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : El Capitan Dam, Test of beach and spoilbank materials for bulking

These tests are on two samples of material brought in by Mr.Holmes August 15. The samples were in two sacks each, those of the beach material being marked as Job Nos. 3067 and 68, taken at coordinates N 3850 and E 4920. Mr. Holmes advised that the two sacks comprised one sample, and were therefore assigned one laboratory number (23042) and were used as one sample. Similarly on the two sacks of spillway spoilbank material (from downstream bank) for Job Nos. 3069 and 70, one laboratory number (23043) was assigned.

After some experimentation with trial methods, the method adopted for making the determinations desired, was to start with the dried material in amount filling a cylindrical one-half cubic foot measure to a depth of six inches, or one-half full, equivalent to a volume of one-fourth cubic foot. Water was then added in increments as shown in the table below, and the resulting volumes recorded as shown therein.

For compacting the material in the cylinder, it was suggested when you were here that the A.S.T.M. standard method for rodding concrete aggregates be used. It was found however, that this method is suitable for dry aggregates only and does not serve when the materials are damp. After After trial of other methods, the tamper used was a piece of iron pipe with a flat-faced cap on the end, two inches in diameter. The material as placed in the cylinder was tamped in four layers of about equal depth. The tamping was not heavy but was sufficient only to consolidate the looseness of the material as dropped into the cylinder.

The samples as received show the following moisture and gradation percentages, with detailed grading of the sand portions shown on the attached report form.

Lab. No.	Job No.	Moisture	Percentages Gravel	Sand	Silt	Clay
23042	3067-68	5.2	3	78	16	3
23043	3069-70	dry	14	75	9	2

Determination of maximum volume.

Condition	No. 3067-68 Volume cu.in.	Increase percent	No. 3069-70 Volume cu.in.	Increase percent
Dry	432		432	
Plus 2% water	453.6	5	468	8.3
4	475.2	10	475.2	10
6	475.2	10	482.4	11.7
8	460.8	6.7	478.8	10.8
10	453.6	5	475.2	10
14	432	0	453.6	5
18	439.2	1.7	468	8.3

Condition	No. 3067-68 Volume cu.in.	Increase percent	No. 3069-70 Volume cu.in.	Increase percent
x Plus 21.4% water	453.6	5		
x 20.7			482.4	11.7

x Saturated

Weight per cubic foot, dry, in tamped condition as used, was 113 pounds and 118 pounds for the two samples respectively.

An ordinary concrete sand, with 5 per cent moisture content, will generally show a bulking of about 20 per cent in volume loose measurement.

Detailed grading of sand portion

Lab. No.	Job No.	Percentages passing sieve No. 1"	1/2"	1/4"	10	20	30	40	50	100	x 200
23042	3067-68		100	97	95	88	75	65	54	33	19
23043	3069.70	100		86	82	72	60	51	41	22	11

x Silt and clay.

J. Y. Jewett
Testing Engineer

JYJ/p

8-27-34

From : Testing Engineer

To : Hydraulic Engineer

Subject : Rolled embankment samples; El Capitan Dam

Six samples from rolled embankment El Capitan Dam, taken August 25, give results for moisture content and gradation as shown in the table below. These are reported by El Capitan office as taken at the instance of Mr. Holmes, State Inspector, and as taken by him, assisted by Messrs. Albert, Converse and Connolly.

The samples are listed as taken at one to three feet in depth, with beach elevation at plus or minus 723. Location of the samples by coordinates is shown in the table; and the following notes are attached to the sample listing as received from the El Capitan office.

Water placed in hole 3078 dropped 11 inches in 10 minutes. Water placed in hole 3080 dropped 6 inches in first 10 minutes, then refilled and dropped 1 inch in second 10 minutes.

Lab. No.	Job No.	Coordinates N	E	Per cent moisture	Gradation percentages Gravel	Sand	Silt	Clay
23077	3078	3620	5030	9.3	0	67	30	3
78	79	3620	5050	11.4	0	67	30	3
79	80	3620	5070	9.5	0	71	26	3
23080	81	3620	4980	7.5	1	71	25	3
81	82	3620	4960	5.4	6	81	11	2
82	83	3620	4930	4.8	3	84	10	3

Detailed grading of sand portion

		Percentages passing screen No. 3/4"	1/2"	1/4"	10	20	30	40	50	100	200 (silt clay)
23077	3078			100	98	93	83	76	67	49	33
78	79			100	99	95	85	78	69	51	33
79	80			100	97	93	83	75	66	46	29
80	81		100	99	96	90	80	72	63	43	28
81	82		100	94	88	78	65	56	46	27	13
82	83	100		97	90	78	66	56	46	27	13

JYJ/b

J. Y. Jewett
Testing Engineer

2-16-35
copy/p

August 27, 1934

From : Hydraulic Engineer

To : Resident Engineer

Subject : San Diego River Project, El Capitan Feature
Rolled fill tests

Tests for compaction of both the upstream and downstream rolled embankments of the El Capitan dam should be made in the field at typical locations to determine the weight per cubic foot of the material in place of the material dry and the percentage of moisture.

Sufficient similar material should be sent to the City testing laboratory for checking the field results found in the above tests and for making gradation analysis.

The discharge of the nozzles used in wetting down the rolled fill should be determined and checked from time to time. The inspectors' reports should show the discharge, the number of hours, and number of nozzles operated each shift, with comments as to maintenance, pressure and results obtained.

The inspectors' reports should also show the number of hours each sheep foot roller was used for each shift, the estimated spped of the roller and the condition of the roller.

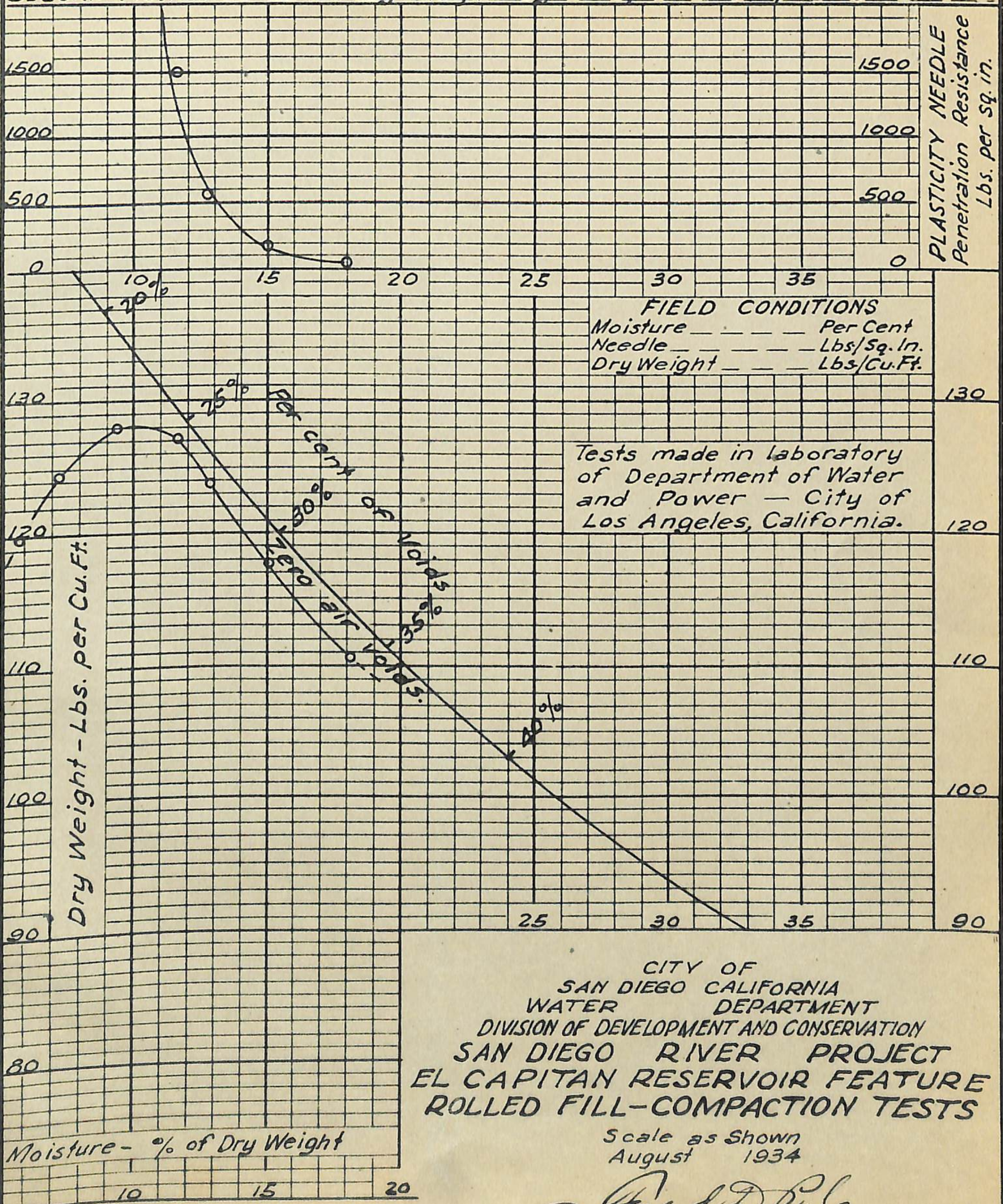
The weight of the rollers should be estimated or determined.

Fred D. Pyle
Hydraulic Engineer

FDP/f
cc City Testing Engineer

SOIL CHARACTERISTICS

S.G. 2.745 % PASS № 200 38.7 JOB El Capitan (S.D.)
TEST BY Green DATE 7-24-34 HOLE № 2959 SD
ELEV. Depth 4' LOCATION: Borrow Pit "B" N 1400, E 11000
DESCRIPTION Brown Sandy Clay. Clay 23%, Silt 26%, Sand 51%



CITY OF
SAN DIEGO CALIFORNIA
WATER DEPARTMENT
DIVISION OF DEVELOPMENT AND CONSERVATION

SAN DIEGO RIVER PROJECT
EL CAPITAN RESERVOIR FEATURE
ROLLED FILL-COMPACTION TESTS

Scale as Shown
August 1934

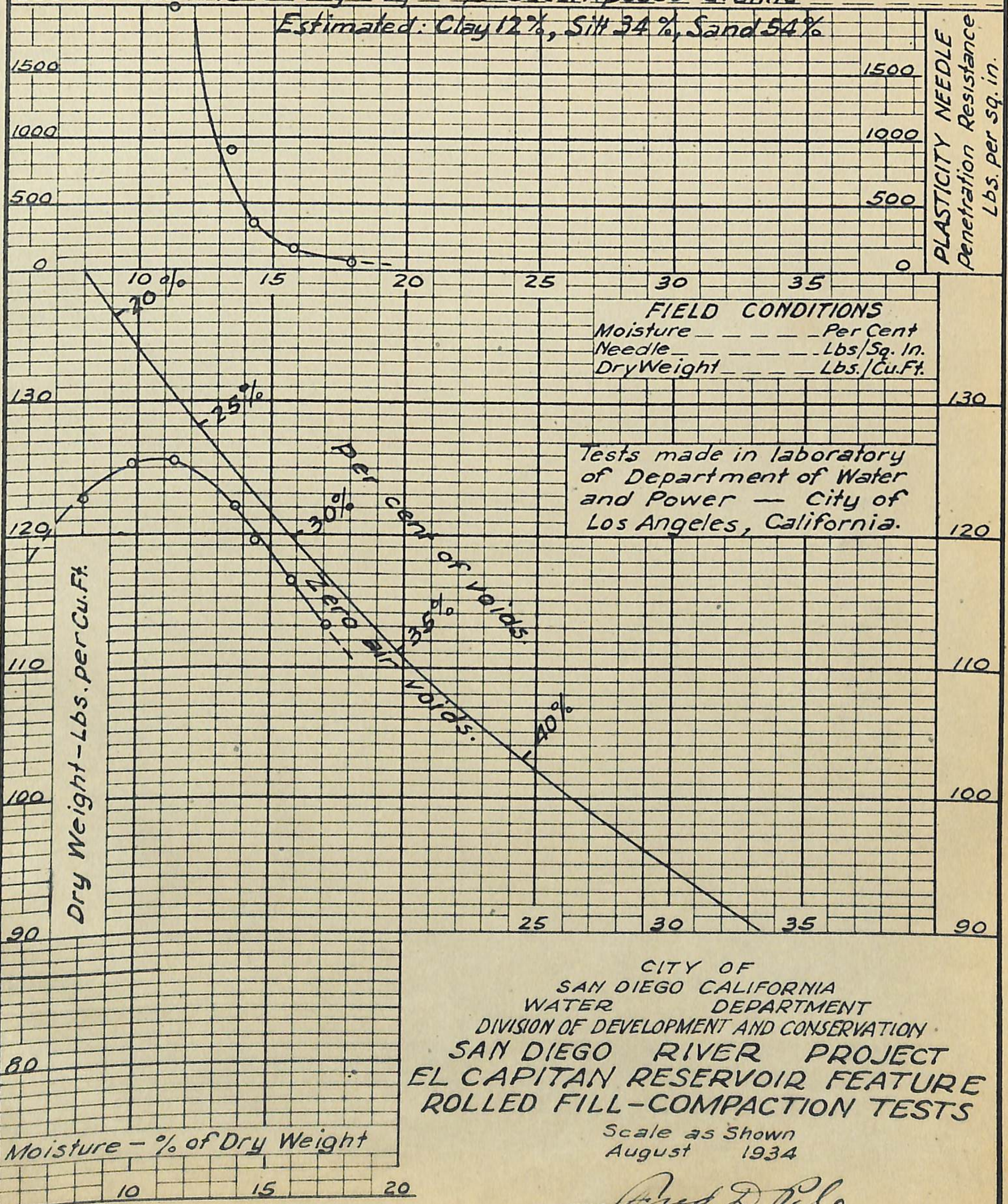
Fred D Pyle
Hydraulic Engineer.

Traced by N.C.
Checked by P.B.
Sheet 1 of 4

WD-510

SOIL CHARACTERISTICS

S.G. 2.745 %PASS Nº 200 34.3 JOB El Capitan (S.D.)
TEST BY Manning DATE 7-24-34 HOLE Nº SD 2959-2960
ELEV. LOCATION
DESCRIPTION 2/5 Sandy Clay – 3/5 Decomposed Granite



CITY OF
SAN DIEGO CALIFORNIA
WATER DEPARTMENT
DIVISION OF DEVELOPMENT AND CONSERVATION
SAN DIEGO RIVER PROJECT
EL CAPITAN RESERVOIR FEATURE
ROLLED FILL-COMPACTION TESTS
Scale as Shown
August 1934

Fred D Pyle
Hydraulic Engineer.

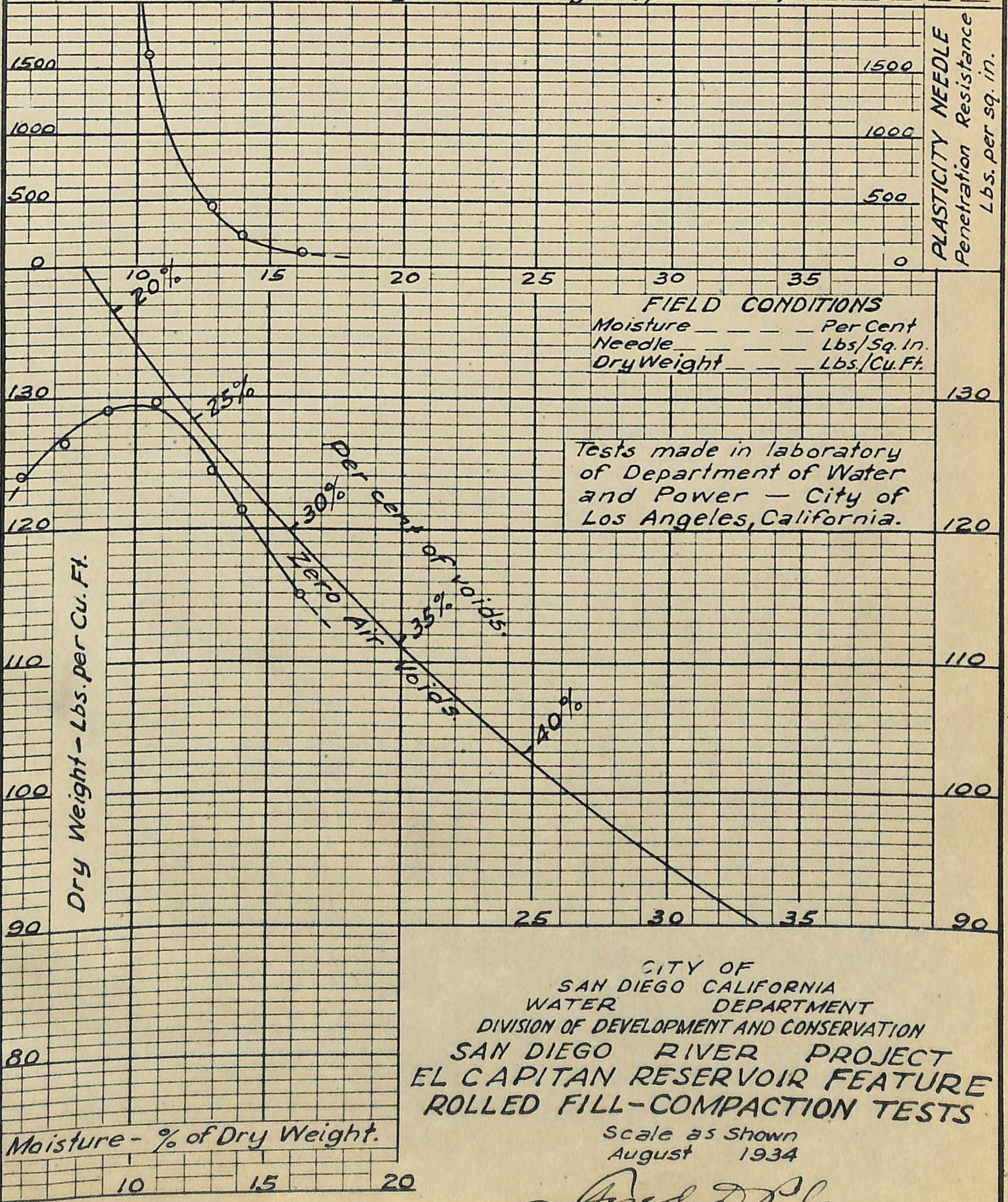
Traced by N.C.
Checked by PB

Sheet 2 of 4

WD-510

SOIL CHARACTERISTICS

S.G. 2.745 % PASS № 200 23.0 JOB El Capitan (SD)
TEST BY Duering DATE 7-24-34 HOLE № SD 2961
ELEV. Depth 12' LOCATION: Borrow Pit "A" N 3000, E 11300
DESCRIPTION Brown Sandy Loam. Clay 3%, Silt 29%, Sand 68%



CITY OF
SAN DIEGO CALIFORNIA
WATER DEPARTMENT
DIVISION OF DEVELOPMENT AND CONSERVATION

SAN DIEGO RIVER PROJECT
EL CAPITAN RESERVOIR FEATURE
ROLLED FILL-COMPACTION TESTS

Scale as Shown
August 1934

Fred D. Pyle
Hydraulic Engineer.

Traced by N.C.
Checked by P.B. Sheet 3 of 4

2-16-35
copy/D

November 13, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : Weight of rolled fill material; El Capitan Dam

On the question of weight per cubic foot of the rolled material in El Capitan dam embankment, it is noted that copy of summary received from your office of the various determinations made during period August 28 to September 24, shows results, when separated into groups as relating to origin of the material, giving averages and range of variation as follows:-

Source	Number	Poundes per cubic foot Average	Maximum	Minimum
Disintegrated granite	9	144	155	121
Borrow pit	9	133	144	122
Mixture of above	4	140	151	133
x Upstream and downstream flanks	3	133	146	112
Not stated	1	129		
Total	26	138	155	112

x Source not stated

A main feature of the above is the wide range of variation in the individual results. Only 19 out of the 26 fall within a range of ten per cent either way from the total average. Mr. L. C. Hill in discussing these tests, when at the laboratory in the early part of October, took the ground that the higher results in the vicinity of 150 pounds or over were unduly high. He also referred to this again when the writer chanced to meet him when calling at his office in Los Angeles on October 12th.

At the time Mr. Hill was here, there was under consideration a sample of disintegrated granite from material proposed for use in rolled fill, before that type of construction was started. This is Job No. 2966; Lab. No. 22871, on which results of consolidation and percolation tests were reported under date of September 6. This report showed a specific gravity of 2.72, and maximum weight per cubic foot under compression in the consolidation test of 133 pounds. At said specific gravity rate, weight of this material if solid would be 169.7 pounds per cubic foot. The highest weight per cubic foot reached in the consolidation test on material approximating in type those used for rolled fill was 145 pounds. This was of course under straight pressure - not tamping - and was under the rate of pressure corresponding to a 225 foot fill. Specific gravity on the sample cited as reaching 145 pounds was 2.77.

As a trial of hand tamping in the laboratory, a 6"x12" brass cylinder was used with vigorous tamping in about one inch layers, using as a tamper a piece of pipe with a flat cap of 2" diameter on the end.

First trial of this method was on a sample of beach material on hand in the laboratory. This gave a weight per cubic foot of 133 pounds.

Moisture content was not determined, but was probably in the vicinity of 10 to 12 per cent of the dry weight. It was sufficient to cause slight quaking under the tamper and a slight forcing out of moisture at the bottom.

On October 27, the writer visited the dam with Paul Beermann to observe the methods in use by the field force in taking the rolled fill samples and computing the weight thereof. For this purpose, a sample was taken in the upstream embankment, which gave a weight of 133 pounds per cubic foot. A second sample taken in the same vicinity gave a similar result. This was in borrow pit material, not disintegrated granite. Hand tamped in the brass cylinder in the method above noted a weight of 129 pounds was obtained. El Capitan office advises moisture content on this sample was not determined. It was a relatively dry sample, with said content probably about 6 per cent of the dry weight.

Mr. Albert ascribed the variations in weight shown in this series of tests, as due both to heavy compaction on portions of the work, as an effect of the trucking operations; and to variations in weight and density of the material itself, especially of the disintegrated granite, which he stated seemed to vary considerably in weight at its original source. On the writer's request for a sample of this latter material to bring back to the laboratory, he obtained a sample from another part of the bank of what he considered as representative of the heaviest material that had been deposited.

This sample is listed in laboratory record as No. 23377. It shows a specific gravity of 2.76. For laboratory use it was broken down to a grain size passing a 1/4" mesh. For producing a suitable moisture content for hand tamping in the brass cylinder, various methods were considered. The percentage adopted (8.9% of the dry weight) was an average of the percentages applying to the 9 samples of disintegrated granite material listed in paragraph 1 above. Due to the wide variation of moisture content among these samples, this does not mean very much, but serves in a way as sort of a standard to work to. Under this procedure a weight of 131 pounds per cubic foot was obtained. Trial with a higher moisture content, yielding some surplus water, gave a slightly higher but not materially different result.

It would seem therefore, in view of the above considerations; that, barring any possible errors in computation on individual samples, the extremely high results are probably due to the heavy compaction referred to; and that, on the other hand, the extremely low results are due to insufficient compaction at the points where taken. The method of computation as practiced by the field force appears to be without error.

JYJ/b J. Y. Jewett

cc 2 encl.

MATERIALS - SAMPLING AND TESTING

REINFORCING STEEL

2-15-35
copy/p

June 21, 1932

From : Resident Engineer

To : Hydraulic Engineer

Subject: : San Diego River Project, El Capitan Feature
Sutherland reinforcing steel

1. The contractor, Mr. T. E. Connolly, together with the contractor's superintendent Ben F. Wells, recently inspected the City's reinforcing steel at Sutherland damsite and orally reported to me that

(1) Size: The size of the steel is somewhat larger than the steel that will be required for the work at the El Capitan dam.

(2) Length: The maximum length of the steel at Sutherland is only 40 feet. Considerable longer lengths than this were contemplated for certain of the steel for the El Capitan dam structures.

(3) Cleaning: All the steel at the Sutherland damsite would have to be thoroughly cleaned probably by sand blasting, to remove the scale and rust.

(4) Road betterment work: There would be required considerable road betterment work to permit the economic hauling of the steel from the damsite to the El Capitan damsite.

All of this combines to make the use of this steel unattractive to the contractor.

2. The Hydraulic Engineer advises that the contractor's superintendent Ben F. Wells stated that he prefers not to use the stock of steel at the Sutherland damsite.

Harold Wood
Resident Engineer

HW/p

June 21, 1932

From : Resident Engineer

To : Hydraulic Engineer

Subject: : San Diego River Project, El Capitan Feature
Sutherland reinforcing steel

1. The contractor, Mr. T. E. Connolly, together with the contractor's superintendent Ben F. Wells, recently inspected the City's reinforcing steel at Sutherland damsite and orally reported to me that

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All of this combines to make the use of this steel unattractive to the contractor.

2. The Hydraulic Engineer advises that the contractor's superintendent Ben F. Wells stated that he prefers not to use the stock of steel at the Sutherland damsite.

Harold Wood
Resident Engineer

HW/p

2-15-35
copy/p

August 5, 1932

From : Hydraulic Engineer

To : Resident Engineer

Subject : El Capitan Dam Installation, reinforcing steel

1. The order placed by the contractor H. W. Rohl and T. E. Connolly, with Pacific Coast Steel Corporation for reinforcing steel for the El Capitan dam job underdrain feature required the shipment from the Los Angeles mill not later than Tuesday August 9.

2. Mr. Bjarne N. Folling of the Pacific Coast Steel Corporation, now in this office, reports having in stock only intermediate reinforcing bars.

3. Mr. Folling further advises that it will not be possible for his corporation to roll the structural type bars and ship them within about two weeks.

4. It is my impression that the contractors' plan is based on having the steel delivered immediately for the underdrains that it may be bent completely before concrete forming is started, which I assume may require delivery before the about three weeks time Mr. Folling indicates may be required before delivery could be assured of the structural type steel.

5. Provided the contractor feels that the delay will materially interfere with his plan of progress of the work it may be dutiful on my part to take responsibility of accepting for this underdrain feature only intermediate type steel.

6. Mr. Folling states that on receiving sufficiently in advance order for structural steel bars, his corporation will be able to furnish specifications type bars.

7. You may reach conclusion on the ground and advise Mr. Folling thereof.

H. N. Savage
Hydraulic Engineer

HNS/f

2-15-35
copy/p

August 8, 1932

Pacific Coast Steel Corporation
725 Pacific Finance Building
Los Angeles, California

Attention Mr. Bjarne N. Folling

Subject: San Diego River Project, El Capitan Feature, diversion tunnel, reinforcing steel for tunnel approach and tunnel outlet and for concrete drains

Gentlemen:

In compliance with your oral request of August 6, 1932, enclosed are prints of drawings WD-390 sheets 1 and 2 of 2, WD-414 and WD-421, San Diego River Project, El Capitan Dam.

Drawing WD-390 Sheets 1 and 2 indicate the general form of steel reinforcing of the tunnel approach and tunnel outlet. Because of the complicated nature of the steel reinforcing, detail drawings showing all steel and bill of material of all steel are being prepared and will be completed about August 10, after which prints will be forwarded to you.

Drawing WD-414 shows the steel in the tunnel section. Because of the simplicity of this steel and arrangement thereof, no further drawings or list of material is contemplated at this time excepting for the tunnel approach transition section. The tunnel is about 1173 feet long between the faces of the portals. The steel is the same in both the timbered section and the sections not timbered.

Drawing WD-421 shows the details for the construction of the concrete drains under the lower rock embankment of the dam and as the steel and its arrangement is not complicated, no further drawings or lists of steel are contemplated.

It is requested that steel details made up by the contractor for El Capitan Dam be furnished the City of San Diego for checking before steel is made up.

Very truly yours,

H. N. Savage
Hydraulic Engineer

HNS/p
encls(4)
Drawings WD-390 Sheets 1 and 2 of 2; WD-414; WD-421
cc-H.W.Rohl and T.E.Connolly, Contractors El Capitan Dam
Harold Wood, Resident Engineer

2-15-35
copy/p

September 10, 1932

Mr. H. N. Savage
Hydraulic Engineer
City of San Diego

Reinforcing steel - El Capitan Dam

Dear Sir:

With reference to supply of reinforcing steel for El Capitan Dam; no mill sheets have as yet been forthcoming on supply furnished for this purpose.

If the manufacturers are unable or unwilling to comply with standard practice in this respect, and furnish the purchaser with the customary mill sheets, showing heat number and chemical composition of the material from which shipment is made, then, in my judgment, the material should not be used on the work.

Yours very truly,

J. Y. Jewett
Testing Engineer

JYJ/b
cc: one enclosed

2-15-35
copy/p

September 20, 1932

Mr. H. N. Savage
Hydraulic Engineer
City of San Diego

Trip to Steel Mill

Dear Sir:

In accordance with your request in telephone conversation of September 14 regarding steel supply of reinforcing bars for El Capitan Dam, a visit was made on September 16 to the steel plant at Los Angeles, from which this supply is coming.

This is the plant of the Pacific Coast Steel Corporation, Subsidiary of Bethlehem Steel Corporation, located on E. Slauson Avenue in the Huntington Park District. A visit was first made to the City Sales Office where Mr. Foling, Sales Manager in charge, was interviewed. This was followed by a visit to the plant, in company with Mr. M. S. Robb, one of his assistants. At the plant, contact was made with Mr. Shuetz, Superintendent of the shipping department, and with Mr. Webster, testing engineer.

In the matter of mill sheets, carrying information as to heat numbers and chemical composition, which were not furnished with the shipments already made; they advise that they do not have a printed form for this purpose, as is customary with other mills with which I have had dealings, and do not furnish this information with shipments except on request. They expressed their readiness to furnish the information when desired, sending it out in letter form from the records of the chemist and the rolling department. They stated that such a letter, covering the recent shipment, was sent to the Resident Engineer at El Capitan the day previous and a copy of the information contained therein was furnished me while there. They advised that this would be furnished as a matter of regular procedure on future orders.

It is understood that this shipment is of the structural-steel grade as called for by the El Capitan specifications, and that a special run was made for this purpose, as their regular output is of the intermediate grade. The rolling mill was not in operation when I was there, but limited operations were under way on other features. Apparently, the principal products of the mill, aside from reinforcing bars, are forgings, and tool steel for oil well machinery.

One item of special note was that their product is made almost entirely from scrap metal, only a small amount of pig iron being used. This would require very close chemical control over the mill operation, to produce a uniform and desirable material, which close control they claim is being exercised. Incidentally, it was noted that railway car wheels were one of the principal items of scrap going into the furnace when I was there. It is noted on looking up A.S.T.M. Specification A 15-14, on which the El Capitan requirements are based, that this does not mention scrap iron as being a prohibitive source of supply, but does state that the bars shall be rolled from new billets, no rerolled material to be accepted. In chemical requirement, this specification places a limit only on phosphorus; but states that percentages of carbon, manganese, and sulphur, shall also be determined on each melt, and reported to the purchaser. Provision is also made for the purchaser to make his own analyses if desired. The phosphorus content as shown on the above mentioned sheet on El Capitan shipment, is well below the limit set in this specification. In the matter of physical tests, it would seem that these should be followed up closely, in view of the above stated course of metal used in the mill, and as perhaps being of more importance in such case, than if pig iron were used.

On the question of inspection service at the mill; it was found that there is no independent inspector stationed there continuously such inspectors being sent out from the City as occasion requires. After your conversation of the 9th, in which you referred to this matter, inquiry was made of the Smith-Emery Co. laboratory as to their facilities for furnishing such service. They were also visited when there on the 16th. They advise that they are doing considerable work of this kind, and have competent inspectors, who could supervise our shipments, and send us samples therefrom if desired. Their charge would be at the rate of two dollars per hour, plus charge for auto service at the rate of 6¢ per mile, on a distance of 14 miles to the plant and return. I judge from remarks in your conversation of yesterday, that you do not consider it necessary to incur this expense, but would like to have confirmation of this, in order to definitely advise Smith-Emery whether we will need their service.

In any case, to properly correlate sampling with mill records, the contractors should advise the Steel Co. when placing further orders, to have all shipments come tagged with mill heat numbers.

6 ________

Visit to Cement Plant

While in that vicinity it seemed desirable to make a visit to the plant of the California Portland Cement Co. at Colton, from which the El Capitan cement supply is coming. This was done on September 17th. Two cars were being loaded for El Capitan while I was there, and from my observation of the personality and methods of our representative, Mr. E.E.Ingold, my impression gained from previous dealings with him, were confirmed that he is of dependable personality, and is handling the work in an efficient manner. There was also the pleasure of renewal of acquaintance with Mr. Hanna, long time chemist at that plant; who gave some interesting information on special work which has been assigned to his company among a group of companies, who are carrying out investigations for the Hoover Dam cement committee.

Enclosed herewith is a memorandum of expense of the trip.

Yours very truly,

J. Y. Jewett
Testing Engineer.

JYJ/b
cc-one enclosed
cc-H. Wood

2-16-35
copy/p

December 3, 1932

Mr. H. N. Savage
Hydraulic Engineer
City of San Diego

Steel Tests - El Capitan Dam

Dear Sir:

Confirming statement by telephone with your office of December 2, samples of reinforcing steel from supply for El Capitan tunnel lining, brought in November 30th, meet specification requirements, except that two specimens were slightly below the low limit and one somewhat above the high limit, on ultimate tensile strength. This is stock from the plant of the Pacific Coast Steel Corporation, Los Angeles, California. Results in detail are as follows:-

Lab.No.	Heat No.	Type	Cross-section sq.in.	Tensile strength lbs. per sq.in. Yield pt.	Ultimate	Elongation in 8" %
19381	4-33 H	1" sq.	1	39,500	61,000	28.1
82	1-274 E	"	specimens not cut suitable length			
83	3-33 H	"	1	39,000	58,500	33.1
84	2-31 HM	"	1	41,000	62,000	30.0
85	3-18 H	"	1	38,000	58,500	34.4
86	3-33 H	"	1	40,000	62,000	31.2
87	1-307 E	"	1	38,000	56,500	33.1
88	1-274 E	"	1	42,000	66,500	28.1
89	2-31 H	"	1	39,500	53,500	33.7
90	3-144 H	"	1	38,000	55,500	31.3
91	3-18 H	"	1	40,500	59,500	30.0
92	3-144 E	"	1	37,500	56,000	31.9
93	1-295 E	"	1	40,000	63,500	31.2
94	2-54 H	"	1	41,000	64,000	29.4
95	1-274 E	3/4"sq.	0.56	37,500	54,400	31.9
96	1-67 HM	"	0.56	42,000	62,500	30.0
97	1-230 E	"	0.56	42,000	60.700	31.3
98	3-58 E	"	0.56	46,500	65,200	28.1
99	1-274 E	"	specimens not cut suitable length			
19400	3-65 H	"	0.56	50.000	72,300	25.6
1	3-16 HM	"	0.56	38,400	56,200	30.6
2	1-230 EM	"	0.56	44,600	65,200	29.4
3	1-67 HM	"	0.56	39,300	59,000	28.8

No bend test specimen received on No. 19394. Bend test on all others O.K.

Yours very truly,

J. Y. Jewett
Testing Engineer

JYJ/b
cc Resident Engineer

2-16-35
copy/p

December 17, 1934

From : Testing Engineer

To : Hydraulic Engineer

Subject : Test of reinforcing steel

Two specimens of reinforcing steel received on December 12th, from supply for the Golden contract at El Capitan, are reported as from stock of the Columbia Steel Co., Torrance plant, furnished locally through the H. G. Fenton Materials Co. These are round deformed bars, structural grade.

Results obtained under test are as follows:

Lab. No.	Job No.	Heat No.	Size	Tensile strength Lbs.per sq. in. Yield Pt.	Ultimate	Percent elongation in 8 in.
23421	3415	22727	7/8"	41300	63300	28.1
22	16	22528	5/8"	39400	60300	24.4

Bend test O.K. on both

J. Y . Jewett

JYJ/b
cc- 1 encl.

DRAINAGE AND SETTLEMENT

April 24, 1933

TO THE HONORABLE, THE MAYOR AND COUNCIL
OF THE CITY OF SAN DIEGO, CALIFORNIA

Subject: San Diego River Project, El Capitan Feature
Observation wells

Gentlemen:

Enclosed is copy of letter dated April 7, 1932 from Mr. Geo. W. Hawley, Deputy State Engineer in Charge of Dams, Department of Public Works, State of California, requesting the City of San Diego to install in the hydraulic fill portion of El Capitan Dam seven observation wells for determining the hydraulic gradient of lines of water saturation within the stability sections of the dam.

These wells may be of particular value during construction and observations made may furnish information that will control the remaining progress or rate of construction of the work.

The cost of installing these observation wells is estimated to be about $350.00 each, or a total of about $2,500.00.

The installation of these wells is not provided for in the schedule items of the contract specifications. According to the provisions of paragraph 14 of the contract specifications the wells may be installed by the contractor as extra work, provided the work order is authorized by the Council.

It is essential that these wells be installed at once, and provision made to install additional lengths of pipe to them as the height of the dam increases.

RECOMMENDATION: It is recommended that the Hydraulic Engineer be authorized to issue an extra work order to the contractor under paragraph 14 of the contract specifications for the installation of seven observation wells in the hydraulic fill at El Capitan Dam.

Respectfully

H. N. Savage
Hydraulic Engineer

HNS/p
encl. Copy letter Geo. W. Hawley 4-7-33
cc City Manager
City Attorney

9/13/34
copy /f

July 19, 1933

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Movements of dam

1. On July 19, 1933 measurements were made on monuments set on upstream and downstream slopes of El Capitan Dam. The measurements were made by transit, steel tape and level and are tabulated below:

POINT NO.	LOCATION N	LOCATION E	MOVEMENT HORIZONTAL Amount feet	MOVEMENT HORIZONTAL Direction	MOVEMENT VERTICAL Amount feet	MOVEMENT VERTICAL Direction
1	3620	4514.42	.03	west	.02	down
2	3620	4600	.04	"	.10	"
3	3500	4650	.15	"	.33	"
4	3605	4650	.20	"	.34	"
5	3740	4650	.13	"	.21	"
6	3660	5332	.05	east	.05	"
7	3660	5412	.00	--	.04	"

Point 1 is on top of downstream toe wall.

Point 7 is on top of upstream toe wall.

Harold Wood
Resident Engineer

HW/p

9/13/34
copy /f

October 25, 1933

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock Embankments - movements of dam

1. On July 19, 1933 a letter was sent the Hydraulic Engineer by the Resident Engineer giving movement measurements of El Capitan Dam made June 14, 1933.

2. There is here given the movement measurements on El Capitan dam made October 11, 1933:

LOCATION			TOTAL MOVEMENT IN FEET	
Point	North	East	Horizontal	Vertical
1	3620	4514	.04 south	-
2	3620	4600	.03 north	.17 down
3	3500	4650	.20 north .27 west	.44 down
4	3605	4650	.18 north .34 west	.49 down
5	3740	4650	.13 north .24 west	.36 down
6	3660	5493	.08 north .25 east	
7	3660	5418	.19 north .17 east	.12 down

Point 1 is on top of downstream toe wall
" 2 " " elevation 600 downstream berm
" 3, 4, and 5 are on rock embankment sprinkled
" 6 is on top of upstream toe wall
" 7 is on elevation 600 upstream berm

Harold Wood
Resident Engineer

HW/P

9/13/34
copy /f

January 15, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock embankments - movements of dam

1. On July 19, 1933 and again on October 25, 1933, letters were addressed to the Hydraulic Engineer giving movement measurements on El Capitan dam made June 14, 1933 and October 11, 1933 respectively.

2. The following are movements measured on El Capitan dam January 15, 1934:

Point No.	Location	Coordinates North	Coordinates East	Total Movement (feet) Horizontal	Total Movement (feet) Vertical
1	Top downstream toe wall	3620	4514	0.04 south	0.01-
2	Center downstream 600 berm	3620	4600	0.10 west	0.17-
6	Top stream toe wall	3660	5493	0.25 east	0.00
7	Center upstream 600 berm	3660	5412	0.20 east	0.20-
8	Center upstream 650 berm	3618	5276	0.01 east	0.17-
9	Center downstream 650 berm	3589	4731	0.01 west	0.10-

3. Points 8 and 9 were set October 11, 1933.

Harold Wood
Resident Engineer

HW/P

9/13/34
copy /f

February 14, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Movements in dam

1. On February 3, 1934, three bench marks were established on the upstream rock embankment at about elevation 700, and three bench marks were established on the downstream rock embankment of El Capitan dam at about the same elevation.

2. On February 13, 1934 the elevations on these bench marks showed settlement as follows:

Downstream rock embankment

Northing of B.M.	Elevation February 13	Elevation February 3	Settlement feet
N 3320	700.18	700.20	.02
N 3570	699.80	699.82	.02
N 3770	700.85	700.88	.03

Upstream rock embankment

N 3330	701.28	701.26	.02
N 3620	704.27	704.25	.02
N 3860	704.24	704.22	.02

Harold Wood
Resident Engineer

HW/P

9/13/34
copy /f

March 1, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock embankments - movements of dam

1. On June 14, 1933, October 11, 1933, January 15, 1934 and February 26, 1934, measurements were made to monuments established at several places on the rock embankments of El Capitan dam to indicate movements of the dam.

2. The movements measured on February 26, 1934 are as follows:

Point	Location	Coordinates N	Coordinates E	Total Movement Horizontal Feet	Total Movement Vertical Feet
1	Top downstream toe wall	3620	4514	0.04 south	0.01-
2	Center downstream 600 berm	3620	4600	0.11 west	0.17-
6	Top upstream toe wall	3660	5493	0.08 east	0.00-
7	Center upstream 600 berm	3660	5412	0.21 east	0.20-
8	Center upstream 650 berm	3618	5276	0.01 east	0.19-
9	Center downstream 650 berm	3589	4731	0.02 west	0.11-

3. On February 3, 1934, three bench marks were established on each the rock embankments about elevation 700. On February 26, 1934 the elevation of these bench marks showed total settlement as follows:

Northing of B.M.	Total settlement feet
Downstream rock embankment	
3320	0.05
3570	0.06
3770	0.05
Upstream rock embankment	
3330	0.04
3620	0.05
3860	0.05

Harold Wood
Resident Engineer

HW/p

9/13/34
copy /f

March 13, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock embankment, movement of

1. On March 12, 1934 elevations were taken on the bench marks established February 3, 1934 on the rock embankment of El Capitan dam near elevation 700 and showed the total settlement as follows:

Northing of B.M.	Elevation February 3	Elevation March 12	Settlement Feet
Upstream rock embankment			
N 3330	701.26	701.21	0.05
N 3620	704.25	704.61	- 0.36
N 3860	704.22	704.18	0.04
Downstream rock embankment			
N 3320	700.20	700.13	0.07
N 3570	699.82	699.75	0.07
N 3770	700.88	700.82	0.06

The point at N 3620 on the upstream embankment evidently was disturbed because it shows a rise.

2. On June 14, 1933 measurements were made to monuments located in the dam. Measurements were again made on March 12, 1934 and the movements are as follows:

Point No.	Location	Coordinates N	Coordinates E	Total movement Horizontal Feet	Total movement Vertical Feet
1	Top downstream toe wall	3620	4514	0.04 SW	0.01-
2	Center downstream 600 berm	3620	4600	0.11 west	0.17-
6	Top upstream toe wall	3660	5493	0.25 east	0.00
7	Center upstream 600 berm	3660	5412	0.21 east	0.21-
8	Center upstream 650 berm	3618	5276	0.01 east	0.20-
9	Center downstream 650 berm	3589	4731	0.03 west	0.12-

Points 8 and 9 were set October 11, 1933.

Harold Wood
Resident Engineer

HW/p

9/13/34
copy /f

May 11, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock embankment - movement of

1. On June 14, 1933 measurements were made to monuments located in the El Capitan dam. Measurements were made to monuments 8 and 9 on October 11, 1933.

2. The following tabulation shows total movement in these monuments since they were set. Measurements were made on April 20, 1934.

Point No.	Location	Coordinates N	Coordinates E	Total movement Horizontal Feet	Total movement Vertical Feet
1	Top downstream toe wall	3620	4514	0.05	0.01
2	Center downstream 600 berm	3620	4600	0.11 west	0.18
6	Top upstream toe wall	3660	5493	0.25 east	0.00
7	Center upstream 600 berm	3660	5412	0.22 east	0.20
8	Center upstream 650 berm	3618	5276	0.01 east	0.22
9	Center downstream 650 berm	3589	4731	0.03 west	0.12

Harold Wood
Resident Engineer

HW/P

9/13/34
copy /f

July 27, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock embankment - movement

1. Measurements made on July 20, 1934, on monuments in the rock embankment at El Capitan dam showed no changes in lateral position or elevation since April 20, 1934, except as follows:

2. Monument 10, set June 18, 1934, at elevation 701.37 and at about the center of the length of the upstream rock embankment, did not move laterally but settled 0.03 foot.

Harold Wood
Resident Engineer

HW/p

9/13/34
copy /f

August 9, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock embankment - movement of

1. Measurements made on monuments located in El Capitan dam rock embankment are here tabulated:

Point No.	Location	Coordinates N	E	Total movement Horizontal Feet	Vertical Feet
1	Top downstream toewall	3620	4514	0.05 west	0.03
2	Center downstream 600 berm	3620	4600	0.11 "	0.19
6	Top upstream toewall	3660	5493	0.25 east	0.01
7	Center upstream 600 berm	3660	5412	0.22 "	0.20
8	Center upstream 650 berm	3618	5276	0.03 "	0.28
9	Center downstream 650 berm	3589	4731	0.04 west	0.18
10	Center upstream embankment 700			0.00	0.21

2. Similar measurements were reported May 11, 1934.

Harold Wood
Resident Engineer

HW/p

September 14, 1934

From : Acting Resident Engineer

To : Hydraulic Engineer

Subject: San Diego River Project, El Capitan Feature
Rock embankment - movement of

1. Measurements made on monuments located in El Capitan dam rock embankment are here tabulated:

Point No.	Location	Coordinates N	Coordinates E	Total movement Horizontal Feet	Total movement Vertical Feet
1	Top Downstream toewall	3620	4514	0.05 west	0.03
2	Center downstream 600 berm	3620	4600	0.11 "	0.19
6	Top upstream toewall	3660	5493	0.25 east	0.02
7	Center upstream 600 berm	3660	5412	0.25 "	0.21
8	Center upstream 650 berm	3618	5276	0.13 "	0.35
9	Center downstream 650 berm	3589	4731	0.12 west	0.19
10	Center upstream 700 berm	3648	5146	0.06 east	0.43
11	Center upstream 700 berm	3309	5146	0.02 "	0.03
12	Center upstream 700 berm	3897	5146	0.03 "	0.09
13	Center downstream 700 berm	3305	4842	0.02 west	0.03
14	Center downdtream 700 berm	3560	4842	0.01 east	0.07
15	Center downstream 700 berm	3767	4842	0.00	0.00

2. Points No. 11, 12, 13 and 14 set September 1, 1934; Point No. 15 set September 12, 1934.

3. Similar measurements were reported August 9, 1934.

J. W. Williams
Acting Resident Engineer

JWW/f

2-28-35
copy/p

December 22, 1934

From : Resident Engineer

To : Hydraulic Engineer

Subject : El Capitan Dam, water test wells

Following the State Engineer's request, the City's water elevation test wells at El Capitan Dam were cleaned by sand pumping by J. W. Brannon, well digger. Cleaning operations were started December 8 and completed December 18, 1934.

Well No.	Original depth below top of casing feet	Depth cleaned below top of casing feet
1	111	95
3	197	casing closed by rock
5	155	137
6	143	117

J. W. Williams
Resident Engineer

JWW/f

MOVEMENT OF DAM EMBANKMENTS

Between June 14 and October 11, 1933, seven permanent points were set on the rock embankments of the dam for the purpose of measuring and recording the amount of settlement and lateral movement of the various portions of the structure.

On October 1, 1934 the State Engineer required that the number of permanent points be increased to about 75 and that daily measurements be furnished him. The rock embankments were then at elevation about 745, the puddle core at elevation 747.5 and the rolled fill at elevation 750. After December 1, 1934, readings were taken at ten day intervals.

After the embankment was completed, ten three-inch pipes ten feet long, were placed along the top of the dam near the center line, with the top of the pipe about three inches below the top of the dam. These three inch pipes were cleaned out and one and one-half inch pipes, twenty feet long, were placed inside each of the three inch pipes so that their tops were below the top of the three inch pipe. Both pipes were capped. Measurements were taken to determine the horizontal and vertical movement of each pipe.

In construction, allowance was made for 1-1/2 per cent settlement, which was computed on the basis of depth of structure above foundation directly below the point in question. This resulted in the top of the dam being at elevation 773 directly over the San Diego River channel and sloping to elevation 770 at the abutments.

The following tabulation gives the location of the different points, the date set, the amount of settlement and the classification and depth of the material under the points.

When all the measurements taken to determine settlement and lateral movement of the various portions of the embankment were plotted, they indicated there had been remarkably little eratic movement of the embankment.

The following prints of three graphs show the movement of the monuments at various levels on the upstream and downstream rock embankments since October 1, 1934; also the progress in the construction of the embankments; the rainfall since February 1, 1934 and the elevation of the water surface in the reservoir.

The points on the upstream rock embankment moved both downward and outward more than the points on the downstream embankment.

As the elevation of the water surface increased from 580 to 600, there was a very noticeable increase in the settlement and lateral movement of the points on the upstream embankment.

This was probably due to the plane of saturation being raised in the upstream portion of the dam.

3-20-35
copy/p

MOVEMENT OF DAM EMBANKMENTS

Point No.	Coordinates North	East	Original Elevation	Date Set	Movement Horiz.	Vert.	Material Class	Depth Feet	
			UPSTREAM ROCK EMBANKMENT						
	Toe Wall (x)								
1	3560	5500	574.98	10-9-34	.0	.01+	concrete	45	
2	3660	5492.97	574.99	6-15-33	.08E	.0	"	44	
3	3760	5503	574.95	10-9-34	.0	.01+	"	38	
	600 berm (xx)								
1	3540	5411.89	600.28	10-3-34	.12E	.06-	rock	51	
2	3660	"	600.99	6-15-33	.44E	.39-	"	51	
3	3790	"	600.68	10-3-34	.06E	.04-	"	49	
	625 elevation								
1	3500	5343.2	626.29	10-4-34	.25E	.39-	"	74	
2	3630	"	625.52	10-4-34	.33E	.38-	"	78	
3	3760	"	626.38	10-4-34	.29E	.35-	"	78	
4	3890	"	625.07	10-4-34	.16E	.22-	"	53	
	650 berm								
1	3390	5275.92	650.76	10-2-34	.19E	.24-	"	59	
2	3500	"	651.25	9-27-34	.32E	.42-	"	101	
3	3618.09	"	651.33	10-11-33	.55E	.82-	"	102	
4	3740	"	650.29	10-24-34	.27E	.40-	"	104	
5	3860	"	650.51	9-27-34	.18E	.31-	"	92	
	675 elevation						Rock	Earth	Rock
1	3290	5208.2	675.34	10-3-34	.21E	.12-	42	18	
2	3410	"	675.01	10-3-34	.39E	.38-	42	27	27
3	3520	"	675.96	10-3-34	.44E	.42-	42	27	58
4	3630	"	676.46	10-3-34	.51E	.46-	42	28	58
5	3740	"	675.94	10-4-34	.54E	.60-	42	28	59
6	3850	"	675.37	10-4-34	.42E	.77-	42	28	50
7	3970	"	675.81	10-4-34	.23E	.19-	43	14	
	700 elevation								
1	3200	5146	696.75	10-2-34	.13E	.09-	24	26	
2	3309	"	697.86	9-1-34	.26E	.33-	25	64	
3	3420	"	698.93	10-2-34	.42E	.43-	25	105	
4	3535	"	699.51	10-2-34	.48E	.51-	25	125	11
5	3648	"	701.34	7-19-34	.46E	1.12-	27	115	9
6	3780	"	702.67	10-2-34	.66E	.63-	28	115	8
7	3897	"	703.88	9-1-34	.67E	.71-	30	74	
8	4020	"	705.59	10-2-34	.30E	.17-	33	24	
	725 elevation								
1	3190	5098	727.03	10-28-34	.09E	.17-	15	58	
2	3310	"	726.83	10-28-34	.12E	.37-	15	114	
3	3430	"	725.81	10-28-34	.16E	.55-	14	154	
4	3540	"	727.60	10-28-34	.18E	.65-	15	175	
5	3650	"	727.86	10-26-34	.21E	.73-	15	172	
6	3760	"	726.73	10-26-34	.27E	.72-	14	163	
7	3880	"	726.65	10-26-34	.30E	.55-	15	131	
8	4000	"	725.94	10-26-34	.13E	.21-	15	52	

E = movement upstream
- = movement down
+ = movement up

(x) Last reading 12-31-34, just before being submerged
(xx) Last reading 2-9-35, just before being submerged
All other readings to 3-11-35

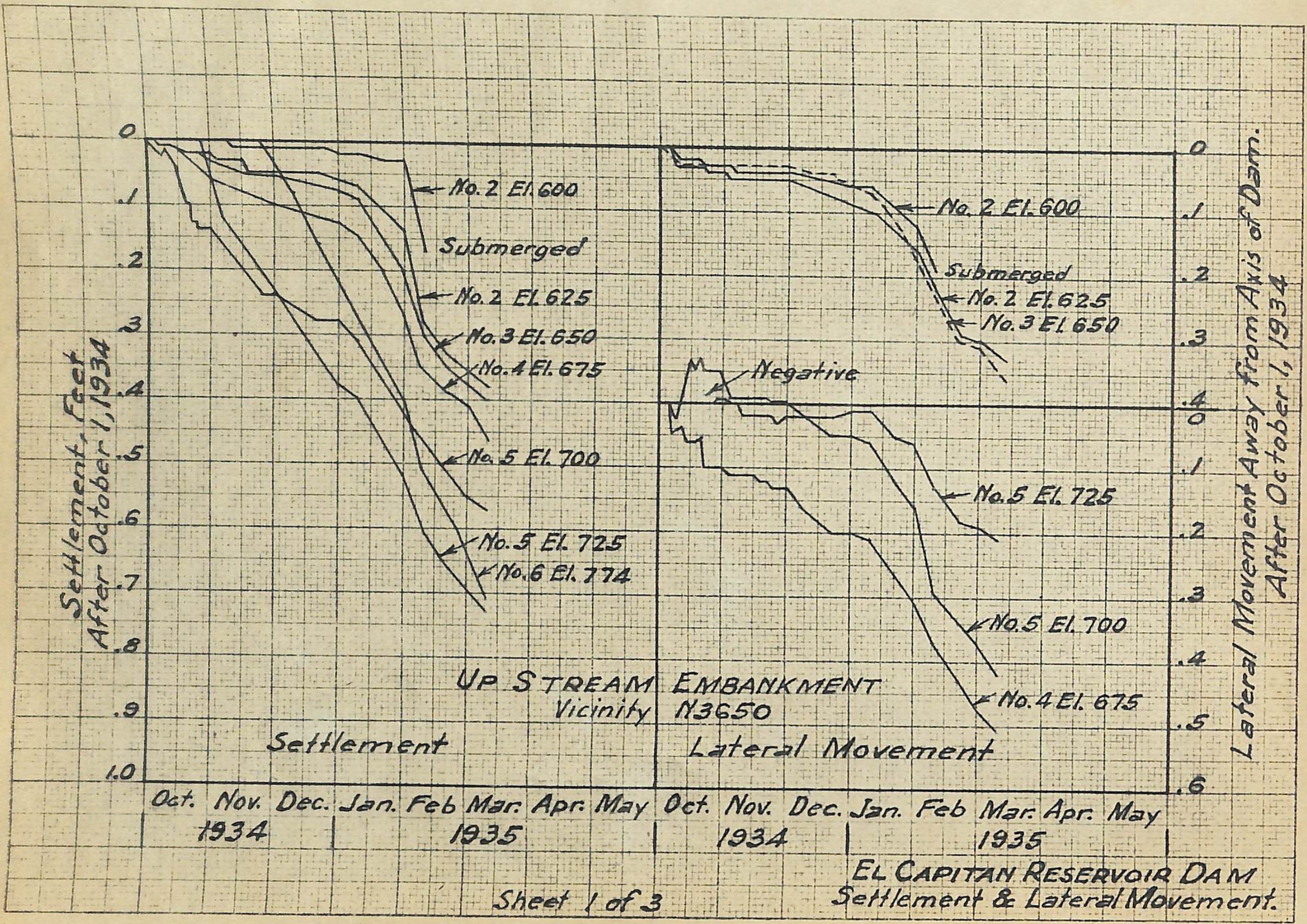
Point No.	Coordinates North	Coordinates East	Original Elevation	Date Set	Movement Horiz.	Movement Vert.	Material		

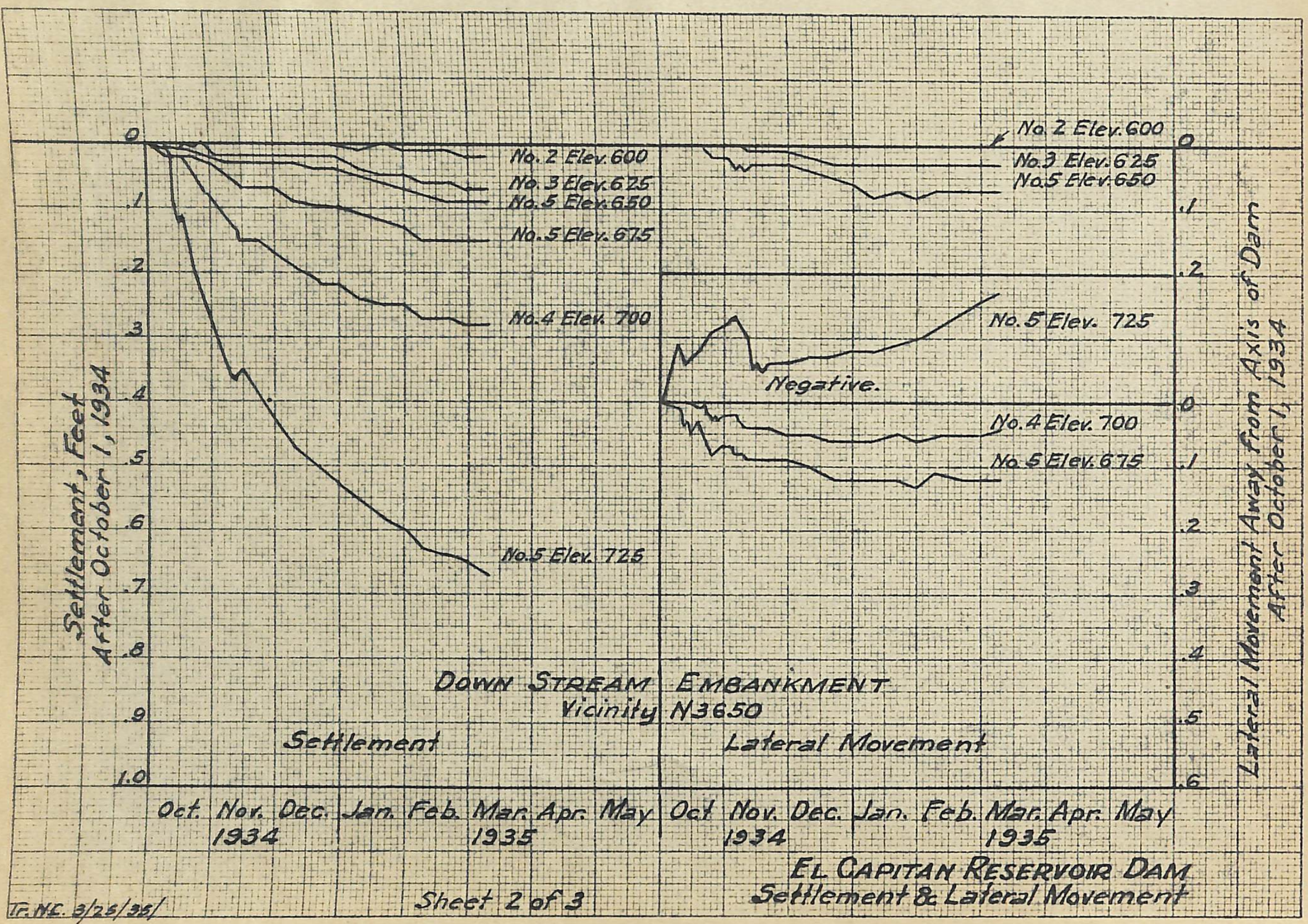
DOWNSTREAM ROCK EMBANKMENT

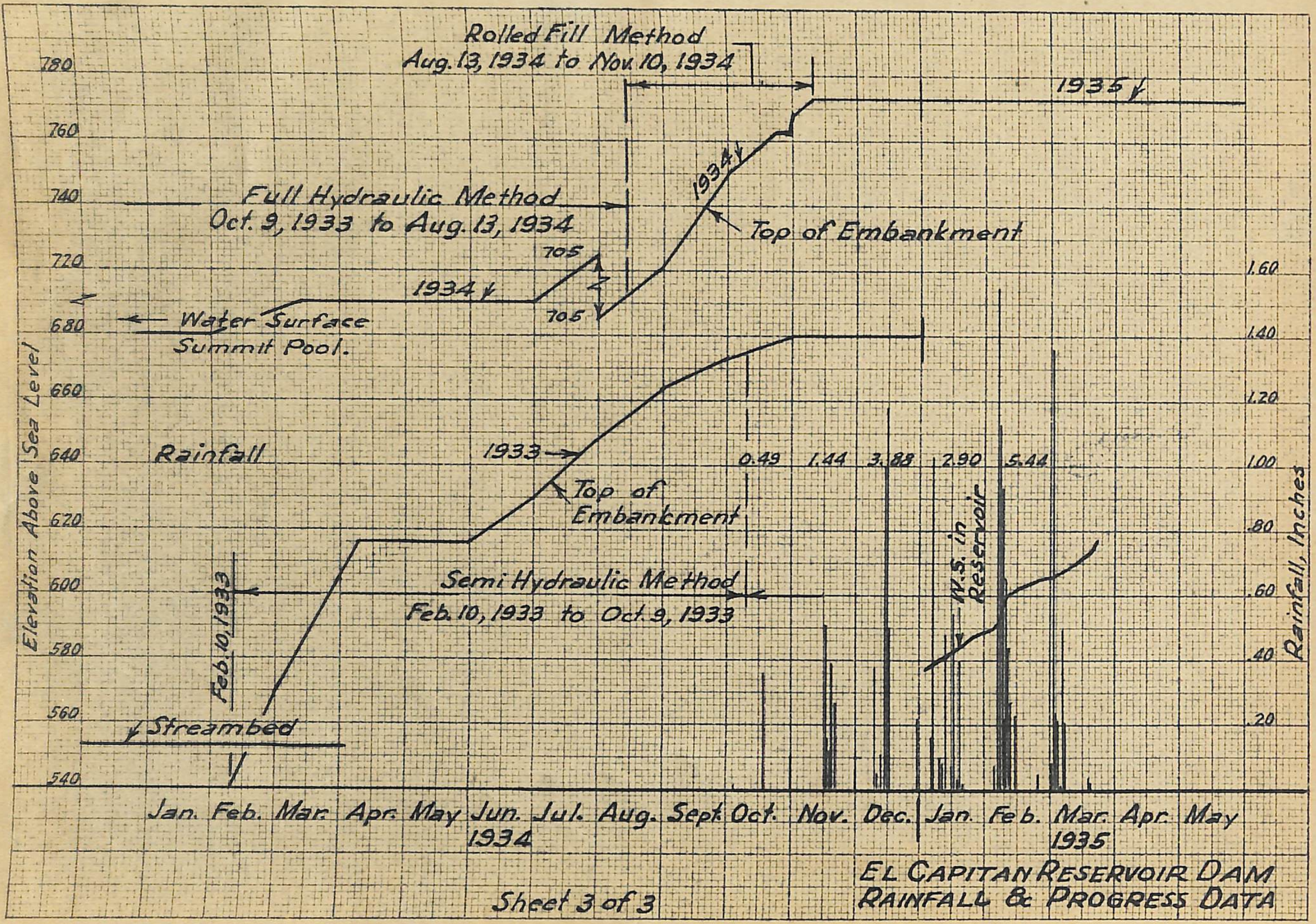
Point No.	North	East	Original Elevation	Date Set	Horiz.	Vert.	Material		
	Toe Wall								
1	3505	4502	575.01	10-8-34	.02W	.01+	concrete	45 feet	
2	3619.77	4514.42	575.02	6-14-33	.05W	.01-	"	43 "	
3	3740	4502	574.90	10-8-34	.02W	.01+		38 "	
	600 berm						Rock	Earth	Rock
1	3480	4597.6	600.67	10-2-34	.03W	.01-	27		
2	3619.8	"	600.86	6-14-33	.12W	.22-	62		
3	3740	"	601.48	10-2-34	.01W	.01-	53		
	625 elevation								
1	3475	4664.4	625.48	10-4-34	.01W	.04-	57		
2	3535	"	625.72	10-4-34	.04W	.06-	79		
3	3650	"	626.39	10-4-34	.03W	.07-	81		
4	3775	"	626.48	10-4-34	.0	.07-	63		
	650 berm								
1	3300	4730.55	650.36	10-2-34	.03W	.03-	26	1	
2	3400	"	650.59	10-2-34	.10W	.07-	26	34	
3	3500	"	650.05	9-28-34	.11W	.09-	25	71	
4	3589.31	"	651.06	10-11-33	.28W	.30-	25	80	
5	3670	"	651.06	10-2-34	.07W	.09-	25	79	1
6	3750	"	650.81	9-28-34	.08W	.09-	25	63	
7	3850	"	650.44	10-2-34	.05W	.04-	26	20	
	675 elevation								
1	3270	4787	675.93	10-3-34	.06W	.04-	25	15	
2	3370	"	675.24	10-3-34	.11W	.13-	24	61	
3	3470	"	675.75	10-3-34	.15W	.15-	24	96	
4	3570	"	676.25	10-3-34	.15W	.16-	25	100	
5	3670	"	676.94	10-3-34	.12W	.15-	24	96	
6	3770	"	675.58	10-3-34	.10W	.14-	24	78	
7	3870	"	675.31	10-3-34	.07W	.08-	25	18	
	700 berm								
1	3305	4842	701.29	9-1-34	.12W	.27-	20	66	
2	3430	"	701.86	10-2-34	.08W	.29-	20	122	
3	3560	"	702.37	9-1-34	.04W	.55-	20	128	
4	3665	"	701.88	10-2-34	.04W	.29-	20	129	
5	3767	"	701.64	9-12-34	.10W	.29-	19	105	
6	3870	"	701.07	10-2-34	.10W	.10-	20	40	
	725 elevation								
1	3250	4897	727.67	10-3-34	.05E	.32-	14	72	
2	3360	"	727.73	10-3-34	.14E	.57-	12	140	
3	3470	"	727.57	10-3-34	.19E	.69-	12	164	
4	3570	"	726.26	10-3-34	.16E	.72-	11	164	
5	3670	"	726.70	10-3-34	.15E	.67-	11	163	
6	3770	"	724.23	10-3-34	.10E	.54-	10	140	
7	3880	"	724.09	10-3-34	.01W	.24-	10	74	

W = movement downstream
\- = movement down
\+ = movement up

Point No.	Coordinates North	Coordinates East	Depth feet fill	Movement 1-1/2" inside pipe Horiz.	Movement 1-1/2" inside pipe Vert.	Movement 3" outside pipe Vert.
				TOP OF DAM		
1	3110	5000	83	.03E	.18-	.17-
2	3220	"	150	.09E	.35-	.34-
3	3340	"	199	.17E	.51-	.51-
4	3460	"	245	.21E	.62-	.62-
5	3560	"	246	.24E	.69-	.68-
6	3660	"	245	.29E	.71-	.71-
7	3760	"	236	.32E	.70-	.69-
8	3860	"	177	.29E	.62-	.62-
9	3960	"	108	.23E	.46-	.46-
10	4060	"	66	.12E	.17-	.17-


Settlement, Feet
After October 1, 1934
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
No. 2 El. 600
Submerged
No. 2 El. 625
No. 3 El. 650
No. 4 El. 675
No. 5 El. 700
No. 5 El. 725
No. 6 El. 774
Settlement
Up Stream Embankment
Vicinity N3650
Lateral Movement
Negative
Lateral Movement Away from Axis of Dam.
After October 1, 1934
Oct. Nov. Dec. Jan. Feb Mar. Apr. May
1934
1935
El Capitan Reservoir Dam
Settlement & Lateral Movement.
Sheet 1 of 3


Settlement, Feet
After October 1, 1934
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
No. 2 Elev. 600
No. 3 Elev. 625
No. 5 Elev. 650
No. 5 Elev. 675
No. 4 Elev. 700
No. 5 Elev. 725
Settlement
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May
1934
1935
DOWN STREAM EMBANKMENT
Vicinity N3650
Lateral Movement
Negative.
No. 2 Elev. 600
No. 3 Elev. 625
No. 5 Elev. 650
No. 5 Elev. 725
No. 4 Elev. 700
No. 5 Elev. 675
Oct Nov. Dec. Jan. Feb. Mar. Apr. May
1934
1935
Lateral Movement Away From Axis of Dam
After October 1, 1934
EL CAPITAN RESERVOIR DAM
Settlement & Lateral Movement
Sheet 2 of 3
Tr. N.C. 3/25/35/



KEUFFEL & ESSER CO., N. Y. NO. 359-11
20 × 20 to the inch.
Rolled Fill Method
Aug. 13, 1934 to Nov. 10, 1934
1935
Full Hydraulic Method
Oct. 9, 1933 to Aug. 13, 1934
1934
Top of Embankment
705
705
1934
Water Surface
Summit Pool.
1933
Top of Embankment
Rainfall
Semi Hydraulic Method
Feb. 10, 1933 to Oct. 9, 1933
Feb. 10, 1933
Streambed
W.S. in Reservoir
0.49
1.44
3.88
2.90
5.44
Elevation Above Sea Level
780
760
740
720
680
660
640
620
600
580
560
540
Rainfall, Inches
1.60
1.40
1.20
1.00
.80
.60
.40
.20
Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sept. Oct. Nov. Dec.
1934
Jan. Feb. Mar. Apr. May
1935
Sheet 3 of 3
EL CAPITAN RESERVOIR DAM
RAINFALL & PROGRESS DATA