Peters & Ross

Geotechnical & Geoenvironmental Consultants

Geotechnical Investigation
Chang Residences

Webster & Illinois Streets, Fairfield, California

Project No. 20115.001

May 2020

Peters & Ross

Geotechnical & Geoenvironmental

Consultants

May 6, 2020
Project No. 20115.001

Mr. Vincent Chang
466 36th Avenue
San Francisco, CA 94121

RE: Geotechnical Investigation – Chang Residences
NW Corner of Webster and Illinois Streets in Fairfield, California

Dear Mr. Chang:

In accordance with your authorization, Peters & Ross has completed a geotechnical investigation for the planned two new residences to be constructed at the above referenced address. The accompanying report presents the results of our field investigation, laboratory testing, and engineering analyses. Based on this information, it is Peters & Ross' opinion that the site is suitable for the proposed residential development.

Peters & Ross should also be retained:

- to review geotechnical aspects of project plans and specifications,
- to provide supplemental recommendations should significant changes in the planned improvements be made, and
- to provide geotechnical engineering observation and testing services during construction, in order to check that the recommendations presented in this report are properly implemented into the completed project.

We appreciate the opportunity to provide geotechnical engineering services to you. If you have any questions, please call.

Sincerely,

Peter K. Mundy, P.E., G.E.
Geotechnical Engineer 2217

REGISTERED PROFESSIONAL ENGINEER
PETER K. MUNDY
No. 2217
Expires 3/21
GEOTECHNICAL
STATE OF CALIFORNIA

INTRODUCTION

This report presents the results of a geotechnical investigation performed by Peters & Ross for the two planned new residences to be constructed on the vacant parcel located on the northwest corner of Illinois and Webster Streets in Fairfield, California. The location of the project is shown on the Site Vicinity Map, Figure 1. The ground surface topography near the site is shown on Figure 2.

Project Description

The subject property consists of two 50 feet by 75 feet rectangular lots, located along the west side of Webster Street. The vacant lots are relatively level and are covered with grass and some mature trees. The nearby neighborhood is residential. Peters & Ross understands that a new two-story, wood-frame home will be constructed in the center of each lot.

Scope of Services

Peters & Ross scope of services for the project was presented in our proposal dated February 28, 2020. Our services on the project were limited to the following:

- Performing two electric piezocone penetrometer tests (CPT) and one exploratory test boring to a depth of 50 feet to assess liquefaction
- Performing engineering analyses sufficient to develop conclusions and recommendations regarding:

    1. Site geology and seismicity
    2. Soil and groundwater conditions
    3. Site preparation, excavation, and grading
    4. The most appropriate foundation type for the new residences
    5. Geotechnical design parameters for the recommended foundation type
    6. Geotechnical aspects of site drainage
    7. Construction considerations

- Preparing this report.

FIELD EXPLORATION

Subsurface conditions were explored by performing two CPT tests and drilling one exploratory test boring to a depth of 50 feet at the locations shown on the Site Plan, Figure 3. Samples of the materials encountered in the boring were obtained at frequent depth intervals, for field classification and laboratory testing. A description of the drilling and sampling equipment used and other details of the subsurface exploration, as well as the CPT and boring logs showing the materials encountered are included in Appendix A. The laboratory tests performed are discussed in Appendix B.

SITE CONDITIONS

Geology and Seismicity

The site is located near the margin of the Great Valley Geomorphic Province of California. The Great Valley Province is an asymmetric trough filled with a thick sequence of sediments from the Jurassic to present age. The sediments within the Great Valley vary between 5 and 10 kilometers in thickness and were mostly derived from erosion of the Sierra Nevada mountain range to the east, with lesser material from the Coast Range to the west. Locally, Bezore et.al. (1998), indicate that the site is underlain by late Holocene age basin deposits which consist of interstratified gravel, sand, silt, and clay, and tend to be more fine-grained.

The site is about 10.5 kilometers northeast of the Concord-Green Valley Fault. This and other regional faults are capable of generating large magnitude earthquakes that could cause strong groundshaking at the site. The site is not within an Alquist-Priolo Earthquake Fault Zone delineated by the State Geologist, and therefore the risk of fault offset across the site is remote. However, the Solano County General Plan indicates that the site is located in an area designated as highly susceptible to liquefaction.

It should also be noted that the site falls within the FEMA High Risk Flood Zone designated AE with a flood elevation of 10 feet. Thus, living space should be established above the 100 year flood level elevation.

Subsurface Conditions

In Boring B-1 we encountered five feet of fill materials. The upper one foot of the fill materials consisted of sandy fat clay. Atterberg limits tests indicate that the sandy fat clay has a liquid limit of 56 percent and a plasticity index of 32 percent, with 57 percent passing the #200 sieve. These results indicate that the sandy fat clay has a high expansion potential (expansive soils shrink and swell in response to changes in moisture). The sandy fat clay graded to clayey sand with gravel. The 5 feet of fill materials were underlain by 7 feet of fat clay materials. Atterberg limits tests at a depth of 11.5 feet have a liquid limit of 53 percent and a plasticity index of 34 percent, with 92 percent passing the #200 sieve. These fat clay materials have a high expansion potential. The fat clay materials were underlain by 11 feet of sandy lean clay to clayey sand materials. The sandy lean clay to clayey sand was underlain by 11 feet of interbedded clayey sand with gravel and sandy lean clay materials. The interbedded materials were underlain by 11 feet of lean clay with sand materials. The lean clay with sand is underlain by silty sand materials which extend to the depths explored. Atterberg limits tests at a depth of 50 feet have a liquid limit of 18 percent and a plasticity index of 2 percent, with 25 percent passing the #200 sieve. These results indicate that the fines in the silty sand materials are non-plastic and liquefiable.

In general, CPT testing revealed highly variable subsurface conditions consistent with Boring B-1 and the mapped geologic description of thick Holocene basin deposits. Both CPT-1 and CPT-2 were advanced to a depth of about 50 feet and generally encountered interbedded clays, silt and sand mixtures to the depth explored.

Groundwater

Groundwater was encountered at a depth of about 3.0 feet during drilling and measured at 5.5 feet prior to grouting the holes per the Solano County boring permit requirements. It should be noted that fluctuations in the groundwater level may occur due to variations in rainfall, temperature and other factors not evident at the time the measurements were made.

CONCLUSIONS AND RECOMMENDATIONS

Based on the field investigation, laboratory testing, engineering analysis, and site observations completed during this investigation, it is Peters & Ross opinion that from a geotechnical engineering perspective the site is suitable for the planned new residences. However, all of the recommendations presented subsequently should be incorporated into project plans and specifications, to reduce the likelihood of foundation problems and settlement. The primary geotechnical concerns are the presence of existing fill, expansive soils, liquefiable soils that are susceptible to seismic compression and/or liquefaction, and that the property is within a mapped FEMA flood zone.

1. Existing Fill Materials

It appears that fill materials were placed during the 1950s to raise the grade of the existing vacant lot. Based on our observations it is likely that these fill materials were not placed and compacted according to accepted modern standards. Improperly placed fill soils could settle if loads were applied directly to them from shallow foundations (such as footings) or slabs. Peters & Ross recommends that the upper 3 feet of existing fill materials be raked, processed, and recompacted.

2. Expansive Soils

The clayey soils that blanket the site have a high expansion potential. When expansive soils are subjected to increases in moisture content, such as during the rainy season, they swell if unconfined. If concrete slabs or shallow foundations confine the expansive soils, they can exert significant pressures when subjected to moisture increases. These pressures can cause slabs and shallow foundations to heave and crack. When the soils dry, they shrink, causing slabs and shallow foundations to settle.

Expansive clays are common in the San Francisco Bay Area. Over the past several decades, expansive soil movements have caused extensive damage to residential and commercial structures, slabs, and pavements throughout the Bay Area. The local climate, with its pronounced wet and dry seasons, is a main cause of significant seasonal moisture changes that cause the expansive soils to shrink and swell.

There are a number of methods available for reducing the adverse effects of expansive soils. These include removing the expansive soils, replacing expansive soils with non-expansive engineered fill, deepening foundations to develop support below the zone of significant seasonal moisture change (about 32 to 48 inches), designing foundation/slab systems to resist uplift pressures generated by swelling soils, and/or providing drainage and landscaping to minimize seasonal moisture fluctuations in the near-surface soils. Drainage and landscaping improvements adjacent to slabs and foundations should be designed to promote efficient runoff during the rainy season and provide occasional sprinkling during the summer.

In order to minimize the adverse effects of expansive soils, the proposed residences should be supported on a stiffened reinforced mat foundation system.

3. **Seismic Concerns**

In accordance with Section 1613 of the 2019 CBC, Peters & Ross classifies the site as a D Site Class with latitude 38.244 degrees and longitude of -122.044 degrees. The CBC parameters presented in the following table should be used for seismic design.

SITE CLASS B - PERIOD (SEC)	0.2	1.0
SPECTRAL RESPONSE S_s, S_l	1.614	0.566
SITE COEFFICIENT F_a, F_v (SITE CLASS D)	1.0	1.75
MAXIMUM SPECTRAL RESPONSE S_{ms}, S_{ml}	1.614	0.991
DESIGN SPECTRAL RESPONSE S_{Ds}, S_{Dl}	1.076	0.660

The site is mapped to be within a potentially liquefiable zone on the Solano County Seismic Hazard map and we encountered liquefiable materials in both the CPT and exploratory test holes. Based on the collected field data and the laboratory test results, Peters & Ross performed an assessment of liquefaction and its impact on the proposed improvements.

4. **Liquefaction Analysis**

Peters & Ross performed an evaluation of liquefaction potential using the data obtained from the exploratory test boring and CPTs, in accordance with the procedures outlined by Boulanger and Idriss dated April 2014. Peters & Ross first used the OSHPD Earthquake

Ground Motion Tool (2018) to find the peak ground accelerations (PGA) of 0.658g with a 10% chance of being exceeded in the next 50 years. A site amplification factor of 1.1 was used for the PGA which resulted in a site modified peak ground acceleration of 0.723g. Then we used the computer software program CLiq by Geologismiki to perform a liquefaction analysis of the CPT results and LiqSVs by Geologismiki to assess the data from the exploratory test boring and laboratory results. In addition, we used the computer program CPeT-IT by Geologismiki to assess the geotechnical performance parameters for use in site class identification and static settlement computations. The results of the analysis are included in Appendix C. The liquefaction induced settlement was estimated to be 4.0 inches with a differential settlement of 2.0 inches. In order to mitigate liquefaction-related settlement, Peters & Ross recommends that the new foundation consist of a well reinforced mat foundation.

5. Site Preparation, Excavation, and Grading

5.1 Clearing and Site Preparation

Since five feet of debris ridden fill materials were encountered, Peters & Ross recommends that the upper 3 feet of the existing fill materials be thoroughly raked and that all debris in excess of 3 inches be removed from the site. This should extend 5 feet beyond the footprint of the new homes and the proposed driveway and patio areas. The raked soils should then be placed and compacted in accordance with the requirements given below under Compaction. We recommend that this process be carried out under the observation of the soil engineer, so that the existing fill materials are properly raked and backfilled.

After clearing, the portions of the site containing surface vegetation or organic laden topsoil should be stripped to an appropriate depth to remove these materials. The amount of actual stripping should be determined in the field by the soil engineer at the time of construction. The cleared and stripped layer should be removed from the site or stockpiled for later use in landscaping, if desired.

5.2 Subgrade Preparation

After the site has been properly cleared and stripped and any necessary excavations made, the exposed soils which will receive structural fill, slabs-on-grade or pavements should be scarified to a depth of 6 inches, moisture conditioned to slightly above optimum water content, and compacted to the requirements for structural fill.

5.3 Material for Fill

All on-site soils below the stripped layer having an organic content of less than 3 percent by volume are suitable for use as fill. Fill placed at the site, should not contain rocks or lumps larger than 6 inches in greatest dimension with not more than 15% larger than 2.5 inches. Import fill should be predominantly granular with a plasticity index of 12 or less.

5.4 Compaction

All structural fill less than 5 feet thick should be compacted to at least 90% relative compaction as determined by ASTM Test Designation D 1557, except for the upper 6 inches of subgrade soils under pavements which should be compacted to at least 95% relative compaction. Fill material should be spread and compacted in lifts not exceeding 8 inches in uncompacted thickness. We should note that if construction proceeds during or immediately after the wet winter months, it may require time to dry the on-site soils to be used as fill since their moisture content will probably be appreciably above optimum.

5.5 Trench Backfill

Pipeline trenches should be backfilled with fill placed in lifts not exceeding 8 inches in uncompacted thickness. Backfill should be compacted to 90% relative compaction. If imported granular soil is used, sufficient water should be added during the trench backfilling operations to prevent the soil from "bulking" during compaction. In all of the cases outlined above, we recommend that the upper 6 inches of subgrade under pavement and baserock be compacted to at least 95% relative compaction. All compaction operations should be performed by mechanical means only.

5.6 Drainage

Positive surface drainage should be provided adjacent to the new residences to direct surface water away from the foundations into closed pipes that discharge to appropriate drainage facilities. Flexible drain pipe (flexline), 2000-pound crush pipe, leachfield, and ASTM F810 pipe are not recommended for use in the surface water drainage system because of the likelihood of damage to the pipe during installation due to the weak strength of these pipes. In addition, these drainpipes are sometimes difficult to clean with mechanical equipment without damaging the pipe. We recommend the use of Schedule 40 PVC, SDR 35 PVC or ABS, Contech A-2000 PVC drainpipe, or equivalent for the drain system. Ponding of surface water should not be allowed in any areas adjacent to site improvements.

We also recommend that rainwater collected from the roofs of the houses and in landscaped areas be transported through gutters, downspouts, and closed pipes that lead to suitable discharge facilities designed in accordance with the project landscape architect or civil engineer. We should note that suitable discharge facilities do not include so called "dry wells" and these should be avoided.

Some nominal maintenance of the drainage facilities should be expected after the initial construction has been completed. Should ownership of these residences change hands, the new owners should be informed of the existence of this report, not adversely change the grading or drainage facilities, and understand the importance of maintaining proper surface drainage.

6. Foundations

The site is blanketed by highly expansive soils underlain by moderately compressible and liquefiable Holocene basin deposits. If the proposed new residences are supported on a shallow foundation system, settlement will occur due to compression of the underlying deposits under static foundation loads. In addition, the shallow foundation system may also experience liquefaction-induced total and differential settlements which will exceed the typical tolerance of a conventional slab foundation system. Therefore Peters & Ross recommends that the proposed new residences be supported on a well reinforced mat foundation.

6.1 Mat Foundation

We recommend that in order to minimize the adverse effects of expansive and liquefiable soils, the proposed new residences could be supported on a well-reinforced concrete mat foundation. The mat can be designed for an allowable bearing capacity of 1000 pounds per square foot for dead plus live loads. This allowable bearing pressure is a net value; therefore, the weight of the mat can be neglected for design purposes. The mat should be designed so that the mat foundation system moves as a unit. The mat should be reinforced with top and bottom steel in both directions to allow the foundation to span local irregularities, on the order of 10 feet in diameter, that may result from potential differential settlements. The corners of the mat should be designed as a 5-foot cantilever.

Peters & Ross used the computer program CPeT-IT to estimate primary consolidation settlement of the mat. We anticipate a total static settlement of 0.5 inches with a differential settlement of 0.25 inches in 30 feet. The seismic settlement would be added to the static values for a total of up to 4.5 inches of settlement with 2.75 inches of differential settlement in 30 feet. Therefore, Peters & Ross recommends that the concrete mat be reinforced to withstand distortions on the order of 0.0075L.

Lateral loads on the structure may be resisted by passive pressures acting against the sides of the mat. We recommend an allowable passive pressure equal to an equivalent fluid weighing 300 pounds per cubic foot per foot of depth. Alternatively, an allowable friction coefficient of 0.35 can be used between the bottom of the mat and the subgrade soils. If the perimeter of the mat is poured neat against the soils, the passive pressure and friction coefficient may be used in combination.

To evaluate pressure distribution beneath the mat foundation, we recommend a modulus of subgrade reaction (K_s) of 50 kips per cubic foot (kcf). This value has been corrected to take into account the mat width and may be increased by 1/3 for total load considerations.

Once the structural engineer estimates the distribution of bearing stress on the bottom of the mat, we should review the distribution and revise the modulus of subgrade reaction, if appropriate.

In areas where floor wetness would be undesirable, either 4 inches of free draining gravel or a properly designed waterproofing membrane can be used. Peters & Ross recommends that an allowable friction coefficient of 0.25 be used between the waterproofing membrane and the subgrade soils. Four inches of gravel should be placed beneath the mat to serve as a capillary barrier between the subgrade soil and the mat. In order to minimize vapor transmission through the gravel, a 10 mil visqueen should be placed over the gravel. The visqueen should be covered with 2 inches of sand to protect it during construction of the mat. The sand should be lightly moistened just prior to placing the concrete. We also recommend that the specifications for the mat require that moisture emission tests be performed on the mat prior to the installation of the flooring. No flooring should be installed until safe moisture emission levels are recorded for the type of flooring to be used.

Due to the possibility of localized differential movements around the new foundation, flexible utility connections should be installed to reduce the likelihood of any utility pipes shearing off over the years or during severe movements. We anticipate that the mat foundation will generally perform well during a major earthquake but may need some releveling after the event.

7.0 Exterior Slabs-on-Grade

We recommend that any slabs-on-grade be supported on a minimum of 9 inches of imported, compacted, non-expansive fill. The subgrade should be recompacted to at least 90 percent relative compaction at a moisture content of 5 percent above optimum. The subgrade should be kept moist until the slab is poured. In any slab area where minor floor wetness would be undesirable, at least 4 inches of ¾ inch gravel should be placed over the prepared subgrade, to provide a capillary moisture break. A 10-mil thick vapor barrier blanketed with 2 inches of clean sand should be placed over the gravel. This can be used in lieu of the upper 6 inches of the non-expansive fill.

The slab should have a minimum thickness of 4-inches and should be reinforced with steel reinforcing bars rather than welded wire mesh. At a minimum, slab reinforcement should consist of No. 4 bars on 18-inch centers in both directions, placed at the center of the slab thickness. Spacers should be placed beneath the mesh of reinforcing bars, to maintain their positioning near the center of the slab during the concrete pour. Score joints should be provided at a maximum spacing of 10 feet in both directions. The slabs should be appropriately reinforced according to structural requirements; concentrated loads may require additional reinforcing.

Exterior slabs should be structurally independent from the mat foundations and be free floating.

8. Plan Review and Geotechnical Engineering Services during Construction

Peters & Ross should review project plans, to check that the geotechnical engineering recommendations contained in this report are properly incorporated.

Peters & Ross should provide geotechnical observation and testing services on an as-needed basis during construction, to check that geotechnical aspects of the work are completed in accordance with the plans. These services should include observing site preparation and grading, testing the compaction of fill, observing foundation excavations, and checking site drainage. In addition, Peters & Ross should provide consultation regarding geotechnical concerns that arise during construction. Peters & Ross cannot accept responsibility for geotechnical aspects of construction that are not observed by its staff.

We will make every reasonable effort to accommodate the contractor's work schedule during construction, so that necessary observations and tests can be performed in a timely manner to avoid construction delays. However, since our field services are often required on several projects concurrently, we request that 48 hours advance notice be given for site visits, in order to minimize scheduling conflicts.

LIMITATIONS

Peters & Ross services consist of professional opinions and recommendations that are made in accordance with generally accepted geotechnical engineering principles and practices. The opinions and recommendations presented in this report are based on a site reconnaissance, two CPT tests and one exploratory test boring, engineering analyses, and preliminary information provided by Monarch Engineers regarding the proposed new residences. This warranty is in lieu of all other warranties either expressed or implied.

Subsurface conditions commonly vary significantly from those encountered at the test boring locations. Unanticipated, adverse soil conditions encountered during construction often require additional expenditures to achieve a properly constructed project. It is advised that a contingency fund be established to accommodate possible consulting and construction cost increases due to unanticipated conditions.

LIST OF FIGURES

APPENDICES

DISTRIBUTION

5 copies: Mr. Vincent Chang
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San Francisco, CA 94121

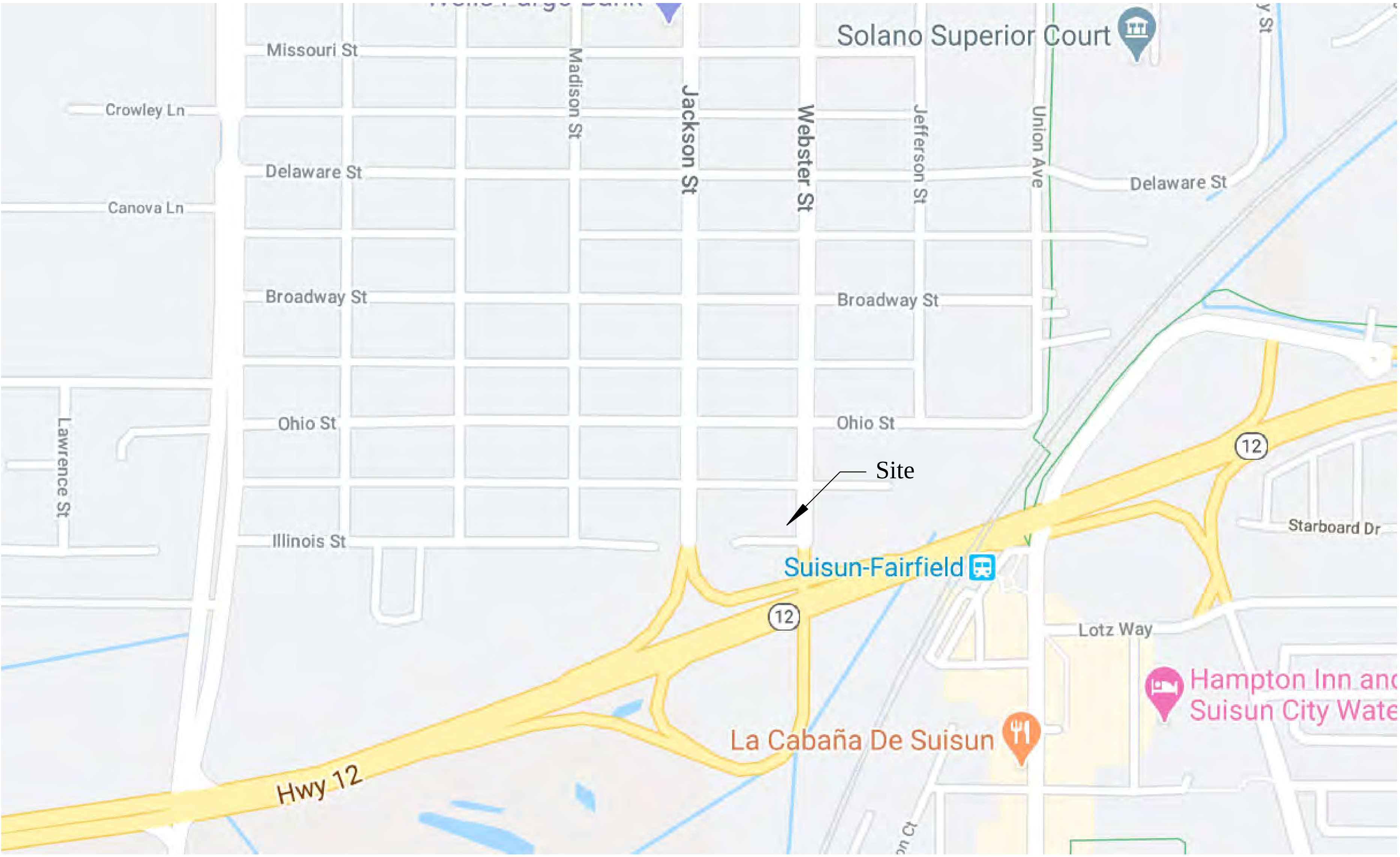

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Figure 1 - Site Vicinity Map

PROJECT No.
20115.001

DATE
May 2020

Chang Residences
NW Corner of Webster
and Illinois Streets
Fairfield, California

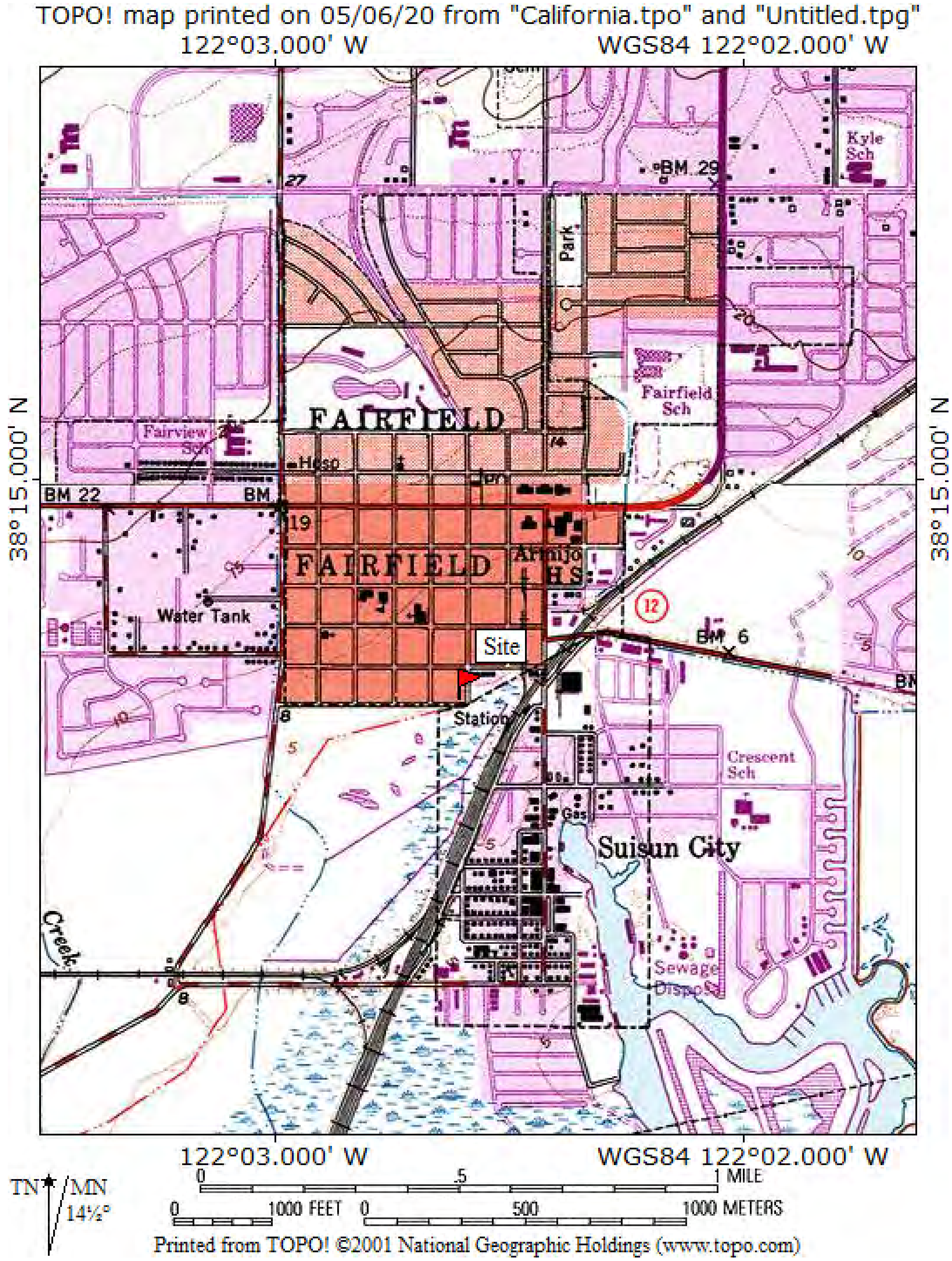

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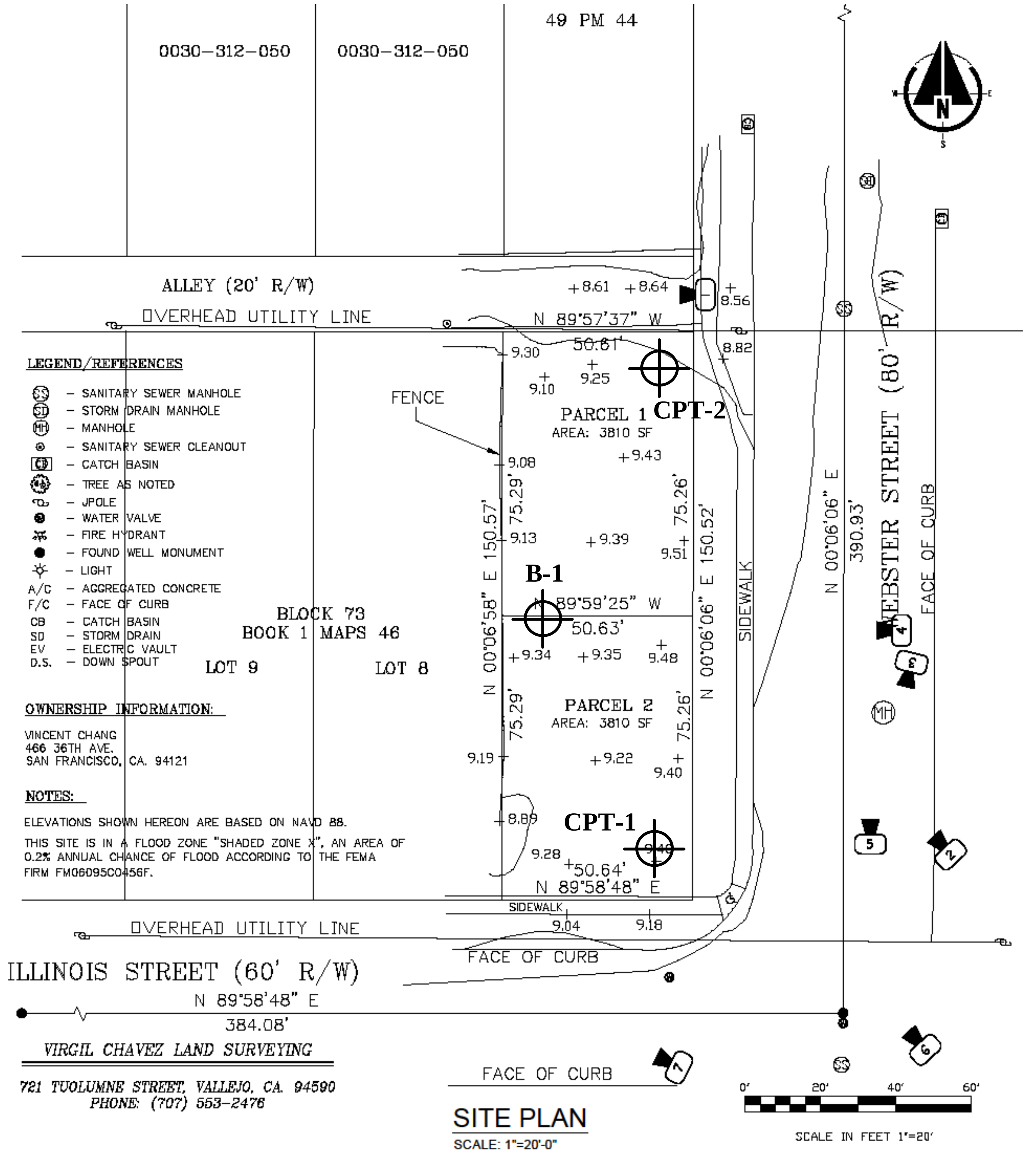
Figure 2 - Site Topography Map

PROJECT No.	Chang Residences NW Corner of Webster and Illinois Streets Fairfield, California
20115.001	
DATE	
May 2020	



EXPLANATION: ⊕ **B-1** Approximate Location of Exploratory Test Borings This Study

Figure 3 - Site Plan

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PROJECT No.	Chang Residences NW Corner of Webster and Illinois Streets Fairfield, California
20115.001	
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APPENDIX A – FIELD INVESTIGATION

Peters & Ross explored subsurface conditions at the site by drilling one exploratory test boring and two electric piezocone penetrometer tests (CPT) to a maximum depth of 50 feet. The locations of the test borings are shown on the Site Plan.

The boring was drilled with a portable, 3.5-inch diameter, hydraulic auger drill rig and the CPT was pushed with a 10-ton portable hydraulic rig. Both the drill and CPT rigs were operated by Benevent Building of Concord, California. Our field engineer continuously logged the materials encountered. The boring log and CPT plots that show the materials encountered are included in this Appendix. Soils are classified in accordance with the Unified Soil Classification System.

The boring and CPT logs indicate Peters & Ross interpretations of subsurface conditions encountered at the locations and times the boring was drilled and CPT pushed, and may not be representative of subsurface conditions at other locations and times. Stratification lines represent the approximate boundaries between soil and rock types. The transitions between soil and rock layers are often gradual.

Samples of the materials encountered were obtained at frequent depth intervals, for visual classification and laboratory testing. Samples in the exploratory test boring were obtained using a Modified California sampler (outer diameter of 3.0 inches, inner diameter of 2.5 inches) with thin-wall brass sampler liners, and a Standard Penetration Test sampler (outer diameter of 2.0 inches, inner diameter of 1.375 inches w/out liners). The samplers were driven using a 140 pound safety hammer lifted and dropped 30 inches using a rope and cathead system.

BOREHOLE B-1

Peters & Ross Geotechnical Services
114 Hopeco Road, Pleasant Hill, CA 94523
925-942-3629 PetersRoss@aol.com

Page: 1 of 3

Project Name: Chang Residences
Project No.: 20115.001
Location: NW Corner of Illinois & Webster St., Fairfield, CA
Client: Vincent Chang
Drilling Method: Portable Hydraulic Drill Rig w/ 3.5 in. SFA
Date Drilled: 4/20/2020
Elevation: 0
Water Level: See Note 3
Remarks: Samplers driven with 140 lb. safety hammer lifted and dropped 30 inches using a rope and cathead system

ELEVATION	DESCRIPTION	SYMBOL	DEPTH (ft)	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (pcf)	UNCONFINED STRENGTH (tsf)	REMARKS
	Ground Surface								
	Sandy Fat CLAY (CH-Fill) black, moist, medium stiff, concrete metal and wood debris	▩	0						LL=56%, PI=32% -200 = 57 percent
	Clayey SAND with Gravel (SC-Fill) dark brown, loose to very loose, wet, mixed with debris	▩	1 2	MC	14	19		>4.5	-200 = 34 percent
		▩	3 4	MC	4	12	106	0.5	-200 = 34 percent
	Fat CLAY (CH) mottled yellow brown with gray and some black specks, wet, medium stiff to stiff	▨	5 6	MC	10	26	84	0.75	-200 = 90 percent
		▨	7 8 9						
		▨	10 11	MC	32	38	85	3.0	LL=53%, PI=34% -200 = 92 percent
	Sandy Lean CLAY (CL) yellowish brown, wet, stiff	░	12 13 14						
		░	15 16	SS	15	22			-200 = 54 percent
		░	17 18						
	Clayey SAND (SC) yellowish brown, wet, medium dense	░	19						

Project Name: Chang Residences

Project No.: 20115.001

Location: NW Corner of Illinois & Webster St., Fairfield, CA

Client: Vincent Chang

Drilling Method: Portable Hydraulic Drill Rig w/ 3.5 in. SFA

Date Drilled: 4/20/2020

Elevation: 0

Water Level: See Note 3

Remarks: Samplers driven with 140 lb. safety hammer lifted and dropped 30 inches using a rope and cathead system

ELEVATION	DESCRIPTION	SYMBOL	DEPTH (ft)	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (pcf)	UNCONFINED STRENGTH (tsf)	REMARKS
	Clayey SAND (SC) yellowish brown, wet, medium dense		20	SS	13	23			-200 = 45 percent
			21						
			22						
	Interbedded Clayey SAND with Gravel (SC) and Sandy Lean CLAY (CL) brown and yellowish brown, wet, loose to medium stiff, subrounded fine gravel to coarse sand		23						
			24						
			25	SS	12	31			-200 = 82 percent
			26						
			27						
			28						
			29						
			30	SS	8	27			-200 = 14 percent -200 = 89 percent
			31						
			32						
			33						
	Lean CLAY with Sand (CL) orangish brown mottled with gray and black specks, wet, stiff		34						
			35	SS	17	24			-200 = 52 percent
			36						
			37						
			38						
			39						

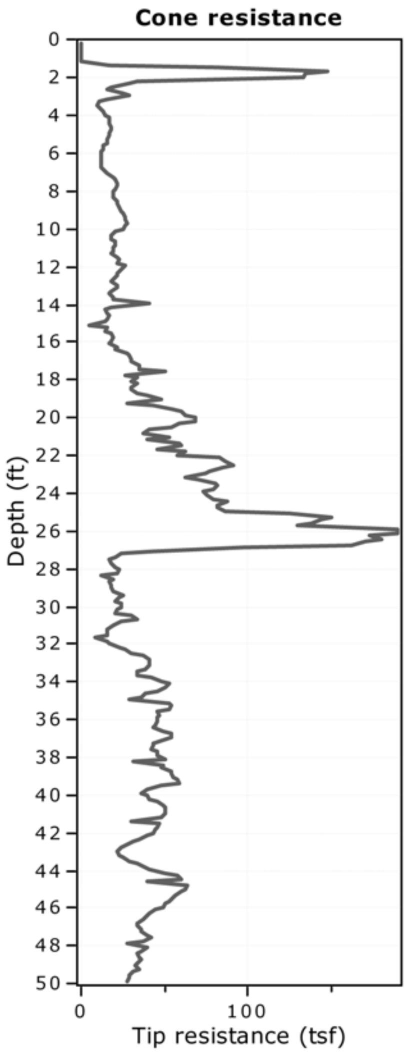
Project Name: Chang Residences
Project No.: 20115.001
Location: NW Corner of Illinois & Webster St., Fairfield, CA
Client: Vincent Chang
Drilling Method: Portable Hydraulic Drill Rig w/ 3.5 in. SFA
Date Drilled: 4/20/2020
Elevation: 0
Water Level: See Note 3
Remarks: Samplers driven with 140 lb. safety hammer lifted and dropped 30 inches using a rope and cathead system

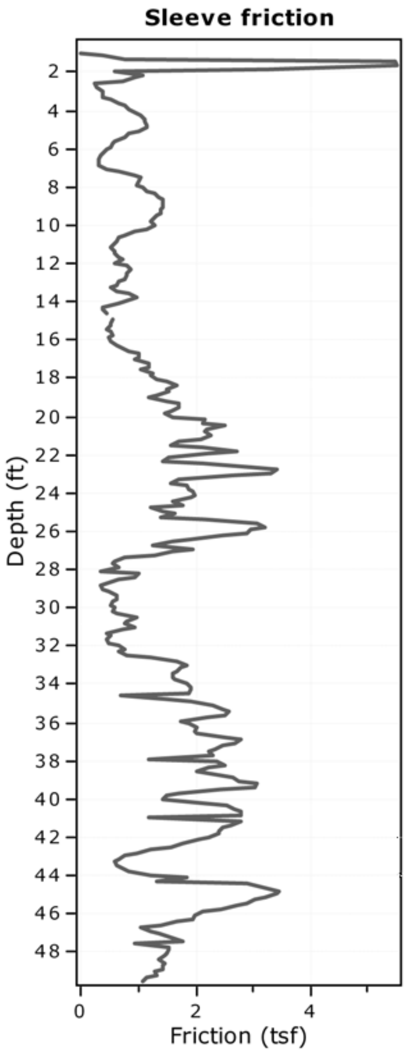
ELEVATION	DESCRIPTION	SYMBOL	DEPTH (ft)	SAMPLE TYPE	BLOWS/FT.	MOISTURE (%)	DRY DENSITY (pcf)	UNCONFINED STRENGTH (tsf)	REMARKS
	Lean CLAY with Sand (CL) orangish brown mottled with gray and black specks, wet, stiff		40						
			41						
			42						
			43	SS	15	27			-200 = 78 percent
			44						
	Silty SAND (SM) dark yellowish brown, wet, medium dense, fine grained		45						
			46						
			47						
			48						
			49	SS	13	24			LL=18%, PI=2% -200 = 25 percent
	End of Log		50						
			51						
			52						
			53						
			56						
			57						
			58						
			59						

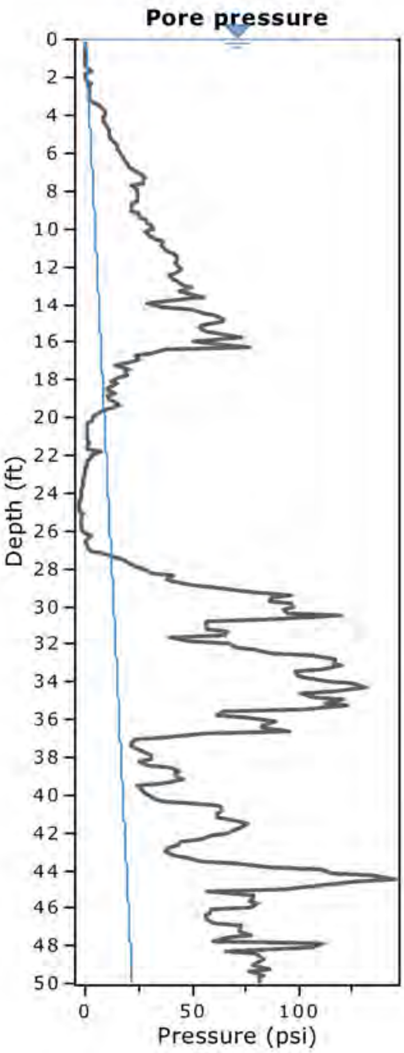
Notes:
1. Penetration resistance values are not standard N values, they are the raw values measured in the field.
2. Stratification lines represent the approximate boundaries between material types, the transitions may be gradual.
3. Groundwater was encountered at a depth of 3 feet during drilling and was measred at 5.5 feet just prior to grouting the hole per the Solano County drilling permit requirements.
4. Unconfined compressive strengths were obtained with a pocket penetrometer.

CPT: CPT-1
Total depth: 49.87 ft, Date: 4/30/2020
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

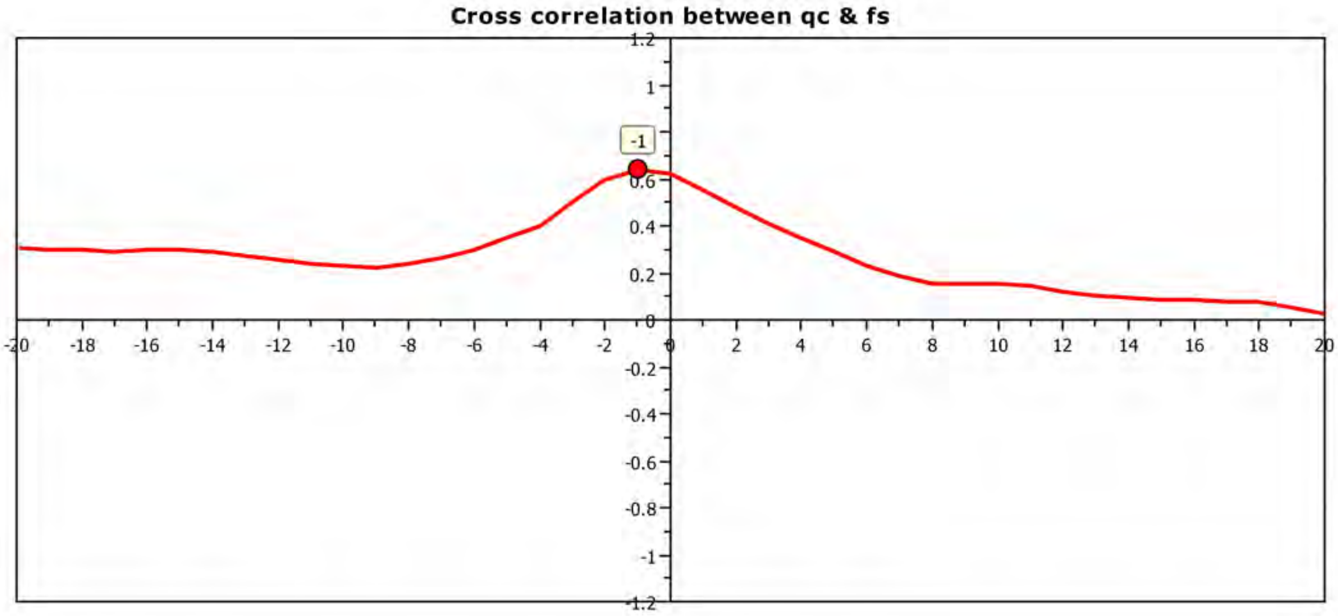
Project: **Chang Residences**
Location: **Webster and Illinois Streets, Fairfield, CA**



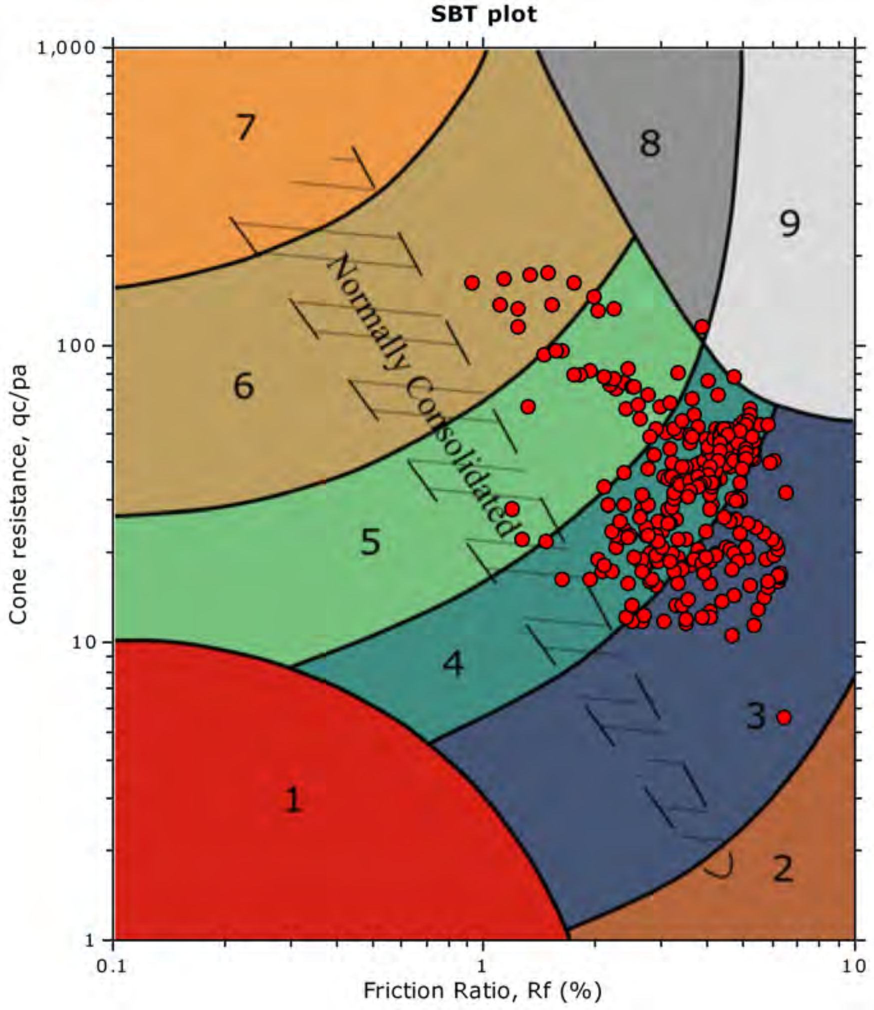


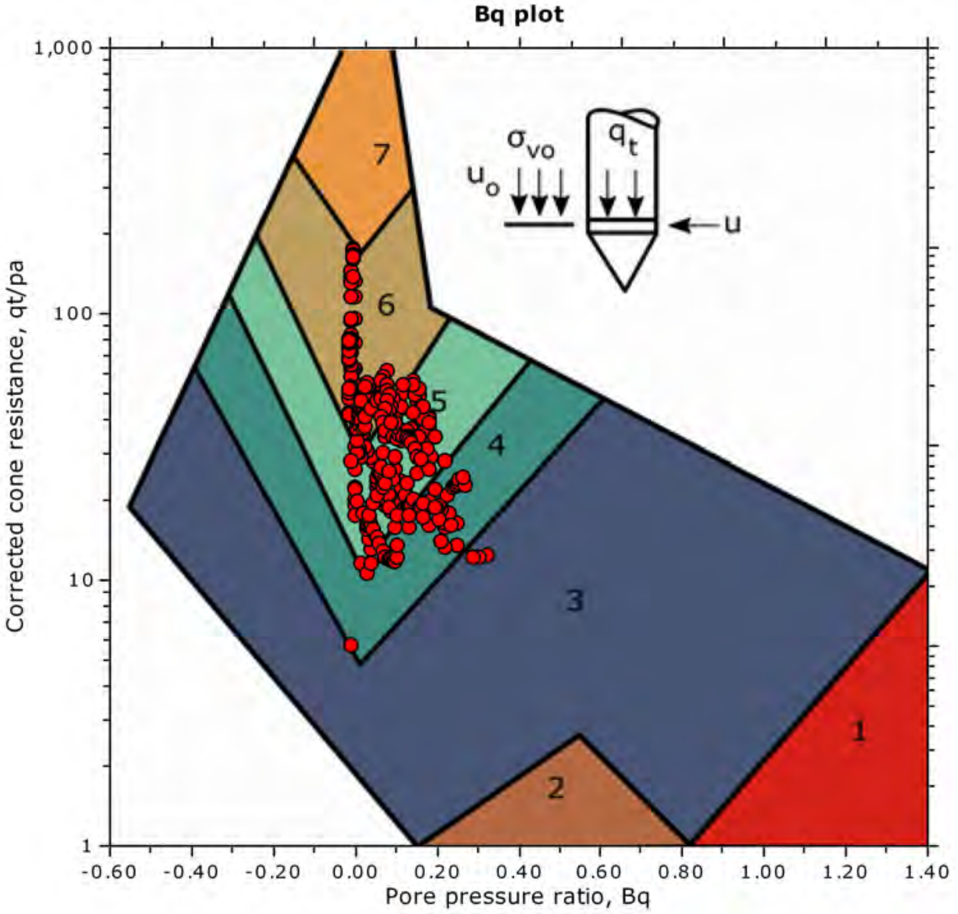


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots





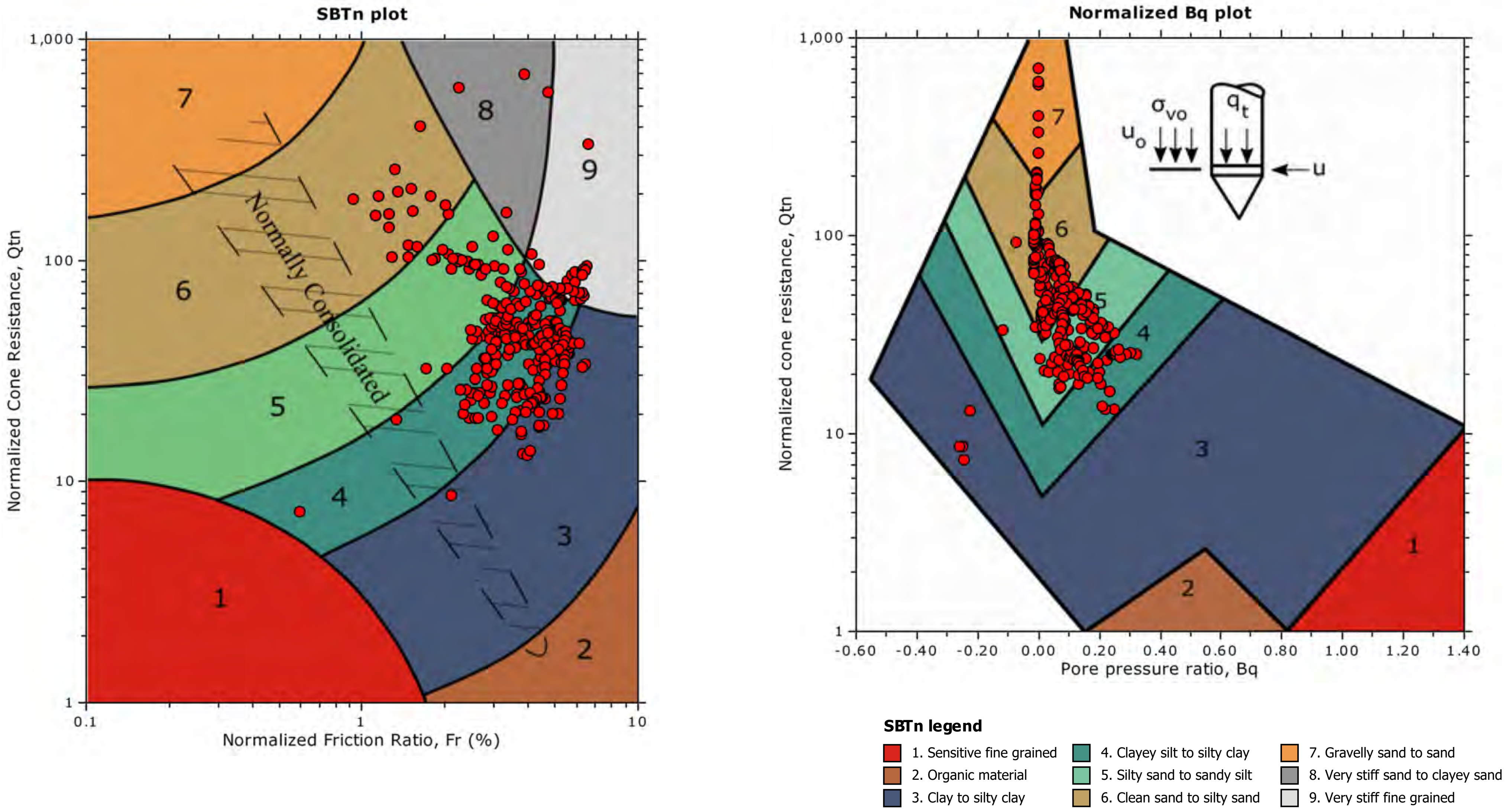
SBT legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty clay
- 🟩 5. Silty sand to sandy silt
- 🟨 6. Clean sand to silty sand
- 🟧 7. Gravelly sand to sand
- ⬛ 8. Very stiff sand to clayey sand
- ⬜ 9. Very stiff fine grained

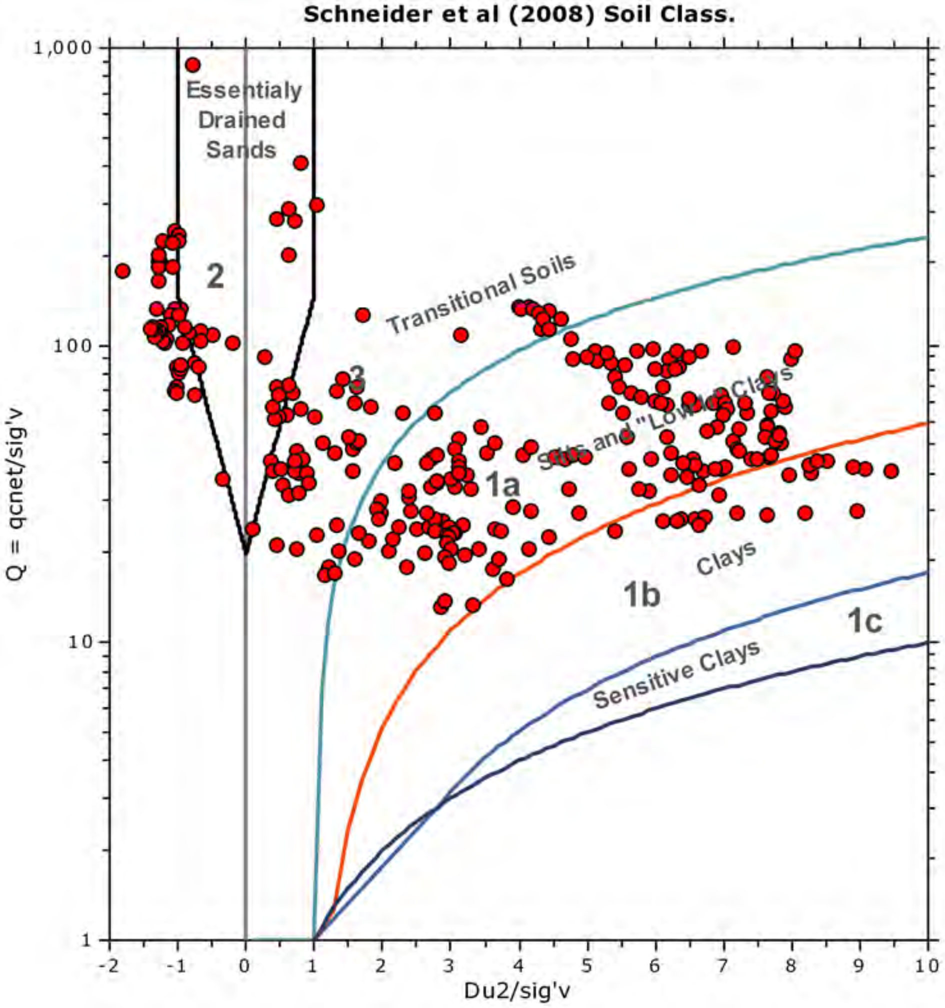
CPT: CPT-1
Total depth: 49.87 ft, Date: 4/30/2020
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

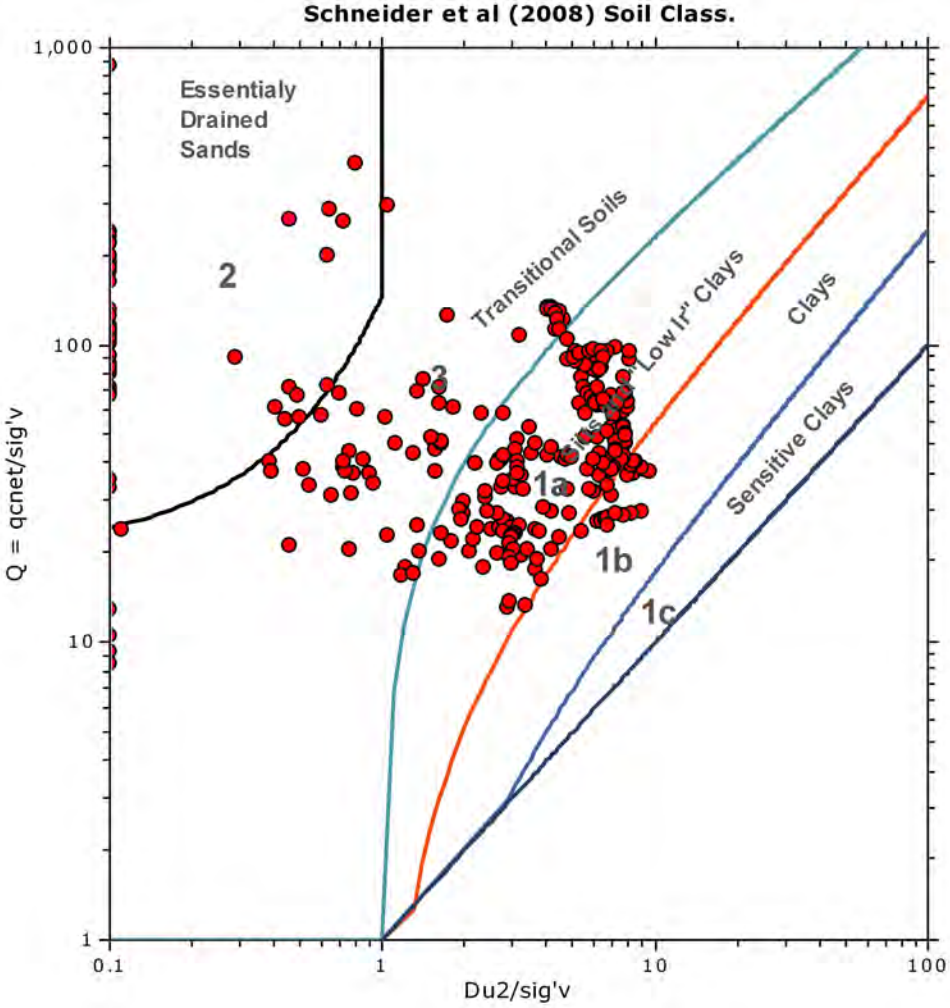
Project: **Chang Residences**
Location: **Webster and Illinois Streets, Fairfield, CA**

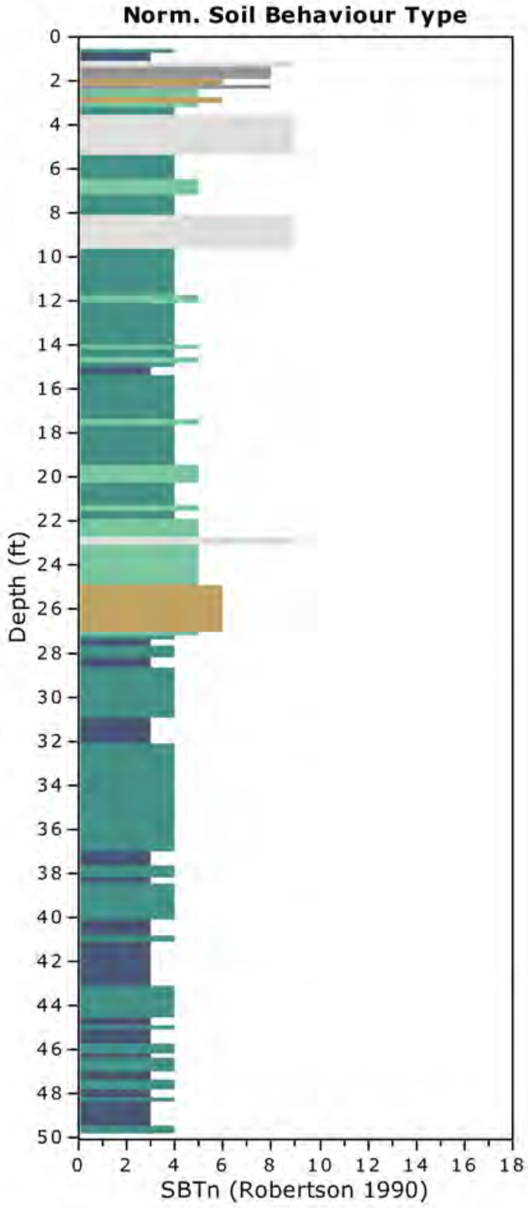
SBT - Bq plots (normalized)

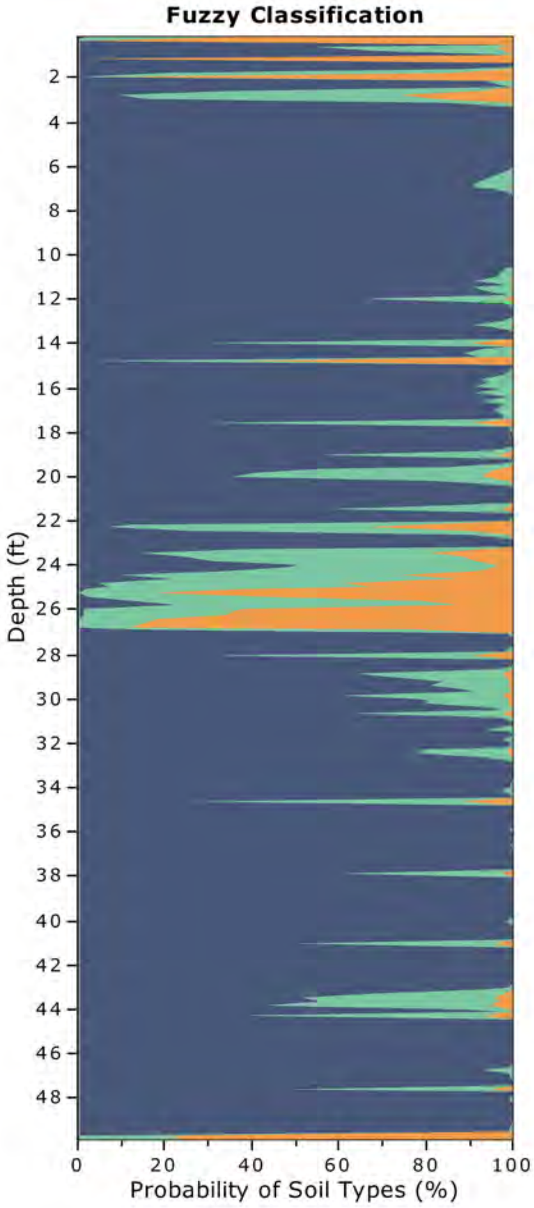


Bq plots (Schneider)

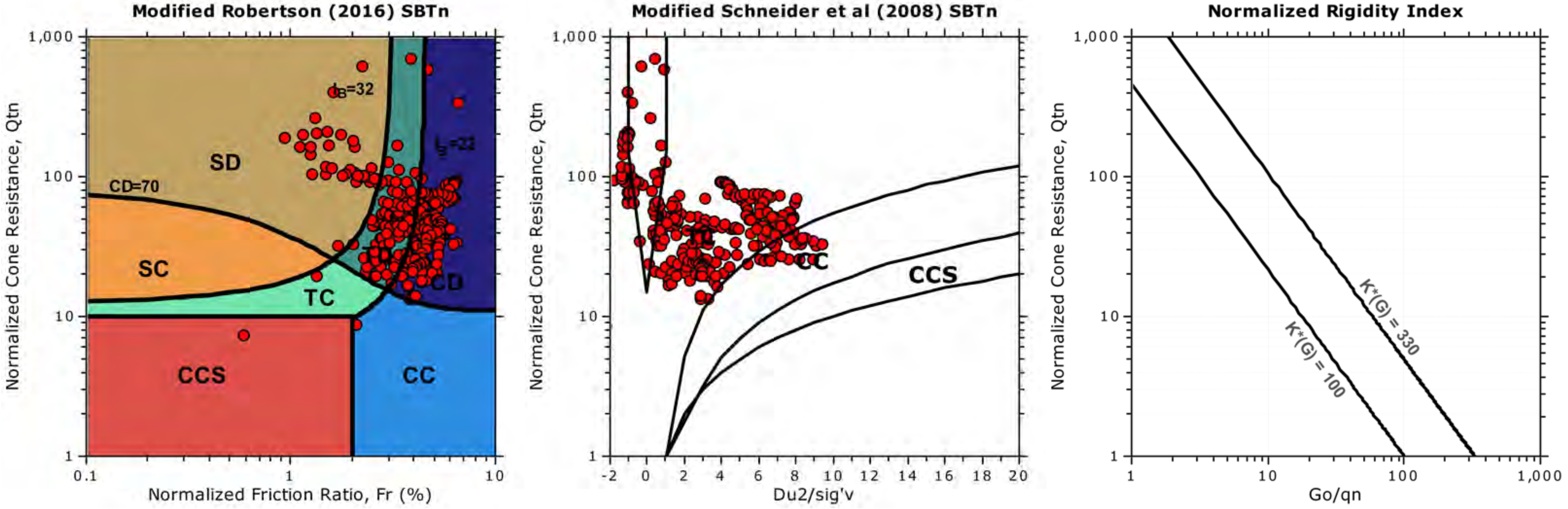





Norm. Soil Behaviour Type
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
0 2 4 6 8 10 12 14 16 18
SBTn (Robertson 1990)

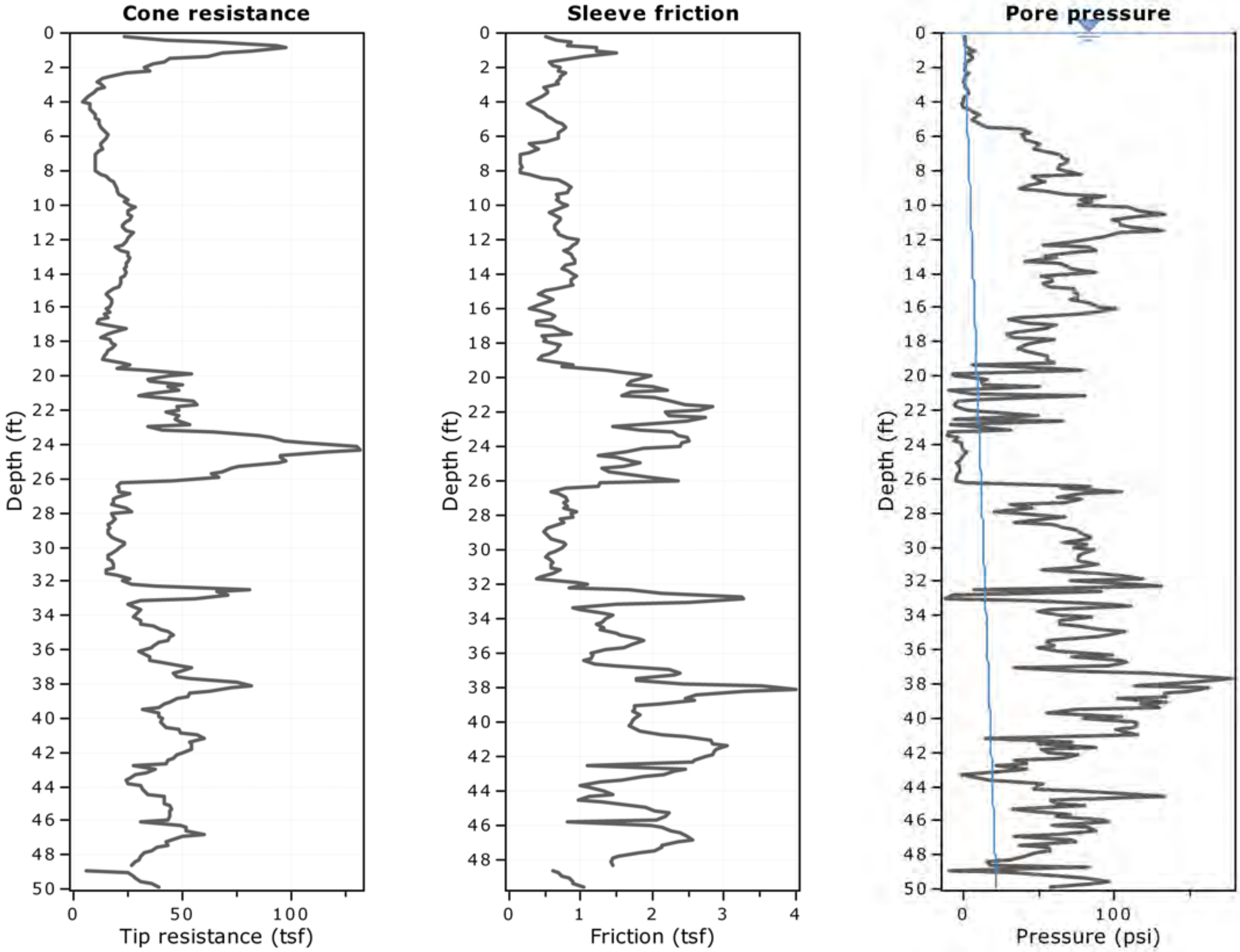

Fuzzy Classification
Depth (ft)
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
0 20 40 60 80 100
Probability of Soil Types (%)

Updated SBTn plots

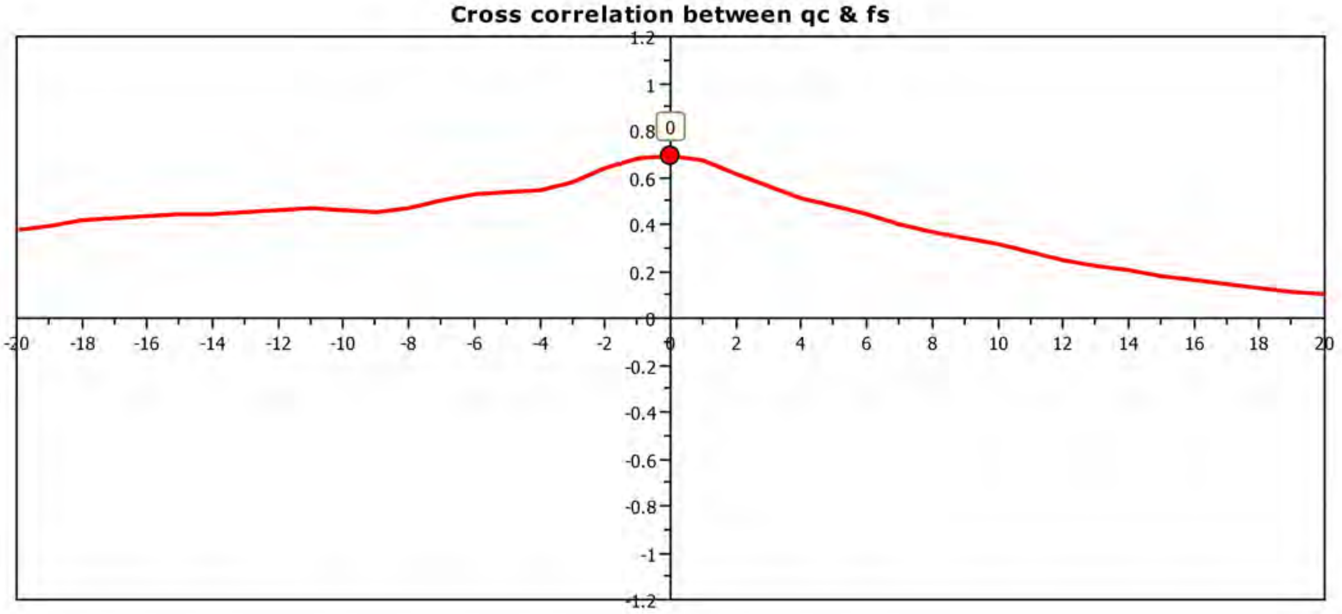


CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

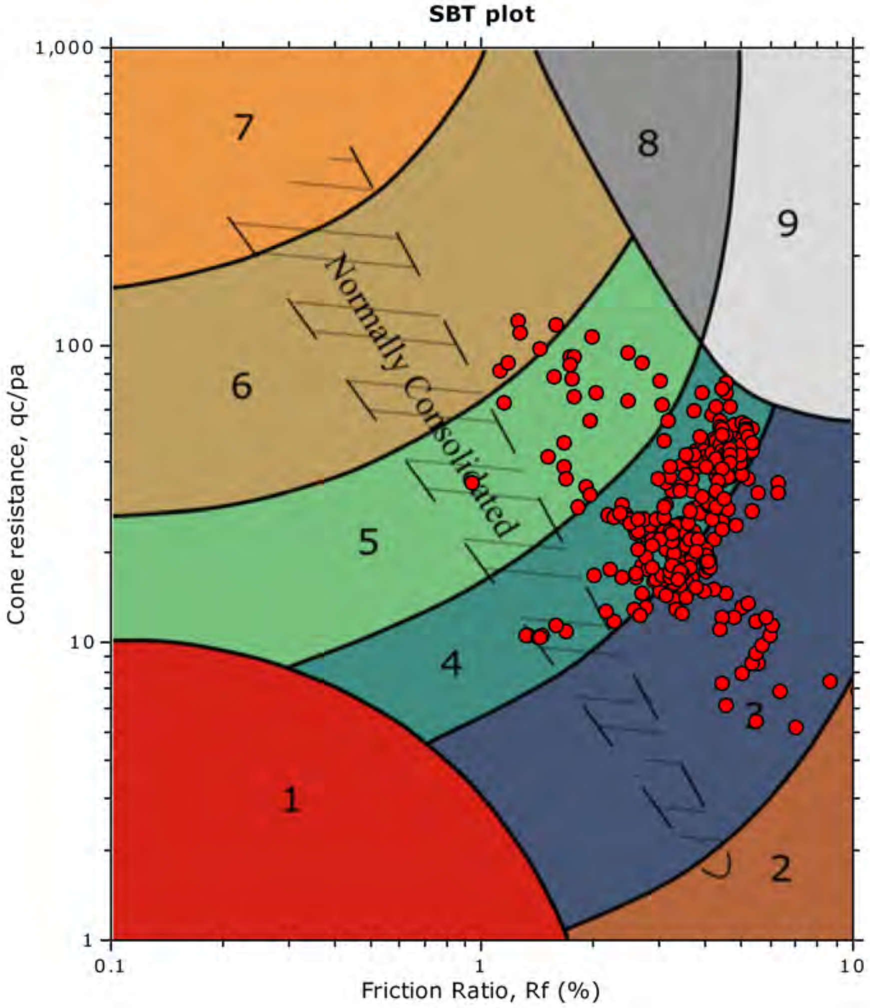
K(G) > 330: Soils with significant microstructure
(e.g. age/cementation)

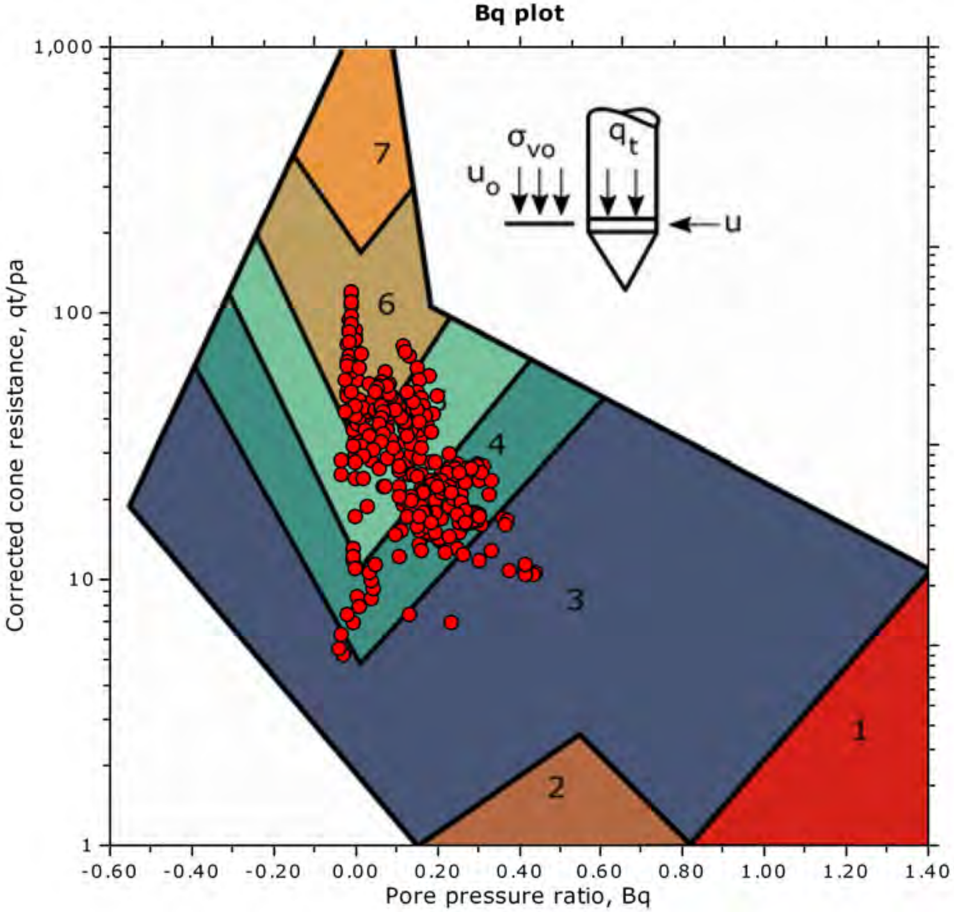


The plot below presents the cross correlation coeficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two sucessive CPT measurements).



SBT - Bq plots



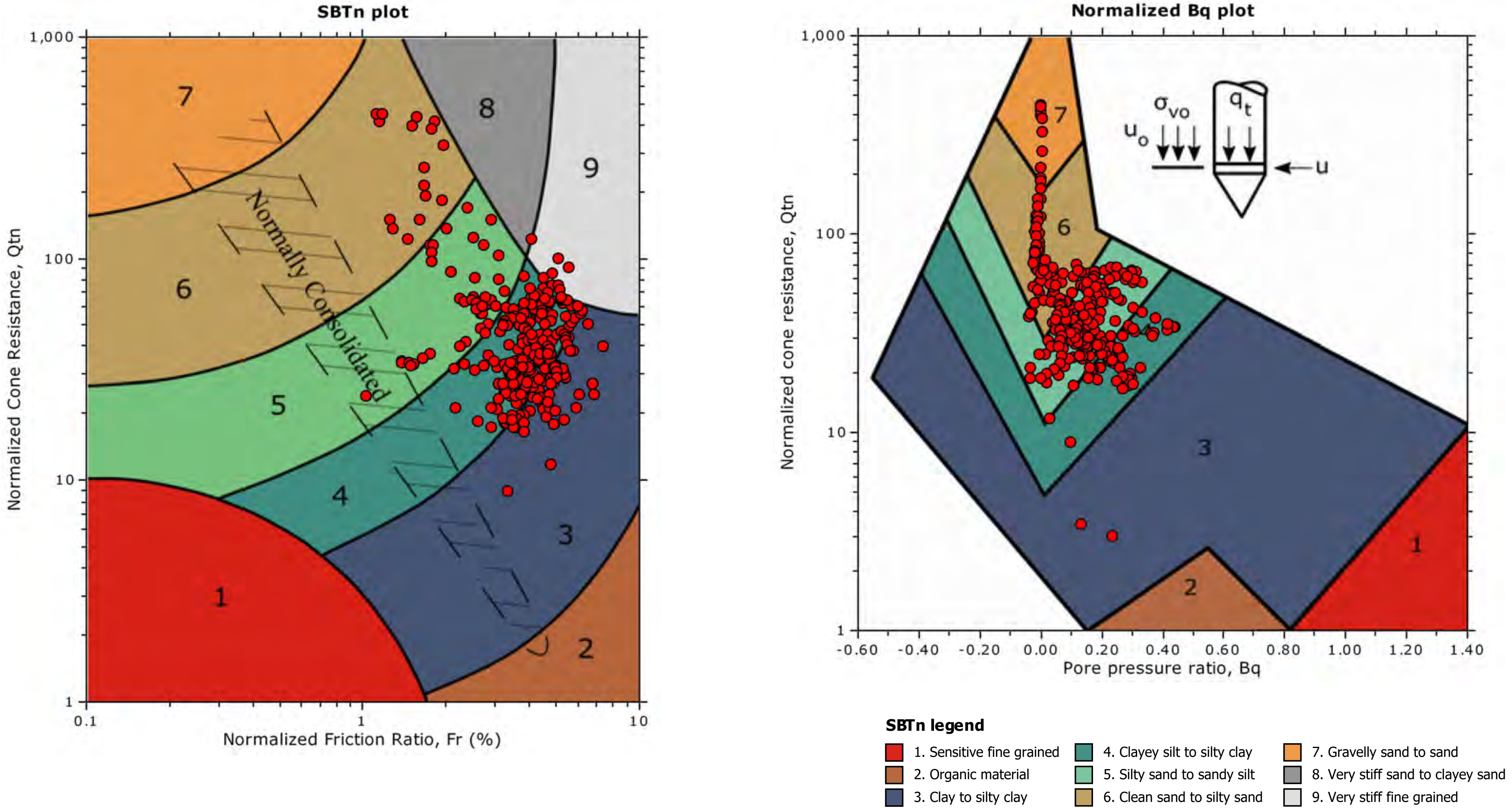


SBT legend

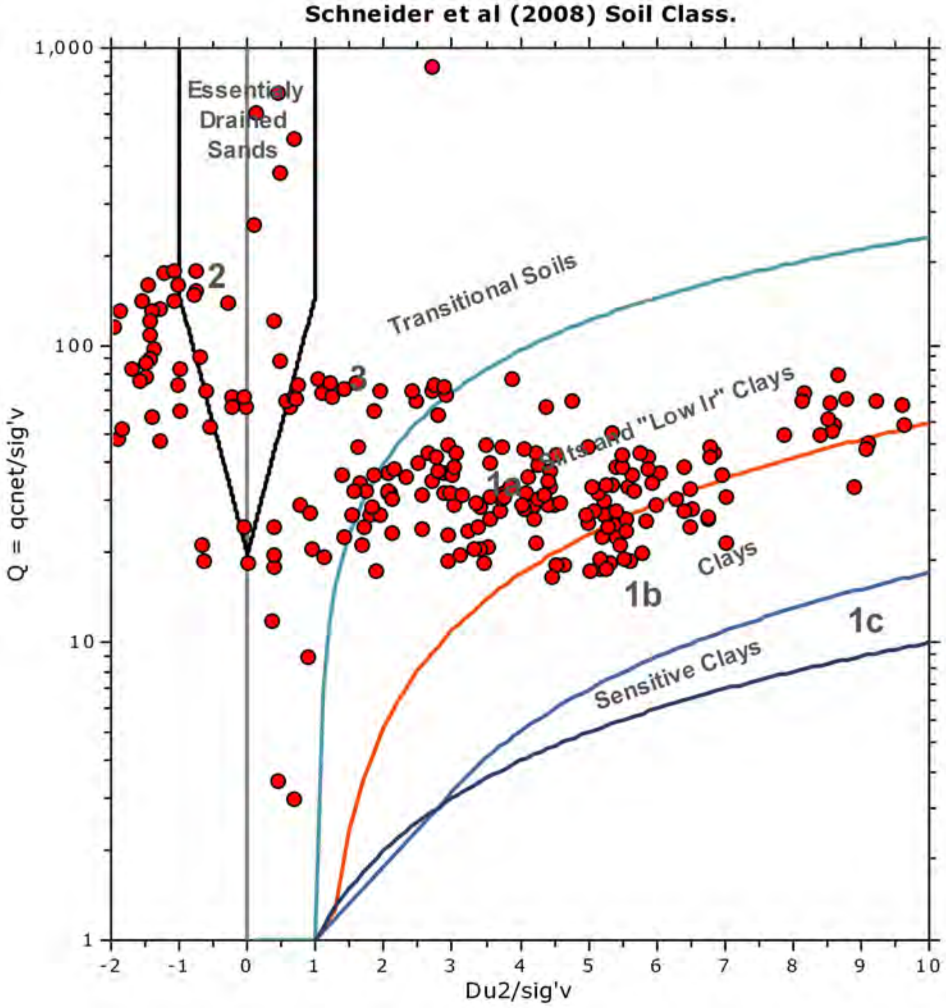
- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty clay
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravelly sand to sand
- ⬛ 8. Very stiff sand to clayey sand
- ⬜ 9. Very stiff fine grained

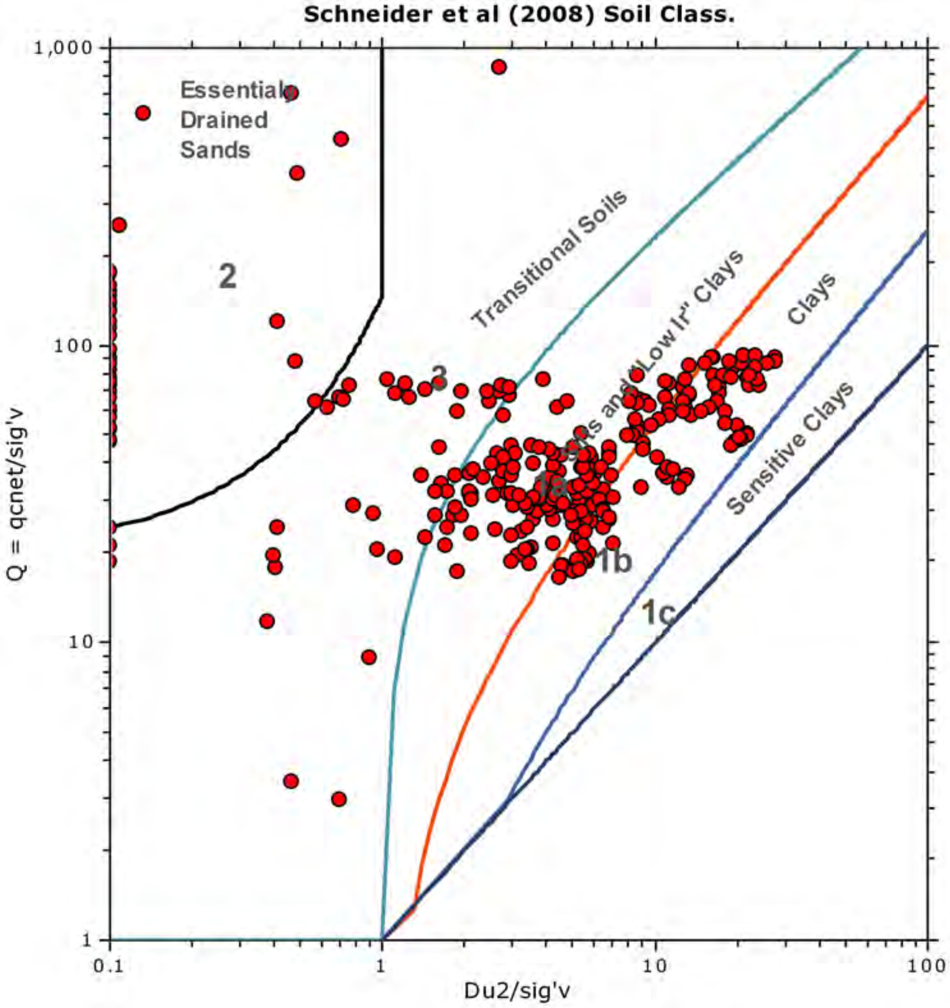
Project: **Chang Residences**
Location: **Webster and Illinois Streets, Fairfield, CA**

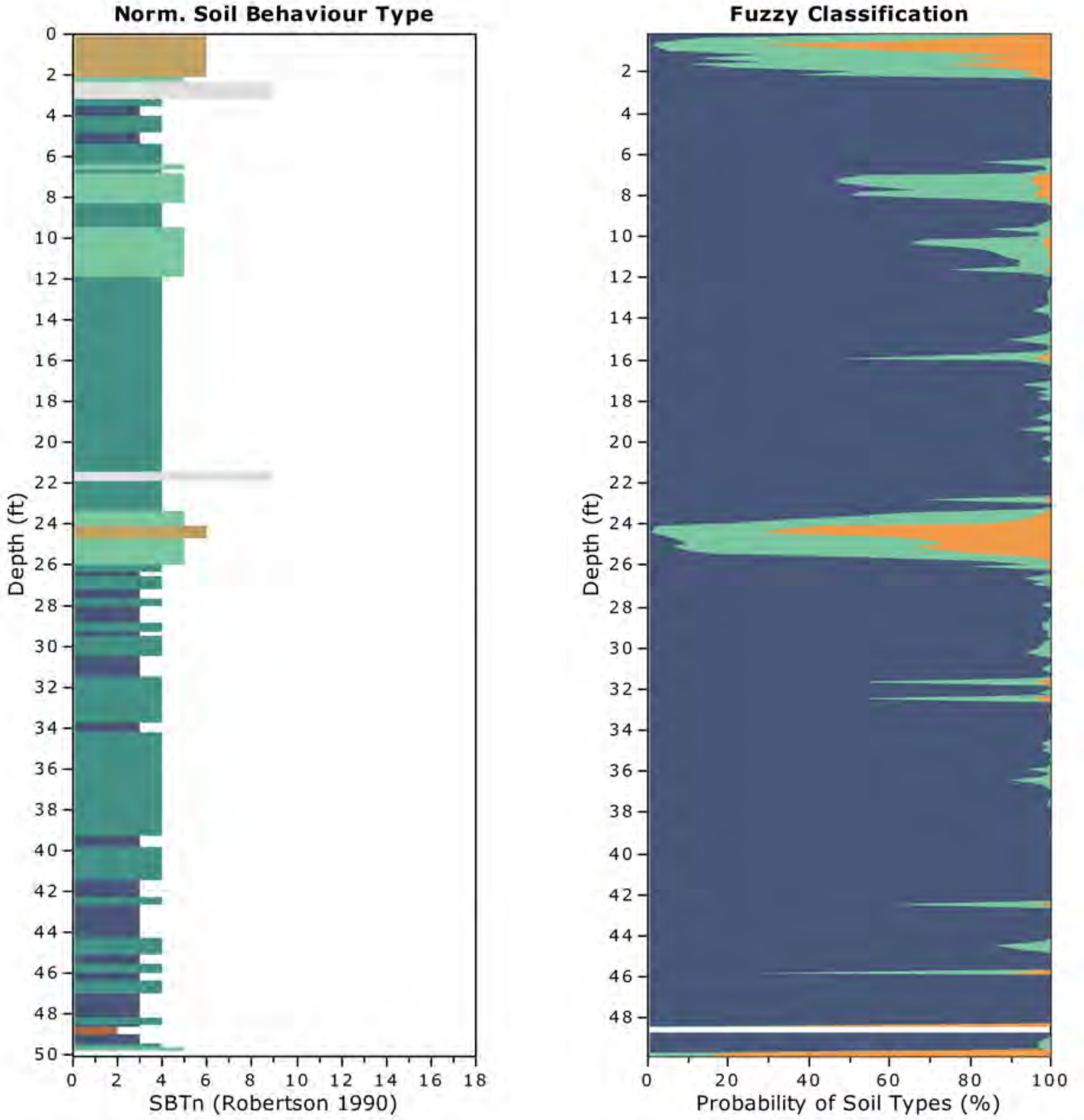
SBT - Bq plots (normalized)



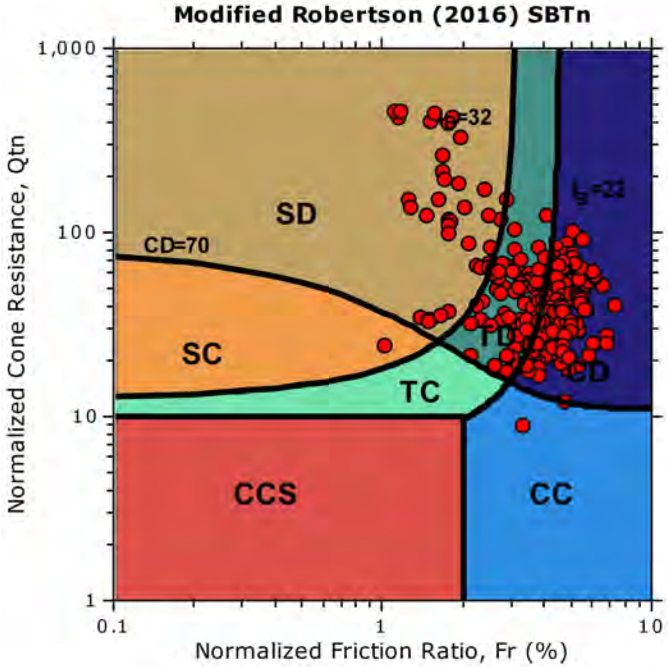
Bq plots (Schneider)

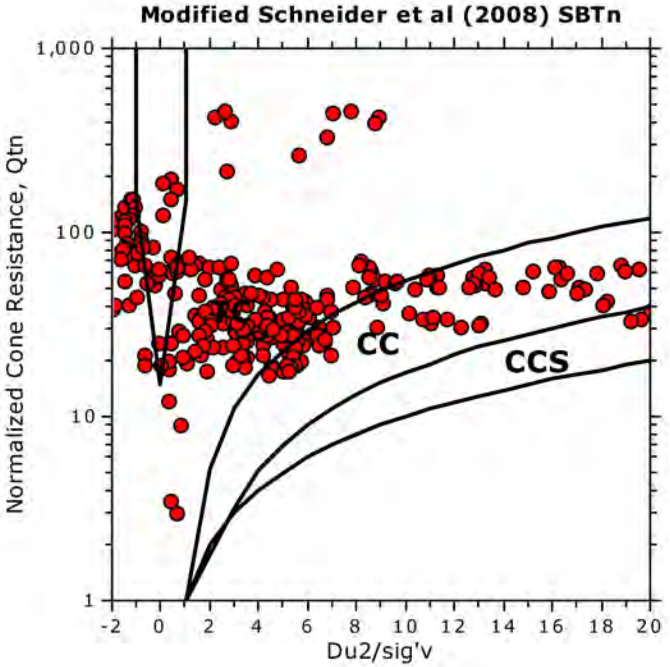


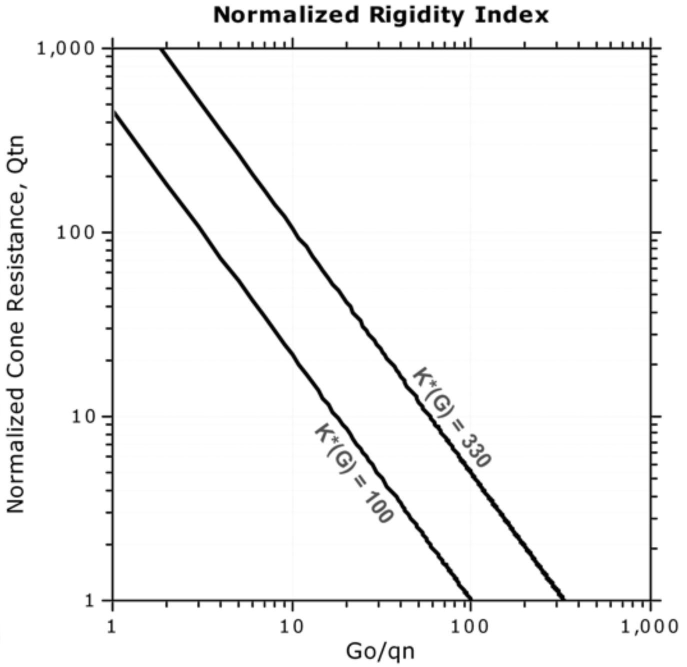



Norm. Soil Behaviour Type
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
SBTn (Robertson 1990)
0
2
4
6
8
10
12
14
16
18
Fuzzy Classification
Depth (ft)
Probability of Soil Types (%)
0
20
40
60
80
100

Updated SBTn plots


Modified Robertson (2016) SBTn


Modified Schneider et al (2008) SBTn


Normalized Rigidity Index

CCS: Clay-like - Contractive - Sensitive
CC: Clay-like - Contractive
CD: Clay-like - Dilative
TC: Transitional - Contractive
TD: Transitional - Dilative
SC: Sand-like - Contractive
SD: Sand-like - Dilative

K(G) > 330: Soils with significant microstructure (e.g. age/cementation)

APPENDIX B - LABORATORY TESTING

Laboratory tests were performed on representative samples of the materials encountered in the test boring, to achieve a quantitative and qualitative evaluation of the physical and mechanical properties of the materials that underlie the site. The tests were performed in B. Hillebrandt Soils Testing, Inc. of Alamo, California. The tests included moisture content determinations, Atterberg limit tests and #200 washed sieve tests. The test results are presented on the boring log in Appendix A. Test reports provided by the testing laboratory are included in this Appendix. Brief descriptions of the tests performed follow.

Moisture Content/Dry Density (ASTM 2937): Performed on undisturbed samples to determine the moisture content (the ratio of the weight of water to the weight of solids in the field sample, expressed as a percentage) and dry density (the ratio of the weight of solids in the field sample to its volume, expressed in pounds per cubic foot).

#200 Washed Sieve Test (ASTM D-1140): Performed on undisturbed or disturbed samples to determine the fine-grained (silt and clay) fraction of the materials. The fine-grained fraction is used to classify the soils according to the Unified Soils Classification System.

Atterberg Limits Test (ASTM D-4318): Performed on undisturbed or disturbed samples to determine the liquid limit (LL) and plastic limit (PL) of the samples. These limits are used to classify fine-grained soils and to evaluate the plasticity index (PI), the moisture content range over which the material exhibits plasticity. Atterberg limits correlations also provide an indication of the compressibility and expansion potential of the sample.

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LAB RESULTS SUMMARY FORM

Project Number: 20115.001
Project Name: Chang Residences
Results Due By:
Requested By: PM
Request Date: 4/22/2020
Throw Samples Out On:

					Atterberg			-200			Compaction				
Boring #	Sample Depth (feet)	Dry Density (pcf)	Moisture Content (%)	TxUU Shear Strength (psf)	Liquid Limit	Plastic Limit	Plasicity Index	Passing #4 Sieve (%)	Passing #40 sieve (%)	Passing #200 sieve (%)	Maximum Dry Density (pcf)	Optimum Moisture (%)	Pocket Penetrometer (tsf)	Torvane (tsf)	Remarks
B-1	1.0		19.3		56	24	32	98	83	57					
B-1	2.5	106	11.9					70	51	34					
B-1	4.5	84	25.8					74	48	34					
B-1	6.5	85	37.7					100	98	90					
B-1	11.5	101	25.2		53	19	34	99	97	92					
B-1	16.5		22.0					100	95	54					
B-1	21.5		22.6					86	82	45					
B-1	26.5		30.7					100	88	82					
B-1	31.5		20.2					77	23	14					sand portion
B-1	31.5		27.2					99	96	89					clay portion
B-1	36.5		24.3					100	92	52					
B-1	44.0		26.7					100	98	78					
B-1	50.0		23.7		18	16	2	100	93	25					

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MOISTURE CONTENT/DRY DENSITY

Job #: **20115.001**
Job Name: **Chang Residences**
Date: **4/22/2020**
Tested by: **Brad Hillebrandt**

Additional Tests:	-200	-200	-200	PI, -200		
Boring #:	B-1	B-1	B-1	B-1		
Depth:	2.5	4.5	6.5	11.5		
Sample Description:	Dark brown clayey SAND with gravel	Dark brown clayey SAND with gravel	Dark brown and olive brown CLAY	Yellowish brown fat CLAY		
Can #:	729	737	735	700		
Wet Sample + can	295.2	323.5	192.6	198.1		
Dry Sample + can	267.5	264.2	149.5	165.5		
Weight can	33.9	34.2	35.2	36.0		
Weight water	27.7	59.3	43.1	32.6		
Weight Dry Sample	233.6	230	114.3	129.5		
WATER CONTENT (%)	**11.9%**	**25.8%**	**37.7%**	**25.2%**		
Weight Sample + Liner	1059.5	862.4	1122.2	474.8		
Weight Liner	225.7	229.8	298.6	0		
Sample Length	6.0	5.1	6.0	3.2		
Sample Diameter	2.39	2.39	2.39	2.39		
DRY DENSITY (pcf)	**105.5**	**83.7**	**84.6**	**100.7**		

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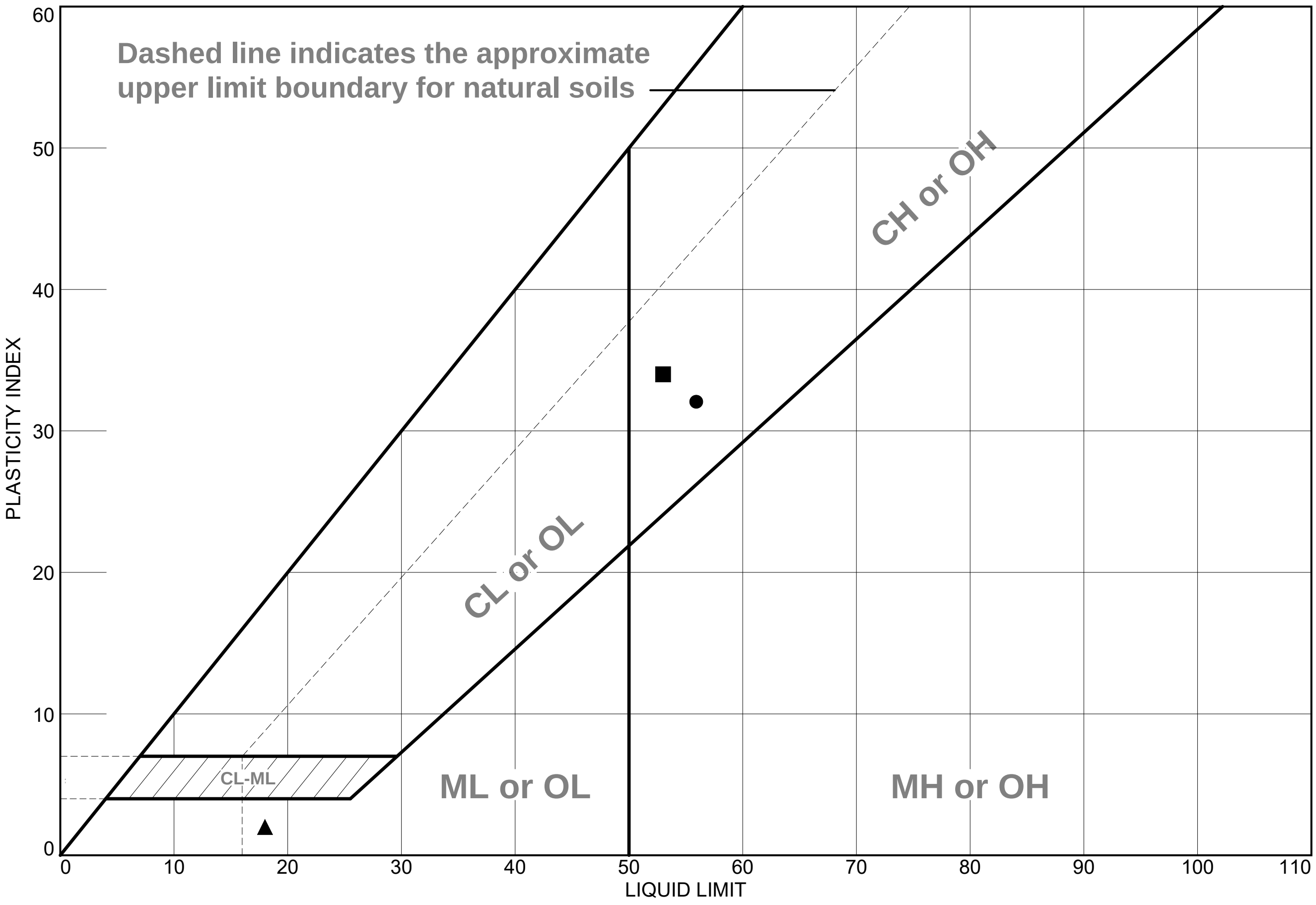
MOISTURE CONTENT WORKSHEET

Job #: **20115.001**
Job Name: **Chang Residences**
Date: **4/22/2020**
Tested by: **B. Hillebrandt**

Additional Tests:	PI, -200	-200	-200	-200	-200	-200	-200	-200	PI, -200
Boring #:	B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1	B-1
Depth:	1.0	16.5	21.5	26.5	31.5	31.5	36.5	44.0	50.0
Sample Description:	Brown sandy fat CLAY	Yellowish brown sandy CLAY	Yellowish brown clayey SAND	Brown and yellowish brown CLAY with sand	Brown clayey SAND with gravel.	Yellowish brown CLAY	Dark yellowish brown sandy CLAY	Dark yellowish brown CLAY with sand	Yellowish brown silty SAND
Can #:	716	713	705	315	736	605	720	704	707
Wet Sample + can	227.4	218.6	233.7	218.5	501.1	223.0	237.2	212.0	286.5
Dry Sample + can	196.1	185.3	196.8	176.2	422.8	182.6	197.5	174.5	238.2
Weight can	33.9	34.2	33.4	38.2	35.7	33.8	33.9	34.1	34.0
Weight water	31.3	33.3	36.9	42.3	78.3	40.4	39.7	37.5	48.3
Weight Dry Sample	162.2	151.1	163.4	138	387.1	148.8	163.6	140.4	204.2
WATER CONTENT (%)	**19.3%**	**22.0%**	**22.6%**	**30.7%**	**20.2%**	**27.2%**	**24.3%**	**26.7%**	**23.7%**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brown sandy fat CLAY	56	24	32	82.7	57.2	CH
■	Yellowish brown fat CLAY	53	19	34	96.8	92.2	CH
▲	Yellowish brown silty SAND	18	16	2	93.3	25.4	SM

Project No. 20115.001 **Client:** Peters & Ross

Project: Chang Residences

●**Source of Sample:** B-1 **Depth:** 1.0'
■**Source of Sample:** B-1 **Depth:** 11.5'
▲**Source of Sample:** B-1 **Depth:** 50.0'

Remarks:

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+1 510-409-2816
SoilTesting@aol.com

Figure

Tested By: BH

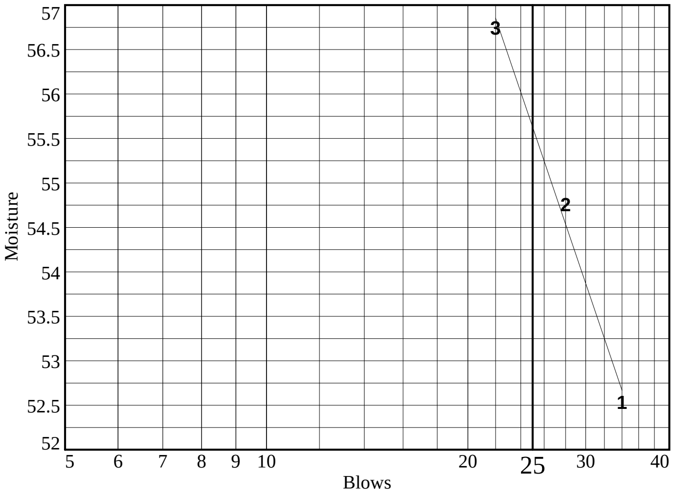
LIQUID AND PLASTIC LIMIT TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 1.0'
Material Description: Brown sandy fat CLAY
%<#40: 82.7 **%<#200:** 57.2 **USCS:** CH **AASHTO:** A-7-6(15)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	26.70	28.64	26.31			
Dry+Tare	21.33	22.43	20.89			
Tare	11.11	11.09	11.34			
# Blows	34	28	22			
Moisture	52.5	54.8	56.8			



Liquid Limit=	56
Plastic Limit=	24
Plasticity Index=	32
Natural Moisture=	19.3
Liquidity Index=	-0.1

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	16.98	17.62			
Dry+Tare	15.86	16.41			
Tare	11.27	11.30			
Moisture	24.4	23.7			

B. Hillebrandt Soils Testing, Inc.

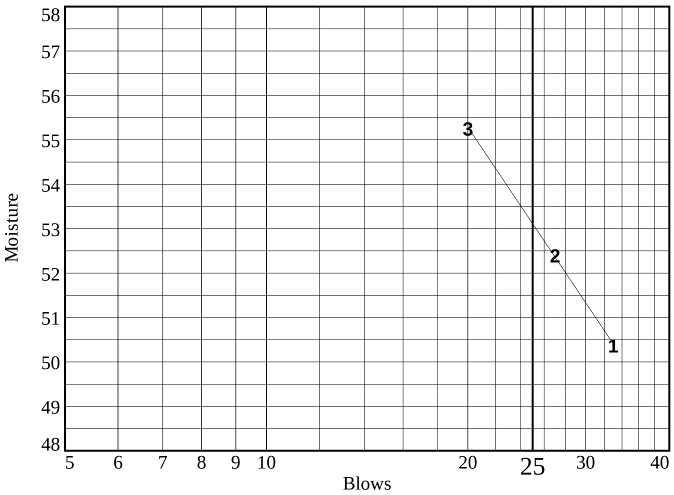
LIQUID AND PLASTIC LIMIT TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 11.5'
Material Description: Yellowish brown fat CLAY
%<#40: 96.8 **%<#200:** 92.2 **USCS:** CH **AASHTO:** A-7-6(34)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	28.77	27.93	26.92			
Dry+Tare	22.83	22.15	21.36			
Tare	11.04	11.12	11.30			
# Blows	33	27	20			
Moisture	50.4	52.4	55.3			



Liquid Limit= 53
Plastic Limit= 19
Plasticity Index= 34
Natural Moisture= 25.2
Liquidity Index= 0.2

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	16.98	17.56			
Dry+Tare	16.01	16.55			
Tare	11.05	11.14			
Moisture	19.6	18.7			

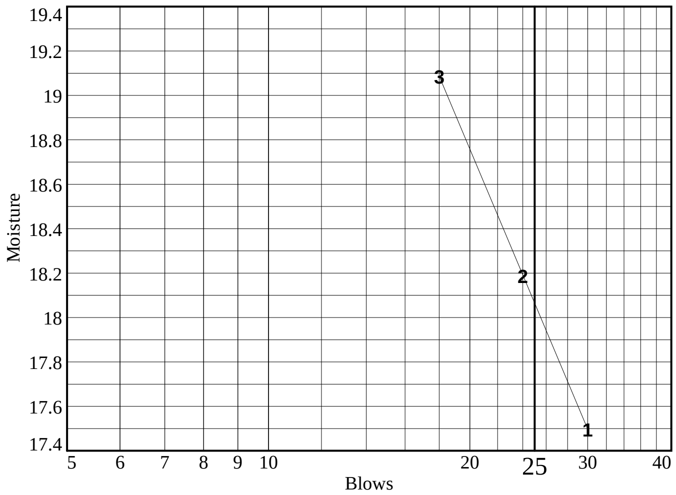
LIQUID AND PLASTIC LIMIT TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 50.0'
Material Description: Yellowish brown silty SAND
%<#40: 93.3 **%<#200:** 25.4 **USCS:** SM **AASHTO:** A-2-4(0)
Tested by: BH

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	28.07	26.96	29.82			
Dry+Tare	25.58	24.55	26.85			
Tare	11.35	11.30	11.29			
# Blows	30	24	18			
Moisture	17.5	18.2	19.1			

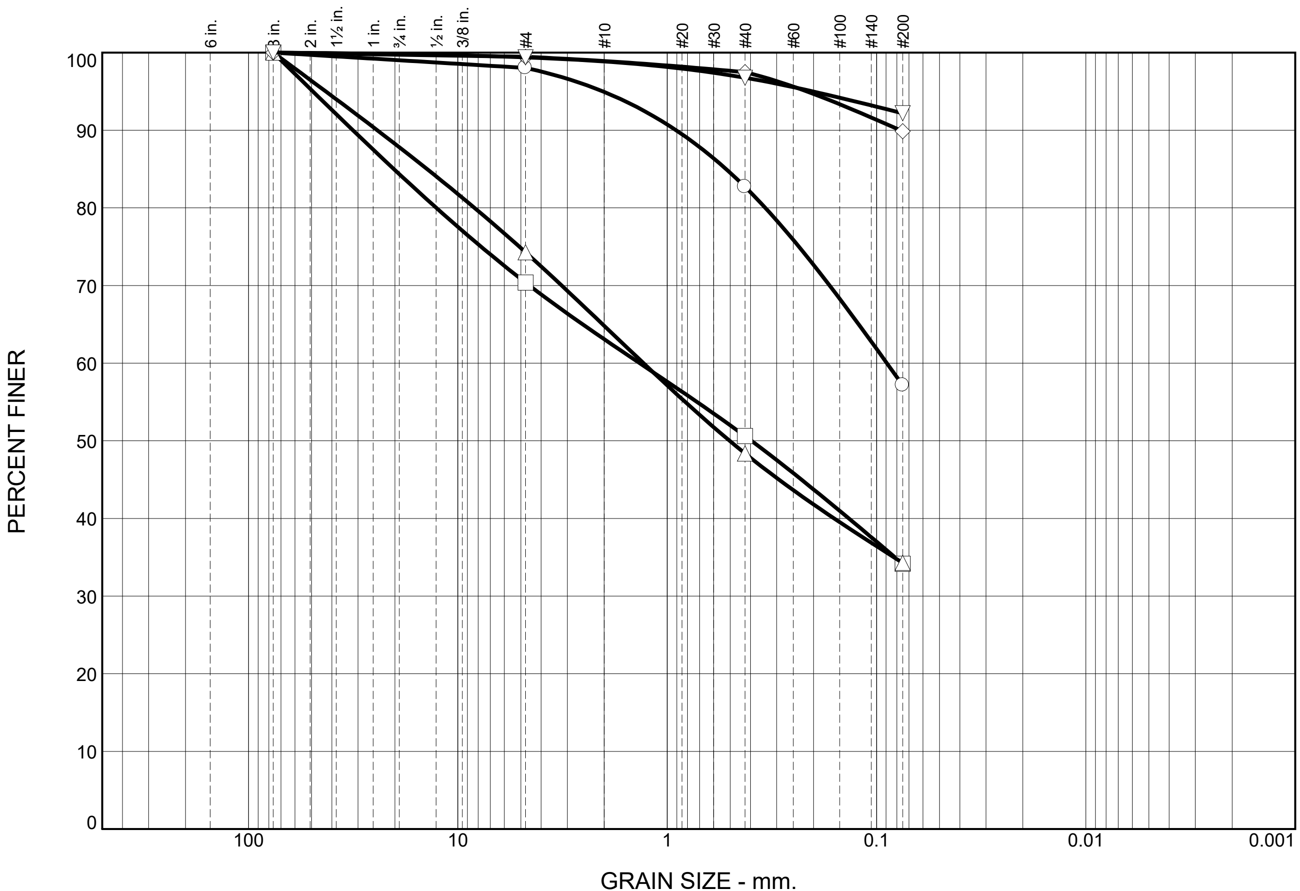


Liquid Limit= 18
Plastic Limit= 16
Plasticity Index= 2
Natural Moisture= 23.7
Liquidity Index= 3.8

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	22.12	18.99			
Dry+Tare	20.55	17.90			
Tare	11.06	11.17			
Moisture	16.5	16.2			

Particle Size Distribution Report



	% +3"	% Gravel	% Sand	% Silt	% Clay
○	0.0	2.0	40.8	57.2	
□	0.0	29.6	36.2	34.2	
△	0.0	25.7	40.0	34.3	
◇	0.0	0.5	9.6	89.9	
▽	0.0	0.6	7.2	92.2	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-1		1.0'	Brown sandy fat CLAY	CH
□	B-1		2.5'	Dark brown clayey SAND with gravel	SC
△	B-1		4.5'	Dark brown clayey SAND with gravel	SC
◇	B-1		6.5'	Dark brown and olive brown CLAY	CL
▽	B-1		11.5'	Yellowish brown fat CLAY	CH

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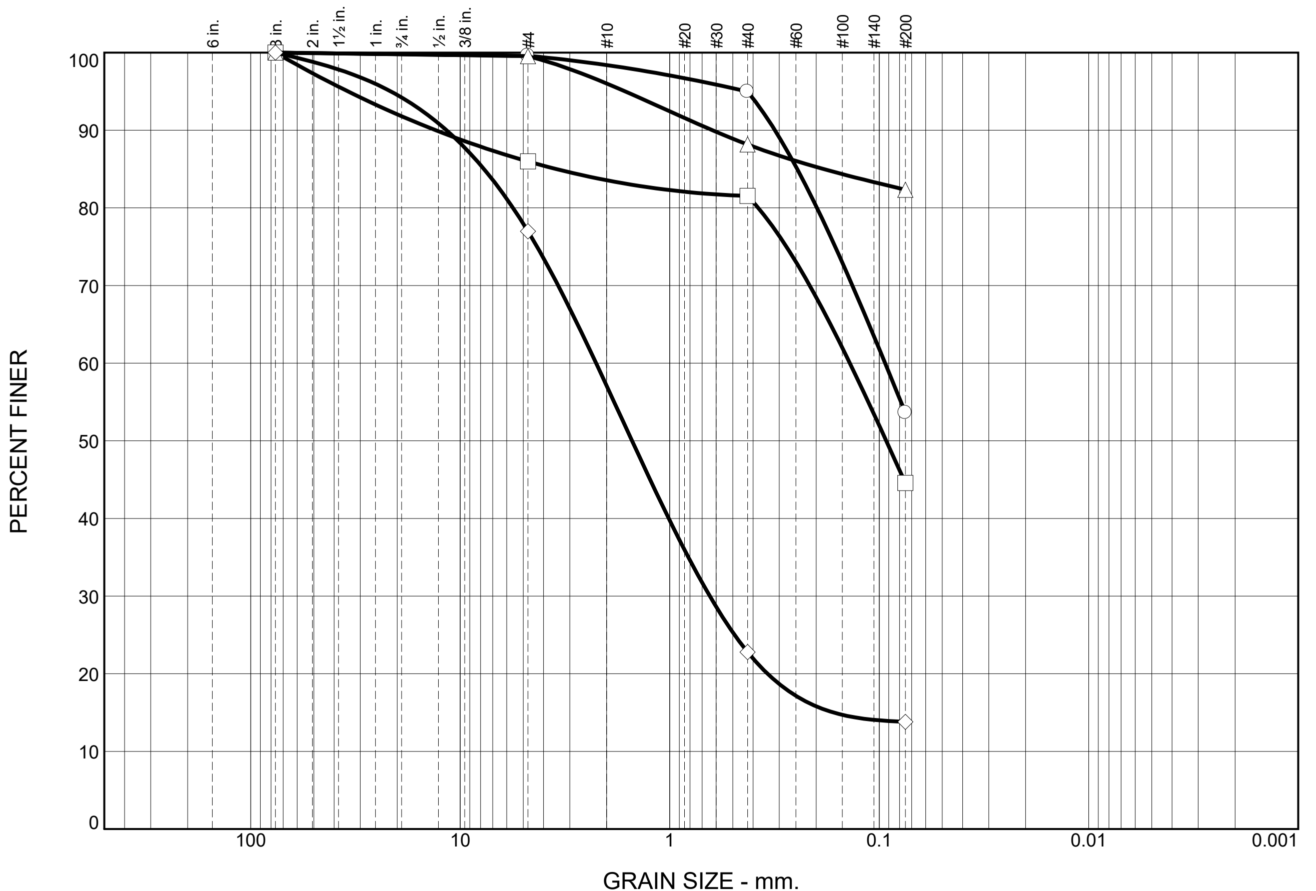
Client: Peters & Ross
Project: Chang Residences

Project No.: 20115.001 **Figure**

Tested By: BH

Particle Size Distribution Report



	% +3"	% Gravel	% Sand	% Silt	% Clay
○	0.0	0.4	46.0	53.6	
□	0.0	14.0	41.4	44.6	
△	0.0	0.5	17.2	82.3	
◇	0.0	23.0	63.2	13.8	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-1		16.5'	Yellowish brown sandy CLAY	CL
□	B-1		21.5'	Yellowish brown clayey SAND	SC
△	B-1		26.5'	Brown and yellowish brown CLAY with sand	CL
◇	B-1		31.5'	Brown clayey SAND with gravel	SC

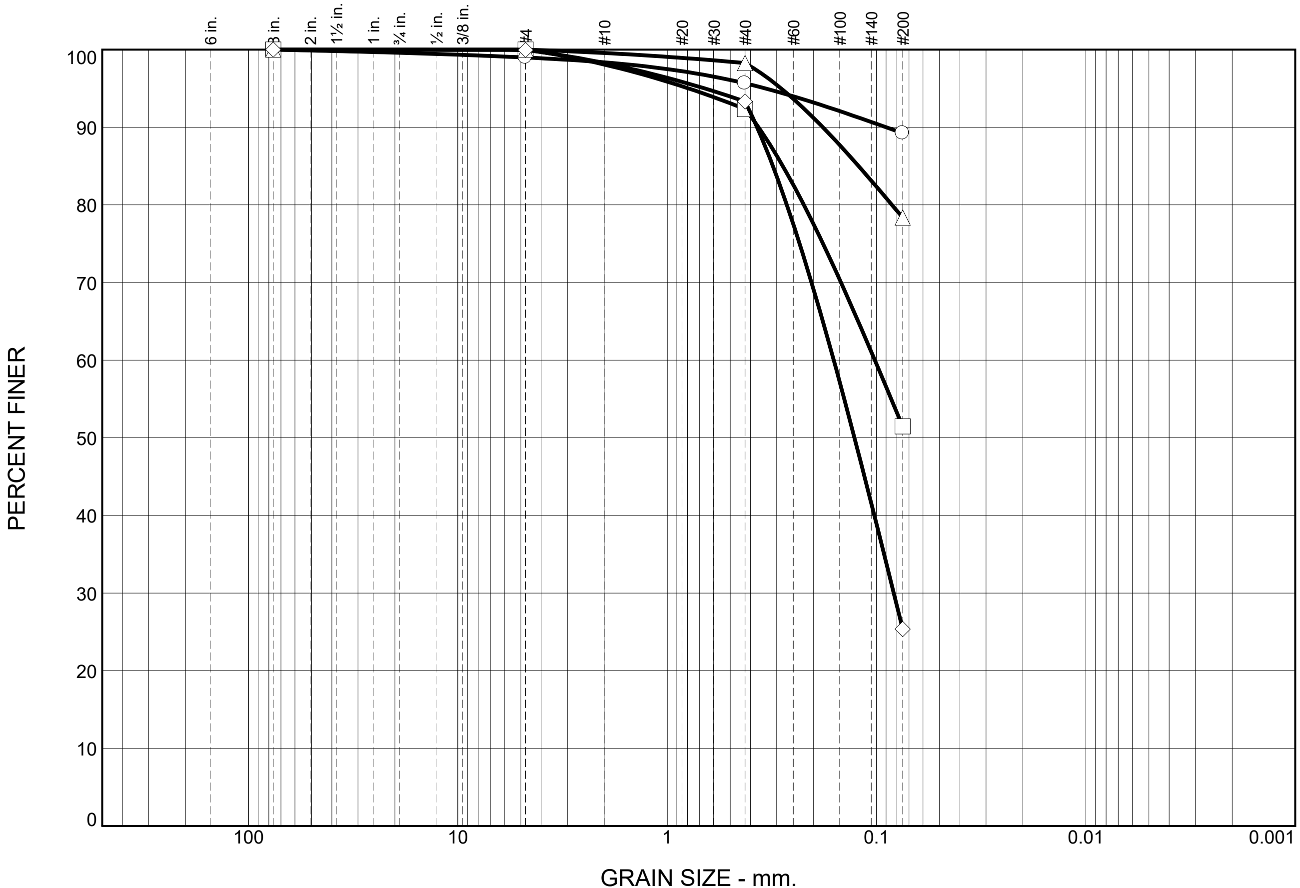
B. HILLEBRANDT SOILS TESTING, INC.
+1 510-409-2816
SoilTesting@aol.com

Client: Peters & Ross
Project: Chang Residences

Project No.: 20115.001 **Figure**

Tested By: BH

Particle Size Distribution Report



	% +3"	% Gravel	% Sand	% Silt	% Clay
○	0.0	1.0	9.8	89.2	
□	0.0	0.0	48.5	51.5	
△	0.0	0.0	21.6	78.4	
◇	0.0	0.0	74.6	25.4	

SOIL DATA

SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	Material Description	USCS
○	B-1		31.5'	Yellowish brown CLAY	CL
□	B-1		36.5'	Dark yellowish brown sandy CLAY	CL
△	B-1		44.0'	Dark yellowisgh brown CLAY with sand	CL
◇	B-1		50.0'	Yellowish brown silty SAND	SM

B. HILLEBRANDT SOILS TESTING, INC.
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SoilTesting@aol.com

Client: Peters & Ross
Project: Chang Residences

Project No.: 20115.001 **Figure**

Tested By: BH

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 1.0'
Material Description: Brown sandy fat CLAY
USCS: CH
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
196.10	33.90	0.00	3"	0.00	100.0
			#4	3.20	98.0
			#40	28.04	82.7
			#200	69.48	57.2

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	2.0	40.8		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
							0.0893	0.3399	0.5233	0.9068	2.0298

Fineness Modulus
0.84

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 2.5'
Material Description: Dark brown clayey SAND with gravel
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
267.50	33.90	0.00	3"	0.00	100.0
			#4	69.19	70.4
			#40	115.37	50.6
			#200	153.79	34.2

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	29.6	36.2		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
					0.1356	0.3961	1.3540	12.6753	20.2172	31.7217	49.2807

Fineness Modulus
3.11

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 4.5'
Material Description: Dark brown clayey SAND with gravel
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
264.20	34.20	0.00	3"	0.00	100.0
			#4	59.15	74.3
			#40	118.74	48.4
			#200	151.15	34.3

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	25.7	40.0		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
					0.1593	0.5032	1.2985	8.3282	14.0334	24.2592	42.7653

Fineness Modulus
3.00

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 6.5'
Material Description: Dark brown and olive brown CLAY
USCS: CL
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
149.50	35.20	0.00	3"	0.00	100.0
			#4	0.62	99.5
			#40	2.89	97.5
			#200	11.58	89.9

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.5	9.6		

D_{5}	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
										0.0769	0.2153

Fineness Modulus
0.16

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 11.5'
Material Description: Yellowish brown fat CLAY
USCS: CH
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
165.50	36.00	0.00	3"	0.00	100.0
			#4	0.80	99.4
			#40	4.19	96.8
			#200	10.12	92.2

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.6	7.2		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
											0.2017

Fineness Modulus
0.16

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 16.5'
Material Description: Yellowish brown sandy CLAY
USCS: CL
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
185.30	34.20	0.00	3"	0.00	100.0
			#4	0.62	99.6
			#40	7.60	95.0
			#200	70.07	53.6

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.4	46.0		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
							0.0937	0.1982	0.2462	0.3147	0.4297

Fineness Modulus
0.47

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 21.5'
Material Description: Yellowish brown clayey SAND
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
196.80	33.40	0.00	3"	0.00	100.0
			#4	22.90	86.0
			#40	30.16	81.5
			#200	90.58	44.6

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	14.0	41.4		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
						0.0926	0.1381	0.3780	3.4705	13.0897	34.3412

Fineness Modulus
1.51

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 26.5'
Material Description: Brown and yellowish brown CLAY with sand
USCS: CL
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
176.20	38.20	0.00	3"	0.00	100.0
			#4	0.63	99.5
			#40	16.33	88.2
			#200	24.38	82.3

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.5	17.2		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
									0.1842	0.6251	1.6301

Fineness Modulus
0.50

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 31.5'
Material Description: Brown clayey SAND with gravel
USCS: SC
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
422.80	35.70	0.00	3"	0.00	100.0
			#4	89.10	77.0
			#40	298.89	22.8
			#200	333.69	13.8

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	23.0	63.2		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
		0.1650	0.3414	0.6436	1.0106	1.5130	2.2460	5.5995	7.7013	11.6224	21.4304

Fineness Modulus
3.76

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 31.5'
Material Description: Yellowish brown CLAY
USCS: CL
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
182.60	33.80	0.00	3"	0.00	100.0
			#4	1.52	99.0
			#40	6.46	95.7
			#200	16.02	89.2

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	1.0	9.8		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
										0.0901	0.3397

Fineness Modulus
0.23

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 36.5'
Material Description: Dark yellowish brown sandy CLAY
USCS: CL
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
197.50	33.90	0.00	3"	0.00	100.0
			#4	0.00	100.0
			#40	12.51	92.4
			#200	79.40	51.5

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.0	48.5		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
							0.1019	0.2224	0.2803	0.3664	0.7908

Fineness Modulus
0.54

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 44.0'
Material Description: Dark yellowisgh brown CLAY with sand
USCS: CL
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
174.50	34.10	0.00	3"	0.00	100.0
			#4	0.00	100.0
			#40	2.43	98.3
			#200	30.37	78.4

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.0	21.6		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
								0.0844	0.1219	0.1806	0.2857

Fineness Modulus
0.19

GRAIN SIZE DISTRIBUTION TEST DATA

4/27/2020

Client: Peters & Ross
Project: Chang Residences
Project Number: 20115.001
Location: B-1
Depth: 50.0'
Material Description: Yellowish brown silty SAND
USCS: SM
Tested by: BH

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer
238.20	34.00	0.00	3"	0.00	100.0
			#4	0.10	100.0
			#40	13.65	93.3
			#200	152.40	25.4

Fractional Components

Cobbles	Gravel	Sand	Silt	Clay
0.0	0.0	74.6		

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.0827	0.1024	0.1275	0.1601	0.2683	0.3128	0.3721	0.6632

Fineness Modulus
0.69

APPENDIX C

CPT Liquefaction Analysis

SPT Liquefaction Analysis

Static Settlement Analysis

APPENDIX C-1

CPT Liquefaction Analysis

TABLE OF CONTENTS

CPT-2 results

CPT-1 results

Peters & Ross
Geotechnical & Geoenvironmental
Consultants

Peters & Ross
Geotechnical Engineers
114 Hopeco Rd., Pleasant Hill, CA
PetersRoss@aol.com

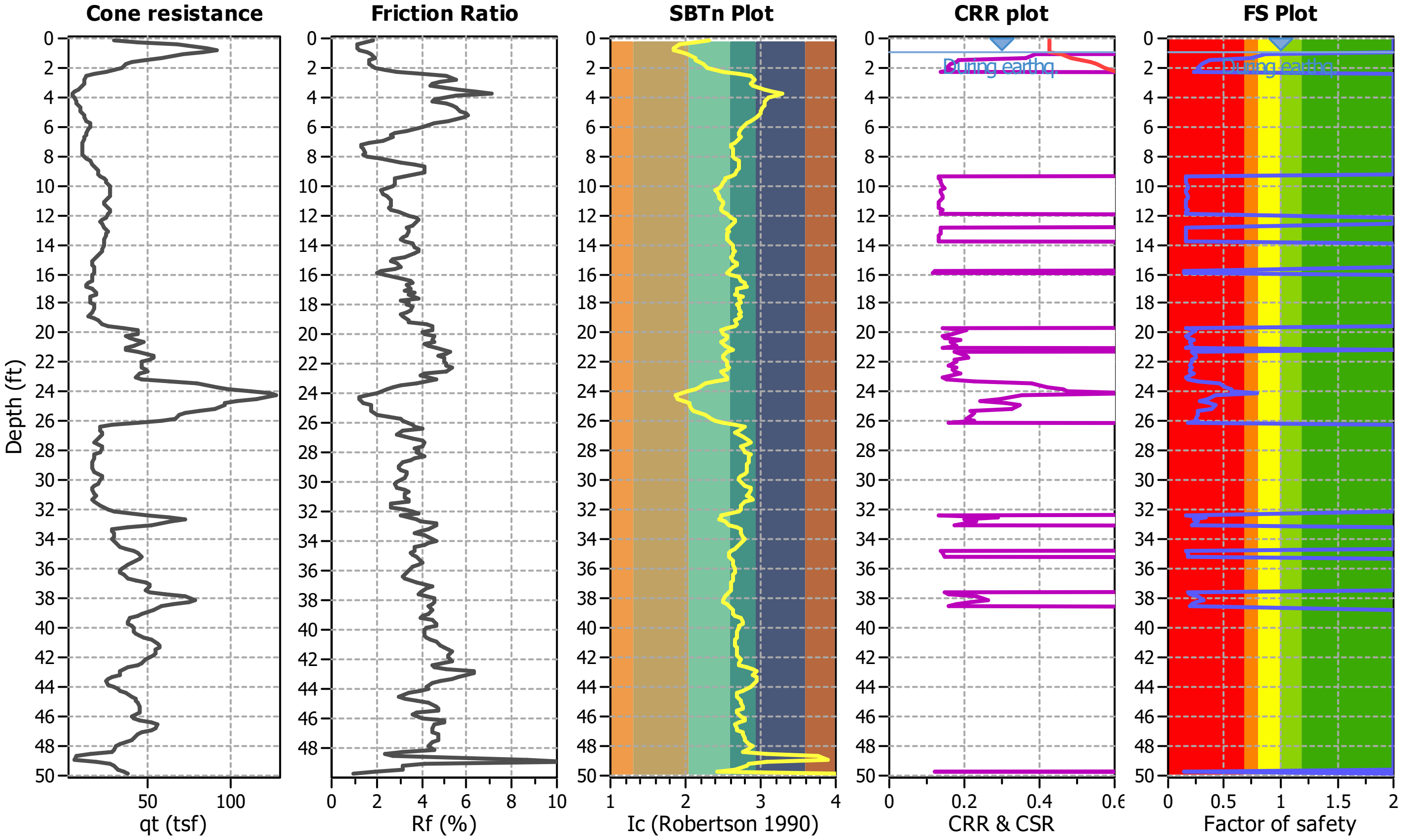
LIQUEFACTION ANALYSIS REPORT

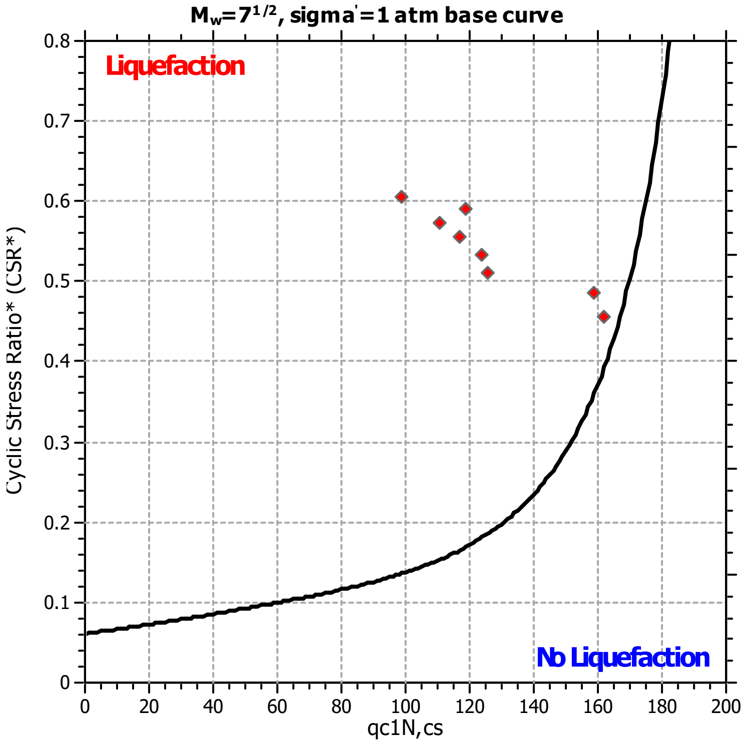
Project title : Webster and Illinois Fairfield CPT1 **Location : NW Corner of Webster and Illinois Streets in Fairfield, CA**

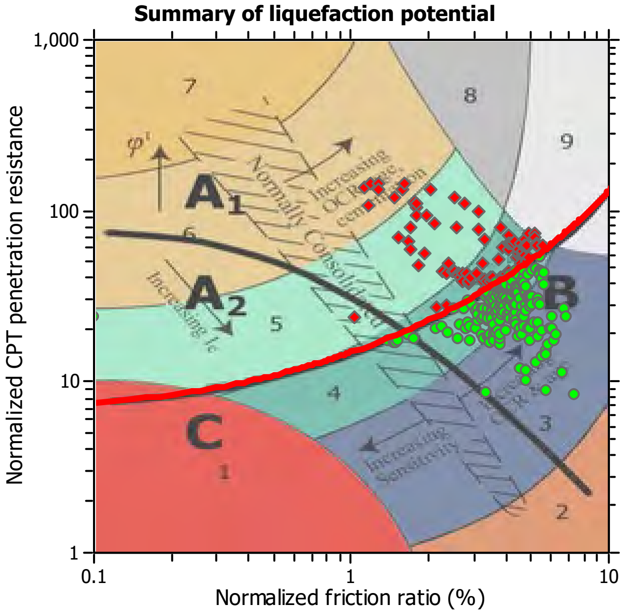
CPT file : CPT-2

Input parameters and analysis data

Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.72	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

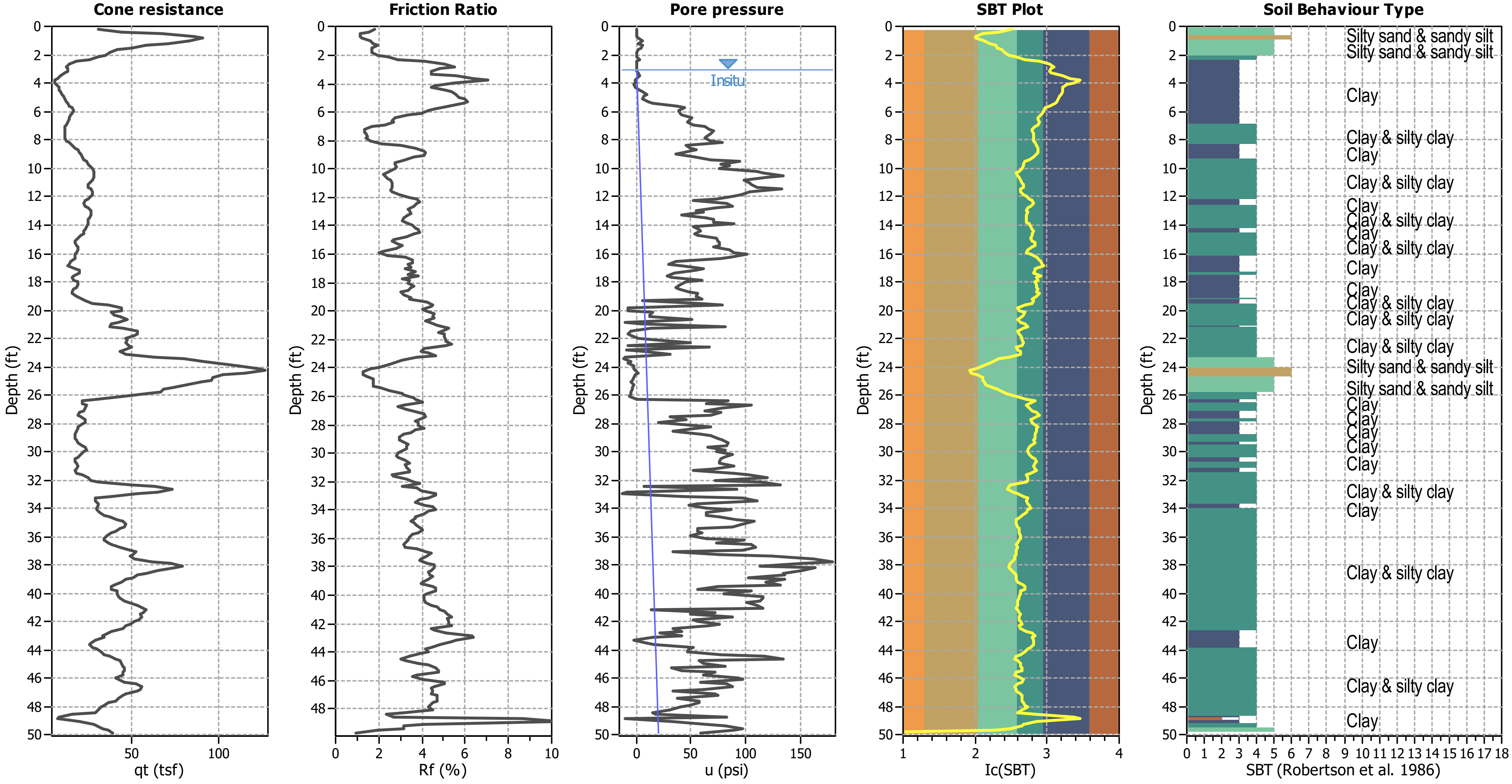






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



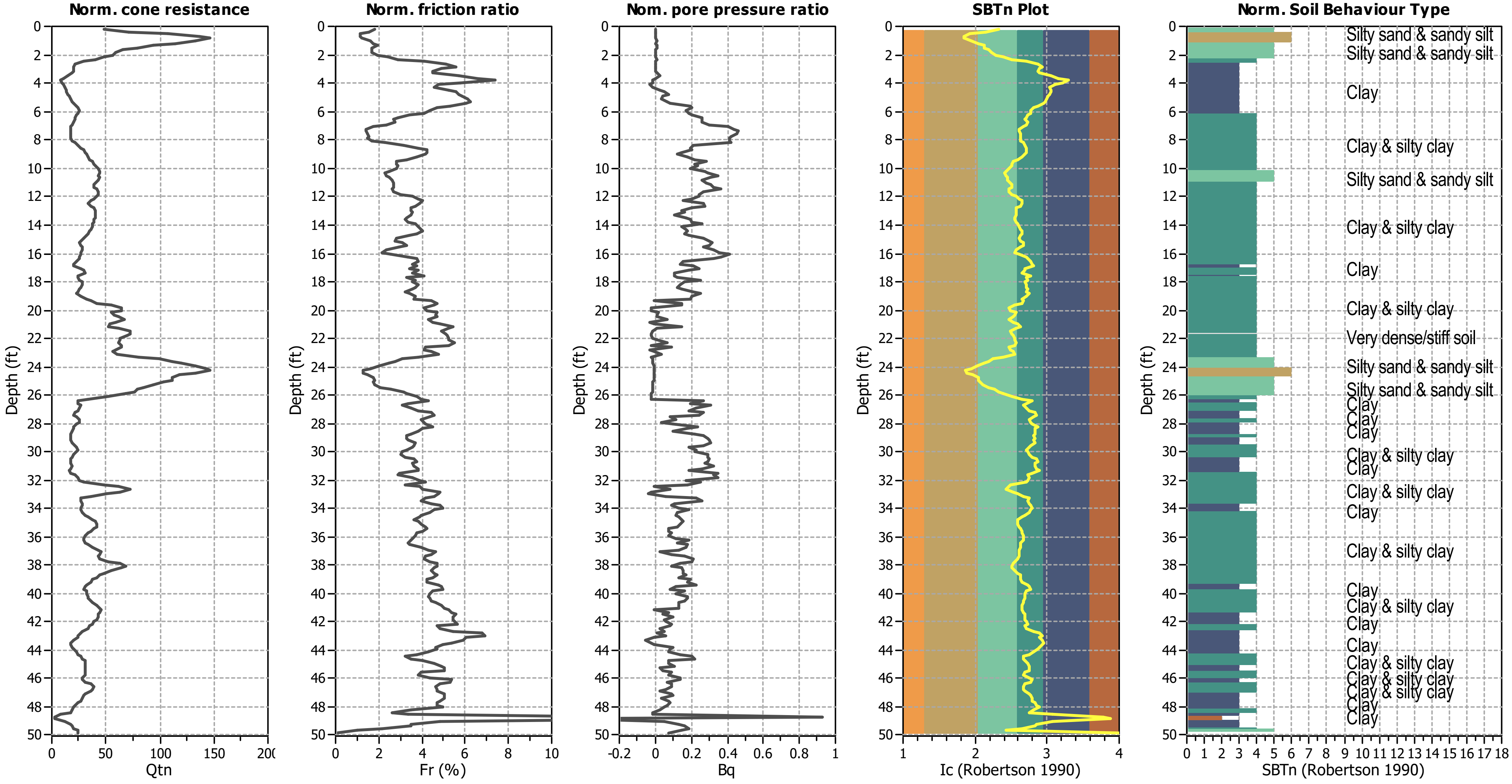
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬜ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟫 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



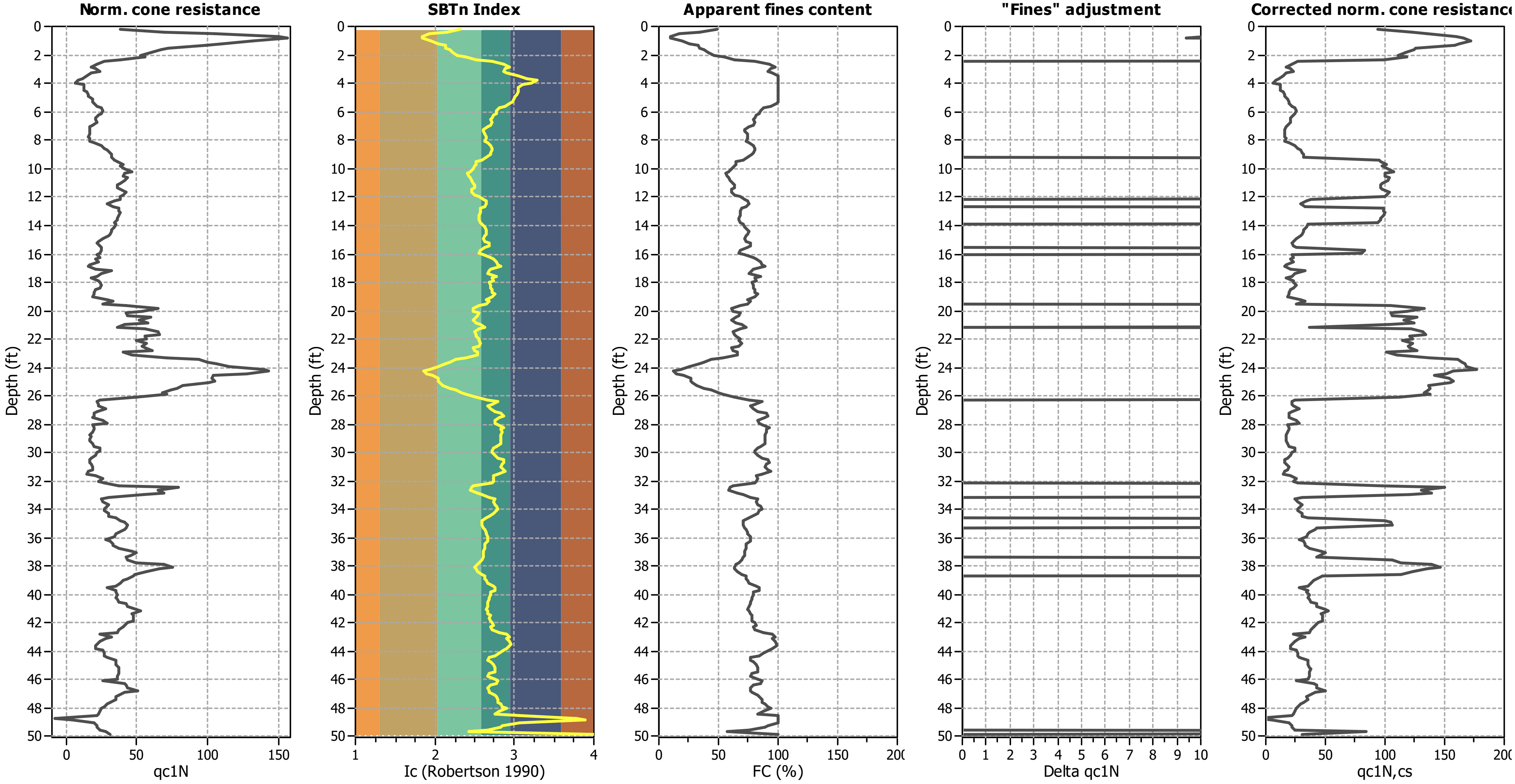
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

- 🟥 1. Sensitive fine grained
- 🟫 2. Organic material
- 🟦 3. Clay to silty clay
- 🟩 4. Clayey silt to silty
- 🟩 5. Silty sand to sandy silt
- 🟫 6. Clean sand to silty sand
- 🟧 7. Gravely sand to sand
- ⬛ 8. Very stiff sand to
- ⬜ 9. Very stiff fine grained

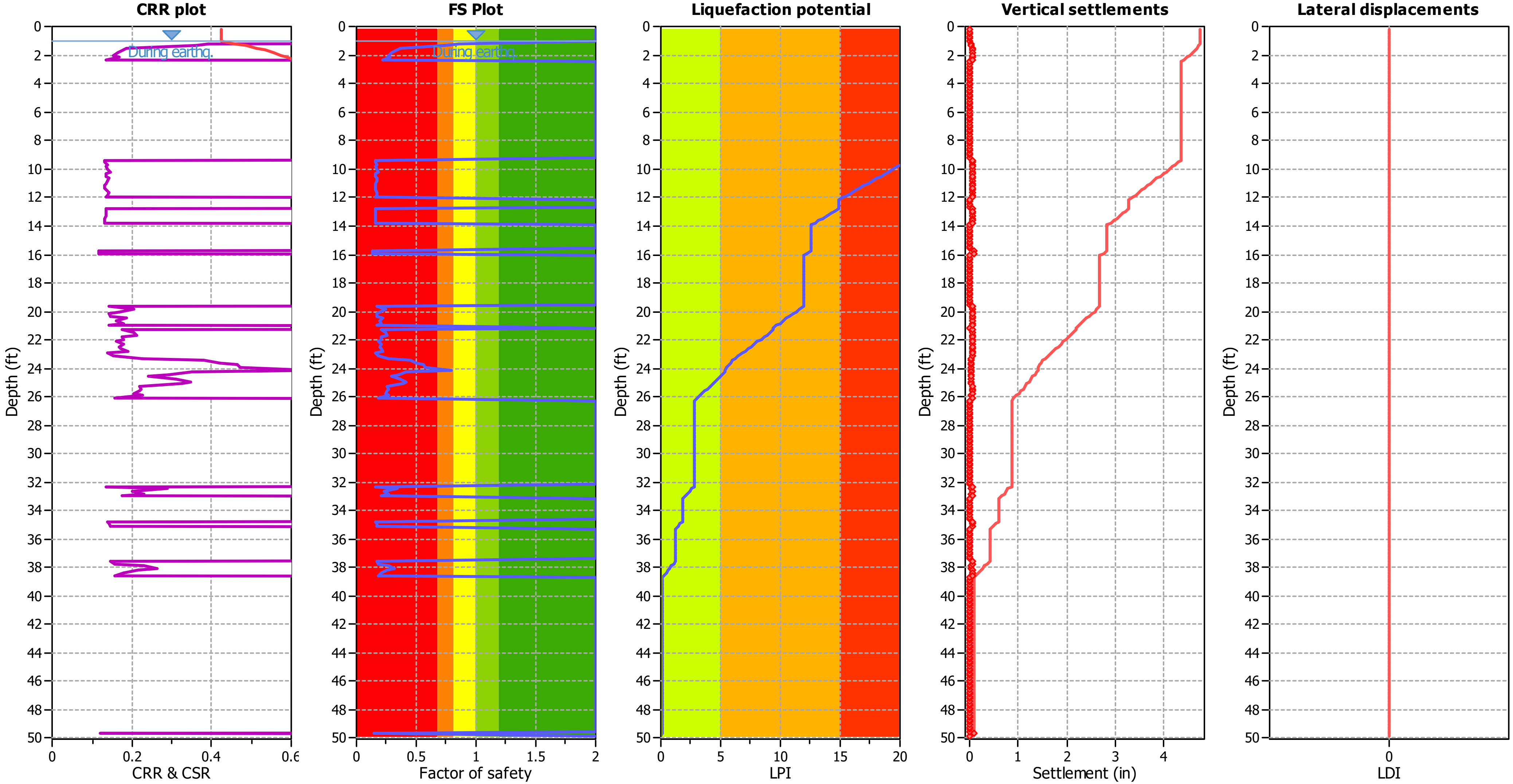
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_{σ} applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

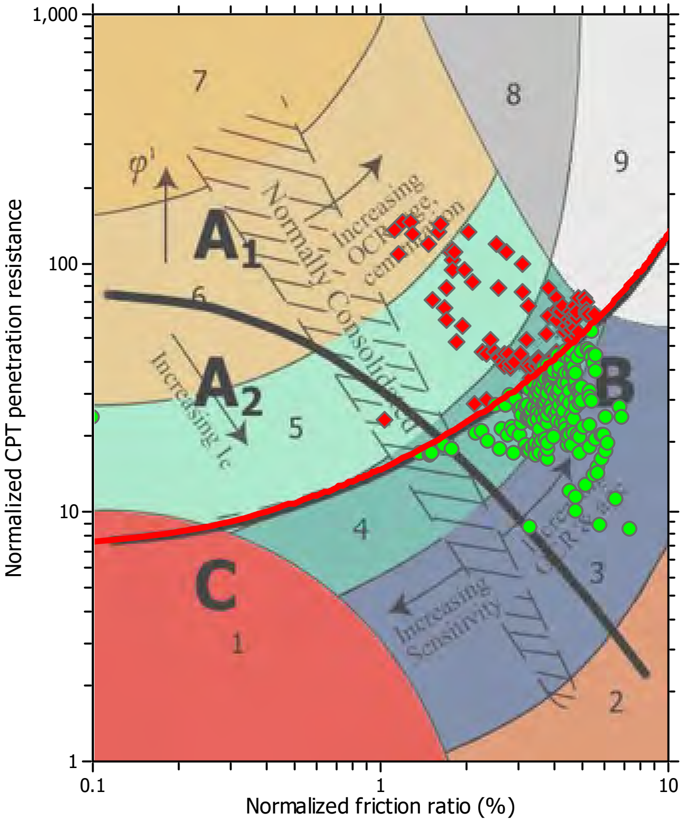
F.S. color scheme

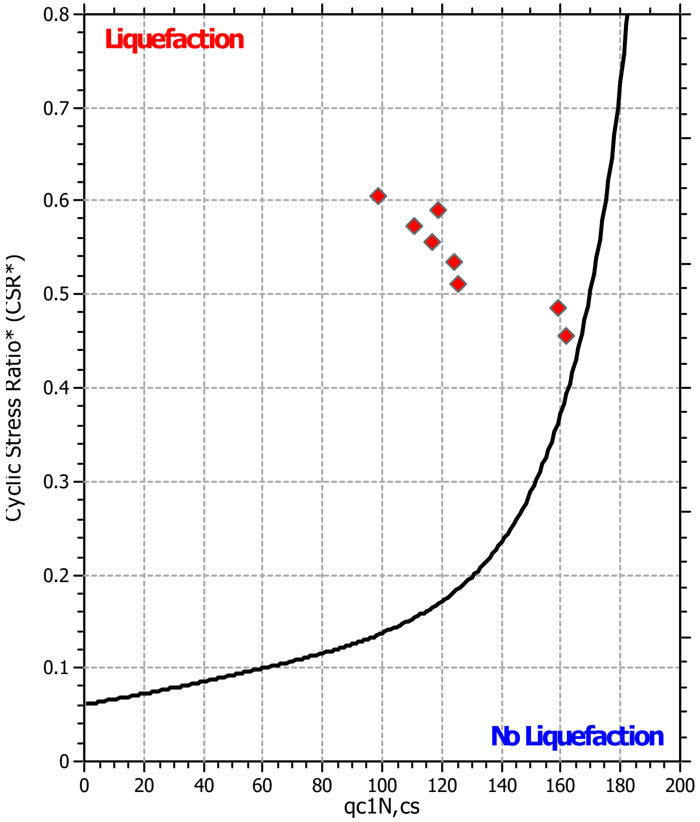
- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

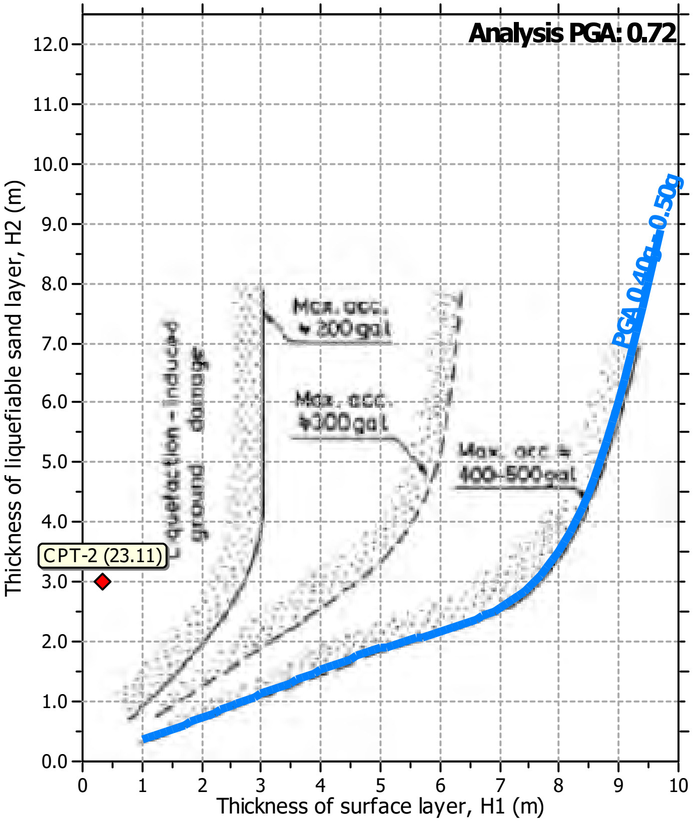
LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟩 Low risk

Liquefaction analysis summary plots



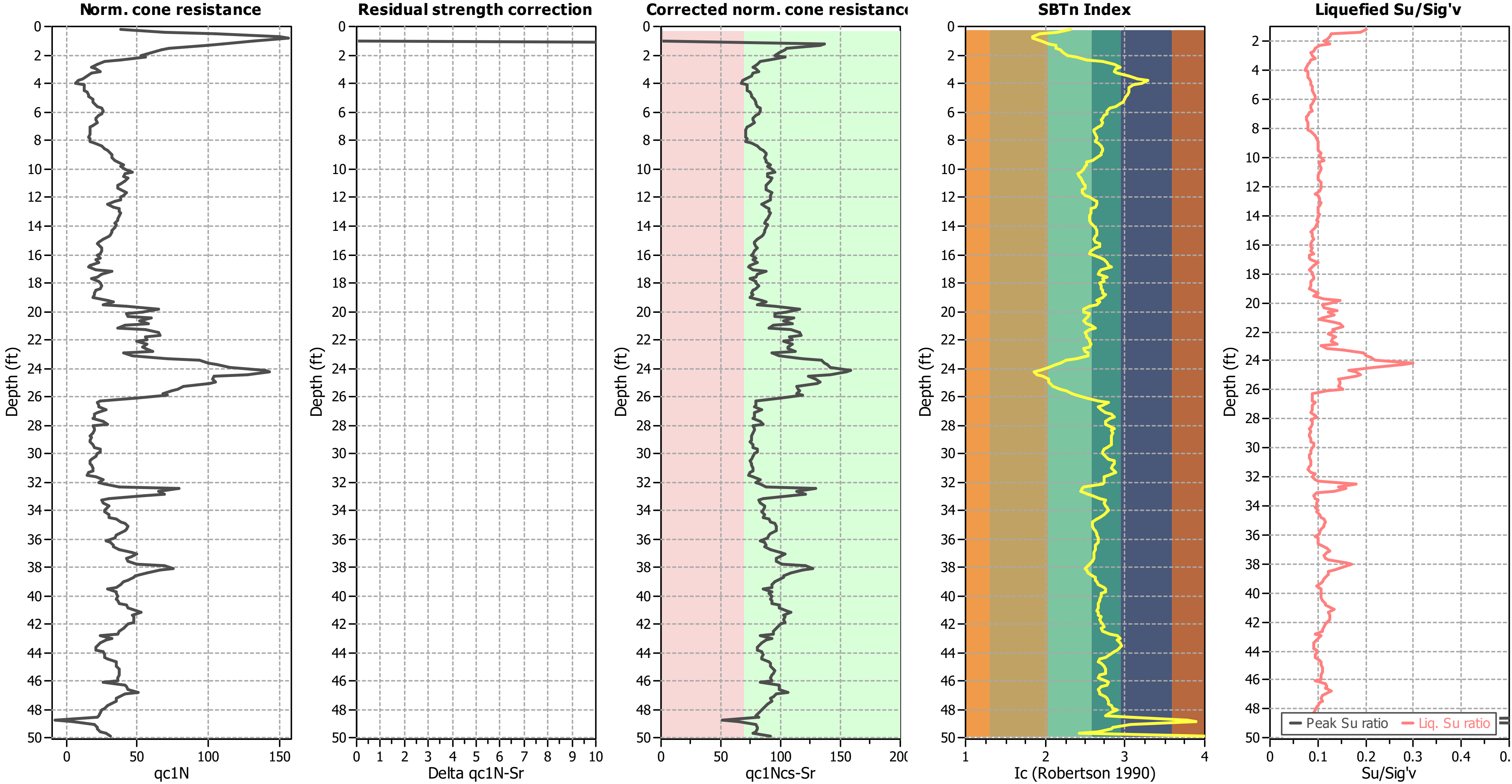




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

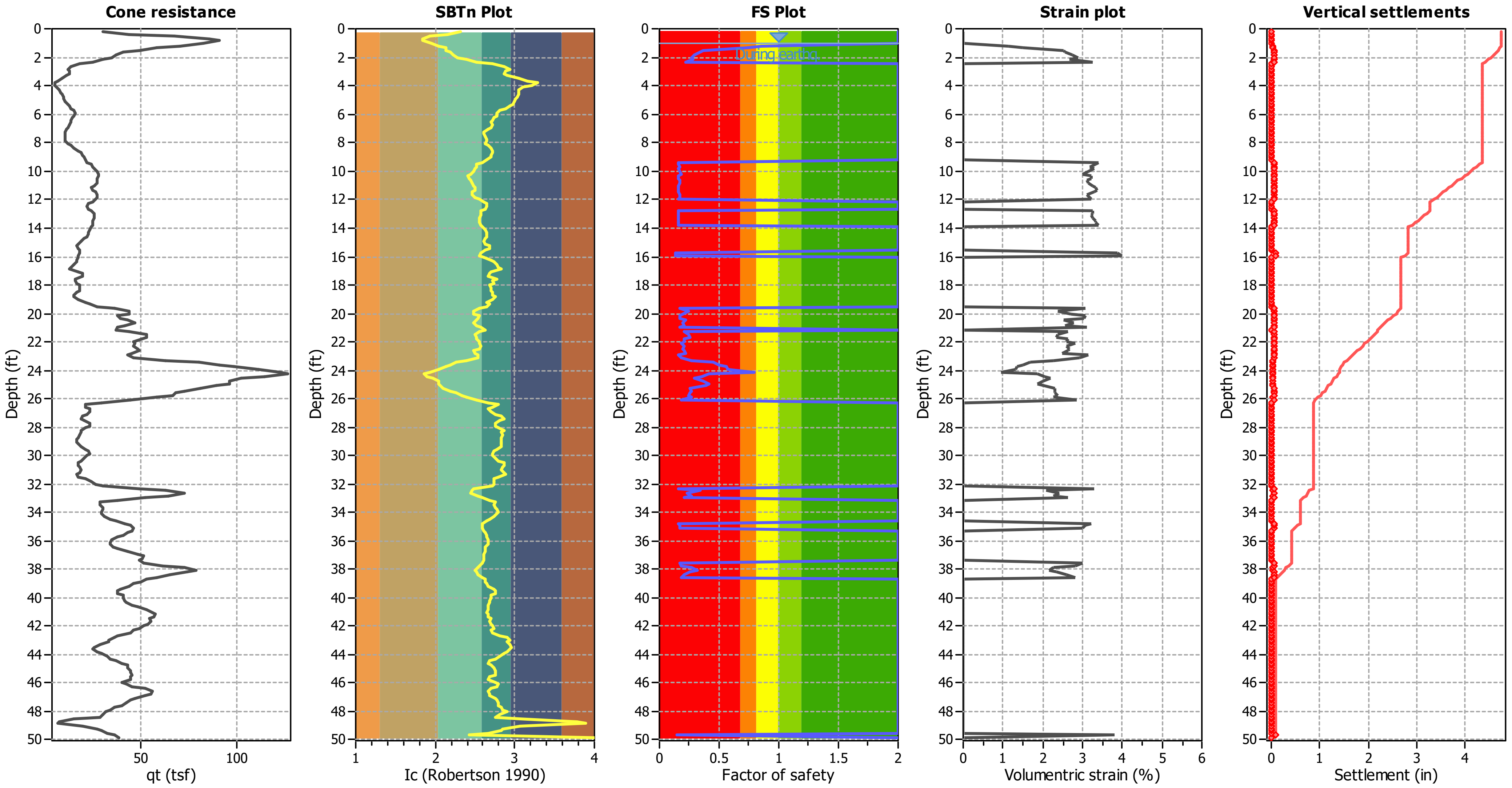
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

Estimation of post-earthquake settlements



Abbreviations

q_t: Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c: Soil Behaviour Type Index
FS: Calculated Factor of Safety against liquefaction
Volumentric strain: Post-liquefaction volumentric strain

LIQUEFACTION ANALYSIS REPORT

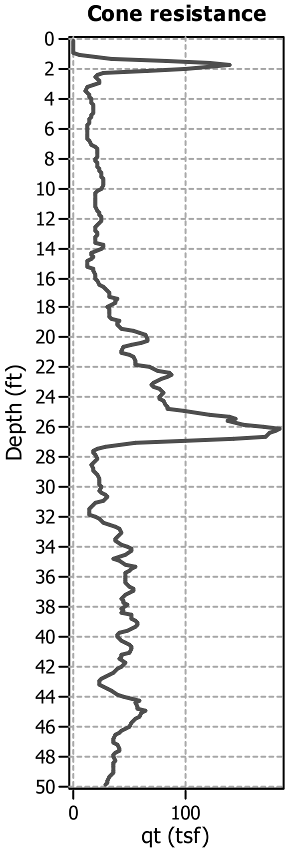
Project title : Webster and Illinois Fairfield CPT1

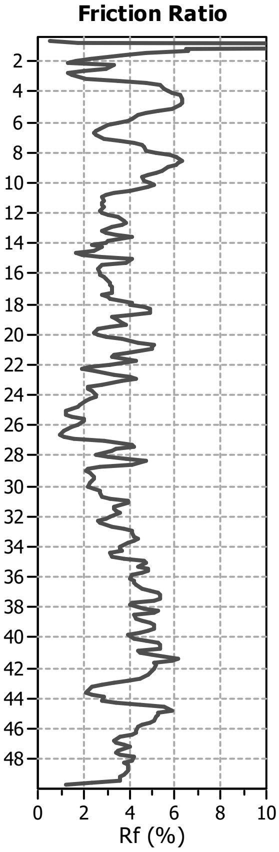
Location : NW Corner of Webster and Illinois Streets in Fairfield, CA

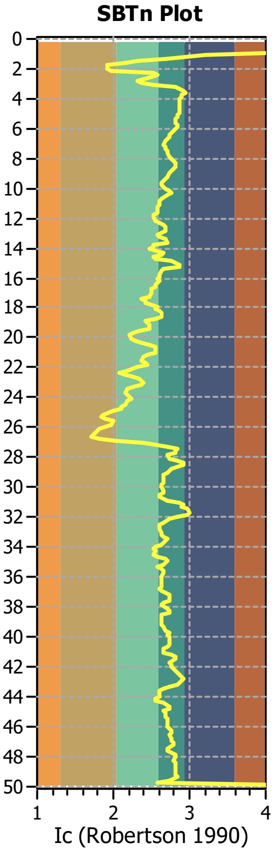
CPT file : CPT-1

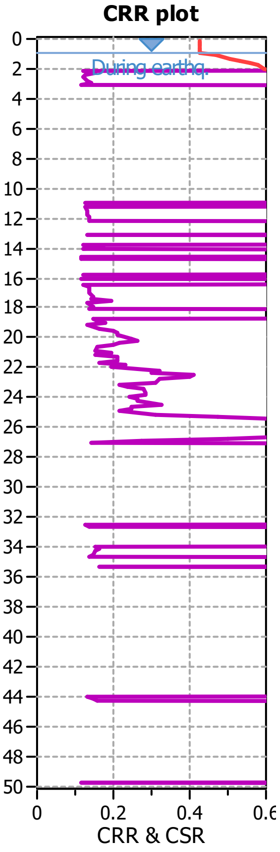
Input parameters and analysis data

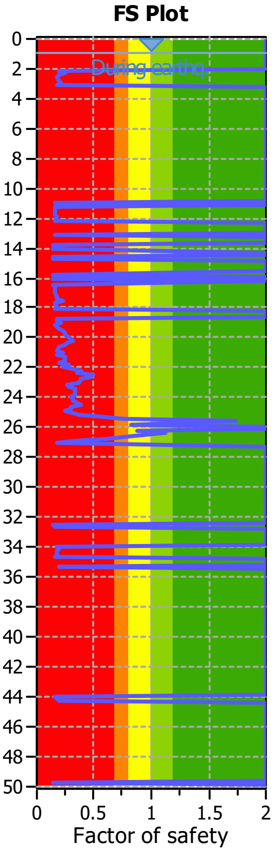
Analysis method:	B&I (2014)	G.W.T. (in-situ):	3.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	B&I (2014)	G.W.T. (earthq.):	1.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	7.50	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.72	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

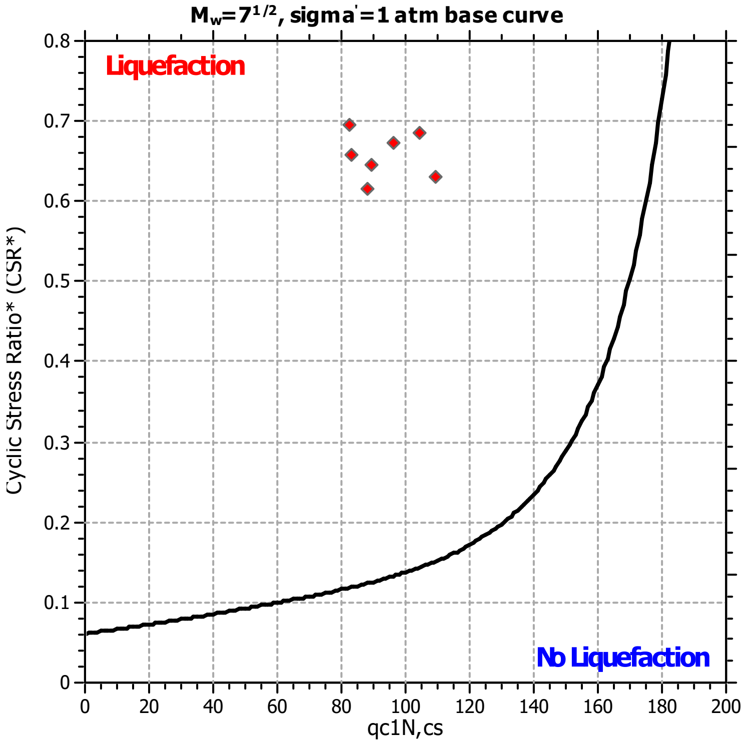

Cone resistance

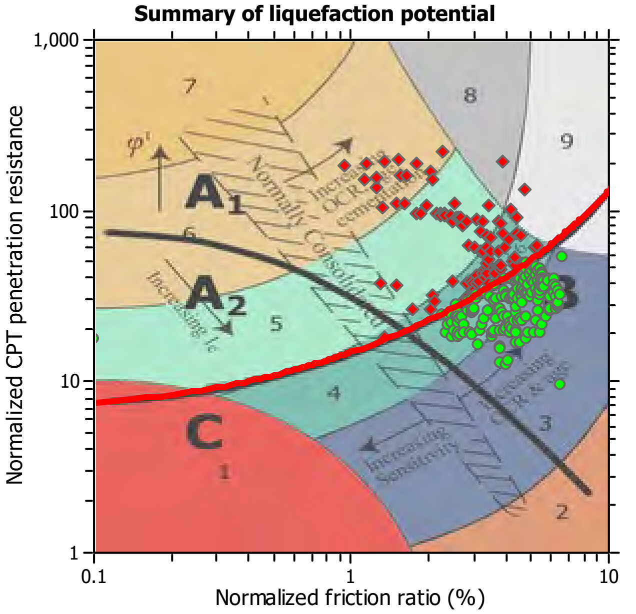

Friction Ratio


SBTn Plot


CRR plot

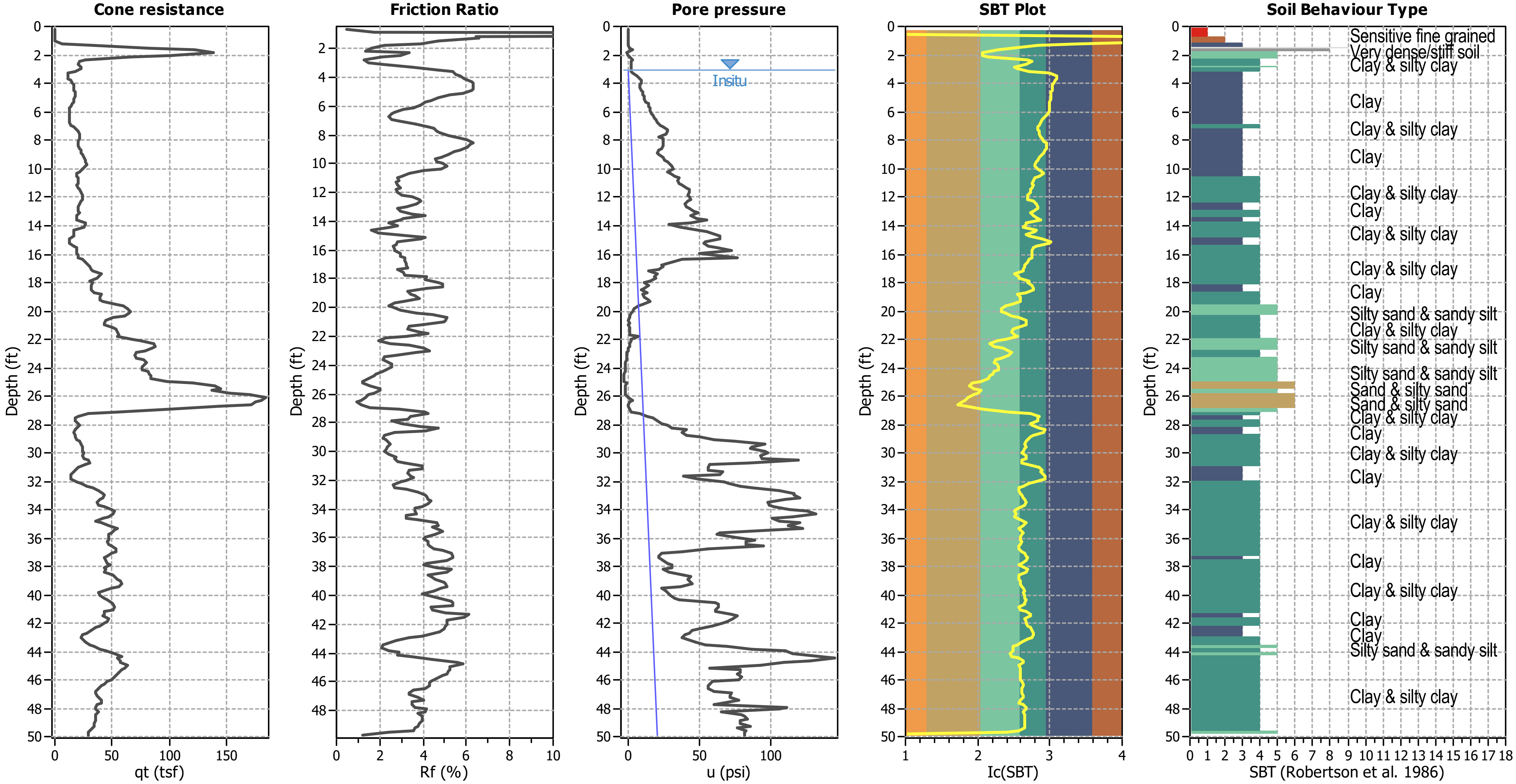

FS Plot


$M_w=7^{1/2}$, sigma'=1 atm base curve


Summary of liquefaction potential

Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



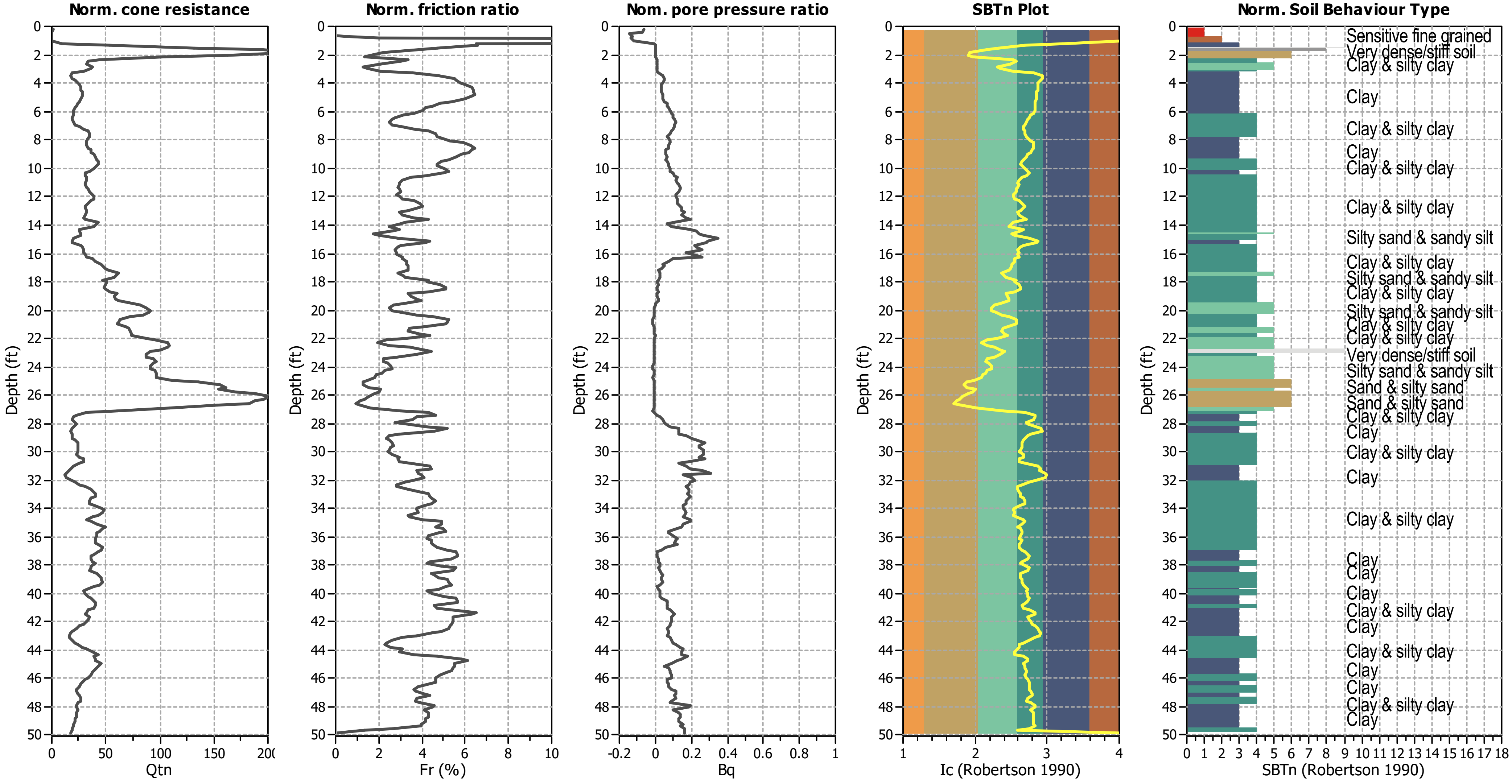
Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟫 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



Norm. cone resistance

Norm. friction ratio

Nom. pore pressure ratio

SBTn Plot

Norm. Soil Behaviour Type

Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.50
Peak ground acceleration: 0.72
Depth to water table (insitu): 3.00 ft

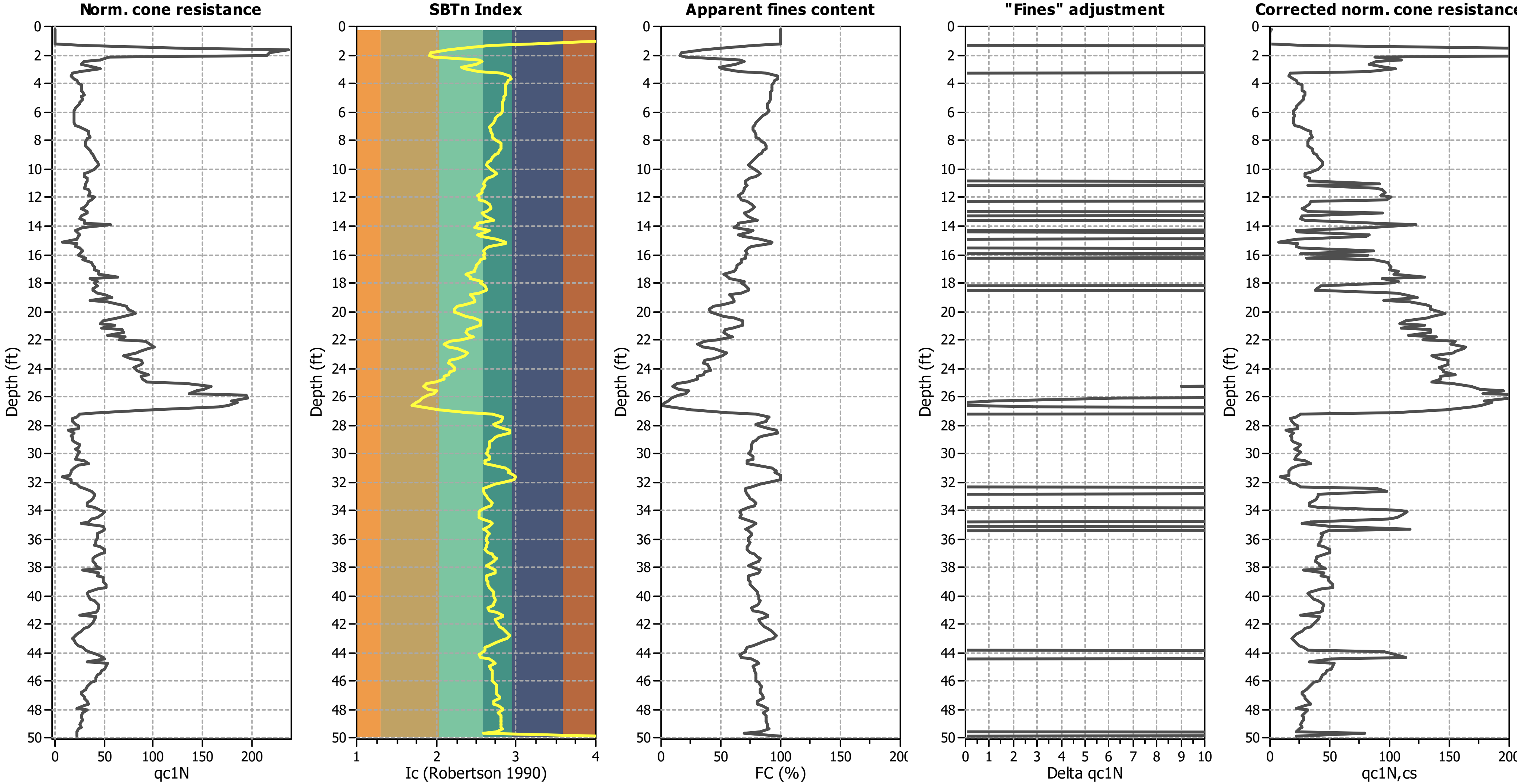
Depth to GWT (erthq.): 1.00 ft
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: No
K_σ applied: Yes
Clay like behavior applied: Sands only
Limit depth applied: No
Limit depth: N/A

SBTn legend

🟥 1. Sensitive fine grained	🟩 4. Clayey silt to silty	🟧 7. Gravely sand to sand
🟫 2. Organic material	🟩 5. Silty sand to sandy silt	⬛ 8. Very stiff sand to
🟦 3. Clay to silty clay	🟨 6. Clean sand to silty sand	⬜ 9. Very stiff fine grained

Liquefaction analysis overall plots (intermediate results)



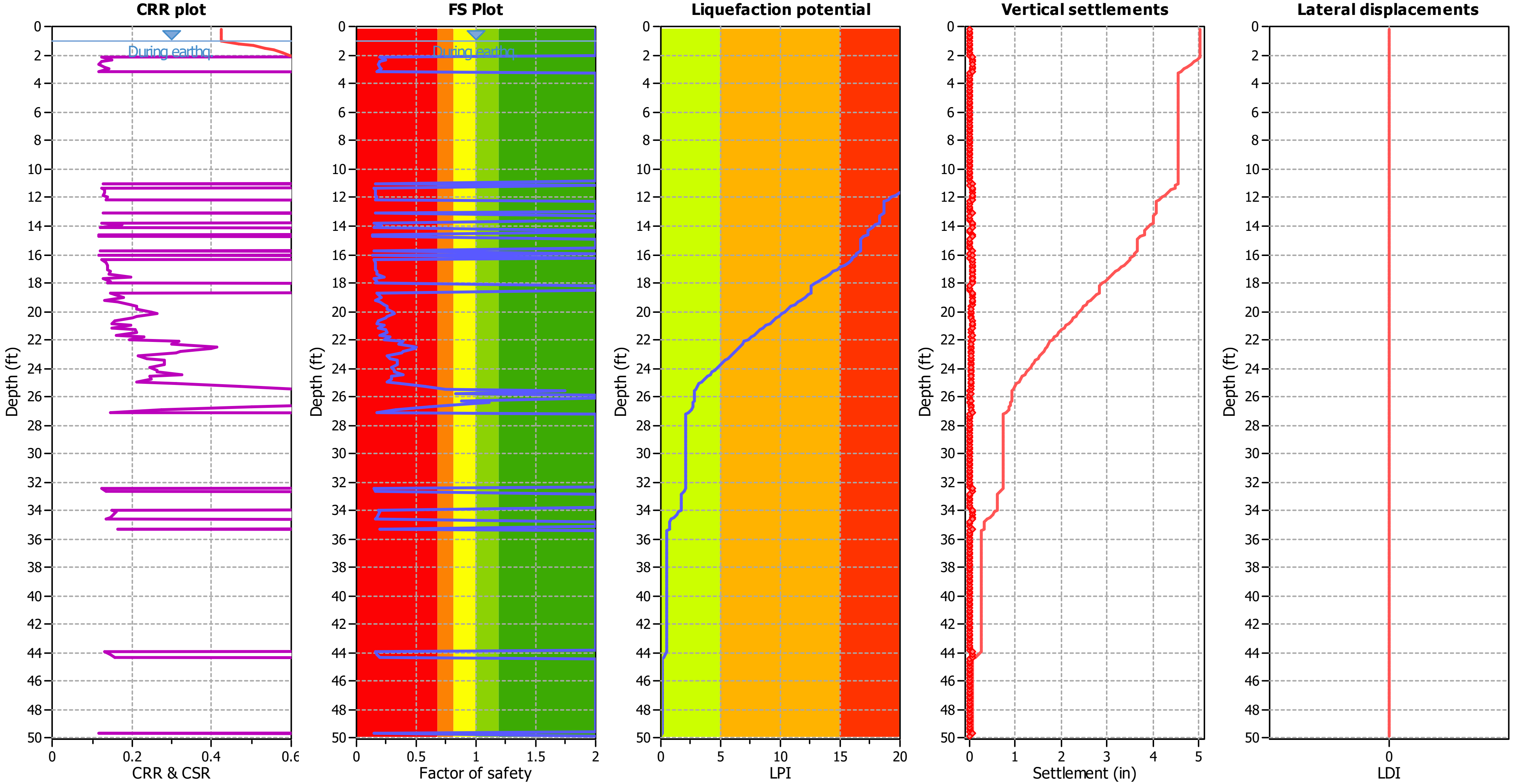
Input parameters and analysis data

Analysis method: B&I (2014)
Fines correction method: B&I (2014)
Points to test: Based on Ic value
Earthquake magnitude M_w: 7.50
Peak ground acceleration: 0.72
Depth to water table (insitu): 3.00 ft

Depth to GWT (erthq.): 1.00 ft
Average results interval: 3
Ic cut-off value: 2.60
Unit weight calculation: Based on SBT
Use fill: No
Fill height: N/A

Fill weight: N/A
Transition detect. applied: No
K_σ applied: Yes
Clay like behavior applied: Sands only
Limit depth applied: No
Limit depth: N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

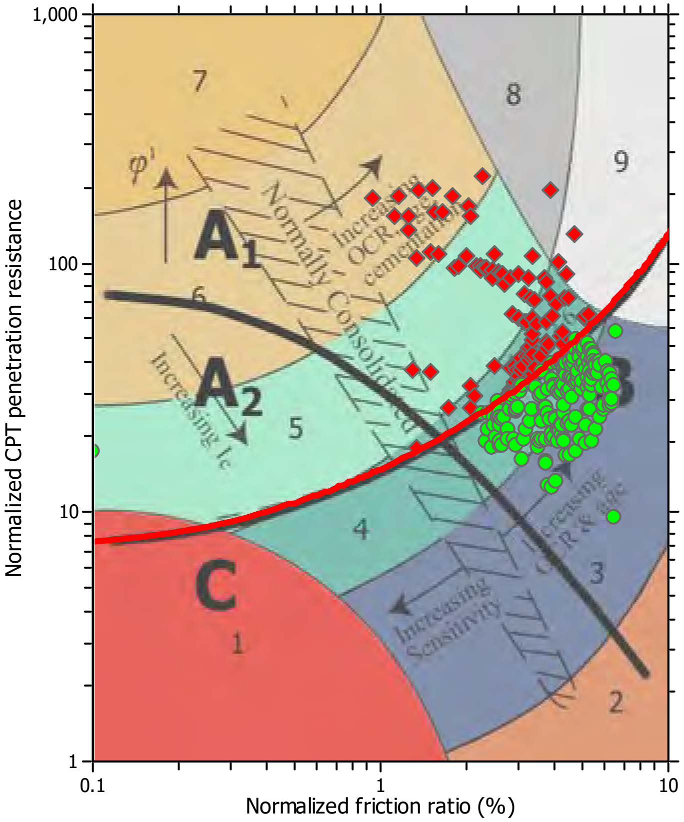
F.S. color scheme

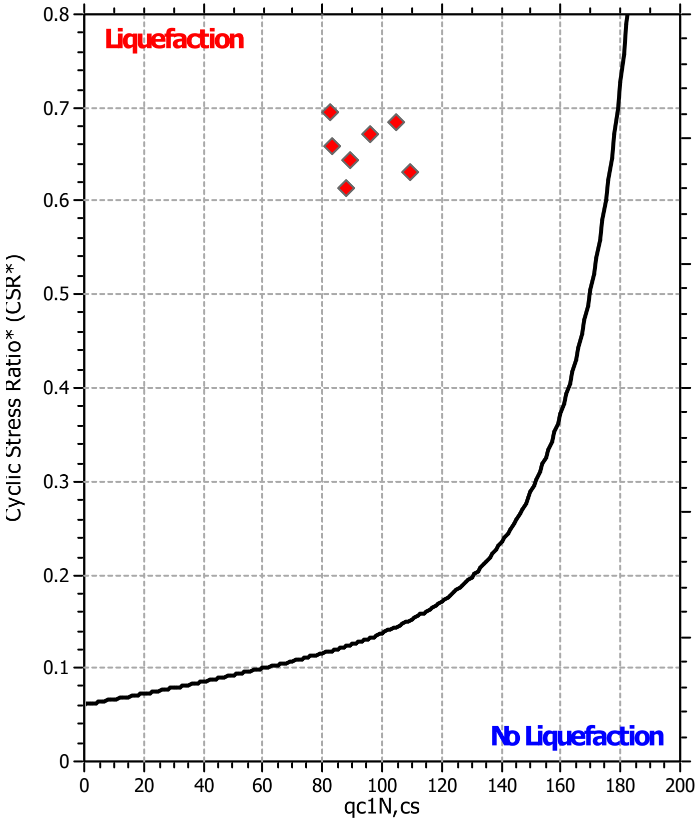
🟥	Almost certain it will liquefy
🟧	Very likely to liquefy
🟨	Liquefaction and no liq. are equally likely
🟩	Unlike to liquefy
🟩	Almost certain it will not liquefy

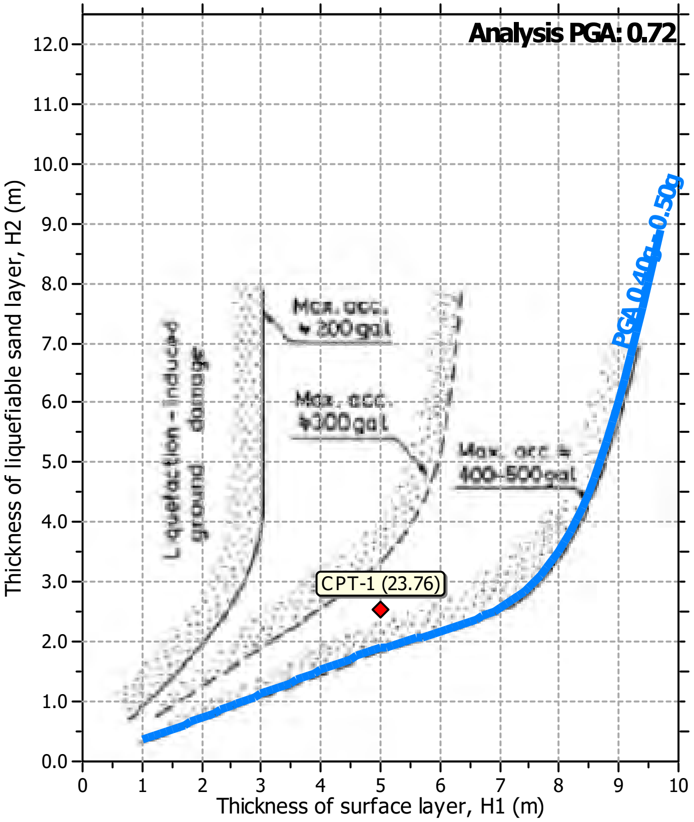
LPI color scheme

🟥	Very high risk
🟧	High risk
🟨	Low risk

Liquefaction analysis summary plots



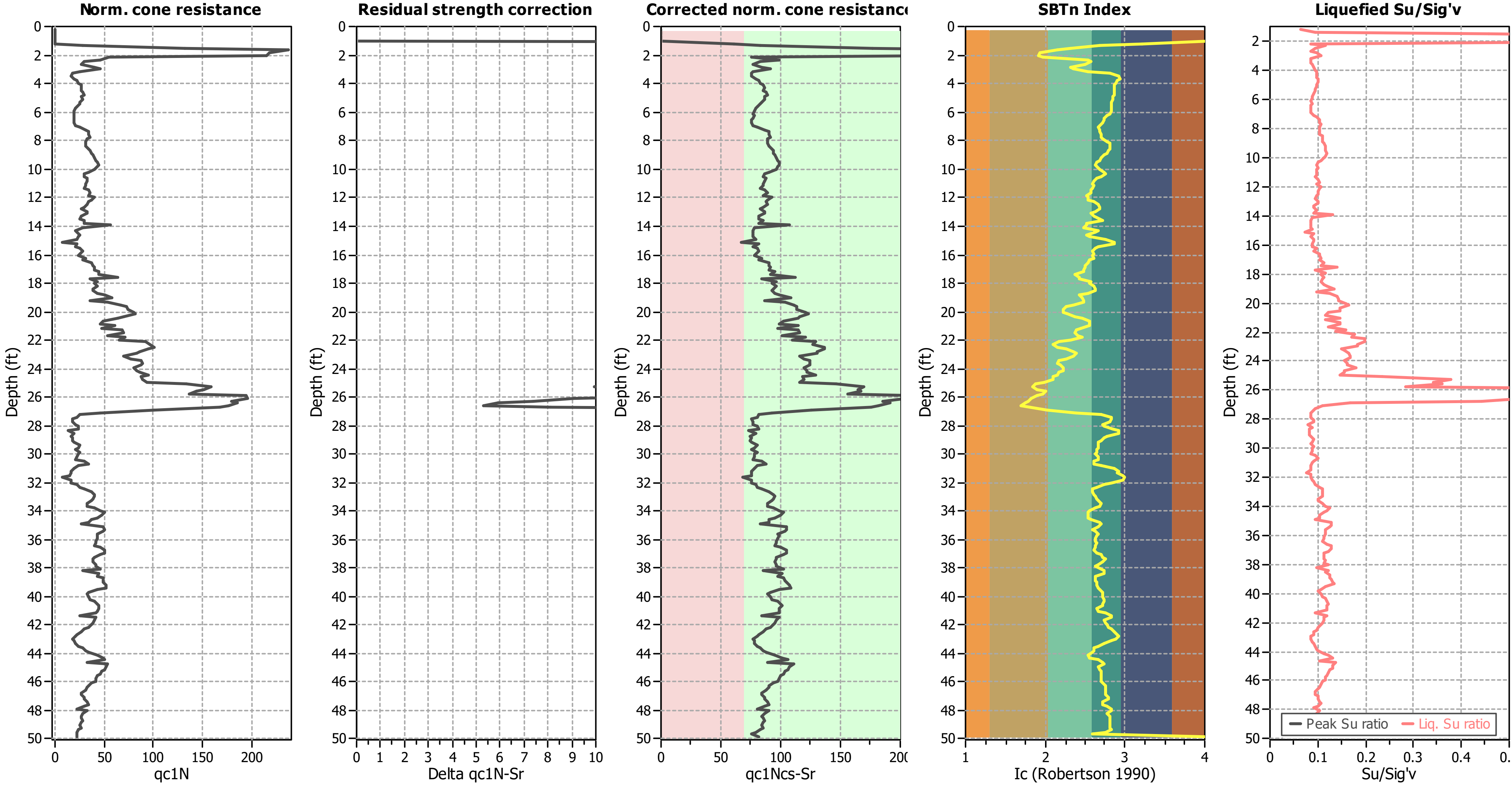




Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

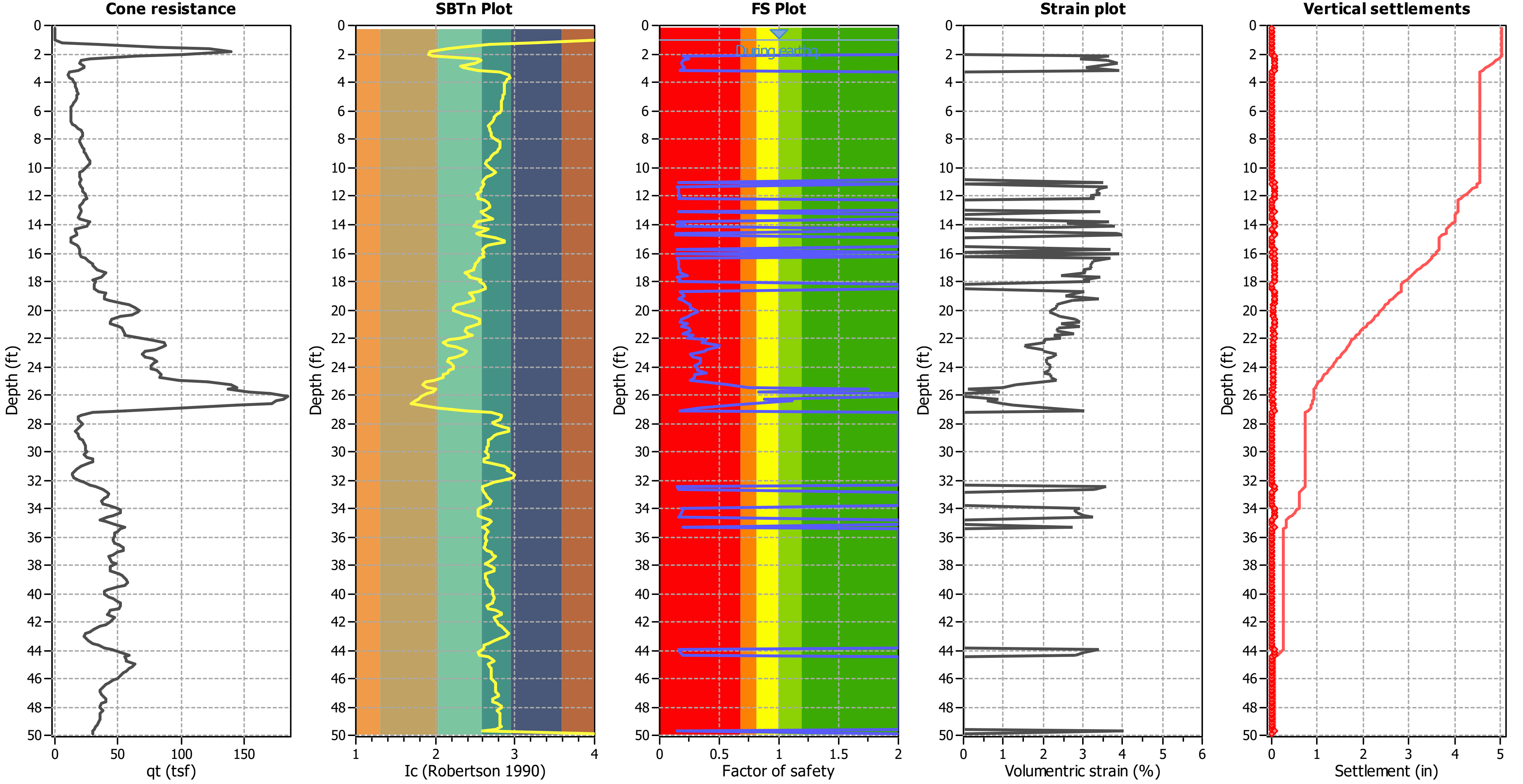
Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	B&I (2014)	Depth to GWT (erthq.):	1.00 ft	Fill weight:	N/A
Fines correction method:	B&I (2014)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.50	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.72	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	3.00 ft	Fill height:	N/A	Limit depth:	N/A

Estimation of post-earthquake settlements

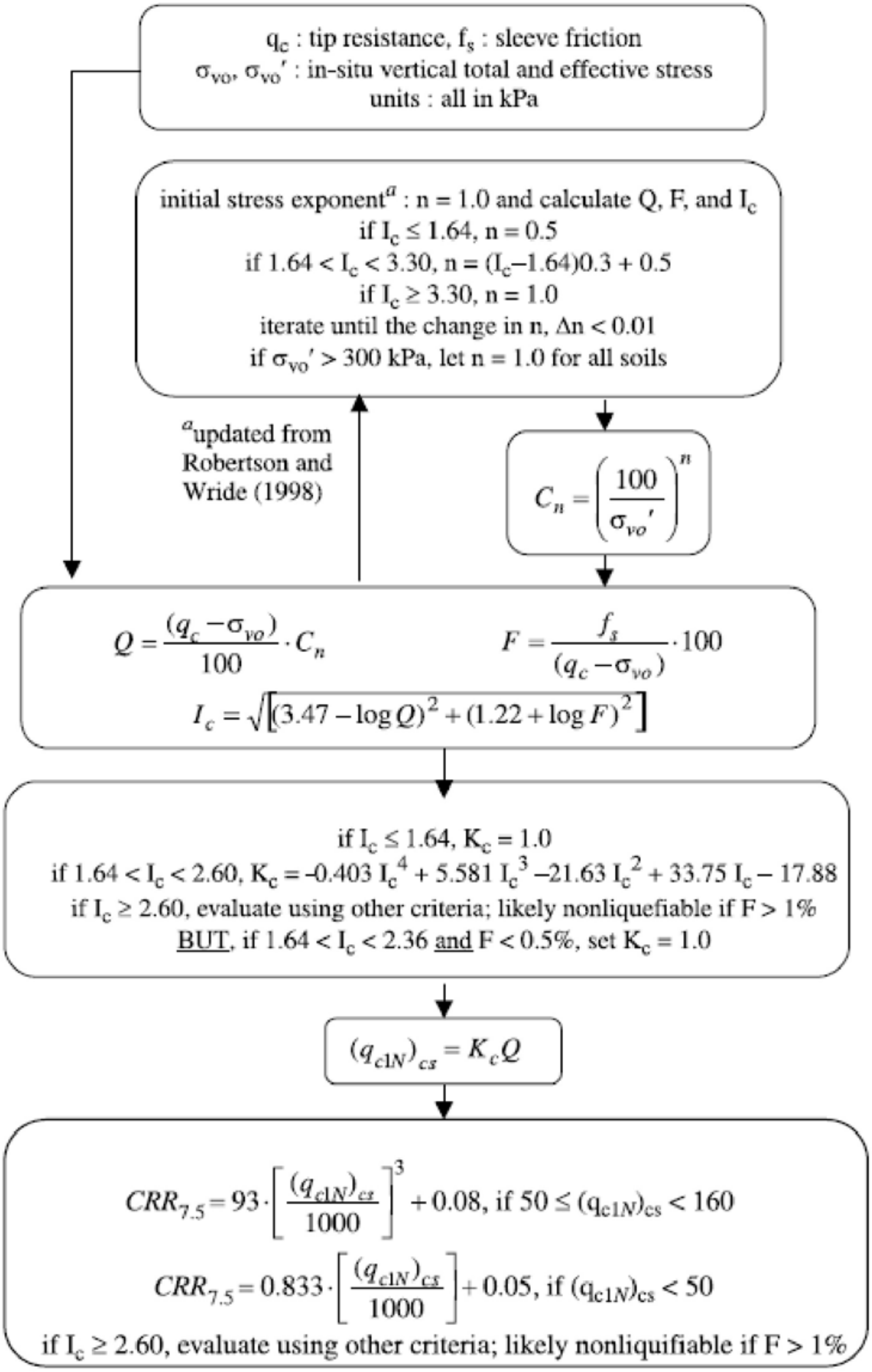


Abbreviations

q_t:	Total cone resistance (cone resistance q_c corrected for pore water effects)
I_c:	Soil Behaviour Type Index
FS:	Calculated Factor of Safety against liquefaction
Volumentric strain:	Post-liquefaction volumentric strain

Procedure for the evaluation of soil liquefaction resistance, NCEER (1998)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. The procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



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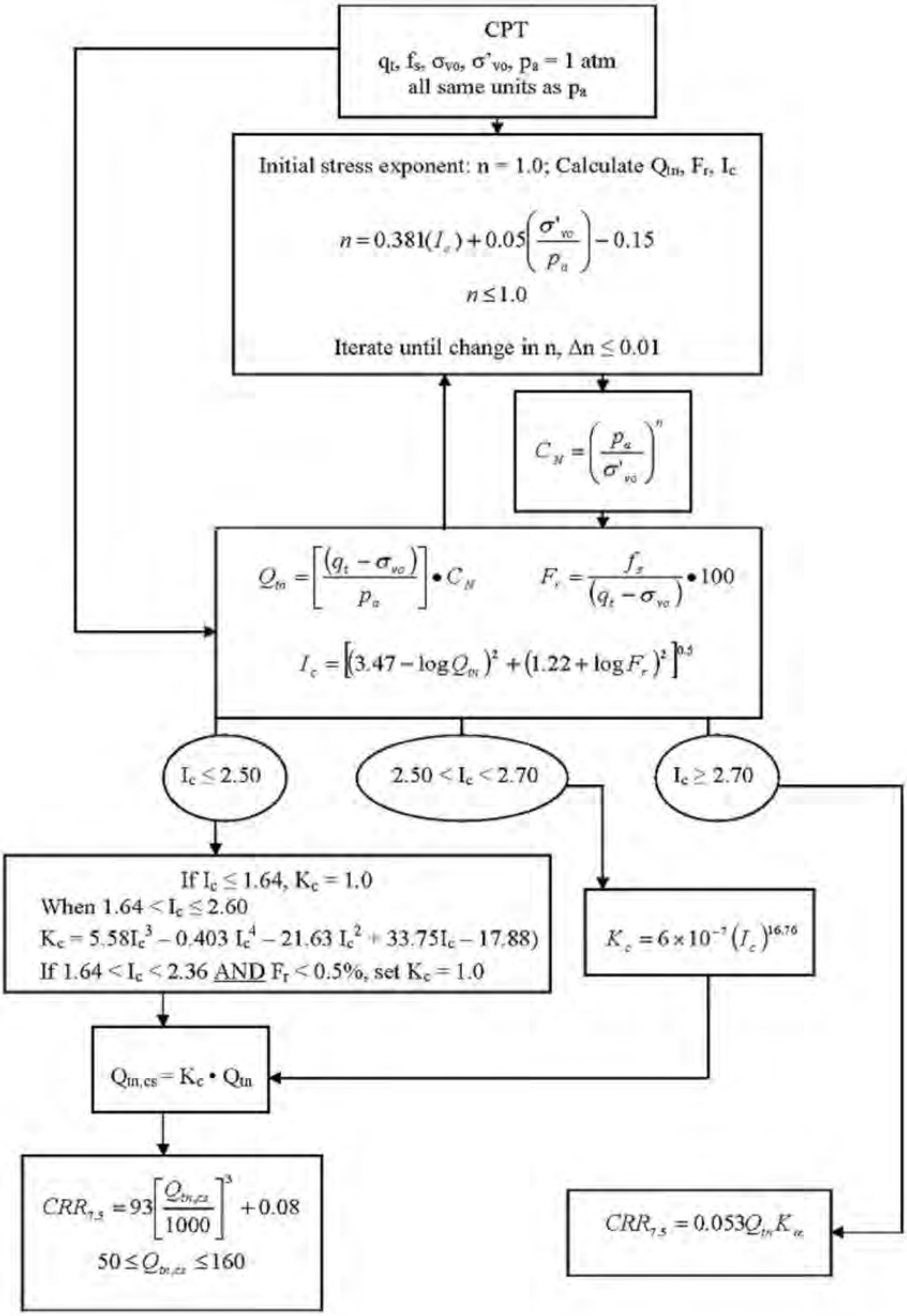
[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the evaluation of soil liquefaction resistance (all soils), Robertson (2010)

Calculation of soil resistance against liquefaction is performed according to the Robertson & Wride (1998) procedure. This procedure used in the software, slightly differs from the one originally published in NCEER-97-0022 (Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils). The revised procedure is presented below in the form of a flowchart[1]:



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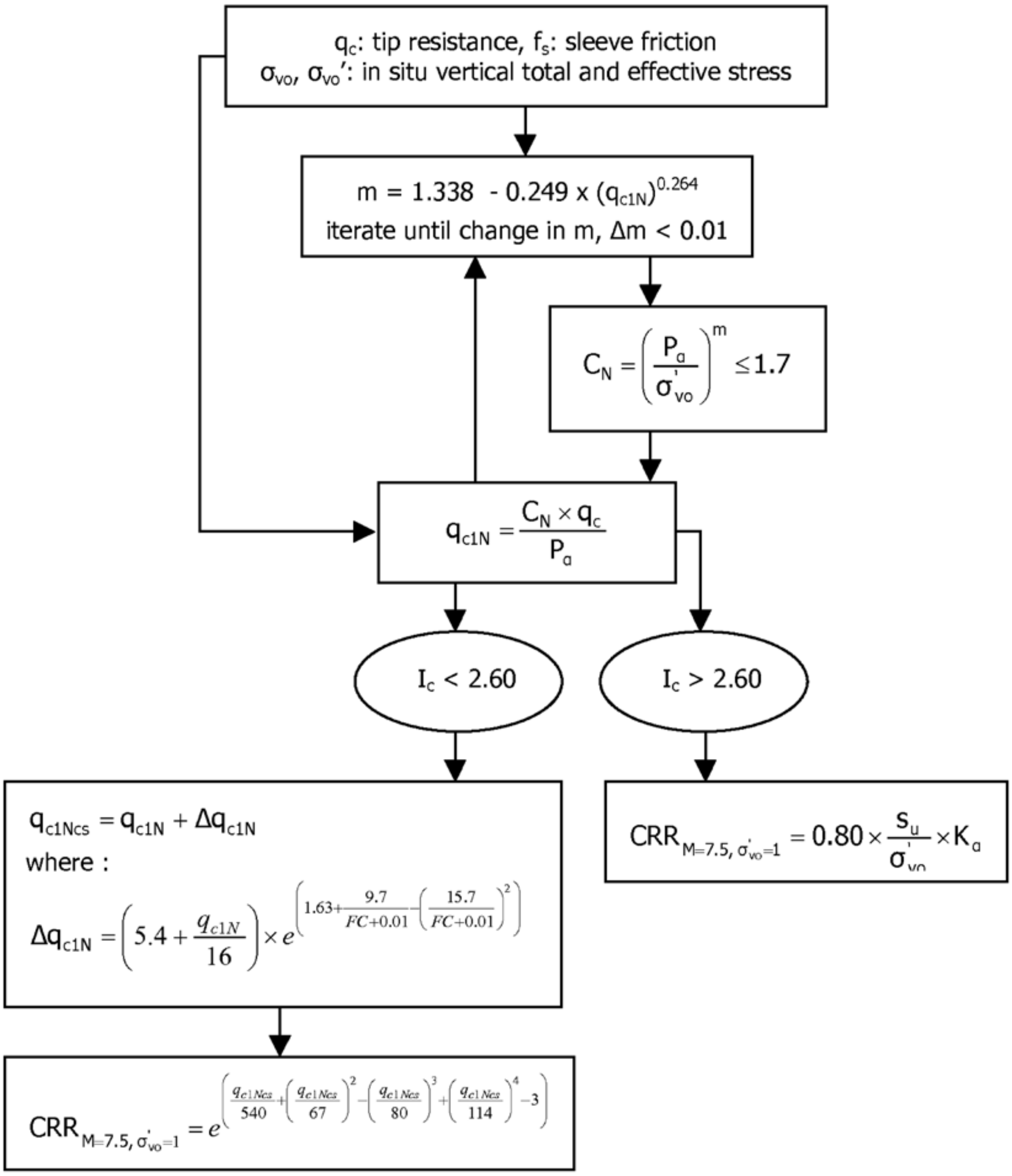
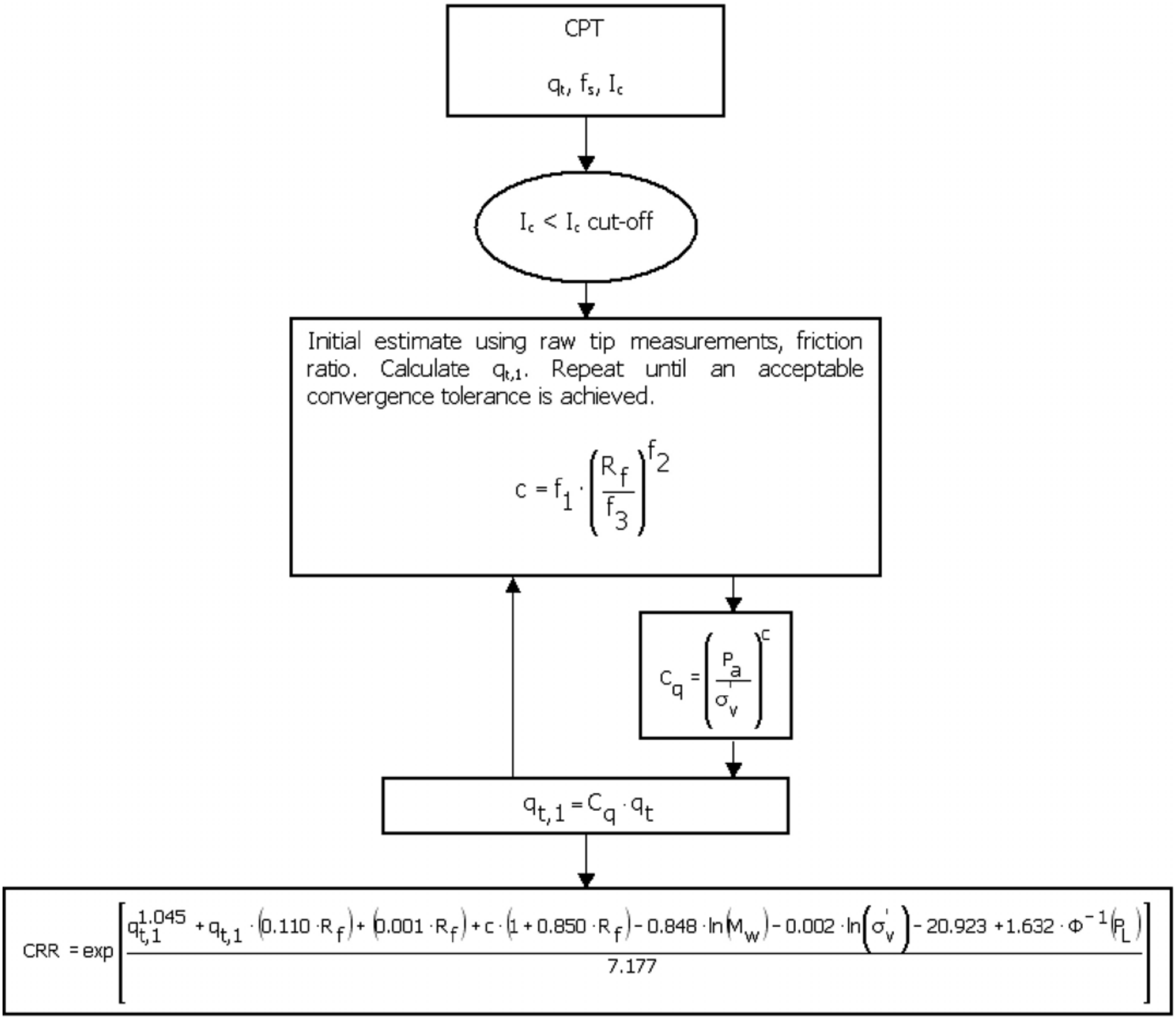
[1] P.K. Robertson, 2009. "Performance based earthquake design using the CPT", Keynote Lecture, International Conference on Performance-based Design in Earthquake Geotechnical Engineering – from case history to practice, IS-Tokyo, June 2009

Procedure for the evaluation of soil liquefaction resistance, Idriss & Boulanger (2008)



Procedure for the evaluation of soil liquefaction resistance (sandy soils), Moss et al. (2006)



Initial estimate using raw tip measurements, friction ratio. Calculate $q_{t,1}$. Repeat until an acceptable convergence tolerance is achieved.

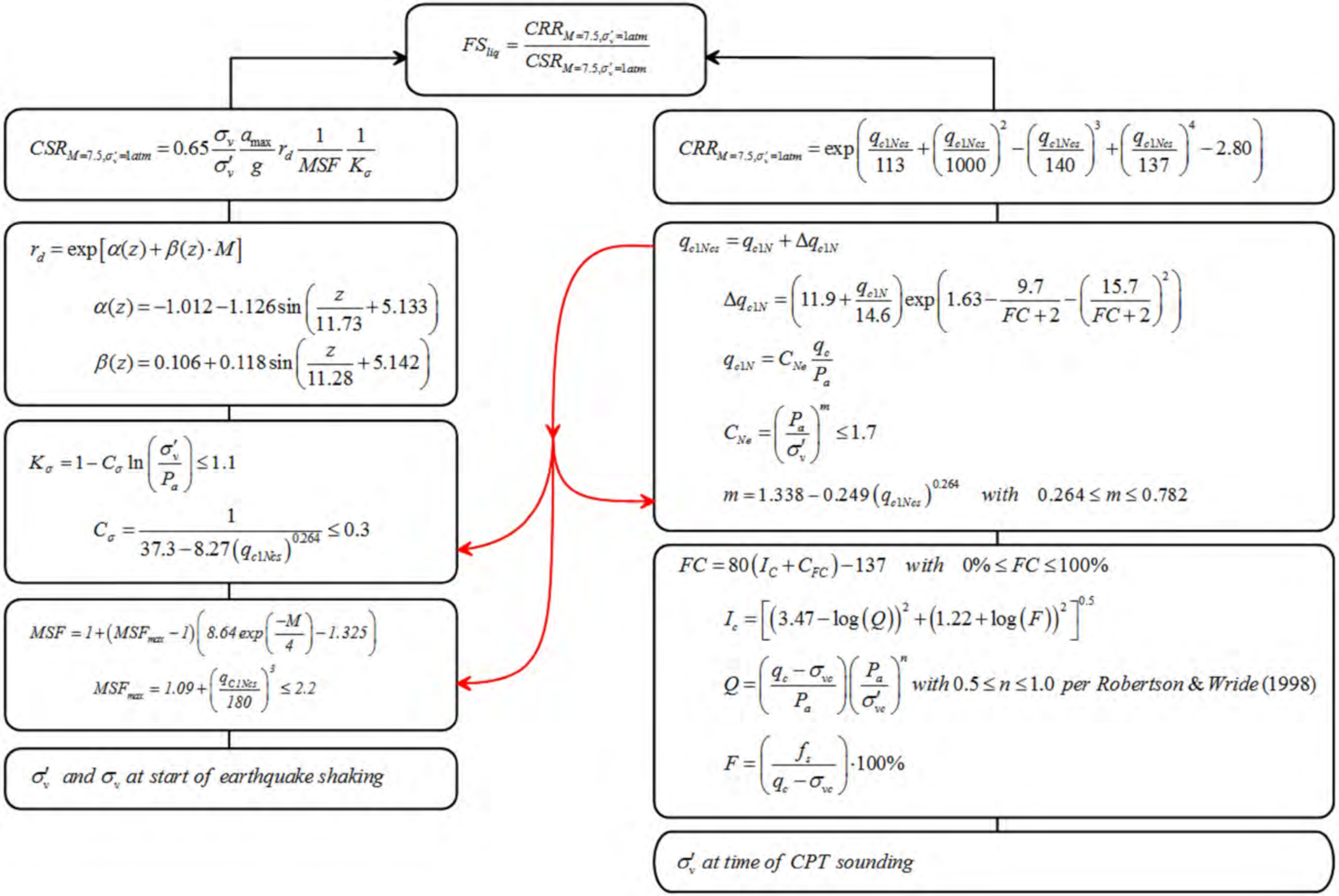
$$c = f_1 \cdot \left(\frac{R_f}{f_3}\right)^{f_2}$$

$$C_q = \left(\frac{P_a}{\sigma'_v}\right)^{c}$$

$$q_{t,1} = C_q \cdot q_t$$

$$CRR = \exp\left[\frac{q_{t,1}^{1.045} + q_{t,1} \cdot (0.110 \cdot R_f) + (0.001 \cdot R_f) + c \cdot (1 + 0.850 \cdot R_f) - 0.848 \cdot \ln(M_w) - 0.002 \cdot \ln(\sigma'_v) - 20.923 + 1.632 \cdot \Phi^{-1}(P_L)}{7.177}\right]$$

Procedure for the evaluation of soil liquefaction resistance, Boulanger & Idriss(2014)



$$FS_{liq} = \frac{CRR_{M=7.5,\sigma'_v=1atm}}{CSR_{M=7.5,\sigma'_v=1atm}}$$

$$CSR_{M=7.5,\sigma'_v=1atm} = 0.65\frac{\sigma_v}{\sigma'_v}\frac{a_{\max}}{g}r_d\frac{1}{MSF}\frac{1}{K_\sigma}$$

$$r_d = \exp\left[\alpha(z)+\beta(z)\cdot M\right]$$

$$\alpha(z) = -1.012-1.126\sin\left(\frac{z}{11.73}+5.133\right)$$

$$\beta(z) = 0.106+0.118\sin\left(\frac{z}{11.28}+5.142\right)$$

$$K_\sigma = 1-C_\sigma\ln\left(\frac{\sigma'_v}{P_a}\right)\le 1.1$$

$$C_\sigma = \frac{1}{37.3-8.27\left(q_{c1Ncs}\right)^{0.264}}\le 0.3$$

$$MSF = 1+\left(MSF_{max}-1\right)\left(8.64\exp\left(\frac{-M}{4}\right)-1.325\right)$$

$$MSF_{max} = 1.09+\left(\frac{q_{c1Ncs}}{180}\right)^3\le 2.2$$

σ'_v and σ_v at start of earthquake shaking

$$CRR_{M=7.5,\sigma'_v=1atm} = \exp\left(\frac{q_{c1Ncs}}{113}+\left(\frac{q_{c1Ncs}}{1000}\right)^2-\left(\frac{q_{c1Ncs}}{140}\right)^3+\left(\frac{q_{c1Ncs}}{137}\right)^4-2.80\right)$$

$$q_{c1Ncs} = q_{c1N}+\Delta q_{c1N}$$

$$\Delta q_{c1N} = \left(11.9+\frac{q_{c1N}}{14.6}\right)\exp\left(1.63-\frac{9.7}{FC+2}-\left(\frac{15.7}{FC+2}\right)^2\right)$$

$$q_{c1N} = C_{Ne}\frac{q_c}{P_a}$$

$$C_{Ne} = \left(\frac{P_a}{\sigma'_v}\right)^m\le 1.7$$

$$m = 1.338-0.249\left(q_{c1Ncs}\right)^{0.264}\quad with\quad 0.264\le m\le 0.782$$

$$FC = 80\left(I_C+C_{FC}\right)-137\quad with\quad 0\%\le FC\le 100\%$$

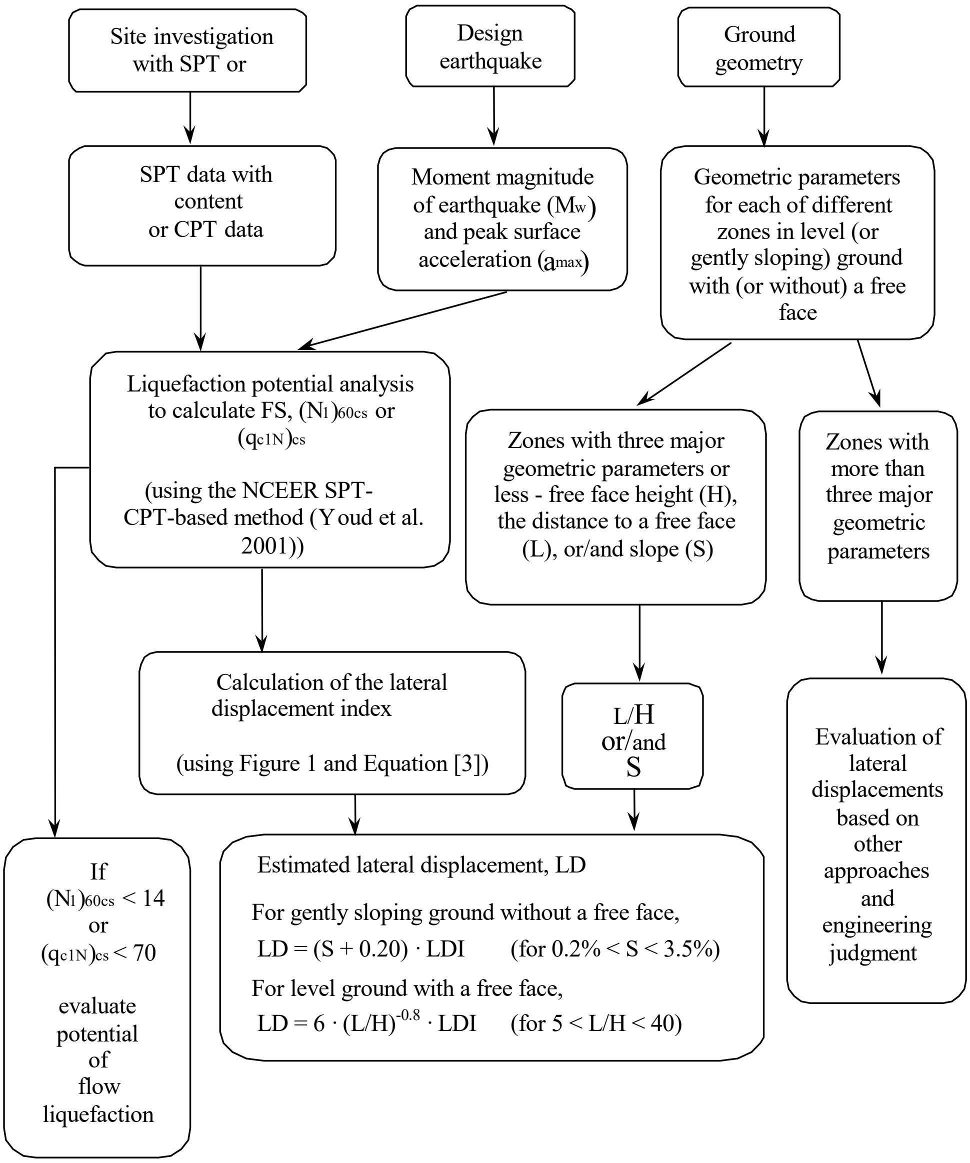
$$I_c = \left[\left(3.47-\log(Q)\right)^2+\left(1.22+\log(F)\right)^2\right]^{0.5}$$

$$Q = \left(\frac{q_c-\sigma_{vc}}{P_a}\right)\left(\frac{P_a}{\sigma'_{vc}}\right)^n \; with\; 0.5\le n\le 1.0\; per\; Robertson\;\&\;Wride\,(1998)$$

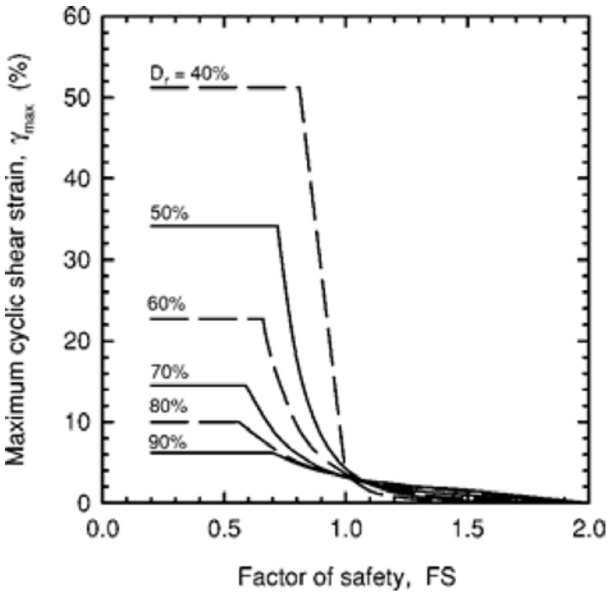
$$F = \left(\frac{f_s}{q_c-\sigma_{vc}}\right)\cdot 100\%$$

σ'_v at time of CPT sounding

Procedure for the evaluation of liquefaction-induced lateral spreading displacements



[1] Flow chart illustrating major steps in estimating liquefaction-induced lateral spreading displacements using the proposed approach



[1] **Figure 1**

$$LDI= \int_{0}^{Z_{max}} \gamma_{max} dz$$

[1] **Equation [3]**

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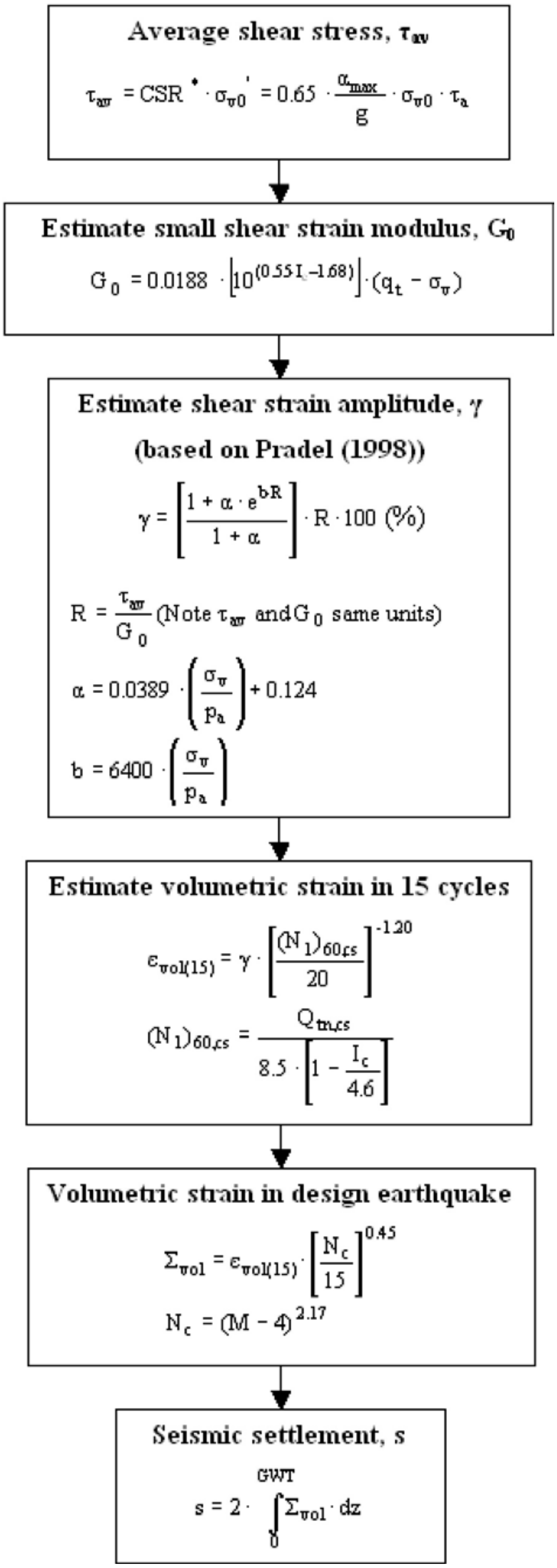
[1] "Estimating liquefaction-induced ground settlements from CPT for level ground", G. Zhang, P.K. Robertson, and R.W.I. Brachman

Procedure for the estimation of seismic induced settlements in dry sands



Average shear stress, τ_{av}

$$\tau_{av} = CSR^{*} \cdot \sigma_{v0}' = 0.65 \cdot \frac{\alpha_{max}}{g} \cdot \sigma_{v0} \cdot \tau_{a}$$

Estimate small shear strain modulus, G_0

$$G_0 = 0.0188 \cdot \left[10^{(0.55 I_c - 1.68)}\right] \cdot (q_t - \sigma_v)$$

Estimate shear strain amplitude, γ

(based on Pradel (1998))

$$\gamma = \left[\frac{1 + \alpha \cdot e^{bR}}{1 + \alpha}\right] \cdot R \cdot 100 \ (\%)$$

$$R = \frac{\tau_{av}}{G_0} \text{(Note } \tau_{av} \text{ and } G_0 \text{ same units)}$$

$$\alpha = 0.0389 \cdot \left(\frac{\sigma_v}{p_a}\right) + 0.124$$

$$b = 6400 \cdot \left(\frac{\sigma_v}{p_a}\right)$$

Estimate volumetric strain in 15 cycles

$$\varepsilon_{vol(15)} = \gamma \cdot \left[\frac{(N_1)_{60,cs}}{20}\right]^{-1.20}$$

$$(N_1)_{60,cs} = \frac{Q_{tn,cs}}{8.5 \cdot \left[1 - \frac{I_c}{4.6}\right]}$$

Volumetric strain in design earthquake

$$\Sigma_{vol} = \varepsilon_{vol(15)} \cdot \left[\frac{N_c}{15}\right]^{0.45}$$

$$N_c = (M - 4)^{2.17}$$

Seismic settlement, s

$$s = 2 \cdot \int_{0}^{GWT} \Sigma_{vol} \cdot dz$$

Robertson, P.K. and Lisheng, S., 2010, “Estimation of seismic compression in dry soils using the CPT” FIFTH INTERNATIONAL CONFERENCE ON RECENT ADVANCES IN GEOTECHNICAL EARTHQUAKE ENGINEERING AND SOIL DYNAMICS, Symposium in honor of professor I. M. Idriss, San Diego, CA

Liquefaction Potential Index (LPI) calculation procedure

Calculation of the Liquefaction Potential Index (LPI) is used to interpret the liquefaction assessment calculations in terms of severity over depth. The calculation procedure is based on the methology developed by Iwasaki (1982) and is adopted by AFPS.

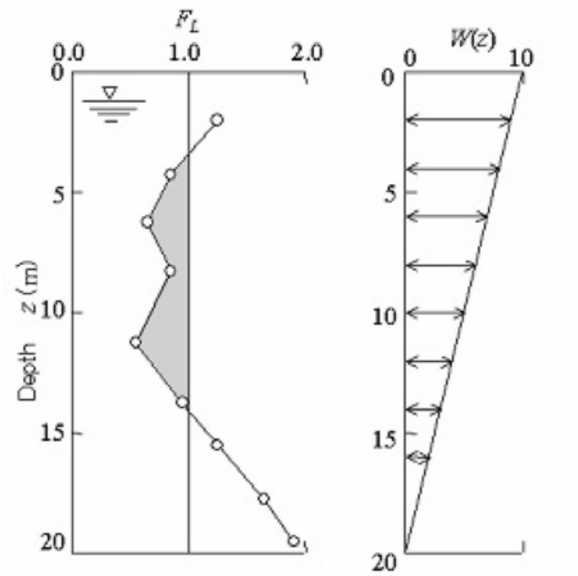
To estimate the severity of liquefaction extent at a given site, LPI is calculated based on the following equation:

$$\textbf{LPI} = \int_0^{20} (10 - 0{,}5_z) \times F_L \times d_z$$

where:
F_L = 1 - F.S. when F.S. less than 1
F_L = 0 when F.S. greater than 1
z depth of measurment in meters

Values of LPI range between zero (0) when no test point is characterized as liquefiable and 100 when all points are characterized as susceptible to liquefaction. Iwasaki proposed four (4) discrete categories based on the numeric value of LPI:

- LPI = 0 : Liquefaction risk is very low
- 0 < LPI <= 5 : Liquefaction risk is low
- 5 < LPI <= 15 : Liquefaction risk is high
- LPI > 15 : Liquefaction risk is very high



Graphical presentation of the LPI calculation procedure

Shear-Induced Building Settlement (Ds) calculation procedure

The shear-induced building settlement (Ds) due to liquefaction below the building can be estimated using the relationship developed by Bray and Macedo (2017):

$$
\begin{aligned}
Ln(Ds) = c1 + c2 * LBS + 0.58 * Ln\left(Tanh\left(\frac{HL}{6}\right)\right) + \\
4.59 * Ln(Q) - 0.42 * Ln(Q)^2 - 0.02 * B + \\
0.84 * Ln(CAVdp) + 0.41 * Ln(Sa1) + \varepsilon
\end{aligned}
$$

where Ds is in the units of mm, c1= -8.35 and c2= 0.072 for LBS ≤ 16, and c1= -7.48 and c2= 0.014 otherwise. Q is the building contact pressure in units of kPa, HL is the cumulative thickness of the liquefiable layers in the units of m, B is the building width in the units of m, CAVdp is a standardized version of the cumulative absolute velocity in the units of g-s, Sa1 is 5%-damped pseudo-acceleration response spectral value at a period of 1 s in the units of g, and ε is a normal random variable with zero mean and 0.50 standard deviation in Ln units. The liquefaction-induced building settlement index (LBS) is:

$$LBS = \sum W * \frac{\varepsilon_{shear}}{z} dz$$

where z (m) is the depth measured from the ground surface > 0, W is a foundation-weighting factor wherein W = 0.0 for z less than Df, which is the embedment depth of the foundation, and W = 1.0 otherwise. The shear strain parameter (ε_shear) is the liquefaction-induced free-field shear strain (in %) estimated using Zhang et al. (2004). It is calculated based on the estimated Dr of the liquefied soil layer and the calculated safety factor against liquefaction triggering (FSL).

References

- Lunne, T., Robertson, P.K., and Powell, J.J.M 1997. Cone penetration testing in geotechnical practice, E & FN Spon Routledge, 352 p, ISBN 0-7514-0393-8.

- Boulanger, R.W. and Idriss, I. M., 2007. Evaluation of Cyclic Softening in Silts and Clays. ASCE Journal of Geotechnical and Geoenvironmental Engineering June, Vol. 133, No. 6 pp 641-652

- Boulanger, R.W. and Idriss, I. M., 2014. CPT AND SPT BASED LIQUEFACTION TRIGGERING PROCEDURES. DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING COLLEGE OF ENGINEERING UNIVERSITY OF CALIFORNIA AT DAVIS

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APPENDIX C-2

SPT Liquefaction Analysis

Peters & Ross
Geotechnical and
Geoenvironmental Consultants

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Pleasant Hill, CA 94523
tel. (925) 942-3829
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PetersRoss@aol.com

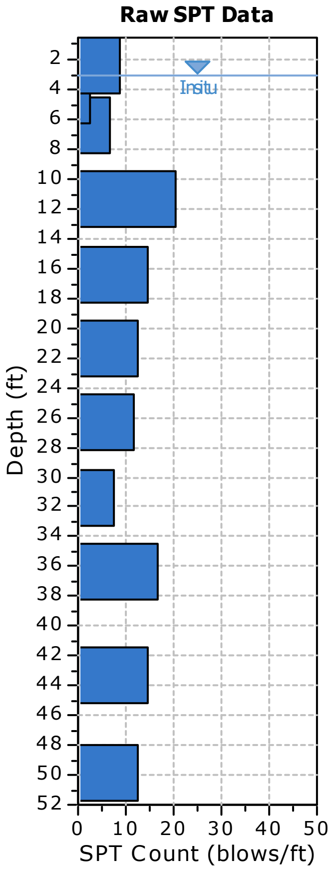
SPT BASED LIQUEFACTION ANALYSIS REPORT

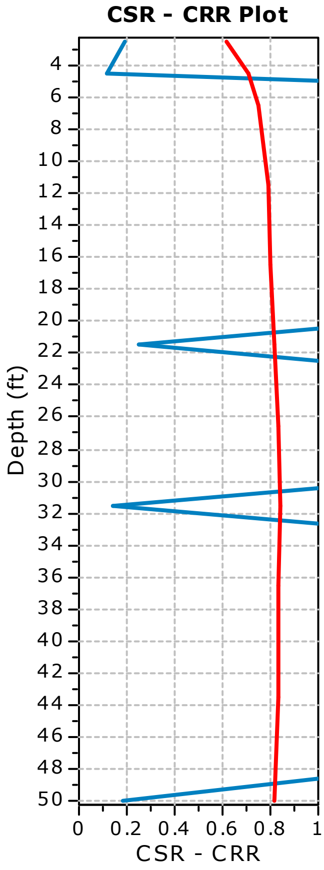
Project title : SPT Liquefaction Assessment **SPT Name: SPT #1**

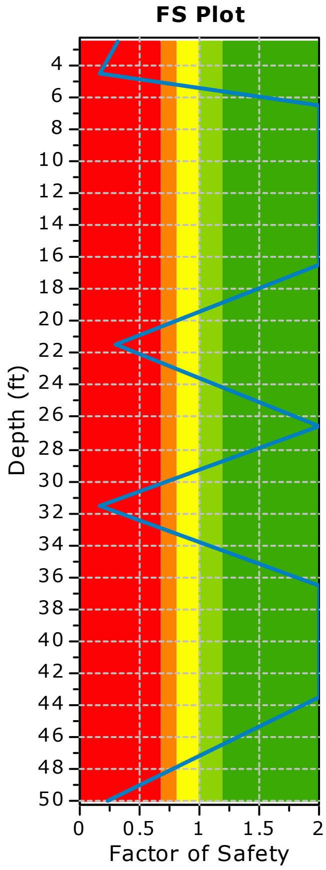
Location : NW Corner of Illinois & Webster St., Fairfield, CA

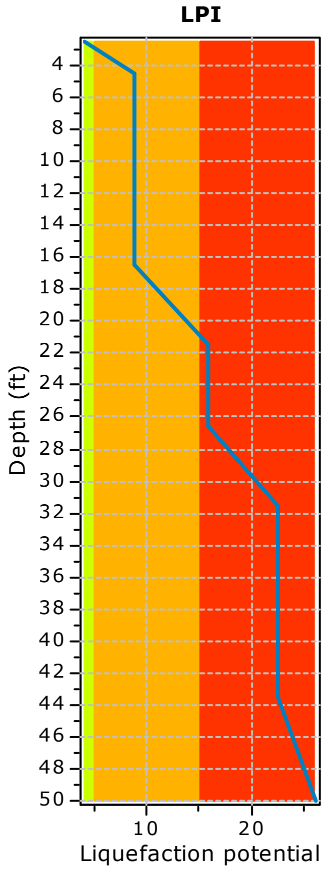
:: Input parameters and analysis properties ::

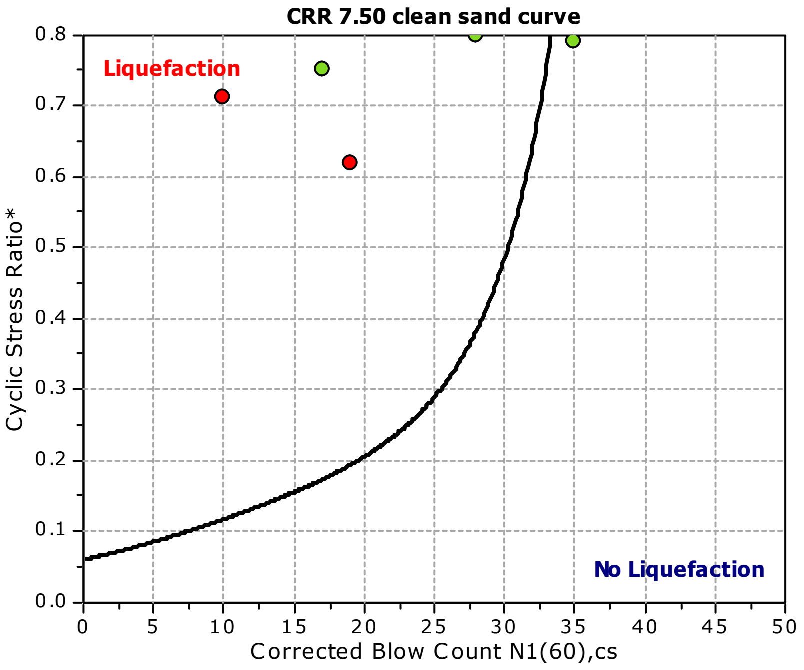
Analysis method:	Boulanger & Idriss, 2014	G.W.T. (in-situ):	3.00 ft
Fines correction method:	Boulanger & Idriss, 2014	G.W.T. (earthq.):	1.00 ft
Sampling method:	Sampler wo liners	Earthquake magnitude M_w:	7.50
Borehole diameter:	65mm to 115mm	Peak ground acceleration:	0.72 g
Rod length:	3.30 ft	Eq. external load:	0.00 tsf
Hammer energy ratio:	1.00		











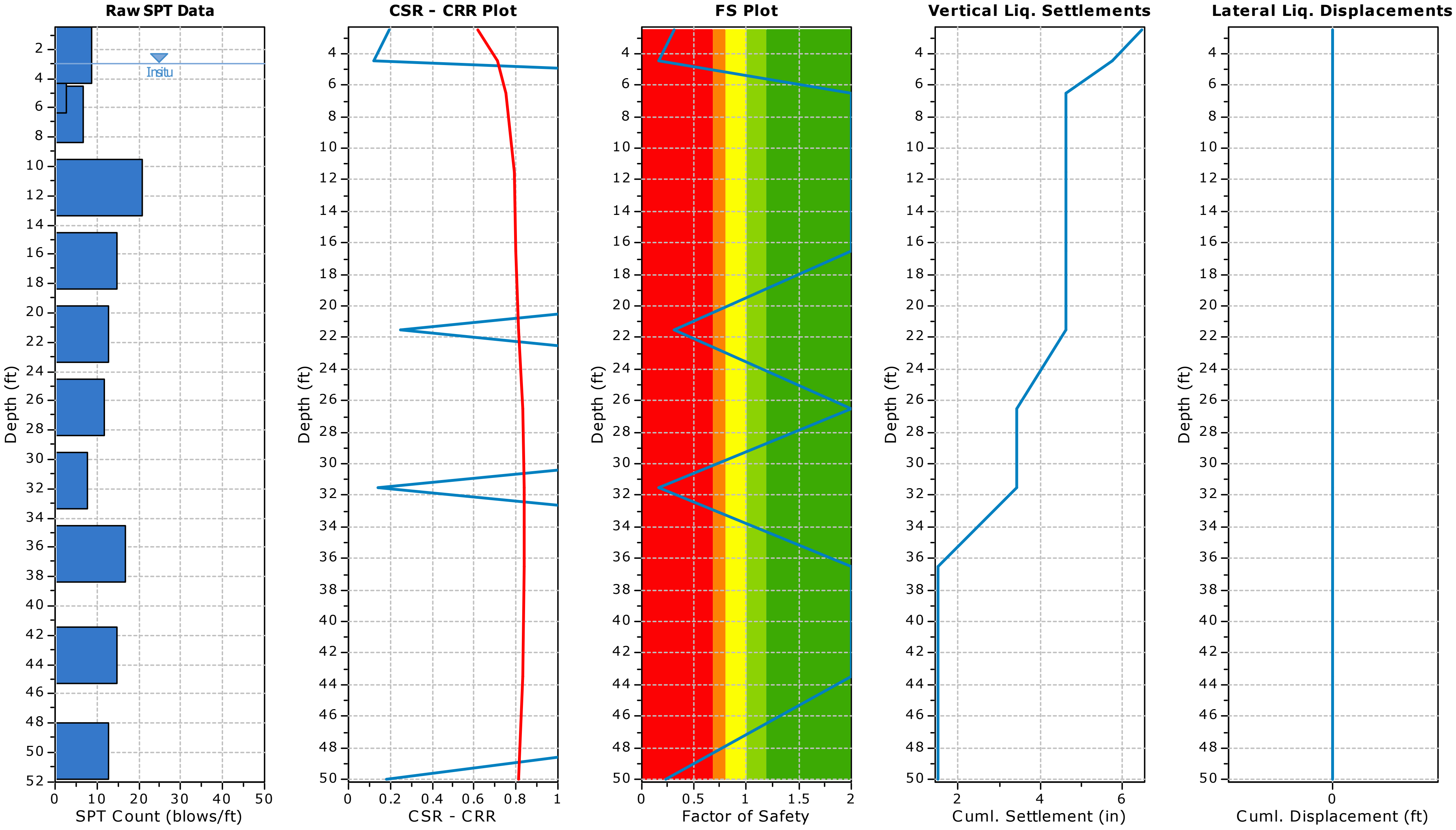
F.S. color scheme

- 🟥 Almost certain it will liquefy
- 🟧 Very likely to liquefy
- 🟨 Liquefaction and no liq. are equally likely
- 🟩 Unlike to liquefy
- 🟩 Almost certain it will not liquefy

LPI color scheme

- 🟥 Very high risk
- 🟧 High risk
- 🟨 Low risk

:: Overall Liquefaction Assessment Analysis Plots ::



:: Field input data ::

Test Depth (ft)	SPT Field Value (blows)	Fines Content (%)	Unit Weight (pcf)	Infl. Thickness (ft)	Can Liquefy
2.50	9	34.00	120.00	2.50	Yes
4.50	3	34.00	120.00	2.50	Yes
6.50	7	90.00	120.00	2.50	No
11.50	21	92.00	120.00	2.50	No
16.50	15	54.00	120.00	5.00	No
21.50	13	45.00	120.00	5.00	Yes
26.50	12	82.00	120.00	5.00	No
31.50	8	14.00	120.00	5.00	Yes
36.50	17	52.00	120.00	5.00	No
43.50	15	78.00	120.00	5.00	No
50.00	13	25.00	120.00	5.00	Yes

Abbreviations

Depth: Depth at which test was performed (ft)
SPT Field Value: Number of blows per foot
Fines Content: Fines content at test depth (%)
Unit Weight: Unit weight at test depth (pcf)
Infl. Thickness: Thickness of the soil layer to be considered in settlements analysis (ft)
Can Liquefy: User defined switch for excluding/including test depth from the analysis procedure

:: Cyclic Resistance Ratio (CRR) calculation data ::

Depth (ft)	SPT Field Value	Unit Weight (pcf)	σ_v (tsf)	u_o (tsf)	σ'_{vo} (tsf)	m	C_N	C_E	C_B	C_R	C_S	$(N_1)_{60}$	FC (%)	$\Delta(N_1)_{60}$	$(N_1)_{60cs}$	$CRR_{7.5}$
2.50	9	120.00	0.15	0.00	0.15	0.41	1.70	1.00	1.00	0.75	1.20	14	34.00	5.49	19	0.194
4.50	3	120.00	0.27	0.05	0.22	0.50	1.70	1.00	1.00	0.75	1.20	5	34.00	5.49	10	0.118
6.50	7	120.00	0.39	0.11	0.28	0.44	1.70	1.00	1.00	0.75	1.20	11	90.00	5.51	17	4.000
11.50	21	120.00	0.69	0.27	0.42	0.32	1.34	1.00	1.00	0.85	1.20	29	92.00	5.51	35	4.000
16.50	15	120.00	0.99	0.42	0.57	0.37	1.26	1.00	1.00	0.95	1.20	22	54.00	5.61	28	4.000
21.50	13	120.00	1.29	0.58	0.71	0.41	1.17	1.00	1.00	0.95	1.20	17	45.00	5.61	23	0.249
26.50	12	120.00	1.59	0.73	0.86	0.43	1.10	1.00	1.00	0.95	1.20	15	82.00	5.54	21	4.000
31.50	8	120.00	1.89	0.89	1.00	0.51	1.03	1.00	1.00	1.00	1.20	10	14.00	2.91	13	0.140
36.50	17	120.00	2.19	1.05	1.14	0.40	0.97	1.00	1.00	1.00	1.20	20	52.00	5.61	26	4.000
43.50	15	120.00	2.61	1.26	1.35	0.43	0.90	1.00	1.00	1.00	1.20	16	78.00	5.55	22	4.000
50.00	13	120.00	3.00	1.47	1.53	0.46	0.84	1.00	1.00	1.00	1.20	13	25.00	5.07	18	0.184

Abbreviations

σ_v: Total stress during SPT test (tsf)
u_o: Water pore pressure during SPT test (tsf)
σ'_{vo}: Effective overburden pressure during SPT test (tsf)
m: Stress exponent normalization factor
C_N: Overburden corretion factor
C_E: Energy correction factor
C_B: Borehole diameter correction factor
C_R: Rod length correction factor
C_S: Liner correction factor
$N_{1(60)}$: Corrected N_{SPT} to a 60% energy ratio
$\Delta(N_1)_{60}$ Equivalent clean sand adjustment
$N_{1(60)cs}$: Corected $N_{1(60)}$ value for fines content
$CRR_{7.5}$: Cyclic resistance ratio for M=7.5

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Depth (ft)	Unit Weight (pcf)	$\sigma_{v,eq}$ (tsf)	$u_{o,eq}$ (tsf)	$\sigma'_{vo,eq}$ (tsf)	r_d	α	CSR	MSF_{max}	$(N_1)_{60cs}$	MSF	$CSR_{eq,M=7.5}$	K_{sigma}	CSR^*	FS	
2.50	120.00	0.15	0.05	0.10	1.00	1.00	0.681	1.45	19	1.00	0.681	1.10	0.619	0.314	🔴
4.50	120.00	0.27	0.11	0.16	1.00	1.00	0.783	1.19	10	1.00	0.783	1.10	0.712	0.166	🔴
6.50	120.00	0.39	0.17	0.22	0.99	1.00	0.828	1.38	17	1.00	0.828	1.10	0.753	2.000	🟢
11.50	120.00	0.69	0.33	0.36	0.98	1.00	0.870	2.20	35	1.00	0.870	1.10	0.791	2.000	🟢
16.50	120.00	0.99	0.48	0.51	0.96	1.00	0.879	1.88	28	1.00	0.879	1.10	0.799	2.000	🟢
21.50	120.00	1.29	0.64	0.65	0.94	1.00	0.875	1.62	23	1.00	0.875	1.07	0.815	0.306	🔴
26.50	120.00	1.59	0.80	0.79	0.92	1.00	0.864	1.53	21	1.00	0.864	1.04	0.831	2.000	🟢
31.50	120.00	1.89	0.95	0.94	0.90	1.00	0.850	1.26	13	1.00	0.850	1.01	0.840	0.167	🔴
36.50	120.00	2.19	1.11	1.08	0.88	1.00	0.833	1.77	26	1.00	0.833	1.00	0.836	2.000	🟢
43.50	120.00	2.61	1.33	1.28	0.85	1.00	0.807	1.58	22	1.00	0.807	0.97	0.830	2.000	🟢
50.00	120.00	3.00	1.53	1.47	0.82	1.00	0.781	1.42	18	1.00	0.781	0.96	0.815	0.225	🔴

Abbreviations

$\sigma_{v,eq}$: Total overburden pressure at test point, during earthquake (tsf)
$u_{o,eq}$: Water pressure at test point, during earthquake (tsf)
$\sigma'_{vo,eq}$: Effective overburden pressure, during earthquake (tsf)
r_d: Nonlinear shear mass factor
α: Improvement factor due to stone columns
CSR : Cyclic Stress Ratio
MSF : Magnitude Scaling Factor
$CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
K_{sigma}: Effective overburden stress factor
CSR^*: CSR fully adjusted (user FS applied)***
FS: Calculated factor of safety against soil liquefaction

*** User FS: 1.00

:: Liquefaction potential according to Iwasaki ::

Depth (ft)	FS	F	wz	Thickness (ft)	I_L
2.50	0.314	0.69	9.62	2.00	4.02
4.50	0.166	0.83	9.31	2.00	4.74
6.50	2.000	0.00	9.01	2.00	0.00
11.50	2.000	0.00	8.25	5.00	0.00
16.50	2.000	0.00	7.49	5.00	0.00
21.50	0.306	0.69	6.72	5.00	7.11
26.50	2.000	0.00	5.96	5.00	0.00
31.50	0.167	0.83	5.20	5.00	6.60
36.50	2.000	0.00	4.44	5.00	0.00
43.50	2.000	0.00	3.37	7.00	0.00
50.00	0.225	0.77	2.38	6.50	3.65

Overall potential I_L : 26.13

I_L = 0.00 - No liquefaction
I_L between 0.00 and 5 - Liquefaction not probable
I_L between 5 and 15 - Liquefaction probable
I_L > 15 - Liquefaction certain

:: Vertical & Lateral displ.acements estimation for saturated sands ::

Depth (ft)	$(N_1)_{60cs}$	γ_{lim} (%)	F_α	FS_{liq}	γ_{max} (%)	e_v (%)	dz (ft)	S_{v-1D} (in)	LDI (ft)
2.50	19	17.78	0.57	0.314	17.78	2.40	2.50	0.721	0.00

:: Vertical & Lateral displ.acements estimation for saturated sands ::

Depth (ft)	$(N_1)_{60cs}$	γ_{lim} (%)	F_α	FS_{liq}	γ_{max} (%)	e_v (%)	dz (ft)	S_{v-1D} (in)	LDI (ft)
4.50	10	47.32	0.91	0.166	47.32	3.74	2.50	1.121	0.00
6.50	17	0.00	0.00	2.000	0.00	0.00	2.50	0.000	0.00
11.50	35	0.00	0.00	2.000	0.00	0.00	2.50	0.000	0.00
16.50	28	0.00	0.00	2.000	0.00	0.00	5.00	0.000	0.00
21.50	23	11.27	0.35	0.306	11.27	2.04	5.00	1.227	0.00
26.50	21	0.00	0.00	2.000	0.00	0.00	5.00	0.000	0.00
31.50	13	34.14	0.83	0.167	34.14	3.17	5.00	1.903	0.00
36.50	26	0.00	0.00	2.000	0.00	0.00	5.00	0.000	0.00
43.50	22	0.00	0.00	2.000	0.00	0.00	5.00	0.000	0.00
50.00	18	19.85	0.62	0.225	19.85	2.51	5.00	1.505	0.00

Cumulative settlements: 6.476 0.00

Abbreviations

γ_{lim}: Limiting shear strain (%)
F_α/N: Maximun shear strain factor
γ_{max}: Maximum shear strain (%)
e_v:: Post liquefaction volumetric strain (%)
S_{v-1D}: Estimated vertical settlement (in)
LDI: Estimated lateral displacement (ft)

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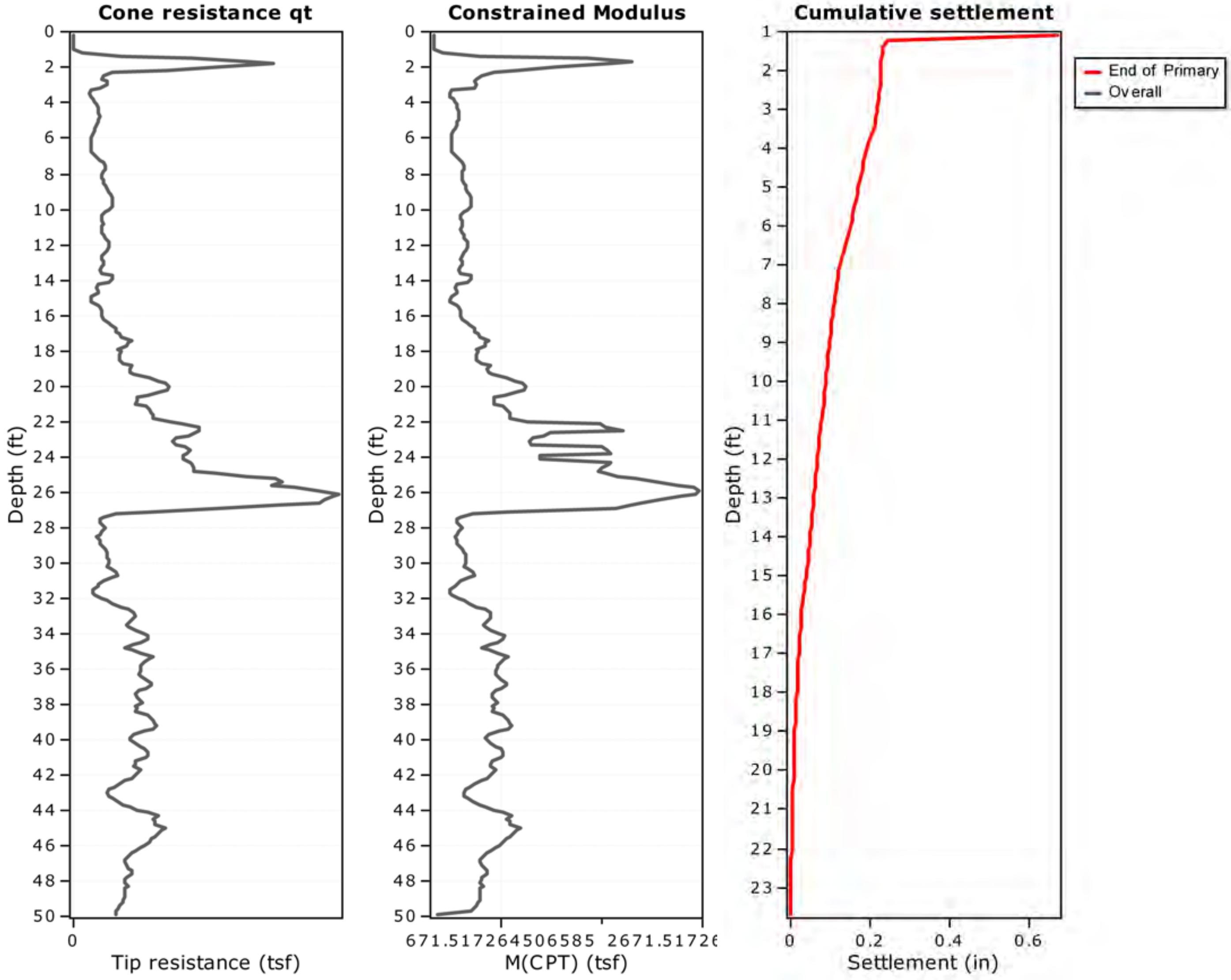
APPENDIX C-3

CPT Static Settlement Analysis

CPT: CPT-1
Total depth: 49.87 ft, Date: 4/30/2020
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project: **Chang Residences**
Location: **Webster and Illinois Streets, Fairfield, CA**

Settlements calculation according to theory of elasticity *



Calculation properties

Footing type: Rectangular
Footing width: 20.00 (ft)
L/B: 2.0
Footing pressure: 0.50 (tsf)
Embedment depth: 1.00 (ft)
Footing is rigid: Yes
Remove excavation load: No
Apply 20% rule: Yes
Calculate secondary settlements: No
Time period for primary consolidation: N/A
Time period for second. settlements: N/A

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

[illegible]

where t_p is the duration of primary consolidation

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
1	0.98	1.15	0.16	0.07	0.50	2.07	1.00	0.429	0.000	0.429
2	1.15	1.31	0.16	0.23	0.50	82.26	1.00	0.012	0.000	0.012
3	1.31	1.48	0.16	0.39	0.50	464.33	1.00	0.002	0.000	0.002
4	1.48	1.64	0.16	0.56	0.50	1532.42	1.00	0.001	0.000	0.001
5	1.64	1.80	0.16	0.72	0.50	1974.99	1.00	0.000	0.000	0.000
6	1.80	1.97	0.17	0.89	0.50	1751.57	0.99	0.001	0.000	0.001
7	1.97	2.13	0.16	1.05	0.49	1209.00	0.99	0.001	0.000	0.001
8	2.13	2.30	0.16	1.22	0.49	820.16	0.98	0.001	0.000	0.001
9	2.30	2.46	0.16	1.38	0.49	592.48	0.97	0.002	0.000	0.002
10	2.46	2.63	0.16	1.54	0.48	480.17	0.97	0.002	0.000	0.002
11	2.63	2.79	0.16	1.71	0.48	413.49	0.96	0.002	0.000	0.002
12	2.79	2.95	0.16	1.87	0.47	404.65	0.95	0.002	0.000	0.002
13	2.95	3.12	0.16	2.04	0.47	422.96	0.93	0.002	0.000	0.002
14	3.12	3.28	0.16	2.20	0.46	402.63	0.92	0.002	0.000	0.002
15	3.28	3.45	0.16	2.36	0.46	168.73	0.91	0.005	0.000	0.005
16	3.45	3.61	0.16	2.53	0.45	152.42	0.90	0.006	0.000	0.006
17	3.61	3.77	0.16	2.69	0.44	165.89	0.89	0.005	0.000	0.005
18	3.77	3.94	0.16	2.86	0.44	187.57	0.87	0.005	0.000	0.005
19	3.94	4.10	0.16	3.02	0.43	207.56	0.86	0.004	0.000	0.004
20	4.10	4.27	0.16	3.18	0.42	223.26	0.85	0.004	0.000	0.004
21	4.27	4.43	0.16	3.35	0.42	232.10	0.84	0.004	0.000	0.004
22	4.43	4.59	0.16	3.51	0.41	238.86	0.82	0.003	0.000	0.003
23	4.59	4.76	0.16	3.68	0.41	246.13	0.81	0.003	0.000	0.003
24	4.76	4.92	0.16	3.84	0.40	248.44	0.80	0.003	0.000	0.003
25	4.92	5.09	0.16	4.00	0.39	245.31	0.79	0.003	0.000	0.003
26	5.09	5.25	0.16	4.17	0.39	233.15	0.78	0.003	0.000	0.003
27	5.25	5.41	0.16	4.33	0.38	224.96	0.77	0.003	0.000	0.003
28	5.41	5.58	0.16	4.50	0.38	209.19	0.75	0.004	0.000	0.004
29	5.58	5.74	0.16	4.66	0.37	196.97	0.74	0.004	0.000	0.004
30	5.74	5.91	0.17	4.82	0.37	182.90	0.73	0.004	0.000	0.004
31	5.91	6.07	0.16	4.99	0.36	174.47	0.72	0.004	0.000	0.004
32	6.07	6.23	0.16	5.15	0.36	170.82	0.71	0.004	0.000	0.004
33	6.23	6.40	0.16	5.32	0.35	169.78	0.70	0.004	0.000	0.004
34	6.40	6.56	0.16	5.48	0.35	168.86	0.69	0.004	0.000	0.004
35	6.56	6.73	0.16	5.64	0.34	167.38	0.68	0.004	0.000	0.004
36	6.73	6.89	0.16	5.81	0.34	172.31	0.67	0.004	0.000	0.004
37	6.89	7.05	0.16	5.97	0.33	191.85	0.66	0.003	0.000	0.003
38	7.05	7.22	0.16	6.14	0.33	224.83	0.66	0.003	0.000	0.003
39	7.22	7.38	0.16	6.30	0.32	261.71	0.65	0.002	0.000	0.002
40	7.38	7.55	0.16	6.46	0.32	287.11	0.64	0.002	0.000	0.002
41	7.55	7.71	0.16	6.63	0.32	300.86	0.63	0.002	0.000	0.002
42	7.71	7.87	0.16	6.79	0.31	297.78	0.62	0.002	0.000	0.002
43	7.87	8.04	0.16	6.96	0.31	289.36	0.62	0.002	0.000	0.002
44	8.04	8.20	0.16	7.12	0.30	277.52	0.61	0.002	0.000	0.002
45	8.20	8.37	0.16	7.28	0.30	274.51	0.60	0.002	0.000	0.002
46	8.37	8.53	0.16	7.45	0.30	283.97	0.59	0.002	0.000	0.002

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
47	8.53	8.69	0.16	7.61	0.29	295.38	0.59	0.002	0.000	0.002
48	8.69	8.86	0.16	7.78	0.29	310.38	0.58	0.002	0.000	0.002
49	8.86	9.02	0.16	7.94	0.29	321.09	0.57	0.002	0.000	0.002
50	9.02	9.19	0.16	8.10	0.28	335.43	0.57	0.002	0.000	0.002
51	9.19	9.35	0.16	8.27	0.28	350.09	0.56	0.002	0.000	0.002
52	9.35	9.51	0.16	8.43	0.28	364.42	0.55	0.001	0.000	0.001
53	9.51	9.68	0.16	8.60	0.27	375.16	0.55	0.001	0.000	0.001
54	9.68	9.84	0.16	8.76	0.27	376.92	0.54	0.001	0.000	0.001
55	9.84	10.01	0.16	8.93	0.27	367.85	0.54	0.001	0.000	0.001
56	10.01	10.17	0.16	9.09	0.27	337.62	0.53	0.002	0.000	0.002
57	10.17	10.34	0.16	9.25	0.26	299.54	0.53	0.002	0.000	0.002
58	10.34	10.50	0.16	9.42	0.26	268.86	0.52	0.002	0.000	0.002
59	10.50	10.66	0.16	9.58	0.26	266.83	0.51	0.002	0.000	0.002
60	10.66	10.83	0.16	9.74	0.25	275.01	0.51	0.002	0.000	0.002
61	10.83	10.99	0.16	9.91	0.25	279.42	0.50	0.002	0.000	0.002
62	10.99	11.16	0.16	10.07	0.25	274.32	0.50	0.002	0.000	0.002
63	11.16	11.32	0.16	10.24	0.25	266.44	0.49	0.002	0.000	0.002
64	11.32	11.48	0.16	10.40	0.24	275.44	0.49	0.002	0.000	0.002
65	11.48	11.65	0.16	10.57	0.24	291.38	0.49	0.002	0.000	0.002
66	11.65	11.81	0.16	10.73	0.24	306.11	0.48	0.002	0.000	0.002
67	11.81	11.98	0.16	10.89	0.24	329.30	0.48	0.001	0.000	0.001
68	11.98	12.14	0.16	11.06	0.24	335.53	0.47	0.001	0.000	0.001
69	12.14	12.30	0.16	11.22	0.23	338.56	0.47	0.001	0.000	0.001
70	12.30	12.47	0.16	11.39	0.23	317.61	0.46	0.001	0.000	0.001
71	12.47	12.63	0.16	11.55	0.23	294.30	0.46	0.002	0.000	0.002
72	12.63	12.80	0.16	11.71	0.23	272.67	0.45	0.002	0.000	0.002
73	12.80	12.96	0.16	11.88	0.23	270.22	0.45	0.002	0.000	0.002
74	12.96	13.12	0.16	12.04	0.22	284.02	0.45	0.002	0.000	0.002
75	13.12	13.29	0.16	12.21	0.22	285.29	0.44	0.002	0.000	0.002
76	13.29	13.45	0.16	12.37	0.22	265.38	0.44	0.002	0.000	0.002
77	13.45	13.62	0.16	12.53	0.22	254.41	0.44	0.002	0.000	0.002
78	13.62	13.78	0.16	12.70	0.22	263.05	0.43	0.002	0.000	0.002
79	13.78	13.94	0.16	12.86	0.21	371.16	0.43	0.001	0.000	0.001
80	13.94	14.11	0.16	13.03	0.21	364.68	0.42	0.001	0.000	0.001
81	14.11	14.27	0.16	13.19	0.21	340.08	0.42	0.001	0.000	0.001
82	14.27	14.44	0.16	13.35	0.21	224.00	0.42	0.002	0.000	0.002
83	14.44	14.60	0.16	13.52	0.21	219.73	0.41	0.002	0.000	0.002
84	14.60	14.76	0.16	13.68	0.21	228.40	0.41	0.002	0.000	0.002
85	14.76	14.93	0.16	13.85	0.20	227.66	0.41	0.002	0.000	0.002
86	14.93	15.09	0.16	14.01	0.20	169.08	0.40	0.002	0.000	0.002
87	15.09	15.26	0.16	14.17	0.20	166.46	0.40	0.002	0.000	0.002
88	15.26	15.42	0.16	14.34	0.20	165.61	0.40	0.002	0.000	0.002
89	15.42	15.58	0.16	14.50	0.20	228.03	0.39	0.002	0.000	0.002
90	15.58	15.75	0.16	14.67	0.20	247.64	0.39	0.002	0.000	0.002
91	15.75	15.91	0.16	14.83	0.19	262.33	0.39	0.001	0.000	0.001
92	15.91	16.08	0.16	14.99	0.19	255.91	0.39	0.001	0.000	0.001

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
93	16.08	16.24	0.16	15.16	0.19	267.93	0.38	0.001	0.000	0.001
94	16.24	16.40	0.16	15.32	0.19	278.15	0.38	0.001	0.000	0.001
95	16.40	16.57	0.16	15.49	0.19	326.15	0.38	0.001	0.000	0.001
96	16.57	16.73	0.16	15.65	0.19	355.70	0.37	0.001	0.000	0.001
97	16.73	16.90	0.16	15.81	0.19	399.44	0.37	0.001	0.000	0.001
98	16.90	17.06	0.16	15.98	0.18	408.32	0.37	0.001	0.000	0.001
99	17.06	17.22	0.16	16.14	0.18	431.28	0.36	0.001	0.000	0.001
100	17.22	17.39	0.16	16.31	0.18	450.46	0.36	0.001	0.000	0.001
101	17.39	17.55	0.16	16.47	0.18	547.75	0.36	0.001	0.000	0.001
102	17.55	17.72	0.16	16.63	0.18	512.29	0.36	0.001	0.000	0.001
103	17.72	17.88	0.16	16.80	0.18	508.81	0.35	0.001	0.000	0.001
104	17.88	18.05	0.16	16.96	0.18	414.11	0.35	0.001	0.000	0.001
105	18.05	18.21	0.16	17.13	0.17	444.23	0.35	0.001	0.000	0.001
106	18.21	18.37	0.16	17.29	0.17	429.01	0.35	0.001	0.000	0.001
107	18.37	18.54	0.16	17.45	0.17	425.05	0.34	0.001	0.000	0.001
108	18.54	18.70	0.16	17.62	0.17	428.72	0.34	0.001	0.000	0.001
109	18.70	18.87	0.16	17.78	0.17	473.82	0.34	0.001	0.000	0.001
110	18.87	19.03	0.16	17.95	0.17	557.03	0.34	0.001	0.000	0.001
111	19.03	19.19	0.16	18.11	0.17	529.05	0.33	0.001	0.000	0.001
112	19.19	19.36	0.16	18.28	0.17	541.40	0.33	0.001	0.000	0.001
113	19.36	19.52	0.16	18.44	0.16	574.73	0.33	0.001	0.000	0.001
114	19.52	19.69	0.16	18.60	0.16	723.96	0.33	0.000	0.000	0.000
115	19.69	19.85	0.16	18.77	0.16	812.01	0.32	0.000	0.000	0.000
116	19.85	20.01	0.16	18.93	0.16	874.72	0.32	0.000	0.000	0.000
117	20.01	20.18	0.16	19.10	0.16	914.49	0.32	0.000	0.000	0.000
118	20.18	20.34	0.16	19.26	0.16	898.99	0.32	0.000	0.000	0.000
119	20.34	20.51	0.16	19.42	0.16	834.69	0.32	0.000	0.000	0.000
120	20.51	20.67	0.16	19.59	0.16	703.72	0.31	0.000	0.000	0.000
121	20.67	20.83	0.16	19.75	0.16	606.45	0.31	0.001	0.000	0.001
122	20.83	21.00	0.16	19.92	0.15	597.10	0.31	0.001	0.000	0.001
123	21.00	21.16	0.16	20.08	0.15	592.54	0.31	0.001	0.000	0.001
124	21.16	21.33	0.16	20.24	0.15	688.88	0.30	0.000	0.000	0.000
125	21.33	21.49	0.16	20.41	0.15	722.76	0.30	0.000	0.000	0.000
126	21.49	21.65	0.16	20.57	0.15	747.43	0.30	0.000	0.000	0.000
127	21.65	21.82	0.16	20.74	0.15	763.81	0.30	0.000	0.000	0.000
128	21.82	21.98	0.16	20.90	0.15	752.60	0.30	0.000	0.000	0.000
129	21.98	22.15	0.16	21.06	0.15	925.81	0.29	0.000	0.000	0.000
130	22.15	22.31	0.16	21.23	0.15	1651.18	0.29	0.000	0.000	0.000
131	22.31	22.47	0.16	21.39	0.15	1703.04	0.29	0.000	0.000	0.000
132	22.47	22.64	0.16	21.56	0.14	1885.50	0.29	0.000	0.000	0.000
133	22.64	22.80	0.16	21.72	0.14	1166.62	0.29	0.000	0.000	0.000
134	22.80	22.97	0.16	21.88	0.14	1091.45	0.28	0.000	0.000	0.000
135	22.97	23.13	0.16	22.05	0.14	985.14	0.28	0.000	0.000	0.000
136	23.13	23.29	0.16	22.21	0.14	951.54	0.28	0.000	0.000	0.000
137	23.29	23.46	0.16	22.38	0.14	975.23	0.28	0.000	0.000	0.000
138	23.46	23.62	0.16	22.54	0.14	1678.37	0.28	0.000	0.000	0.000

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
139	23.62	23.79	0.16	22.70	0.14	1719.30	0.28	0.000	0.000	0.000

Total primary settlement: 0.67
Total secondary settlement: 0.00

Total calculated settlement: 0.67

Abbreviations

Start depth:	Start depth of soil layer (penetration depth measured from ground free surface)
End depth:	End depth of soil layer (penetration depth measured from ground free surface)
Thickness:	Thickness of soil layer
Relative depth:	Depth of calculation relative to footing
Iz:	Stress influence factor
Delta P:	Footing impossed stress:
Eff. stress:	Effective stress
$M_{(CPT)}$:	Constrained modulus from CPT
Settlement:	Primary settlement
Second. settlement:	Secondary settlemends due to creep

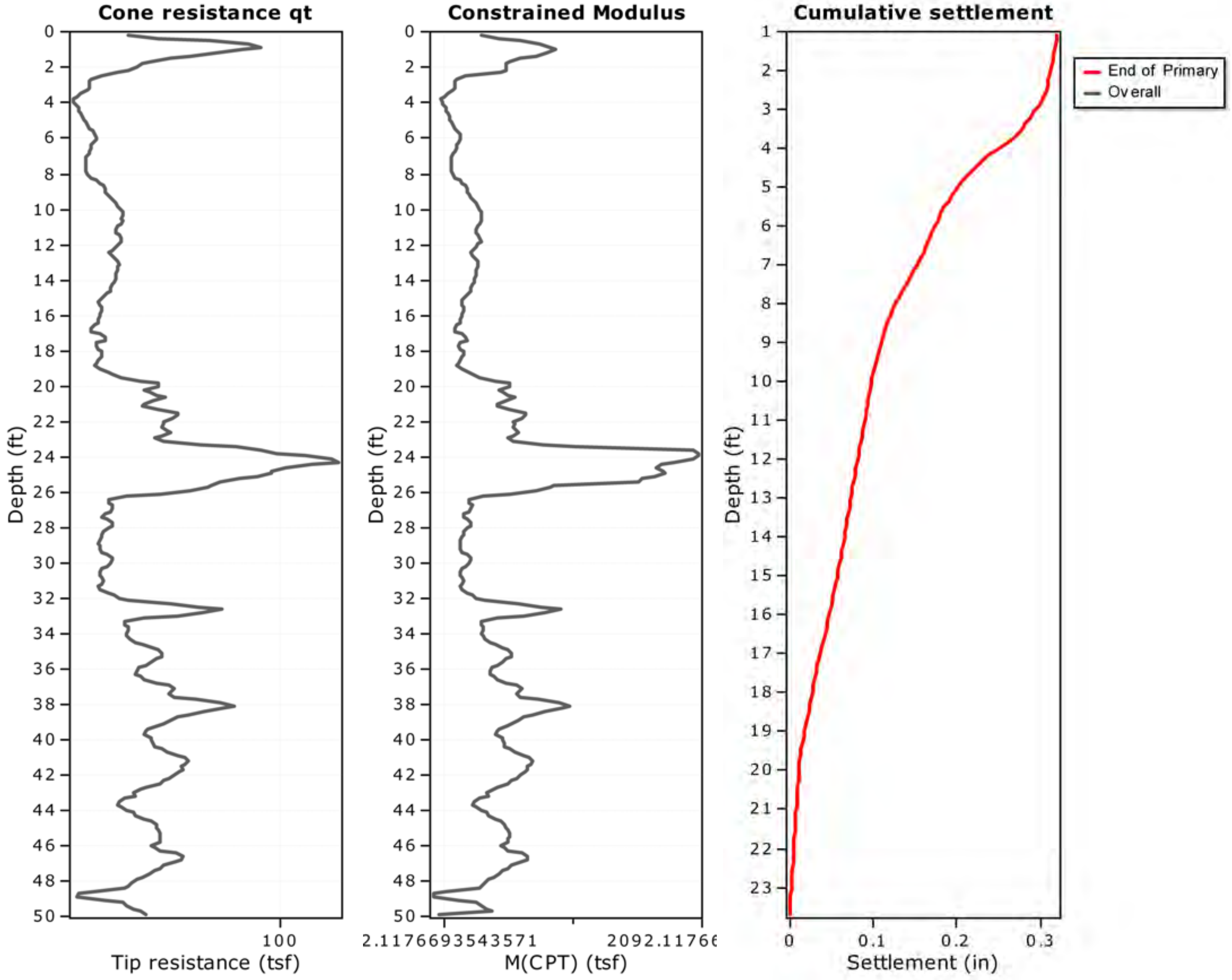
Peters & Ross
Geotechnical & Geoenvironmental
Consultants

Peters & Ross
114 Hopeco Road
Pleasant Hill, CA 94523
PetersRoss@aol.com

CPT: CPT-2
Total depth: 49.87 ft, Date: 4/30/2020
Surface Elevation: 0.00 ft
Coords: X:0.00, Y:0.00
Cone Type:
Cone Operator:

Project: **Chang Residences**
Location: **Webster and Illinois Streets, Fairfield, CA**

Settlements calculation according to theory of elasticity *



Calculation properties

Footing type: Rectangular
Footing width: 20.00 (ft)
L/B: 2.0
Footing pressure: 0.50 (tsf)
Embedment depth: 1.00 (ft)
Footing is rigid: Yes
Remove excavation load: No
Apply 20% rule: Yes
Calculate secondary settlements: No
Time period for primary consolidation: N/A
Time period for second. settlements: N/A

* Primary settlements calculation is performed according to the following formula:

$$S = \sum \frac{\Delta\sigma_v}{M_{CPT}} \Delta z$$

* Secondary (creep) settlements calculation is performed according to the following formula:

where t_p is the duration of primary consolidation

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
1	0.98	1.15	0.16	0.07	0.50	952.35	1.00	0.001	0.000	0.001
2	1.15	1.31	0.16	0.23	0.50	893.88	1.00	0.001	0.000	0.001
3	1.31	1.48	0.16	0.39	0.50	809.97	1.00	0.001	0.000	0.001
4	1.48	1.64	0.16	0.56	0.50	686.67	1.00	0.001	0.000	0.001
5	1.64	1.80	0.16	0.72	0.50	605.60	1.00	0.002	0.000	0.002
6	1.80	1.97	0.17	0.89	0.50	572.37	0.99	0.002	0.000	0.002
7	1.97	2.13	0.16	1.05	0.49	576.68	0.99	0.002	0.000	0.002
8	2.13	2.30	0.16	1.22	0.49	568.18	0.98	0.002	0.000	0.002
9	2.30	2.46	0.16	1.38	0.49	532.48	0.97	0.002	0.000	0.002
10	2.46	2.63	0.16	1.54	0.48	252.02	0.97	0.004	0.000	0.004
11	2.63	2.79	0.16	1.71	0.48	190.53	0.96	0.005	0.000	0.005
12	2.79	2.95	0.16	1.87	0.47	171.50	0.95	0.005	0.000	0.005
13	2.95	3.12	0.16	2.04	0.47	175.75	0.93	0.005	0.000	0.005
14	3.12	3.28	0.16	2.20	0.46	175.83	0.92	0.005	0.000	0.005
15	3.28	3.45	0.16	2.36	0.46	159.74	0.91	0.006	0.000	0.006
16	3.45	3.61	0.16	2.53	0.45	123.57	0.90	0.007	0.000	0.007
17	3.61	3.77	0.16	2.69	0.44	98.09	0.89	0.009	0.000	0.009
18	3.77	3.94	0.16	2.86	0.44	73.51	0.87	0.012	0.000	0.012
19	3.94	4.10	0.16	3.02	0.43	77.09	0.86	0.011	0.000	0.011
20	4.10	4.27	0.16	3.18	0.42	87.60	0.85	0.010	0.000	0.010
21	4.27	4.43	0.16	3.35	0.42	104.51	0.84	0.008	0.000	0.008
22	4.43	4.59	0.16	3.51	0.41	111.67	0.82	0.007	0.000	0.007
23	4.59	4.76	0.16	3.68	0.41	121.26	0.81	0.007	0.000	0.007
24	4.76	4.92	0.16	3.84	0.40	131.00	0.80	0.006	0.000	0.006
25	4.92	5.09	0.16	4.00	0.39	141.23	0.79	0.005	0.000	0.005
26	5.09	5.25	0.16	4.17	0.39	151.23	0.78	0.005	0.000	0.005
27	5.25	5.41	0.16	4.33	0.38	163.13	0.77	0.005	0.000	0.005
28	5.41	5.58	0.16	4.50	0.38	175.94	0.75	0.004	0.000	0.004
29	5.58	5.74	0.16	4.66	0.37	193.60	0.74	0.004	0.000	0.004
30	5.74	5.91	0.17	4.82	0.37	211.92	0.73	0.003	0.000	0.003
31	5.91	6.07	0.16	4.99	0.36	219.01	0.72	0.003	0.000	0.003
32	6.07	6.23	0.16	5.15	0.36	214.36	0.71	0.003	0.000	0.003
33	6.23	6.40	0.16	5.32	0.35	200.94	0.70	0.003	0.000	0.003
34	6.40	6.56	0.16	5.48	0.35	189.47	0.69	0.004	0.000	0.004
35	6.56	6.73	0.16	5.64	0.34	185.04	0.68	0.004	0.000	0.004
36	6.73	6.89	0.16	5.81	0.34	177.69	0.67	0.004	0.000	0.004
37	6.89	7.05	0.16	5.97	0.33	167.60	0.66	0.004	0.000	0.004
38	7.05	7.22	0.16	6.14	0.33	154.09	0.66	0.004	0.000	0.004
39	7.22	7.38	0.16	6.30	0.32	149.35	0.65	0.004	0.000	0.004
40	7.38	7.55	0.16	6.46	0.32	148.54	0.64	0.004	0.000	0.004
41	7.55	7.71	0.16	6.63	0.32	147.58	0.63	0.004	0.000	0.004
42	7.71	7.87	0.16	6.79	0.31	148.36	0.62	0.004	0.000	0.004
43	7.87	8.04	0.16	6.96	0.31	147.97	0.62	0.004	0.000	0.004
44	8.04	8.20	0.16	7.12	0.30	160.69	0.61	0.004	0.000	0.004
45	8.20	8.37	0.16	7.28	0.30	181.65	0.60	0.003	0.000	0.003
46	8.37	8.53	0.16	7.45	0.30	211.91	0.59	0.003	0.000	0.003

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
47	8.53	8.69	0.16	7.61	0.29	237.06	0.59	0.002	0.000	0.002
48	8.69	8.86	0.16	7.78	0.29	256.40	0.58	0.002	0.000	0.002
49	8.86	9.02	0.16	7.94	0.29	270.40	0.57	0.002	0.000	0.002
50	9.02	9.19	0.16	8.10	0.28	277.55	0.57	0.002	0.000	0.002
51	9.19	9.35	0.16	8.27	0.28	287.78	0.56	0.002	0.000	0.002
52	9.35	9.51	0.16	8.43	0.28	304.08	0.55	0.002	0.000	0.002
53	9.51	9.68	0.16	8.60	0.27	328.72	0.55	0.002	0.000	0.002
54	9.68	9.84	0.16	8.76	0.27	340.67	0.54	0.002	0.000	0.002
55	9.84	10.01	0.16	8.93	0.27	354.61	0.54	0.001	0.000	0.001
56	10.01	10.17	0.16	9.09	0.27	375.05	0.53	0.001	0.000	0.001
57	10.17	10.34	0.16	9.25	0.26	385.91	0.53	0.001	0.000	0.001
58	10.34	10.50	0.16	9.42	0.26	386.20	0.52	0.001	0.000	0.001
59	10.50	10.66	0.16	9.58	0.26	378.37	0.51	0.001	0.000	0.001
60	10.66	10.83	0.16	9.74	0.25	380.10	0.51	0.001	0.000	0.001
61	10.83	10.99	0.16	9.91	0.25	371.55	0.50	0.001	0.000	0.001
62	10.99	11.16	0.16	10.07	0.25	350.58	0.50	0.001	0.000	0.001
63	11.16	11.32	0.16	10.24	0.25	335.21	0.49	0.001	0.000	0.001
64	11.32	11.48	0.16	10.40	0.24	337.56	0.49	0.001	0.000	0.001
65	11.48	11.65	0.16	10.57	0.24	360.21	0.49	0.001	0.000	0.001
66	11.65	11.81	0.16	10.73	0.24	374.96	0.48	0.001	0.000	0.001
67	11.81	11.98	0.16	10.89	0.24	375.83	0.48	0.001	0.000	0.001
68	11.98	12.14	0.16	11.06	0.24	359.69	0.47	0.001	0.000	0.001
69	12.14	12.30	0.16	11.22	0.23	338.51	0.47	0.001	0.000	0.001
70	12.30	12.47	0.16	11.39	0.23	309.95	0.46	0.001	0.000	0.001
71	12.47	12.63	0.16	11.55	0.23	296.94	0.46	0.002	0.000	0.002
72	12.63	12.80	0.16	11.71	0.23	309.73	0.45	0.001	0.000	0.001
73	12.80	12.96	0.16	11.88	0.23	335.54	0.45	0.001	0.000	0.001
74	12.96	13.12	0.16	12.04	0.22	353.18	0.45	0.001	0.000	0.001
75	13.12	13.29	0.16	12.21	0.22	354.26	0.44	0.001	0.000	0.001
76	13.29	13.45	0.16	12.37	0.22	352.02	0.44	0.001	0.000	0.001
77	13.45	13.62	0.16	12.53	0.22	344.89	0.44	0.001	0.000	0.001
78	13.62	13.78	0.16	12.70	0.22	335.76	0.43	0.001	0.000	0.001
79	13.78	13.94	0.16	12.86	0.21	335.98	0.43	0.001	0.000	0.001
80	13.94	14.11	0.16	13.03	0.21	330.62	0.42	0.001	0.000	0.001
81	14.11	14.27	0.16	13.19	0.21	323.73	0.42	0.001	0.000	0.001
82	14.27	14.44	0.16	13.35	0.21	312.22	0.42	0.001	0.000	0.001
83	14.44	14.60	0.16	13.52	0.21	303.36	0.41	0.001	0.000	0.001
84	14.60	14.76	0.16	13.68	0.21	297.03	0.41	0.001	0.000	0.001
85	14.76	14.93	0.16	13.85	0.20	279.53	0.41	0.001	0.000	0.001
86	14.93	15.09	0.16	14.01	0.20	254.29	0.40	0.002	0.000	0.002
87	15.09	15.26	0.16	14.17	0.20	231.27	0.40	0.002	0.000	0.002
88	15.26	15.42	0.16	14.34	0.20	224.63	0.40	0.002	0.000	0.002
89	15.42	15.58	0.16	14.50	0.20	233.50	0.39	0.002	0.000	0.002
90	15.58	15.75	0.16	14.67	0.20	245.27	0.39	0.002	0.000	0.002
91	15.75	15.91	0.16	14.83	0.19	246.42	0.39	0.002	0.000	0.002
92	15.91	16.08	0.16	14.99	0.19	236.24	0.39	0.002	0.000	0.002

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
93	16.08	16.24	0.16	15.16	0.19	231.51	0.38	0.002	0.000	0.002
94	16.24	16.40	0.16	15.32	0.19	220.99	0.38	0.002	0.000	0.002
95	16.40	16.57	0.16	15.49	0.19	221.41	0.38	0.002	0.000	0.002
96	16.57	16.73	0.16	15.65	0.19	195.11	0.37	0.002	0.000	0.002
97	16.73	16.90	0.16	15.81	0.19	175.78	0.37	0.002	0.000	0.002
98	16.90	17.06	0.16	15.98	0.18	170.34	0.37	0.002	0.000	0.002
99	17.06	17.22	0.16	16.14	0.18	229.34	0.36	0.002	0.000	0.002
100	17.22	17.39	0.16	16.31	0.18	262.06	0.36	0.001	0.000	0.001
101	17.39	17.55	0.16	16.47	0.18	265.97	0.36	0.001	0.000	0.001
102	17.55	17.72	0.16	16.63	0.18	211.43	0.36	0.002	0.000	0.002
103	17.72	17.88	0.16	16.80	0.18	207.53	0.35	0.002	0.000	0.002
104	17.88	18.05	0.16	16.96	0.18	215.83	0.35	0.002	0.000	0.002
105	18.05	18.21	0.16	17.13	0.17	244.03	0.35	0.001	0.000	0.001
106	18.21	18.37	0.16	17.29	0.17	246.29	0.35	0.001	0.000	0.001
107	18.37	18.54	0.16	17.45	0.17	236.86	0.34	0.001	0.000	0.001
108	18.54	18.70	0.16	17.62	0.17	217.66	0.34	0.002	0.000	0.002
109	18.70	18.87	0.16	17.78	0.17	203.83	0.34	0.002	0.000	0.002
110	18.87	19.03	0.16	17.95	0.17	195.40	0.34	0.002	0.000	0.002
111	19.03	19.19	0.16	18.11	0.17	233.85	0.33	0.001	0.000	0.001
112	19.19	19.36	0.16	18.28	0.17	281.68	0.33	0.001	0.000	0.001
113	19.36	19.52	0.16	18.44	0.16	311.15	0.33	0.001	0.000	0.001
114	19.52	19.69	0.16	18.60	0.16	363.23	0.33	0.001	0.000	0.001
115	19.69	19.85	0.16	18.77	0.16	494.75	0.32	0.001	0.000	0.001
116	19.85	20.01	0.16	18.93	0.16	601.89	0.32	0.001	0.000	0.001
117	20.01	20.18	0.16	19.10	0.16	598.82	0.32	0.001	0.000	0.001
118	20.18	20.34	0.16	19.26	0.16	511.95	0.32	0.001	0.000	0.001
119	20.34	20.51	0.16	19.42	0.16	540.38	0.32	0.001	0.000	0.001
120	20.51	20.67	0.16	19.59	0.16	585.73	0.31	0.001	0.000	0.001
121	20.67	20.83	0.16	19.75	0.16	645.80	0.31	0.000	0.000	0.000
122	20.83	21.00	0.16	19.92	0.15	571.15	0.31	0.001	0.000	0.001
123	21.00	21.16	0.16	20.08	0.15	510.39	0.31	0.001	0.000	0.001
124	21.16	21.33	0.16	20.24	0.15	504.66	0.30	0.001	0.000	0.001
125	21.33	21.49	0.16	20.41	0.15	604.08	0.30	0.000	0.000	0.000
126	21.49	21.65	0.16	20.57	0.15	725.54	0.30	0.000	0.000	0.000
127	21.65	21.82	0.16	20.74	0.15	727.30	0.30	0.000	0.000	0.000
128	21.82	21.98	0.16	20.90	0.15	695.71	0.30	0.000	0.000	0.000
129	21.98	22.15	0.16	21.06	0.15	629.36	0.29	0.000	0.000	0.000
130	22.15	22.31	0.16	21.23	0.15	638.92	0.29	0.000	0.000	0.000
131	22.31	22.47	0.16	21.39	0.15	628.35	0.29	0.000	0.000	0.000
132	22.47	22.64	0.16	21.56	0.14	659.04	0.29	0.000	0.000	0.000
133	22.64	22.80	0.16	21.72	0.14	676.05	0.29	0.000	0.000	0.000
134	22.80	22.97	0.16	21.88	0.14	621.71	0.28	0.000	0.000	0.000
135	22.97	23.13	0.16	22.05	0.14	582.59	0.28	0.000	0.000	0.000
136	23.13	23.29	0.16	22.21	0.14	632.15	0.28	0.000	0.000	0.000
137	23.29	23.46	0.16	22.38	0.14	866.94	0.28	0.000	0.000	0.000
138	23.46	23.62	0.16	22.54	0.14	1101.67	0.28	0.000	0.000	0.000

:: Tabular results ::

Point No	Start depth (ft)	End depth (ft)	Thickness (ft)	Relative depth (ft)	Delta P (tsf)	$M_{(CPT)}$ (tsf)	Iz	Settlement (in)	Second. settlement (in)	Overall settlement (in)
139	23.62	23.79	0.16	22.70	0.14	2030.25	0.28	0.000	0.000	0.000

Total primary settlement: 0.32
Total secondary settlement: 0.00

Total calculated settlement: 0.32

Abbreviations

Start depth:	Start depth of soil layer (penetration depth measured from ground free surface)
End depth:	End depth of soil layer (penetration depth measured from ground free surface)
Thickness:	Thickness of soil layer
Relative depth:	Depth of calculation relative to footing
Iz:	Stress influence factor
Delta P:	Footing impossed stress:
Eff. stress:	Effective stress
$M_{(CPT)}$:	Constrained modulus from CPT
Settlement:	Primary settlement
Second. settlement:	Secondary settlemends due to creep