

RED ROCK CONSULTING

November 5, 2019

SRB
100 Northeast 5th Street
Oklahoma City, Oklahoma 73104

Attention: Mr. Greg Allen, PE

Re: Addendum to Report of Geotechnical Investigation
Embankment Analysis
State Highway 29 West – Phase I
Stephens County, Oklahoma
29657(04)
Project No. 18029

Dear Mr. Allen,

This addendum provides the results of the additional settlement analysis at stations 752+00 and 868+00, which were requested for this project by ODOT. All recommendations in the Red Rock Consulting report number 18029, dated December 5, 2018, remain valid.

ADDITIONAL FOUNDATION SOIL SETTLEMENT ANALYSIS

Additional settlement analysis was performed for the foundation materials of the proposed embankment sections at the two locations with the most significant settlement, stations 752+00 and 868+00. The initial analysis included a limited number of DMT and one-dimensional consolidation test results. The test results were used to estimate settlement as outlined in the report. No further testing has been performed.

Embankment foundation soil settlement estimated from the DMT results was shown in the original report. The results from the original report for stations 752+00 and 868+00 are shown again in Table 1 for reference.

Table 1 – Foundation Soil Settlement Analysis Using DMT Results

Borings / Soundings	Station	S _{total} (inches)	Depth Analyzed (feet)
EW-8, EW-9 / DW-5	752+00	25.6	49.5
EW-14 / DW-8	868+00	22	55

The time rate of settlement was initially calculated using an assumption of drainage in the vertical direction only. For the additional settlement analysis, the original one-dimensional settlement calculations and the time rate of settlement calculations were re-evaluated using both vertical and horizontal drainage conditions. Furthermore, Settle 3D, finite element analysis software for settlement and consolidation, was used to evaluate the same conditions. The software was used to evaluate several different scenarios, including different methods for distributing the stress on the foundation soil from the embankment load.

The time required for soil settlement was evaluated using two different approaches: the time required to achieve enough of the total settlement so that only 1 inch or less settlement remains over time and the time required to achieve 90 and 95 percent of the total settlement in all layers. These approaches were used with vertical drainage only and with both vertical and horizontal drainage conditions. Actual conditions at this project site will most closely resemble the results using the combined vertical and horizontal drainage condition. Table 2 on the following page summarizes the results of the original and the additional settlement analysis using the consolidation test results.

Table 2 - Foundation Soil Settlement Analysis Using 1D Consolidation Test Results

Borings / Soundings	Station	Consolidation Testing / Traditional Settlement Equations					Consolidation Testing / Settle 3D Program					
		Stotal (inches)	Depth Analyzed (feet)	Time Required to Reach*			Stotal (inches)	S _{total} Settlement to Occur During Construction (inches)	Depth Analyzed (feet)	Time Required to Reach*		
				≤ 1" Settlement (days)	90% Settlement (days)	95% Settlement (days)				≤ 1" Settlement (days)	90% Settlement (days)	95% Settlement (days)
EW-8, EW-9 / DW-5	752+00											
original - verticle drainage only		21.5	51	960	n/a	1,270	n/a	n/a	n/a	n/a	n/a	n/a
revised - vertical drainage only		8.3	51	550	1,496	1,992	13.6	5.6	51	1,426	1,170	1,736
vertical and horizontal drainage		8.3	51	135	374	498	13.6	9	51	138	102	187
EW-14 / DW-8	868+00											
original - verticle drainage only		17.2	55	950	n/a	965	n/a	n/a	n/a	n/a	n/a	n/a
revised - vertical drainage only		5.9	55	250	468	623	7.8	4.3	55	235	291	455
vertical and horizontal drainage		5.9	55	60	117	156	7.8	6.4	55	14	27	63

*Time required is the amount of time required after embankment construction is complete

At station 752+00, **up to 13.6 inches of total settlement** can be expected. An estimated 9 inches of the 13.6 inches of total settlement is anticipated to occur during the embankment construction, which was estimated to be completed in 35 days. **The embankment should be allowed to settle for at least 140 days following completion of the embankment construction.** If all ODOT specifications for fill placement and compaction are followed, 1 inch (or less) of settlement can be expected. If the foundation materials are not allowed to consolidate under the load of the embankment material, anywhere from 0 to 13.6 inches of settlement can be expected in various areas and at various rates.

At station 868+00, **up to 7.8 inches of total settlement** can be expected. An estimated 6.4 inches of the 7.8 inches of total settlement is anticipated to occur during the embankment construction, which was estimated to be completed in 45 days. **The embankment should be allowed to settle for at least 30 days following completion of the embankment construction.** If all ODOT specifications for fill placement and compaction are followed, 1 inch (or less) of settlement can be expected. If the foundation materials are not allowed to consolidate under the load of the embankment material, anywhere from 0 to 7.8 inches of settlement can be expected in various areas and at various rates.

Refer to the original report, Red Rock Consulting report number 18029, dated December 5, 2018, for more information regarding the embankment analysis as well as design and construction considerations.

In an effort to provide a more environmentally friendly service, this addendum has been provided electronically.

It has been our pleasure to assist you with this project. Should you have any questions regarding the contents of this report, please contact Red Rock Consulting.

Yours very truly,

RED ROCK CONSULTING, LLC

CA No. 5707 Exp. 06/30/21



Kristi K. Bumpas, PE, LEED AP
President / Project Engineer
Oklahoma PE No. 23667



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18029 SH 29 West - Phase I Embankment Analysis
752+00 (Single Drainage)

Settlement

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
0 - 4 feet	Layer	95	1.129	36.1	0.33	0.02
OCR > 1 OVERCONSOLIDATED	Sandy Silty Clay	90	0.848	27.1	0.31	0.03
po = 230	0 - 4	85	0.684	21.9	0.29	0.05
Δp = 1500 (I _n =I _n =0.5)		80	0.565	18.1	0.27	0.07
pc = 2500	Hc= 4 ft	75	0.477	15.3	0.26	0.09
po + Δp = 1730	Hd= 4 ft	70	0.405	13.0	0.24	0.10
	cv= 0.5 ft ² /day	65	0.342	10.9	0.22	0.12
Hc = 4		60	0.287	9.2	0.21	0.14
Cr = 0.015		55	0.238	7.6	0.19	0.15
Cc = 0.225	Est S = 0.34 inches	50	0.197	6.3	0.17	0.17
eo = 0.84		45	0.159	5.1	0.15	0.19
		40	0.126	4.0	0.14	0.21
		35	0.096	3.1	0.12	0.22
		30	0.071	2.3	0.10	0.24
If po + Δp > pc		25	0.049	1.6	0.09	0.26
S = -0.044419 feet = -0.533 inches		20	0.031	1.0	0.07	0.27
		15	0.018	0.6	0.05	0.29
If po + Δp < or = pc		10	0.008	0.3	0.03	0.31
S = 0.0285756 feet = 0.3429 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
4 - 10 feet	Layer	95	1.129	193.5	1.13	0.06
OCR > 1 OVERCONSOLIDATED	Lean Clay with Sand	90	0.848	145.4	1.07	0.12
po = 820	4 - 10	85	0.684	117.3	1.01	0.18
Δp = 1500 (I _n =I _n =0.5)		80	0.565	96.9	0.95	0.24
pc = 4840	Hc= 6 ft	75	0.477	81.8	0.89	0.30
po + Δp = 2320	Hd= 6 ft	70	0.405	69.4	0.83	0.36
	cv= 0.21 ft ² /day	65	0.342	58.6	0.77	0.42
Hc = 6		60	0.287	49.2	0.71	0.48
Cr = 0.065		55	0.238	40.8	0.65	0.53
Cc = 0.289	Est S = 1.19 inches	50	0.197	33.8	0.59	0.59
eo = 0.78		45	0.159	27.3	0.53	0.65
		40	0.126	21.6	0.48	0.71
		35	0.096	16.5	0.42	0.77
		30	0.071	12.2	0.36	0.83
If po + Δp > pc		25	0.049	8.4	0.30	0.89
S = -0.14217 feet = -1.706 inches		20	0.031	5.3	0.24	0.95
		15	0.018	3.1	0.18	1.01
If po + Δp < or = pc		10	0.008	1.4	0.12	1.07
S = 0.0989623 feet = 1.1875 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
10 - 15 feet	Layer	95	1.129	88.2	0.59	0.03
OCR > 1 OVERCONSOLIDATED	Sandy Lean Clay	90	0.848	66.3	0.56	0.06
po = 1500	10 - 15	85	0.684	53.4	0.53	0.09
Δp = 1495 (I _n =I _n =0.499)		80	0.565	44.1	0.50	0.12
pc = 2500	Hc= 5 ft	75	0.477	37.3	0.46	0.15
po + Δp = 2995	Hd= 5 ft	70	0.405	31.6	0.43	0.19
	cv= 0.32 ft ² /day	65	0.342	26.7	0.40	0.22
Hc = 5		60	0.287	22.4	0.37	0.25
Cr = 0.014		55	0.238	18.6	0.34	0.28
Cc = 0.175	Est S = 0.62 inches	50	0.197	15.4	0.31	0.31
eo = 0.6307		45	0.159	12.4	0.28	0.34
		40	0.126	9.8	0.25	0.37
		35	0.096	7.5	0.22	0.40
		30	0.071	5.5	0.19	0.43
If po + Δp > pc		25	0.049	3.8	0.15	0.46
S = 0.0516215 feet = 0.6195 inches		20	0.031	2.4	0.12	0.50
		15	0.018	1.4	0.09	0.53
If po + Δp < or = pc		10	0.008	0.6	0.06	0.56
S = 0.012891 feet = 0.1547 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
15 - 25 feet	Layer	95	1.129	752.7	2.56	0.13
OCR > 1 OVERCONSOLIDATED	Lean Clay (Very Soft)	90	0.848	565.3	2.42	0.27
po = 2400	15 - 25	85	0.684	456.0	2.29	0.40
Δp = 1445 (I _n =I _n =0.49)		80	0.565	376.7	2.15	0.54
pc = 3000	Hc= 10 ft	75	0.477	318.0	2.02	0.67
po + Δp = 3845	Hd= 10 ft	70	0.405	270.0	1.88	0.81
	cv= 0.15 ft ² /day	65	0.342	228.0	1.75	0.94
Hc = 10		60	0.287	191.3	1.61	1.08
Cr = 0.033		55	0.238	158.7	1.48	1.21
Cc = 0.336	Est S = 2.69 inches	50	0.197	131.3	1.35	1.35
eo = 0.7573		45	0.159	106.0	1.21	1.48
		40	0.126	84.0	1.08	1.61
		35	0.096	64.0	0.94	1.75
		30	0.071	47.3	0.81	1.88
If po + Δp > pc		25	0.049	32.7	0.67	2.02
S = 0.2242671 feet = 2.6912 inches		20	0.031	20.7	0.54	2.15
		15	0.018	12.0	0.40	2.29
If po + Δp < or = pc		10	0.008	5.3	0.27	2.42
S = 0.0384374 feet = 0.4612 inches						

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18029 SH 29 West - Phase I Embankment Analysis
752+00 (Single Drainage)

Settlement

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
25 - 30 feet						
OCR > 1 OVERCONSOLIDATED	Layer	95	1.129	282.3	0.87	0.05
	Lean Clay (Stiff)	90	0.848	212.0	0.82	0.09
po = 3300	25 - 30	85	0.684	171.0	0.78	0.14
Δp = 1425 (I _n =I _n =0.47)		80	0.565	141.3	0.73	0.18
pc = 4120	Hc= 5 ft	75	0.477	119.3	0.69	0.23
	Hd= 5 ft	70	0.405	101.3	0.64	0.27
po + Δp = 4725	cv= 0.1 ft ² /day	65	0.342	85.5	0.59	0.32
		60	0.287	71.8	0.55	0.37
Hc = 5		55	0.238	59.5	0.50	0.41
Cr = 0.05	Est S = 0.91 inches	50	0.197	49.3	0.46	0.46
Cc = 0.27		45	0.159	39.8	0.41	0.50
eo = 0.37		40	0.126	31.5	0.37	0.55
		35	0.096	24.0	0.32	0.59
		30	0.071	17.8	0.27	0.64
If po + Δp > pc		25	0.049	12.3	0.23	0.69
S = 0.0762241 feet = 0.9147 inches		20	0.031	7.8	0.18	0.73
		15	0.018	4.5	0.14	0.78
If po + Δp < or = pc		10	0.008	2.0	0.09	0.82
S = 0.0284467 feet = 0.3414 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
30 - 51 feet						
OCR > 1 OVERCONSOLIDATED	Layer	95	1.129	1991.6	2.41	0.13
	Sandy Lean Clay (Very Soft)	90	0.848	1495.9	2.29	0.25
po = 4860	30 - 51	85	0.684	1206.6	2.16	0.38
Δp = 1295 (I _n =I _n =0.43)		80	0.565	996.7	2.03	0.51
pc = 5000	Hc= 21 ft	75	0.477	841.4	1.90	0.63
	Hd= 21 ft	70	0.405	714.4	1.78	0.76
po + Δp = 6155	cv= 0.25 ft ² /day	65	0.342	603.3	1.65	0.89
		60	0.287	506.3	1.52	1.02
Hc = 21		55	0.238	419.8	1.40	1.14
Cr = 0.014	Est S = 2.54 inches	50	0.197	347.5	1.27	1.27
Cc = 0.18		45	0.159	280.5	1.14	1.40
eo = 0.63		40	0.126	222.3	1.02	1.52
		35	0.096	169.3	0.89	1.65
		30	0.071	125.2	0.76	1.78
If po + Δp > pc		25	0.049	86.4	0.63	1.90
S = 0.2115347 feet = 2.5384 inches		20	0.031	54.7	0.51	2.03
		15	0.018	31.8	0.38	2.16
If po + Δp < or = pc		10	0.008	14.1	0.25	2.28
S = 0.0185043 feet = 0.2221 inches						

Est S_{total} = 8.29 inches

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18029 SH 29 West - Phase I Embankment Analysis
752+00 (Double Drainage)

Settlement

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
0 - 4 feet	Layer	95	1.129	9.0	0.37	0.02
OCR > 1 OVERCONSOLIDATED	Sandy Silty Clay	90	0.848	6.8	0.35	0.04
po = 230	0 - 4	85	0.684	5.5	0.33	0.06
Δp = 1500 (I _n =I _n =0.5)		80	0.565	4.5	0.31	0.08
pc = 2500	Hc= 4 ft	75	0.477	3.8	0.29	0.10
	Hd= 2 ft	70	0.405	3.2	0.27	0.12
po + Δp = 1730	cv= 0.5 ft ² /day	65	0.342	2.7	0.25	0.14
		60	0.287	2.3	0.23	0.16
Hc = 4		55	0.238	1.9	0.21	0.18
Cr = 0.015	Est S = 0.39 inches	50	0.197	1.6	0.19	0.19
Cc = 0.2		45	0.159	1.3	0.18	0.21
eo = 0.62		40	0.126	1.0	0.16	0.23
		35	0.096	0.8	0.14	0.25
		30	0.071	0.6	0.12	0.27
If po + Δp > pc		25	0.049	0.4	0.10	0.29
S = -0.040582 feet = -0.487 inches		20	0.031	0.2	0.08	0.31
		15	0.018	0.1	0.06	0.33
If po + Δp < or = pc		10	0.008	0.1	0.04	0.35
S = 0.0324562 feet = 0.3895 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
4 - 10 feet	Layer	95	1.129	48.4	1.13	0.06
OCR > 1 OVERCONSOLIDATED	Lean Clay with Sand	90	0.848	36.3	1.07	0.12
po = 820	4 - 10	85	0.684	29.3	1.01	0.18
Δp = 1500 (I _n =I _n =0.5)		80	0.565	24.2	0.95	0.24
pc = 4840	Hc= 6 ft	75	0.477	20.4	0.89	0.30
	Hd= 3 ft	70	0.405	17.4	0.83	0.36
po + Δp = 2320	cv= 0.21 ft ² /day	65	0.342	14.7	0.77	0.42
		60	0.287	12.3	0.71	0.48
Hc = 6		55	0.238	10.2	0.65	0.53
Cr = 0.065	Est S = 1.19 inches	50	0.197	8.4	0.59	0.59
Cc = 0.289		45	0.159	6.8	0.53	0.65
eo = 0.78		40	0.126	5.4	0.48	0.71
		35	0.096	4.1	0.42	0.77
		30	0.071	3.0	0.36	0.83
If po + Δp > pc		25	0.049	2.1	0.30	0.89
S = -0.14217 feet = -1.706 inches		20	0.031	1.3	0.24	0.95
		15	0.018	0.8	0.18	1.01
If po + Δp < or = pc		10	0.008	0.3	0.12	1.07
S = 0.0989623 feet = 1.1875 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
10 - 15 feet	Layer	95	1.129	22.1	0.59	0.03
OCR > 1 OVERCONSOLIDATED	Sandy Lean Clay	90	0.848	16.6	0.56	0.06
po = 1500	10 - 15	85	0.684	13.4	0.53	0.09
Δp = 1495 (I _n =I _n =0.499)		80	0.565	11.0	0.50	0.12
pc = 2500	Hc= 5 ft	75	0.477	9.3	0.46	0.15
	Hd= 2.5 ft	70	0.405	7.9	0.43	0.19
po + Δp = 2995	cv= 0.32 ft ² /day	65	0.342	6.7	0.40	0.22
		60	0.287	5.6	0.37	0.25
Hc = 5		55	0.238	4.6	0.34	0.28
Cr = 0.014	Est S = 0.62 inches	50	0.197	3.8	0.31	0.31
Cc = 0.175		45	0.159	3.1	0.28	0.34
eo = 0.6307		40	0.126	2.5	0.25	0.37
		35	0.096	1.9	0.22	0.40
		30	0.071	1.4	0.19	0.43
If po + Δp > pc		25	0.049	1.0	0.15	0.46
S = 0.0516215 feet = 0.6195 inches		20	0.031	0.6	0.12	0.50
		15	0.018	0.4	0.09	0.53
If po + Δp < or = pc		10	0.008	0.2	0.06	0.56
S = 0.012891 feet = 0.1547 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
15 - 25 feet	Layer	95	1.129	188.2	2.56	0.13
OCR > 1 OVERCONSOLIDATED	Lean Clay (Very Soft)	90	0.848	141.3	2.42	0.27
po = 2400	15 - 25	85	0.684	114.0	2.29	0.40
Δp = 1445 (I _n =I _n =0.49)		80	0.565	94.2	2.15	0.54
pc = 3000	Hc= 10 ft	75	0.477	79.5	2.02	0.67
	Hd= 5 ft	70	0.405	67.5	1.88	0.81
po + Δp = 3845	cv= 0.15 ft ² /day	65	0.342	57.0	1.75	0.94
		60	0.287	47.8	1.61	1.08
Hc = 10		55	0.238	39.7	1.48	1.21
Cr = 0.033	Est S = 2.69 inches	50	0.197	32.8	1.35	1.35
Cc = 0.336		45	0.159	26.5	1.21	1.48
eo = 0.7573		40	0.126	21.0	1.08	1.61
		35	0.096	16.0	0.94	1.75
		30	0.071	11.8	0.81	1.88
If po + Δp > pc		25	0.049	8.2	0.67	2.02
S = 0.2242671 feet = 2.6912 inches		20	0.031	5.2	0.54	2.15
		15	0.018	3.0	0.40	2.29
If po + Δp < or = pc		10	0.008	1.3	0.27	2.42
S = 0.0384374 feet = 0.4612 inches						

RED ROCK CONSULTING

18029 SH 29 West - Phase I Embankment Analysis
752+00 (Double Drainage)

Settlement

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
25 - 30 feet						
OCR > 1 OVERCONSOLIDATED	Layer	95	1.129	70.6	0.87	0.05
	Lean Clay (Stiff)	90	0.848	53.0	0.82	0.09
po = 3300	25 - 30	85	0.684	42.8	0.78	0.14
Δp = 1425 (I _n =I _h =0.47)		80	0.565	35.3	0.73	0.18
pc = 4120	Hc= 5 ft	75	0.477	29.8	0.69	0.23
	Hd= 2.5 ft	70	0.405	25.3	0.64	0.27
po + Δp = 4725	cv= 0.1 ft ² /day	65	0.342	21.4	0.59	0.32
		60	0.287	17.9	0.55	0.37
Hc = 5		55	0.238	14.9	0.50	0.41
Cr = 0.05	Est S = 0.91 inches	50	0.197	12.3	0.46	0.46
Cc = 0.27		45	0.159	9.9	0.41	0.50
eo = 0.37		40	0.126	7.9	0.37	0.55
		35	0.096	6.0	0.32	0.59
		30	0.071	4.4	0.27	0.64
If po + Δp > pc		25	0.049	3.1	0.23	0.69
S = 0.0762241 feet = 0.9147 inches		20	0.031	1.9	0.18	0.73
		15	0.018	1.1	0.14	0.78
If po + Δp < or = pc		10	0.008	0.5	0.09	0.82
S = 0.0284467 feet = 0.3414 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
30 - 51 feet						
OCR > 1 OVERCONSOLIDATED	Layer	95	1.129	497.9	2.41	0.13
	Sandy Lean Clay (Very Soft)	90	0.848	374.0	2.28	0.25
po = 4860	30 - 51	85	0.684	301.6	2.16	0.38
Δp = 1295 (I _n =I _h =0.43)		80	0.565	249.2	2.03	0.51
pc = 5000	Hc= 21 ft	75	0.477	210.4	1.90	0.63
	Hd= 10.5 ft	70	0.405	178.6	1.78	0.76
po + Δp = 6155	cv= 0.25 ft ² /day	65	0.342	150.8	1.65	0.89
		60	0.287	126.6	1.52	1.02
Hc = 21		55	0.238	105.0	1.40	1.14
Cr = 0.014	Est S = 2.54 inches	50	0.197	86.9	1.27	1.27
Cc = 0.18		45	0.159	70.1	1.14	1.40
eo = 0.63		40	0.126	55.6	1.02	1.52
		35	0.096	42.3	0.89	1.65
		30	0.071	31.3	0.76	1.78
If po + Δp > pc		25	0.049	21.6	0.63	1.90
S = 0.2115347 feet = 2.5384 inches		20	0.031	13.7	0.51	2.03
		15	0.018	7.9	0.38	2.16
If po + Δp < or = pc		10	0.008	3.5	0.25	2.28
S = 0.0185043 feet = 0.2221 inches						

Est S_{total} = 8.34 inches

RED ROCK CONSULTING

18029 SH 29 West - Phase I Embankment Analysis
868+00 (Single Drainage)

Settlement

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
0 - 4 feet						
OCR > 1 OVERCONSOLIDATED	Layer	95	1.129	10.2	0.55	0.03
	Clayey Sand	90	0.848	7.6	0.53	0.06
	0 - 4	85	0.684	6.2	0.50	0.09
po = 230		80	0.565	5.1	0.47	0.12
Δp = 1740 (l _r =l _e =0.5)	Hc= 3 ft	75	0.477	4.3	0.44	0.15
pc = 2000	Hd= 3 ft	70	0.405	3.6	0.41	0.18
po + Δp = 1970	cv= 1 ft ² /day	65	0.342	3.1	0.38	0.20
		60	0.287	2.6	0.35	0.23
Hc = 4		55	0.238	2.1	0.32	0.26
Cr = 0.03	Est S = 0.58 inches	50	0.197	1.8	0.29	0.29
Cc = 0.2		45	0.159	1.4	0.26	0.32
eo = 1.3		40	0.126	1.1	0.23	0.35
		35	0.096	0.9	0.20	0.38
		30	0.071	0.6	0.18	0.41
If po + Δp > pc		25	0.049	0.4	0.15	0.44
S = 0.04672402 feet = 0.5607 inches		20	0.031	0.3	0.12	0.47
		15	0.018	0.2	0.09	0.50
If po + Δp < or = pc		10	0.008	0.1	0.06	0.53
S = 0.04866461 feet = 0.584 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
4 - 7 feet						
OCR > 1 OVERCONSOLIDATED	Layer	95	1.129	20.3	0.53	0.03
	Sandy Lean Clay	90	0.848	15.3	0.50	0.06
	4 - 7	85	0.684	12.3	0.47	0.08
po = 640		80	0.565	10.2	0.45	0.11
Δp = 1740 (l _r =l _e =0.5)	Hc= 3 ft	75	0.477	8.6	0.42	0.14
pc = 2500	Hd= 3 ft	70	0.405	7.3	0.39	0.17
po + Δp = 2380	cv= 0.5 ft ² /day	65	0.342	6.2	0.36	0.20
		60	0.287	5.2	0.33	0.22
Hc = 3		55	0.238	4.3	0.31	0.25
Cr = 0.05	Est S = 0.56 inches	50	0.197	3.5	0.28	0.28
Cc = 0.2		45	0.159	2.9	0.25	0.31
eo = 0.84		40	0.126	2.3	0.22	0.33
		35	0.096	1.7	0.20	0.36
		30	0.071	1.3	0.17	0.39
If po + Δp > pc		25	0.049	0.9	0.14	0.42
S = 0.04127509 feet = 0.4953 inches		20	0.031	0.6	0.11	0.45
		15	0.018	0.3	0.08	0.47
If po + Δp < or = pc		10	0.008	0.1	0.06	0.50
S = 0.04649975 feet = 0.558 inches						

Settlement of Overconsolidated Soils	Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
7 - 10 feet						
OCR > 1 OVERCONSOLIDATED	Layer	95	1.129	11.3	0.14	0.01
	Silty, Clayey Sand	90	0.848	8.5	0.14	0.02
	7 - 10	85	0.684	6.8	0.13	0.02
po = 995		80	0.565	5.7	0.12	0.03
Δp = 1737 (l _r =l _e =0.499)	Hc= 3 ft	75	0.477	4.8	0.11	0.04
pc = 3000	Hd= 3 ft	70	0.405	4.1	0.11	0.05
po + Δp = 2732	cv= 0.9 ft ² /day	65	0.342	3.4	0.10	0.05
		60	0.287	2.9	0.09	0.06
Hc = 3		55	0.238	2.4	0.08	0.07
Cr = 0.02	Est S = 0.15 inches	50	0.197	2.0	0.08	0.08
Cc = 0.2		45	0.159	1.6	0.07	0.08
eo = 1.1		40	0.126	1.3	0.06	0.09
		35	0.096	1.0	0.05	0.10
		30	0.071	0.7	0.05	0.11
If po + Δp > pc		25	0.049	0.5	0.04	0.11
S = 0.00208265 feet = 0.025 inches		20	0.031	0.3	0.03	0.12
		15	0.018	0.2	0.02	0.13
If po + Δp < or = pc		10	0.008	0.1	0.02	0.14
S = 0.01253307 feet = 0.1504 inches						

RED ROCK CONSULTING

18029 SH 29 West - Phase I Embankment Analysis
868+00 (Single Drainage)

Settlement

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
10 - 12 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	9.0	0.22	0.01
		Sandy Lean Clay	90	0.848	6.8	0.21	0.02
10 - 12			85	0.684	5.5	0.19	0.03
po = 1400			80	0.565	4.5	0.18	0.05
$\Delta p = 1737$ ($i_r = i_e = 0.499$)		Hc= 2 ft	75	0.477	3.8	0.17	0.06
pc = 3000		Hd= 2 ft	70	0.405	3.2	0.16	0.07
po + $\Delta p = 3137$		cv= 0.5 ft ² /day	65	0.342	2.7	0.15	0.08
Hc = 2			60	0.287	2.3	0.14	0.09
Cr = 0.05			55	0.238	1.9	0.13	0.10
Cc = 0.2		Est S = 0.23 inches	50	0.197	1.6	0.11	0.11
eo = 0.84			45	0.159	1.3	0.10	0.13
			40	0.126	1.0	0.09	0.14
			35	0.096	0.8	0.08	0.15
			30	0.071	0.6	0.07	0.16
If po + $\Delta p > pc$			25	0.049	0.4	0.06	0.17
S = 0.02220469 feet = 0.2665 inches			20	0.031	0.2	0.05	0.18
			15	0.018	0.1	0.03	0.19
If po + $\Delta p < or = pc$			10	0.008	0.1	0.02	0.21
S = 0.01904274 feet = 0.2285 inches							

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
12 - 34 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	546.4	1.25	0.07
		Clayey Sand	90	0.848	410.4	1.18	0.13
12 - 34			85	0.684	331.1	1.12	0.20
po = 2670			80	0.565	273.5	1.05	0.26
$\Delta p = 1713$ ($i_r = i_e = 0.492$)		Hc= 22 ft	75	0.477	230.9	0.99	0.33
pc = 4000		Hd= 22 ft	70	0.405	196.0	0.92	0.39
po + $\Delta p = 4383$		cv= 1 ft ² /day	65	0.342	165.5	0.85	0.46
Hc = 22			60	0.287	138.9	0.79	0.53
Cr = 0.02			55	0.238	115.2	0.72	0.59
Cc = 0.2		Est S = 1.31 inches	50	0.197	95.3	0.66	0.66
eo = 1.3			45	0.159	77.0	0.59	0.72
			40	0.126	61.0	0.53	0.79
			35	0.096	46.5	0.46	0.85
			30	0.071	34.4	0.39	0.92
If po + $\Delta p > pc$			25	0.049	23.7	0.33	0.99
S = 0.10955302 feet = 1.3146 inches			20	0.031	15.0	0.26	1.05
			15	0.018	8.7	0.20	1.12
If po + $\Delta p < or = pc$			10	0.008	3.9	0.13	1.18
S = 0.04118021 feet = 0.4942 inches							

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
34 - 55 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	622.4	2.93	0.15
		Sandy Silty Clay	90	0.848	467.5	2.78	0.31
34 - 55			85	0.684	377.1	2.62	0.46
po = 5195			80	0.565	311.5	2.47	0.62
$\Delta p = 1095$ ($i_r = i_e = 0.5$)		Hc= 21 ft	75	0.477	262.9	2.32	0.77
pc = 5000		Hd= 21 ft	70	0.405	223.3	2.16	0.93
po + $\Delta p = 6290$		cv= 0.8 ft ² /day	65	0.342	188.5	2.01	1.08
Hc = 21			60	0.287	158.2	1.85	1.24
Cr = 0.02			55	0.238	131.2	1.70	1.39
Cc = 0.2		Est S = 3.09 inches	50	0.197	108.6	1.54	1.54
eo = 0.6			45	0.159	87.6	1.39	1.70
			40	0.126	69.5	1.24	1.85
			35	0.096	52.9	1.08	2.01
			30	0.071	39.1	0.93	2.16
If po + $\Delta p > pc$			25	0.049	27.0	0.77	2.32
S = 0.2573001 feet = 3.0876 inches			20	0.031	17.1	0.62	2.47
			15	0.018	9.9	0.46	2.62
If po + $\Delta p < or = pc$			10	0.008	4.4	0.31	2.78
S = 0.02180459 feet = 0.2617 inches							

Est S_{total} = 5.92 inches

RED ROCK CONSULTING

18029 SH 29 West - Phase I Embankment Analysis
868+00 (Double Drainage)

Settlement

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
0 - 4 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	2.5	0.55	0.03
		Clayey Sand	90	0.848	1.9	0.53	0.06
0 - 4			85	0.684	1.5	0.50	0.09
po = 230			80	0.565	1.3	0.47	0.12
Δp = 1740 (I _{IT} =I _{LT} =0.5)		Hc= 3 ft	75	0.477	1.1	0.44	0.15
pc = 2000		Hd= 1.5 ft	70	0.405	0.9	0.41	0.18
po + Δp = 1970		cv= 1 ft ² /day	65	0.342	0.8	0.38	0.20
Hc = 4			60	0.287	0.6	0.35	0.23
Cr = 0.03			55	0.238	0.5	0.32	0.26
Cc = 0.2		Est S = 0.58 inches	50	0.197	0.4	0.29	0.29
eo = 1.3			45	0.159	0.4	0.26	0.32
			40	0.126	0.3	0.23	0.35
			35	0.096	0.2	0.20	0.38
			30	0.071	0.2	0.18	0.41
If po + Δp > pc			25	0.049	0.1	0.15	0.44
S = 0.04672402 feet = 0.561 inches			20	0.031	0.1	0.12	0.47
If po + Δp < or = pc			15	0.018	0.0	0.09	0.50
S = 0.04866461 feet = 0.584 inches			10	0.008	0.0	0.06	0.53

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
4 - 7 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	5.1	0.53	0.03
		Sandy Lean Clay	90	0.848	3.8	0.50	0.06
4 - 7			85	0.684	3.1	0.47	0.08
po = 640			80	0.565	2.5	0.45	0.11
Δp = 1740 (I _{IT} =I _{LT} =0.5)		Hc= 3 ft	75	0.477	2.1	0.42	0.14
pc = 2500		Hd= 1.5 ft	70	0.405	1.8	0.39	0.17
po + Δp = 2380		cv= 0.5 ft ² /day	65	0.342	1.5	0.36	0.20
Hc = 3			60	0.287	1.3	0.33	0.22
Cr = 0.05			55	0.238	1.1	0.31	0.25
Cc = 0.2		Est S = 0.56 inches	50	0.197	0.9	0.28	0.28
eo = 0.84			45	0.159	0.7	0.25	0.31
			40	0.126	0.6	0.22	0.33
			35	0.096	0.4	0.20	0.36
			30	0.071	0.3	0.17	0.39
If po + Δp > pc			25	0.049	0.2	0.14	0.42
S = 0.04127509 feet = 0.495 inches			20	0.031	0.1	0.11	0.45
If po + Δp < or = pc			15	0.018	0.1	0.08	0.47
S = 0.04649975 feet = 0.558 inches			10	0.008	0.0	0.06	0.50

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
7 - 10 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	2.8	0.14	0.01
		Silty, Clayey Sand	90	0.848	2.1	0.14	0.02
7 - 10			85	0.684	1.7	0.13	0.02
po = 995			80	0.565	1.4	0.12	0.03
Δp = 1737 (I _{IT} =I _{LT} =0.499)		Hc= 3 ft	75	0.477	1.2	0.11	0.04
pc = 3000		Hd= 1.5 ft	70	0.405	1.0	0.11	0.05
po + Δp = 2732		cv= 0.9 ft ² /day	65	0.342	0.9	0.10	0.05
Hc = 3			60	0.287	0.7	0.09	0.06
Cr = 0.02			55	0.238	0.6	0.08	0.07
Cc = 0.2		Est S = 0.15 inches	50	0.197	0.5	0.08	0.08
eo = 1.1			45	0.159	0.4	0.07	0.08
			40	0.126	0.3	0.06	0.09
			35	0.096	0.2	0.05	0.10
			30	0.071	0.2	0.05	0.11
If po + Δp > pc			25	0.049	0.1	0.04	0.11
S = 0.00208265 feet = 0.025 inches			20	0.031	0.1	0.03	0.12
If po + Δp < or = pc			15	0.018	0.0	0.02	0.13
S = 0.01253307 feet = 0.15 inches			10	0.008	0.0	0.02	0.14

RED ROCK CONSULTING

18029 SH 29 West - Phase I Embankment Analysis
868+00 (Double Drainage)

Settlement

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
10 - 12 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	2.3	0.22	0.01
		Sandy Lean Clay	90	0.848	1.7	0.21	0.02
10 - 12			85	0.684	1.4	0.19	0.03
po =	1400		80	0.565	1.1	0.18	0.05
Δp =	1737 ($I_{IT}=I_{IT}=0.499$)	Hc= 2 ft	75	0.477	1.0	0.17	0.06
pc =	3000	Hd= 1 ft	70	0.405	0.8	0.16	0.07
po + Δp =	3137	cv= 0.5 ft ² /day	65	0.342	0.7	0.15	0.08
			60	0.287	0.6	0.14	0.09
Hc =	2		55	0.238	0.5	0.13	0.10
Cr =	0.05	Est S = 0.23 inches	50	0.197	0.4	0.11	0.11
Cc =	0.2		45	0.159	0.3	0.10	0.13
eo =	0.84		40	0.126	0.3	0.09	0.14
			35	0.096	0.2	0.08	0.15
			30	0.071	0.1	0.07	0.16
If po + Δp > pc			25	0.049	0.1	0.06	0.17
S =	0.02220469 feet = 0.266 inches		20	0.031	0.1	0.05	0.18
If po + Δp < or = pc			15	0.018	0.0	0.03	0.19
S =	0.01904274 feet = 0.229 inches		10	0.008	0.0	0.02	0.21

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
12 - 34 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	136.6	1.25	0.07
		Clayey Sand	90	0.848	102.6	1.18	0.13
12 - 34			85	0.684	82.8	1.12	0.20
po =	2670		80	0.565	68.4	1.05	0.26
Δp =	1713 ($I_{IT}=I_{IT}=0.492$)	Hc= 22 ft	75	0.477	57.7	0.99	0.33
pc =	4000	Hd= 11 ft	70	0.405	49.0	0.92	0.39
po + Δp =	4383	cv= 1 ft ² /day	65	0.342	41.4	0.85	0.46
			60	0.287	34.7	0.79	0.53
Hc =	22		55	0.238	28.8	0.72	0.59
Cr =	0.02	Est S = 1.31 inches	50	0.197	23.8	0.66	0.66
Cc =	0.2		45	0.159	19.2	0.59	0.72
eo =	1.3		40	0.126	15.2	0.53	0.79
			35	0.096	11.6	0.46	0.85
			30	0.071	8.6	0.39	0.92
If po + Δp > pc			25	0.049	5.9	0.33	0.99
S =	0.10955302 feet = 1.315 inches		20	0.031	3.8	0.26	1.05
If po + Δp < or = pc			15	0.018	2.2	0.20	1.12
S =	0.04118021 feet = 0.494 inches		10	0.008	1.0	0.13	1.18

Settlement of Overconsolidated Soils		Time Rate of Settlement	%	T	Time (days)	Settlement (in)	Remaining to Settle (in)
34 - 55 feet							
OCR > 1 OVERCONSOLIDATED		Layer	95	1.129	155.6	2.93	0.15
		Sandy Silty Clay	90	0.848	116.9	2.78	0.31
34 - 55			85	0.684	94.3	2.62	0.46
po =	5195		80	0.565	77.9	2.47	0.62
Δp =	1095 ($I_{IT}=I_{IT}=0.5$)	Hc= 21 ft	75	0.477	65.7	2.32	0.77
pc =	5000	Hd= 10.5 ft	70	0.405	55.8	2.16	0.93
po + Δp =	6290	cv= 0.8 ft ² /day	65	0.342	47.1	2.01	1.08
			60	0.287	39.6	1.85	1.24
Hc =	21		55	0.238	32.8	1.70	1.39
Cr =	0.02	Est S = 3.09 inches	50	0.197	27.1	1.54	1.54
Cc =	0.2		45	0.159	21.9	1.39	1.70
eo =	0.6		40	0.126	17.4	1.24	1.85
			35	0.096	13.2	1.08	2.01
			30	0.071	9.8	0.93	2.16
If po + Δp > pc			25	0.049	6.8	0.77	2.32
S =	0.2573001 feet = 3.088 inches		20	0.031	4.3	0.62	2.47
If po + Δp < or = pc			15	0.018	2.5	0.46	2.62
S =	0.02180459 feet = 0.262 inches		10	0.008	1.1	0.31	2.78

Est S_{total} = 5.92 inches

Settle3D Analysis Information

18029 SH 29 Embankments West

Project Settings

Document Name	18029 Settle 752+00.EW8 only.SD.s3z
Project Title	18029 SH 29 Embankments West
Analysis	752+00
Author	KKB
Company	Red Rock Consulting
Date Created	10/28/2019, 3:10:16 PM

Comments

Vertical Drainage Only	
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	days
Permeability Units	feet/day
Poisson ratio for Boussinesq stress computation	0.5

Calculate settlement with mean stress

Include vertical stress reduction due to settlement above a point

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [days]
1	Begin Construction	0
2	Embkmt Layer 1	14
3	Embkmt Layer 2	21
4	Embkmt Layer 3	28
5	Embkmt Constructed	35
6	1 Year After	400
7	2 Years After	765
8	5 Years After	1860
9	10 Years After	3685
10	20 Years After	7335
11	50 Years After	18285

Results

Time taken to compute: 106.872 seconds

Stage: Begin Construction = 0 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	0
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0	0
Effective Stress ZZ [ksf]	0	3.43
Mean Stress [ksf]	0	0
Total Stress ZZ [ksf]	0	6.31
Total Strain	0	0
Pore Water Pressure [ksf]	0	2.87
Excess Pore Water Pressure [ksf]	0	0
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1.1	7.8
Void Ratio	0.372	0.841
Permeability [ft/d]	1.7e-005	0.00481
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	100	100

Stage: Embkmt Layer 1 = 14 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.142	0.615
Total Consolidation Settlement [in]	-0.142	0.615
Virgin Consolidation Settlement [in]	0	0.0844
Recompression Consolidation Settlement [in]	-0.142	0.542
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	-2.88e-007	0.591
Effective Stress ZZ [ksf]	-0.0234	3.64
Mean Stress [ksf]	-7.43e-006	0.796
Total Stress ZZ [ksf]	-2.88e-007	6.79
Total Strain	-0.0093	0.0211
Pore Water Pressure [ksf]	-5.14e-006	3.16
Excess Pore Water Pressure [ksf]	-5.14e-006	0.551
Degree of Consolidation [%]	0	51
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	37.4
Void Ratio	0.369	0.858
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	0	10

Stage: Embkmt Layer 2 = 21 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.254	2.83
Total Consolidation Settlement [in]	-0.254	2.83
Virgin Consolidation Settlement [in]	0	1.87
Recompression Consolidation Settlement [in]	-0.254	1.01
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	7.1e-005	1.05
Effective Stress ZZ [ksf]	-0.0214	4.07
Mean Stress [ksf]	0.00731	1.32
Total Stress ZZ [ksf]	7.1e-005	7.13
Total Strain	-0.0078	0.133
Pore Water Pressure [ksf]	0.00506	3.11
Excess Pore Water Pressure [ksf]	0.00506	0.836
Degree of Consolidation [%]	0	79.1
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	24.5
Void Ratio	0.368	0.855
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	0	67.5

Stage: Embkmt Layer 3 = 28 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.238	4.4
Total Consolidation Settlement [in]	-0.238	4.4
Virgin Consolidation Settlement [in]	0	3.18
Recompression Consolidation Settlement [in]	-0.238	1.24
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000161	1.29
Effective Stress ZZ [ksf]	-0.00879	4.32
Mean Stress [ksf]	0.0111	1.58
Total Stress ZZ [ksf]	0.000161	7.26
Total Strain	-0.00259	0.158
Pore Water Pressure [ksf]	0.00265	3.14
Excess Pore Water Pressure [ksf]	0.00265	0.967
Degree of Consolidation [%]	0	93.2
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	9.18
Void Ratio	0.367	0.843
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	0	86.2

Stage: Embkmt Constructed = 35 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.231	5.62
Total Consolidation Settlement [in]	-0.231	5.62
Virgin Consolidation Settlement [in]	0	4.17
Recompression Consolidation Settlement [in]	-0.236	1.45
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000233	1.49
Effective Stress ZZ [ksf]	-0.00444	4.43
Mean Stress [ksf]	0.0136	1.77
Total Stress ZZ [ksf]	0.000233	7.34
Total Strain	-0.0024	0.168
Pore Water Pressure [ksf]	0.00172	3.14
Excess Pore Water Pressure [ksf]	0.00172	1.06
Degree of Consolidation [%]	0	96.2
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	9.08
Void Ratio	0.367	0.842
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	0	90.2

Stage: 1 Year After = 400 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.0452	8.35
Total Consolidation Settlement [in]	-0.0452	8.35
Virgin Consolidation Settlement [in]	0	6.38
Recompression Consolidation Settlement [in]	-0.0452	1.97
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000233	1.49
Effective Stress ZZ [ksf]	0.000233	4.46
Mean Stress [ksf]	0.0136	1.77
Total Stress ZZ [ksf]	0.000233	7.33
Total Strain	-0.000352	0.173
Pore Water Pressure [ksf]	0	2.87
Excess Pore Water Pressure [ksf]	0	0.83
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	7.86
Void Ratio	0.366	0.841
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	7.7	99.9

Stage: 2 Years After = 765 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.0122	10.4
Total Consolidation Settlement [in]	-0.0122	10.4
Virgin Consolidation Settlement [in]	0	8.25
Recompression Consolidation Settlement [in]	-0.0122	2.13
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000233	1.49
Effective Stress ZZ [ksf]	0.000233	4.45
Mean Stress [ksf]	0.0136	1.77
Total Stress ZZ [ksf]	0.000233	7.32
Total Strain	-0.000178	0.173
Pore Water Pressure [ksf]	-0.00127	2.87
Excess Pore Water Pressure [ksf]	-0.00127	0.591
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	7.82
Void Ratio	0.364	0.841
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	28.7	100

Stage: 5 Years After = 1860 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	12.6
Total Consolidation Settlement [in]	0	12.6
Virgin Consolidation Settlement [in]	0	10.4
Recompression Consolidation Settlement [in]	0	2.26
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000233	1.49
Effective Stress ZZ [ksf]	0.000233	4.44
Mean Stress [ksf]	0.0136	1.77
Total Stress ZZ [ksf]	0.000233	7.31
Total Strain	1.27e-006	0.173
Pore Water Pressure [ksf]	0	2.88
Excess Pore Water Pressure [ksf]	0	0.22
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	7.8
Void Ratio	0.361	0.841
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	67.6	99.9

Stage: 10 Years After = 3685 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	13.4
Total Consolidation Settlement [in]	0	13.4
Virgin Consolidation Settlement [in]	0	11.1
Recompression Consolidation Settlement [in]	0	2.32
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000233	1.49
Effective Stress ZZ [ksf]	0.000233	4.43
Mean Stress [ksf]	0.0136	1.77
Total Stress ZZ [ksf]	0.000233	7.3
Total Strain	6.31e-006	0.173
Pore Water Pressure [ksf]	0	2.88
Excess Pore Water Pressure [ksf]	-0.00287	0.0723
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	7.79
Void Ratio	0.36	0.841
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	85.3	100

Stage: 20 Years After = 7335 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	13.6
Total Consolidation Settlement [in]	0	13.6
Virgin Consolidation Settlement [in]	0	11.3
Recompression Consolidation Settlement [in]	0	2.33
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000233	1.49
Effective Stress ZZ [ksf]	0.000233	4.43
Mean Stress [ksf]	0.0136	1.77
Total Stress ZZ [ksf]	0.000233	7.3
Total Strain	7.53e-006	0.173
Pore Water Pressure [ksf]	0	2.88
Excess Pore Water Pressure [ksf]	-0.00789	0.0132
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	7.78
Void Ratio	0.36	0.841
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	94.4	100

Stage: 50 Years After = 18285 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	13.6
Total Consolidation Settlement [in]	0	13.6
Virgin Consolidation Settlement [in]	0	11.3
Recompression Consolidation Settlement [in]	0	2.33
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000233	1.49
Effective Stress ZZ [ksf]	0.000233	4.43
Mean Stress [ksf]	0.0136	1.77
Total Stress ZZ [ksf]	0.000233	7.3
Total Strain	7.58e-006	0.173
Pore Water Pressure [ksf]	-0.000164	2.87
Excess Pore Water Pressure [ksf]	-0.0109	0.00833
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0621	6.72
Over-consolidation Ratio	1	7.78
Void Ratio	0.36	0.841
Permeability [ft/d]	1.7e-005	0.0721
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	99.8	100

Embankments

1. Embankment: "Embankment Load 1"

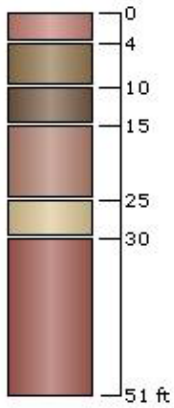
Label Embankment Load 1
 Center Line (0, -270) to (0, 200)
 Number of Layers 4
 Near End Angle 18.4 degrees
 Far End Angle 18.4 degrees
 Base Width 135

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft ³)	Right Angle (deg)	Right Bench Width (ft)
1	Embkmt Layer 1 = 14 d	0	16.3	4.75	0.12	16.3	0
2	Embkmt Layer 2 = 21 d	0	16.3	4	0.12	16.3	0
3	Embkmt Layer 3 = 28 d	0	10.6	2	0.12	10.6	0
4	Embkmt Constructed = 35 d	0	10.6	1.75	0.12	10.6	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sandy Silty CL, soft	4	0	No
2	CL w/Sand, soft	6	4	No
3	Sandy CL, v soft 1	5	10	No
4	CL w/Sa, v soft	10	15	No
5	CL w/Sa, stiff	5	25	No
6	Sandy CL, v soft 2	21	30	Yes



Soil Properties

Property	Sandy Silty CL, soft	CL w/Sand, soft	Sandy CL, v soft 1	CL w/Sa, v soft
Color				
Unit Weight [kips/ft ³]	0.115	0.12	0.12	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125	0.12	0.125
Poisson's Ratio	0.35	0.49	0.499	0.499
K0	1	1.6	0.8	0.6
Primary Consolidation	Enabled	Enabled	Enabled	Enabled
Material Type	Non-Linear	Non-Linear	Non-Linear	Non-Linear
Cc	0.225	0.289	0.175	0.336
Cr	0.015	0.065	0.014	0.033
e0	0.841	0.78	0.6307	0.7573
OCR	2.7	7.8	1.6	1.25
Cv [ft ² /d]	0.5	0.21	0.322	0.15
Cvr [ft ² /d]	0.5	0.21	0.322	0.15
B-bar	0.9	0.9	0.95	0.95
Undrained Su A [kips/ft ²]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Property	CL w/Sa, stiff	Sandy CL, v soft 2
Color		
Unit Weight [kips/ft ³]	0.12	0.12
Saturated Unit Weight [kips/ft ³]	0.125	0.125
Poisson's Ratio	0.499	0.499
K0	0.75	1
Primary Consolidation	Enabled	Enabled
Material Type	Non-Linear	Non-Linear
Cc	0.268	0.18
Cr	0.051	0.014
e0	0.3716	0.63
OCR	3	1.1
Cv [ft ² /d]	0.1	0.25
Cvr [ft ² /d]	0.1	0.25
B-bar	0.95	0.95
Undrained Su A [kips/ft ²]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft ³
Generating excess pore pressure above water table	

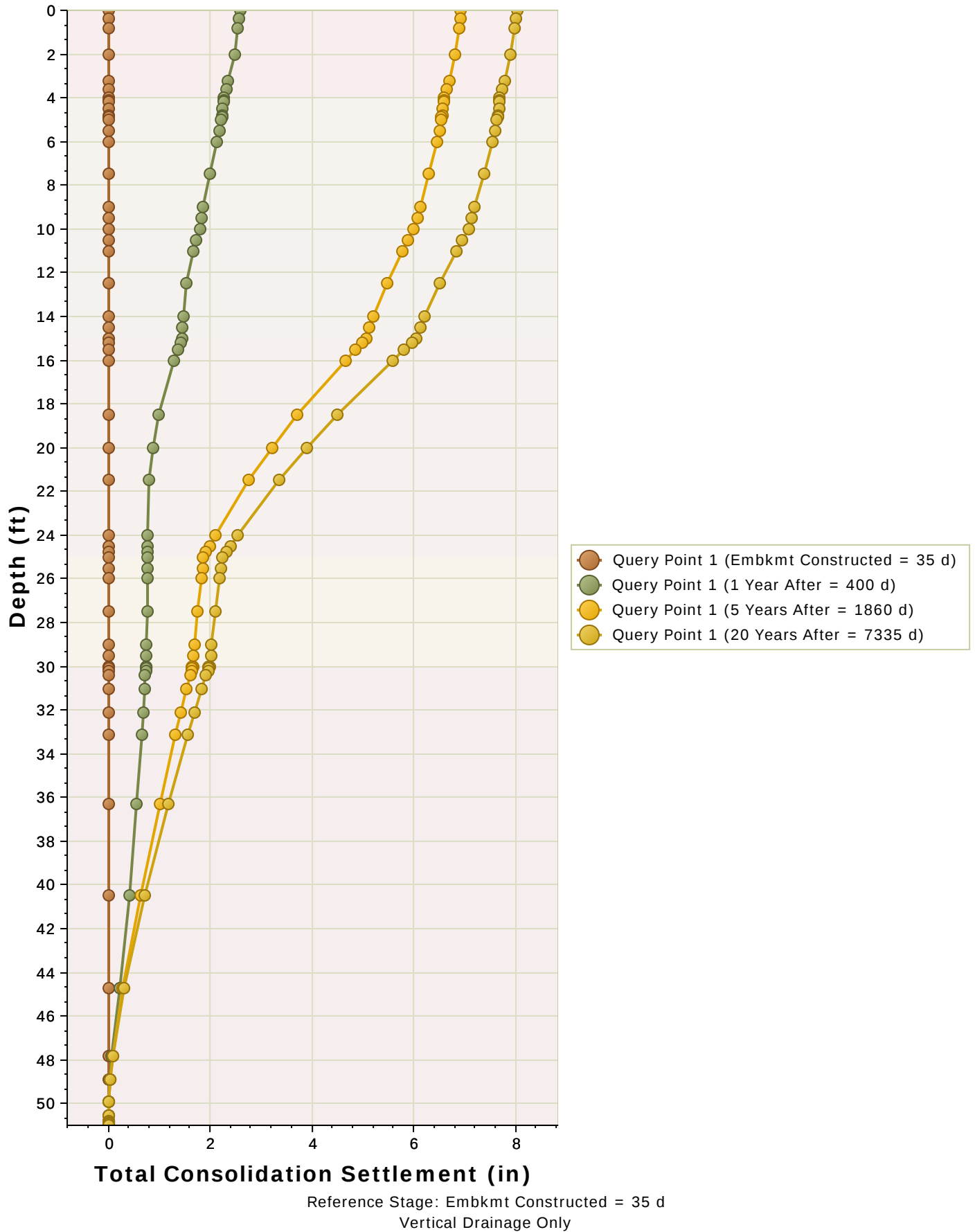
Piezometric Line Entities

ID	Depth (ft)
1	5 ft

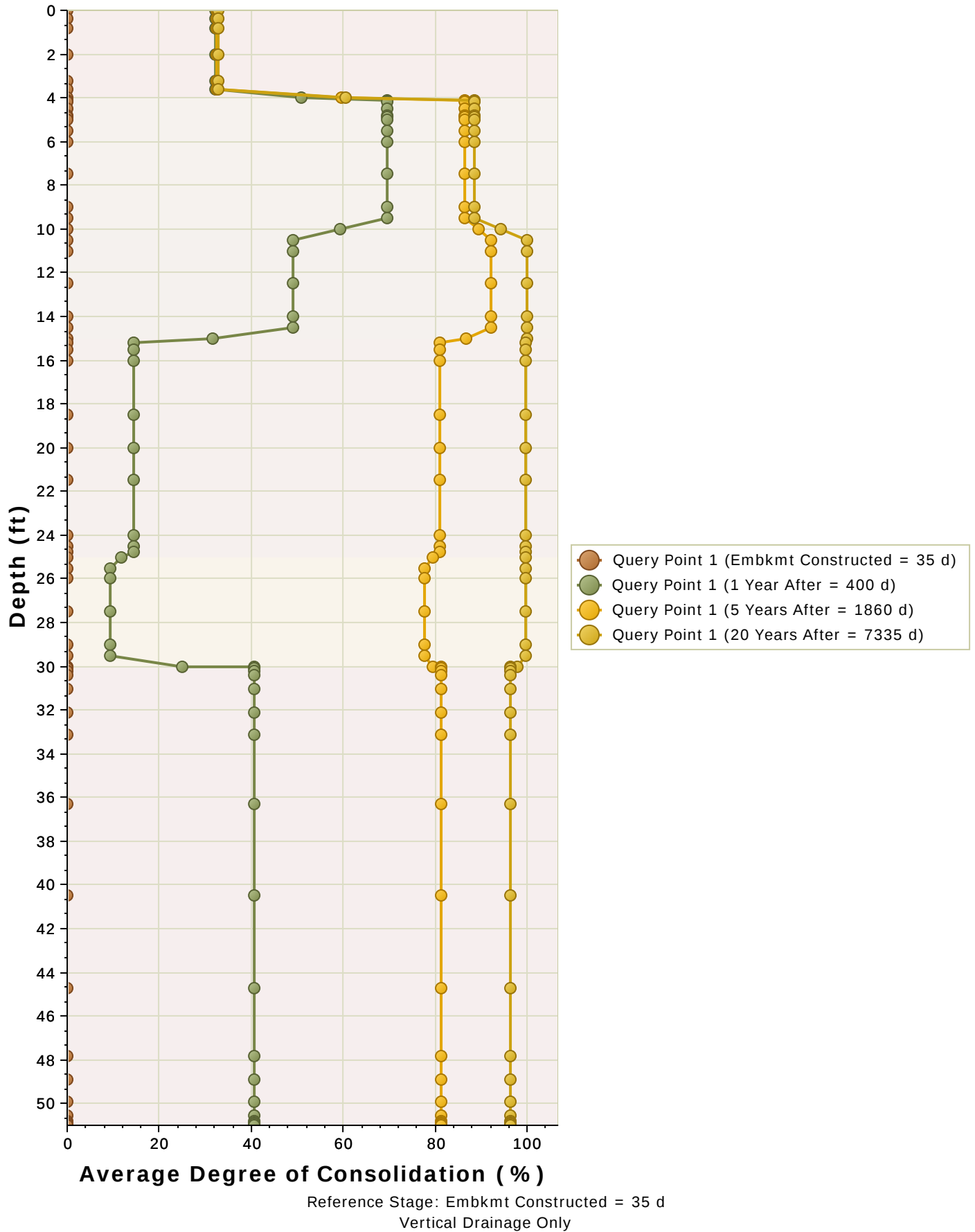
Time Points

Point #	(X,Y) Location	Depth	Goal Type	Goal	Time Until Goal
1	15, 0	0 ft	Degree of Consolidation	90%	1169.47 d
2	15, 0	0 ft	Degree of Consolidation	95%	1735.35 d
3	15, 0	0 ft	Total Settlement	12.62 in	2017.85 d
4	15, 0	0 ft	Degree of Consolidation	92.66%	1425.94 d

752+00 Total Consolidation Settlement vs. Depth



752+00 Average Degree of Consolidation vs. Depth



Settle3D Analysis Information

18029 SH 29 Embankments West

Project Settings

Document Name	18029 Settle 752+00.EW8 only.DD.s3z
Project Title	18029 SH 29 Embankments West
Analysis	752+00
Author	KKB
Company	Red Rock Consulting
Date Created	10/28/2019, 3:10:16 PM

Comments

Vertical & Horizontal Drainage	
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	days
Permeability Units	feet/day
Poisson ratio for Boussinesq stress computation	0.5

Calculate settlement with mean stress

Include vertical stress reduction due to settlement above a point

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [days]
1	Begin Construction	0
2	Embkmt Layer 1	14
3	Embkmt Layer 2	21
4	Embkmt Layer 3	28
5	Embkmt Constructed	35
6	100 Days After	135
7	180 Days After	215
8	1 Year After	400
9	10 Years After	3685

Results

Time taken to compute: 97.8474 seconds

Stage: Embkmt Constructed = 35 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.038253	8.95349
Total Consolidation Settlement [in]	-0.038253	8.95349
Virgin Consolidation Settlement [in]	0	6.9791
Recompression Consolidation Settlement [in]	-0.038253	1.97439
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000232564	1.48945
Effective Stress ZZ [ksf]	-0.00444255	4.40149
Mean Stress [ksf]	0.0136153	1.77358
Total Stress ZZ [ksf]	0.000232564	7.31421
Total Strain	-0.000511267	0.168075
Pore Water Pressure [ksf]	0.00171828	3.13938
Excess Pore Water Pressure [ksf]	0.00171828	0.811492
Degree of Consolidation [%]	0	96.1519
Pre-consolidation Stress [ksf]	0.0621	6.72126
Over-consolidation Ratio	1	8.05555
Void Ratio	0.361756	0.841642
Permeability [ft/d]	1.69679e-005	0.0720821
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	8.28764	97.7998

Stage: 100 Days After = 135 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	12.2469
Total Consolidation Settlement [in]	0	12.2469
Virgin Consolidation Settlement [in]	0	9.91769
Recompression Consolidation Settlement [in]	0	2.32978
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000232564	1.48945
Effective Stress ZZ [ksf]	0.000232564	4.42884
Mean Stress [ksf]	0.0136153	1.77358
Total Stress ZZ [ksf]	0.000232564	7.29924
Total Strain	7.58725e-006	0.172819
Pore Water Pressure [ksf]	0	2.88501
Excess Pore Water Pressure [ksf]	0	0.449907
Degree of Consolidation [%]	0	99.9829
Pre-consolidation Stress [ksf]	0.0621	6.72126
Over-consolidation Ratio	1	7.78239
Void Ratio	0.36022	0.840986
Permeability [ft/d]	1.69679e-005	0.0720821
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	53.5552	100

Stage: 180 Days After = 215 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	12.8836
Total Consolidation Settlement [in]	0	12.8836
Virgin Consolidation Settlement [in]	0	10.5522
Recompression Consolidation Settlement [in]	0	2.33167
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000232564	1.48945
Effective Stress ZZ [ksf]	0.000232564	4.42597
Mean Stress [ksf]	0.0136153	1.77358
Total Stress ZZ [ksf]	0.000232564	7.29637
Total Strain	7.58725e-006	0.172819
Pore Water Pressure [ksf]	0	2.8704
Excess Pore Water Pressure [ksf]	0	0.286041
Degree of Consolidation [%]	0	99.9896
Pre-consolidation Stress [ksf]	0.0621	6.72126
Over-consolidation Ratio	1	7.78236
Void Ratio	0.360213	0.840986
Permeability [ft/d]	1.69679e-005	0.0720821
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	70.576	100

Stage: 1 Year After = 400 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	13.3779
Total Consolidation Settlement [in]	0	13.3779
Virgin Consolidation Settlement [in]	0	11.0463
Recompression Consolidation Settlement [in]	0	2.33163
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000232564	1.48945
Effective Stress ZZ [ksf]	0.000232564	4.42377
Mean Stress [ksf]	0.0136153	1.77358
Total Stress ZZ [ksf]	0.000232564	7.29417
Total Strain	7.58725e-006	0.172819
Pore Water Pressure [ksf]	-1.17267e-032	2.8704
Excess Pore Water Pressure [ksf]	-1.17267e-032	0.099151
Degree of Consolidation [%]	0	99.9965
Pre-consolidation Stress [ksf]	0.0621	6.72126
Over-consolidation Ratio	1	7.78236
Void Ratio	0.360218	0.840986
Permeability [ft/d]	1.69679e-005	0.0720821
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	89.7872	100

Stage: 10 Years After = 3685 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	13.5781
Total Consolidation Settlement [in]	0	13.5781
Virgin Consolidation Settlement [in]	0	11.2465
Recompression Consolidation Settlement [in]	0	2.33167
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000232564	1.48945
Effective Stress ZZ [ksf]	0.000232564	4.42289
Mean Stress [ksf]	0.0136153	1.77358
Total Stress ZZ [ksf]	0.000232564	7.29329
Total Strain	7.58725e-006	0.172819
Pore Water Pressure [ksf]	-3.68256e-020	2.8704
Excess Pore Water Pressure [ksf]	-7.31566e-011	1.92064e-006
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.0621	6.72126
Over-consolidation Ratio	1	7.78236
Void Ratio	0.360218	0.840986
Permeability [ft/d]	1.69679e-005	0.0720821
Coefficient of Consolidation [ft ² /d]	0.1	0.5
Average Degree of Consolidation [%]	99.9993	100

Embankments

1. Embankment: "Embankment Load 1"

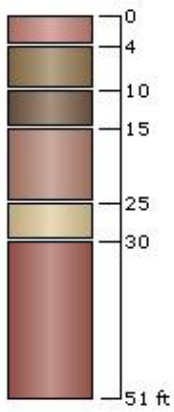
Label	Embankment Load 1
Center Line	(0, -270) to (0, 200)
Number of Layers	4
Near End Angle	18.4 degrees
Far End Angle	18.4 degrees
Base Width	135

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft ³)	Right Angle (deg)	Right Bench Width (ft)
1	Embkmt Layer 1 = 14 d	0	16.3	4.75	0.12	16.3	0
2	Embkmt Layer 2 = 21 d	0	16.3	4	0.12	16.3	0
3	Embkmt Layer 3 = 28 d	0	10.6	2	0.12	10.6	0
4	Embkmt Constructed = 35 d	0	10.6	1.75	0.12	10.6	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Sandy Silty CL, soft	4	0	Yes
2	CL w/Sand, soft	6	4	Yes
3	Sandy CL, v soft 1	5	10	Yes
4	CL w/Sa, v soft	10	15	Yes
5	CL w/Sa, stiff	5	25	Yes
6	Sandy CL, v soft 2	21	30	Yes



Soil Properties

Property	Sandy Silty CL, soft	CL w/Sand, soft	Sandy CL, v soft 1	CL w/Sa, v soft
Color				
Unit Weight [kips/ft ³]	0.115	0.12	0.12	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125	0.12	0.125
Poisson's Ratio	0.35	0.49	0.499	0.499
K0	1	1.6	0.8	0.6
Primary Consolidation	Enabled	Enabled	Enabled	Enabled
Material Type	Non-Linear	Non-Linear	Non-Linear	Non-Linear
Cc	0.225	0.289	0.175	0.336
Cr	0.015	0.065	0.014	0.033
e0	0.841	0.78	0.6307	0.7573
OCR	2.7	7.8	1.6	1.25
Cv [ft ² /d]	0.5	0.21	0.322	0.15
Cvr [ft ² /d]	0.5	0.21	0.322	0.15
B-bar	0.9	0.9	0.95	0.95
Undrained Su A [kips/ft ²]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Property	CL w/Sa, stiff	Sandy CL, v soft 2
Color		
Unit Weight [kips/ft ³]	0.12	0.12
Saturated Unit Weight [kips/ft ³]	0.125	0.125
Poisson's Ratio	0.499	0.499
K0	0.75	1
Primary Consolidation	Enabled	Enabled
Material Type	Non-Linear	Non-Linear
Cc	0.268	0.18
Cr	0.051	0.014
e0	0.3716	0.63
OCR	3	1.1
Cv [ft ² /d]	0.1	0.25
Cvr [ft ² /d]	0.1	0.25
B-bar	0.95	0.95
Undrained Su A [kips/ft ²]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	1	1

Groundwater

Groundwater method Piezometric Lines
 Water Unit Weight 0.0624 kips/ft³
 Generating excess pore pressure above water table

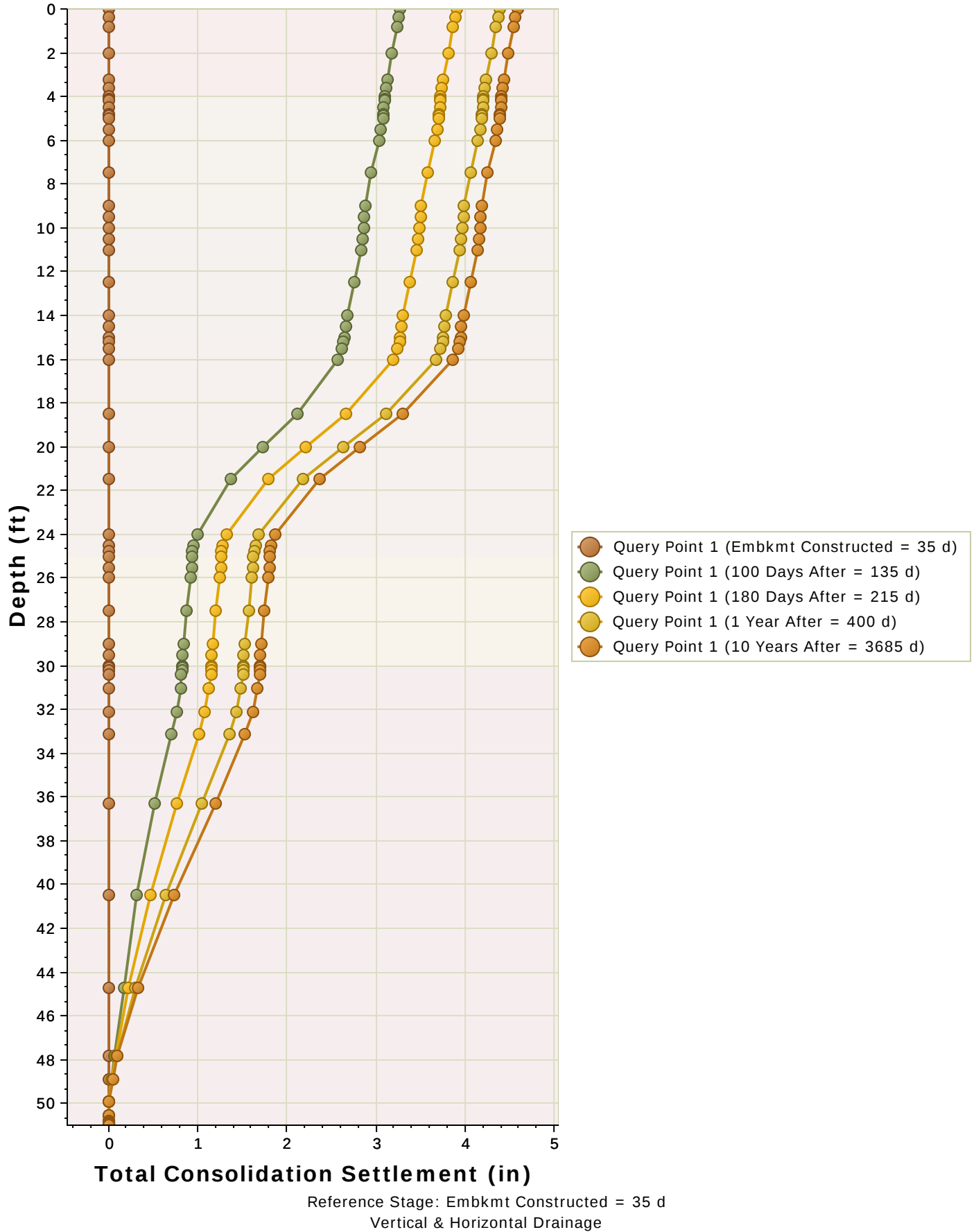
Piezometric Line Entities

ID	Depth (ft)
1	5 ft

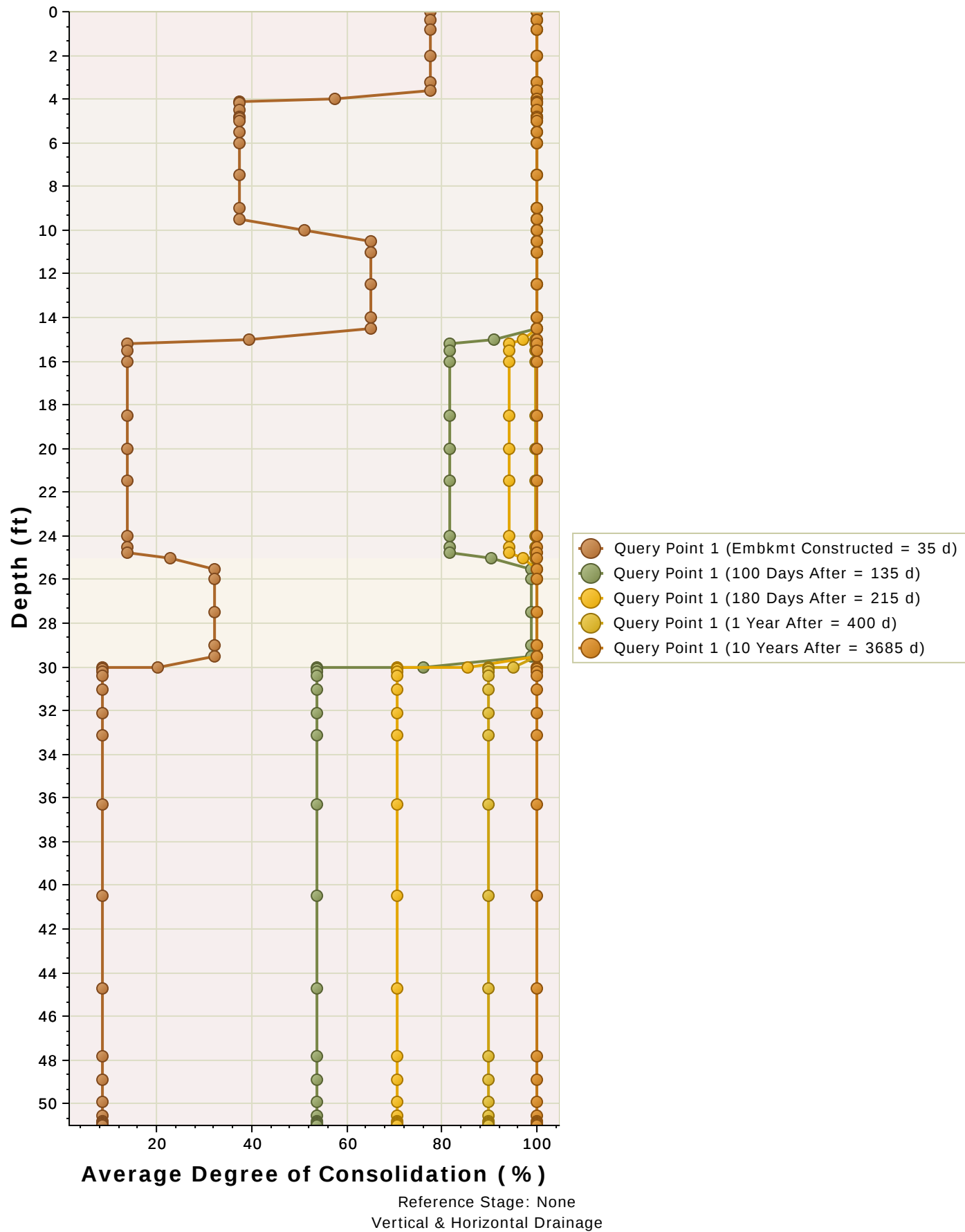
Time Points

Point #	(X,Y) Location	Depth	Goal Type	Goal	Time Until Goal
1	15, 0	0 ft	Degree of Consolidation	90%	101.478 d
2	15, 0	0 ft	Degree of Consolidation	95%	186.539 d
3	15, 0	0 ft	Total Settlement	12.62 in	240.735 d
4	15, 0	0 ft	Degree of Consolidation	92.66%	137.902 d

752+00 Total Consolidation Settlement vs. Depth



752+00 Average Degree of Consolidation vs. Depth



Settle3D Analysis Information

18029 SH 29 Embankments West

Project Settings

Document Name	18029 Settle 868+00.EW14 only.SD.s3z
Project Title	18029 SH 29 Embankments West
Analysis	868+00
Author	KKB
Company	Red Rock Consulting
Date Created	10/11/2019, 11:28:38 AM

Comments

Vertical Drainage Only	
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	days
Permeability Units	feet/day
Poisson ratio for Boussinesq stress computation	0.5

Calculate settlement with mean stress

Include vertical stress reduction due to settlement above a point

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [days]
1	Begin Construction	0
2	Embkmt Layer 1	14
3	Embkmt Layer 2	28
4	Embkmt Layer 3	38
5	Embkmt Complete	45
6	180 Days After	225
7	270 Days After	315
8	1 Year After	410
9	5 Years After	1870

Results

Time taken to compute: 1.96962 seconds

Stage: Embkmt Complete = 45 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.0661357	4.28645
Total Consolidation Settlement [in]	-0.0661357	4.28645
Virgin Consolidation Settlement [in]	0	3.01907
Recompression Consolidation Settlement [in]	-0.0661357	1.28898
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000239669	1.70982
Effective Stress ZZ [ksf]	0.000239669	5.14134
Mean Stress [ksf]	0.0158999	2.16033
Total Stress ZZ [ksf]	0.000239669	7.82454
Total Strain	-0.00077713	0.127845
Pore Water Pressure [ksf]	0	2.73667
Excess Pore Water Pressure [ksf]	0	1.13811
Degree of Consolidation [%]	0	99.9857
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.86129
Void Ratio	0.592169	1.30053
Permeability [ft/d]	6.80731e-005	0.102573
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	0.645249	97.3721

Stage: 180 Days After = 225 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	6.53649
Total Consolidation Settlement [in]	0	6.53649
Virgin Consolidation Settlement [in]	0	4.88986
Recompression Consolidation Settlement [in]	0	1.64663
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000239669	1.70982
Effective Stress ZZ [ksf]	0.000239669	5.1309
Mean Stress [ksf]	0.0158999	2.16033
Total Stress ZZ [ksf]	0.000239669	7.8141
Total Strain	-7.24858e-005	0.127866
Pore Water Pressure [ksf]	0	2.6832
Excess Pore Water Pressure [ksf]	0	0.485064
Degree of Consolidation [%]	0	99.979
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.52112
Void Ratio	0.589029	1.30008
Permeability [ft/d]	6.80731e-005	0.102573
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	47.34	99.736

Stage: 270 Days After = 315 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	6.95678
Total Consolidation Settlement [in]	0	6.95678
Virgin Consolidation Settlement [in]	0	5.25417
Recompression Consolidation Settlement [in]	0	1.70261
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000239669	1.70982
Effective Stress ZZ [ksf]	0.000239669	5.12892
Mean Stress [ksf]	0.0158999	2.16033
Total Stress ZZ [ksf]	0.000239669	7.81212
Total Strain	-3.41778e-005	0.127866
Pore Water Pressure [ksf]	0	2.6832
Excess Pore Water Pressure [ksf]	0	0.360456
Degree of Consolidation [%]	0	99.9872
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.50783
Void Ratio	0.585875	1.30003
Permeability [ft/d]	6.80731e-005	0.102573
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	54.5368	99.8776

Stage: 1 Year After = 410 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.2375
Total Consolidation Settlement [in]	0	7.2375
Virgin Consolidation Settlement [in]	0	5.50543
Recompression Consolidation Settlement [in]	0	1.73207
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000239669	1.70982
Effective Stress ZZ [ksf]	0.000239669	5.1276
Mean Stress [ksf]	0.0158999	2.16033
Total Stress ZZ [ksf]	0.000239669	7.8108
Total Strain	-7.83262e-006	0.127867
Pore Water Pressure [ksf]	0	2.6832
Excess Pore Water Pressure [ksf]	0	0.312775
Degree of Consolidation [%]	0	99.9915
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.49881
Void Ratio	0.583558	1.3
Permeability [ft/d]	6.80731e-005	0.102573
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	56.7349	99.9394

Stage: 5 Years After = 1870 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.79566
Total Consolidation Settlement [in]	0	7.79566
Virgin Consolidation Settlement [in]	0	6.02123
Recompression Consolidation Settlement [in]	0	1.77442
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.000239669	1.70982
Effective Stress ZZ [ksf]	0.000239669	5.12498
Mean Stress [ksf]	0.0158999	2.16033
Total Stress ZZ [ksf]	0.000239669	7.80818
Total Strain	1.12499e-005	0.127867
Pore Water Pressure [ksf]	-0.000585067	2.6832
Excess Pore Water Pressure [ksf]	-0.00178016	0.0574057
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.48453
Void Ratio	0.578566	1.29997
Permeability [ft/d]	6.80731e-005	0.102573
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	88.3442	100

Embankments

1. Embankment: "Embankment Load 1"

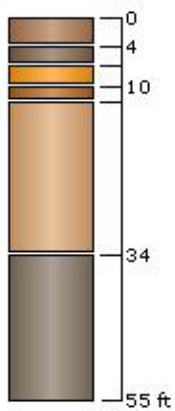
Label	Embankment Load 1
Center Line	(0, -200) to (0, 400)
Number of Layers	4
Near End Angle	18.4 degrees
Far End Angle	18.4 degrees
Base Width	144

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft ³)	Right Angle (deg)	Right Bench Width (ft)
1	Embkmt Layer 1 = 14 d	0	16.3	5	0.12	16.3	0
2	Embkmt Layer 2 = 28 d	0	16.3	5	0.12	16.3	0
3	Embkmt Layer 3 = 38 d	0	10.6	3	0.12	10.6	0
4	Embkmt Layer 3 = 38 d	0	10.6	1.5	0.12	10.6	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Clayey Sand, loose	4	0	No
2	Sandy CL, very soft 1	3	4	No
3	Silty, Clayey Sand, v loose	3	7	No
4	Sandy CL, very soft 2	2	10	No
5	Clayey Sand, v loose	22	12	No
6	Sandy Silty Clay, very soft	21	34	Yes



Soil Properties

Property	Clayey Sand, loose	Sandy CL, very soft 1	Silty, Clayey Sand, v loose	Sandy CL, very soft 2
Color				
Unit Weight [kips/ft ³]	0.115	0.12	0.115	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125	0.12	0.125
Poisson's Ratio	0.3	0.3	0.3	0.35
K0	0.87	1.6	0.9	1.6
Primary Consolidation	Enabled	Enabled	Enabled	Enabled
Material Type	Non-Linear	Non-Linear	Non-Linear	Non-Linear
Cc	0.2	0.2	0.2	0.2
Cr	0.03	0.05	0.02	0.05
e0	1.3	0.841	1.1	0.84
OCR	3	7.5	1.1	1.5
Cv [ft ² /d]	1	0.5	0.9	0.5
Cvr [ft ² /d]	1	0.5	0.9	0.5
B-bar	0.9	0.9	0.9	0.95
Undrained Su A [kips/ft ²]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Property	Clayey Sand, v loose	Sandy Silty Clay, very soft
Color		
Unit Weight [kips/ft ³]	0.115	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125
Poisson's Ratio	0.499	0.499
K0	0.8	0.72
Primary Consolidation	Enabled	Enabled
Material Type	Non-Linear	Non-Linear
Cc	0.2	0.2
Cr	0.02	0.02
e0	1.3	0.6
OCR	2	1.2
Cv [ft ² /d]	1	0.8
Cvr [ft ² /d]	1	0.8
B-bar	0.999	0.999
Undrained Su A [kips/ft ²]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	1	1

Groundwater

Groundwater method Piezometric Lines
 Water Unit Weight 0.0624 kips/ft³
 Generating excess pore pressure above water table

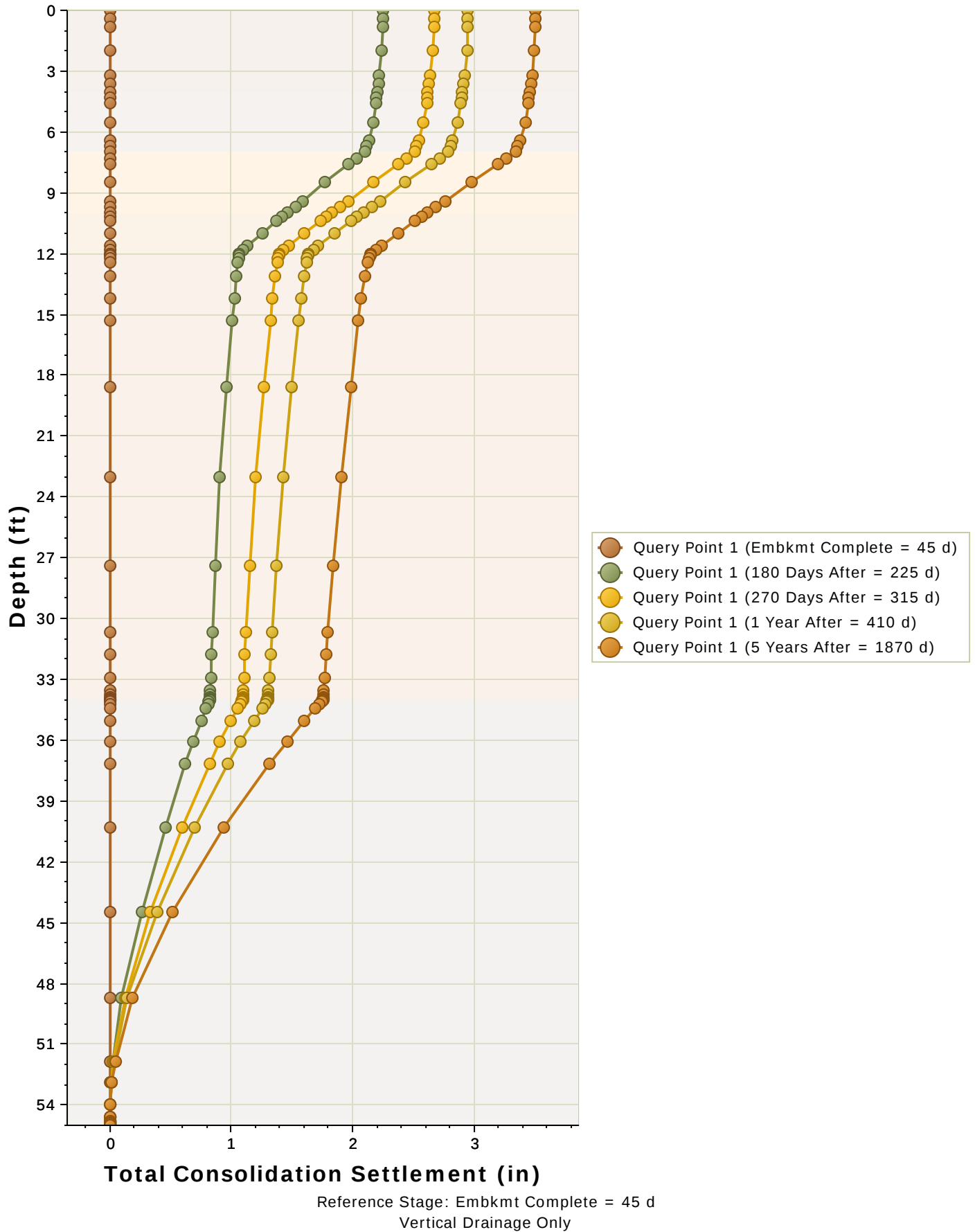
Piezometric Line Entities

ID	Depth (ft)
1	12 ft

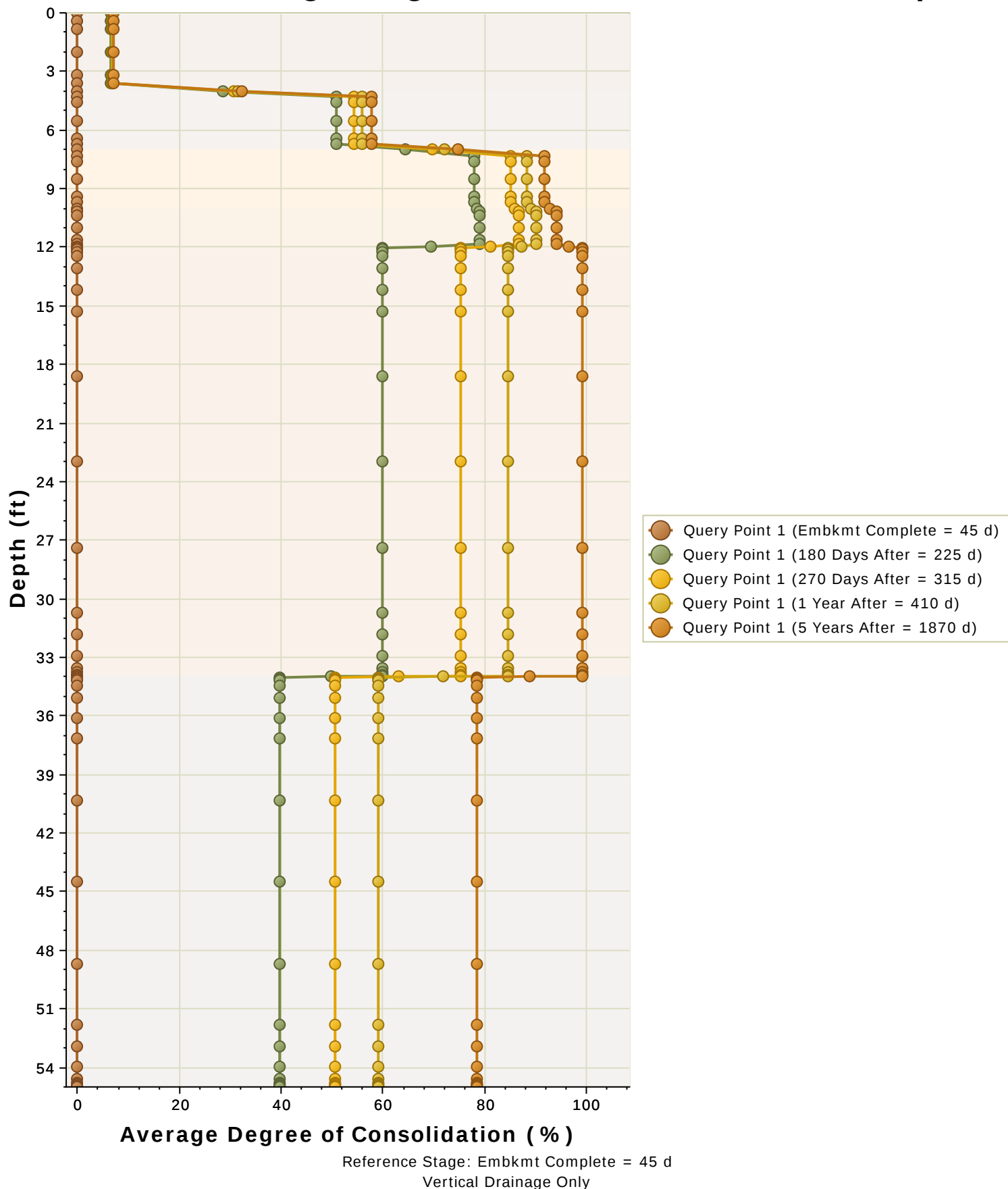
Time Points

Point #	(X,Y) Location	Depth	Goal Type	Goal	Time Until Goal
1	-5, 0	0 ft	Degree of Consolidation	95%	454.477 d
2	-5, 0	0 ft	Degree of Consolidation	90%	290.983 d
3	-5, 0	0 ft	Total Settlement	6.8 in	232.298 d
4	-5, 0	0 ft	Degree of Consolidation	87.2%	234.462 d

868+00 Total Consolidation Settlement vs. Depth



868+00 Average Degree of Consolidation vs. Depth



Settle3D Analysis Information

18029 SH 29 Embankments West

Project Settings

Document Name	18029 Settle 868+00.EW14 only.DD.s3z
Project Title	18029 SH 29 Embankments West
Analysis	868+00
Author	KKB
Company	Red Rock Consulting
Date Created	10/11/2019, 11:28:38 AM

Comments

Vertical & Horizontal Drainage	
Stress Computation Method	Boussinesq
Time-dependent Consolidation Analysis	
Time Units	days
Permeability Units	feet/day
Poisson ratio for Boussinesq stress computation	0.5

Calculate settlement with mean stress

Include vertical stress reduction due to settlement above a point

Use average properties to calculate layered stresses

Improve consolidation accuracy

Ignore negative effective stresses in settlement calculations

Stage Settings

Stage #	Name	Time [days]
1	Begin Construction	0
2	Embkmt Layer 1	14
3	Embkmt Layer 2	28
4	Embkmt Layer 3	38
5	Embkmt Complete	45
6	30 Days After	75
7	60 Days After	105
8	1 Year After	410

Results

Time taken to compute: 2.01544 seconds

Stage: Embkmt Complete = 45 d

Data Type	Minimum	Maximum
Total Settlement [in]	-0.00378	6.44
Total Consolidation Settlement [in]	-0.00378	6.44
Virgin Consolidation Settlement [in]	0	4.84
Recompression Consolidation Settlement [in]	-0.00378	1.6
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.00024	1.71
Effective Stress ZZ [ksf]	0.00024	5.13
Mean Stress [ksf]	0.0159	2.16
Total Stress ZZ [ksf]	0.00024	7.81
Total Strain	-7.23e-005	0.128
Pore Water Pressure [ksf]	0	2.74
Excess Pore Water Pressure [ksf]	0	0.862
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.49
Void Ratio	0.579	1.3
Permeability [ft/d]	6.81e-005	0.103
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	27.2	100

Stage: 30 Days After = 75 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.06
Total Consolidation Settlement [in]	0	7.06
Virgin Consolidation Settlement [in]	0	5.36
Recompression Consolidation Settlement [in]	0	1.7
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.00024	1.71
Effective Stress ZZ [ksf]	0.00024	5.12
Mean Stress [ksf]	0.0159	2.16
Total Stress ZZ [ksf]	0.00024	7.81
Total Strain	-2.1e-005	0.128
Pore Water Pressure [ksf]	0	2.68
Excess Pore Water Pressure [ksf]	0	0.434
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.48
Void Ratio	0.579	1.3
Permeability [ft/d]	6.81e-005	0.103
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	59	100

Stage: 60 Days After = 105 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.38
Total Consolidation Settlement [in]	0	7.38
Virgin Consolidation Settlement [in]	0	5.64
Recompression Consolidation Settlement [in]	0	1.74
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.00024	1.71
Effective Stress ZZ [ksf]	0.00024	5.12
Mean Stress [ksf]	0.0159	2.16
Total Stress ZZ [ksf]	0.00024	7.81
Total Strain	6.29e-006	0.128
Pore Water Pressure [ksf]	-2.35e-028	2.68
Excess Pore Water Pressure [ksf]	-2.35e-028	0.215
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.48
Void Ratio	0.579	1.3
Permeability [ft/d]	6.81e-005	0.103
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	76.3	100

Stage: 1 Year After = 410 d

Data Type	Minimum	Maximum
Total Settlement [in]	0	7.78
Total Consolidation Settlement [in]	0	7.78
Virgin Consolidation Settlement [in]	0	6.01
Recompression Consolidation Settlement [in]	0	1.77
Immediate Settlement [in]	0	0
Secondary Settlement [in]	0	0
Loading Stress ZZ [ksf]	0.00024	1.71
Effective Stress ZZ [ksf]	0.00024	5.12
Mean Stress [ksf]	0.0159	2.16
Total Stress ZZ [ksf]	0.00024	7.8
Total Strain	1.13e-005	0.128
Pore Water Pressure [ksf]	-2.72e-031	2.68
Excess Pore Water Pressure [ksf]	-2.72e-031	0.00627
Degree of Consolidation [%]	0	100
Pre-consolidation Stress [ksf]	0.069	5.88
Over-consolidation Ratio	1	7.48
Void Ratio	0.579	1.3
Permeability [ft/d]	6.81e-005	0.103
Coefficient of Consolidation [ft ² /d]	0.5	1
Average Degree of Consolidation [%]	98.7	100

Embankments

1. Embankment: "Embankment Load 1"

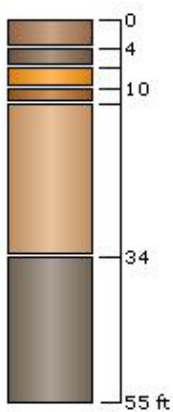
Label Embankment Load 1
 Center Line (0, -200) to (0, 400)
 Number of Layers 4
 Near End Angle 18.4 degrees
 Far End Angle 18.4 degrees
 Base Width 144

Layer	Stage	Left Bench Width (ft)	Left Angle (deg)	Height (ft)	Unit Weight (kips/ft ³)	Right Angle (deg)	Right Bench Width (ft)
1	Embkmt Layer 1 = 14 d	0	16.3	5	0.12	16.3	0
2	Embkmt Layer 2 = 28 d	0	16.3	5	0.12	16.3	0
3	Embkmt Layer 3 = 38 d	0	10.6	3	0.12	10.6	0
4	Embkmt Layer 3 = 38 d	0	10.6	1.5	0.12	10.6	0

Soil Layers

Ground Surface Drained: Yes

Layer #	Type	Thickness [ft]	Depth [ft]	Drained at Bottom
1	Clayey Sand, loose	4	0	Yes
2	Sandy CL, very soft 1	3	4	Yes
3	Silty, Clayey Sand, v loose	3	7	Yes
4	Sandy CL, very soft 2	2	10	Yes
5	Clayey Sand, v loose	22	12	Yes
6	Sandy Silty Clay, very soft	21	34	Yes



Soil Properties

Property	Clayey Sand, loose	Sandy CL, very soft 1	Silty, Clayey Sand, v loose	Sandy CL, very soft 2
Color				
Unit Weight [kips/ft ³]	0.115	0.12	0.115	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125	0.12	0.125
Poisson's Ratio	0.3	0.3	0.3	0.35
K0	0.87	1.6	0.9	1.6
Primary Consolidation	Enabled	Enabled	Enabled	Enabled
Material Type	Non-Linear	Non-Linear	Non-Linear	Non-Linear
Cc	0.2	0.2	0.2	0.2
Cr	0.03	0.05	0.02	0.05
e0	1.3	0.841	1.1	0.84
OCR	3	7.5	1.1	1.5
Cv [ft ² /d]	1	0.5	0.9	0.5
Cvr [ft ² /d]	1	0.5	0.9	0.5
B-bar	0.9	0.9	0.9	0.95
Undrained Su A [kips/ft ²]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Property	Clayey Sand, v loose	Sandy Silty Clay, very soft
Color		
Unit Weight [kips/ft ³]	0.115	0.12
Saturated Unit Weight [kips/ft ³]	0.12	0.125
Poisson's Ratio	0.499	0.499
K0	0.8	0.72
Primary Consolidation	Enabled	Enabled
Material Type	Non-Linear	Non-Linear
Cc	0.2	0.2
Cr	0.02	0.02
e0	1.3	0.6
OCR	2	1.2
Cv [ft ² /d]	1	0.8
Cvr [ft ² /d]	1	0.8
B-bar	0.999	0.999
Undrained Su A [kips/ft ²]	0	0
Undrained Su S	0.2	0.2
Undrained Su m	0.8	0.8
Piezo Line ID	1	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft ³
Generating excess pore pressure above water table	

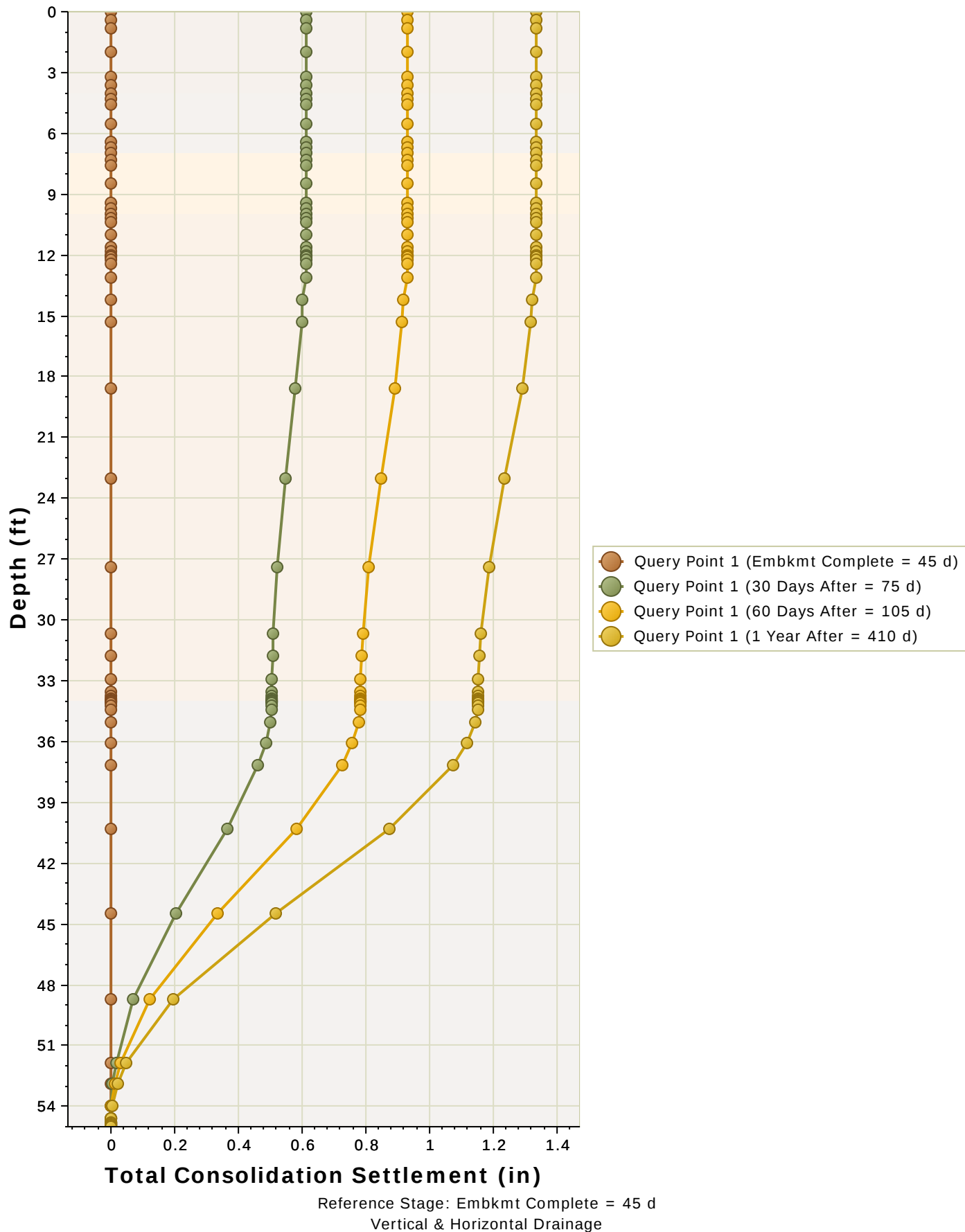
Piezometric Line Entities

ID	Depth (ft)
1	12 ft

Time Points

Point #	(X,Y) Location	Depth	Goal Type	Goal	Time Until Goal
1	-5, 0	0 ft	Degree of Consolidation	95%	62.3832 d
2	-5, 0	0 ft	Degree of Consolidation	90%	26.6305 d
3	-5, 0	0 ft	Total Settlement	6.78 in	13.5565 d
4	-5, 0	0 ft	Degree of Consolidation	86.9%	13.0396 d

868+00 Total Consolidation Settlement vs. Depth



868+00 Average Degree of Consolidation vs. Depth

