INFRASTRUCTURE
CONSULTING & ENGINEERING

April 25, 2023

Mr. Billy Hardwick
Senior Project Manager
Archer-United Joint Venture
billy.hardwick@uig.net

Re: **Report of Dynamic Pile Testing**
Bent 3 Pile 3
Bridge 36 - Colonial Life Blvd. Ramp B Bridge over I-126, I-126 Ramp & S-287 (Arrowwood Road)
Project ID: P039718
Richland County, South Carolina

Dear Mr. Hardwick:

The attached results of dynamic pile testing for the subject pile and project includes measurements and analysis performed by Infrastructure Consulting & Engineering in accordance with ASTM D4945. Measurements were made with the Pile Dynamics, Inc. Model 8G and signal matching analysis was performed with CAPWAP version 2014. For further information on the test method please refer to the ASTM.

Also included are the production pile driving recommendations for Bent 3 of the subject project. The Geotechnical Engineer of Record should ultimately make final recommendations for foundation design and construction.

Thank you for the opportunity to provide these services.

Sincerely,
Infrastructure Consulting & Engineering (ICE), PLLC

Michael J Simpson, P.E.
Digitally signed by Michael J Simpson, P.E.
Date: 2023.04.25 08:34:46-04'00'

SOUTH CAROLINA LICENSED PROFESSIONAL ENGINEER No. 35396 MICHAEL JOEL SIMPSON

SOUTH CAROLINA INFRASTRUCTURE CONSULTING & ENGINEERING, PLLC No. 4470 CERTIFICATE OF AUTHORIZATION

Michael J. Simpson, P.E.
Geotechnical Testing Manager
Certified PDA Signatory "Advanced"
South Carolina Registration Number: 35396

Sally G. Thomson, P.E.
Geotechnical Designer
Certified PDA Signatory "Advanced"

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Summary of Provided Project and Pile Driving Information

Project Description	Colonial Life Blvd. Ramp B Bridge over I-126, I-126 Ramp & S-287 (Arrowwood Road) Richland County, South Carolina
Pile Driving Contractor	Archer United Joint Venture
Project ID	P039718
ICE Field Personnel	Sally G. Thomson, P.E.
ICE Responsible Engineer	Michael J. Simpson, P.E.

Bent Number	**Station**	**Pile Type**	**Pile Batter**	**Hammer Used**	**Pile Cushion Type and Thickness**
Bent 3	34+14.51	HP14x89 with Pile Tip	Plumb	ICE I-19v2	N/A

Pile Number	**Total Pile Length (feet)**	**Pile Length Below Gages (feet)**	**Pile Splice Location(s) above Pile Tip (feet)**	**Initial Drive Test Date**	**Restrike Test Date**
3	50.0	47.7	N/A	4/21/23	N/A

Factored Design Load (kips)	**Geotechnical Resistance Factor**	**Nominal Resistance of Pile (kips)**	**Required Driving Resistance of Pile (kips)**	**Minimum Tip Elevation of Pile (feet)**
345	0.65	531	531	+163.0

Installation Records Provided to ICE	Please Refer to SCDOT Pile Driving Logs
Project Information and Soil Borings Provided to ICE	Yes, Attached in Appendix C
Pile Driving Equipment Data Form Provided to ICE	ICE I-19v2 Data Hammer Sheet Attached in Appendix D
Strain and Accelerometer Calibrations Attached	Yes, Attached in Appendix E

Steel Acceptable Compression Driving Stress Limit (ksi)*	45
Steel Acceptable Tension Driving Stress Limit (ksi)*	45

*For steel piles based on Section 711.4.2.2 and a steel yield strength (Fy) of 50 ksi.

Approximate Reference Elevation (feet)	+179.3
Approximate Ground/Mudline Elevation (feet)	+178.3
Approximate Final Pile Penetration Below Reference at End of Initial Drive (feet)	43.9
Approximate Final Pile Tip Elevation at End of Initial Drive (feet)	+135.4
Approximate Final Pile Penetration Below Reference at End of Restrike (feet)	N/A
Approximate Final Pile Tip Elevation at End of Restrike (feet)	N/A

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Additional Notes on Pile Installation
-Pile 3 was monitored with instrumentation for the entire initial drive. -For additional detailed information on the hammer driving system, bridge plans, and soils information please refer to the project documents. -The blows per foot of penetration for the pile was kept by the PDA operator on the PDA during the initial drive. A pile driving log was also maintained by a SCDOT representative.

Summary of Results

Dynamic Pile Testing Results (Detailed Results in Appendix A)

Location*	Capacity (kips)	Case Method	Max. Comp. Stress (ksi)	Avg. Comp. Stress (ksi)	Max. Comp. Stress at Pile Bottom (ksi)	Avg. Comp. Stress at Pile Bottom (ksi)	Avg. Transferred Energy (k-ft)	Avg. Stroke (feet)
EOD	609	RX7	31.1	24.0	28.8	12.5	15.2	7.5

Signal Matching Analyses Results (Detailed Result in Appendix A)

Location*	R_{ult} (kips)	R_{side} / R_{end} (kips)	Equiv. BPF*	Stroke (ft)	EMX (k-ft)	Qs (in)	Qt (in)	Ss (sec/ft)	St (sec/ft)	MQN*
EOD (Blow 803)	610	252 / 358	160	10.3	21.7	0.12	0.16	0.16	0.03	2.35

*EOD – End of Drive; BPF – Blows per foot; MQN – Match Quality Number

Dynamic Pile Testing Interpretation and Commentary

The capacity listed in the Summary of Dynamic Pile Testing Results is based on the RX7 (Maximum Case Method with J(c)=0.7) solution for the maximum for the last increment of the initial drive. The summary plot and table attached for the dynamic pile testing results are based on the same capacity solution.

Signal matching analysis was performed for a blow (Blow 803) near the end of the initial drive. The signal matching mobilized capacity near the end of initial drive was above the required driving resistance of 531 kips for Bent 3.

Compression and tension pile driving stresses were below the acceptable limit for the pile tested during the initial drive. The pile tested did not show any signs of integrity problems below the gage locations based on the test results.

Recommended Production Pile Driving Criteria

The recommended drive criteria for the up to 50.0 feet long HP 14x89 steel piles in Bent 3 is based on the wave equation analysis and the dynamic testing results. Please see the attached wave equation outputs for additional information.

The driving criteria also only apply to piles driven with the ICE I-19v2 hammer driving system. A hammer helmet weight of 2.3 kips and a hammer cushion of 2.0 total inches of nylon, based on the project pile installation plan, was used to develop the production pile driving criteria. A change in the hammer driving system, installation procedures, and/or pile type would require re-analysis and likely would warrant modifications to the driving criteria. ICE should be notified immediately should any changes occur.

Bent 3

The up to 50.0 foot HP 14x89 steel piles at Bent 3 may be stopped if one of the following conditions is met, provided pile rebound is less than ¼ inch per blow and the minimum tip elevation or minimum penetration requirements in the project plans and/or specifications are met.

1. Practical refusal (20 blows per one inch or ½ inch in 10 blows with at least a stroke of 8.5 feet) is reached during driving.
2. The following maximum set per 10 blows is not exceeded for the respective stroke during driving:

Stroke (feet)	Maximum Set in inches per 10 blows	Minimum Blows Per Foot
9.0	5/8	172
9.5	7/8	134
10.0 or greater	1	120

Piles not meeting the above requirements should be brought to the Engineer's attention and may require additional testing and/or driving to meet the requirements.

Limitations

This report presents test measurement made by ICE. Interpretations were made based upon the measurements made by ICE with the latest techniques available and currently accepted standards of care recognized by Geotechnical Engineering professionals. The Geotechnical Engineer of Record should ultimately make final recommendations for foundation design and construction.

Appendix A

Dynamic Pile Testing, Signal Matching Results, and Calibration WEAP

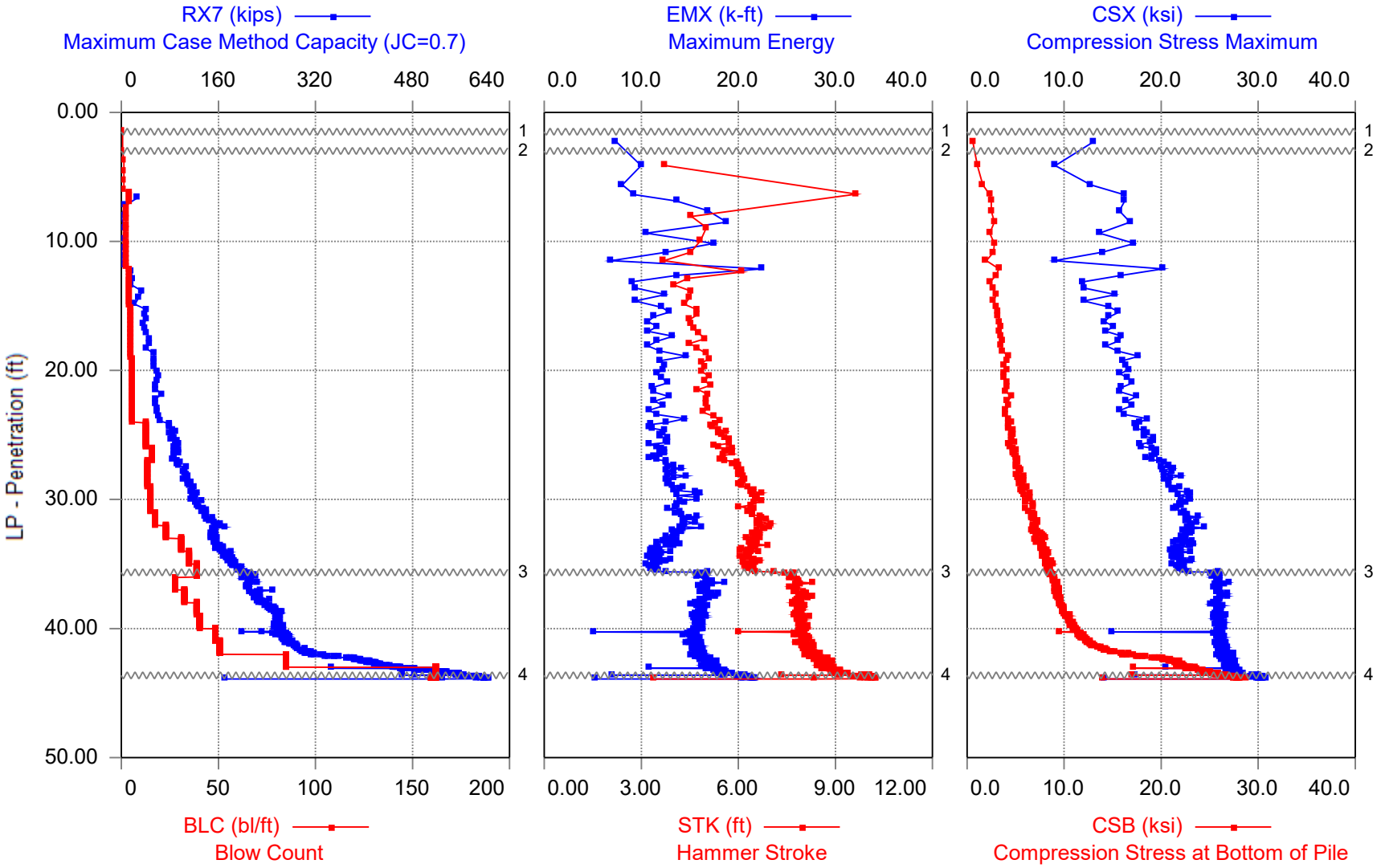
Bridge 36, Bent 3, Pile 3

Pile Dynamics, Inc. - PDIPLOT2 Ver 2017.2.58.3 - Case Method & iCAP® Results

Printed: 24-April-2023

Test started: 21-April-2023

CCRP1 Bridge 36 Bent 3 - Pile 3



1 - Template/Ground Reference Elevation 179.3

2 - Fuel Setting 2

3 - Fuel Setting 3

4 - Fuel Setting 4

CCRP1 Bridge 36 Bent 3 - Pile 3 HP 14x89 w tips
OP: ICE Date: 21-April-2023

AR: 26.10 in² SP: 0.492 k/ft³
LE: 47.67 ft EM: 30,000 ksi
WS: 16,807.9 f/s JC: 0.70

RMX: Maximum Case Method Capacity (JC)
EMX: Maximum Energy
STK: Hammer Stroke
CSX: Compression Stress Maximum
CSB: Compression Stress at Bottom of Pile
TSX: Tension Stress Maximum - Full Record Search
DMX: Maximum Displacement
DFN: Final Displacement
BTA: Integrity Factor (1)

BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
2	3.00	1	AV2	0	7.4	**	13.1	0.6	10.3	18.01	18.01	89.0
			STD	0	2.7	**	1.6	0.5	1.2	0.01	0.01	11.0
			MAX	0	10.0	**	14.7	1.1	11.5	18.02	18.02	100.0
			@BL	1	2	**	2	2	2	1	1	2
6	6.00	1	AV4	0	9.0	7.14	10.9	1.4	7.2	9.00	9.00	82.3
			STD	0	1.6	4.83	3.4	0.4	3.0	0.00	0.00	13.5
			MAX	0	11.3	13.92	16.1	1.8	11.7	9.01	9.01	100.0
			@BL	3	3	5	6	6	6	4	4	6
10	7.00	4	AV4	13	11.5	**	16.2	2.4	10.7	3.60	3.00	100.0
			STD	13	3.7	**	0.1	0.1	1.4	0.61	0.00	0.0
			MAX	27	17.8	**	16.3	2.6	11.6	4.66	3.00	100.0
			@BL	8	10	**	8	10	8	10	9	7
17	10.00	2	AV7	5	15.8	4.78	15.6	2.6	9.2	5.19	5.14	100.0
			STD	6	4.0	0.51	2.3	0.3	1.8	0.08	0.00	0.0
			MAX	13	19.9	5.39	18.8	3.0	10.7	5.38	5.14	100.0
			@BL	16	14	11	11	14	14	14	16	11
23	12.00	3	AV6	1	13.0	4.40	13.5	2.6	7.8	4.27	4.00	100.0
			STD	1	5.4	0.70	3.6	0.5	2.3	0.34	0.00	0.0
			MAX	3	21.7	5.52	17.9	3.0	11.1	4.85	4.00	100.0
			@BL	22	23	18	18	18	18	18	22	18
31	14.00	4	AV8	22	12.6	4.78	14.8	2.8	8.9	3.38	3.00	100.0
			STD	12	4.6	0.96	3.7	0.4	2.7	0.68	0.00	0.0
			MAX	36	23.2	7.16	23.3	3.7	14.8	5.10	3.00	100.0
			@BL	31	24	24	24	24	24	24	29	24
35	15.00	4	AV4	25	10.7	4.41	13.6	2.9	7.9	3.00	3.00	100.0
			STD	6	1.4	0.31	1.6	0.2	1.2	0.00	0.00	0.0
			MAX	31	12.2	4.74	15.4	3.1	9.3	3.00	3.00	100.0
			@BL	32	35	32	32	35	32	33	33	32
51	18.00	5	AV16	41	11.6	4.68	14.9	3.4	8.6	2.41	2.25	100.0
			STD	4	1.1	0.20	0.9	0.2	0.6	0.12	0.00	0.0
			MAX	50	13.6	5.00	16.3	3.8	9.7	2.68	2.25	100.0
			@BL	51	48	49	49	49	37	37	51	36
56	19.00	5	AV5	48	12.9	4.95	16.3	3.9	9.1	2.44	2.40	100.0
			STD	6	1.5	0.25	1.1	0.3	0.6	0.04	0.00	0.0
			MAX	58	15.1	5.30	17.8	4.3	10.0	2.49	2.40	100.0
			@BL	54	55	55	55	55	55	56	53	52

CCRP1 Bridge 36 Bent 3 - Pile 3 HP 14x89 w tips
OP: ICE Date: 21-April-2023

BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
62	20.00	6	AV6	56	12.2	4.96	16.4	4.0	8.9	2.06	2.00	100.0
			STD	4	0.2	0.08	0.4	0.1	0.3	0.05	0.00	0.0
			MAX	62	12.6	5.06	17.0	4.2	9.6	2.15	2.00	100.0
			@BL	62	59	62	62	62	62	59	57	57
79	23.00	6	AV17	60	11.9	4.99	16.4	4.1	8.5	2.12	2.12	100.0
			STD	5	0.9	0.19	0.8	0.3	0.6	0.00	0.00	0.0
			MAX	69	13.5	5.30	17.7	5.0	9.5	2.12	2.12	100.0
			@BL	73	73	78	78	73	68	78	70	63
85	24.00	6	AV6	62	12.8	5.21	17.3	4.2	8.4	2.02	2.00	100.0
			STD	6	1.5	0.27	1.1	0.3	0.6	0.02	0.00	0.0
			MAX	70	14.7	5.64	18.8	4.6	9.4	2.06	2.00	100.0
			@BL	83	84	84	84	85	84	84	81	80
98	25.00	13	AV13	82	11.6	5.36	17.9	4.5	8.5	1.36	0.89	99.2
			STD	6	0.7	0.16	0.6	0.2	0.3	0.05	0.01	2.7
			MAX	90	12.7	5.69	19.0	4.8	9.3	1.47	0.90	100.0
			@BL	94	94	95	95	97	90	86	91	86
111	26.00	13	AV13	89	12.0	5.57	18.6	4.6	8.7	1.25	0.90	100.0
			STD	5	0.8	0.23	0.9	0.2	0.6	0.07	0.01	0.0
			MAX	100	12.9	5.82	19.7	5.1	9.4	1.32	0.92	100.0
			@BL	106	102	102	102	105	104	101	110	99
127	27.00	16	AV16	90	11.9	5.64	19.2	5.0	8.7	1.11	0.73	100.0
			STD	5	0.7	0.17	0.6	0.2	0.6	0.06	0.01	0.0
			MAX	98	12.9	5.94	20.0	5.3	9.6	1.21	0.75	100.0
			@BL	127	113	113	119	126	119	113	125	112
155	29.00	14	AV28	105	13.3	6.06	20.8	5.4	8.9	1.04	0.85	99.6
			STD	8	0.9	0.30	1.0	0.3	0.8	0.07	0.01	2.2
			MAX	120	15.1	6.69	22.5	6.1	10.7	1.16	0.86	100.0
			@BL	151	155	146	146	143	132	128	154	128
170	30.00	15	AV15	120	14.8	6.53	22.2	6.1	8.7	0.97	0.79	98.7
			STD	6	1.3	0.32	1.0	0.5	0.7	0.06	0.01	3.4
			MAX	136	16.8	7.08	24.0	7.0	10.0	1.05	0.80	100.0
			@BL	162	163	163	170	168	161	163	164	156
185	31.00	15	AV15	130	13.7	6.40	22.0	6.4	8.3	0.84	0.80	100.0
			STD	8	1.0	0.28	0.9	0.4	0.7	0.04	0.00	0.0
			MAX	144	15.5	6.88	23.4	7.0	9.5	0.90	0.80	100.0
			@BL	183	173	173	173	177	173	173	175	171
203	32.00	18	AV18	148	14.7	6.68	23.0	7.0	8.1	0.80	0.66	100.0
			STD	10	0.9	0.25	0.8	0.4	0.6	0.04	0.01	0.0
			MAX	173	16.4	7.20	24.6	7.7	9.5	0.88	0.67	100.0
			@BL	201	194	192	192	200	192	194	199	186
226	33.00	23	AV23	155	13.8	6.65	22.8	7.3	7.3	0.69	0.51	100.0
			STD	9	1.1	0.30	0.8	0.6	0.7	0.05	0.01	0.0
			MAX	187	16.3	7.37	24.6	8.2	9.0	0.79	0.52	100.0

CCRP1 Bridge 36 Bent 3 - Pile 3 HP 14x89 w tips
OP: ICE Date: 21-April-2023

BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
			@BL	207	207	208	208	225	208	207	224	204
257	34.00	31	AV31	160	12.5	6.47	22.2	7.6	6.2	0.58	0.38	100.0
			STD	6	1.1	0.30	0.9	0.4	0.8	0.05	0.01	0.0
			MAX	176	14.8	7.11	24.2	8.6	7.9	0.67	0.39	100.0
			@BL	249	237	237	237	246	237	233	251	227
292	35.00	35	AV35	178	11.7	6.37	22.0	8.2	5.1	0.51	0.34	100.0
			STD	9	0.9	0.25	0.8	0.3	0.6	0.03	0.01	0.0
			MAX	196	14.5	7.12	24.4	8.8	7.2	0.60	0.35	100.0
			@BL	279	259	259	259	285	259	259	266	258
331	36.00	39	AV39	200	13.3	6.89	23.5	8.6	5.1	0.53	0.30	100.0
			STD	13	2.4	0.62	1.8	0.2	0.8	0.06	0.01	0.0
			MAX	239	16.9	7.80	26.2	9.2	6.4	0.64	0.31	100.0
			@BL	328	317	325	329	293	327	317	312	293
359	37.00	28	AV28	211	16.8	7.83	25.9	9.2	5.4	0.60	0.42	100.0
			STD	6	0.7	0.22	0.5	0.2	0.4	0.02	0.01	0.0
			MAX	224	19.6	8.70	27.9	9.7	6.8	0.66	0.44	100.0
			@BL	343	344	344	344	359	344	343	341	332
392	38.00	33	AV33	228	16.7	7.94	26.1	9.5	5.1	0.57	0.35	100.0
			STD	12	0.8	0.20	0.5	0.2	0.4	0.02	0.01	0.0
			MAX	258	18.8	8.59	27.7	10.0	6.3	0.62	0.36	100.0
			@BL	383	375	375	375	382	375	369	368	360
431	39.00	39	AV39	249	16.0	7.89	25.9	9.9	4.3	0.52	0.30	100.0
			STD	11	0.5	0.13	0.4	0.3	0.3	0.02	0.01	0.0
			MAX	271	17.0	8.16	26.6	10.6	4.9	0.55	0.31	100.0
			@BL	422	401	412	401	431	403	401	420	393
472	40.00	41	AV41	259	16.0	8.00	26.1	10.7	3.5	0.50	0.28	100.0
			STD	7	0.5	0.15	0.4	0.3	0.4	0.02	0.01	0.0
			MAX	275	17.8	8.55	27.2	11.2	4.7	0.56	0.29	100.0
			@BL	463	435	435	435	469	435	435	461	432
521	41.00	49	AV49	264	15.1	7.92	25.6	11.7	2.5	0.46	0.24	100.0
			STD	18	2.2	0.60	2.3	0.6	0.7	0.04	0.01	0.0
			MAX	287	16.6	8.31	26.9	12.6	4.9	0.52	0.25	100.0
			@BL	521	476	505	493	519	484	476	483	473
572	42.00	51	AV51	293	15.8	8.18	26.4	13.9	1.1	0.44	0.23	100.0
			STD	14	0.6	0.19	0.5	1.2	0.6	0.02	0.01	0.0
			MAX	325	17.5	8.76	28.1	16.7	2.2	0.50	0.24	100.0
			@BL	567	567	567	567	568	524	530	531	522
657	43.00	85	AV85	391	16.7	8.55	26.9	20.3	1.1	0.43	0.14	100.0
			STD	38	0.6	0.21	0.5	1.9	0.6	0.02	0.00	0.0
			MAX	452	18.0	9.00	28.0	22.9	2.2	0.46	0.14	100.0
			@BL	655	622	622	630	655	656	630	598	573
796	43.85	163	AV139	524	18.5	9.19	28.0	24.9	3.0	0.46	0.07	100.0

CCRP1 Bridge 36 Bent 3 - Pile 3 HP 14x89 w tips
OP: ICE Date: 21-April-2023

BL#	Depth ft	BLC bl/ft	TYPE	RMX kips	EMX k-ft	STK ft	CSX ksi	CSB ksi	TSX ksi	DMX in	DFN in	BTA (%)
			STD	52	2.3	0.57	2.1	2.2	0.4	0.04	0.00	0.0
			MAX	598	22.0	10.35	31.0	28.3	3.7	0.53	0.08	100.0
			@BL	795	795	783	767	791	790	761	758	658
806	43.92	160	AV10	546	18.3	9.14	27.3	25.5	3.2	0.44	0.07	100.0
			STD	131	6.8	2.26	7.2	6.6	0.9	0.12	0.00	0.0
			MAX	609	22.1	10.45	31.1	28.8	3.6	0.52	0.08	100.0
			@BL	803	803	804	798	803	800	797	806	797
			Average	263	15.2	7.47	24.0	12.5	4.8	0.89	0.65	99.8
			Std. Dev.	161	2.9	1.47	4.3	7.6	2.8	1.29	1.32	1.9
			Maximum	609	23.2	13.92	31.1	28.8	14.8	18.02	18.02	100.0
			@ Blow#	803	24	5	798	803	24	1	1	2

Total number of blows analyzed: 806

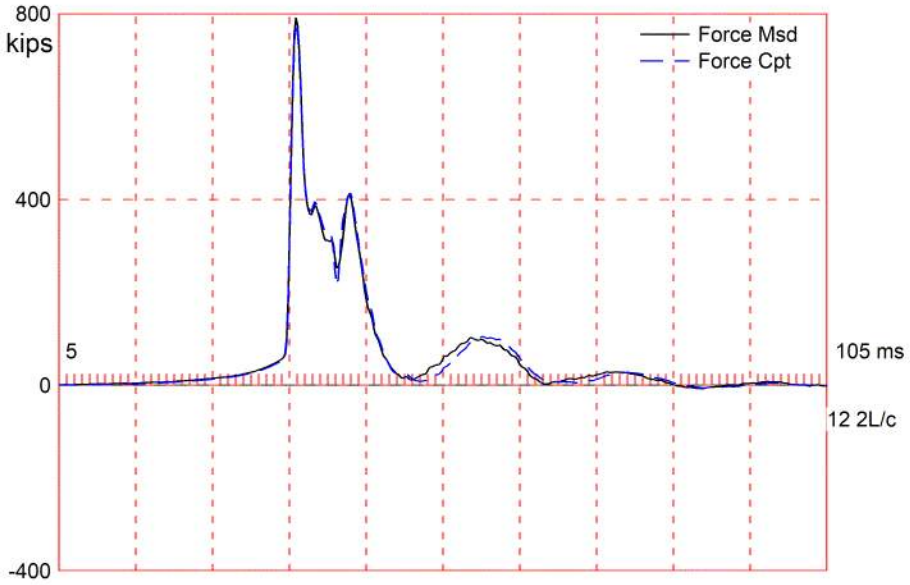
BL#	Sensors
1-566	F2: [P821] 145.1 (1.00); F4: [S868] 145.1 (1.00); A1: [K12389] 483.2 (1.00); A3: [K12388] 451.0 (1.00)
567-568	F2: [P821] 145.1 (1.00); A1: [K12389] 483.2 (1.00)
569	F2: [P821] 145.1 (1.00); F4: [S868] 145.1 (1.00); A1: [K12389] 483.2 (1.00); A3: [K12388] 451.0 (1.00)
570	F2: [P821] 145.1 (1.00); A1: [K12389] 483.2 (1.00)
571-664	F2: [P821] 145.1 (1.00); F4: [S868] 145.1 (1.00); A1: [K12389] 483.2 (1.00); A3: [K12388] 451.0 (1.00)
665	F2: [P821] 145.1 (1.00); A1: [K12389] 483.2 (1.00)
666-806	F2: [P821] 145.1 (1.00); F4: [S868] 145.1 (1.00); A1: [K12389] 483.2 (1.00); A3: [K12388] 451.0 (1.00)

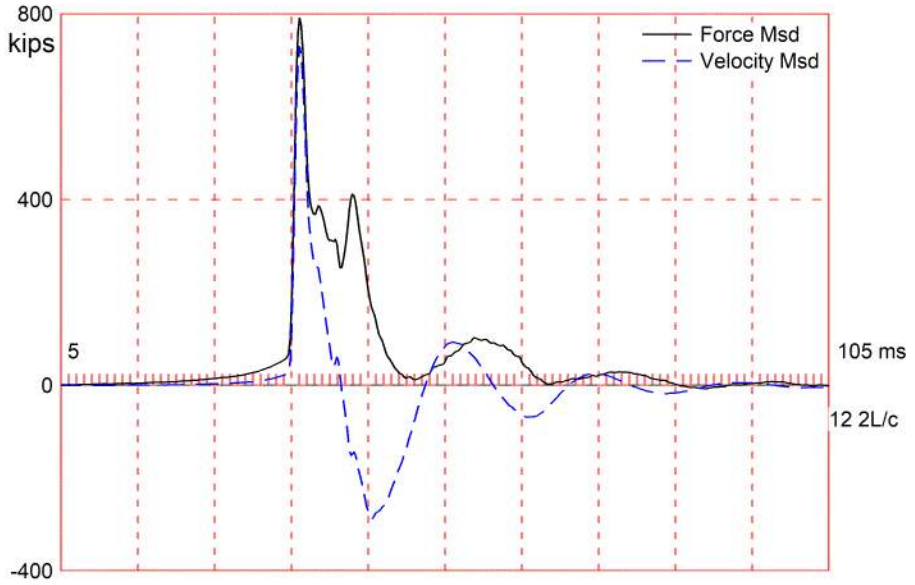
BL#	Comments
1	Template/Ground Reference Elevation 179.3
2	Fuel Setting 2
317	Fuel Setting 3
759	Fuel Setting 4

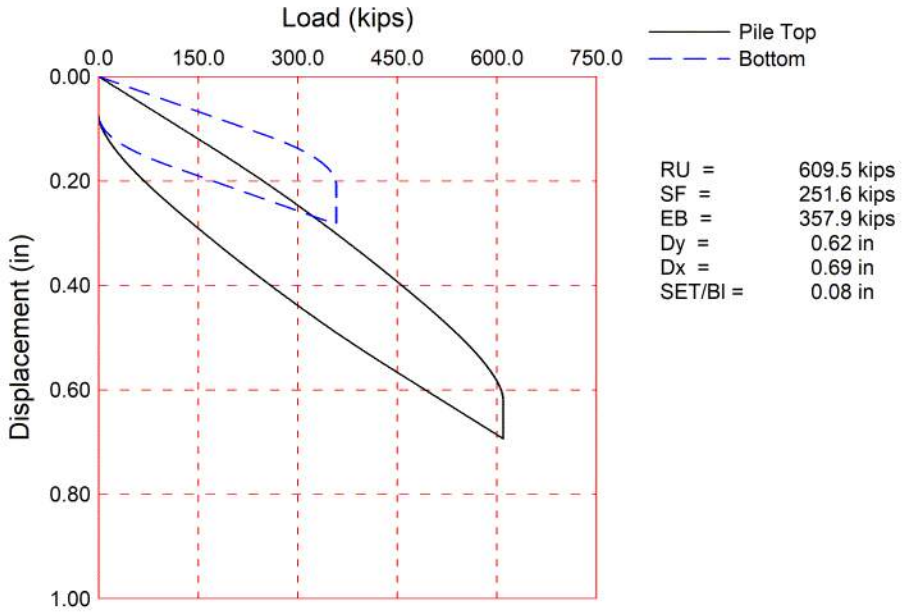
Time Summary

Drive	30 minutes 51 seconds	2:36 PM - 3:07 PM (4/21/2023) BN 1 - 757
Stop	11 minutes 34 seconds	3:07 PM - 3:18 PM
Drive	1 minute 15 seconds	3:18 PM - 3:19 PM BN 758 - 806

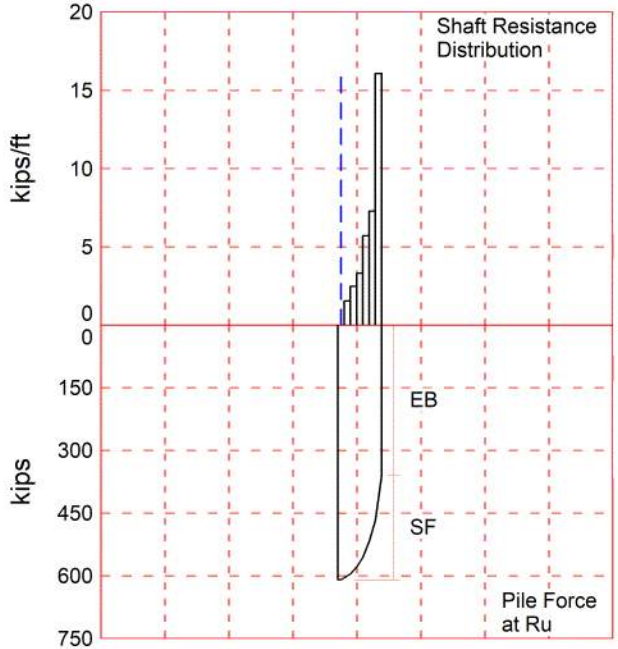
Total time [00:43:41] = (Driving [00:32:07] + Stop [00:11:34])







RU =	609.5 kips
SF =	251.6 kips
EB =	357.9 kips
Dy =	0.62 in
Dx =	0.69 in
SET/Bl =	0.08 in



Length b. Sensors	47.7 ft
Embedment	42.9 ft
Top Area	26.1 in^2
End Bearing Area	203.2 in^2
Top Perimeter	4.75 ft
Top E-Modulus	30000 ksi
Top Spec. Weight	492.0 lb/ft^3
Top Wave Spd.	16808 ft/s
Overall W.S.	16808 ft/s
Match Quality	2.35
Top Compr. Stress	29.9 ksi
Max Compr. Stress	31.1 ksi
Max Tension Stress	-2.44 ksi
Avg. Shaft Quake	0.12 in
Toe Quake	0.16 in
Avg. Shaft Smith Dpg.	0.16 s/ft
Toe Smith Damping	0.03 s/ft

About the CAPWAP Results

The CAPWAP program performs a signal matching or reverse analysis based on measurements taken on a deep foundation under an impact load. The program is based on a one-dimensional mathematical model. Under certain conditions, the model only crudely approximates the often complex dynamic situations.

The CAPWAP analysis relies on the input of accurately measured dynamic data plus additional parameters describing pile and soil behavior. If the field measurements of force and velocity are incorrect or were taken under inappropriate conditions (e.g., at an inappropriate time or with too much or too little energy) or if the input pile model is incorrect, then the solution cannot represent the actual soil behavior.

Generally the CAPWAP analysis is used to estimate the axial compressive pile capacity and the soil resistance distribution. The long-term capacity is best evaluated with restrike tests since they incorporate soil strength changes (set-up gains or relaxation losses) that occur after installation. The calculated load settlement graph does not consider creep or long term consolidation settlements. When uplift is a controlling factor in the design, use of the CAPWAP results to assess uplift capacity should be made only after very careful analysis of only good measurement quality, and further used only with longer pile lengths and with nominally higher safety factors.

CAPWAP is also used to evaluate driving stresses along the length of the pile. However, it should be understood that the analysis is one dimensional and does not take into account bending effects or local contact stresses at the pile toe.

Furthermore, if the user of this software was not able to produce a solution with satisfactory signal "match quality" (MQ), then the associated CAPWAP results may be unreliable. There is no absolute scale for solution acceptability but solutions with MQ above 5 are generally considered less reliable than those with lower MQ values and every effort should be made to improve the analysis, for example, by getting help from other independent experts.

Considering the CAPWAP model limitations, the nature of the input parameters, the complexity of the analysis procedure, and the need for a responsible application of the results to actual construction projects, it is recommended that at least one static load test be performed on sites where little experience exists with dynamic behavior of the soil resistance or when the experience of the analyzing engineer with both program use and result application is limited.

Finally, the CAPWAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors. The CAPWAP results should be reviewed by the Engineer of Record with consideration of applicable geotechnical conditions including, but not limited to, group effects, potential settlement from underlying compressible layers, soil resistances provided from any layers unsuitable for long term support, as well as effective stress changes due to soil surcharges, excavation or change in water table elevation.

The CAPWAP analysis software is one of many means by which the capacity of a deep foundation can be assessed. The engineer performing the analysis is responsible for proper software application and the analysis results. Pile Dynamics accepts no liability whatsoever of any kind for the analysis solution and/or the application of the analysis result.

CAPWAP SUMMARY RESULTS

Total CAPWAP Capacity: 609.5; along Shaft 251.6; at Toe 357.9 kips

Soil Sgmnt No.	Dist. Below Gages ft	Depth Below Grade ft	Ru kips	Force in Pile kips	Sum of Ru kips	Unit Resist. (Depth) kips/ft	Unit Resist. (Area) ksf
				609.5			
1	13.6	8.8	13.7	595.8	13.7	1.55	0.33
2	20.4	15.7	17.0	578.8	30.7	2.50	0.53
3	27.2	22.5	22.7	556.1	53.4	3.33	0.70
4	34.1	29.3	39.0	517.1	92.4	5.73	1.20
5	40.9	36.1	49.7	467.4	142.1	7.30	1.54
6	47.7	42.9	109.5	357.9	251.6	16.08	3.38
Avg. Shaft			41.9			5.87	1.23
Toe			357.9				253.59

Soil Model Parameters/Extensions		Shaft	Toe
Smith Damping Factor		0.16	0.03
Quake	(in)	0.12	0.16
Case Damping Factor		0.86	0.23
Damping Type		Viscous	Sm+Visc
Reloading Level	(% of Ru)	100	100
Unloading Level	(% of Ru)	47	

CAPWAP match quality = 2.35 (Wave Up Match) ; RSA = 0
Observed: Final Set = 0.08 in; Blow Count = 160 b/ft
Computed: Final Set = 0.08 in; Blow Count = 160 b/ft

max. Top Comp. Stress = 29.9 ksi (T= 36.3 ms, max= 1.040 x Top)
max. Comp. Stress = 31.1 ksi (Z= 13.6 ft, T= 36.9 ms)
max. Tens. Stress = -2.44 ksi (Z= 34.1 ft, T= 51.9 ms)
max. Energy (EMX) = 21.7 kip-ft; max. Measured Top Displ. (DMX)= 0.51 in

EXTREMA TABLE

Pile Sgmnt No.	Dist. Below Gages ft	max. Force kips	min. Force kips	max. Comp. Stress ksi	max. Tens. Stress ksi	max. Trnsfd. Energy kip-ft	max. Veloc. ft/s	max. Displ. in
1	3.4	781.3	-6.7	29.9	-0.26	21.7	15.9	0.51
2	6.8	788.0	-17.1	30.2	-0.65	21.4	15.7	0.49
3	10.2	798.8	-29.3	30.6	-1.12	21.1	15.5	0.47
4	13.6	812.3	-40.2	31.1	-1.54	20.9	15.2	0.46
5	17.0	778.4	-41.0	29.8	-1.57	19.4	14.9	0.44
6	20.4	795.2	-51.8	30.5	-1.99	19.0	14.5	0.42
7	23.8	755.6	-50.9	28.9	-1.95	17.3	14.1	0.39
8	27.2	779.2	-59.7	29.9	-2.29	16.8	13.6	0.37
9	30.6	736.4	-55.9	28.2	-2.14	14.8	13.1	0.34
10	34.1	766.3	-63.7	29.4	-2.44	14.2	12.4	0.31
11	37.5	672.8	-49.8	25.8	-1.91	11.6	12.0	0.29
12	40.9	633.7	-55.4	24.3	-2.12	11.0	13.1	0.26
13	44.3	546.1	-36.4	20.9	-1.40	8.3	13.3	0.24
14	47.7	654.9	-40.6	25.1	-1.55	4.8	11.9	0.21
Absolute	13.6			31.1			(T =	36.9 ms)
	34.1				-2.44		(T =	51.9 ms)

CASE METHOD

J =	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
RP	919.3	857.2	795.0	732.8	670.6	608.4	546.3	484.1	421.9	359.7
RX	926.9	866.0	808.0	750.8	696.4	660.5	633.6	609.2	592.3	577.7
RU	922.1	860.2	798.3	736.4	674.4	612.5	550.6	488.7	426.8	364.9

RAU = 460.3 (kips); RA2 = 617.8 (kips)

Current CAPWAP Ru = 609.5 (kips); Corresponding J(RP)= 0.50; J(RX) = 0.70

VMX ft/s	TVP ms	VT1*Z kips	FT1 kips	FMX kips	DMX in	DFN in	SET in	EMX kip-ft	QUS kips	KEB kips/in
15.9	36.06	740.4	800.7	800.7	0.51	0.08	0.08	22.1	903.9	2237

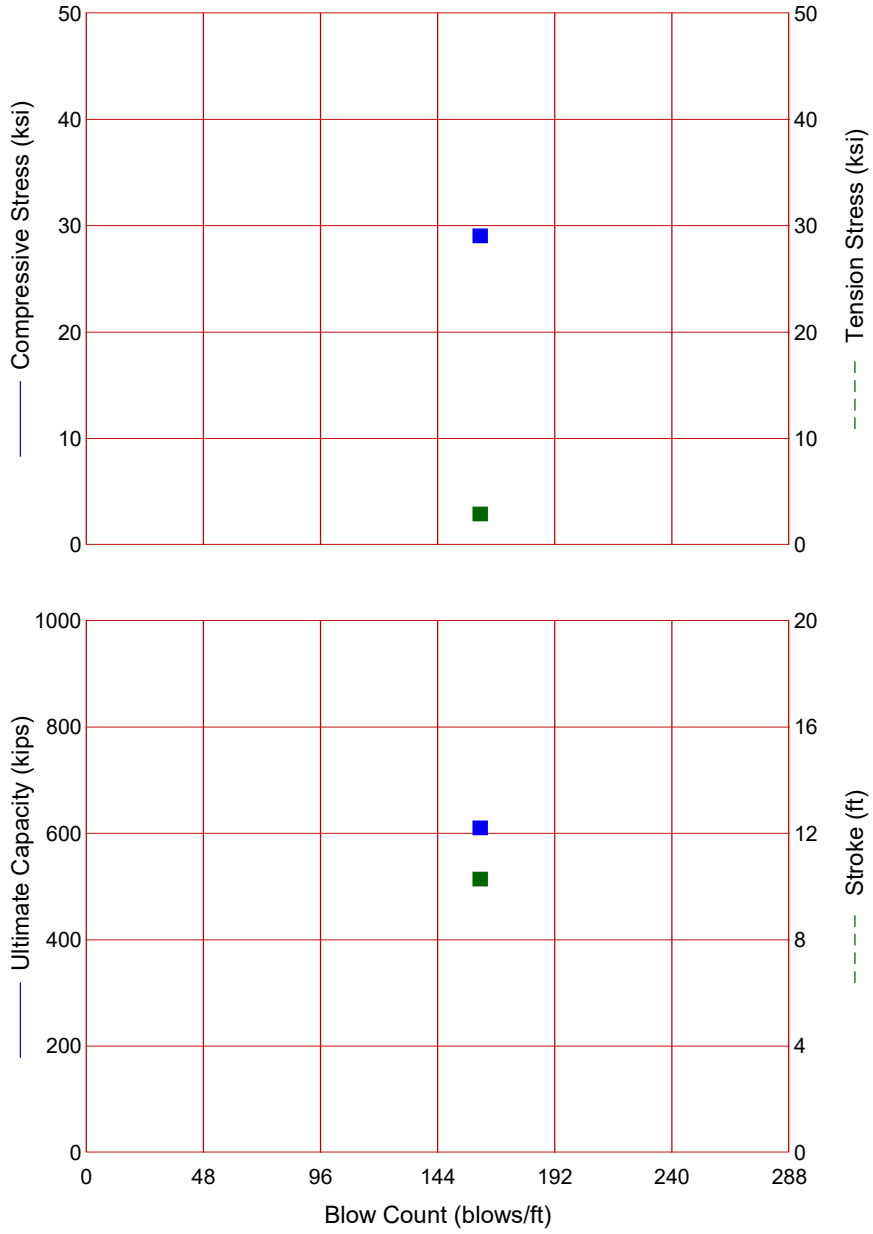
PILE PROFILE AND PILE MODEL

Depth ft	Area in^2	E-Modulus ksi	Spec. Weight lb/ft^3	Perim. ft
0.0	26.1	30000.0	492.000	4.75
47.7	26.1	30000.0	492.000	4.75

Toe Area 203.2 in^2

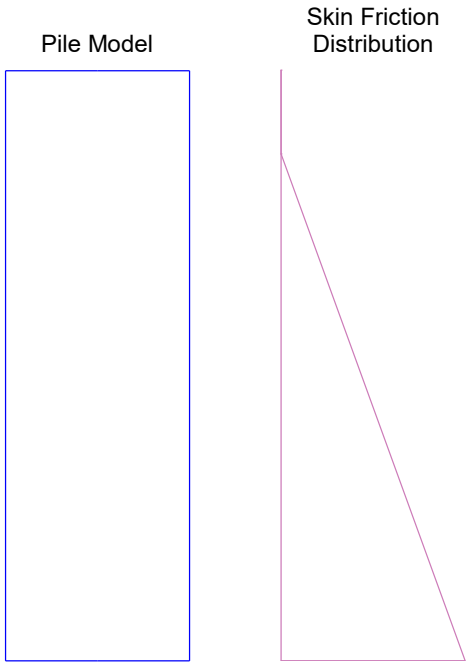
Top Segment Length 3.41 ft, Top Impedance 47 kips/ft/s

Wave Speed: Pile Top 16807.9, Elastic 16807.8, Overall 16807.8 ft/s
Pile Damping 1.00 %, Time Incr 0.203 ms, 2L/c 5.7 ms
Total volume: 8.640 ft^3; Volume ratio considering added impedance: 1.000



ICE I-19v2

Ram Weight	4.01	kips
Efficiency	0.780	
Pressure	1590 (100%)	psi
Helmet Weight	2.31	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.900	
Skin Quake	0.120	in
Toe Quake	0.160	in
Skin Damping	0.160	s/ft
Toe Damping	0.030	s/ft
Pile Length	50.00	ft
Pile Penetration	42.90	ft
Pile Top Area	26.10	in2



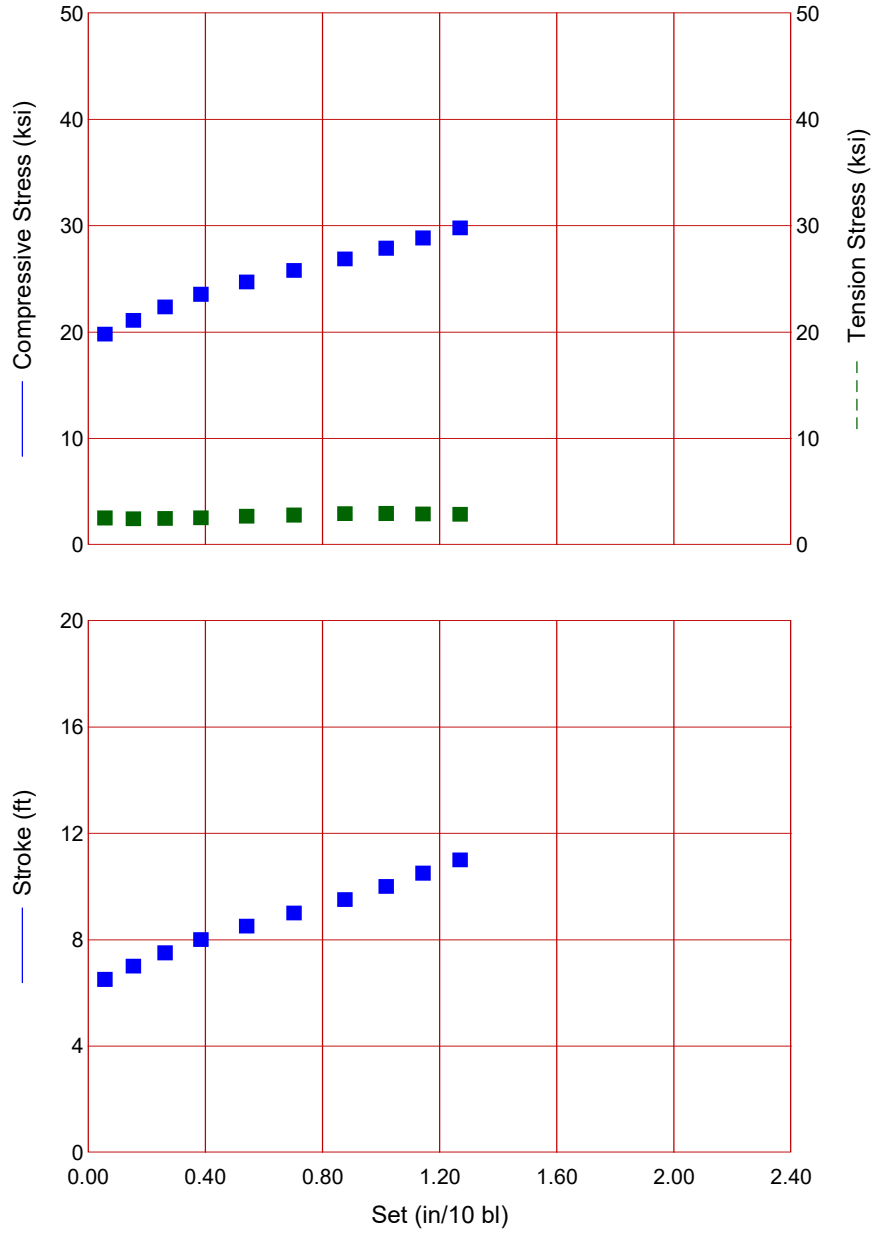
Res. Shaft = 41 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/ft	Stroke ft	Energy kips-ft
610.0	29.02	2.87	161.5	10.27	21.74

Appendix B

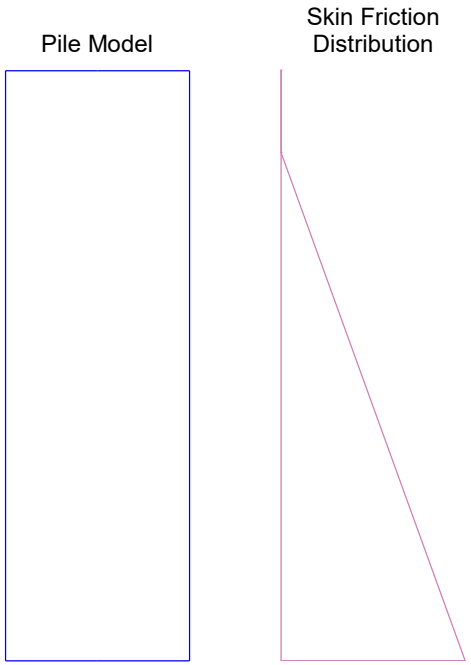
Pile Driving Criteria

Bent 3



ICE I-19v2

Capacity	531.0	kips
Ram Weight	4.01	kips
Efficiency	0.750	
Pressure	1590 (100%)	psi
Helmet Weight	2.31	kips
Hammer Cushion	34825	kips/in
COR of H.C.	0.900	
Skin Quake	0.120	in
Toe Quake	0.160	in
Skin Damping	0.160	s/ft
Toe Damping	0.050	s/ft
Pile Length	50.00	ft
Pile Penetration	43.00	ft
Pile Top Area	26.10	in2



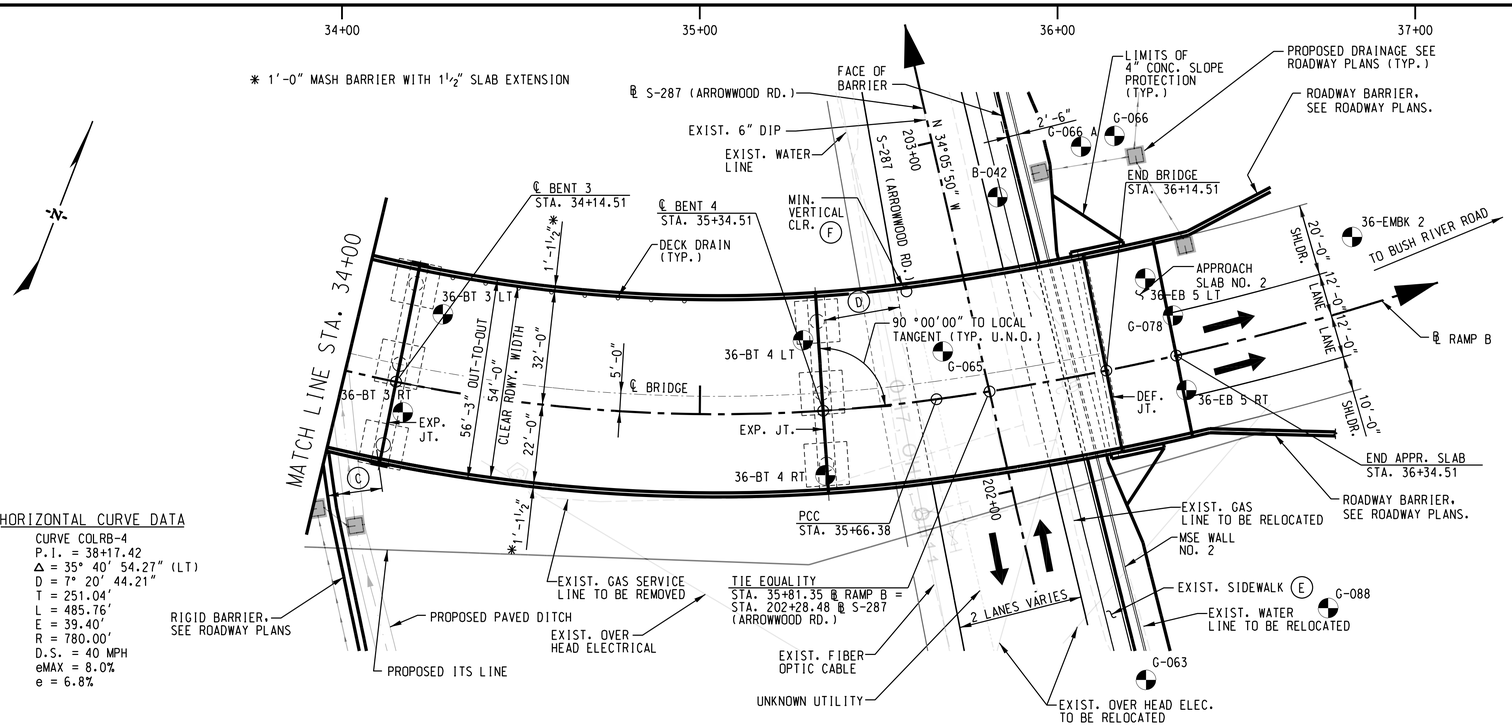
Res. Shaft = 41 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Set in/10 bl	Stroke ft	Energy kips-ft
531.0	19.80	2.51	0.1	6.50	10.01
531.0	21.09	2.43	0.2	7.00	11.42
531.0	22.36	2.46	0.3	7.50	12.91
531.0	23.54	2.53	0.4	8.00	14.39
531.0	24.69	2.67	0.5	8.50	15.91
531.0	25.79	2.79	0.7	9.00	17.43
531.0	26.86	2.92	0.9	9.50	19.07
531.0	27.87	2.93	1.0	10.00	20.43
531.0	28.83	2.89	1.1	10.50	21.64
531.0	29.77	2.85	1.3	11.00	22.89

Appendix C

Project Information and Nearby Soil Borings

BRIDGE PLANS ID	SHEET NO.
P039718-B36	17



HORIZONTAL CURVE DATA

CURVE COLRB-4
P.I. = 38+17.42
Δ = 35° 40' 54.27" (LT)
D = 7° 20' 44.21"
T = 251.04'
L = 485.76'
E = 39.40'
R = 780.00'
D.S. = 40 MPH
eMAX = 8.0%
e = 6.8%

PLAN

NOTES:

U.N.O. = UNLESS NOTED OTHERWISE.

DECK DRAINS AS NOTED.

SKEW ANGLE AT END BENT 5 IS MEASURED AT END BRIDGE.

(C) 27'-4½" MIN. HORIZONTAL CLEARANCE

(D) 21'-4 13/16" MIN. HORIZONTAL CLEARANCE

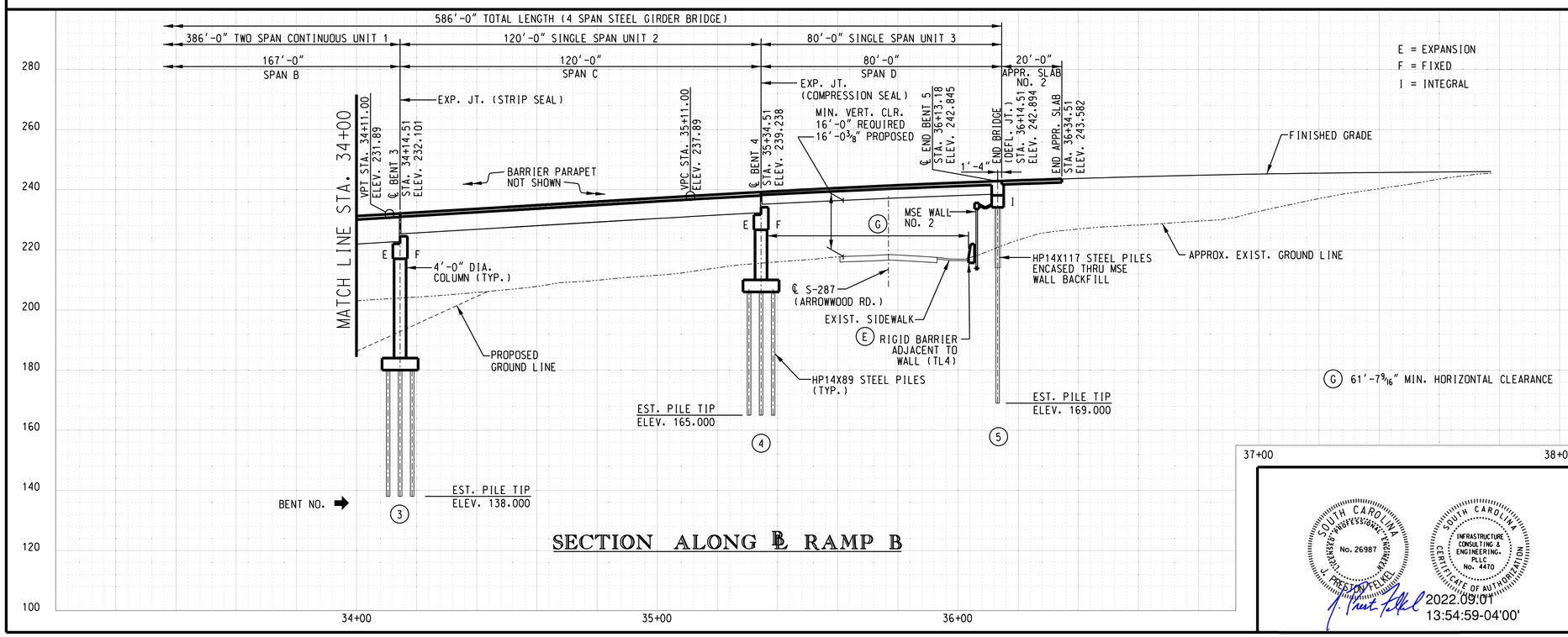
(E) EXISTING SIDEWALK TO REMAIN OR BE RECONSTRUCTED. SEE ROADWAY PLANS.

(F) STA. 35+61.83, OFFSET = 30' LT. (℄ RAMP B) EXISTING ARROWWOOD PAVEMENT ELEV. 218.657

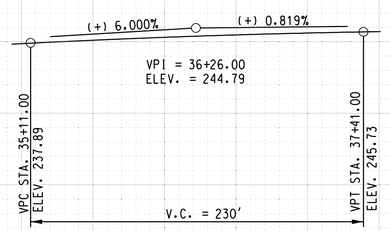
TEST BORING LOCATIONS

BORING	STATION	OFFSET
B-042	35+92.76	53.3' LT.
G-078	36+36.11	11.1' LT.
G-088	36+57.90	78.6' RT.
G-063	36+09.00	87.0' RT.
G-065	35+70.00	13.0' LT.
G-066	36+31.02	63.7' LT.
G-066 A	36+20.39	62.7' LT.
36-BT 3 LT	34+24.00	21.0' LT.
36-BT 3 RT	34+18.00	8.0' RT.
36-BT 4 LT	35+30.00	20.0' LT.
36-BT 4 RT	35+34.00	18.0' RT.
36-EB 5 LT	36+30.73	23.0' LT.
36-EB 5 RT	36+35.14	10.0' RT.
36-EMBK 2	36+91.29	19.4' LT.

STATIONS AND OFFSETS ARE REFERENCED TO PROPOSED ℄ RAMP B.



SECTION ALONG ℄ RAMP B



VERTICAL GRADE DATA

ARCHER UNITED JOINT VENTURE — UNITED INFRASTRUCTURE GROUP

INFRASTRUCTURE CONSULTING & ENGINEERING

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

BRIDGE PLAN AND PROFILE (2)

COLONIAL LIFE BLVD. RAMP B BRIDGE OVER I-126, I-126 RAMP & S-287 (ARROWWOOD ROAD)

SOUTH CAROLINA PROFESSIONAL ENGINEER No. 26987 J. PRESTON FELKEL

SOUTH CAROLINA INFRASTRUCTURE CONSULTING & ENGINEERING, PLLC No. 4470 CERTIFICATE OF AUTHORIZATION

2022.09.01 13:54:59-04'00'

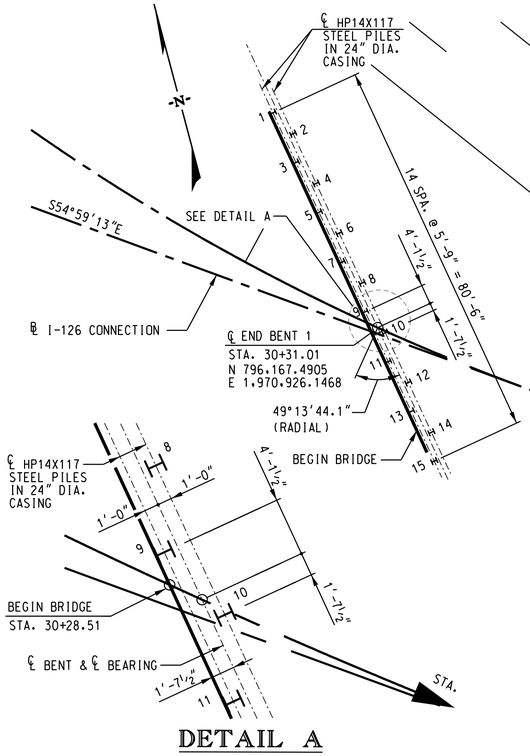
REV. 0	JPF	09-01-22	RFC PLANS
REV. 1			
REV.			
REVIEWED	J. FELKEL		
QUAN.			
DR.	BFS	DKY	04-22
DES.	CSB	DKY	04-22
	BY	CHK.	DATE

COUNTY: RICHLAND

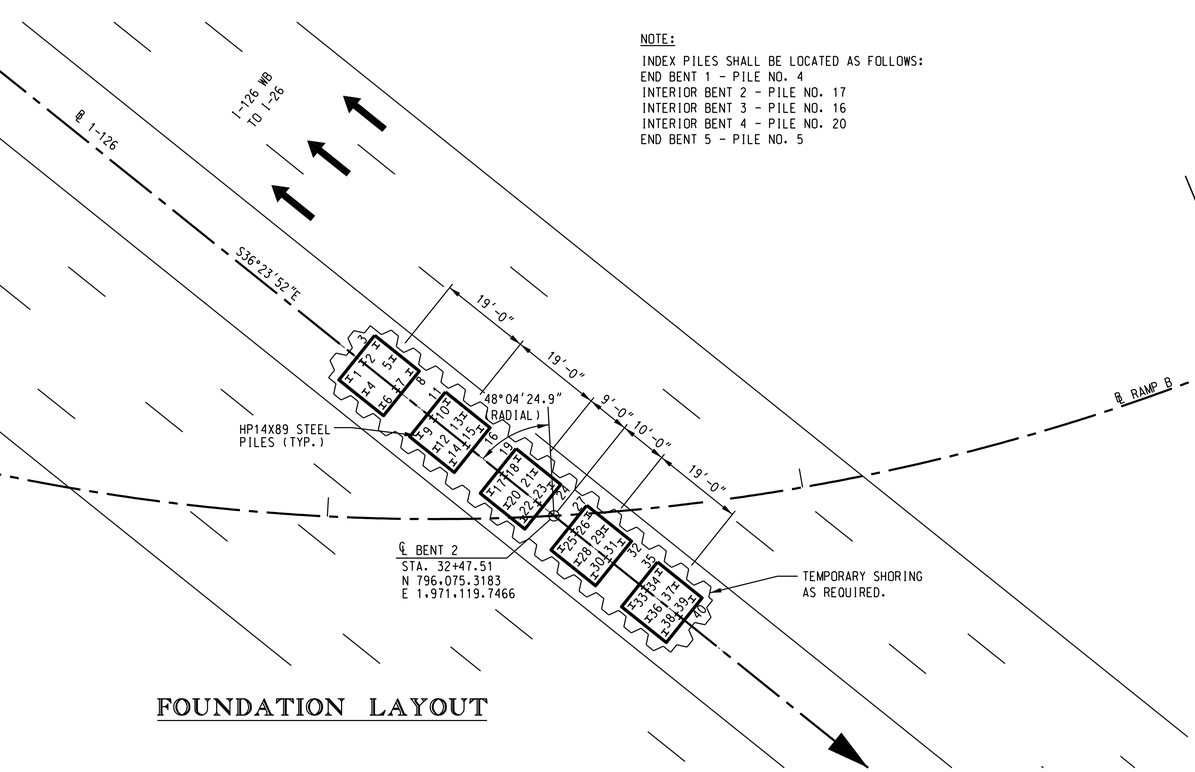
ROUTE: RAMP B

T:\Projects\20-61CCR Phase I\Structures\BR_36\Final Plans\17_BRIDGE 36_PLAN & PROFILE (2).dgn
9/1/2022
9:58:49 AM

BRIDGE PLANS ID	SHEET NO.
P039718-B36	27



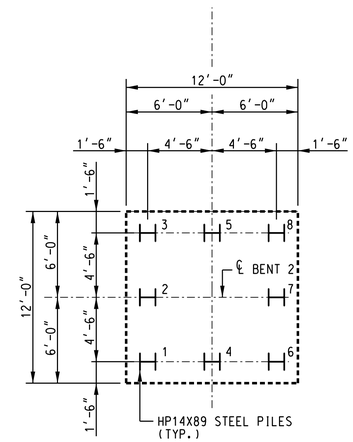
DETAIL A



FOUNDATION LAYOUT

NOTE:

INDEX PILES SHALL BE LOCATED AS FOLLOWS:
END BENT 1 - PILE NO. 4
INTERIOR BENT 2 - PILE NO. 17
INTERIOR BENT 3 - PILE NO. 16
INTERIOR BENT 4 - PILE NO. 20
END BENT 5 - PILE NO. 5



TYPICAL PILE LAYOUT AT BENT 2

FOOTING NO. 1 SHOWN.
FOOTING NO. 2 THRU 5 SIMILAR

GENERAL NOTES - PILE BEARING:

BENT I.D.	END BENT 1	INT. BENT 2	INT. BENT 3	INT. BENT 4	END BENT 5
PILE SECTION	HP14X117	HP14X89	HP14X89	HP14X89	HP14X117
CONTROL LIMIT STATE	STRENGTH	STRENGTH	STRENGTH	STRENGTH	STRENGTH
FACTORED DESIGN LOAD (KIPS)	477	360	345	273	338
GEOTECHNICAL RESISTANCE FACTOR	0.65	0.65	0.65	0.65	0.65
NOMINAL RESISTANCE (KIPS)	734	554	531	420	520
LIQUEFACTION INDUCED DOWNDRAG (KIPS)	0	0	0	0	0
SETTLEMENT INDUCED UNFACTORED DOWNDRAG (KIPS)	0	0	0	0	0
SETTLEMENT INDUCED FACTORED DOWNDRAG (KIPS)	0	0	0	0	0
REQUIRED DRIVING RESISTANCE (KIPS)	734	554	531	420	520
REQUIRED MINIMUM TIP ELEVATION TO ACHIEVE LATERAL STABILITY (FEET MSL)	164	156	163	187	202
ESTIMATED PILE TIP ELEVATION (FEET MSL)	159	152	138	165	169

Initially drive End Bent 1 and End Bent 5 piles to at least the required minimum tip elevation and no deeper than tip elevation 164 at End Bent 1 and 185 at End Bent 5 before MSE wall and bridge embankment construction.

Method of controlling installation of piles and verifying their resistance: Resistance and stresses will be verified by Pile Driving Analyzer (PDA) and CAPWAP analysis of index piles during driving. A Pile Installation Chart developed from the analysis will be used to verify the resistance of production piles.

Perform Pile Driving Analyzer (PDA) testing on one (1) index pile per Bent. An index pile shall be the first pile driven at each required bent location. Include an additional two feet of (HP14x117 or HP14x89) length to accommodate the initial PDA testing. If a CAPWAP analysis determines that capacity has not been achieved, restrike one of the production piles. Perform the restrike on the production pile exhibiting the least blows per foot. On initial drive, piles shall be stopped at the highest allowable finished grade on the plans to accommodate a restrike while remaining within an allowable plan finished grade elevation. Perform PDA testing during the restrike. The Geotechnical Engineer of Record will determine the time between initial driving and any required restrikes.

PDA testing is only required during final driving at End Bent 1 and End Bent 5.

Reinforced pile tips are required to penetrate partially weathered rock at all bents. Install the reinforced pile tips in accordance with the manufacturer's installation recommendations.

The top of partially weathered rock elevation may vary across each bent and result in varying pile lengths. Practical refusal of a pile is defined as 20 blows per inch.

If required minimum tip elevation cannot be achieved by driving alone, predrill pile locations at End Bent 1 to an elevation no lower than 164 feet with equipment that will result in a maximum predrilling diameter of 20". For predrilling for piles, see section 711.4.5.2 of the Standard Specifications.

Drive piles at End Bent 1 and 5 to a minimum pile movement of 0.5 inches during final driving to negate any induced downdrag loads from prior MSE wall settlement.

Reference the Standard Specifications for Highway Construction for Driven Pile Foundations, Section 711. Notes included in these plans are in addition to the requirements of the Standard Specifications.

The following estimated parameters were used for performing a drivability analysis for End Bent 1, Interior Bents 2 thru 4, & End Bent 5:

DRIVABILITY ANALYSIS

BENT I.D.	END BENT 1	INT. BENT 2	INT. BENT 3	INT. BENT 4	END BENT 5
SKIN QUAKE (QS)	0.10 in	0.10 in	0.10 in	0.10 in	0.10 in
TOE QUAKE (QT)	0.10 in	0.10 in	0.10 in	0.10 in	0.10 in
SKIN DAMPING (SD)	0.20 s/ft	0.20 s/ft	0.20 s/ft	0.20 s/ft	0.20 s/ft
TOE DAMPING (TD)	0.15 s/ft	0.15 s/ft	0.15 s/ft	0.15 s/ft	0.15 s/ft
% SKIN FRICTION	3%	15%	20%	40%	18%
DISTRIBUTION SHAPE NO.	0	0	0	0	0
PILE INSTALLATION CHART	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL	PROPORTIONAL
PILE PENETRATION	26%	83%	86%	85%	58%
HAMMER ENERGY RANGE	60 to 90 kip-ft	40 to 80 kip-ft	40 to 80 kip-ft	40 to 80 kip-ft	40 to 80 kip-ft

Note: GRLWEAP 2010-7 was used to perform the wave equation analysis.

A pile hammer having the rated energy as indicated above is considered suitable for driven pile installation. However, final hammer approval is based on a wave equation analysis that accurately reflects the Contractor's proposed driving system.

The Contractor shall retain a geotechnical engineering firm to perform the pre-construction condition assessment and Earth-borne Vibration Monitoring in accordance with the RFP.

SCDOT Supplemental Technical Specification SC-M-713 (01/19) shall apply to the project except as modified herein.

SOUTH CAROLINA PROFESSIONAL ENGINEER No. 26987 J. FRANK FELKEL
SOUTH CAROLINA INFRASTRUCTURE CONSULTING & ENGINEERING, PLLC No. 4470 CERTIFICATE OF AUTHORIZATION
2022.09.01 13:57:04-04'00'

REV.			
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REV. 1			
REV.			
REVIEWED	J. FELKEL		
QUAN.			
DR.	BFS	DKY	05-22
DES.	VD	DVW	05-22
	BY	CHK.	DATE

ARCHER UNITED JOINT VENTURE UNITED INFRASTRUCTURE GROUP
INFRASTRUCTURE CONSULTING & ENGINEERING

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

FOUNDATION LAYOUT (1)

COLONIAL LIFE BLVD. RAMP B BRIDGE OVER I-126, I-126 RAMP & S-287 (ARROWWOOD ROAD)

COUNTY RICHLAND | ROUTE RAMP B

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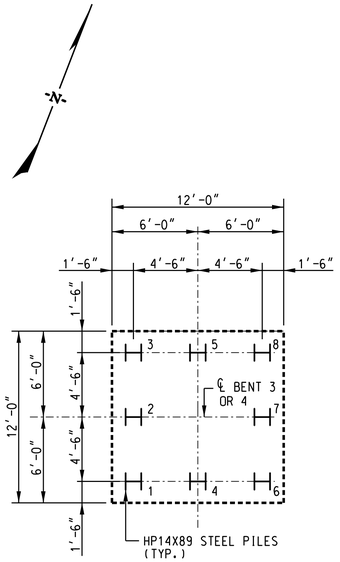
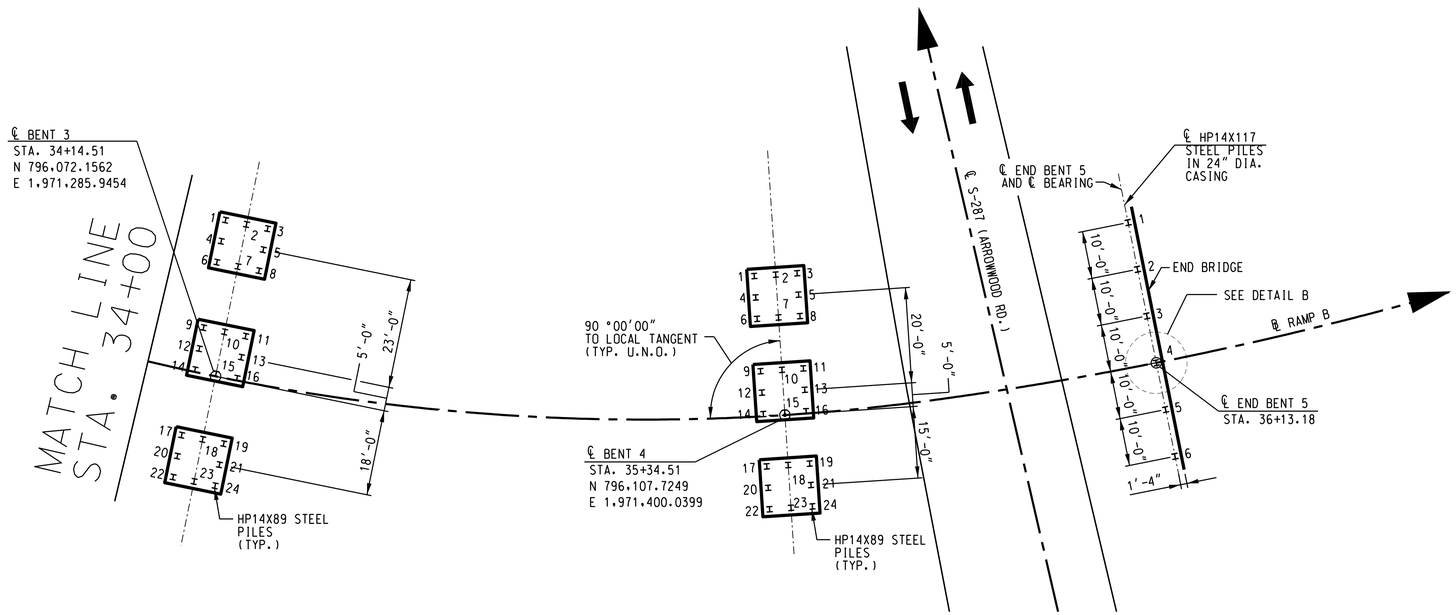
BRIDGE PLANS ID	SHEET NO.
P039718-B36	28

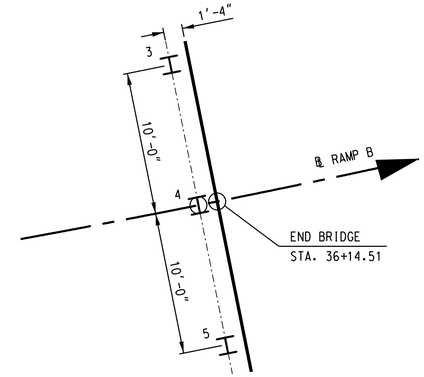


TYPICAL PILE LAYOUT AT BENT 3 AND 4

FOOTING NO. 1 SHOWN.
FOOTING NO. 2 AND NO.3 SIMILAR



FOUNDATION LAYOUT



DETAIL B

Temporary Shoring Notes:

Designer shall determine appropriate water level and consider all unbalanced water forces in design. Design shall accommodate live loading. Use the following soil strength parameters for determining earth pressure coefficients.

Temporary Shoring Wall Soil Design Parameters

	Elevation Top/Bottom	Stress State	Internal Friction, φ (deg)	Cohesion, c (psf)
Roadway Embankment/ Alluvial	189	Total	0	500
	176	Effective	32	0
Coastal Plain	176	Total	18	700
	159	Effective	34	100
Residual	159	Total	0	1800
	156	Effective	30	0

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INFRASTRUCTURE CONSULTING & ENGINEERING

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

SOUTH CAROLINA PROFESSIONAL ENGINEER No. 26987 J. TRENT FELKEL

SOUTH CAROLINA INFRASTRUCTURE CONSULTING & ENGINEERING, PLLC No. 4470 CERTIFICATE OF AUTHORIZATION

J. Trent Felkel 2022.09.07 13:57:32-04'00'

REV. 0	JPF	09-01-22	RFC PLANS	
REV. 1				
REV.				
REVIEWED	J. FELKEL			
QUAN.				
DR.	BFS	DKY	05-22	
DES.	VD	DVW	05-22	
	BY	CHK.	DATE	

FOUNDATION LAYOUT (2)

COLONIAL LIFE BLVD. RAMP B BRIDGE OVER I-126, I-126 RAMP & S-287 (ARROWWOOD ROAD)

COUNTY RICHLAND

ROUTE RAMP B

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9/1/2022
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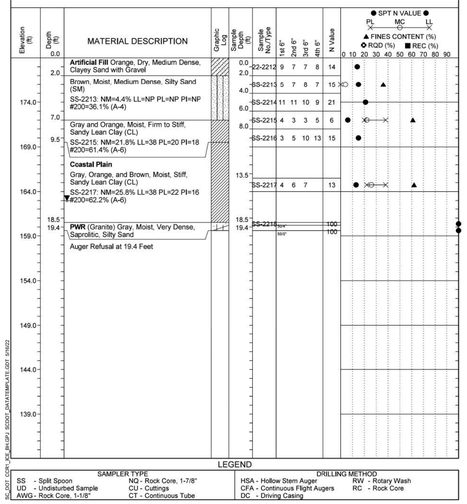
BRIDGE PLANS ID	SHEET NO.
P039718-B36	20

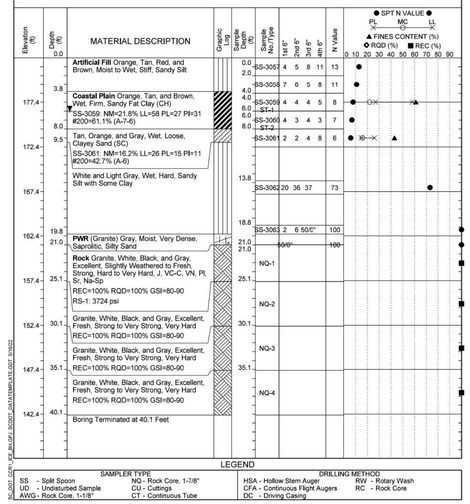
INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-Embk-1		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	MS	**Boring Location:**	29+49	**Offset:**	65 RT	**Alignment:**	COLRB
Elev.:	179.0 ft	**Latitude:**	34.02168711	**Longitude:**	-81.09389358	**Date Started:**	11/10/2021
Total Depth:	19.4 ft	**Soil Depth:**	19.4 ft	**Core Depth:**	NA ft	**Date Completed:**	11/10/2021
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	D-50 #0439	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	91%
Core Size:	NA	**Driller:**	R. Cassell	**Groundwater:**	TOB 16.1 ft	**24HR**	16.0 ft



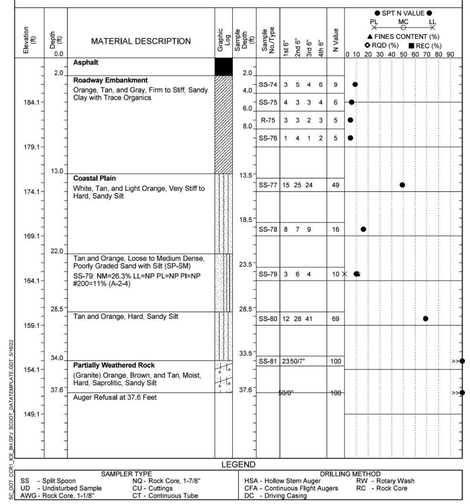
INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-End Bent 1 RT		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	CM & NM	**Boring Location:**	30+51	**Offset:**	16 RT	**Alignment:**	COLRB
Elev.:	182.4 ft	**Latitude:**	34.02151348	**Longitude:**	-81.09593049	**Date Started:**	11/15/2021
Total Depth:	40.1 ft	**Soil Depth:**	21.0 ft	**Core Depth:**	19.1 ft	**Date Completed:**	11/16/2021
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	D-50 #0435	**Drill Method:**	Casing w/ Adv	**Hammer Type:**	Automatic	**Energy Ratio:**	84%
Core Size:	NQ2	**Driller:**	M. Morgan	**Groundwater:**	TOB NM	**24HR**	6.0 ft



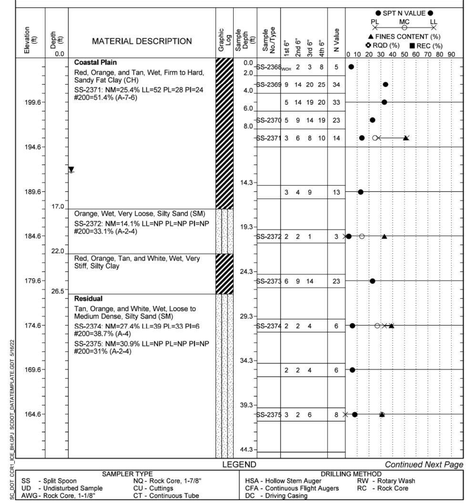
INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-Bent 2 C		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	CM	**Boring Location:**	32+40	**Offset:**	1 RT	**Alignment:**	COLRB
Elev.:	189.1 ft	**Latitude:**	34.02132833	**Longitude:**	-81.09533669	**Date Started:**	2/3/2022
Total Depth:	37.6 ft	**Soil Depth:**	37.6 ft	**Core Depth:**	NA ft	**Date Completed:**	2/3/2022
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	D-50 #0435	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	84%
Core Size:	NA	**Driller:**	M. Morgan	**Groundwater:**	TOB 14.5 ft	**24HR**	FIAD



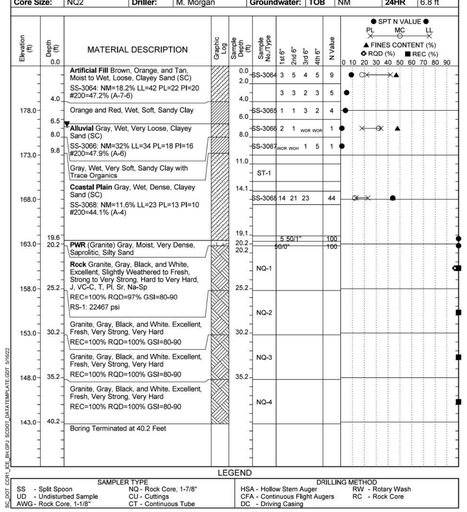
INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-Bent 3 LT		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	CM & NM	**Boring Location:**	34+24	**Offset:**	21 LT	**Alignment:**	COLRB
Elev.:	204.6 ft	**Latitude:**	34.02138011	**Longitude:**	-81.09474598	**Date Started:**	12/8/2021
Total Depth:	85.4 ft	**Soil Depth:**	64.3 ft	**Core Depth:**	20.4 ft	**Date Completed:**	12/9/2021
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	D-50 #0439	**Drill Method:**	Casing w/ Adv	**Hammer Type:**	Automatic	**Energy Ratio:**	91%
Core Size:	NQ2	**Driller:**	R. Cassell	**Groundwater:**	TOB NM	**24HR**	12.8 ft



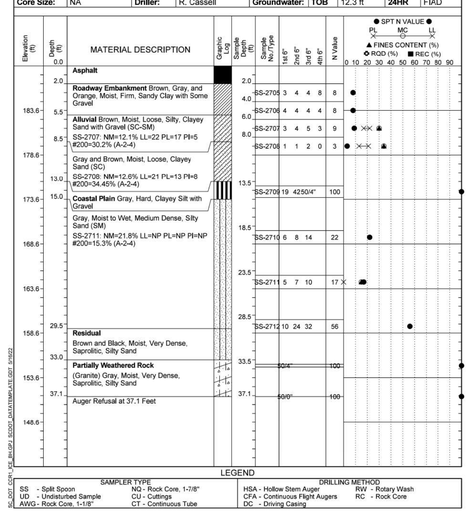
INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-Bent 1 LT		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	CM & NM	**Boring Location:**	30+01	**Offset:**	26 LT	**Alignment:**	COLRB
Elev.:	183.0 ft	**Latitude:**	34.02168598	**Longitude:**	-81.09596711	**Date Started:**	11/16/2021
Total Depth:	40.2 ft	**Soil Depth:**	20.2 ft	**Core Depth:**	20 ft	**Date Completed:**	11/16/2021
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	D-50 #0435	**Drill Method:**	Casing w/ Adv	**Hammer Type:**	Automatic	**Energy Ratio:**	84%
Core Size:	NQ2	**Driller:**	M. Morgan	**Groundwater:**	TOB NM	**24HR**	6.8 ft



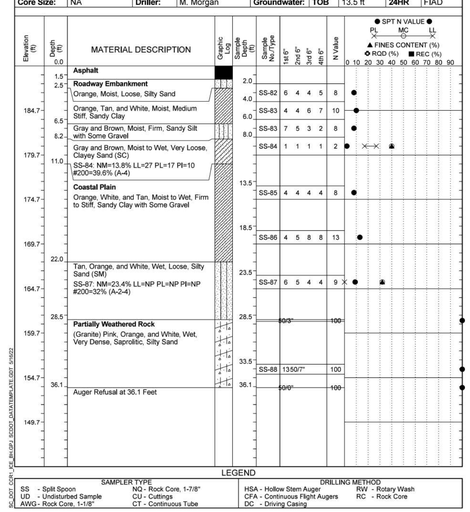
INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-Bent 2 LT		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	MS	**Boring Location:**	32+09	**Offset:**	21 LT	**Alignment:**	COLRB
Elev.:	188.6 ft	**Latitude:**	34.02140775	**Longitude:**	-81.09541527	**Date Started:**	2/3/2022
Total Depth:	37.1 ft	**Soil Depth:**	37.1 ft	**Core Depth:**	NA ft	**Date Completed:**	2/3/2022
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	D-50 #0439	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	91%
Core Size:	NA	**Driller:**	R. Cassell	**Groundwater:**	TOB 12.3 ft	**24HR**	FIAD



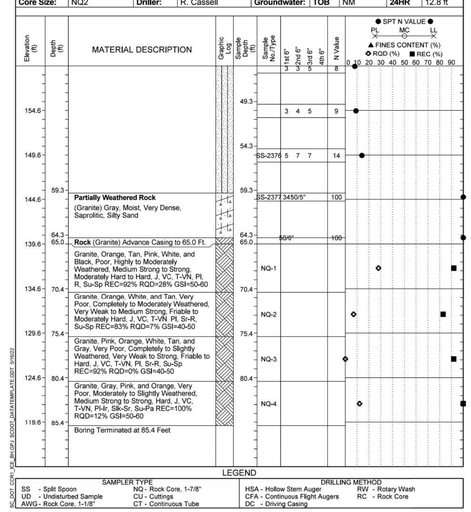
INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-Bent 2 RT		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	CM	**Boring Location:**	32+60	**Offset:**	22 RT	**Alignment:**	COLRB
Elev.:	189.7 ft	**Latitude:**	34.0212607	**Longitude:**	-81.09528389	**Date Started:**	2/3/2022
Total Depth:	36.1 ft	**Soil Depth:**	36.1 ft	**Core Depth:**	NA ft	**Date Completed:**	2/3/2022
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y N	**Liner Used:**	Y N
Drill Machine:	D-50 #0435	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	84%
Core Size:	NA	**Driller:**	M. Morgan	**Groundwater:**	TOB 13.5 ft	**24HR**	FIAD



INFRASTRUCTURE CONSULTING & ENGINEERING

Project ID:	P039718	**County:**	Richland	**Boring No.:**	36-Bent 3 LT		
Site Description:	Carolina Crossroads Phase 1 - Bridge 36			**Route:**	Bridge 36		
Eng./Geo.:	CM & NM	**Boring Location:**	34+24	**Offset:**	21 LT	**Alignment:**	COLRB
Elev.:	204.6 ft	**Latitude:**	34.02138011	**Longitude:**	-81.09474598	**Date Started:**	12/8/2021
Total Depth:	85.4 ft	**Soil Depth:**	64.3 ft	**Core Depth:**	20.4 ft	**Date Completed:**	12/9/2021
Bore Hole Diameter (in):	2.25	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	D-50 #0439	**Drill Method:**	Casing w/ Adv	**Hammer Type:**	Automatic	**Energy Ratio:**	91%
Core Size:	NQ2	**Driller:**	R. Cassell	**Groundwater:**	TOB NM	**24HR**	12.8 ft



FOR INFORMATION ONLY

REV.			
0	JPF	09-01-22	RFC PLANS
1			
REV.			
REVIEWED	J. FELKEL		
QUAN.			
DR.	BFS	DKY	05-22
DES.	DKY	CSB	05-22
	BY	CHK.	DATE

ARCHER UNITED JOINT VENTURE — UNITED INFRASTRUCTURE GROUP

INFRASTRUCTURE CONSULTING & ENGINEERING

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

BORING LOGS (3)

COLONIAL LIFE BLVD. RAMP B BRIDGE OVER I-126, I-126 RAMP & S-287 (ARROWWOOD ROAD)

COUNTY	ROUTE
RICHLAND	RAMP B

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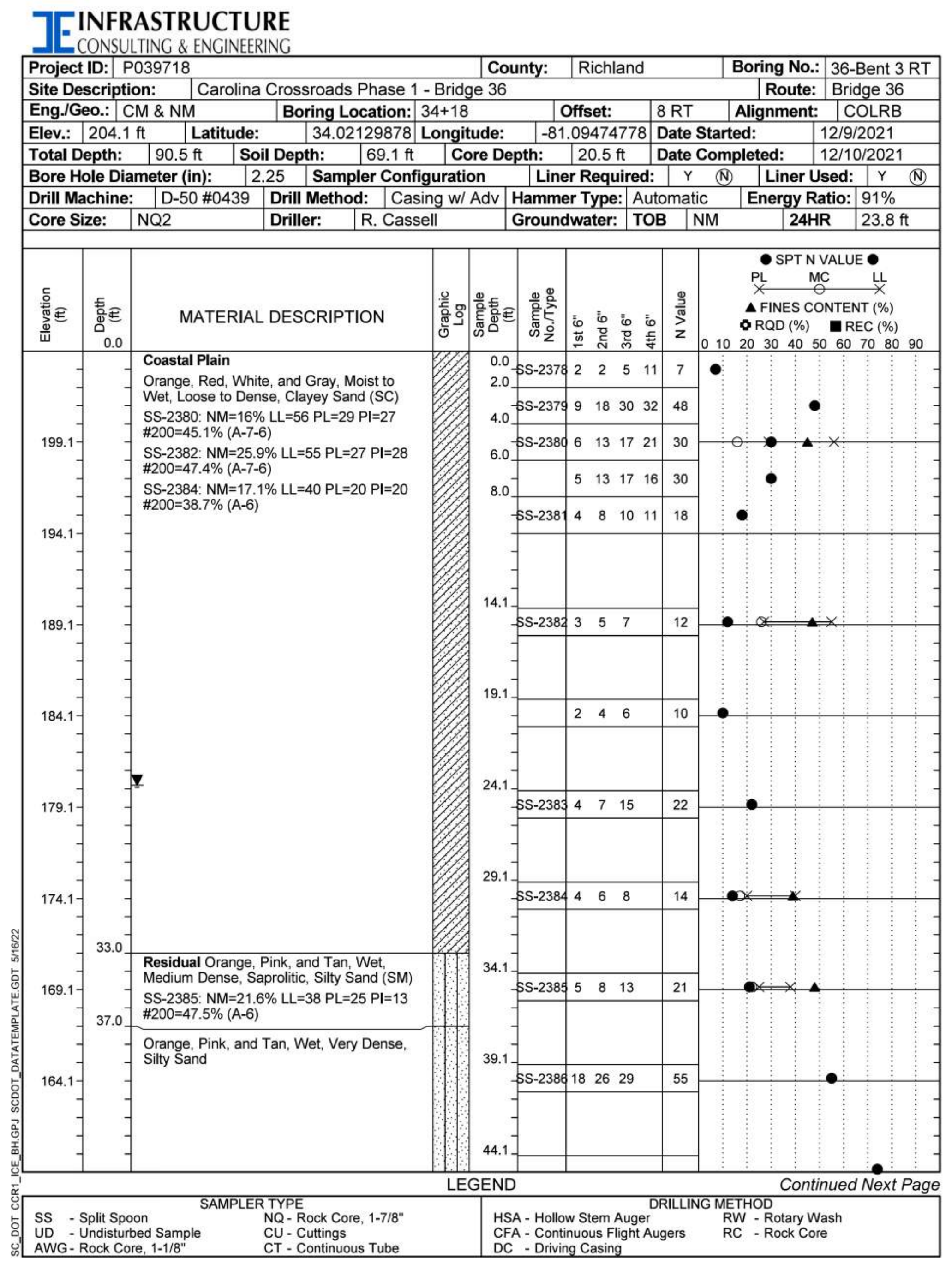
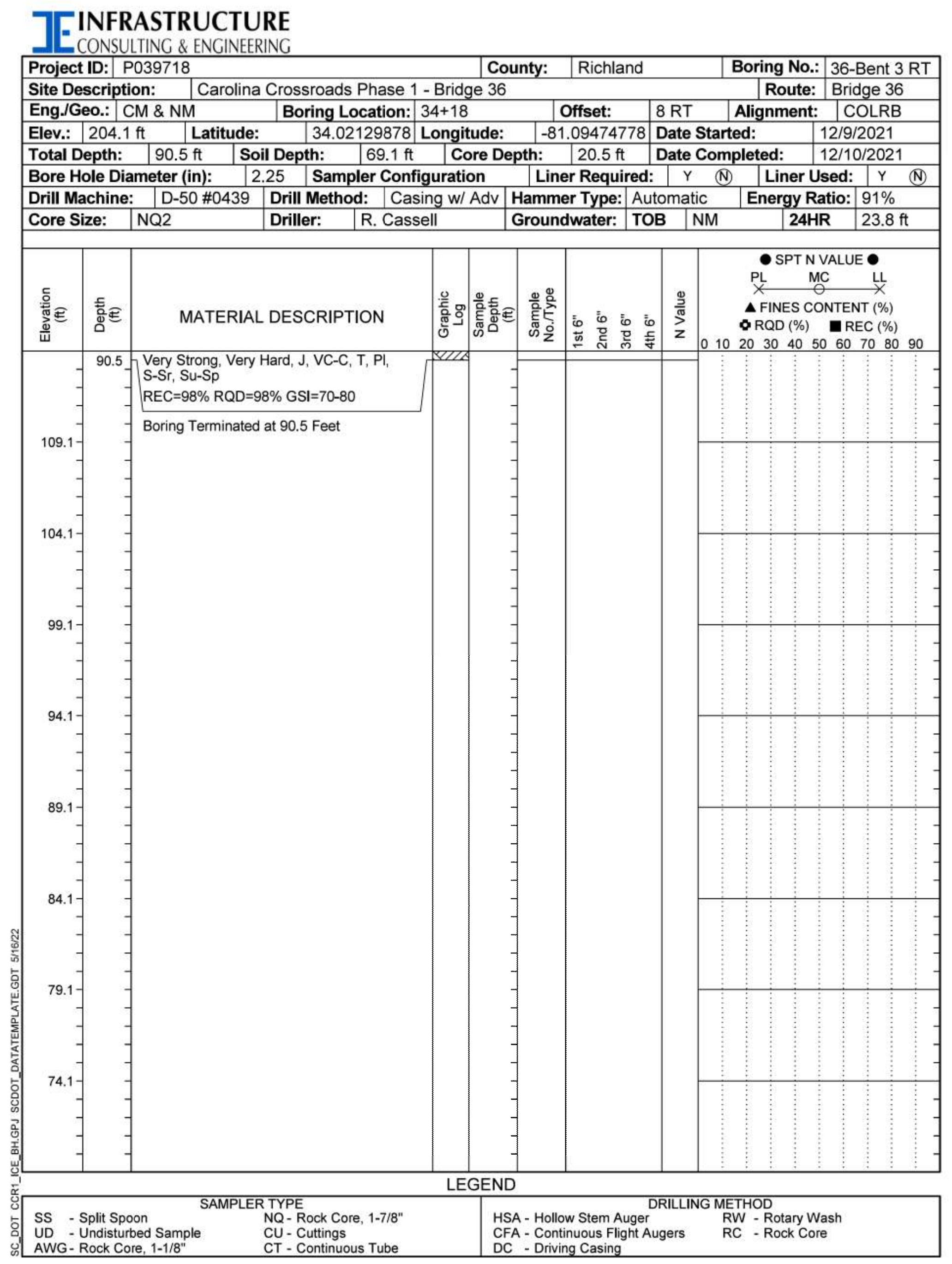
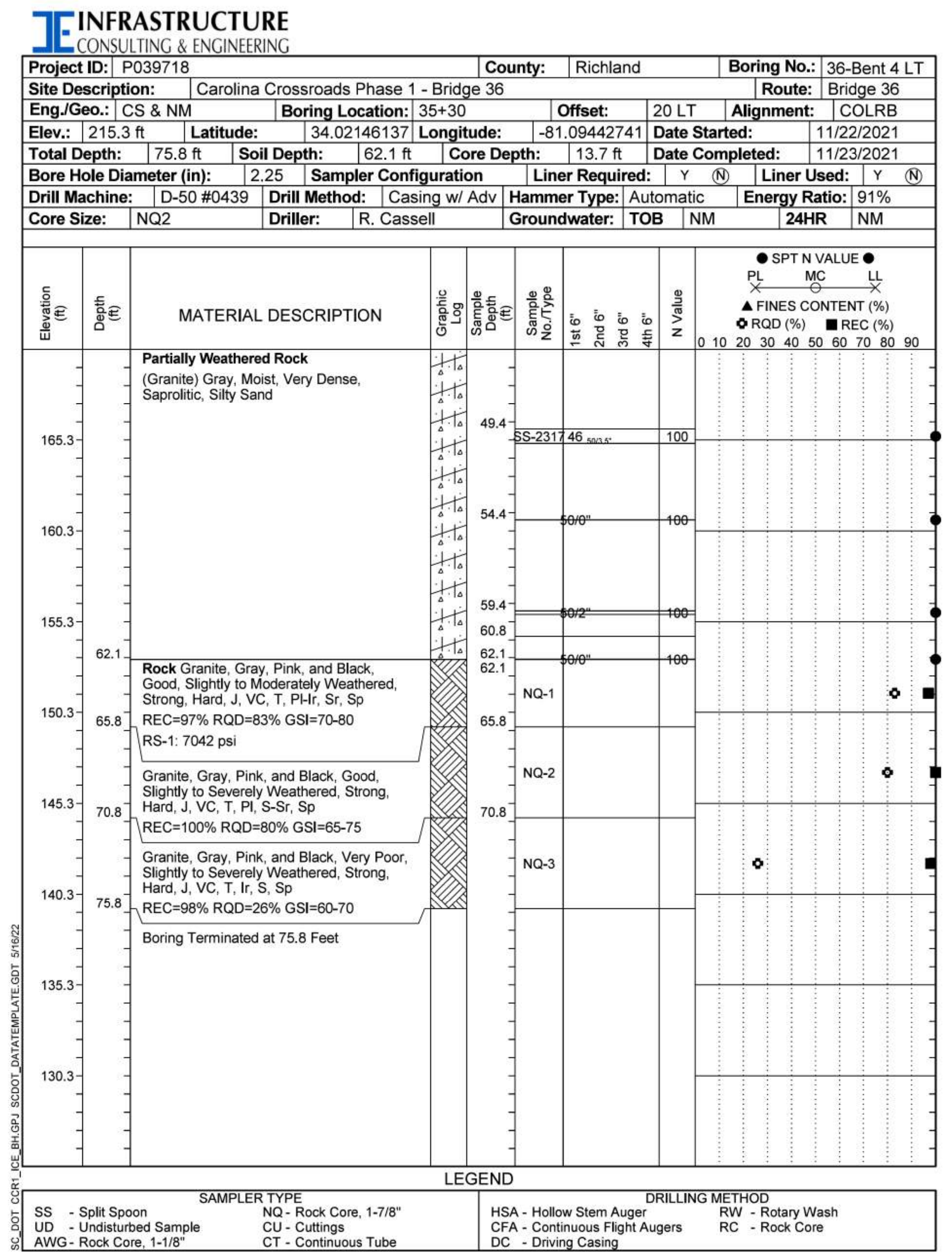
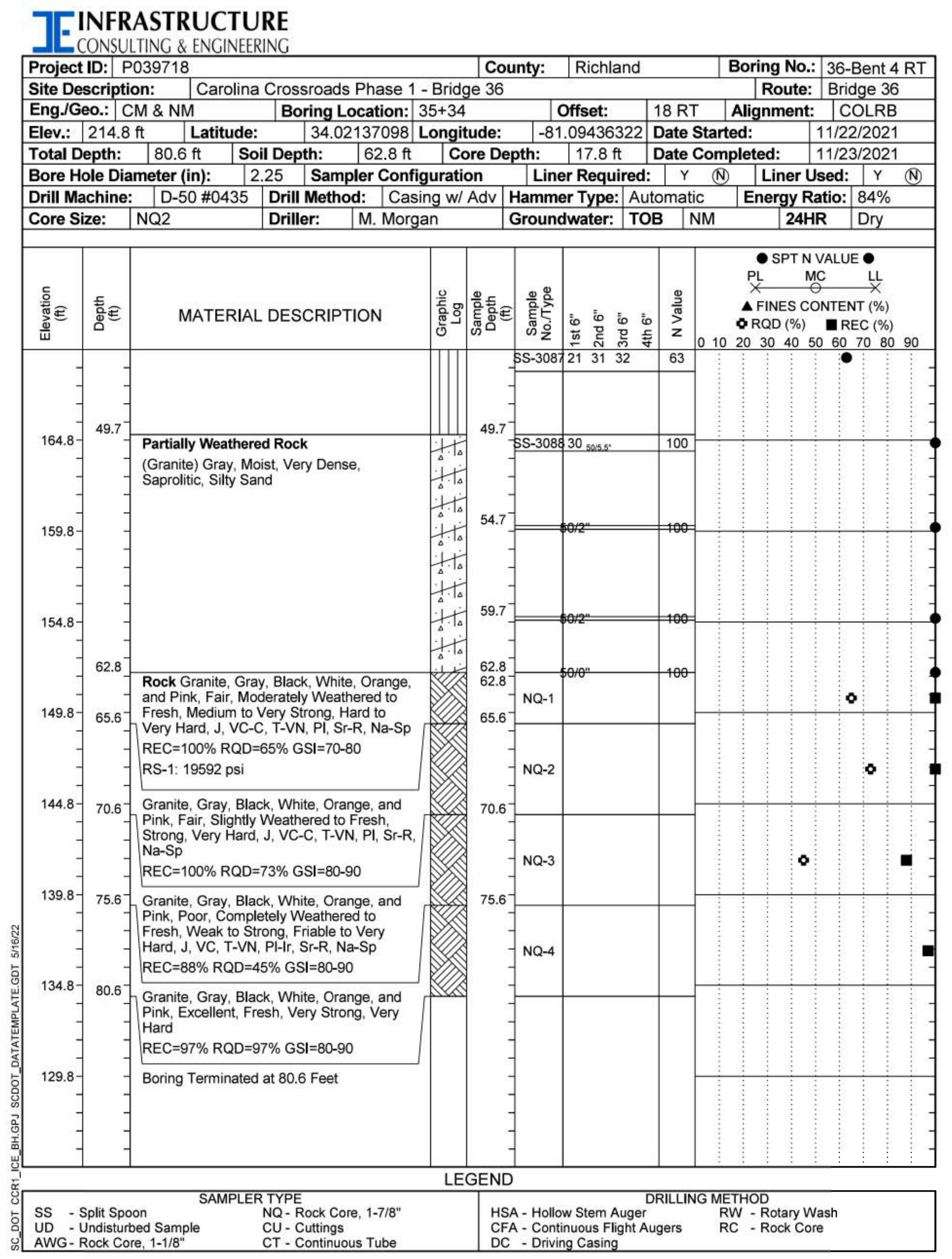
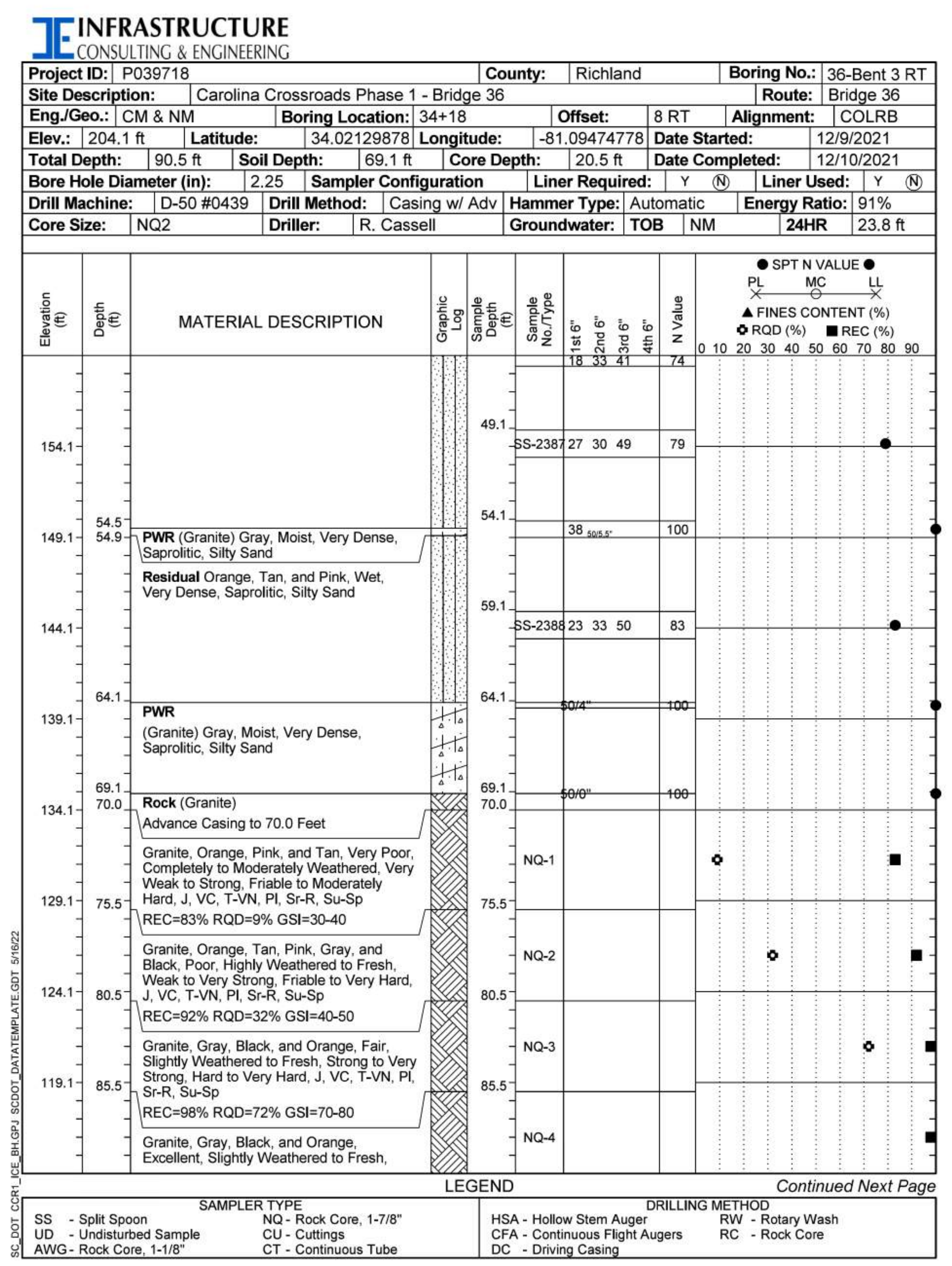
BRIDGE PLANS ID	SHEET NO.
P039718-B36	21

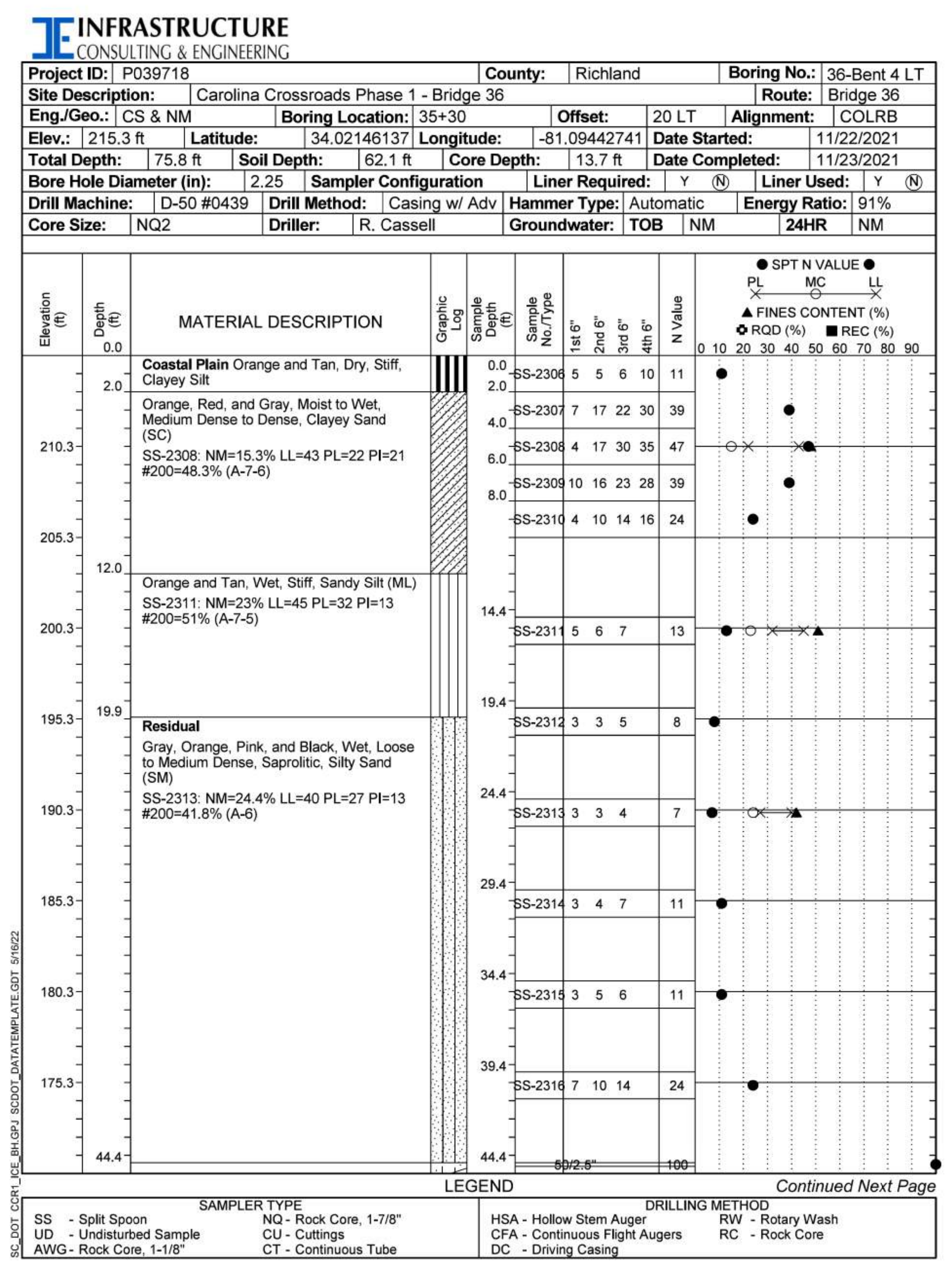


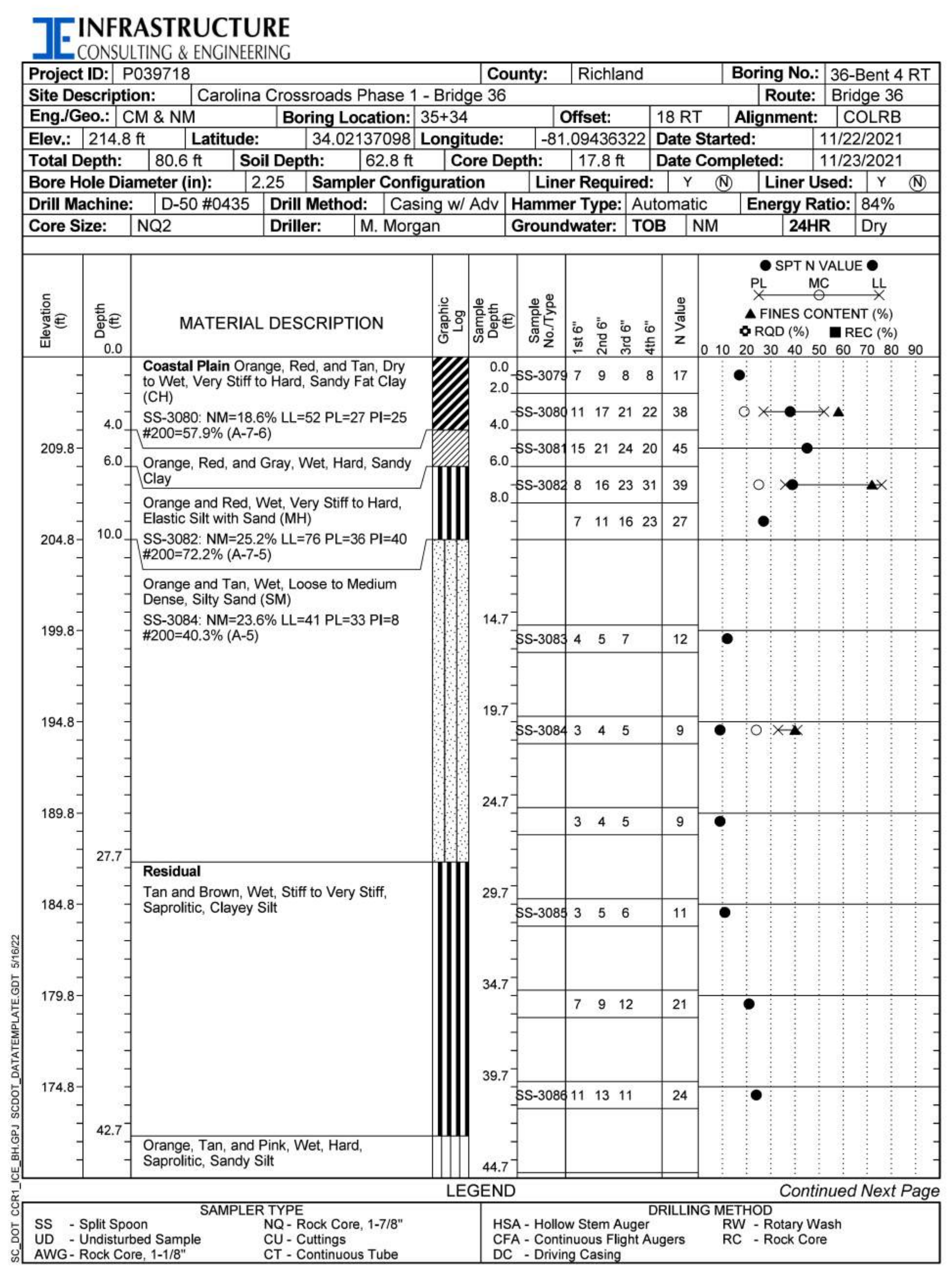












ARCHER UNITED JOINT VENTURE

INFRASTRUCTURE CONSULTING & ENGINEERING

FOR INFORMATION ONLY

	BY	CHK.	DATE
REV. 0	JPF		09-01-22
	RFC PLANS		
REV. 1			
REV.			
REVIEWED	J. FELKEL		
QUAN.			
DR.	BFS	DKY	05-22
DES.	DKY	CSB	05-22

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

BORING LOGS (4)

COLONIAL LIFE BLVD. RAMP B BRIDGE OVER I-126, I-126 RAMP & S-287 (ARROWWOOD ROAD)

COUNTY RICHLAND | ROUTE RAMP B

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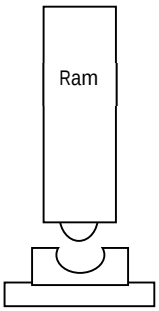
Appendix D

Pile Driving Hammer Information

County:	Lexington/Richland	Bridge Plans ID:	P039718
Route:	I- S-2963 Road Colonial Life Blvd. Ramp B Bridge		
Description:	Carolina Crossroads Phase 1 Bridge 36		
Contractor:	Archer United		



Hammer

Manufacturer:	ICE			Model:	I-19		
Type:	Single Act Diesel			Serial No.	TBD		
Rated Energy (k-ft)	46.17	at	11.5	Length of stroke (ft)			
Lead Size (in):	26						
Modifications:	None						

Note: Attach any hammer modification specifications. Manufacturer's Specifications may be required if hammer is not found in Wave Equation database.

Date of Last Maintenance:	TBD
Type of Maintenance:	TBD
Performed By:	TBD

Striker Plate

Weight (kips):	.46		
Diameter (in):	22.5	Thickness (in):	4

Hammer Cushion

Description:				
	Material Description	No. of Layers	Modulus of Elasticity (ksi)	Thickness (in)
1	MC-904 Blue Nylon	1	175	2
2				
Area (sq. in):	398	Total Thickness (in)		2.0
Coefficient of Restitution:	.90			

Pile Cap (Helmet)

Dimension:	DCB-1 Drive Cap & DCH-1 Cap Insert
Pile Cap Weight (kips):	1.065
Inserts Weight (kips):	.78

Pile Cushion

Material:	N/A		
Thickness (in.)	N/A	Area (sq. in):	N/A
Modulus of Elasticity (ksi):	N/A		
Coefficient of Restitution:	N/A		

Pile

Pile Type/Size & Pile Point:	HP 14X89 and HP14X117 14X89 & 14X117 Reinf. Pile Tips		
Total Pile & Point Length (ft):	BR36 IB2 – 31 IB3 – 43.5 IB4 – 44 EB5 - 67	Exposed Pile Point Length (ft):	N/A
Pile Cross-Sectional Area (sq.in):	26.1		
Pipe Pile Wall Thickness (in):	N/A		
Pile Tip Description:	Welded Reinf. Tip		
Splice Description:	Bevel butt weld per SCDOT Specs		
Splice Location From Pile Top (ft):	N/A		

		Concrete Pile Strength, f'_c (psi):	N/A
		Steel Pile Yield Strength, F_y (ksi):	50

Note: Within 30 calendar days after award of contract or no later than 30 days before driving the first pile, submit form and Pile Installation Plan to the Geotechnical Design Engineer, with copy to the Bridge Construction Engineer and RCE.

SCDOT – Design-Build Section Geotechnical Design Engineer P.O. Box 191 Columbia, SC 29202-0191 Telephone (803) 737-0766 FAX (803) 737-9868	Submitted By:	Josh Bennett		
	Title:	Project Engineer		
	Telephone No.	(803)374-9108	Date:	9/12/2022

Appendix E

Instrumentation Calibrations

Accelerometer Calibration Certificate
Pile Dynamics, Inc.

Calibrated by Pile Dynamics, Inc.
Calibration performed on OCT 2 2 2021

Serial No:	K12388	**Temperature:**	22.6 °C
Model:	PR	**Humidity:**	44%
Calibrated on:	Channel 3 on 8G 5161 LE		

Ref Acc 1:	69132! 960 g's/volt	**Cal on:**	09Feb2021
Ref Acc 2:	69096! 978 g's/volt	**Cal on:**	27Jan2021

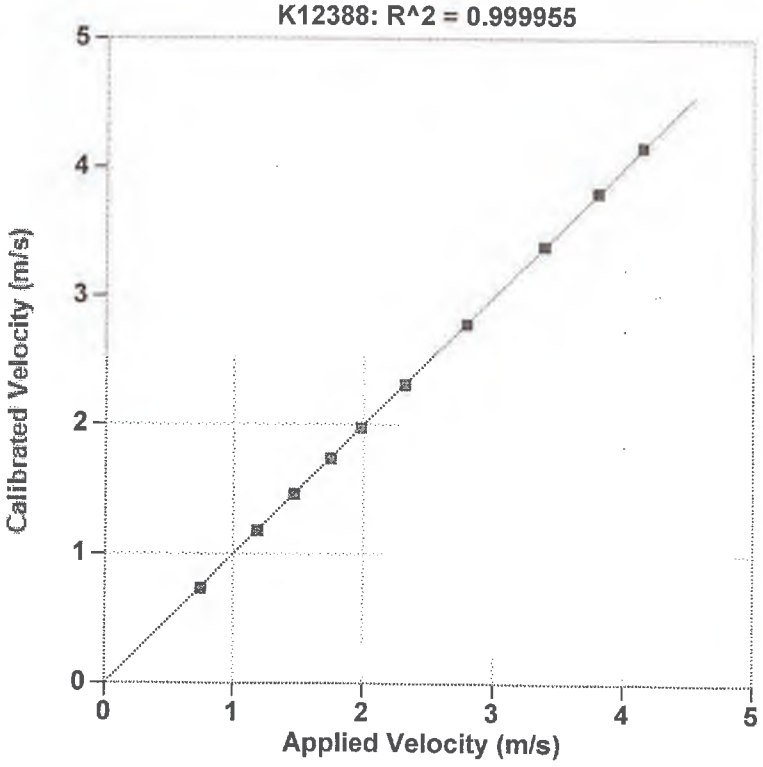
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).

PDA CALIBRATION FACTOR

451.0 mv/5000g
(90.2 µv/g)
R^2: 0.999955 [Chip programmed]

Operator: William Johnson

Signed



Reference Velocity	S/N K12388 Velocity
m/s	m/s
0.741	0.734
1.184	1.178
1.464	1.459
1.744	1.739
1.980	1.976
2.319	2.306
2.790	2.783
3.384	3.388
3.798	3.805
4.147	4.158

Maximum Acceleration: 919 g's

Accelerometer Calibration Certificate
Pile Dynamics, Inc.

Calibrated by Pile Dynamics, Inc.
Calibration performed on OCT 2 2 2021

Serial No:	K12389	**Temperature:**	22.8 °C
Model:	PR	**Humidity:**	44%
Calibrated on:	Channel 3 on 8G 5161 LE		

Ref Acc 1:	69132! 960 g's/volt	**Cal on:**	09Feb2021
Ref Acc 2:	69096! 978 g's/volt	**Cal on:**	27Jan2021

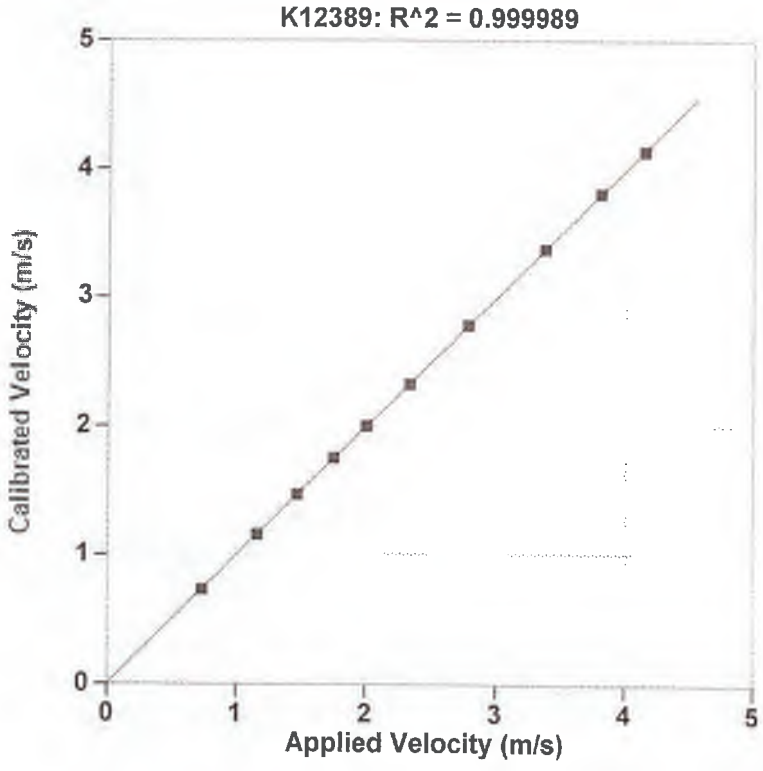
Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).

PDA CALIBRATION FACTOR

483.2 mv/5000g
(96.6 µv/g)
R^2: 0.999989 [Chip programmed]

Operator: William Johnson

Signed



Reference Velocity	S/N K12389 Velocity
m/s	m/s
0.730	0.728
1.158	1.158
1.470	1.471
1.748	1.755
2.001	2.004
2.330	2.326
2.780	2.782
3.372	3.373
3.803	3.807
4.144	4.137

Maximum Acceleration: 914 g's

Certificate of Calibration

Pile Dynamics, Inc.

Transducer Model: PDI Transducer

Serial Number: P821

PDI Gage Factor: 145.1 me/V

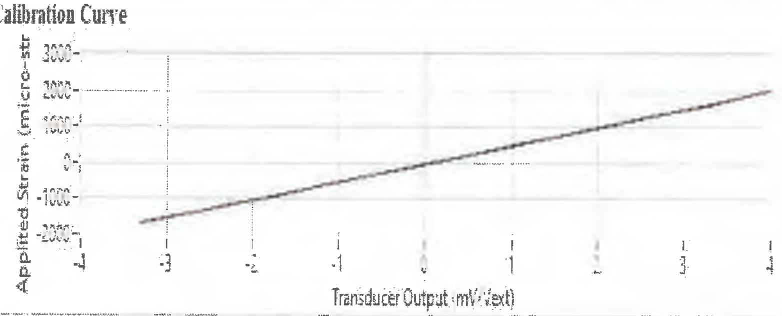
General Gage Factor: 503.9 **me**/mV/Vext

Initial Offset Voltage: 0.006 mV/Vext

Table 1: Representative Calibration Data

Applied Strain (micro-strain)	Transducer Output (mV/Vext)	Applied Strain (micro-strain)	Transducer Output (mV/Vext)
[illegible]	[illegible]	[illegible]	0.442
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1.645
[illegible]	[illegible]	[illegible]	2.052
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	3.996
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2.645
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0.354
-274.157	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Calibration Curve



Mean Linear Correlation Coefficient (LCC): 0.999973

LCC Standard Deviation: 1.354270E-6

Calibrated By: DJC

Signature:

Date and Time: 9/9/2021 8:53 AM

Temperature (Degrees C): 24.2

Pile Dynamics, Inc.

Certificate of Calibration

Transducer Model: PDI Transducer

Serial Number: S868

PDI Gage Factor: 145.1 me/V

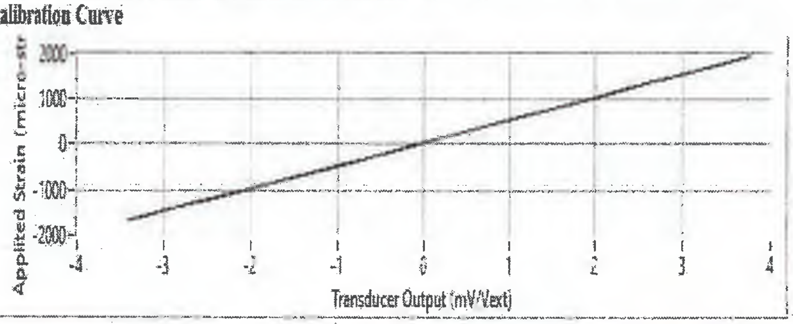
General Gage Factor: 503.9 me/mV/V$_{ext}$

Initial Offset Voltage: -0.058 mV/V$_{ext}$

Table 1: Representative Calibration Data

Applied Strain (micro-strain)	Transducer Output (mV/Vext)	Applied Strain (micro-strain)	Transducer Output (mV/Vext)
17.468	-0.059	166.544	0.227
-136.739	-0.384	451.152	0.797
-418.764	-0.925	757.082	1.404
-668.733	-1.429	1070.886	2.030
-912.547	-1.918	1386.164	2.657
-1166.488	-2.414	1690.646	3.279
-1411.174	-2.898	1952.867	3.759
-1620.474	-3.337	1899.336	3.660
-1676.677	-3.479	1574.566	3.030
-1601.680	-3.333	1252.012	2.389
-1367.026	-2.524	945.462	1.781
-1100.823	-2.290	663.515	1.225
-831.345	-1.782	408.055	0.711
-582.470	-1.223	164.516	0.224
-303.681	-0.706	17.591	-0.027
-29.718	-0.160	17.211	-0.058

Calibration Curve



Mean Linear Correlation Coefficient (LCC): 0.999993

LCC Standard Deviation: 1.772938E-6

Calibrated By: DJC

Signature:

Date and Time: 2/10/2021 7:16 AM

Temperature (Degrees C): 25.2

Specifications

PDI Automated Strain Transducer Calibration System (PDI - ASTCS)

ASTCS Serial Number:	PDI CAL 2015-02
ASTCS Software Version Number:	3.001
ASTCS Independant Verification Date:	9/22/2015 1:48 PM
Transducer Gage Length:	3 inches (76.2 mm)
Full Scale Displacement Range:	+/- 0.0075 (inches)
Method for Applying Displacement:	Precision Stepper Motor Connected to Linear Stage
Excitation Voltage for Calibration:	2.5 VDC
Displacement Measurements:	Dual Precision LVDTs, Output Averaged
Displacement Certification:	NIST 274437-07
Linearity Verification Technique:	Linear Correlation Coefficient < 0.9996
Repeatability Verification Technique	Standard Deviation < 0.5% of mean

ASTCS System Check

Reference Strain Transducer:	35580
Reference General Gage Factor:	529.70 micro-strain/mv/v
LVDT #1 Sensitivity (inches/volt):	0.0079
LVDT #2 Sensitivity (inches/volt):	0.0081
System Temperature Status	Passed
Date/Time of Last System Check	9/22/2015 1:48 PM

PDI Strain Transducer Connections

Black	Excitation +
Green:	Excitation -
Red:	Signal +
White	Signal -
Grey BARE	Shield

NIST Reference:

PDI certifies the above PDI-ASTCS instrument meets or exceeds published specifications and has been verified using standards and instruments whose accuracies are traceable to the National Institute of Standards and Technology (NIST), an accepted value of a natural physical constant or a ratio calibration technique. The calibration of this instrument was performed in accordance with the PDI Quality Assurance program. Measurements and information provided on this report are valid at the time of calibration only.

Appendix F

PDA Proficiency Certifications

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Sally Thomson
Infrastructure Consulting Engineering

has on August 11, 2021 achieved the rank of

ADVANCED

on the **Dynamic Measurement and Analysis Proficiency Test**.

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended*** **that Individuals at the Advanced level seek Master or Expert levels through additional study within six years of the date of this document.**

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate.

Frank T. Peters, Executive Director
Pile Driving Contractors Association

SEAL
OHIO

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 3139

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Michael Simpson
Infrastructure Consulting & Engineering

has on August 25, 2021 achieved the rank of

ADVANCED

on the Dynamic Measurement and Analysis Proficiency Test.

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended*** **that Individuals at the Advanced level seek Master or Expert levels through additional study within six years of the date of this document.**

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate.

Frank T. Peters, Executive Director
Pile Driving Contractors Association

SEAL
1972
OHIO

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 3149