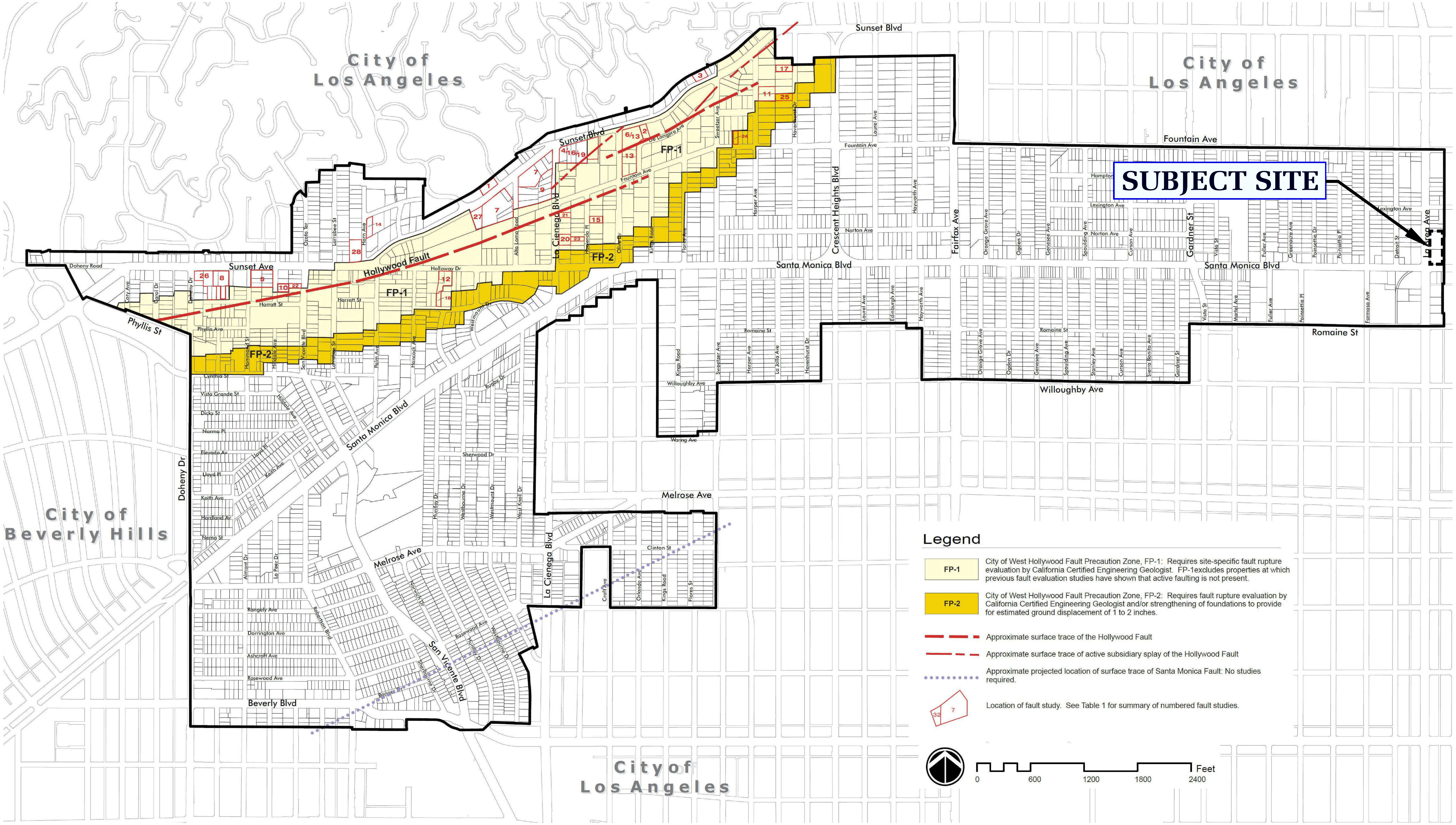
Appendix F4

Geotechnical Investigation



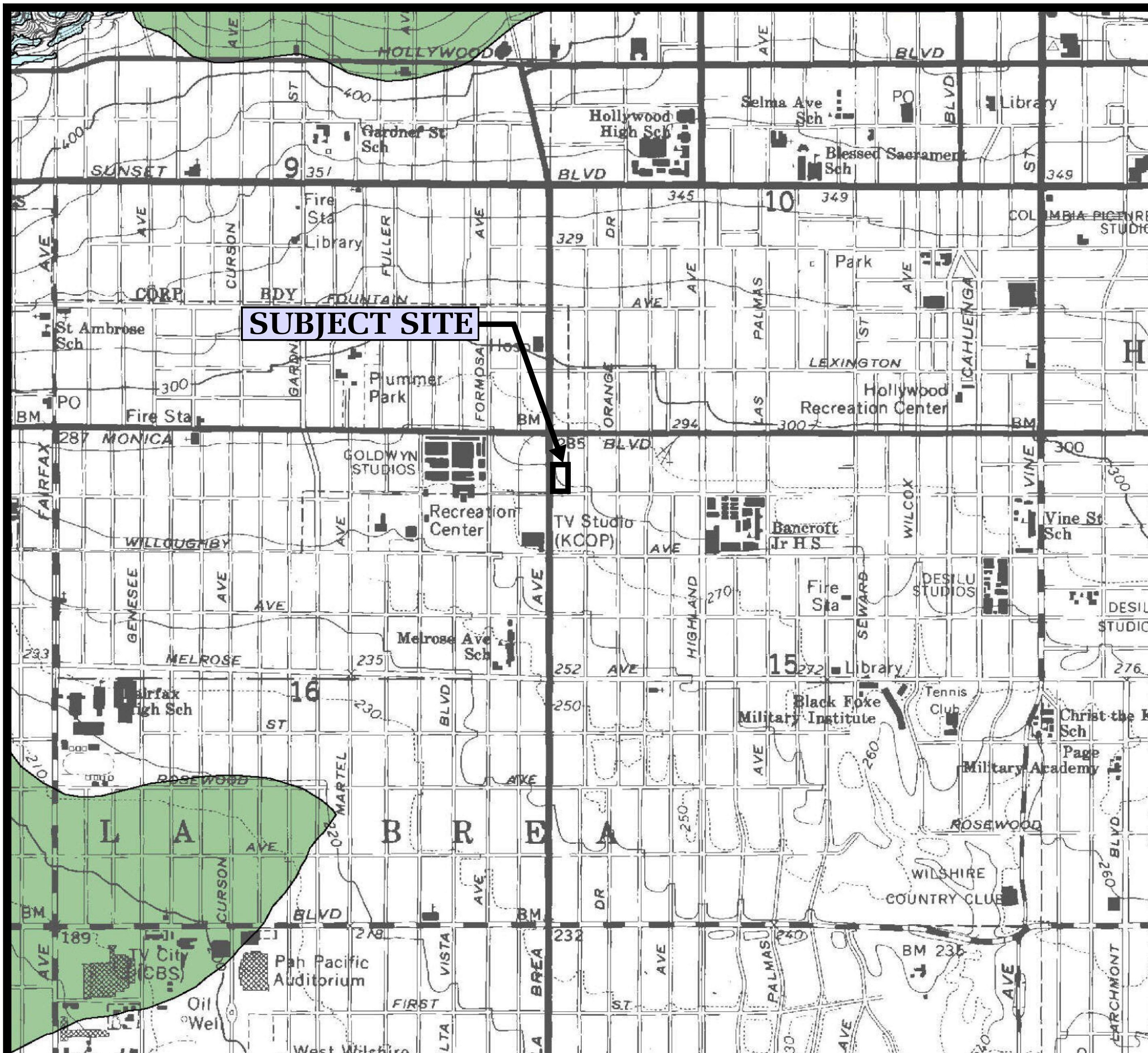
CITY FAULT LOCATION AND PRECAUTION ZONE MAP

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1010, 1014 & 1020 N. LA BREA AVE., WEST HOLLYWOOD

FILE No. 21848

REFERENCE: City Fault Location and Precaution Zone Map by KFM Geoscience, dated March 2010



SCALE 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

N

LIQUEFACTION AREA

REFERENCE: SEISMIC HAZARD ZONES, BURBANK QUADRANGLE OFFICIAL MAP (CDMG, 1999)

SEISMIC HAZARD ZONE MAP

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1010, 1014 & 1020 N. LA BREA AVE., WEST HOLLYWOOD

FILE NO. 21848

BORING LOG NUMBER 1

Faring | **Date: 08/06/19**

File No. 21848 | **Method: 8-inch diameter Hollow Stem Auger**

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description Surface Conditions: Concrete Slab
				0 --		6-inch Concrete, 1-inch Slab
				-		
				1 --		FILL: Sandy Silt, dark brown, moist, stiff
				-		
				2 --		
				-		
				3 --		
				-		
				4 --		
				-		
5	32	14.8	118.7	5 --		
				-	ML	OLDER ALLUVIUM: Sandy Silt, dark brown, moist, stiff
				6 --		
				-		
				7 --		
				-		
				8 --		
				-		
				9 --		
				-		
10	22	15.0	SPT	10 --		
				-	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, stiff
				11 --		
				-		
				12 --		
				-		
				13 --		
				-		
				14 --		
				-		
15	64	17.1	113.6	15 --		
				-		
				16 --		
				-		
				17 --		
				-		
				18 --		
				-		
				19 --		
				-		
20	24	23.0	SPT	20 --		
				-		
				21 --		
				-		
				22 --		
				-		
				23 --		
				-		
				24 --		
				-		
25	52	28.3	98.9	25 --		
				-		

BORING LOG NUMBER 1

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				26 --		
				-		
				27 --		
				-		
				28 --		
				-		
				29 --		
				-		
30	14	30.8	SPT	30 --		
				-	ML/CL	Clayey Silt to Silty Clay, dark brown, moist to very moist, stiff
				31 --		
				-		
				32 --		
				-		
				33 --		
				-		
				34 --		
				-		
35	41	21.4	107.2	35 --		
				-	SP	Sand, dark brown, wet, medium dense, fine grained
				36 --		
				-		
				37 --		
				-		
				38 --		
				-		
				39 --		
				-		
40	41	16.4	SPT	40 --		
				-		
				41 --		
				-		
				42 --		
				-		
				43 --		
				-		
				44 --		
				-		
45	48	23.6	104.5	45 --		
				-	ML	Sandy to Clayey Silt, dark brown, moist, stiff
				46 --		
				-		
				47 --		
				-		
				48 --		
				-		
				49 --		
				-		
50	27	23.5	SPT	50 --		
				-	SM/ML	Silty Sand to Sandy Silt, dark brown, wet, medium dense, stiff, fine grained

BORING LOG NUMBER 1

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				51 --		
				-		
				52 --		
				-		
				53 --		
				-		
				54 --		
				-		
55	72	9.6	121.3	55 --		
				-	SP	Sand, dark brown, wet, dense, fine to medium grained
				56 --		
				-		
				57 --		
				-		
				58 --		
				-		
				59 --		
				-		
60	31	25.3	SPT	60 --		
				-	ML/CL	Clayey Silt to Silty Clay, dark brown, moist, stiff
				61 --		
				-		
				62 --		
				-		
				63 --		
				-		
				64 --		
				-		
65	79	10.0	117.9	65 --		
				-	SC/CL	Sandy Clay to Clayey Sand, dark brown, moist, very stiff, very dense, fine grained
				66 --		
				-		
				67 --		
				-		
				68 --		
				-		
				69 --		
				-		
70	40	25.9	SPT	70 --		
				-	ML	Sandy Silt, dark and yellowish brown, moist, stiff
				71 --		
				-		
				72 --		
				-		
				73 --		
				-		
				74 --		
				-		
75	73	22.1	106.6	75 --		
	50/2"			-		

BORING LOG NUMBER 1

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				- 76 -- - 77 -- - 78 -- - 79 -- -		
80	37	31.8	SPT	80 -- - 81 -- - 82 -- - 83 -- - 84 -- -	ML/CL	Clayey Silt to Silty Clay, dark brown, moist, stiff
85	78	20.6	107.0	85 -- - 86 -- - 87 -- - 88 -- - 89 -- -	SM/CL	Silty Sand to Silty Clay, dark brown, and gray, moist, very dense, very stiff, fine grained
90	42	19.3	SPT	90 -- - 91 -- - 92 -- - 93 -- - 94 -- -	SP	Sand, dark and gray, wet, medium dense, fine to medium grained
95	89	8.5	132.0	95 -- - 96 -- - 97 -- - 98 -- - 99 -- -		dense
100	49	10.7	SPT	100 -- -	SP/ML	Sand to Sandy Silt, dark and gray, moist to wet, dense, stiff, fine to coarse grained

BORING LOG NUMBER 1

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				- 101 -- - 102 -- - 103 -- - 104 -- -		
105	45 50/4"	24.1	104.0	105 -- - 106 -- - 107 -- - 108 -- - 109 -- -		BEDROCK (PUENTE FORMATION): Siltstone, gray, moist, hard
110	56	29.7	SPT	110 -- - 111 -- - 112 -- - 113 -- - 114 -- -		
115	40 50/3"	26.2	97.4	115 -- - 116 -- - 117 -- - 118 -- - 119 -- -		
120	72	28.6	SPT	120 -- - 121 -- - 122 -- - 123 -- - 124 -- -		
125	88	26.4	98.7	125 -- -		gray to dark gray

BORING LOG NUMBER 1

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				- 126 -- - 127 -- - 128 -- - 129 -- -		
130	57	28.3	SPT	130 --		
				- 131 -- - 132 -- - 133 -- - 134 -- - 135 -- - 136 -- - 137 -- - 138 -- - 139 -- - 140 -- - 141 -- - 142 -- - 143 -- - 144 -- - 145 -- - 146 -- - 147 -- - 148 -- - 149 -- - 150 -- -		Total Depth 130 feet Water at 18½ feet Fill to 5 feet NOTE: The stratification lines represent the approximate boundary between earth types; the transition may be gradual. Used 8-inch diameter Hollow-Stem Auger 140-lb. Automatic Hammer, 30-inch drop Modified California Sampler used unless otherwise noted SPT=Standard Penetration Test

BORING LOG NUMBER 2

Faring **Date: 08/01/19**

File No. 21848 **Method: 8-inch diameter Hollow Stem Auger**

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description Surface Conditions: Concrete Slab
				0 --		8-inch Concrete over 4-inch Base
				-		
				1 --		
				-		FILL: Silty clay, dark brown, moist, stiff
				2 --		
				-		
				3 --		
				-		
				4 --		
				-		
5	5	23.6	SPT	5 --		
				-		Silty Sand to Silty Clay, dark brown and gray, moist, medium dense, stiff, fine grained
				6 --		
				-		
				7 --		
				-		
				8 --		
				-	SM	OLDER ALLUVIUM: Silty Sand, dark and yellowish brown, moist, medium dense to dense, fine grained
				9 --		
				-		
10	53 50/5"	16.6	114.5	10 --		
				-		
				11 --		
				-		
				12 --		
				-		
				13 --		
				-		
				14 --		
				-		
15	12	23.9	SPT	15 --		
				-	CL	Sandy Clay, dark brown, moist, stiff
				16 --		
				-		
				17 --		
				-		
				18 --		
				-		
				19 --		
				-		
20	33	17.9	113.7	20 --		
				-	SM/SP	Silty Sand to Sand, dark brown, moist, medium dense, fine grained
				21 --		
				-		
				22 --		
				-		
				23 --		
				-		
				24 --		
				-		
25	36	27.3	SPT	25 --		
				-	ML	Sandy to Clayey Silt, dark brown, moist, stiff

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				26		
				27		
				28		
				29		
30	56	24.5	99.8	30		
				31	CL	Silty Clay, dark and grayish brown, moist, stiff
				32		
				33		
				34		
35	22	28.4	SPT	35		
				36		yellowish brown
				37		
				38		
				39		
40	35	14.0	116.3	40		
				41		Sandy Clay, yellowish brown, moist, stiff
				42		
				43		
				44		
45	24	21.6	SPT	45		
				46		
				47		
47.5	82	14.7	113.3			
				48	SP/SW	Sand, dark brown, moist to wet, very dense, fine grained, few gravel
				49		
50	28	14.6	SPT	50		
					SM/ML	Silty Sand to Sandy Silt, dark and gray, moist to wet, medium dense, stiff, fine to coarse grained

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				51 --		
				52 --		
52.5	72	20.7	109.1	-		
				53 --	SM	Silty Sand, dark brown, moist, dense, fine grained, few cobbles
				54 --		
55	32	15.7	SPT	55 --		
				-	SP/SM	Sand to Silty Sand, dark brown, wet, medium dense, fine to medium grained
				56 --		
				57 --		
57.5	63	20.3	110.5	-		
				58 --	SM/ML	Silty Sand to Sandy Silt, brown, moist, dense, stiff, fine grained
				59 --		
60	30	25.4	SPT	60 --		
				-	SP/SM	Sand to Silty Sand, dark brown, moist, medium dense, fine grained
				61 --		
				62 --		
62.5	61	20.6	108.1	-		
				63 --	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, dense, stiff, fine grained, few gravel
				64 --		
65	44	18.6	SPT	65 --		
				-	SP/SM	Silty Sand to Sand, dark and yellowish brown, wet, dense, fine grained, few gravel
				66 --		
				67 --		
67.5	48 50/4"	15.5	116.2	-		
				68 --		
				69 --		
70	47	20.2	SPT	70 --		
				-	SC/CL	Sandy Clay to Clayey Sand, yellowish brown, wet, dense, stiff, fine to medium grained
				71 --		
				72 --		
72.5	35 50/5"	25.8	98.3	-		
				73 --		
				74 --		
75	35	18.9	SPT	75 --		
				-		dark and yellowish brown, medium dense, stiff

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				76		
				77		
77.5	36 50/5"	27.2	95.4	78	CL	Sandy to Silty Clay, dark and gray, moist, stiff
				79		
80	34	17.8	SPT	80		
				81		
				82		
82.5	40 50/5"	17.7	113.5	83	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, very dense, very stiff, fine grained
				84		
85	31	21.6	SPT	85	ML/CL	Clayey Silt to Silty Clay, dark and gray, moist, stiff
				86		
				87		
87.5	90	20.6	108.1	88		
				89		
90	35	34.2	SPT	90		
				91		
				92		
92.5	39	30.6	93.0	93	CL	Silty Clay, dark and grayish brown, moist, stiff
				94		
95	33	16.8	SPT	95	SP	Sand, dark and gray, wet, medium dense, fine grained
				96		
				97		
97.5	40 50/4"	18.0	109.3	98		very dense
				99		
100	74	17.9	SPT	100		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				101 --		
				-		
				102 --		
102.5	45	14.9	121.6	-		
	50/4"			103 --		fine to medium grained, few gravel
				-		
				104 --		
				-		
105	49	19.3	SPT	105 --		
				-		dense
				106 --		
				-		
				107 --		
107.5	88	24.8	99.9	-		
				108 --		BEDROCK (PUENTE FORMATION): Siltstone, dark gray,
				-		moist, moderately hard
				109 --		
				-		
110	43	28.4	SPT	110 --		
				-		
				111 --		
				-		
				112 --		
112.5	72	27.8	95.2	-		
				113 --		
				-		
				114 --		
				-		
115	33	26.3	SPT	115 --		
				-		
				116 --		
				-		
				117 --		
117.5	45	23.8	103.8	-		
	50/4"			118 --		
				-		
				119 --		
				-		
120	48	23.9	SPT	120 --		
				-		
				121 --		
				-		
				122 --		
122.5	88	23.8	101.3	-		
				123 --		
				-		
				124 --		
				-		
125	54	27.0	SPT	125 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				126 --		
				-		
				127 --		
127.5	40	24.4	101.2	-		
	50/4"			128 --		Claystone, dark gray, moist, hard
				-		
				129 --		
				-		
130	56	26.0	SPT	130 --		
				-		Siltstone, dark gray, moist, moderately hard
				131 --		
				-		
				132 --		
				-		
				133 --		
				-		
				134 --		
				-		
135	79	23.2	103.3	135 --		
				-		
				136 --		
				-		
				137 --		
				-		
				138 --		
				-		
				139 --		
				-		
140	47	25.9	SPT	140 --		
				-		
				141 --		
				-		
				142 --		
				-		
				143 --		
				-		
				144 --		
				-		
145	46	23.2	102.5	145 --		
	50/4"			-		gray
				146 --		
				-		
				147 --		
				-		
				148 --		
				-		
				149 --		
				-		
150	61	26.7	SPT	150 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				151		
				152		
				153		
				154		
155	100/8"	26.8	98.2	155		
				156		
				157		
				158		
				159		
160	50	25.6	SPT	160		
				161		
				162		
				163		
				164		
165	40 50/3"	24.8	105.4	165		dark gray
				166		
				167		
				168		
				169		
170	57	24.7	SPT	170		
				171		
				172		
				173		
				174		
175	68	24.8	102.2	175		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				176		
				177		
				178		
				179		
180	92	25.9	SPT	180		
				181		Total Depth 180 feet Water at 19 feet Fill to 8 feet
				182		
				183		NOTE: The stratification lines represent the approximate boundary between earth types; the transition may be gradual.
				184		
				185		Used 8-inch diameter Hollow-Stem Auger 140-lb. Automatic Hammer, 30-inch drop Modified California Sampler used unless otherwise noted
				186		
				187		SPT=Standard Penetration Test
				188		
				189		
				190		
				191		
				192		
				193		
				194		
				195		
				196		
				197		
				198		
				199		
				200		

ASTM D 1557

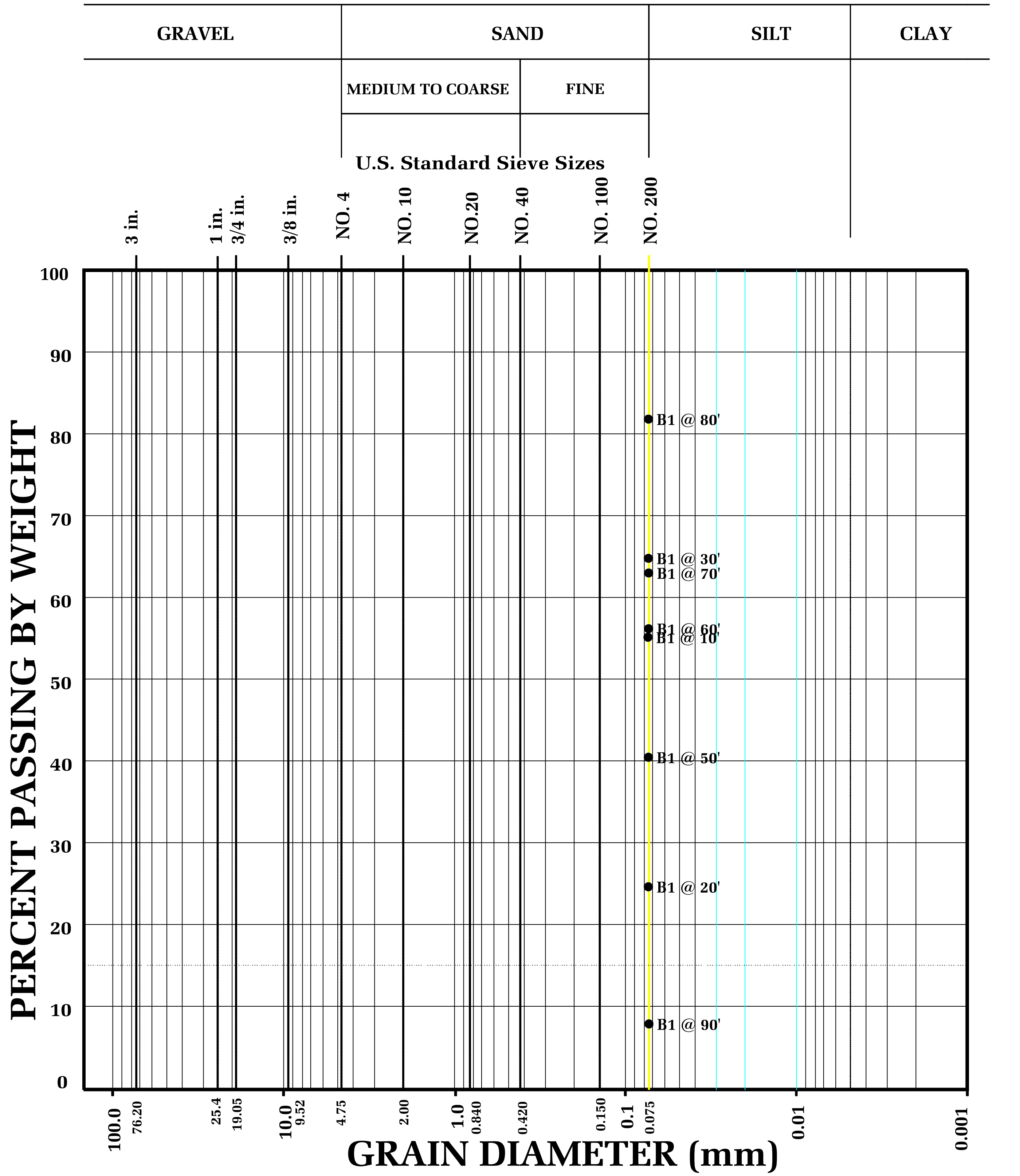
SAMPLE	B1 @ 1- 5'	B2 @ 1-5'
SOIL TYPE:	SM/ML	SM/ML
MAXIMUM DENSITY pcf.	120.0	117.9
OPTIMUM MOISTURE %	12.9	14.1

ASTM D 4829

SAMPLE	B1 @ 1- 5'	B2 @ 1-5'
SOIL TYPE:	SM/ML	SM/ML
EXPANSION INDEX UBC STANDARD 18-2	94	82
EXPANSION CHARACTER	HIGH	MODERATE

SULFATE CONTENT

SAMPLE	B1 @ 1-5'	B2 @ 1-5'
SULFATE CONTENT: (percentage by weight)	< 0.10%	< 0.10%

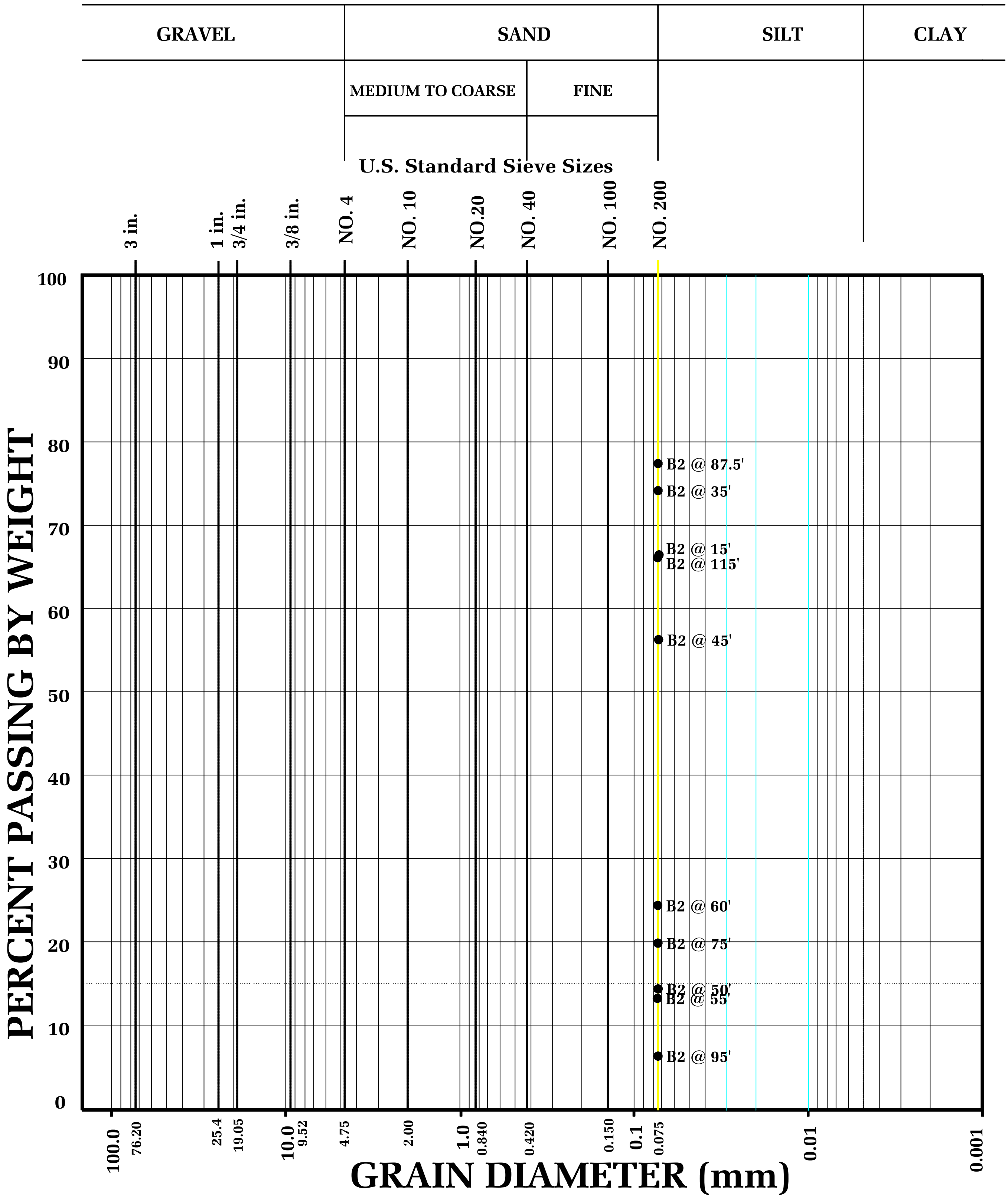


GRAIN SIZE DISTRIBUTION

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1010, 1014 & 1020 N. LA BREA AVE., WEST HOLLYWOOD

FILE NO. 21848 | **PLATE: E-1**



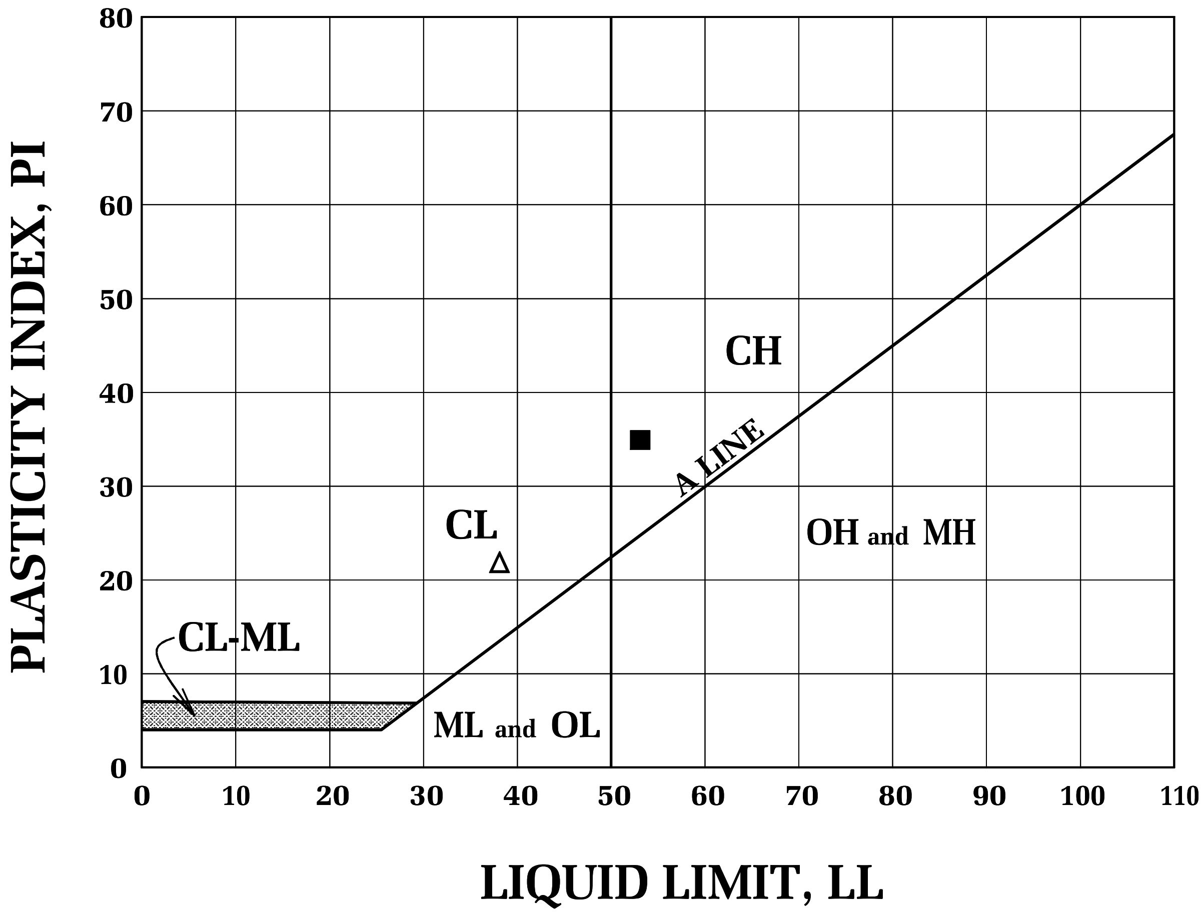
GRAIN SIZE DISTRIBUTION

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1010, 1014 & 1020 N. LA BREA AVE., WEST HOLLYWOOD

FILE NO. 21848 | **PLATE: E-2**

ASTM D4318



BORING NUMBER	DEPTH (FEET)	TEST SYMBOL	LL	PL	PI	DESCRIPTION
B1	30	△	38	16	22	CL
B1	60	■	53	18	35	CH

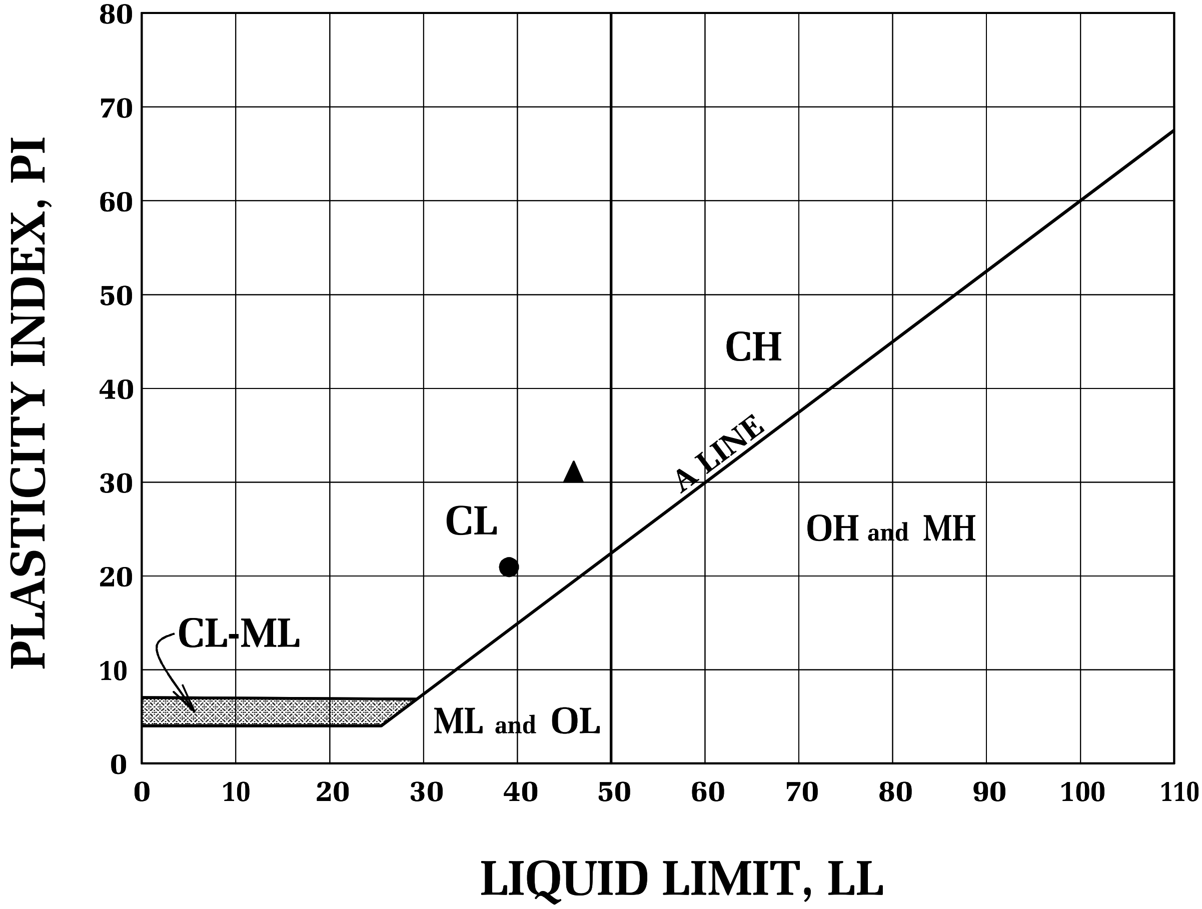
ATTERBERG LIMITS DETERMINATION

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1010, 1014 & 1020 N. LA BREA AVE., WEST HOLLYWOOD

FILE NO. 21848 | PLATE: F-1

ASTM D4318



BORING NUMBER	DEPTH (FEET)	TEST SYMBOL	LL	PL	PI	DESCRIPTION
B2	15	●	39	18	21	CL
B2	35	▲	46	15	31	CL

ATTERBERG LIMITS DETERMINATION

Geotechnologies, Inc.
Consulting Geotechnical Engineers

FARING
1010, 1014 & 1020 N. LA BREA AVE., WEST HOLLYWOOD

FILE NO. 21848 | PLATE: F-2

Geotechnologies, Inc.

Project: FARING
File No.: 21848
Description: Liquefaction Analysis
Boring No: B1

LIQUEFACTION EVALUATION (Idriss & Boulanger, EERI NO 12)

EARTHQUAKE INFORMATION:

Earthquake Magnitude (M):	6.9
Peak Ground Horizontal Acceleration, PGA (g):	0.99
Calculated Mag.Wtg.Factor:	1.171

GROUNDWATER INFORMATION:

Current Groundwater Level (ft):	18.0
Historically Highest Groundwater Level* (ft):	10.0
Unit Weight of Water (pcf):	62.4

* Based on California Geological Survey Seismic Hazard Evaluation Report

BOREHOLE AND SAMPLER INFORMATION:

Borehole Diameter (inches):	8
SPT Sampler with room for Liner (Y/N):	Y

LIQUEFACTION BOUNDARY:

Plastic Index Cut Off (PI):	18
Minimum Liquefaction FS:	1.3

Depth to Base Layer (feet)	Total Unit Weight (pcf)	Current Water Level (feet)	Historical Water Level (feet)	Field SPT Blowcount N	Depth of SPT Blowcount (feet)	Fines Content #200 Sieve (%)	Plastic Index (PI)	Vetical Stress σ_{vc}, (psf)	Effective Vert. Stress σ_{vc}', (psf)	Fines Corrected $(N_1)_{60-cs}$	Stress Reduction Coeff, r_d	Cyclic Shear Ratio CSR	Mag. Scaling Factor (Sand) MSF	Overburden Corr. Factor K_σ	Cyclic Resist. Ratio $CRR_{M7.5,\sigma vc'=1}$	Cyclic Resistance Ratio (CRR)	Factor of Safety CRR/CSR (F.S.)	Liquefaction Settlment ΔS_i (inches)
1	136.3	Unsaturated	Unsaturated	22	10	55.2	23	136.3	136.3	10.1	1.00	0.646	1.17	1.10	0.119	0.153	Non-Liq.	0.00
2	136.3	Unsaturated	Unsaturated	22	10	55.2	23	272.6	272.6	10.1	1.00	0.644	1.17	1.10	0.119	0.153	Non-Liq.	0.00
3	136.3	Unsaturated	Unsaturated	22	10	55.2	23	408.9	408.9	10.1	1.00	0.642	1.17	1.10	0.119	0.153	Non-Liq.	0.00
4	136.3	Unsaturated	Unsaturated	22	10	55.2	23	545.2	545.2	10.1	0.99	0.640	1.17	1.10	0.119	0.153	Non-Liq.	0.00
5	136.3	Unsaturated	Unsaturated	22	10	55.2	23	681.5	681.5	10.8	0.99	0.638	1.17	1.10	0.123	0.159	Non-Liq.	0.00
6	136.3	Unsaturated	Unsaturated	22	10	55.2	23	817.8	817.8	10.4	0.99	0.636	1.17	1.09	0.121	0.153	Non-Liq.	0.00
7	136.3	Unsaturated	Unsaturated	22	10	55.2	23	954.1	954.1	9.6	0.98	0.633	1.17	1.07	0.115	0.145	Non-Liq.	0.00
8	136.3	Unsaturated	Unsaturated	22	10	55.2	23	1090.4	1090.4	9.0	0.98	0.631	1.17	1.06	0.111	0.137	Non-Liq.	0.00
9	136.3	Unsaturated	Unsaturated	22	10	55.2	23	1226.7	1226.7	27.3	0.98	0.628	1.17	1.09	0.358	0.459	Non-Liq.	0.00
10	136.3	Unsaturated	Unsaturated	22	10	55.2	23	1363.0	1363.0	26.3	0.97	0.626	1.17	1.07	0.324	0.406	Non-Liq.	0.00
11	136.3	Unsaturated	Saturated	22	10	55.2	23	1499.3	1436.9	25.3	0.97	0.650	1.17	1.05	0.298	0.368	Non-Liq.	0.00
12	136.3	Unsaturated	Saturated	22	10	55.2	23	1635.6	1510.8	24.5	0.96	0.671	1.17	1.04	0.279	0.338	Non-Liq.	0.00
13	136.3	Unsaturated	Saturated	22	10	55.2	23	1771.9	1584.7	23.8	0.96	0.690	1.17	1.02	0.263	0.315	Non-Liq.	0.00
14	136.3	Unsaturated	Saturated	22	10	55.2	23	1908.2	1658.6	23.1	0.95	0.707	1.17	1.01	0.251	0.297	Non-Liq.	0.00
15	136.3	Unsaturated	Saturated	22	10	55.2	23	2044.5	1732.5	24.7	0.95	0.722	1.17	1.00	0.283	0.332	Non-Liq.	0.00
16	133.1	Unsaturated	Saturated	22	10	55.2	21	2177.6	1803.2	24.1	0.95	0.735	1.17	0.99	0.269	0.313	Non-Liq.	0.00
17	133.1	Unsaturated	Saturated	22	10	55.2	21	2310.7	1873.9	23.5	0.94	0.746	1.17	0.98	0.258	0.297	Non-Liq.	0.00
18	133.1	Unsaturated	Saturated	22	10	55.2	21	2443.8	1944.6	22.9	0.94	0.757	1.17	0.97	0.248	0.283	Non-Liq.	0.00
19	133.1	Saturated	Saturated	22	10	55.2	21	2576.9	2015.3	22.6	0.93	0.766	1.17	0.97	0.243	0.276	Non-Liq.	0.00
20	133.1	Saturated	Saturated	22	10	55.2	21	2710.0	2086.0	22.4	0.93	0.774	1.17	0.97	0.239	0.270	Non-Liq.	0.00
21	133.1	Saturated	Saturated	24	20	24.6	0	2843.1	2156.7	22.1	0.92	0.781	1.17	0.96	0.235	0.264	Non-Liq.	0.00
22	133.1	Saturated	Saturated	24	20	24.6	0	2976.2	2227.4	21.8	0.92	0.787	1.17	0.96	0.231	0.259	Non-Liq.	0.00
23	133.1	Saturated	Saturated	24	20	24.6	0	3109.3	2298.1	21.6	0.91	0.793	1.17	0.95	0.227	0.254	Non-Liq.	0.00
24	133.1	Saturated	Saturated	24	20	24.6	0	3242.4	2368.8	21.4	0.90	0.797	1.17	0.95	0.224	0.249	Non-Liq.	0.00
25	133.1	Saturated	Saturated	24	20	24.6	0	3375.5	2439.5	21.1	0.90	0.801	1.17	0.95	0.220	0.245	Non-Liq.	0.00
26	126.9	Saturated	Saturated	24	20	24.6	0	3502.4	2504.0	57.6	0.89	0.805	1.17	0.88	2.000	2.000	Non-Liq.	0.00
27	126.9	Saturated	Saturated	24	20	24.6	0	3629.3	2568.5	57.2	0.89	0.808	1.17	0.88	2.000	2.000	Non-Liq.	0.00
28	126.9	Saturated	Saturated	24	20	24.6	0	3756.2	2633.0	59.8	0.88	0.811	1.17	0.87	2.000	2.000	Non-Liq.	0.00
29	126.9	Saturated	Saturated	24	20	24.6	0	3883.1	2697.5	59.5	0.88	0.813	1.17	0.86	2.000	2.000	Non-Liq.	0.00
30	126.9	Saturated	Saturated	24	20	24.6	0	4010.0	2762.0	59.1	0.87	0.815	1.17	0.85	2.000	2.000	Non-Liq.	0.00
31	126.9	Saturated	Saturated	14	30	64.7	22	4136.9	2826.5	20.8	0.87	0.816	1.17	0.93	0.216	0.235	Non-Liq.	0.00
32	126.9	Saturated	Saturated	14	30	64.7	22	4263.8	2891.0	20.6	0.86	0.817	1.17	0.93	0.213	0.231	Non-Liq.	0.00
33	126.9	Saturated	Saturated	14	30	64.7	22	4390.7	2955.5	20.4	0.85	0.817	1.17	0.92	0.211	0.228	Non-Liq.	0.00
34	126.9	Saturated	Saturated	14	30	64.7	22	4517.6	3020.0	20.2	0.85	0.817	1.17	0.92	0.209	0.225	Non-Liq.	0.00
35	126.9	Saturated	Saturated	14	30	64.7	22	4644.5	3084.5	20.0	0.84	0.817	1.17	0.92	0.206	0.222	Non-Liq.	0.00
36	130.2	Saturated	Saturated	41	40	0.0	0	4774.7	3152.3	19.9	0.84	0.816	1.17	0.92	0.204	0.220	Non-Liq.	0.00
37	130.2	Saturated	Saturated	41	40	0.0	0	4904.9	3220.1	19.7	0.83	0.815	1.17	0.92	0.202	0.217	Non-Liq.	0.00
38	130.2	Saturated	Saturated	41	40	0.0	0	5035.1	3287.9	19.5	0.83	0.814	1.17	0.91	0.200	0.214	Non-Liq.	0.00
39	130.2	Saturated	Saturated	41	40	0.0	0	5165.3	3355.7	19.4	0.82	0.813	1.17	0.91	0.198	0.212	Non-Liq.	0.00
40	130.2	Saturated	Saturated	41	40	0.0	0	5295.5	3423.5	19.2	0.81	0.811	1.17	0.91	0.197	0.210	Non-Liq.	0.00
41	130.2	Saturated	Saturated	41	40	0.0	0	5425.7	3491.3	19.1	0.81	0.809	1.17	0.91	0.195	0.207	Non-Liq.	0.00
42	130.2	Saturated	Saturated	41	40	0.0	0	5555.9	3559.1	18.9	0.80	0.807	1.17	0.91	0.193	0.205	Non-Liq.	0.00
43	130.2	Saturated	Saturated	41	40	0.0	0	5686.1	3626.9	18.8	0.80	0.804	1.17	0.90	0.192	0.203	Non-Liq.	0.00
44	130.2	Saturated	Saturated	41	40	0.0	0	5816.3	3694.7	18.6	0.79	0.802	1.17	0.90	0.190	0.201	Non-Liq.	0.00
45	130.2	Saturated	Saturated	41	40	0.0	0	5946.5	3762.5	18.5	0.79	0.799	1.17	0.90	0.189	0.199	Non-Liq.	0.00
46	129.1	Saturated	Saturated	41	40	0.0	0	6075.6	3829.2	38.3	0.78	0.796	1.17	0.76	2.000	1.790	Non-Liq.	0.00
47	129.1	Saturated	Saturated	41	40	0.0	0	6204.7	3895.9	38.0	0.77	0.793	1.17	0.76	2.000	1.779	Non-Liq.	0.00
48	129.1	Saturated	Saturated	41	40	0.0	0	6333.8	3962.6	43.9	0.77	0.790	1.17	0.75	2.000	1.768	Non-Liq.	0.00
49	129.1	Saturated	Saturated	41	40	0.0	0	6462.9	4029.3	43.5	0.76	0.787	1.17	0.75	2.000	1.757	Non-Liq.	0.00
50	129.1	Saturated	Saturated	41	40	0.0	0	6592.0	4096.0	43.2	0.76	0.784	1.17	0.75	2.000	1.746	Non-Liq.	0.00
51	129.1	Saturated	Saturated	27	50	40.5	0	6721.1	4162.7	42.9	0.75	0.781	1.17	0.74	2.000	1.735	Non-Liq.	0.00
52	129.1	Saturated	Saturated	27	50	40.5	0	6850.2	4229.4	42.6	0.75	0.778	1.17	0.74	2.000	1.725	Non-Liq.	0.00
53	129.1	Saturated	Saturated	27	50	40.5	0	6979.3	4296.1	42.4	0.74	0.774	1.17	0.73	2.000	1.714	Non-Liq.	0.00
54	129.1	Saturated	Saturated	27	50	40.5	0	7108.4	4362.8	42.1	0.73	0.771	1.17	0.73	2.000	1.704	Non-Liq.	0.00
55	129.1	Saturated	Saturated	27	50	40.5	0	7237.5	4429.5	41.8	0.73	0.767	1.17	0.72	2.000	1.694	Non-Liq.	0.00
56	132.9	Saturated	Saturated	27	50	40.5	0	7370.4	4500.0	49.2	0.72	0.763	1.17	0.72	2.000	1.684	Non-Liq.	0.00
57	132.9	Saturated	Saturated	27	50	40.5	0	7503.3	4570.5	49.0	0.72	0.759	1.17	0.71	2.000	1.674	Non-Liq.	0.00
58	132.9	Saturated	Saturated	27	50	40.5	0	7636.2	4641.0	48.8	0.71	0.755	1.17	0.71	2.000	1.665	Non-Liq.	0.00
59	132.9	Saturated	Saturated	27	50	40.5	0	7769.1	4711.5	48.7	0.71	0.752	1.17	0.71	2.000	1.655	Non-Liq.	0.00
60	132.9	Saturated	Saturated	27	50	40.5	0	7902.0	4782.0	48.5	0.70	0.748	1.17	0.70	2.000	1.646	Non-Liq.	0.00
61	132.9	Saturated	Saturated	31	60	56.3	0	8034.9	4852.5	46.7	0.70	0.744	1.17	0.70	2.000	1.637	Non-Liq.	0.00
62	132.9	Saturated	Saturated	31	60	56.3	0	8167.8	4923.0	46.4	0.69	0.740	1.17	0.69	2.000	1.628	Non-Liq.	0.00
63	132.9	Saturated	Saturated	31	60	56.3	0	8300.7	4993.5	46.2	0.69	0.736	1.17	0.69	2.000	1.619	Non-Liq.	0.00
64	132.9	Saturated	Saturated	31	60	56.3	0	8433.6	5064.0	45.9	0.68	0.732	1.17	0.69	2.000	1.610	Non-Liq.	0.00
65	132.9	Saturated	Saturated	31	60	56.3	0	8566.5	5134.5	45.6	0.68	0.728	1.17	0.68	2.000	1.601	Non-Liq.	0.00
66	129.6	Saturated	Saturated	31	60	56.3	0	8696.1	5201.7	61.8	0.67	0.724	1.17	0.68	2.000	1.592	Non-Liq.	0.00
67	129.6	Saturated	Saturated	31	60	56.3	0	8825.7	5268.9	61.6	0.67	0.721	1.17	0.68	2.000	1.584	Non-Liq.	0.00
68	129.6	Saturated	Saturated	31	60	56.3	0	8955.3	5336.1	61.4	0.66	0.717	1.17	0.67	2.000	1.576	Non-Liq.	0.00
69	129.6	Saturated	Saturated	31	60	56.3	0	9084.9	5403.3	61.2	0.66	0.713	1.17	0.67	2.000	1.567	Non-Liq.	0.00
70	129.6	Saturated	Saturated	31	60	56.3	0	9214.5	5470.5	61.0	0.65	0.710	1.17	0.67	2.000	1.559	Non-Liq.	0.00
71	129.6	Saturated	Saturated	40	70	62.9	0	9344.1	5537.7	65.0	0.65	0.706	1.17	0.66	2.000	1.551	Non-Liq.	0.00
72	129.6	Saturated	Saturated	40	70	62.9	0	9473.7	5604.9	64.8	0.65	0.703	1.17	0.66	2.000	1.543	Non-Liq.	0.00
73	129.6	Saturated	Saturated	40	70	62.9	0	9603.3	5672.1	64.6	0.64	0.699	1.17	0.66	2.000	1.535	Non-Liq.	0.00
74	129.6	Saturated	Saturated	40	70	62.9	0	9732.9	5739.3	64.4	0.64	0.696	1.17	0.65	2.000	1.527	Non-Liq.	0.00
75	129.6	Saturated	Saturated	40	70	62.9	0	9862.5	5806.5	64.2	0.63	0.692	1.17	0.65	2.000	1.519	Non-Liq.	0.00
76	130.2	Saturated	Saturated	40	70	62.9	0	9992.7	5874.3	52.1	0.63	0.689	1.17	0.65	2.000	1.512	Non-Liq.	0.00
77	130.2	Saturated	Saturated	40	70	62.9	0	10122.9	5942.1	52.0	0.63	0.685	1.17	0.64	2.000	1.504	Non-Liq.	0.00
78	130.2	Saturated	Saturated	40	70	62.9	0	10253.1	6009.9	46.0	0.62	0.682	1.17	0.64	2.000	1.496	Non-Liq.	0.00
79	130.2	Saturated	Saturated	40	70	62.9	0	10383.3	6077.7	45.9	0.62	0.679	1.17	0.64	2.000	1.489	Non-Liq.	0.00
80	130.2	Saturated	Saturated	40	70	62.9	0	10513.5	6145.5	45.7	0.61	0.676	1.17	0.63	2.000	1.482	Non-Liq.	0.00
81	130.2	Saturated	Saturated	37	80	81.9	0	10643.7	6213.3	45.5	0.61	0.672	1.17	0.63	2.000	1.474	Non-Liq.	0.00
82	130.2	Saturated	Saturated	37	80	81.9	0	10773.9	6281.1	45.3	0.61	0.669	1.17	0.63	2.000	1.467	Non-Liq.	0.00
83	130.2	Saturated	Saturated	37	80	81.9	0	10904.1	6348.9	45.1	0.60	0.666	1.17	0.62	2.000	1.460	Non-Liq.	0.00
84	130.2	Saturated	Saturated	37	80	81.9	0	11034.3	6416.7	44.9	0.60	0.664	1.17	0.62	2.000	1.453	Non-Liq.	0.00
85	130.2	Saturated	Saturated	37	80	81.9	0	11164.5	6484.5	44.7	0.60	0.661	1.17	0.62	2.000	1.446	Non-Liq.	0.00
86	129.1	Saturated	Saturated	37	80	81.9	0	11293.6	6551.2	43.5	0.59	0.658	1.17	0.61	2.000	1.439	Non-Liq.	0.00
87	129.1	Saturated	Saturated	37	80	81.9	0	11422.7	6617.9	43.3	0.59	0.655	1.17	0.61	2.000	1.432	Non-Liq.	0.00
88	129.1	Saturated	Saturated	37	80	81.9	0	11551.8	6684.6	43.1	0.59	0.653	1.17	0.61	2.000	1.425	Non-Liq.	0.00
89	129.1	Saturated	Saturated	37	80	81.9	0	11680.9	6751.3	42.9	0.58	0.650	1.17	0.61	2.000	1.419	Non-Liq.	0.00
90	129.1	Saturated	Saturated	37	80	81.9	0	11810.0	6818.0	42.7	0.58	0.648	1.17	0.60	2.000	1.412	Non-Liq.	0.00
91	129.1	Saturated	Saturated	42	90	7.8	0	12068.2	7013.8	45.3	0.58	0.640	1.17	0.59	2.000	1.394	Non-Liq.	0.00
92	129.1	Saturated	Saturated	42	90	7.8	0	12197.3	7080.5	45.2	0.58	0.638	1.17	0.59	2.000	1.387	Non-Liq.	0.00
93	129.1	Saturated	Saturated	42	90	7.8	0	12326.4	7147.2	45.0	0.57	0.636	1.17	0.59	2.000	1.381	Non-Liq.	0.00
94	129.1	Saturated	Saturated	42	90	7.8	0	12455.5	7213.9	44.8	0.57	0.634	1.17	0.59	2.000	1.375	Non-Liq.	0.00
95	129.1	Saturated	Saturated	42	90	7.8	0	12584.6	7280.6	44.7	0.57	0.632	1.17	0.58	2.000	1.368	Non-Liq.	0.00
96	143.2	Saturated	Saturated	42	90	7.8	0	12727.8	7361.4	40.3	0.57	0.630	1.17	0.58	2.000	1.362	Non-Liq.	0.00
97	143.2	Saturated	Saturated	42	90	7.8	0	12871.0	7442.2	40.1	0.56	0.627	1.17	0.58	2.000	1.356	Non-Liq.	0.00
98	143.2	Saturated	Saturated	42	90	7.8	0	13014.2	7523.0	94.8	0.56	0.625	1.17	0.58	2.000	1.350	Non-Liq.	0.00
99	143.2	Saturated	Saturated	42	90	7.8	0	13157.4	7603.8	94.6	0.56	0.623	1.17	0.57	2.000	1.344	Non-Liq.	0.00
100	143.2	Saturated	Saturated	42	90	7.8	0	13300.6	7684.6	94.3	0.56	0.621	1.17	0.57	2.000	1.338	Non-Liq.	0.00
101	143.2	Saturated	Saturated	49	100	0.0	0	13443.8	7765.4	94.1	0.56	0.619	1.17	0.57	2.000	1.332	Non-Liq.	0.00
102	143.2	Saturated	Saturated	49	100	0.0	0	13587.0	7846.2	93.9	0.55	0.617	1.17	0.57	2.000	1.326	Non-Liq.	0.00
103	143.2	Saturated	Saturated	49	100	0.0	0	13730.2	7927.0	93.7	0.55	0.616	1.17	0.56	2.000	1.320	Non-Liq.	0.00
104	143.2	Saturated	Saturated	49	100	0.0	0	13873.4	8007.8	93.5	0.55	0.614	1.17	0.56	2.000	1.315	Non-Liq.	0.00
105	143.2	Saturated	Saturated	49	100	0.0	0	14016.6	8088.6	93.3	0.55	0.613	1.17	0.56	2.000	1.309	Non-Liq.	0.00
106	129.1	Saturated	Saturated	56	110	0.0	0	14145.7	8155.3	61.6	0.55	0.612	1.17	0.56	2.000	1.303	Non-Liq.	0.00
107	129.1	Saturated	Saturated	56	110	0.0	0	14274.8	8222.0	61.5	0.55	0.611	1.17	0.55	2.000	1.298	Non-Liq.	0.00
108	129.1	Saturated	Saturated	56	110	0.0	0	14403.9	8288.7	53.9	0.55	0.610	1.17	0.55	2.000	1.292	Non-Liq.	0.00
109	129.1	Saturated	Saturated	56	110	0.0	0	14533.0	8355.4	53.8	0.54	0.610	1.17	0.55	2.000	1.287	Non-Liq.	0.00
110	129.1	Saturated	Saturated	56	110	0.0	0	14662.1	8422.1	53.6	0.54	0.609	1.17	0.55	2.000	1.281	Non-Liq.	0.00
111	129.1	Saturated	Saturated	56	110	0.0	0	14791.2	8488.8	53.5	0.54	0.609	1.17	0.54	2.000	1.276	Non-Liq.	0.00
112	129.1	Saturated	Saturated	56	110	0.0	0	14920.3	8555.5	53.4	0.54	0.608	1.17	0.54	2.000	1.270	Non-Liq.	0.00
113	129.1	Saturated	Saturated	56	110	0.0	0	15049.4	8622.2	53.3	0.54	0.608	1.17	0.54	2.000	1.265	Non-Liq.	0.00
114	129.1	Saturated	Saturated	56	110	0.0	0	15178.5	8688.9	53.2	0.54	0.608	1.17	0.54	2.000	1.259	Non-Liq.	0.00
115	129.1	Saturated	Saturated	56	110	0.0	0	15307.6	8755.6	53.1	0.54	0.608	1.17	0.54	2.000	1.254	Non-Liq.	0.00
116	122.9	Saturated	Saturated	56	110	0.0	0	15430.5	8816.1	42.0	0.54	0.608	1.17	0.53	2.000	1.249	Non-Liq.	0.00
117	122.9	Saturated	Saturated	56	110	0.0	0	15553.4	8876.6	41.9	0.54	0.609	1.17	0.53	2.000	1.244	Non-Liq.	0.00
118	122.9	Saturated	Saturated	56	110	0.0	0	15676.3	8937.1	41.7	0.54	0.609	1.17	0.53	2.000	1.239	Non-Liq.	0.00
119	122.9	Saturated	Saturated	56	110	0.0	0	15799.2	8997.6	41.5	0.54	0.610	1.17	0.53	2.000	1.233	Non-Liq.	0.00
120	122.9	Saturated	Saturated	56	110	0.0	0	15922.1	9058.1	41.4	0.54	0.611	1.17	0.52	2.000	1.228	Non-Liq.	0.00
121	122.9	Saturated	Saturated	72	120	0.0	0	16045.0	9118.6	58.6	0.54	0.611	1.17	0.52	2.000	1.223	Non-Liq.	0.00
122	122.9	Saturated	Saturated	72	120	0.0	0	16167.9	9179.1	58.5	0.54	0.612	1.17	0.52	2.000	1.218	Non-Liq.	0.00
123	122.9	Saturated	Saturated	72	120	0.0	0	16290.8	9239.6	58.4	0.54	0.613	1.17	0.52	2.000	1.213	Non-Liq.	0.00
124	122.9	Saturated	Saturated	72	120	0.0	0	16413.7	9300.1	58.2	0.54	0.614	1.17	0.52	2.000	1.208	Non-Liq.	0.00
125	122.9	Saturated	Saturated	72	120	0.0	0	16536.6	9360.6	58.1	0.54	0.616	1.17	0.51	2.000	1.203	Non-Liq.	0.00
126	124.8	Saturated	Saturated	57	125	0.0	0	16661.4	9423.0	65.3	0.54	0.617	1.17	0.51	2.000	1.199	Non-Liq.	0.00
127	124.8	Saturated	Saturated	57	125	0.0	0	16786.2	9485.4	65.2	0.54	0.618	1.17	0.51	2.000	1.194	Non-Liq.	0.00
128	124.8	Saturated	Saturated	57	125	0.0	0	16911.0	9547.8	65.0	0.54	0.620	1.17	0.51	2.000	1.189	Non-Liq.	0.00
129	124.8	Saturated	Saturated	57	125	0.0	0	17035.8	9610.2	64.9	0.54	0.621	1.17	0.51	2.000	1.184	Non-Liq.	0.00
130	124.8	Saturated	Saturated	57	125	0.0	0	17160.6	9672.6	64.8	0.55	0.623	1.17	0.50	2.000	1.179	Non-Liq.	0.00

Geotechnologies, Inc.

Project: FARING
File No.: 2848
Description: Liquefaction Analysis
Boring No: B2

LIQUEFACTION EVALUATION (Idriss & Boulanger, EERI NO 12)

EARTHQUAKE INFORMATION:

Earthquake Magnitude (M):	6.9
Peak Ground Horizontal Acceleration, PGA (g):	0.99
Calculated Mag.Wtg.Factor:	1.171

GROUNDWATER INFORMATION:

Current Groundwater Level (ft):	18.0
Historically Highest Groundwater Level* (ft):	10.0
Unit Weight of Water (pcf):	62.4

* Based on California Geological Survey Seismic Hazard Evaluation Report

BOREHOLE AND SAMPLER INFORMATION:

Borehole Diameter (inches):	8
SPT Sampler with room for Liner (Y/N):	Y

LIQUEFACTION BOUNDARY:

Plastic Index Cut Off (PI):	18
Minimum Liquefaction FS:	1.3

Depth to Base Layer (feet)	Total Unit Weight (pcf)	Current Water Level (feet)	Historical Water Level (feet)	Field SPT Blowcount N	Depth of SPT Blowcount (feet)	Fines Content #200 Sieve (%)	Plastic Index (PI)	Vetical Stress σ_{vc}, (psf)	Effective Vert. Stress σ_{vc}', (psf)	Fines Corrected $(N_1)_{60-cs}$	Stress Reduction Coeff, r_d	Cyclic Shear Ratio CSR	Mag. Scaling Factor (Sand) MSF	Overburden Corr. Factor K_σ	Cyclic Resist. Ratio $CRR_{M7.5,\sigma vc'=1}$	Cyclic Resistance Ratio (CRR)	Factor of Safety CRR/CSR (F.S.)	Liquefaction Settlment ΔS_i (inches)
1	133.6	Unsaturated	Unsaturated	5	5	0.0	0	133.6	133.6	10.1	1.00	0.646	1.17	1.10	0.119	0.153	Non-Liq.	0.00
2	133.6	Unsaturated	Unsaturated	5	5	0.0	0	267.2	267.2	10.1	1.00	0.644	1.17	1.10	0.119	0.153	Non-Liq.	0.00
3	133.6	Unsaturated	Unsaturated	5	5	0.0	0	400.8	400.8	10.1	1.00	0.642	1.17	1.10	0.119	0.153	Non-Liq.	0.00
4	133.6	Unsaturated	Unsaturated	5	5	0.0	0	534.4	534.4	10.1	0.99	0.640	1.17	1.10	0.119	0.153	Non-Liq.	0.00
5	133.6	Unsaturated	Unsaturated	5	5	0.0	0	668.0	668.0	10.8	0.99	0.638	1.17	1.10	0.123	0.159	Non-Liq.	0.00
6	133.6	Unsaturated	Unsaturated	5	5	0.0	0	801.6	801.6	10.6	0.99	0.636	1.17	1.09	0.122	0.156	Non-Liq.	0.00
7	133.6	Unsaturated	Unsaturated	5	5	0.0	0	935.2	935.2	9.8	0.98	0.633	1.17	1.07	0.117	0.147	Non-Liq.	0.00
8	133.6	Unsaturated	Unsaturated	5	5	0.0	0	1068.8	1068.8	9.2	0.98	0.631	1.17	1.06	0.113	0.140	Non-Liq.	0.00
9	133.6	Unsaturated	Unsaturated	12	15	66.5	21	1202.4	1202.4	27.8	0.98	0.628	1.17	1.10	0.376	0.485	Non-Liq.	0.00
10	133.6	Unsaturated	Unsaturated	12	15	66.5	21	1336.0	1336.0	26.8	0.97	0.626	1.17	1.08	0.338	0.428	Non-Liq.	0.00
11	133.6	Unsaturated	Saturated	12	15	66.5	21	1469.6	1407.2	25.8	0.97	0.651	1.17	1.06	0.310	0.386	Non-Liq.	0.00
12	133.6	Unsaturated	Saturated	12	15	66.5	21	1603.2	1478.4	25.0	0.96	0.673	1.17	1.04	0.289	0.354	Non-Liq.	0.00
13	133.6	Unsaturated	Saturated	12	15	66.5	21	1736.8	1549.6	24.2	0.96	0.692	1.17	1.03	0.272	0.328	Non-Liq.	0.00
14	133.6	Unsaturated	Saturated	12	15	66.5	21	1870.4	1620.8	23.5	0.95	0.709	1.17	1.02	0.258	0.308	Non-Liq.	0.00
15	133.6	Unsaturated	Saturated	12	15	66.5	21	2004.0	1692.0	25.2	0.95	0.724	1.17	1.01	0.294	0.347	Non-Liq.	0.00
16	133.6	Unsaturated	Saturated	12	15	66.5	21	2137.6	1763.2	24.5	0.95	0.738	1.17	1.00	0.279	0.326	Non-Liq.	0.00
17	133.6	Unsaturated	Saturated	12	15	66.5	21	2271.2	1834.4	23.9	0.94	0.750	1.17	0.99	0.267	0.309	Non-Liq.	0.00
18	133.6	Unsaturated	Saturated	12	15	66.5	21	2404.8	1905.6	23.4	0.94	0.760	1.17	0.98	0.256	0.294	Non-Liq.	0.00
19	133.6	Saturated	Saturated	12	15	66.5	21	2538.4	1976.8	23.1	0.93	0.769	1.17	0.98	0.251	0.287	Non-Liq.	0.00
20	133.6	Saturated	Saturated	12	15	66.5	21	2672.0	2048.0	22.8	0.93	0.777	1.17	0.97	0.246	0.281	Non-Liq.	0.00
21	134.0	Saturated	Saturated	12	15	66.5	21	2806.0	2119.6	22.6	0.92	0.784	1.17	0.97	0.242	0.274	Non-Liq.	0.00
22	134.0	Saturated	Saturated	12	15	66.5	21	2940.0	2191.2	22.3	0.92	0.791	1.17	0.96	0.238	0.269	Non-Liq.	0.00
23	134.0	Saturated	Saturated	12	15	66.5	21	3074.0	2262.8	22.1	0.91	0.796	1.17	0.96	0.234	0.264	Non-Liq.	0.00
24	134.0	Saturated	Saturated	12	15	66.5	21	3208.0	2334.4	21.8	0.90	0.800	1.17	0.96	0.231	0.259	Non-Liq.	0.00
25	134.0	Saturated	Saturated	12	15	66.5	21	3342.0	2406.0	21.6	0.90	0.804	1.17	0.95	0.227	0.254	Non-Liq.	0.00
26	134.0	Saturated	Saturated	36	25	0.0	0	3476.0	2477.6	58.4	0.89	0.807	1.17	0.90	2.000	2.000	2.9	0.00
27	134.0	Saturated	Saturated	36	25	0.0	0	3610.0	2549.2	58.0	0.89	0.810	1.17	0.89	2.000	2.000	2.9	0.00
28	134.0	Saturated	Saturated	36	25	0.0	0	3744.0	2620.8	60.7	0.88	0.812	1.17	0.88	2.000	2.000	2.9	0.00
29	134.0	Saturated	Saturated	36	25	0.0	0	3878.0	2692.4	60.3	0.88	0.813	1.17	0.88	2.000	2.000	2.9	0.00
30	134.0	Saturated	Saturated	36	25	0.0	0	4012.0	2764.0	60.0	0.87	0.814	1.17	0.87	2.000	2.000	2.9	0.00
31	124.3	Saturated	Saturated	22	35	74.2	31	4136.3	2825.9	39.8	0.87	0.816	1.17	0.87	2.000	2.000	Non-Liq.	0.00
32	124.3	Saturated	Saturated	22	35	74.2	31	4260.6	2887.8	39.5	0.86	0.817	1.17	0.86	2.000	2.000	Non-Liq.	0.00
33	124.3	Saturated	Saturated	22	35	74.2	31	4384.9	2949.7	39.2	0.85	0.818	1.17	0.85	2.000	2.000	Non-Liq.	0.00
34	124.3	Saturated	Saturated	22	35	74.2	31	4509.2	3011.6	38.9	0.85	0.818	1.17	0.85	2.000	1.991	Non-Liq.	0.00
35	124.3	Saturated	Saturated	22	35	74.2	31	4633.5	3073.5	38.6	0.84	0.818	1.17	0.84	2.000	1.979	Non-Liq.	0.00
36	124.3	Saturated	Saturated	22	35	74.2	31	4757.8	3135.4	38.4	0.84	0.818	1.17	0.84	2.000	1.967	Non-Liq.	0.00
37	124.3	Saturated	Saturated	22	35	74.2	31	4882.1	3197.3	38.1	0.83	0.817	1.17	0.83	2.000	1.955	Non-Liq.	0.00
38	124.3	Saturated	Saturated	22	35	74.2	31	5006.4	3259.2	37.8	0.83	0.817	1.17	0.83	2.000	1.944	Non-Liq.	0.00
39	124.3	Saturated	Saturated	22	35	74.2	31	5130.7	3321.1	37.6	0.82	0.815	1.17	0.82	2.000	1.932	Non-Liq.	0.00
40	124.3	Saturated	Saturated	22	35	74.2	31	5255.0	3383.0	37.3	0.81	0.814	1.17	0.82	1.899	1.824	Non-Liq.	0.00
41	132.6	Saturated	Saturated	22	35	74.2	31	5387.6	3453.2	37.0	0.81	0.812	1.17	0.81	1.767	1.686	Non-Liq.	0.00
42	132.6	Saturated	Saturated	22	35	74.2	31	5520.2	3523.4	36.8	0.80	0.809	1.17	0.81	1.649	1.569	Non-Liq.	0.00
43	132.6	Saturated	Saturated	22	35	74.2	31	5652.8	3593.6	36.5	0.80	0.807	1.17	0.81	1.543	1.465	Non-Liq.	0.00
44	132.6	Saturated	Saturated	22	35	74.2	31	5785.4	3663.8	36.2	0.79	0.804	1.17	0.81	1.449	1.372	Non-Liq.	0.00
45	132.6	Saturated	Saturated	22	35	74.2	31	5918.0	3734.0	36.0	0.79	0.801	1.17	0.81	1.364	1.289	Non-Liq.	0.00
46	132.6	Saturated	Saturated	24	45	56.3	0	6050.6	3804.2	39.8	0.78	0.798	1.17	0.79	2.000	1.850	2.7	0.00
47	132.6	Saturated	Saturated	24	45	56.3	0	6183.2	3874.4	39.5	0.77	0.795	1.17	0.78	2.000	1.839	2.7	0.00
48	130.0	Saturated	Saturated	28	50	14.4	0	6313.2	3942.0	45.4	0.77	0.792	1.17	0.78	2.000	1.828	2.7	0.00
49	130.0	Saturated	Saturated	28	50	14.4	0	6443.2	4009.6	45.2	0.76	0.789	1.17	0.78	2.000	1.818	2.7	0.00
50	130.0	Saturated	Saturated	28	50	14.4	0	6573.2	4077.2	45.0	0.76	0.786	1.17	0.77	2.000	1.807	2.7	0.00
51	130.0	Saturated	Saturated	28	50	14.4	0	6703.2	4144.8	44.7	0.75	0.782	1.17	0.77	2.000	1.797	2.7	0.00
52	130.0	Saturated	Saturated	28	50	14.4	0	6833.2	4212.4	44.4	0.75	0.779	1.17	0.76	2.000	1.787	2.7	0.00
53	131.8	Saturated	Saturated	28	50	14.4	0	6965.0	4281.8	44.1	0.74	0.775	1.17	0.76	2.000	1.777	2.7	0.00
54	131.8	Saturated	Saturated	28	50	14.4	0	7096.8	4351.2	43.8	0.73	0.771	1.17	0.75	2.000	1.767	2.7	0.00
55	131.8	Saturated	Saturated	28	50	14.4	0	7228.6	4420.6	43.6	0.73	0.768	1.17	0.75	2.000	1.757	2.7	0.00
56	131.8	Saturated	Saturated	32	55	13.3	0	7360.4	4490.0	50.3	0.72	0.764	1.17	0.75	2.000	1.748	2.7	0.00
57	131.8	Saturated	Saturated	32	55	13.3	0	7492.2	4559.4	50.1	0.72	0.760	1.17	0.74	2.000	1.738	2.7	0.00
58	132.9	Saturated	Saturated	32	55	13.3	0	7625.1	4629.9	50.0	0.71	0.756	1.17	0.74	2.000	1.729	2.7	0.00
59	132.9	Saturated	Saturated	32	55	13.3	0	7758.0	4700.4	49.8	0.71	0.752	1.17	0.73	2.000	1.719	2.7	0.00
60	132.9	Saturated	Saturated	32	55	13.3	0	7890.9	4770.9	49.6	0.70	0.748	1.17	0.73	2.000	1.710	2.7	0.00
61	132.9	Saturated	Saturated	30	60	24.4	0	8023.8	4841.4	48.3	0.70	0.744	1.17	0.73	2.000	1.701	2.7	0.00
62	132.9	Saturated	Saturated	30	60	24.4	0	8156.7	4911.9	48.1	0.69	0.740	1.17	0.72	2.000	1.692	2.7	0.00
63	130.4	Saturated	Saturated	30	60	24.4	0	8287.1	4979.9	47.9	0.69	0.737	1.17	0.72	2.000	1.683	2.7	0.00
64	130.4	Saturated	Saturated	30	60	24.4	0	8417.5	5047.9	47.7	0.68	0.733	1.17	0.71	2.000	1.674	2.7	0.00
65	130.4	Saturated	Saturated	30	60	24.4	0	8547.9	5115.9	47.5	0.68	0.729	1.17	0.71	2.000	1.666	2.7	0.00
66	130.4	Saturated	Saturated	44	65	0.0	0	8678.3	5183.9	63.4	0.67	0.725	1.17	0.71	2.000	1.658	2.7	0.00
67	130.4	Saturated	Saturated	44	65	0.0	0	8808.7	5251.9	63.2	0.67	0.722	1.17	0.70	2.000	1.649	2.7	0.00
68	134.2	Saturated	Saturated	44	65	0.0	0	8942.9	5323.7	62.9	0.66	0.718	1.17	0.70	2.000	1.641	2.7	0.00
69	134.2	Saturated	Saturated	44	65	0.0	0	9077.1	5395.5	62.7	0.66	0.714	1.17	0.70	2.000	1.632	2.7	0.00
70	134.2	Saturated	Saturated	44	65	0.0	0	9211.3	5467.3	62.5	0.65	0.710	1.17	0.69	2.000	1.624	2.7	0.00
71	134.2	Saturated	Saturated	47	70	0.0	0	9345.5	5539.1	66.6	0.65	0.706	1.17	0.69	2.000	1.616	2.7	0.00
72	134.2	Saturated	Saturated	47	70	0.0	0	9479.7	5610.9	66.4	0.65	0.702	1.17	0.69	2.000	1.608	2.7	0.00
73	123.7	Saturated	Saturated	47	70	0.0	0	9603.4	5672.2	66.2	0.64	0.699	1.17	0.68	2.000	1.601	2.7	0.00
74	123.7	Saturated	Saturated	47	70	0.0	0	9727.1	5733.5	66.0	0.64	0.696	1.17	0.68	2.000	1.594	2.7	0.00
75	123.7	Saturated	Saturated	47	70	0.0	0	9850.8	5794.8	65.9	0.63	0.693	1.17	0.68	2.000	1.587	2.7	0.00
76	123.7	Saturated	Saturated	35	75	19.9	0	9974.5	5856.1	53.4	0.63	0.690	1.17	0.67	2.000	1.580	2.7	0.00
77	123.7	Saturated	Saturated	35	75	19.9	0	10098.2	5917.4	53.3	0.63	0.687	1.17	0.67	2.000	1.574	2.7	0.00
78	121.4	Saturated	Saturated	34	80	0.0	0	10219.6	5976.4	47.3	0.62	0.684	1.17	0.67	2.000	1.567	2.7	0.00
79	121.4	Saturated	Saturated	34	80	0.0	0	10341.0	6035.4	47.2	0.62	0.681	1.17	0.67	2.000	1.561	2.7	0.00
80	121.4	Saturated	Saturated	34	80	0.0	0	10462.4	6094.4	47.1	0.61	0.678	1.17	0.66	2.000	1.555	2.7	0.00
81	121.4	Saturated	Saturated	34	80	0.0	0	10583.8	6153.4	47.0	0.61	0.675	1.17	0.66	2.000	1.549	2.7	0.00
82	121.4	Saturated	Saturated	34	80	0.0	0	10705.2	6212.4	46.9	0.61	0.673	1.17	0.66	2.000	1.543	2.7	0.00
83	133.5	Saturated	Saturated	34	80	0.0	0	10838.7	6283.5	46.7	0.60	0.669	1.17	0.66	2.000	1.535	2.7	0.00
84	133.5	Saturated	Saturated	34	80	0.0	0	10972.2	6354.6	46.6	0.60	0.666	1.17	0.65	2.000	1.528	2.7	0.00
85	133.5	Saturated	Saturated	34	80	0.0	0	11105.7	6425.7	46.5	0.60	0.663	1.17	0.65	2.000	1.521	2.7	0.00
86	133.5	Saturated	Saturated	31	85	77.5	0	11239.2	6496.8	45.9	0.59	0.660	1.17	0.65	2.000	1.514	2.7	0.00
87	133.5	Saturated	Saturated	31	85	77.5	0	11372.7	6567.9	45.7	0.59	0.657	1.17	0.64	2.000	1.507	2.7	0.00
88	130.3	Saturated	Saturated	31	85	77.5	0	11503.0	6635.8	45.4	0.59	0.655	1.17	0.64	2.000	1.500	2.7	0.00
89	130.3	Saturated	Saturated	31	85	77.5	0	11633.3	6703.7	45.2	0.58	0.652	1.17	0.64	2.000	1.494	2.7	0.00
90	130.3	Saturated	Saturated	31	85	77.5	0	11763.6	6771.6	45.0	0.58	0.650	1.17	0.63	2.000	1.487	2.7	0.00
91	130.3	Saturated	Saturated	35	90	0.0	0	12024.2	6969.8	46.9	0.58	0.642	1.17	0.63	2.000	1.469	2.7	0.00
92	130.3	Saturated	Saturated	35	90	0.0	0	12154.5	7037.7	46.8	0.58	0.640	1.17	0.62	2.000	1.462	2.7	0.00
93	121.4	Saturated	Saturated	35	90	0.0	0	12275.9	7096.7	46.7	0.57	0.638	1.17	0.62	2.000	1.457	2.7	0.00
94	121.4	Saturated	Saturated	35	90	0.0	0	12397.3	7155.7	46.6	0.57	0.636	1.17	0.62	2.000	1.452	2.7	0.00
95	121.4	Saturated	Saturated	35	90	0.0	0	12518.7	7214.7	46.5	0.57	0.634	1.17	0.62	2.000	1.446	2.7	0.00
96	121.4	Saturated	Saturated	33	95	6.3	0	12640.1	7273.7	42.7	0.57	0.633	1.17	0.62	2.000	1.441	2.7	0.00
97	121.4	Saturated	Saturated	33	95	6.3	0	12761.5	7332.7	42.6	0.56	0.631	1.17	0.61	2.000	1.436	2.6	0.00
98	128.9	Saturated	Saturated	74	100	0.0	0	12890.4	7399.2	97.7	0.56	0.630	1.17	0.61	2.000	1.430	2.6	0.00
99	128.9	Saturated	Saturated	74	100	0.0	0	13019.3	7465.7	97.5	0.56	0.628	1.17	0.61	2.000	1.424	2.6	0.00
100	128.9	Saturated	Saturated	74	100	0.0	0	13148.2	7532.2	97.3	0.56	0.626	1.17	0.61	2.000	1.419	2.6	0.00
101	128.9	Saturated	Saturated	74	100	0.0	0	13277.1	7598.7	97.1	0.56	0.625	1.17	0.60	2.000	1.413	2.6	0.00
102	128.9	Saturated	Saturated	74	100	0.0	0	13406.0	7665.2	96.9	0.55	0.624	1.17	0.60	2.000	1.407	2.6	0.00
103	139.7	Saturated	Saturated	74	100	0.0	0	13545.7	7742.5	96.6	0.55	0.622	1.17	0.60	2.000	1.401	2.6	0.00
104	139.7	Saturated	Saturated	74	100	0.0	0	13685.4	7819.8	96.4	0.55	0.620	1.17	0.60	2.000	1.394	2.6	0.00
105	139.7	Saturated	Saturated	74	100	0.0	0	13825.1	7897.1	96.1	0.55	0.619	1.17	0.59	2.000	1.388	2.6	0.00
106	139.7	Saturated	Saturated	49	105	0.0	0	13964.8	7974.4	63.5	0.55	0.618	1.17	0.59	2.000	1.382	2.6	0.00
107	139.7	Saturated	Saturated	49	105	0.0	0	14104.5	8051.7	63.4	0.55	0.617	1.17	0.59	2.000	1.375	2.6	0.00
108	124.8	Saturated	Saturated	43	110	0.0	0	14229.3	8114.1	55.5	0.55	0.616	1.17	0.58	2.000	1.370	2.6	0.00
109	124.8	Saturated	Saturated	43	110	0.0	0	14354.1	8176.5	55.4	0.54	0.615	1.17	0.58	2.000	1.365	2.6	0.00
110	124.8	Saturated	Saturated	43	110	0.0	0	14478.9	8238.9	55.3	0.54	0.615	1.17	0.58	2.000	1.360	2.6	0.00
111	124.8	Saturated	Saturated	43	110	0.0	0	14603.7	8301.3	55.2	0.54	0.615	1.17	0.58	2.000	1.355	2.6	0.00
112	124.8	Saturated	Saturated	43	110	0.0	0	14728.5	8363.7	55.1	0.54	0.614	1.17	0.58	2.000	1.350	2.6	0.00
113	121.6	Saturated	Saturated	43	110	0.0	0	14850.1	8422.9	55.0	0.54	0.614	1.17	0.57	2.000	1.346	2.6	0.00
114	121.6	Saturated	Saturated	43	110	0.0	0	14971.7	8482.1	54.9	0.54	0.614	1.17	0.57	2.000	1.341	2.5	0.00
115	121.6	Saturated	Saturated	43	110	0.0	0	15093.3	8541.3	54.8	0.54	0.615	1.17	0.57	2.000	1.337	2.5	0.00
116	121.6	Saturated	Saturated	33	115	66.1	0	15214.9	8600.5	44.8	0.54	0.615	1.17	0.57	2.000	1.332	2.5	0.00
117	121.6	Saturated	Saturated	33	115	66.1	0	15336.5	8659.7	44.6	0.54	0.615	1.17	0.57	2.000	1.328	2.5	0.00
118	128.5	Saturated	Saturated	33	115	66.1	0	15465.0	8725.8	44.5	0.54	0.616	1.17	0.56	2.000	1.323	2.5	0.00
119	128.5	Saturated	Saturated	33	115	66.1	0	15593.5	8791.9	44.3	0.54	0.616	1.17	0.56	2.000	1.318	2.5	0.00
120	128.5	Saturated	Saturated	33	115	66.1	0	15722.0	8858.0	44.2	0.54	0.616	1.17	0.56	2.000	1.313	2.5	0.00
121	128.5	Saturated	Saturated	48	120	0.0	0	15850.5	8924.1	60.5	0.54	0.617	1.17	0.56	2.000	1.308	2.5	0.00
122	128.5	Saturated	Saturated	48	120	0.0	0	15979.0	8990.2	60.4	0.54	0.618	1.17	0.56	2.000	1.303	2.5	0.00
123	125.5	Saturated	Saturated	48	120	0.0	0	16104.5	9053.3	60.3	0.54	0.619	1.17	0.55	2.000	1.299	2.4	0.00
124	125.5	Saturated	Saturated	48	120	0.0	0	16230.0	9116.4	60.2	0.54	0.620	1.17	0.55	2.000	1.294	2.4	0.00
125	125.5	Saturated	Saturated	48	120	0.0	0	16355.5	9179.5	60.1	0.54	0.621	1.17	0.55	2.000	1.290	2.4	0.00
126	125.5	Saturated	Saturated	54	120	0.0	0	16481.0	9242.6	67.5	0.54	0.622	1.17	0.55	2.000	1.285	2.4	0.00
127	125.5	Saturated	Saturated	54	120	0.0	0	16606.5	9305.7	67.4	0.54	0.623	1.17	0.55	2.000	1.281	2.4	0.00
128	125.9	Saturated	Saturated	54	120	0.0	0	16732.4	9369.2	67.2	0.54	0.625	1.17	0.54	2.000	1.276	2.4	0.00
129	125.9	Saturated	Saturated	54	120	0.0	0	16858.3	9432.7	67.1	0.54	0.627	1.17	0.54	2.000	1.272	2.4	0.00
130	125.9	Saturated	Saturated	54	120	0.0	0	16984.2	9496.2	67.0	0.55	0.628	1.17	0.54	2.000	1.267	2.3	0.00
131	125.9	Saturated	Saturated	56	130	0.0	0	17110.1	9559.7	69.4	0.55	0.630	1.17	0.54	2.000	1.263	2.3	0.00
132	125.9	Saturated	Saturated	56	130	0.0	0	17236.0	9623.2	69.3	0.55	0.632	1.17	0.54	2.000	1.259	2.3	0.00
133	125.9	Saturated	Saturated	56	130	0.0	0	17361.9	9686.7	69.2	0.55	0.634	1.17	0.54	2.000	1.254	2.3	0.00
134	125.9	Saturated	Saturated	56	130	0.0	0	17487.8	9750.2	69.0	0.55	0.636	1.17	0.53	2.000	1.250	2.3	0.00
135	125.9	Saturated	Saturated	56	130	0.0	0	17613.7	9813.7	68.9	0.55	0.639	1.17	0.53	2.000	1.246	2.3	0.00
136	127.3	Saturated	Saturated	56	130	0.0	0	17741.0	9878.6	68.8	0.55	0.641	1.17	0.53	2.000	1.241	2.3	0.00
137	127.3	Saturated	Saturated	56	130	0.0	0	17868.3	9943.5	68.7	0.56	0.643	1.17	0.53	2.000	1.237	2.2	0.00
138	127.3	Saturated	Saturated	56	130	0.0	0	17995.6	10008.4	68.6	0.56	0.646	1.17	0.53	2.000	1.233	2.2	0.00
139	127.3	Saturated	Saturated	56	130	0.0	0	18122.9	10073.3	68.5	0.56	0.649	1.17	0.52	2.000	1.229	2.2	0.00
140	127.3	Saturated	Saturated	56	130	0.0	0	18250.2	10138.2	68.4	0.56	0.652	1.17	0.52	2.000	1.224	2.2	0.00
141	127.3	Saturated	Saturated	47	140	0.0	0	18377.5	10203.1	57.3	0.56	0.655	1.17	0.52	2.000	1.220	2.2	0.00
142	127.3	Saturated	Saturated	47	140	0.0	0	18504.8	10268.0	57.2	0.57	0.658	1.17	0.52	2.000	1.216	2.2	0.00
143	127.3	Saturated	Saturated	47	140	0.0	0	18632.1	10332.9	57.1	0.57	0.661	1.17	0.52	2.000	1.212	2.1	0.00
144	127.3	Saturated	Saturated	47	140	0.0	0	18759.4	10397.8	57.0	0.57	0.664	1.17	0.52	2.000	1.208	2.1	0.00
145	127.3	Saturated	Saturated	47	140	0.0	0	18886.7	10462.7	56.9	0.57	0.668	1.17	0.51	2.000	1.204	2.1	0.00
146	126.3	Saturated	Saturated	47	140	0.0	0	19013.0	10526.6	56.8	0.58	0.671	1.17	0.51	2.000	1.200	2.1	0.00
147	126.3	Saturated	Saturated	47	140	0.0	0	19139.3	10590.5	56.8	0.58	0.675	1.17	0.51	2.000	1.196	2.1	0.00
148	126.3	Saturated	Saturated	47	140	0.0	0	19265.6	10654.4	56.7	0.58	0.679	1.17	0.51	2.000	1.192	2.0	0.00
149	126.3	Saturated	Saturated	47	140	0.0	0	19391.9	10718.3	56.6	0.59	0.683	1.17	0.51	2.000	1.188	2.0	0.00
150	126.3	Saturated	Saturated	47	140	0.0	0	19518.2	10782.2	56.5	0.59	0.687	1.17	0.51	2.000	1.184	2.0	0.00
151	126.3	Saturated	Saturated	61	150	0.0	0	19644.5	10846.1	73.2	0.59	0.692	1.17	0.50	2.000	1.180	2.0	0.00
152	126.3	Saturated	Saturated	61	150	0.0	0	19770.8	10910.0	73.1	0.60	0.696	1.17	0.50	2.000	1.176	2.0	0.00
153	126.3	Saturated	Saturated	61	150	0.0	0	19897.1	10973.9	73.0	0.60	0.701	1.17	0.50	2.000	1.172	1.9	0.00
154	126.3	Saturated	Saturated	61	150	0.0	0	20023.4	11037.8	72.9	0.60	0.705	1.17	0.50	2.000	1.168	1.9	0.00
155	126.3	Saturated	Saturated	61	150	0.0	0	20149.7	11101.7	72.8	0.61	0.710	1.17	0.50	2.000	1.164	1.9	0.00
156	124.4	Saturated	Saturated	61	150	0.0	0	20274.1	11163.7	72.7	0.61	0.715	1.17	0.50	2.000	1.161	1.9	0.00
157	124.4	Saturated	Saturated	61	150	0.0	0	20398.5	11225.7	72.6	0.62	0.720	1.17	0.49	2.000	1.157	1.9	0.00
158	124.4	Saturated	Saturated	61	150	0.0	0	20522.9	11287.7	72.5	0.62	0.725	1.17	0.49	2.000	1.153	1.9	0.00
159	124.4	Saturated	Saturated	61	150	0.0	0	20647.3	11349.7	72.4	0.62	0.731	1.17	0.49	2.000	1.150	1.8	0.00
160	124.4	Saturated	Saturated	61	150	0.0	0	20771.7	11411.7	72.3	0.63	0.736	1.17	0.49	2.000	1.146	1.8	0.00
161	124.4	Saturated	Saturated	50	160	0.0	0	20896.1	11473.7	59.2	0.63	0.742	1.17	0.49	2.000	1.143	1.8	0.00
162	124.4	Saturated	Saturated	50	160	0.0	0	21020.5	11535.7	59.1	0.64	0.748	1.17	0.49	2.000	1.139	1.8	0.00
163	124.4	Saturated	Saturated	50	160	0.0	0	21144.9	11597.7	59.0	0.64	0.754	1.17	0.48	2.000	1.135	1.8	0.00
164	124.4	Saturated	Saturated	50	160	0.0	0	21269.3	11659.7	58.9	0.65	0.760	1.17	0.48	2.000	1.132	1.7	0.00
165	124.4	Saturated	Saturated	50	160	0.0	0	21393.7	11721.7	58.9	0.65	0.766	1.17	0.48	2.000	1.128	1.7	0.00
166	131.6	Saturated	Saturated	50	160	0.0	0	21525.3	11790.9	58.8	0.66	0.772	1.17	0.48	2.000	1.124	1.7	0.00
167	131.6	Saturated	Saturated	50	160	0.0	0	21656.9	11860.1	58.7	0.66	0.778	1.17	0.48	2.000	1.121	1.7	0.00
168	131.6	Saturated	Saturated	50	160	0.0	0	21788.5	11929.3	58.6	0.67	0.784	1.17	0.48	2.000	1.117	1.7	0.00
169	131.6	Saturated	Saturated	50	160	0.0	0	21920.1	11998.5	58.5	0.67	0.791	1.17	0.48	2.000	1.113	1.6	0.00
170	131.6	Saturated	Saturated	50	160	0.0	0	22051.7	12067.7	58.4	0.68	0.797	1.17	0.47	2.000	1.109	1.6	0.00
171	131.6	Saturated	Saturated	57	170	0.0	0	22183.3	12136.9	66.5	0.68	0.804	1.17	0.47	2.000	1.105	1.6	0.00
172	131.6	Saturated	Saturated	57	170	0.0	0	22314.9	12206.1	66.4	0.69	0.811	1.17	0.47	2.000	1.101	1.6	0.00
173	131.6	Saturated	Saturated	57	170	0.0	0	22446.5	12275.3	66.3	0.69	0.818	1.17	0.47	2.000	1.098	1.6	0.00
174	131.6	Saturated	Saturated	57	170	0.0	0	22578.1	12344.5	66.2	0.70	0.825	1.17	0.47	2.000	1.094	1.5	0.00
175	131.6	Saturated	Saturated	57	170	0.0	0	22709.7	12413.7	66.1	0.71	0.832	1.17	0.47	2.000	1.090	1.5	0.00
176	137.6	Saturated	Saturated	57	170	0.0	0	22847.3	12488.9	66.0	0.71	0.839	1.17	0.46	2.000	1.086	1.5	0.00
177	137.6	Saturated	Saturated	57	170	0.0	0	22984.9	12564.1	65.9	0.72	0.846	1.17	0.46	2.000	1.082	1.5	0.00
178	137.6	Saturated	Saturated	57	170	0.0	0	23122.5	12639.3	65.8	0.73	0.854	1.17	0.46	2.000	1.078	1.5	0.00
179	137.6	Saturated	Saturated	57	170	0.0	0	23260.1	12714.5	65.7	0.73	0.861	1.17	0.46	2.000	1.074	1.5	0.00
180	137.6	Saturated	Saturated	92	180	0.0	0	23397.7	12789.7	105.9	0.74	0.868	1.17	0.46	2.000	1.070	1.4	0.00

October 22, 2019

Project No. 19041A

Mr. Gregorio Varela
Geotechnologies, Inc.
439 Western Avenue
Glendale, California 91201

SUBJECT: DOWNHOLE SEISMIC TEST RESULTS
BORING NUMBER 2
1010-1020 NORTH LA BREA AVENUE
WEST HOLLYWOOD, CALIFORNIA

Dear Mr. Varela,

Per your request and in accordance with the provisions of our proposal, dated June 3, 2019, we performed downhole seismic tests within Boring Number 2 drilled by Geotechnologies on the property located at 1010-1020 North La Brea Avenue in West Hollywood, California. The log of Boring Number 2 provided by Geotechnologies, Inc. is included in Attachment 1 and indicates that the subsurface materials are composed of:

1. Fill primarily consisting of silty clay to silty sand (CL, SM) from the ground surface to approximately 8 feet below ground surface;
2. Older Alluvium consisting of alternating layers of sand, silt, and clay (SP, SM, ML, CL) from approximately 8 to 108 feet; and
3. Puente Formation Bedrock consisting of predominantly siltstone and claystone from approximately 108 to 180 feet (bottom of hole).

Additionally, the groundwater surface was noted at a depth of 19 feet during borehole drilling on August 1, 2019. At the time of the downhole seismic test on September 3, 2019, GeoPentech staff measured the depth to water in the cased boring at approximately 26 ft below the ground surface and the bottom of the casing at 149 ft below ground surface. Downhole seismic tests were performed within the boring to assist Geotechnologies, Inc. with their evaluation of the site. This letter summarizes the results of the downhole seismic tests and the evaluation of V_{s30}.

Seismic Downhole Methods and Procedures

Downhole seismic tests were collected within Boring Number 2 on September 3, 2019. The downhole seismic test method makes direct measurements of in-situ vertically propagating compression (P) and horizontally polarized shear (SH) wave velocities as a function of depth within the geologic material adjacent to a borehole. Measurement procedures followed ASTM D7400-08, "Standard Test Methods for Downhole Seismic Testing”. The geophysical data were collected, processed, and interpreted by a GeoPentech senior staff scientist and reviewed by a California-licensed Professional Geophysicist (PGp).

The boring was drilled with an 8-inch diameter bit using hollow stem auger drilling methods, and a 2-inch diameter PVC casing was installed under the direction of Geotechnologies, Inc. as part of their geotechnical investigation program. The annular space between the 8-inch diameter hole and 2-inch diameter casing was backfilled with bentonite-cement grout, which was assumed to be formulated to approximate the density of the surrounding geologic material and pumped in from the base of the borehole to completely fill the annular space.

A seismic source was used to generate a seismic wave (P or SH) at the ground surface. The seismic source was offset 5 feet horizontally from the borehole. The P-wave seismic source consisted of a ground plate that was struck vertically with a sledgehammer. The SH-wave seismic source consisted of an 8-foot long by 6-inch wide by 4-inch high wood beam capped on both ends with a steel plate, which was loaded in place by the front end of a vehicle parked on top of the beam. The ends of this beam were positioned equidistant from the borehole. Initially, one end of the beam was struck horizontally with a sledgehammer to produce an SH-wave (forward hit). Next, the opposite end of the beam was struck horizontally with the sledgehammer to produce an opposite polarity SH-wave (reverse hit). The combination of the two opposite polarity SH-waves were used to determine SH travel times.

A downhole receiver positioned at a selected depth within the borehole was used to record the arrival of the seismic wave (P or SH). A three-component triaxial borehole geophone (one vertical channel and two orthogonal horizontal channels) that could be firmly fixed pneumatically against the PVC casing sidewall was used to collect the downhole seismic measurements. Multiple downhole seismic measurements were performed at successive receiver depths within the borehole. The receiver depth was referenced to ground surface, and measurements were made at 5-foot intervals from 5 feet below ground surface to the bottom of the cased boring (149 ft).

A Geometrics S12 signal enhancing seismograph was used to record the response of the downhole receiver. The seismic source (sledgehammer) contained a trigger that was connected to the seismograph and initiated signal recording, allowing the travel time between seismic source and downhole receiver to be measured. Downhole seismic test records were digitally recorded and stored with a 0.062 ms sample interval.

The recorded digital downhole seismic records were analyzed using the OYO Corporation program PickWin Version 5.1.1.2. The digital waveforms were analyzed to identify arrival times. The first prominent departure of the vertical receiver trace was identified as the P-wave first arrival. The SH-wave forward and reverse hits recorded on the two horizontal receiver channels were superimposed. The SH-wave first arrival was identified at the location of the first prominent relatively low-frequency departure of the forward hit and an 180º polarity change is noted to have occurred on the reverse hit. For analysis, 57 Hz low-cut and 262 Hz high-cut filters were applied to the P waveforms, and 25 Hz low-cut and 69 Hz high-cut filters were applied to the SH waveforms.

After correcting the P and SH-wave travel time for the source offset, the P and SH-wave travel-times were plotted versus depth. P and SH layer and interval velocities were calculated as the slope of lines drawn through the plotted data.

Seismic Downhole Results

The results of the seismic downhole measurements collected within the boring are presented on Figure 1. Figure 1 shows (1) a table of the measured P- and SH-wave travel-times and depths; (2) a plot of the P- and SH-wave travel-times as a function of depth showing the interpreted layer velocities; (3) a table of the calculated P- and SH-wave interval velocities and depth ranges; (4) a table of the interpreted P- and SH-wave layer velocities and depth ranges; and (5) a plot of the layer and interval velocity models as a function of depth.

Table 1 below summarizes the interpreted P and SH layer velocities and depths shown on Figure 1 for the various geologic units within the boring, as logged by Geotechnologies, Inc. It is noted that the groundwater level was measured at a depth of 19 feet during drilling on August 1, 2019 and at 26 feet during the downhole seismic measurements on September 3, 2019. The measured P-wave velocities agree with the observed depths to water, suggesting the material adjacent to the borehole is saturated below a depth of approximately 25 feet with water first encountered below a depth of about 15 feet.

Based on the results shown on Figure 1, the V_{s30} was calculated based on the procedures outlined in the National Earthquake Hazards Reduction Program (NEHRP) and UBC. The V_{s30} was calculated from the following equation from these references:

$$v_s = \frac{\sum_{i=1}^{n} di}{\sum_{i=1}^{n} \frac{d_i}{v_{si}}}$$

where:

i = distinct different soil and/or rock layer between 1 and n
v_{si} = shear wave velocity in feet per second of layer i
d_i = thickness of any layer within the 100-foot interval
$\sum_{i=1}^{n} d_i$ = 100 feet

Based on this procedure, the V_{s30} for Boring Number 2 was calculated between various depth ranges. The results are summarized on Table 2.

TABLE 1
SUMMARY OF SH-WAVE AND P-WAVE VELOCITY LAYERS WITHIN BORING NUMBER 2

<table>
<tr><th>PREDOMINANT LITHOLOGY</th><th>Depth Range (ft)</th><th>SH-WAVE Velocity (ft/sec)</th><th>P-WAVE Velocity (ft/sec)</th></tr>
<tr><td>Stiff, silty CLAY (CL)
[Fill]</td><td>0 to 5</td><td>863</td><td rowspan="2">1,901</td></tr>
<tr><td>Medium dense to dense, silty SAND (SM)
[Older Alluvium]</td><td>5 to 15</td><td rowspan="4">1,166</td></tr>
<tr><td>Stiff, sandy CLAY (CL), Boring log indicates water at 19 ft
[Older Alluvium]</td><td>15 to 20</td><td>3,548</td></tr>
<tr><td>Medium dense, silty SAND to SAND (SM/SP)
[Older Alluvium]</td><td>20 to 25</td><td>4,478</td></tr>
<tr><td>Stiff, SILT and CLAY (ML/CL)
[Older Alluvium]</td><td>25 to 35</td><td rowspan="3">5,333</td></tr>
<tr><td>Stiff, Silty CLAY (CL), SAND (SP/SW) seam from 47.5 to 50 ft
[Older Alluvium]</td><td>35 to 50</td><td>934</td></tr>
<tr><td>Alternating layers of Stiff, Sandy SILT (ML) and
Medium dense to dense SAND (SM, SC)
[Older Alluvium]</td><td>50 to 75</td><td>1,256</td></tr>
<tr><td>Stiff Clay(CL), Stiff to very stiff SILT (ML),
and Medium dense to very dense SAND (SC, SM)
[Older Alluvium]</td><td>75 to 95</td><td>1,010</td><td rowspan="2">6,184</td></tr>
<tr><td>Very dense, SAND (SP) 95 to 108 ft;
[Older Alluvium]
Moderately Hard, Siltstone 108 to 115 ft
(Puente Formation Bedrock)</td><td>95 to 115</td><td rowspan="3">1,459</td></tr>
<tr><td>Moderately Hard Siltstone and Hard Claystone
(Puente Formation Bedrock)</td><td>115 to 140</td><td>5,588</td></tr>
<tr><td>Moderately Hard, Siltstone
(Puente Formation Bedrock)</td><td>140 to 149</td><td>5,085</td></tr>
</table>

TABLE 2
CALCULATED V_{s30} WITHIN BORING NUMBER 2

DEPTH RANGE (ft, below ground surface)	V_{s30} (ft/sec)	NEHRP Site Class
0 to 100	1,102	D
10 to 110	1,143	D
20 to 120	1,166	D
30 to 130	1,190	D
40 to 140	1,231	C
49 to 149	1,286	C

Limitations

The above information is based on limited observations and geophysical measurements made as described above. GeoPentech does not guarantee the performance of the project, only that the information provided meets the standard of care of the profession at this time under the same scope limitations imposed by the project. In this regard, our scope of work included making the P- and SH-wave velocity measurements in one borehole under the direction of Geotechnologies, Inc. personnel. We relied upon the assumption that the annular space between the PVC casing and the borehole wall was properly filled with bentonite-cement grout so that PVC casing and the borehole wall were in continuous contact and that the grout was formulated to approximate the density of the surrounding geologic material.

We trust the contents of this letter will meet your current needs. If you have questions or require additional information, please call.

Very Truly Yours,

GeoPentech

REGISTERED GEOPHYSICIST
STEVE DUKE
No. 1013
Exp. 7-31-21
STATE OF CALIFORNIA

Steven K. Duke
Geophysicist
GP 1013

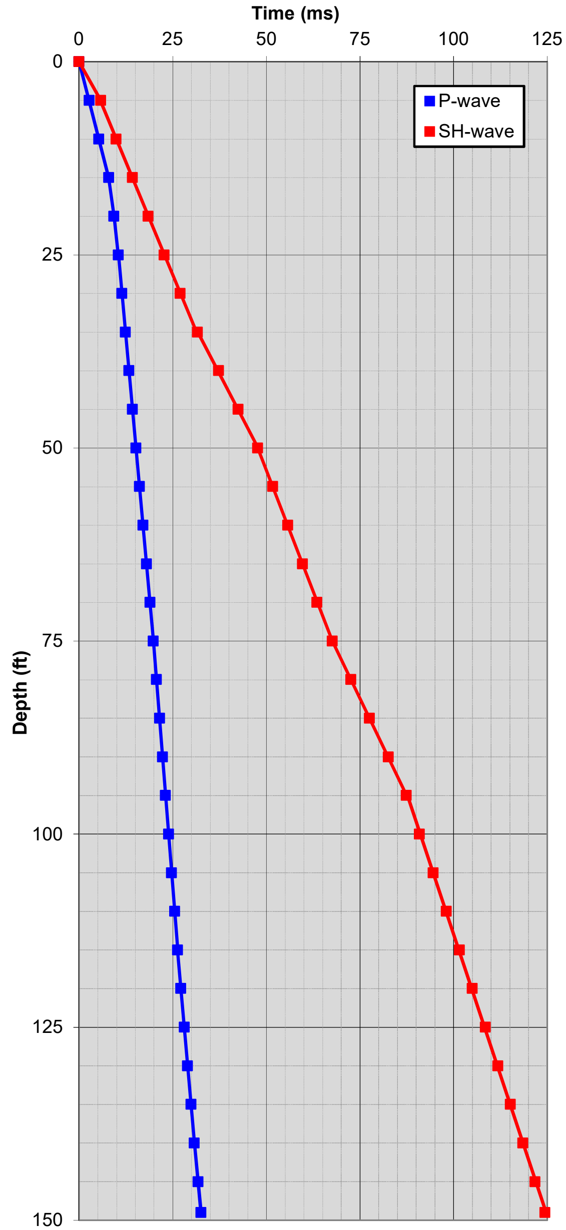
Ryan D. Hort, Ph.D.
Senior Staff Scientist

SEISMIC WAVE TRAVEL TIMES

Depth (ft)	P-time (ms)	P-layer	SH-wave (ms)	SH layer
0	0	1	0	1
5	3.82	1	8.19	12
10	5.85	1	11.06	2
15	8.35	12	14.98	2
20	9.62	23	18.99	2
25	10.65	34	23.17	2
30	11.60	4	27.34	2
35	12.53	4	31.90	23
40	13.45	4	37.54	3
45	14.37	4	42.75	3
50	15.28	4	47.91	34
55	16.19	4	51.90	4
60	17.10	4	55.88	4
65	18.10	4	59.86	4
70	18.99	4	63.67	4
75	19.88	45	67.80	45
80	20.72	5	72.72	5
85	21.53	5	77.64	5
90	22.33	5	82.70	5
95	23.13	5	87.51	56
100	23.94	5	90.95	6
105	24.74	5	94.67	6
110	25.54	5	98.15	6
115	26.35	56	101.62	6
120	27.20	6	105.09	6
125	28.10	6	108.56	6
130	29.00	6	111.89	6
135	29.91	6	115.21	6
140	30.81	67	118.53	6
145	31.77	7	121.85	6
149	32.58	7	124.43	6

Source Offset (ft)
5

TRAVEL TIME PLOT



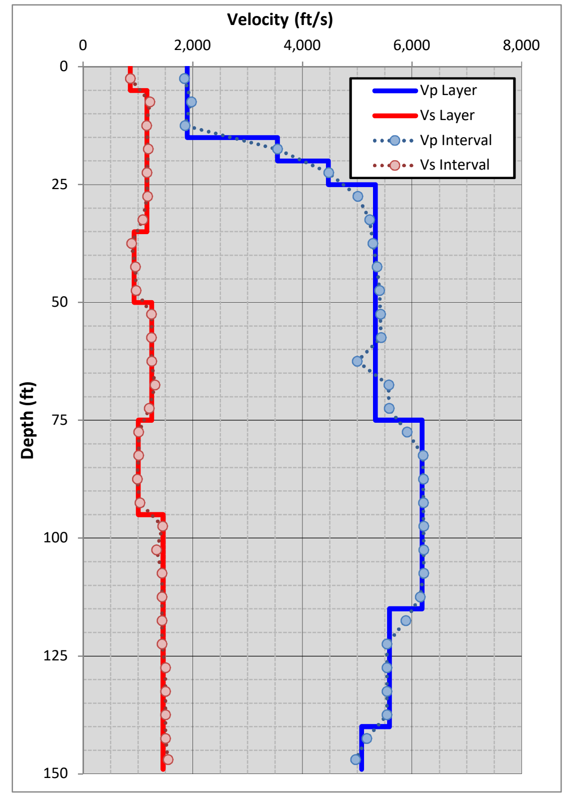
INTERVAL VELOCITES

Depth Range	P-Velocity (ft/s)	SH-Velocity (ft/s)
0 to 5	1,849	863
5 to 10	1,975	1,220
10 to 15	1,861	1,157
15 to 20	3,548	1,189
20 to 25	4,478	1,164
25 to 30	5,012	1,175
30 to 35	5,230	1,086
35 to 40	5,285	881
40 to 45	5,363	954
45 to 50	5,408	964
50 to 55	5,424	1,247
55 to 60	5,435	1,249
60 to 65	5,002	1,250
65 to 70	5,575	1,310
70 to 75	5,581	1,207
75 to 80	5,912	1,014
80 to 85	6,203	1,014
85 to 90	6,206	988
90 to 95	6,209	1,038
95 to 100	6,211	1,450
100 to 105	6,213	1,341
105 to 110	6,215	1,438
110 to 115	6,148	1,438
115 to 120	5,884	1,438
120 to 125	5,542	1,438
125 to 130	5,542	1,501
130 to 135	5,543	1,504
135 to 140	5,543	1,505
140 to 145	5,175	1,505
145 to 149	4,970	1,548

LAYER VELOCITES

Layer	P-Depth (ft)	P-Velocity (ft/s)	SH-Depth (ft)	SH-Velocity (ft/s)
1	0 to 15	1,901	0 to 5	863
2	15 to 20	3,548	5 to 35	1,166
3	20 to 25	4,478	35 to 50	934
4	25 to 75	5,333	50 to 75	1,256
5	75 to 115	6,184	75 to 95	1,010
6	115 to 140	5,588	95 to 149	1,459
7	140 to 149	5,085		
8				
9				
10				

VELOCITY MODEL



V_{S30} CALCULATION

Vs30 (ft/s)	Depth (ft)
1,102	0 to 100
1,286	49 to 149

GeoPentech

SEISMIC DOWNHOLE TEST RESULTS
1010 - 1020 LA BREA AVENUE

PROJECT: **1010-1020 LA BREA AVE**

PROJECT #: **19041A** | DATE: **OCT 2019** | FIGURE: **A-1**

ATTACHMENT 1

BORING LOG NUMBER 2
GEOTECHNOLOGIES, INC.

BORING LOG NUMBER 2

Faring | **Date: 08/01/19**

File No. 21848 | **Method: 8-inch diameter Hollow Stem Auger**

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description Surface Conditions: Concrete Slab
				0 --		8-inch Concrete over 4-inch Base
				-		
				1 --		
				-		FILL: Silty clay, dark brown, moist, stiff
				2 --		
				-		
				3 --		
				-		
				4 --		
				-		
5	5	23.6	SPT	5 --		
				-		Silty Sand to Silty Clay, dark brown and gray, moist, medium dense, stiff, fine grained
				6 --		
				-		
				7 --		
				-		
				8 --		
				-	SM	OLDER ALLUVIUM: Silty Sand, dark and yellowish brown, moist, medium dense to dense, fine grained
				9 --		
				-		
10	53 50/5"	16.6	114.5	10 --		
				-		
				11 --		
				-		
				12 --		
				-		
				13 --		
				-		
				14 --		
				-		
15	12	23.9	SPT	15 --		
				-	CL	Sandy Clay, dark brown, moist, stiff
				16 --		
				-		
				17 --		
				-		
				18 --		
				-		
				19 --		
				-		
20	33	17.9	113.7	20 --		
				-	SM/SP	Silty Sand to Sand, dark brown, moist, medium dense, fine grained
				21 --		
				-		
				22 --		
				-		
				23 --		
				-		
				24 --		
				-		
25	36	27.3	SPT	25 --		
				-	ML	Sandy to Clayey Silt, dark brown, moist, stiff

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				26 --		
				-		
				27 --		
				-		
				28 --		
				-		
				29 --		
				-		
30	56	24.5	99.8	30 --		
				-	CL	Silty Clay, dark and grayish brown, moist, stiff
				31 --		
				-		
				32 --		
				-		
				33 --		
				-		
				34 --		
				-		
35	22	28.4	SPT	35 --		
				-		yellowish brown
				36 --		
				-		
				37 --		
				-		
				38 --		
				-		
				39 --		
				-		
40	35	14.0	116.3	40 --		
				-		Sandy Clay, yellowish brown, moist, stiff
				41 --		
				-		
				42 --		
				-		
				43 --		
				-		
				44 --		
				-		
45	24	21.6	SPT	45 --		
				-		
				46 --		
				-		
				47 --		
47.5	82	14.7	113.3	-		
				48 --	SP/SW	Sand, dark brown, moist to wet, very dense, fine grained, few gravel
				-		
				49 --		
				-		
50	28	14.6	SPT	50 --		
				-	SM/ML	Silty Sand to Sandy Silt, dark and gray, moist to wet, medium dense, stiff, fine to coarse grained

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				51 --		
				-		
				52 --		
52.5	72	20.7	109.1	-		
				53 --	SM	Silty Sand, dark brown, moist, dense, fine grained, few cobbles
				-		
				54 --		
				-		
55	32	15.7	SPT	55 --		
				-	SP/SM	Sand to Silty Sand, dark brown, wet, medium dense, fine to medium grained
				56 --		
				-		
				57 --		
57.5	63	20.3	110.5	-		
				58 --	SM/ML	Silty Sand to Sandy Silt, brown, moist, dense, stiff, fine grained
				-		
				59 --		
				-		
60	30	25.4	SPT	60 --		
				-	SP/SM	Sand to Silty Sand, dark brown, moist, medium dense, fine grained
				61 --		
				-		
				62 --		
62.5	61	20.6	108.1	-		
				63 --	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, dense, stiff, fine grained, few gravel
				-		
				64 --		
				-		
65	44	18.6	SPT	65 --		
				-	SP/SM	Silty Sand to Sand, dark and yellowish brown, wet, dense, fine grained, few gravel
				66 --		
				-		
				67 --		
67.5	48 50/4"	15.5	116.2	-		
				68 --		
				-		
				69 --		
				-		
70	47	20.2	SPT	70 --		
				-	SC/CL	Sandy Clay to Clayey Sand, yellowish brown, wet, dense, stiff, fine to medium grained
				71 --		
				-		
				72 --		
72.5	35 50/5"	25.8	98.3	-		
				73 --		
				-		
				74 --		
				-		
75	35	18.9	SPT	75 --		
				-		dark and yellowish brown, medium dense, stiff

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				76 --		
				77 --		
77.5	36 50/5"	27.2	95.4	-		
				78 --	CL	Sandy to Silty Clay, dark and gray, moist, stiff
				79 --		
80	34	17.8	SPT	80 --		
				81 --		
				82 --		
82.5	40 50/5"	17.7	113.5	-		
				83 --	SM/ML	Silty Sand to Sandy Silt, dark brown, moist, very dense, very stiff, fine grained
				84 --		
85	31	21.6	SPT	85 --		
				-	ML/CL	Clayey Silt to Silty Clay, dark and gray, moist, stiff
				86 --		
				87 --		
87.5	90	20.6	108.1	-		
				88 --		
				89 --		
90	35	34.2	SPT	90 --		
				91 --		
				92 --		
92.5	39	30.6	93.0	-		
				93 --	CL	Silty Clay, dark and grayish brown, moist, stiff
				94 --		
95	33	16.8	SPT	95 --		
				-	SP	Sand, dark and gray, wet, medium dense, fine grained
				96 --		
				97 --		
97.5	40 50/4"	18.0	109.3	-		
				98 --		very dense
				99 --		
100	74	17.9	SPT	100 --		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				101 --		
				-		
				102 --		
102.5	45	14.9	121.6	-		
	50/4"			103 --		fine to medium grained, few gravel
				-		
				104 --		
				-		
105	49	19.3	SPT	105 --		
				-		dense
				106 --		
				-		
				107 --		
107.5	88	24.8	99.9	-		
				108 --		BEDROCK (PUENTE FORMATION): Siltstone, dark gray, moist, moderately hard
				-		
				109 --		
				-		
110	43	28.4	SPT	110 --		
				-		
				111 --		
				-		
				112 --		
112.5	72	27.8	95.2	-		
				113 --		
				-		
				114 --		
				-		
115	33	26.3	SPT	115 --		
				-		
				116 --		
				-		
				117 --		
117.5	45	23.8	103.8	-		
	50/4"			118 --		
				-		
				119 --		
				-		
120	48	23.9	SPT	120 --		
				-		
				121 --		
				-		
				122 --		
122.5	88	23.8	101.3	-		
				123 --		
				-		
				124 --		
				-		
125	54	27.0	SPT	125 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				126 --		
				-		
				127 --		
127.5	40	24.4	101.2	-		
	50/4"			128 --		Claystone, dark gray, moist, hard
				-		
				129 --		
				-		
130	56	26.0	SPT	130 --		
				-		Siltstone, dark gray, moist, moderately hard
				131 --		
				-		
				132 --		
				-		
				133 --		
				-		
				134 --		
				-		
135	79	23.2	103.3	135 --		
				-		
				136 --		
				-		
				137 --		
				-		
				138 --		
				-		
				139 --		
				-		
140	47	25.9	SPT	140 --		
				-		
				141 --		
				-		
				142 --		
				-		
				143 --		
				-		
				144 --		
				-		
145	46	23.2	102.5	145 --		
	50/4"			-		gray
				146 --		
				-		
				147 --		
				-		
				148 --		
				-		
				149 --		
				-		
150	61	26.7	SPT	150 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				151 --		
				-		
				152 --		
				-		
				153 --		
				-		
				154 --		
				-		
155	100/8"	26.8	98.2	155 --		
				-		
				156 --		
				-		
				157 --		
				-		
				158 --		
				-		
				159 --		
				-		
160	50	25.6	SPT	160 --		
				-		
				161 --		
				-		
				162 --		
				-		
				163 --		
				-		
				164 --		
				-		
165	40	24.8	105.4	165 --		
	50/3"			-		dark gray
				166 --		
				-		
				167 --		
				-		
				168 --		
				-		
				169 --		
				-		
170	57	24.7	SPT	170 --		
				-		
				171 --		
				-		
				172 --		
				-		
				173 --		
				-		
				174 --		
				-		
175	68	24.8	102.2	175 --		
				-		

BORING LOG NUMBER 2

Faring

File No. 21848

km

Sample Depth ft.	Blows per ft.	Moisture content %	Dry Density p.c.f.	Depth in feet	USCS Class.	Description
				-		
				176 --		
				-		
				177 --		
				-		
				178 --		
				-		
				179 --		
				-		
180	92	25.9	SPT	180 --		
				-		Total Depth 180 feet
				181 --		Water at 19 feet
				-		Fill to 8 feet
				182 --		
				-		
				183 --		NOTE: The stratification lines represent the approximate
				-		boundary between earth types; the transition may be gradual.
				184 --		
				-		Used 8-inch diameter Hollow-Stem Auger
				185 --		140-lb. Automatic Hammer, 30-inch drop
				-		Modified California Sampler used unless otherwise noted
				186 --		
				-		SPT=Standard Penetration Test
				187 --		
				-		
				188 --		
				-		
				189 --		
				-		
				190 --		
				-		
				191 --		
				-		
				192 --		
				-		
				193 --		
				-		
				194 --		
				-		
				195 --		
				-		
				196 --		
				-		
				197 --		
				-		
				198 --		
				-		
				199 --		
				-		
				200 --		
				-		

Soil Corrosivity Evaluation Report for Faring

October 9, 2019

Prepared for:
Gregorio Varela
Geotechnologies, Inc
439 Western Ave.
Glendale, CA, 91201
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Project X Job #: S191003A
Client Job or PO #: 21848 & 21849

Contents

1 Executive Summary

A corrosion evaluation of the soils at Faring was performed to provide corrosion control recommendations for general construction materials. The site is located at 1010-1020 North La Brea Avenue, West Hollywood, CA and 1011 North Sycamore Avenue, Los Angeles, CA. (34.089367, -118.343410). Seven (7) samples were tested to a depth of 75.0 ft. Site ground water and topography information was provided via Geotechnologies, Inc. and determined to be 19 feet below finished grade.

Every material has its weakness. Aluminums, galvanized/zinc coatings, and coppers do not survive well in very alkaline or very acidic pH environments. Copper and brasses do not survive well in high nitrate or ammonia environments. Steels and irons do not survive well in low soil resistivity and high chloride environments. High chloride environments can even overcome and attack steel encased in normally protective concrete. Concrete does not survive well in high sulfate environments. And nothing survives well in high sulfide and low redox potential environments with corrosive bacteria. This is why Project X tests for these 8 factors to determine a soil's corrosivity towards various construction materials. **Depending solely on soil resistivity or Caltrans corrosion guidelines, which over-simplify descriptions as corrosive or non-corrosive, will not detect these other factors because it is possible to have bad levels of corrosive ions and still have greater than 1,100 ohm-cm soil resistivity. We have observed this fact on thousands of soil samples tested in our laboratory.**

It should not be forgotten that import soil also be tested for all factors to avoid making your site more corrosive than it was to begin with.

The recommendations outlined herein are not a substitute for any design documents previously prepared for the purpose of construction and apply only to the depth of samples collected.

Soil samples were tested for minimum resistivity, pH, chlorides, sulfates, ammonia, nitrates, sulfides and redox.

As-Received soil resistivities ranged between 804 ohm-cm and 2,814 ohm-cm. This data would be similar to a Wenner 4 pin test in the field and used in the design of a cathodic protection or grounding bed system. This resistivity can change seasonally depending on the weather and moisture in the ground. This reading alone can be misleading because condensation or minor water leaks will occur underground along pipe surfaces creating a saturated soil environment in the trench along infrastructure surfaces which is why minimum or saturated soil resistivity measurements are more important than as-received resistivities.

Saturated soil resistivities ranged between 804 ohm-cm to 2,077 ohm-cm. The worst of these values is considered to be severely corrosive to general metals.

PH levels ranged between 7.8 to 8.2 pH. PH levels were determined to be at levels not detrimental to copper or aluminum alloys. The pH of these samples can allow corrosion of steel and iron in moist environments.

Chlorides ranged between 8 mg/kg to 23 mg/kg. Chloride levels in these samples are low and may cause insignificant corrosion of metals.

Sulfates ranged between 21 mg/kg to 56 mg/kg. Sulfate levels in these samples are negligible for corrosion of metals and cement. Any type of cement can be used that does not contain encased metal.

Ammonia ranged between 0.0 mg/kg to 0.3 mg/kg. Nitrates ranged between 0.0 mg/kg to 1.1 mg/kg. Concentrations of these elements were not high enough to cause accelerated corrosion of copper and copper alloys such as brass.

Sulfides presence was determined to be trace. REDOX ranged between + 215 mV to + 243 mV. Though sulfides were detected, the probability of corrosive bacteria was determined to be low due to very positive REDOX levels determined in these samples.

2 Corrosion Control Recommendations

The following recommendations are based upon the results of soil testing.

2.1 Cement

The highest reading for sulfates was 56 mg/kg or 0.0056 percent by weight.

Per ACI 318-14, Table 19.3.1.1, sulfate levels in these samples categorized as S0 and are negligible for corrosion of metals and cement. Per ACI 318-14 Table 19.3.2.1 any type of cement not containing steel or other metal can be used.

2.2 Steel Reinforced Cement/ Cement Mortar Lined & Coated (CML&C)

Chlorides in soil can overcome the corrosion inhibiting property of cement for steel, as it can also break through passivated surfaces of aluminum and stainless steels.[1,2] The highest concentration of chlorides was 23 mg/kg.

Chloride levels in these samples are not significantly corrosive to metals not in tension. Standard cement cover may be used in these soils.

1) Use hardware coated with epoxy or equivalent where 3 inches of cement cover cannot be achieved, or
2) Since chlorides in these soil samples were not high enough to require DCI or special cement additives, additives such as DCI can be used in the slabs if 3 inches of cement cover cannot be achieved on steel items where epoxy coated hardware is not desired or possible.

As the cost of cement, epoxy coated hardware, cement additives, and waterproofing systems seem to vary throughout the year and between contractors, we provide OPTIONS so that the most cost effect decision can be made.

2.3 Stainless Steel Pipe/Conduit/Fittings

Stainless steels derive their corrosion resistance from their chromium content and oxide layer which needs oxygen to regenerate if damaged. Thus stainless steel is not good for deep soil applications where oxygen levels are extremely low. Stainless steels should not be installed deeper than a plant root zone. Stainless steels typically have the same nobility as copper on the

[1] Design Manual 303: Cement Cylinder Pipe. Ameron. p.65
[2] *Chapter 19, Table 1904.2.2(1), 2012 International Building Code*

galvanic series and can be connected to copper. If stainless steel must be used, it must be backfilled with soil having greater than 10,000 ohm-cm resistivity and excellent drainage. 304 Stainless steel will also corrode if in contact with carbon materials such as activated carbon. Stainless steel welds should be pickled.

The soil at this site has low probability for anaerobic corrosive bacteria and low chloride levels. Per Nickel Institute guidelines, 316 Stainless steels can be used in these soils.

2.4 Steel Post Tensioning Systems

The proper sealing of stressing holes is of utmost importance in PT Systems. Cut off excess strand 1/2" to 3/4" back in the hole. Coat or paint exposed anchorage, grippers, and stub of strands with "Rust-o-leum" or equal. After tendons have been coated, the cement contractor shall dry pack blockouts within ten (10) days. A non-shrink, non-metallic, non-porous moisture-insensitive grout (Master EMACO S 488 or equivalent), or epoxy grout shall be used for this purpose. If an encapsulated post-tension system is used, regular non-shrink grout can be used.

Due to the low chloride concentrations measured on samples obtained from this site, post-tensioned slabs should be protected in accordance with soil considered normal (non-corrosive).[3,4]

2.5 Steel Piles

Steel piles are most susceptible to corrosion in disturbed soil where oxygen is available. Further, a dissimilar environment corrosion cell would exist between the steel embedded in cement, such as pile caps and the steel in the soil. In the cell, the steel in the soil is the anode (corroding metal), and the steel in cement is the cathode (protected metal). This cell can be minimized by coating the part of the steel piles that will be embedded in cement to prevent contact with cement and reinforcing steel.

Piles driven into soils without disturbing soils will avoid oxygen introduction and low corrosion rates unless there is a probability for corrosive anaerobic bacteria. Galvanized steel's zinc coating can provide significant protection for driven piles. In corrosive soils in which normal zinc coatings are not enough, the life of piles can be extended by increasing zinc coating thickness, using sacrificial metal, or providing a combination of epoxy coatings and cathodic protection. Corrosion has been observed to be extremely localized even at and below underground water tables. Pit depths of this magnitude do not have an appreciable effect on the strength or useful life of piling structures because the reduction in pile cross section is not significant.[5] Pitting is of more importance to pipes transporting liquids or gases which should not be leaked into the ground.

The following recommendations are recommended to achieve desired life. We defer to structural engineers to use our estimated corrosion rates and to choose from the corrosion control options listed below.

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[3] *Post-Tensioning Manual, sixth edition. Post-Tensioning Institute (PTI), Phoenix, AZ, 2006.*
[4] *Specification for Unbonded Single Strand Tendons. Post-tensioning Institute (PTI), Phoenix, AZ, 2000.*

[5] Melvin Romanoff, Corrosion of Steel Pilings in Soils, National Bureau of Standards Monograph 58, pg 20.

1) Sacrificial metal by use of thicker piles per non-disturbed soil corrosion rates, or
2) Galvanized steel piles per non-disturbed soil corrosion rates, or
3) Combination of galvanized and sacrificial metal per non-disturbed soil corrosion rates, or
4) For no loss of metal, coat entire pile with abrasion resistant epoxy coating such as 3M Scotchkote 323, or PowercreteDD, or equivalent, or
5) Use high yield steel which will corrode at the same rate as mild steel but have greater yield strength and thus be able to suffer more material loss than mild steel.

2.5.1 *Expected Corrosion Rate of Steel and Zinc in disturbed soil*

In general, the corrosion rate of metals in soil depends on the electrical resistivity, the elemental composition, and the oxygen content of the soil. Soils can vary greatly from one acre to the next, especially at earthquake faults. The better a soil is for farming; the easier it will be for corrosion to take place. Expansive soils will also be considered disturbed simply because of their nature from dry to wet seasons.

In Melvin Romanoff's NBS Circular 579, the corrosion rates of carbon steels and various metals was studied over long term periods. Various metals were placed in various soil types to gather corrosion rate data of all metals in all soil types. Samples were collected and material loss measured over the course of 20 years in some sites. The following corrosion rates were estimated by comparing the worst results of soils tested with similar soils in Romanoff's studies and Highway Research Board's publications.[6] The corrosion rate of zinc in disturbed soils is determined per Romanoff studies and King Nomograph.[7]

Expected Corrosion Rate for Steel = 2.28 mils/year for one sided attack

Expected Corrosion Rate for Zinc = 0.84 mils/year for one sided attack.

Note: 1 mil = 0.001 inch

In undisturbed soils, a corrosion rate of 1 mil/year for steel is expected with little change in the corrosion rate of zinc due to it's low nobility in the galvanic series.

Per CTM 643: Years to perforation of corrugated galvanized steel culverts

- 22.8 Years to Perforation for a 18 gage metal culvert
- 29.7 Years to Perforation for a 16 gage metal culvert
- 36.5 Years to Perforation for a 14 gage metal culvert
- 50.2 Years to Perforation for a 12 gage metal culvert
- 63.9 Years to Perforation for a 10 gage metal culvert
- 77.6 Years to Perforation for a 8 gage metal culvert

2.5.2 *Expected Corrosion Rate of Steel and Zinc in Undisturbed soil*

Expected Corrosion Rate for Steel = 1 mils/year for one sided attack

Expected Corrosion Rate for Zinc = 0.84 mils/year for one sided attack.

[6] Field test for Estimating Service Life of Corrugated Metal Culverts, J.L. Beaton, Proc. Highway Research Board, Vol 41, P. 255, 1962
[7] King, R.A. 1977, Corrosion Nomograph, TRRC Supplementary Report, British Corrosion Journal

Note: 1 mil = 0.001 inch

2.6 Steel Storage tanks

Underground fuel tanks must be constructed and protected in accordance with California Underground Storage Tank Regulations, CCR, Title 23, Division 3, Chapter 16. Metals should be protected with cathodic protection or isolated from backfill material with an epoxy coating.

2.7 Steel Pipelines

Though a site may not be corrosive in nature at the time of construction, **installation of corrosion test stations and electrical continuity joint bonding should be performed during construction** so that future corrosion inspections can be performed. If steel pipes with gasket joints or other possibly non-conductive type joints are installed, their joints should be bonded across by welding or pin brazing a #8 AWG copper strand bond cable. Electrical continuity is necessary for corrosion inspections and for cathodic protection.

Corrosion test stations should be installed every 1,000 feet of pipeline.

Test stations shall have two #8 HMWPE copper strand wire test leads welded or pin brazed to the underground pipe, brought up into the test station hand hole and marked CTS. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

At isolation joints and pipe casings, 4 wire test stations shall be installed using #8 HMWPE copper strand wire test leads. Use different color wires to distinguish which wires are bonded to one side of isolation joint or to casing. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

Prevent dissimilar metal corrosion cells per NACE SP0286:

1) Electrically isolate dissimilar metal connections
2) Electrically isolate dissimilar coatings (Epoxy vs CML&C) segments connections
3) Electrically isolate river crossing segments
4) Electrically isolate freeway crossing segments
5) Electrically isolate old existing pipelines from new pipelines
6) Electrically isolate aboveground and underground pipe segments with flange isolation joint kits. **These are especially important for fire risers.**

The corrosivity at this site is corrosive to steel. Any piping that must be jack bored should use abrasion resistant epoxy coating such as 3M Scotchkote 323, or PowercreteDD, or equivalent. The corrosion control options for this site are as follows:

1) Wax tape, or
2) Coal tar enamel, or
3) Fusion bonded epoxy
4) And install cathodic protection system per NACE SP0169.

Or instead of CP and Dielectric coating

5) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the pipe that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.8 Steel Fittings

The corrosivity at this site is very corrosive to steel. The corrosion control options for this site are as follows:

1) Apply impermeable dielectric coating such as minimum 8 mil thick polyethylene, or
2) Tape coating system, or
3) Wax tape, or
4) Coal tar enamel, or
5) Fusion bonded epoxy, or
6) And install cathodic protection system per NACE SP0169.

Or instead of CP and Dielectric coating

7) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.9 Ductile Iron (DI) Fittings

AWWA C105 developed a 10 point system to classify sites as aggressive or non-aggressive to ductile iron materials. The 10-point system does not, and was never intended to, quantify the corrosivity of a soil. It is a tool used to distinguish nonaggressive from aggressive soils relative to iron pipe. Soils <10 points are considered nonaggressive to iron pipe, whereas soils ≥10 points are considered aggressive. A 15 and a 20 point soil are both considered aggressive to iron pipe, however, because of the nature of the soil parameters measured, the 20 point soil may not necessarily be more aggressive than the 15 point soil. The criterion is based upon soil resistivities, soil drainage, pH, sulfide presence, and reduction-oxidation (REDOX) potential. The soil samples tested for this site resulted in a score of 12 out of 25.5. A score greater or equal to 10 points classifies soils as aggressive to iron materials.

The corrosivity at this site is very corrosive to iron. The corrosion control options for this site are as follows:

1) Apply impermeable dielectric coating such as minimum 8 mil thick polyethylene, or
2) Wax tape, or
3) Coal tar enamel, or
4) Fusion bonded epoxy, or
5) And install cathodic protection system per NACE SP0169.

   Or instead of CP and Dielectric coating

6) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.10 Ductile Iron Pipe

AWWA C105 developed a 10 point system to classify sites as aggressive or non-aggressive to ductile iron materials. The 10-point system does not, and was never intended to, quantify the corrosivity of a soil. It is a tool used to distinguish nonaggressive from aggressive soils relative to iron pipe. Soils <10 points are considered nonaggressive to iron pipe, whereas soils ≥10 points are considered aggressive. A 15 and a 20 point soil are both considered aggressive to iron pipe, however, because of the nature of the soil parameters measured, the 20 point soil may not necessarily be more aggressive than the 15 point soil. The criterion is based upon soil resistivities, soil drainage, pH, sulfide presence, and reduction-oxidation (REDOX) potential. The soil samples tested for this site resulted in a score of 12 out of 25.5. A score greater or equal to 10 points classifies soils as aggressive to iron materials.

Though a site may not be corrosive in nature at the time of construction, **installation of corrosion test stations and electrical continuity joint bonding should be performed during construction** so that future corrosion inspections can be performed. If steel pipes with gasket joints or other possibly non-conductive type joints are installed, their joints should be bonded across by welding or pin brazing a #8 AWG copper strand bond cable. Electrical continuity is necessary for corrosion inspections and for cathodic protection.

Pea gravel is used by plumbers to lay pipes and establish slopes. If the gravel has more than 200 ppm chlorides or is not tested, a 25 mil plastic should be placed between the gravel and pipe to avoid corrosion.

Corrosion test stations should be installed every 1,000 feet of pipeline.

Test stations shall have two #8 HMWPE copper strand wire test leads welded or pin brazed to the underground pipe, brought up into the test station hand hole and marked CTS. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

At isolation joints and pipe casings, 4 wire test stations shall be installed using #8 HMWPE copper strand wire test leads. Use different color wires to distinguish which wires are bonded to one side of isolation joint or to casing. Wires should be brought into test station hand hole at finished grade with 12 inches of wire coiled within test station.

Prevent dissimilar metal corrosion cells per NACE SP0286:

1) Electrically isolate dissimilar metal connections
2) Electrically isolate dissimilar coatings (Epoxy vs CML&C) segments connections
3) Electrically isolate river crossing segments
4) Electrically isolate freeway crossing segments
5) Electrically isolate old existing pipelines from new pipelines
6) Electrically isolate aboveground and underground pipe segments with flange isolation joint kits**. These are especially important for fire risers.**

The corrosivity at this site is corrosive to iron. The corrosion control options for this site are as follows:

1) Apply impermeable dielectric coating such as minimum 8 mil thick polyethylene, or
2) Tape coating system, or
3) Wax tape, or
4) Coal tar enamel, or
5) Fusion bonded epoxy, or
6) And install cathodic protection system per NACE SP0169.

   Or instead of CP and Dielectric coating

7) Apply 3 inch coating of Type II cement or high pH slurry that will maintain pH higher than 12. Cement is both a corrosion inhibitor and a coating for ferrous metals. Cement naturally holds a pH of 12 or higher for many years if not exposed to high levels of carbon dioxide.

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.11 Copper Materials

Copper is an amphoteric material which is susceptible to corrosion at very high and very low pH. It is one of the most noble metals used in construction thus typically making it a cathode when connected to dissimilar metals. Copper's nobility can change with temperature, similar to the phenomenon in zinc. When zinc is at room temperature, it is less noble than steel and can provide cathodic protection to steel. But when zinc is at a temperature above 140F such as in a water heater, it becomes nobler than the steel and the steel becomes the sacrificial anode. This is why zinc is not used in steel water heaters or boilers. Copper when cold has one native potential, but when heated develops a more electronegative electro-potential. Thus hot and cold copper pipes should be electrically isolated from each other to avoid creation of a thermo-galvanic corrosion cell.

2.11.1 Copper Pipes

The lowest pH for this area was measured to be 7.8. Copper is greatly affected by pH, ammonia and nitrate concentrations[8]. The highest nitrate concentration was 1.1 mg/kg and the highest ammonia concentration was 0.3 mg/kg at this site.

These soils were determined to be corrosive to copper and copper alloys such as brass.

Aboveground, underground, cold water and hot water pipes should be electrically isolated from each other by use of dielectric unions and plastic in-wall pipe supports. The following are corrosion control options for underground copper water pipes.

1) Run copper pipes within PVC pipes to prevent soil contact, or
2) Cover piping with a 20 mil epoxy coating free of scratches and defects, or
3) Cover copper pipes with minimum 10 mil polyethylene sleeve over a suitable primer and apply cathodic protection per NACE SP0169

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.11.2 Brass Fittings

Brass fittings should be electrically isolated from dissimilar metals by use of dielectric unions or isolation joint kits.

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[8] Corrosion Data Handbook, Table 6, Corrosion Resistance of copper alloys to various environments, 1995

These soils were determined to be corrosive to copper and copper alloys such as brass.

The following are corrosion control options for underground brass.

1) Prevent soil contact by use of impermeable coating system such as wax tape, or
2) Prevent soil contact by use of a 20 mil epoxy coating free of scratches and defects, or
3) Cover brass with minimum 10 mil polyethylene sleeve over a suitable primer and apply cathodic protection per NACE SP0169

It is critical for the life of the metal that the protective wrap contains no openings or holes. Prevent damage to the protective sleeve during backfilling of the pipe trench. Penetrations of any kind within these or other protective materials generally leads to accelerated corrosion failure due to the fact that the corrosion attack is concentrated at the location of these penetrations. Cathodic protection will protect these defects. The better the coating, the less expensive a cathodic protection system will be in anode material and power requirement if needed.

2.11.3 Bare Copper Grounding Wire

It is assumed that corrosion will occur at all sides of the bare wire, thus the corrosion rate is calculated as a two sided attack determining the time it takes for the corrosion from two sides to meet at the center of the wire. The estimated life of bare copper wire for this site is the following:[9]

Size (AWG)	**Diameter (mils)**	**Est. Time to penetration (Yrs)**
14	64.1	160.3
13	72	180.0
12	80.8	202.0
11	90.7	226.8
10	101.9	254.8
9	114.4	286.0
8	128.5	321.3
7	144.3	360.8
6	162	405.0
5	181.9	454.8
4	204.3	510.8
3	229.4	573.5
2	257.6	644.0
1	289.3	723.3

If the bare copper wire is being used as a grounding wire connected to less noble metals such as galvanized steel or carbon steel, the less noble metals will provide additional cathodic protection to the copper reducing the corrosion rate of the copper.

It is recommended that a corrosion inhibiting and water-repelling coating such as Corrosion X Part No. 90102 by Corrosion Technologies (no affiliation to Project X) be applied to

[9] Soil-Corrosion studies 1946 and 1948: Copper Alloys, Lead, and Zinc, Melvin Romanoff, National Bureau of Standards, Research Paper RP2077, 1950

aboveground and belowground copper-to-dissimilar metal connections to reduce risk of dissimilar corrosion.

2.12 Aluminum Pipe/Conduit/Fittings

Aluminum is an amphoteric material prone to pitting corrosion in environments that are very acidic or very alkaline or high in chlorides.

Conditions at this site are safe for aluminum.

Aluminum derives its corrosion resistance from its oxide layer which needs oxygen to regenerate if damaged, similar to stainless steels. Thus aluminum is not good for deep soil applications. Since aluminum corrodes at very alkaline environments, it cannot be encased or placed against cement or mortar such as brick wall mortar up against an aluminum window frame.

Aluminum is also very low on the galvanic series scale making it most likely to become a sacrificial anode when in contact with dissimilar metals in moist environments. Avoid electrical continuity with dissimilar metals by use of insulators, dielectric unions, or isolation joints. Pooling of water at post bottoms or surfaces should be avoided by integrating good drainage.

2.13 Carbon Fiber or Graphite Materials

Carbon fiber or other graphite materials are extremely noble on the galvanic series and should always be electrically isolated from dissimilar metals. They can conduct electricity and will create corrosion cells if placed in contact within a moist environment with any metal.

2.14 Plastic and Vitrified Clay Pipe

No special precautions are required for plastic and vitrified clay piping from a corrosion viewpoint.

Protect all metallic fittings and pipe restraining joints with wax tape per AWWA C217, cement if previously recommended, or epoxy.

3 CLOSURE

In addition to soils chemistry and resistivity, another contributing influence to the corrosion of buried metallic structures is stray electrical currents. These electrical currents flowing through the earth originate from buried electrical systems, grounding of electrical systems in residences, commercial buildings, and from high voltage overhead power grids. Therefore, it is imperative that the application of protective wraps and/or coatings and electrical isolation joints be properly applied and inspected.

It is the responsibility of the builder and/or contractor to closely monitor the installation of such materials requiring protection in order to assure that the protective wraps or coatings are not damaged.

The recommendations outlined herein are in conformance with current accepted standards of practice that meet or exceed the provisions of the Uniform Building Code (UBC), the

International Building Code (IBC), California Building Code (CBC), the American Cement Institute (ACI), Nickel Institute, National Association of Corrosion Engineers (NACE International), Post-Tensioning Institute Guide Specifications and State of California Department of Transportation, Standard Specifications, American Water Works Association (AWWA) and the Ductile Iron Pipe Research Association (DIPRA).

Our services have been performed with the usual thoroughness and competence of the engineering profession. No other warranty or representation, either expressed or implied, is included or intended.

Please call if you have any questions.

Prepared by,

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Respectfully Submitted,

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STATE OF CALIFORNIA

4 SOIL ANALYSIS LAB RESULTS

Client: Geotechnologies, Inc
Job Name: Faring
Client Job Number: 21848 & 21849
Project X Job Number: S191003A
October 9, 2019

	Method	ASTM D4327		ASTM D4327		ASTM G187		ASTM G51	ASTM G200	SM 4500-S2-D	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327	ASTM D4327
Bore# / Description	**Depth**	**Sulfates** SO_4^{2-}		**Chlorides** Cl^-		**Resistivity** As Rec'd	Minimum	**pH**	**Redox**	**Sulfide** S^{2-}	**Nitrate** NO_3^-	**Ammonium** NH_4^+	**Lithium** Li^+	**Sodium** Na^+	**Potassium** K^+	**Magnesium** Mg^{2+}	**Calcium** Ca^{2+}	**Flouride** F_2^{--}	**Phosphate** PO_4^{3-}
	(ft)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(Ohm-cm)	(Ohm-cm)		(mV)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
B2	5.0	30.0	0.0030	12.1	0.0012	1,474	1,340	8.2	243.0	1.9	0.1	0.3	ND	100.4	0.2	25.6	40.7	3.5	4.3
B2	15.0	21.2	0.0021	7.9	0.0008	1,541	1,474	7.9	215.0	1.1	0.0	0.2	0.0	44.0	0.1	7.1	17.6	2.8	2.0
B2	25.0	55.6	0.0056	22.6	0.0023	804	804	8.1	222.0	4.1	0.1	0.2	0.0	49.5	0.3	29.6	76.1	3.7	2.3
B2	40.0	50.4	0.0050	11.9	0.0012	1,943	1,742	7.9	228.0	0.9	1.1	0.0	ND	43.0	0.1	9.0	23.3	3.7	2.0
B2	52.5	41.7	0.0042	8.2	0.0008	2,010	1,809	7.9	226.0	0.7	0.7	0.1	ND	34.8	0.3	7.9	21.4	3.6	2.1
B2	65.0	46.1	0.0046	22.6	0.0023	2,814	2,077	7.8	233.0	0.3	0.3	0.2	0.0	42.1	0.3	5.9	15.2	3.2	0.6
B2	75.0	37.4	0.0037	19.0	0.0019	1,072	1,005	7.9	224.0	0.8	0.3	0.0	0.0	30.3	0.2	8.2	21.4	3.2	1.4

Unk = Unknown
NT = Not Tested
ND = 0 = Not Detected
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
Chemical Analysis performed on 1:3 Soil-To-Water extract
Anions and Cations tested via Ion Chromatograph except Sulfide.

Figure 1 Soil Sample Locations, 1010-1020 North La Brea Avenue, West Hollywood, CA and 1011 North Sycamore Avenue, Los Angeles, CA. (34.0893, -118.3434)

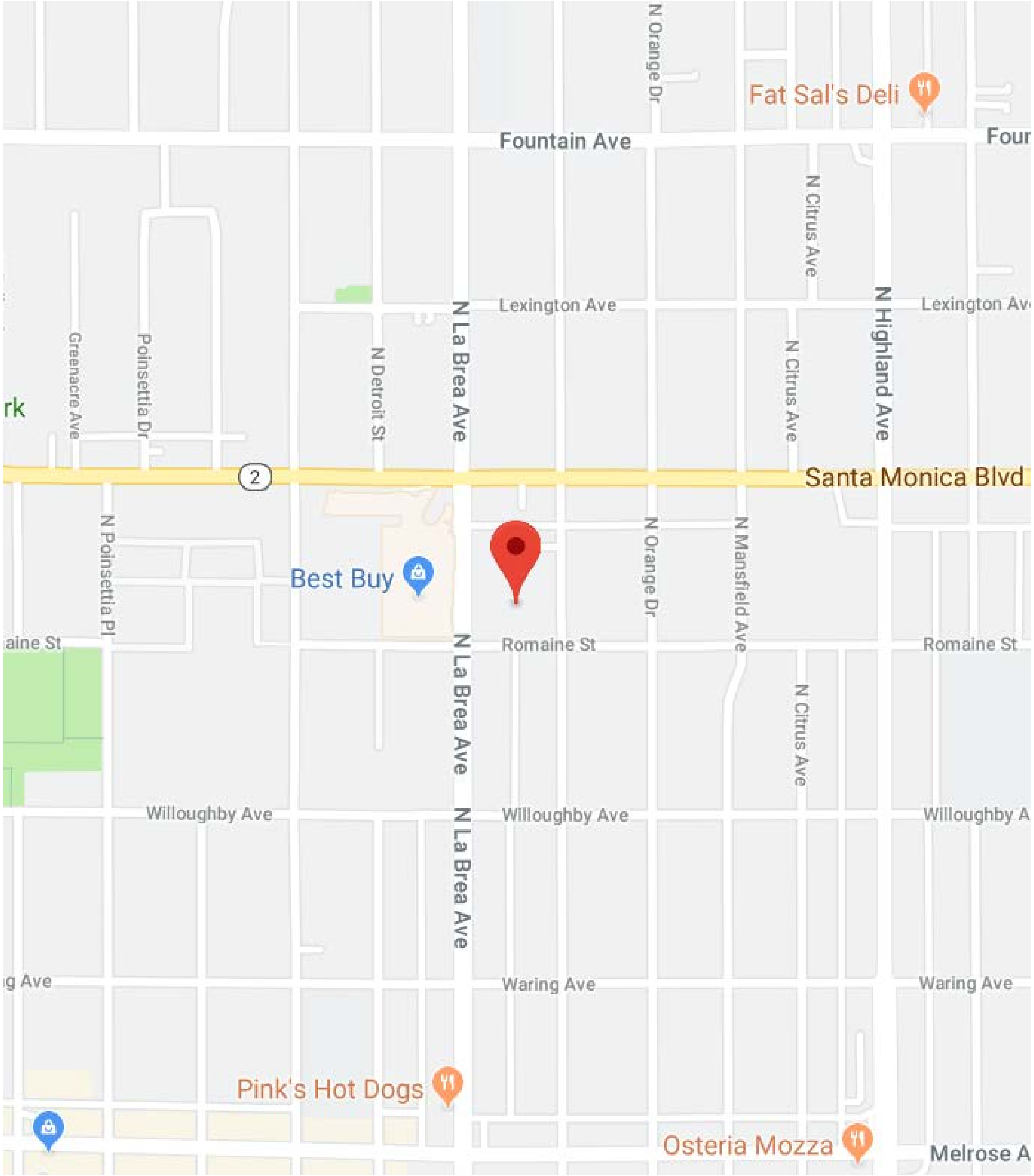


Figure 2 Vicinity Map, 1010-1020 North La Brea Avenue, West Hollywood, CA and 1011 North Sycamore Avenue, Los Angeles, CA. (34.0893, -118.3434)

5 Corrosion Basics

In general, the corrosion rate of metals in soil depends on the electrical resistivity, the elemental composition, and the oxygen content of the soil. Soils can vary greatly from one acre to the next, especially at earthquake faults. The better a soil is for farming; the easier it will be for corrosion to take place. Oxygen content in soil can be increased during construction. These soils are considered disturbed soils. When construction equipment at a site is simply driving piles into soil without digging into the soil, the activity can still disturb soil down to 3 feet. Expansive soils will also be considered disturbed simply because of their nature from dry to wet seasons.

5.1 Pourbaix Diagram – In regards to a material's environment

All metals are unique and have a weakness. Some metals do not like acidic (low pH) environments. Some metals do not like alkaline (high pH) environments. Some metals don't like either high or low pH environments such as aluminum. These are called amphoteric materials. Some metals become passivated and do not corrode at high pH environments such as steel. These characteristics are documented in Marcel Pourbaix's book "Atlas of electrochemical equilibria in aqueous solutions"

In the mid 1900's, Marcel Pourbaix developed the Pourbaix diagram which describes a metal's reaction to an environment dependant on pH and voltage conditions. It describes when a metal remains passive (non-corroding) and in which conditions metals become soluble (corrode). Steels are passive in pH over 12 such as the condition when it is encased in cement. If the cement were to carbonate and its pH reduce to below 12, the cement would no longer be able to act as a corrosion inhibitor and the steel will begin to corrode when moist.

Some metals such as aluminum are amphoteric, meaning that they react with acids and bases. They can corrode in low pH and in high pH conditions. Aluminum alloys are generally passive within a pH of 4 and 8.5 but will corrode outside of those ranges. This is why aluminum cannot be embedded in cement and why brick mortar should not be laid against an aluminum window frame without a protective barrier between them.

5.2 Galvanic Series – In regards to dissimilar metal connections

All metals have a natural electrical potential. This electrical potential is measured using a high impedance voltmeter connected to the metal being tested and with the common lead connected to a copper copper-sulfate reference electrode (CSE) in water or soil. There are many types of reference electrodes. In laboratory measurements, a Standard Hydrogen Electrode (SHE) is commonly used. When different metal alloys are tested they can be ranked into an order from most noble (less corrosion), to least noble (more active corrosion). When a more noble metal is connected to a less noble metal, the less noble metal will become an anode and sacrifice itself through corrosion providing corrosion protection to the more noble metal. This hierarchy is known as the galvanic series named after Luigi Galvani whose experiments with electricity and muscles led Alessandro Volta to discover the reactions between dissimilar metals leading to the early battery. The greater the voltage difference between two metals, the faster the corrosion rate will be.

Table 1- Dissimilar Metal Corrosion Risk

	Zinc	Galvanized Steel	Aluminum	Cast Iron	Lead	Mild Steel	Tin	Copper	Stainless Steel
Zinc	None	Low	Medium	High	High	High	High	High	High
Galvanized Steel	Low	None	Medium	Medium	Medium	High	High	High	High
Aluminum	Medium	Medium	None	Medium	Medium	Medium	Medium	High	High
Cast Iron	High	Medium	Medium	None	Low	Low	Low	Medium	Medium
Lead	High	Medium	Medium	Low	None	Low	Low	Medium	Medium
Mild Steel	High	High	Medium	Low	Low	None	Low	Medium	Medium
Tin	High	High	Medium	Low	Low	Low	None	Medium	Medium
Copper	High	High	High	Medium	Medium	Medium	Medium	None	Low
Stainless Steel	High	High	High	Medium	Medium	Medium	Medium	Low	None

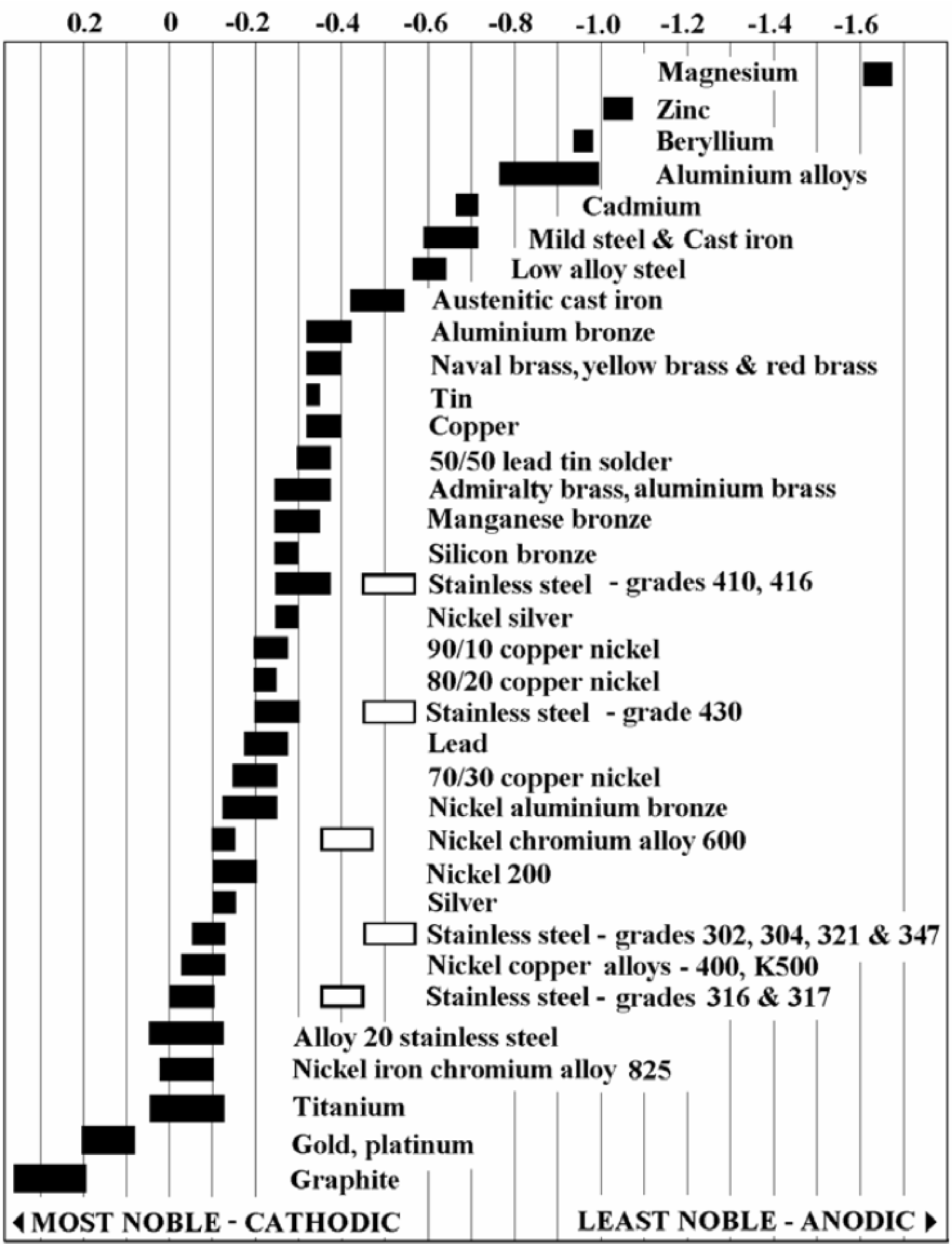
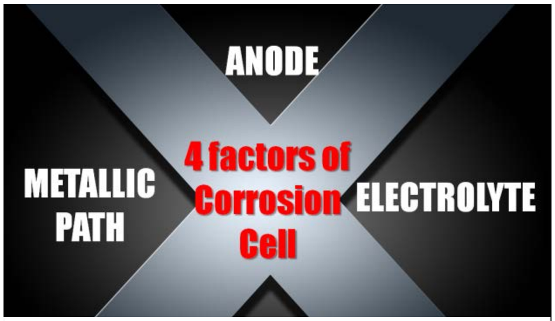
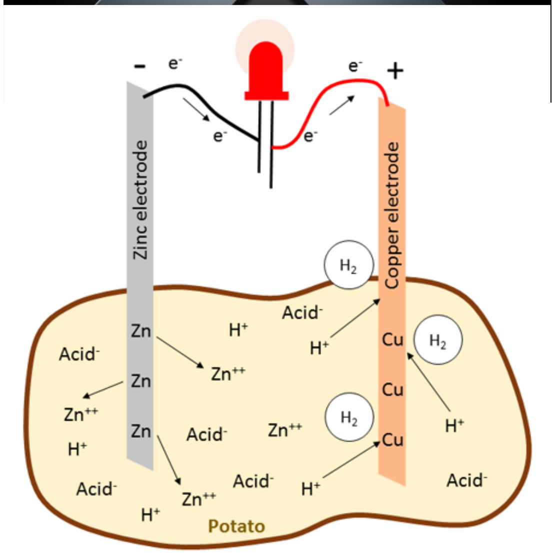


Figure 3 - Galvanic series of metals relative to CSE half cell.

5.3 Corrosion Cell

In order for corrosion to occur, four factors must be present. (1) The anode (2) the cathode (3) the electrolyte and (4) the metallic or conductive path joining the anode and the cathode. If any one of these is removed, corrosion activity will stop. This is how a simple battery produces electricity. An example of a non-metallic yet conductive material is graphite. Graphite is similar in nobility to gold. Do not connect graphite to anything in moist environments.





The anode is where the corrosion occurs, and the cathode is the corrosion free material. Sometimes the anode and cathode are different materials connected by a wire or union. Sometimes the anode and cathode are on the same pipe with one area of the pipe in a low oxygen zone while the other part of the pipe is in a high oxygen zone. A good example of this is a post in the ocean that is repeatedly splashed. Deep underwater, corrosion is minimal, but at the splash zone, the corrosion rate is greatest.

Low oxygen zones and crevices can also harbor corrosive bacteria which in moist environments will lead to corrosion. This is why pipes are laid on backfill instead of directly on native cut soil in a trench. Filling a trench slightly with backfill before installing pipe then finishing the backfill creates a uniform environment around the entire surface of the pipe.

The electrolyte is generally water, seawater, or moist soil which allows for the transfer of ions and electrical current. Pure water itself is not very conductive. It is when salts and minerals dissolve into pure water that it becomes a good conductor of electricity and chemical reactions. Metal ores are turned into metal alloys which we use in construction. They naturally want to return to their natural metal ore state but it requires energy to return to it. The corrosion cell, creates the energy needed to return a metal to its natural ore state.

The metallic or conductive path can be a wire or coupling. Examples are steel threaded into a copper joint, or an electrician grounding equipment to steel pipes inadvertently connecting electrical grid copper grounding systems to steel or iron underground pipes.

The ratio of surface area between the anode and the cathode is very important. If the anode is very large, and the cathode is very small, then the corrosion rate will be very small and the anode may live a long life. An example of this is when short copper laterals were connected to a large and long steel pipeline. The steel had plenty of surface area to spread the copper's attack, thus corrosion was not noticeable. But if the copper was the large pipe and the steel the short laterals, the steel would corrode at an amazing rate.

5.4 Design Considerations to Avoid Corrosion

The following recommendations are based upon typical observations and conclusions made by forensic engineers in construction defect lawsuits and NACE International (Corrosion Society) recommendations.

5.4.1 Testing Soil Factors (Resistivity, pH, REDOX, SO, CL, NO3, NH3)

As previously mentioned, different factors can cause corrosion. The most useful and common test for categorizing a soil's corrosivity has been the measure of soil resistivity which is typically measured in units of (ohm-cm) by corrosion engineers and geologists. Soil resistivity is the ability of soil to conduct or resist electrical currents and ion transfer. The lower the soil resistivity, the more conductive and corrosive it is. The following are "generally" accepted categories but keep in mind, the question is not "Is my soil corrosive?", the question should be, "What is my soil corrosive to?" and to answer that question, soil resistivity and chemistry must be tested. Though **soil resistivity is a good corrosivity indicator for steel materials, high chlorides or other corrosive elements do not always lower soil resistivity, thus if you don't test for chlorides and other water soluble salts, you can get an unpleasant surprise.** The largest contributing factor to a soil's electrical resistivity is its clay, mineral, metal, or sand make-up.

Table 2 - Corrosion Basics- An Introduction, NACE, 1984, pg 191

(Ohm-cm)	Corrosivity Description
0-500	Very Corrosive
500-1,000	Corrosive
1,000-2,000	Moderately Corrosive
2,000-10,000	Mildly Corrosive
Above 10,000	Progressively less corrosive

Testing a soil's pH provides information to reference the Pourbaix diagram of specific metals. Some elements such as ammonia and nitrates can create localized alkaline conditions which will greatly affect amphoteric materials such as aluminum and copper alloys.

Excess sulfates can break-down the structural integrity of cement and high concentrations of chlorides can overcome cement's corrosion inhibiting effect on encased ferrous metals and break down protective passivated surface layers on stainless steels and aluminum.

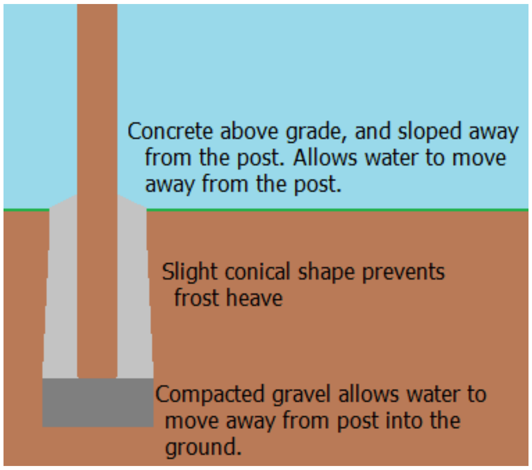
Corrosive bacteria are everywhere but can multiply significantly in anaerobic conditions with plentiful sulfates. The bacteria themselves do not eat the metal but their by-products can form corrosive sulfuric acids. The probability of corrosive bacteria is tested by measuring a soil's oxidation-reduction (REDOX) electro-potential and by testing for the presence of sulfides.

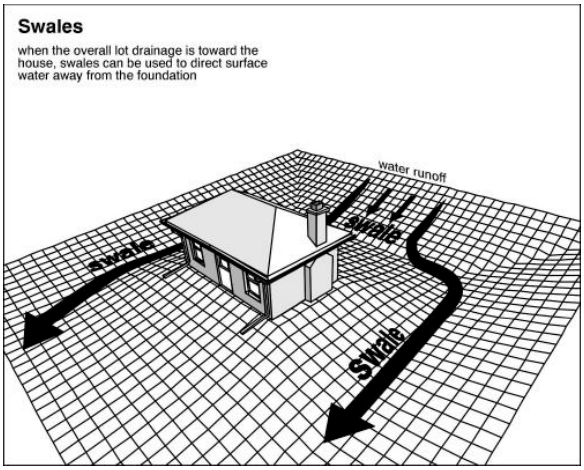
Only by testing a soil's chemistry for minimum resistivity, pH, chlorides, sulfates, sulfides, ammonia, nitrate, and redox potential can one have the information to evaluate the corrosion risk to construction materials such as steel, stainless steel, galvanized steel, iron, copper, brass, aluminum, and concrete.

5.4.2 Proper Drainage

It cannot be emphasized enough that pooled stagnant water on metals will eventually lead to corrosion. This stands for internal corrosion and external corrosion situations. In soils, providing good drainage will lower soil moisture content reducing corrosion rates. Attention to properly sealing polyethylene wraps around valves and piping will avoid water intrusion which would allow water to pool against metals. Above ground structures should not have cupped or flat surfaces that will pond water after rain or irrigation events.

Buildings typically are built on pads and have swales when constructed to drain water away from buildings directing it towards an acceptable exit point such as a driveway where it continues draining to a local storm drain. Many homeowners, landscapers and flatwork contractors appear to not be aware of this and destroy swales during remodeling. The majority of garage floor and finished grade elevations are governed by drainage during design. [10,11]





5.4.3 Avoiding Crevices

Crevices are excellent locations for oxygen differential induced corrosion cells to begin. Crevices can also harbor corrosive bacteria even in the most chemically treated waters. Crevices will also gather salts. If water's total alkalinity is low, its ability to maintain a stable pH can also become more difficult within a crevice allowing the pH to drop to acidic levels continuing a pitting process. Welds in extremely corrosive environments should be complete and well filleted without sharp edges to avoid crevices. Sharp edges should be avoided to allow uniform coating of protective epoxy. Detection of crevices in welds should be treated immediately. If pressures and loads are low, sanding and rewelding or epoxy patching can be suitable repairs. Damaged coatings can usually be repaired with Direct to Metal paints. **Scratches and crevice corrosion are like infections, they should not be left to fester or the infection will spread making things worse.**

[10] https://www.fencedaddy.com/blogs/tips-and-tricks/132606467-how-to-repair-a-broken-fence-post

[11] http://southdownstudio.co.uk/problme-drainage-maison.html

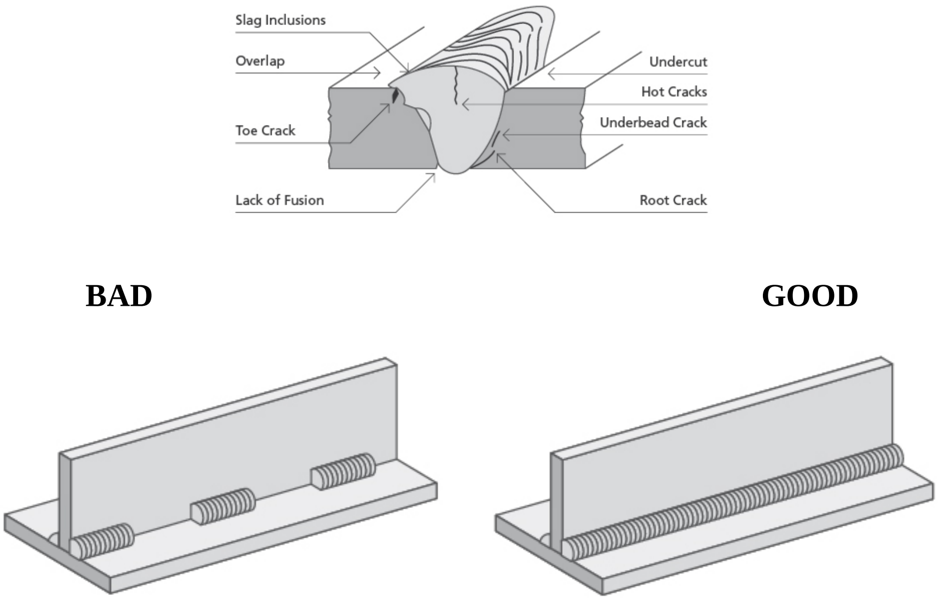


Figure 4 Defects which form weld crevices[12]

5.4.4 ***Coatings and Cathodic Protection***

When faced with a corrosive environment, the best defense against corrosion is removing the electrolyte from the corrosion cell by applying coatings to separate the metal from the soil. During construction and installation, there is always some scratch or damage made to a coating. NACE training recommends that coatings be used as a first line of defense and that sacrificial or impressed current cathodic protection is used as a 2nd line of defense to protect the scratched areas. Use of a good coating dramatically reduces the amount of anodes a CP system would need. If CP is not installed as a 2nd line of defense in an extremely corrosive environment, the small scratched zones will suffer accelerated corrosion. CP details such as anode installation instructions must be designed by corrosion engineers or vessel manufacturers on a per project basis because it depends on electrolyte resistivity, surface area of infrastructure to be protected, and system geometry.

There are two types of cathodic protection systems, a Galvanic Anode Cathodic Protection (GACP) system and an Impressed Current Cathodic Protection (ICCP) system. A Galvanic Anode Cathodic Protection (GACP) system is simpler to install and maintain than an Impressed Current Cathodic Protection (ICCP) system. To protect the metals, they must all be electrically continuous to each other. In a GACP system, sacrificial zinc or magnesium anodes are then buried at locations per the CP design and connected by wire to a structure at various points in system. At the connection points, a wire connecting to the structure and the wire from the anode are joined in a Cathodic Protection Test Station hand hole which looks similar in size and shape to an irrigation valve pull box. By coating the underground structures, one can reduce the number of anodes needed to provide cathodic protection by 80% in many instances.

An ICCP system requires a power source, a rectifier, significantly more trenching, and more expensive type anodes. These systems are typically specified when bare metal is requiring protection

[12] http://www.daroproducts.co.uk/makes-good-weld/

in severely corrosive environments in which galvanic anodes do not provide enough power to polarize infrastructure to -850 mV structure-to-soil potential or be able to create a 100 mV potential shift as required by NACE SP169 to control corrosion. In severely corrosive environments, a GACP system simply may not last a required lifetime due to the high rate of consumption of the sacrificial anodes. ICCP system rectifiers must be inspected and adjusted quarterly or at a minimum bi-annually per NACE recommendations. Different anode installations may be possible but for large sites, anodes are placed evenly throughout the site and all anode wires must be trenched to the rectifier. For a large site, it may be beneficial to use two or more rectifiers to reduce wire lengths or trenching.

To simplify, a GACP system can be installed and practically forgotten with minor trenching because the anodes can be installed very close to the structures. An ICCP system must be inspected annually and anode wires run back to the rectifier which itself connects to the pile system. If any type of trenching or development is expected to occur at the site during the life of the site, it is a good idea to inspect the anode connections once a year to make sure wires are not cut and that the infrastructure is still being provided adequate protection. A common situation that occurs with ICCP systems is that a contractor accidently cuts the wires during construction then reconnects them incorrectly, turning the once cathode, into a sacrificing anode.

Design of a cathodic protection system protecting against soil side corrosion requires that Wenner Four Pin ground resistance measurements per ASTM G57 be performed by corrosion engineers at various locations of the site to determine the best depths and locations for anode installations. Ideally, a sample pile is installed and experiments determining current requirement are conducted. Using this data, the decision is made whether a GACP system is feasible or if an ICCP must be used.

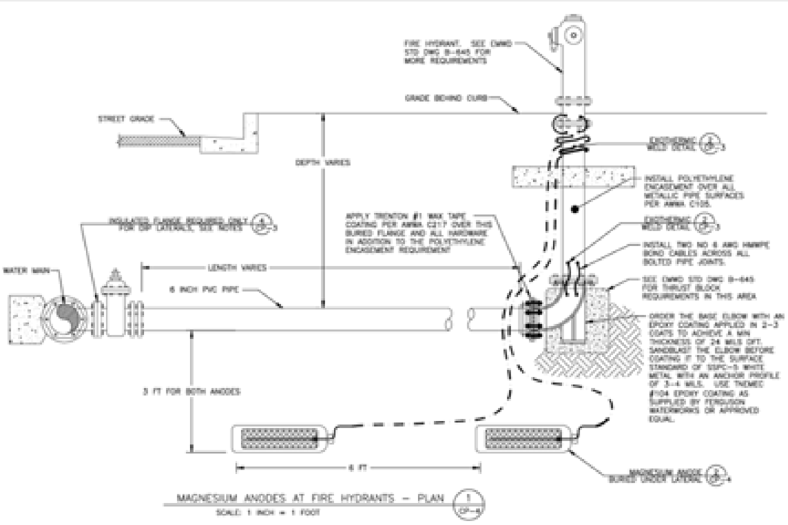


Figure 5 Sample anode design for fire hydrant underground piping

Vessels such as water tanks will have protective interior coatings and anodes to protect the interior surfaces. Anodes can also be buried on site and connected to system skid supports to protect the metal in contact with soil. A good example of a vessel cathodic protection system exists in all home water heaters which contain sacrificial aluminum or magnesium anodes. In environments that exceed 140F, zinc anodes cannot be used with carbon steel because they become the aggressor (Cathodic) to the steel instead of sacrificial (anodic). Anodes in vessels containing extremely brackish water with chloride levels over 2,000 ppm should inspect or change out their anodes every 6 months.

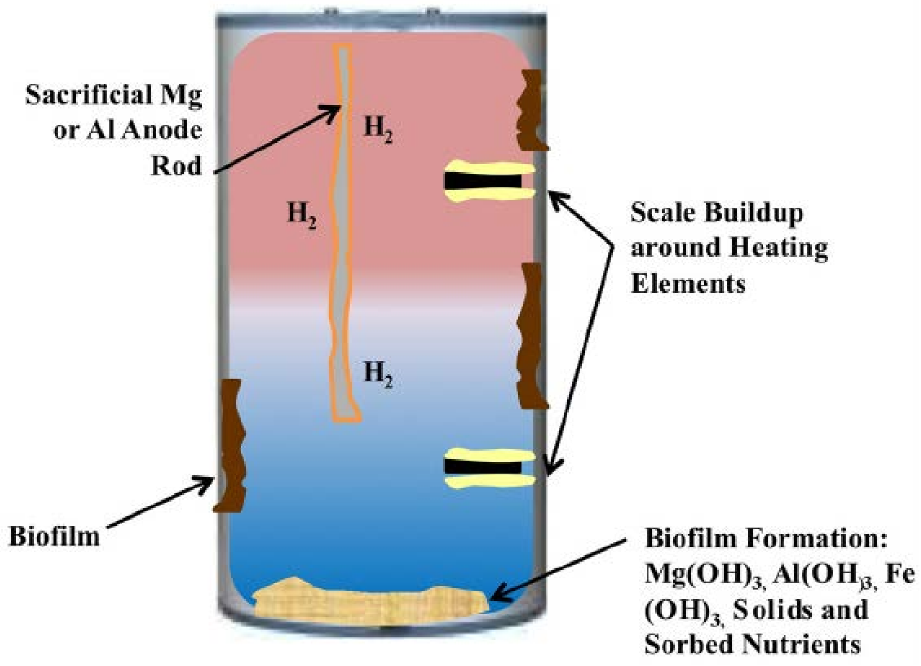


Figure 6 Cross section of boiler with anode

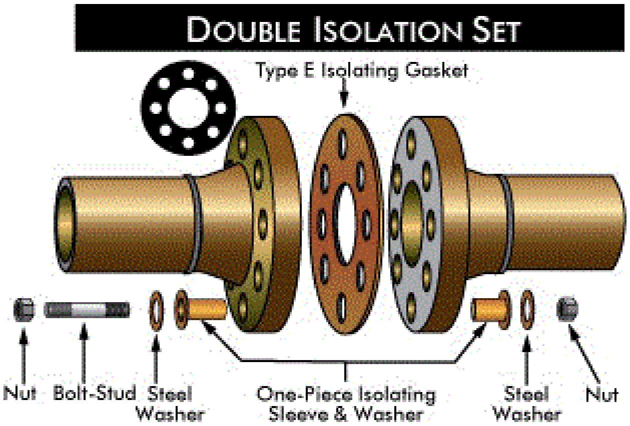
Cathodic protection can only protect a few diameters within a pipeline thus it is not recommended for small diameter pipelines and tubing internal corrosion protection. Anodes are like a lamp shining light in a room. They can only protect along their line of sight.

5.4.5 Good Electrical Continuity

In order for cathodic protection to protect a long pipeline or system of pipes from external soil side corrosion, they must all be electrically continuous to each other so that the electric current from the anode can travel along the pipes, then return through the earth to the anode. Electrical continuity is achieved by welding or pin brazing #8 AWG copper strand bond cable to the end of pipe sticks which have rubber gaskets at bell and spigots. If steel pipes are joined by full weld, bonding wires are not needed.

Electrical continuity between dissimilar metals is not desirable. Isolation joints or di-electric unions should be installed between dissimilar metals, such as steel pipes connecting to a brass valve. Bonding wires should then be welded onto the steel pipes by-passing the brass valve so that the cathodic protection system's current can continue to travel along the steel piping but isolate the brass valve from the steel pipeline. Another option would be to provide a separate cathodic protection system for steel pipes on both sides of the brass valve.

Typically, water heater inlets and outlets, gas meters and water meters have dielectric unions installed in them to separate utility property from homeowner property. This also protects them in the case that a home owner somehow electrically connects water pipes or gas pipes to a neighborhood electrical grounding system which can potentially have less noble steel in soil now connected to much more noble copper in soil which will then create a corrosion cell. This is exactly how a lemon powered clock works when a galvanized zinc nail and a steel nail are inserted into a lemon then connected to a clock. The clock is powered by the corrosion cell created.



5.4.6 Bad Electrical Continuity

Bad electrical continuity is when two different materials or systems are made electrically continuous (aka shorted) when they were not designed to be electrically continuous. Examples of this would be when gas lines are shorted to water lines or to electrical grounding beds. Very often, fire risers are shorted to electrical grounding systems, and water pipes at business parks. Since fire risers usually have a very short ductile iron pipe in the ground which connects to PVC pipe systems, they tend to experience leaks after 7 to 10 years of being attacked by underground copper systems.

It is absolutely imperative that any copper water piping or other metal conduits penetrating cement slab or footings, not come in contact with the reinforcing steel or post-tensioning tendons to avoid creation of galvanic corrosion cells.

5.4.7 Corrosion Test Stations

Corrosion test stations should be installed every 1,000 feet along pipelines in order to measure corrosion activity in the future. For a simple pipeline, two #8 AWG copper strand bond cable welded or pin brazed onto the pipeline are run up to finished grade and left in a hand hole. Corrosion test stations are used to measure pipe-to-soil electro potential relative to a copper copper-sulfate reference electrode to determine if the pipe is experiencing significant corrosion activity. By measuring test stations along a pipeline, hot spots can be determined, if any. The wires also allow for electrical continuity testing, condition assessment, and a multitude of other types of tests.

At isolation joints and pipe casings, two wires should be welded to either side of the isolation joint for a total of 4 wires to be brought up to the hand hole. This allows for future tests of the isolation joint, casing separation confirmation, and pipe-to-soil potential readings during corrosion surveys.

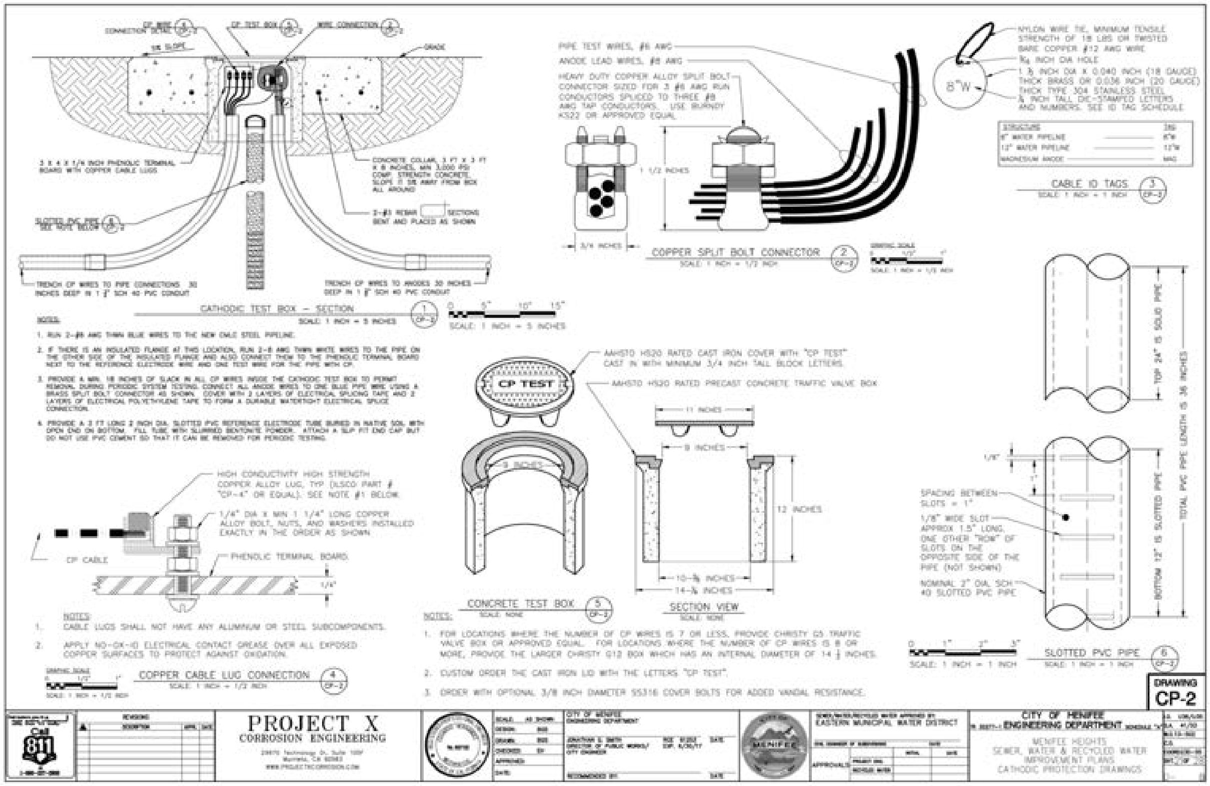


Figure 7 Sample of corrosion test station specification drawing

5.4.8 *Excess Flux in Plumbing*

Investigations of internal corrosion of domestic water plumbing systems almost always finds excess flux to be the cause of internal pitting of copper pipes. Some people believe that there is no such thing as too much flux. Flux runs have been observed to travel up to 20 feet with pitting occurring along the flux run. Flushing a soldered plumbing system with hot water for 15 minutes can remove significant amounts of excess flux left in the pipes. If a plumbing system is expected to be stagnant for some time, it should be drained to avoid stagnant water conditions that can lead to pitting and dezincification of yellow brasses.

5.4.9 *Landscapers and Irrigation Sprinkler Systems*

A significant amount of corrosion of fences is due to landscaper tools scratching fence coatings and irrigation sprinklers spraying these damaged fences. Recycled water typically has a higher salt content than potable drinking water, meaning that it is more corrosive than regular tap water. The same risk from damage and water spray exists for above ground pipe valves and backflow preventers. Fiber glass covers, cages, and cement footings have worked well to keep tools at an arm’s length.

5.4.10 *Roof Drainage splash zones*

Unbelievably, even the location where your roof drain splashes down can matter. We have seen drainage from a home’s roof valley fall directly down onto a gas meter causing it’s piping to corrode at an accelerated rate reaching 50% wall thickness within 4 years. It is the same effect as a splash zone in the ocean or in a pool which has a lot of oxygen and agitation that can remove material as it corrodes.

5.4.11 Stray Current Sources

Stray currents which cause material loss when jumping off of metals may originate from direct-current distribution lines, substations, or street railway systems, etc., and flow into a pipe system or other steel structure. Alternating currents may occasionally cause corrosion. The corrosion resulting from stray currents (external sources) is similar to that from galvanic cells (which generate their own current) but different remedial measures may be indicated. In the electrolyte and at the metal-electrolyte interfaces, chemical and electrical reactions occur and are the same as those in the galvanic cell; specifically, the corroding metal is again considered to be the anode from which current leaves to flow to the cathode. Soil and water characteristics affect the corrosion rate in the same manner as with galvanic-type corrosion.

However, stray current strengths may be much higher than those produced by galvanic cells and, as a consequence, corrosion may be much more rapid. Another difference between galvanic-type currents and stray currents is that the latter are more likely to operate over long distances since the anode and cathode are more likely to be remotely separated from one another. Seeking the path of least resistance, the stray current from a foreign installation may travel along a pipeline causing severe corrosion where it leaves the line. Knowing when stray currents are present becomes highly important when remedial measures are undertaken since a simple sacrificial anode system is likely to be ineffectual in preventing corrosion under such circumstances.[13] Stray currents can be avoided by installing proper electrical shielding, installation of isolation joints, or installation of sacrificial jump off anodes at crossings near protected structures such as metal gas pipelines or electrical feeders.

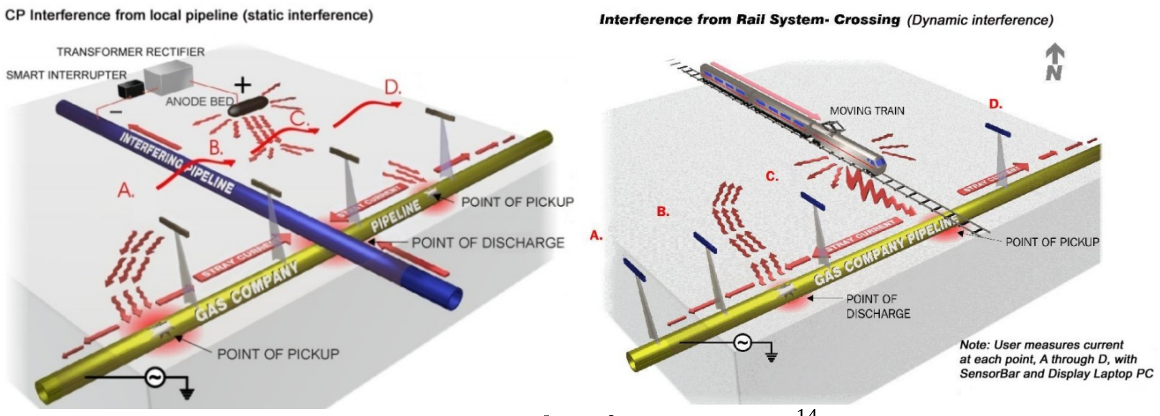


Figure 8 Examples of Stray Current[14]

[13] http://corrosion-doctors.org/StrayCurrent/Introduction.htm

[14] http://www.eastcomassoc.com/

APPENDIX D

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APGD PILE SPECIFICATIONS

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APGD PILE SPECIFICATIONS

Piling Equipment

The piling equipment used for the project shall conform to the specifications below.

Piling Rig – The contractor shall use equipment of adequate torque, crowd force, and power, to achieve the design tip elevation. As a minimum, the piling rig shall be capable of providing a minimum torque of 150,000 ft-lbs, and 25 tons of down crowd thrust.

Automated Monitoring Equipment – The drilling rig shall be equipped with an automated monitoring equipment (AME) designed to monitor the pile installation process. During the drilling process, the AME shall record auger depth, drill torque, and elapsed time. During the grouting process, the AME shall record the auger depth, grout pressure, and elapsed time.

Augers – The augers shall be capable of creating a minimum 18-inch diameter pile.

Grouting Equipment – A grout port shall be located near the tip of the displacement auger. A continuous system of grout mixing, pumping, and agitating equipment shall be utilized. Equipment shall be maintained in good working order to maintain a continuous flow of concrete during auger withdrawal. The grout pump shall be capable of developing displacement pressures of 250-psi.

Pile Installation Procedures

The following installation procedures may be followed to install the APGD piles.

1. Contractor is responsible for using equipment of adequate torque, crowd, and power to achieve the design tip elevation. The piling rig and the flight augers used for the production pile installation shall be of identical design to that used for the indicator pile test program.
2. The flight auger is advanced until it reaches the design tip elevation. The grout port in the auger tool shall be closed with a plug that prevents soil and/or water from entering the hollow shaft while the auger is advanced into the ground.
3. The flight auger shall be capable of creating a smooth walled shaft with a minimum of 18 inches in diameter (both test piles and production piles shall be a minimum of 18 inches in diameter).
4. A minimum delivery pressure of 250 psi plus the hydraulic pressure developed by the grout column in the drill stem shall be applied to create the pile. The operator shall maintain positive rotation of the displacement auger continuously throughout the grouting process until the displacement element is completely retracted from the ground.

5. The piling rig shall be equipped with automated monitoring equipment (AME) to record the auger depth, drill torque, grout pressure, and elapsed time. All recorded data shall be provided for review.
6. Once the grouted pile shaft is filled with concrete, the steel reinforcing cage shall be inserted into the wet concrete pile. All reinforcing elements shall be fitted with centralizers or clip spacers.

Indicator Pile Test Program

An indicator pile test program must be performed and approved prior to installation of the production piles. The number of indicator test piles shall be a minimum of 2 test piles, or equivalent to 1 percent of the total number of production piles, whichever is greater. Pile load tests shall be performed from the proposed subgrade elevation.

Compression load tests will be performed on all indicator test piles. Axial compressive load test shall be performed in accordance with ASTM D1143. The test piles and reaction piles shall be considered sacrificial and shall not be utilized for foundation support of the proposed buildings. The allowable pile capacities and pile lengths presented herein are subject to be confirmed, or altered depending on the results of the indicator pile load test program. Additional foundation piles may be necessary if the actual load tests do not meet the recommended allowable loads presented in this report.

Below is a summary of the indicator pile load test program.

- The number of indicator test piles shall be a minimum of 2 test piles, or equivalent to 1 percent of the total number of production piles, whichever is greater.
- Load tests shall be performed on sacrificial test piles in accordance with ASTM D1143 (Axial Compressive Load). The design load shall be held until the measured creep does not exceed 0.005 inch per hour. Piles with a settlement rate exceeding 0.005 inch/hour under the design load during a pile test will be rejected.
- Pile load tests shall be performed to a minimum load equivalent to the ultimate capacity, which is two times the allowable capacity.
- Test piles and reaction piles shall be sacrificial and shall not be incorporated as foundation piles. Sacrificial test piles and reaction piles shall be cut off 3 feet below the finished grade and abandoned in place following the completion of the testing program.
- Gamma-Gamma density logging (GDL) and Low Strain Pile Integrity Tests (PIT) shall be performed on all test piles and reaction piles. GDL shall be performed in accordance with Caltrans CT 233. PIT shall be performed in accordance with ASTM D5882.
- One test pile shall be exhumed from the ground to physically examine the pile integrity.
- Results of the pile load testing will be submitted as a summary letter for review and approval.

Geotechnical Pile Inspections

During pile installation, a Grading Inspector shall record and maintain data for each pile, including the following:

- Pile Number
- Installed pile length
- Auger torque vs. depth
- Head pressure inside the tremie pipe vs. depth
- Drilling rate vs. depth
- Concrete volume vs. depth
- Unanticipated site conditions if any

Non-Destructive Testing

None-destructive testing methods shall be employed to evaluate the integrity of the piles installed to provide quality control and assurance of the pile construction method.

- Gamma-Gamma density logging (GDL) and Low Strain Pile Integrity Tests (PIT) shall be performed on all test piles and reaction piles. GDL shall be performed in accordance with Caltrans CT 233. PIT shall be performed in accordance with ASTM D5882.
- Low Strain Pile Integrity Tests (PIT) shall be performed on 10 percent of the production piles.
- If any PIT test indicates a discontinuity within a tested pile, that pile shall be evaluated by the geotechnical and structural engineers. Unsatisfactory piles may be abandoned in place and shall be replaced with replacement piles.