Improving Design Phase Evaluations of High Pile Rebound Soils with an Emphasis on SPT Testing

Task Work Order BDV28 Two 977-05

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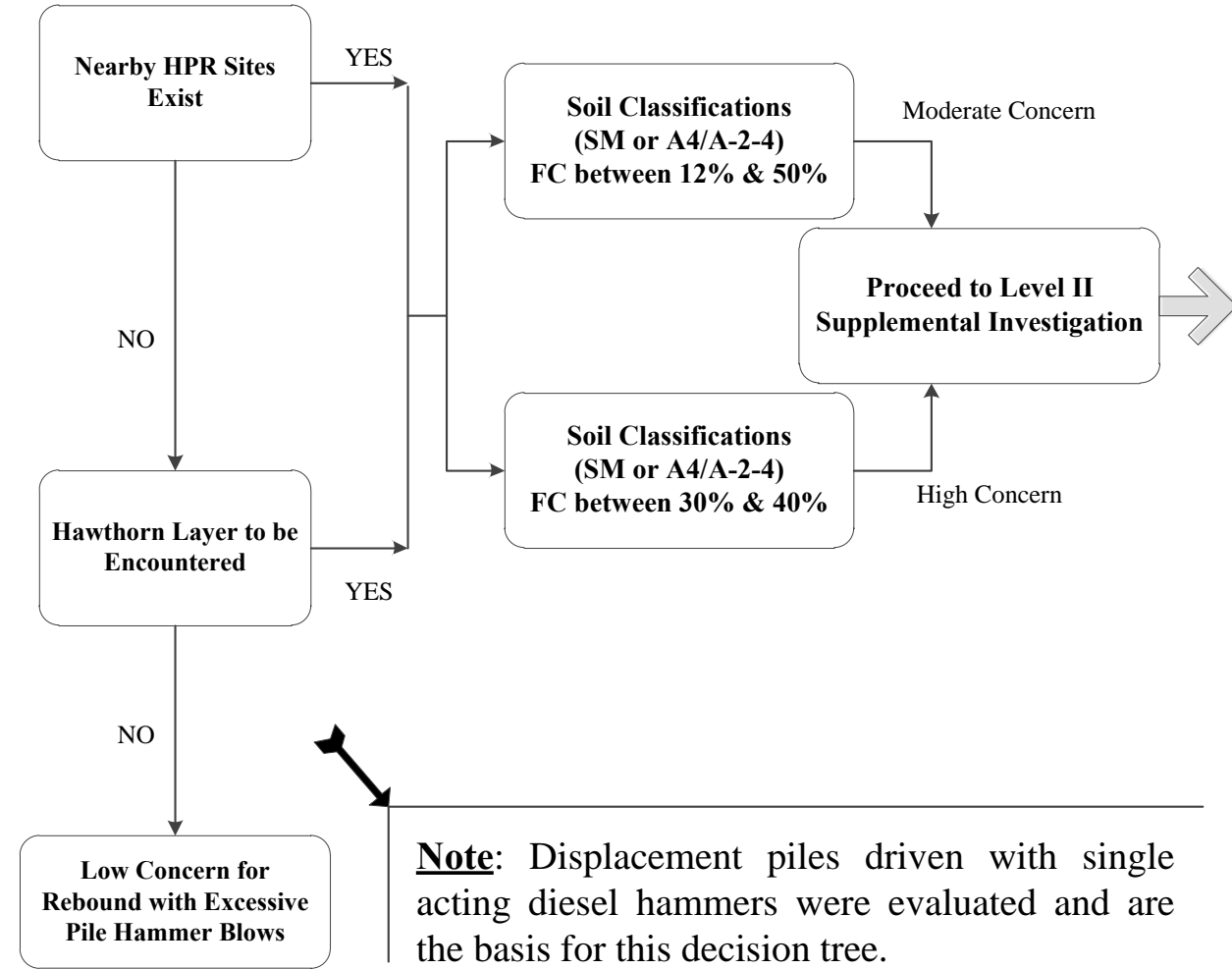Melbourne Fl 32901-6975
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Objective

Refine the BDV28 977-01 Decision Matrix Level I soil classification criteria based on rebound level with N values and FC.

Existing HPR Decision Tree

- 🖊 Three Levels Available
  - 🖊 Only Level 1 shown
  - 🖊 Level 1 should be refined
- 🖊 Based on limited data
- 🖊 Based on ½ " rebound
  - 🖊 ¼ " produced poor results
  - 🖊 Other rebound levels may help clarify or reinforce findings

High Pile Rebound Decision Tree

Level I: Basic Design Phase Information

- Nearby HPR Sites Exist
  - YES → Soil Classifications (SM or A4/A-2-4) FC between 12% & 50% → Moderate Concern → Proceed to Level II Supplemental Investigation
  - NO → Hawthorn Layer to be Encountered
    - YES → Soil Classifications (SM or A4/A-2-4) FC between 30% & 40% → High Concern → Proceed to Level II Supplemental Investigation
    - NO → Low Concern for Rebound with Excessive Pile Hammer Blows

Note: Displacement piles driven with single acting diesel hammers were evaluated and are the basis for this decision tree.

Approach

- Identify & Organize Additional HPR and NonHPR sites Based on Rebound Level
    - Acceptable [rebound but pile driven]
    - No Rebound [< 1/4 inch rebound]
    - Unacceptable [Rebound Greater than ¼ ½ or 1"]
- Evaluation of HPR Rebound Trends
- Draft Final Report and Closeout Teleconference
- Final Report

FDOT Sites Tested & Evaluated Previously

17 Locations @ 9 Sites

Site Description	Test Pile	Visual Rebound (in)	PDA Rebound (In)	Blowcount	Rebound Classification
417 and International	EB1P14	N.A.	0.43	N.A.	No Rebound
	EB2P5	N.A.	0.56	N.A.	No Rebound
Abderson Street Overpass	P6P6	1.00	1.18	240+	Unacceptable
Heritage Parkway	EB1P1	N.A.	0.72	N.A.	No Rebound
	IB3P1	N.A.	0.69	N.A.	No Rebound
	EB5P1	N.A.	0.53	N.A.	No Rebound
I4 and 192	BD EB1P3	0.50-1.00	1.05	50-391	Unacceptable
	CA P8P4	0.50-0.75	0.96	164	Unacceptable
I4 Extension Daytona	EB 3-1 P5	N.A.	0.48	N.A.	No Rebound
Ramsey Branch	EB1 P1	N.A.	0.96	136	Unacceptable
	B4P5	0.50-0.75	1.47	100+	Unacceptable
	EB5P2	0.50-0.75	1.41	140	Unacceptable
Chaffee and I-10	P2P9	2.00-3.00	2.63	10	Unacceptable
I4 and JYP	RA P2P1	0.75-1.00	1.09	125	Unacceptable
	RA P9P12	0.75-1.00	1.01	227	Unacceptable
50 & 436	EB4 P10	N.A.	0.40	40	No Rebound
	P3 EB P10	N.A.	0.40	40	No Rebound

New FDOT Sites Evaluated

20 Locations @ 8 Sites

Site Description	Test Pile	Visual Rebound (in)	PDA Rebound (In)	Blowcount	Rebound Classification
SR 600 Over Saddle Creek	B2 P2	0.25	0.65	210	unacceptable
I-75 Over University Parkway	B1SB P2	0.25	0.50	126	acceptable
	B2SB P3	N.A.	0.50	N.A.	No Rebound
	B2NB P3	N.A.	0.59	N.A.	No Rebound
	B3NB P7	0.375	0.55	317	unacceptable
I-75 over Deer Prairie Creek (170124)	B2 P3	> 0.25	1.34	<72	unacceptable
	B5 P3	> 0.25	1.18	<83	unacceptable
I-75 over Deer Prairie Creek (170125)	B1 P1	> 0.25	1.25	<118	unacceptable
	B4 P1	> 0.25	1.4	<83	unacceptable
SR 64 and I-75	B1 P3	N.A.	0.80	240+	unacceptable
	B2 P9	N.A.	0.87	240+	unacceptable
	B3 P1	0.30	0.80	173	unacceptable
Alligator Creek	B1SB P5	HR	1.00	240+	unacceptable
	B2SB P5	HR	1.05	173	Unacceptable
	B3NB P5	N.A.	0.86	<108	unacceptable
	B4SB P5	HR	0.77	65	Acceptable
JTB Blvd and I-95 (720817)	B1 P9	N.A.	0.50	N.A.	No Rebound
	B2 P1	N.A.	0.38	N.A.	No Rebound
	B4 P9	N.A.	0.50	N.A.	No Rebound
JTB Blvd and I-95 (720816)	B5 P3	1.0	1.20	122.0	unacceptable
	B6 P4	0.50-1.00	1.31	<111	unacceptable
	B7 P14	0.75	0.95	>120	unacceptable

Trends from CPTu Charts

Rebound CPTu Data

Nonrebound CPTu Data

- 🦬 Based on Layers 4B thick
- 🦬 Layer Thickness is critical
- 🦬 Similar Trends maybe available using SPT data
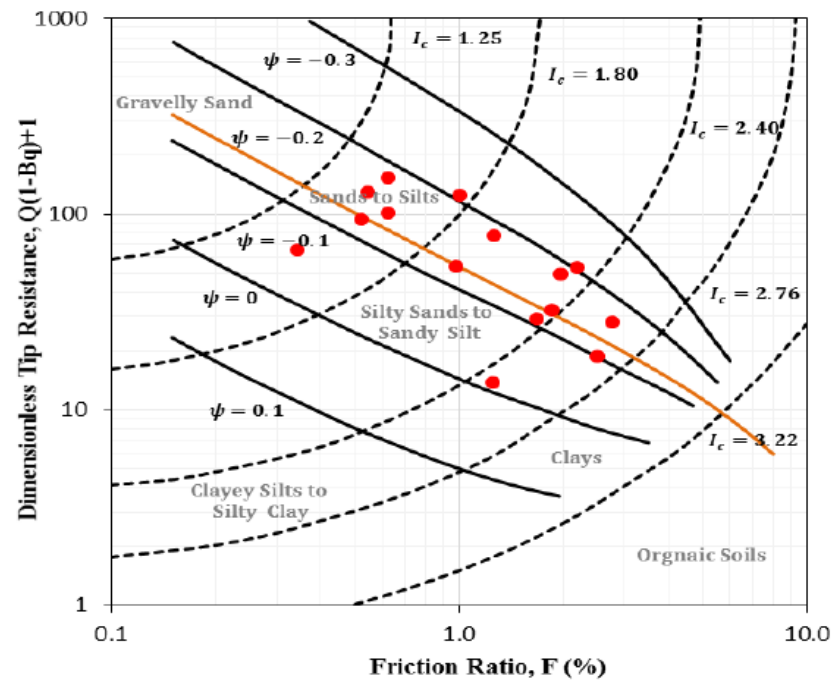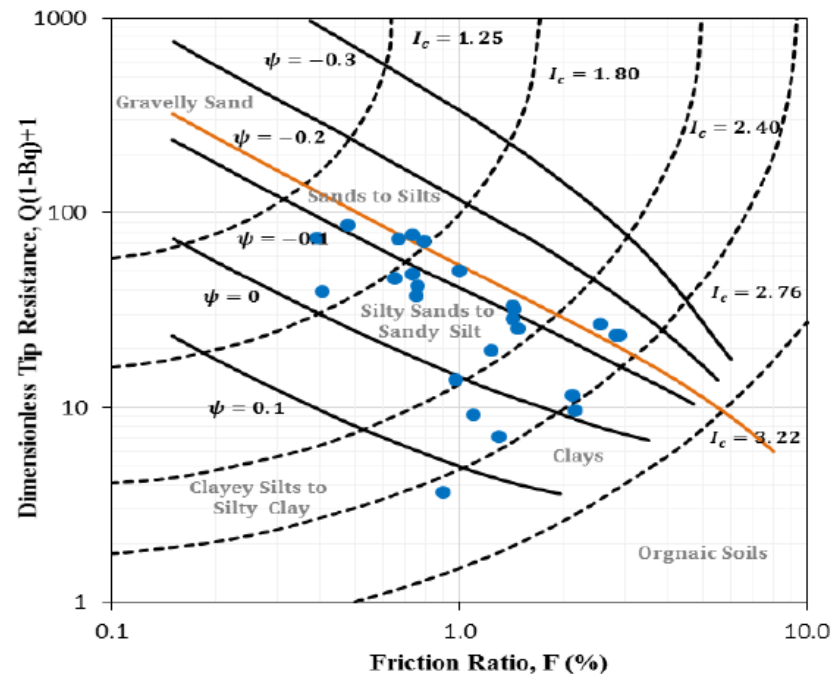
Task 1 Identification and Organization of Additional HPR and NonHPR sites Based on Rebound Level

- Up to SIX new HPR sites will be identified- 4 identified to date

- Soil profiles with SPT plus PDA data from these sites will be organized so that the rebound can be categorized as follows:

  - acceptable (rebound with acceptable set i.e. the pile driven),

  - no rebound (less than 0.25 inches of rebound)

  - unacceptable (rebound greater than one of the three proposed rebound levels ¼-inch, ½-inch and 1-inch).

Sites Evaluated

Original Sites
New Sites

SR 83 over Ramsey Branch– 3 TP
Chaffee Road I-10 Interchange, Jacksonville – 1 TP
Jackson Turner Butler (JTB) Blvd I-95 – 6 TP
Alligator Creek Starke– 4 TP
I-4 Deer Crossing, Volusia - 1 TP
SR 417 I-4 International Parkway Interchange– 2 TP
Anderson Street Overpass SR 408 and I-4 – 1 TP
John Young Parkway I-4 Interchange – 2 TP
N John Young Pkwy
I-4 US 192 Kissimmee – 2 TP
SR 600 Bridge over Saddle Creek – 1 TP
Saint John Heritiage Parkway, Palm Bay– 3 TP
Ramp D2 SR 64 and I-75 Bradenton –3 TP
I-75 over University Parkway – 4 TP
I-75 over Deer Prarie Creek NB and SB –4 TP

Task 2 Evaluation of HPR Rebound Trends

- Existing and New Data to be used
- Divided into 4 subtasks
  - CPTu Soil Behavior Type Charts will be used to determine CPTu rebound trends and correlations
    - Based on pile penetration into the rebound layers of 2B, 4B and 8B
  - Correlations will be developed between the CPTu N equivalent values and the measured N values
  - SPT N and FC versus rebound correlations will be investigated using the 2B, 4B and 8B layer thicknesses
  - Conclusions will be developed and the Level I Decision Tree will be updated to reflect the new findings

Reevaluations of Rebound Vs. N & FC

Rebound vs. N (Previous Work)
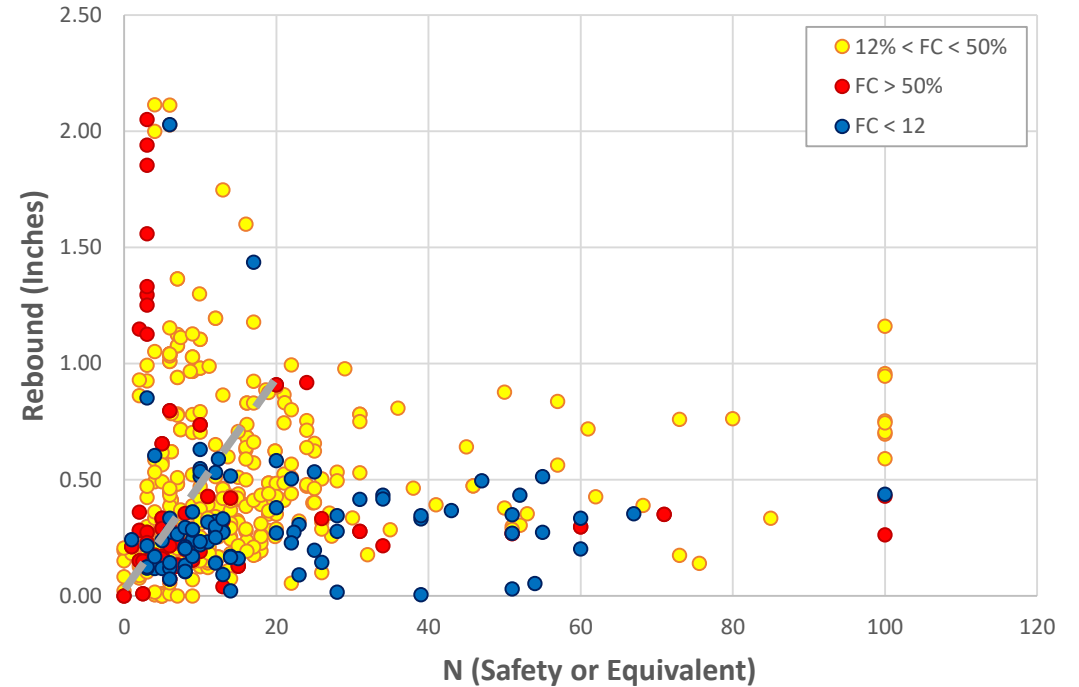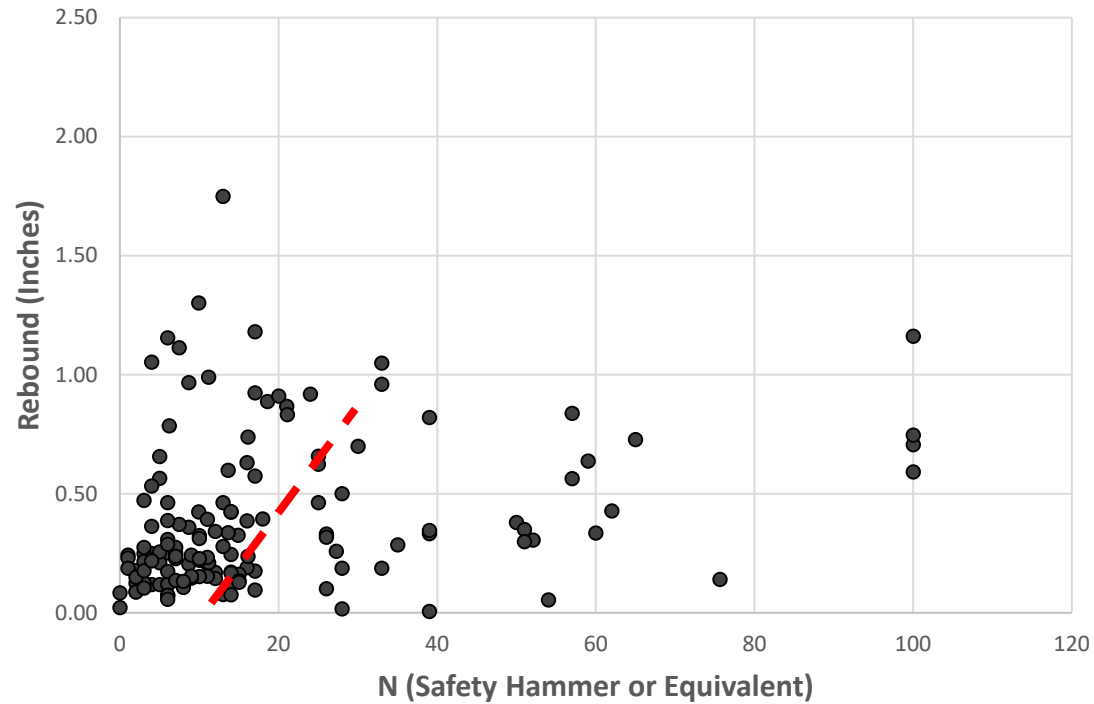
Shows some increase up to 1-inch; No real trends; Also evaluated various Fines Contents still no trends

Rebound vs. N (New Work)

Predrill Depth & Fuel Setting 2
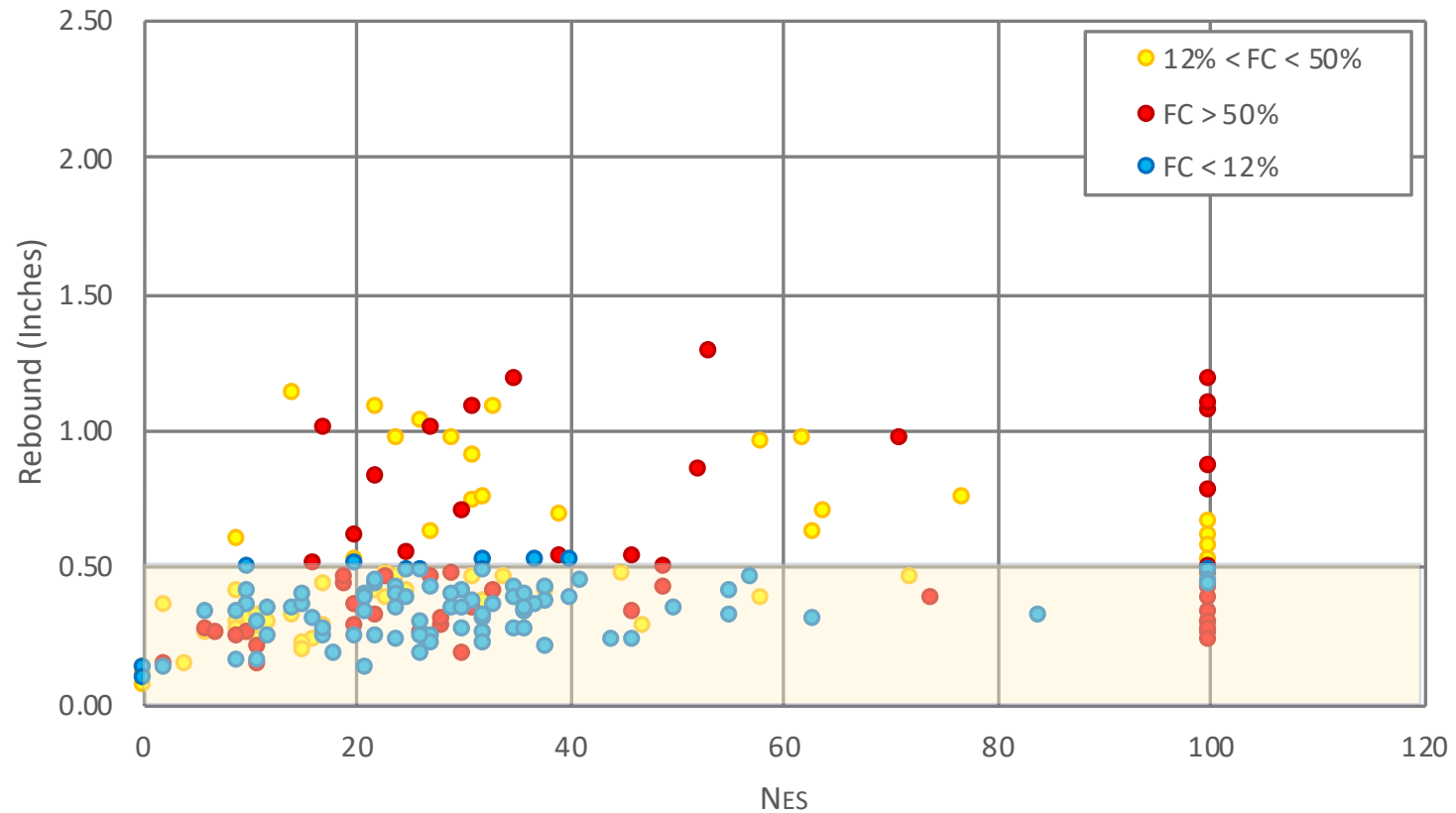
FC < 12% rebound is below 1/2-inch

Is Soil Dilation Related to Rebound through $N_{1(60)}$?

Previous Work

Rebound > < 0.50 inches

CPT Behavior Type	Percentage	
	Rebound	**Nonrebound**
Contractive	53%	72%
Intermediate	27%	17%
Dilative	20%	11%
Total	100%	100%

Contractive behavior also liquefaction resistant due to fines & clays in sands

New Work
Predrill Depth & Fuel Setting 2

Rebound > < 0.50 inches

CPT Behavior Type	Percentage	
	Rebound	**Nonrebound**
Contractive	8%	38%
Intermediate	12%	30%
Dilative	80%	32%
Total	100%	100%

$N_{1(60)}$ plus Seed (1985) dilative > 30 recommendation & rebound shows more frequent dilation

Rebound vs. Fines Content from SPT samples Previous Work
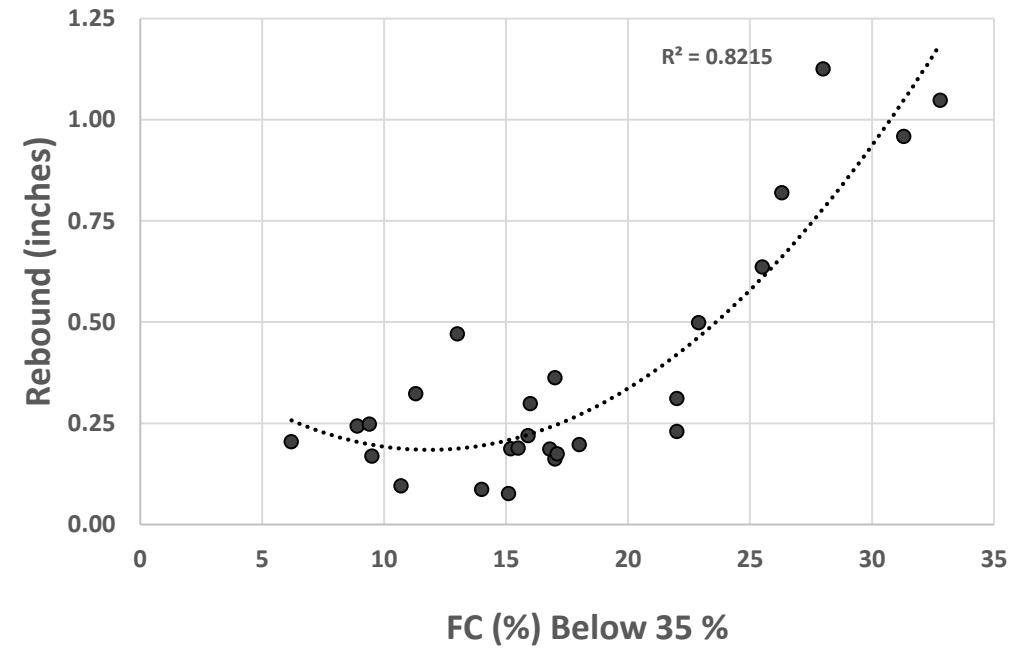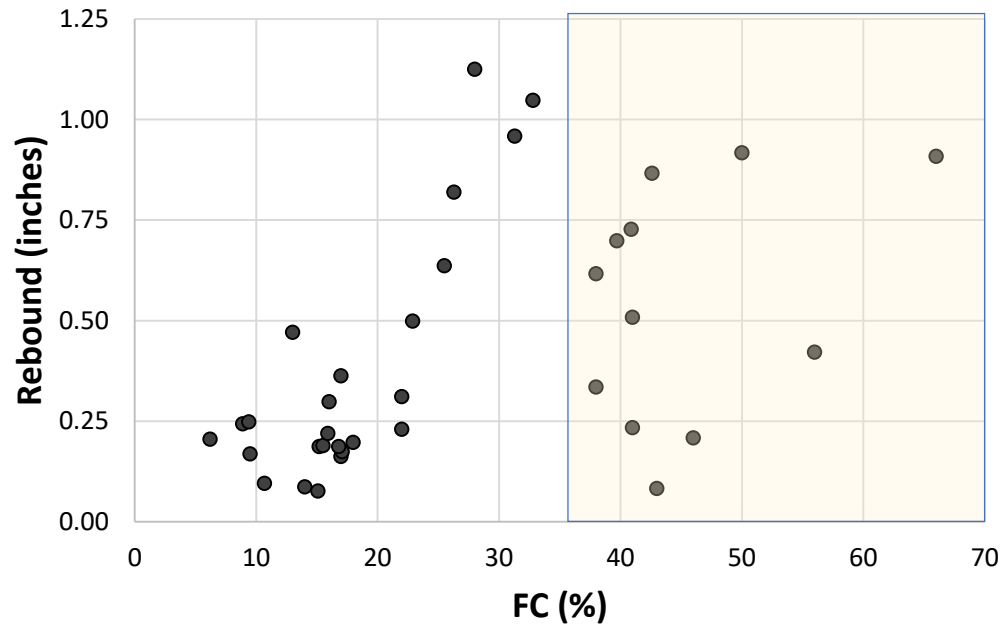
How Fines Content affect Rebound Previous Work

34 samples

91 samples
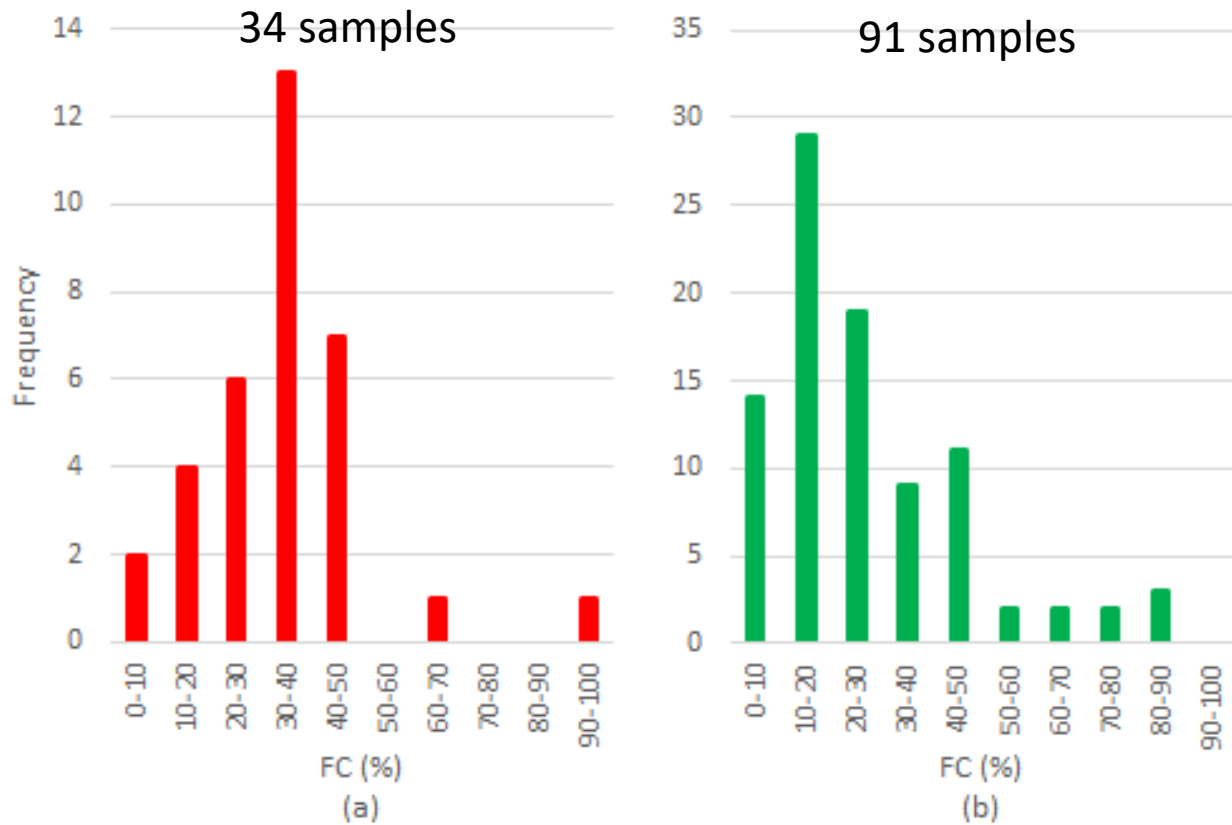
Rebound > < 0.50 inches

| Fines Content % Range | | Percentages | |
Min	Max	Rebound	Nonrebound
0	10	6%	15%
10	20	12%	32%
20	30	18%	21%
30	40	38%	10%
40	50	21%	12%
50	60	0%	2%
60	70	3%	2%
70	80	0%	2%
80	90	0%	3%
90	100	3%	0%
Total %		100%	100%

58% vs **31%**

How Fines affect Rebound
New Work

Soil Classification	Percentages	
	Rebound	**Nonrebound**
SP	**2%**	**28%**
SP-SM	**4%**	**24%**
SM	**40%**	**12%**
SC	**9%**	**11%**
SC/CL/CH	**13%**	**13%**
ML/MH	**27%**	**11%**
WL	**4%**	**1%**
	100%	**100%**

Rebound > < 0.50 inches

SPT vs Rebound ½ Inch New Work
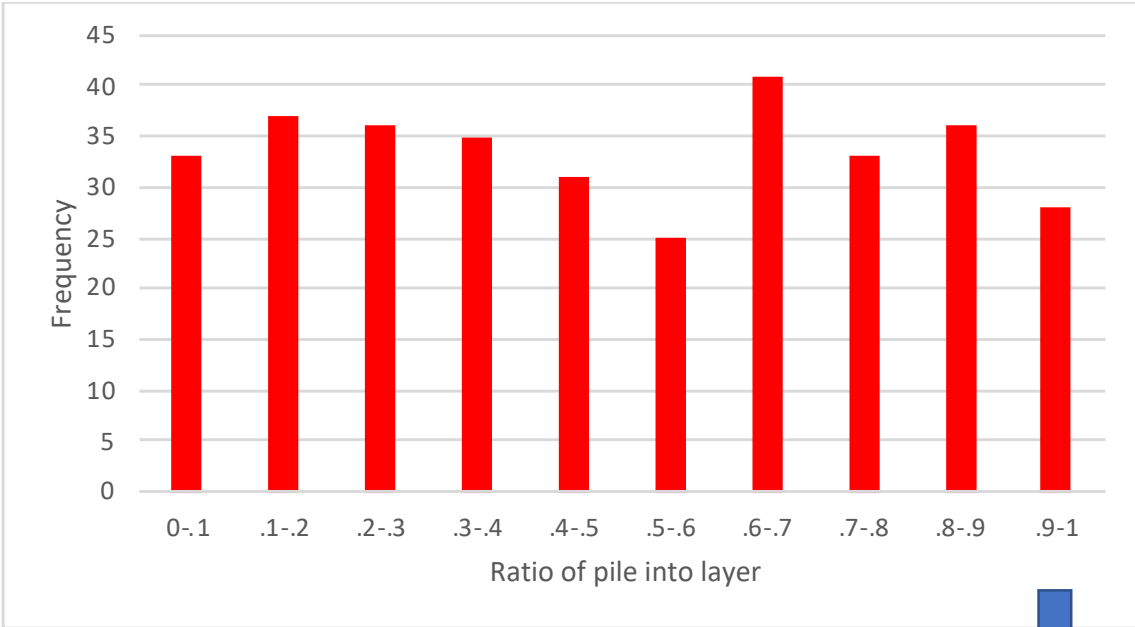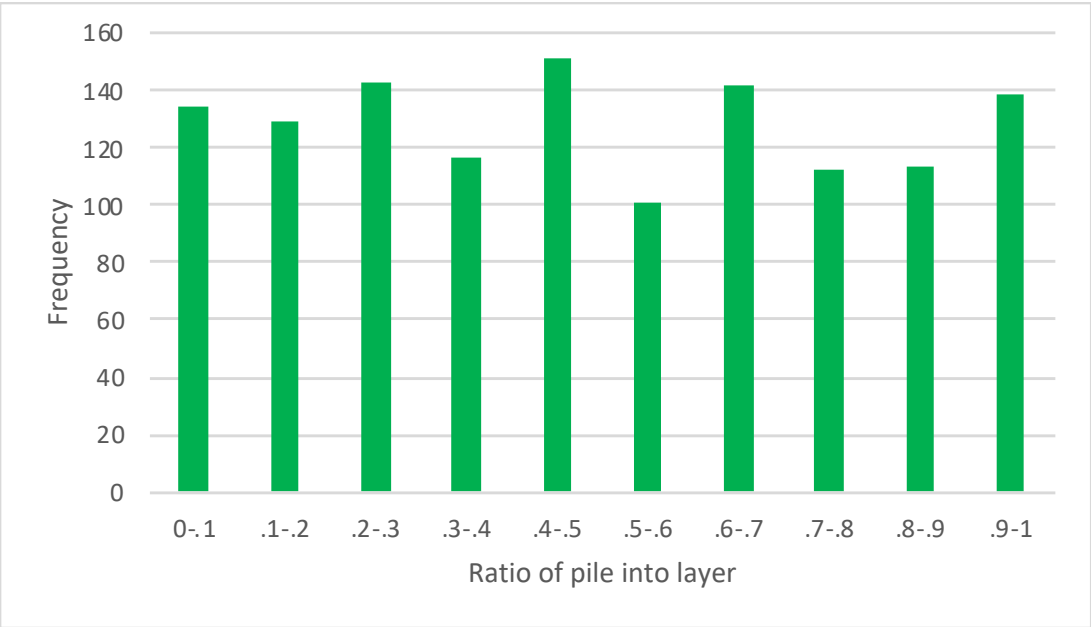
Frequency of driving through a layer of thickness shown
SPT averaged over 4 foot maximum
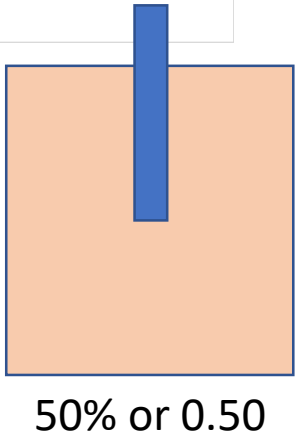
50% or 0.50

Analysis of CPTu Data

🐾 Robertson Software **CPeT-IT** with Correlations

🐾 Geotechnical soil properties estimated from CPTu data were used to evaluate HPR soil behavior

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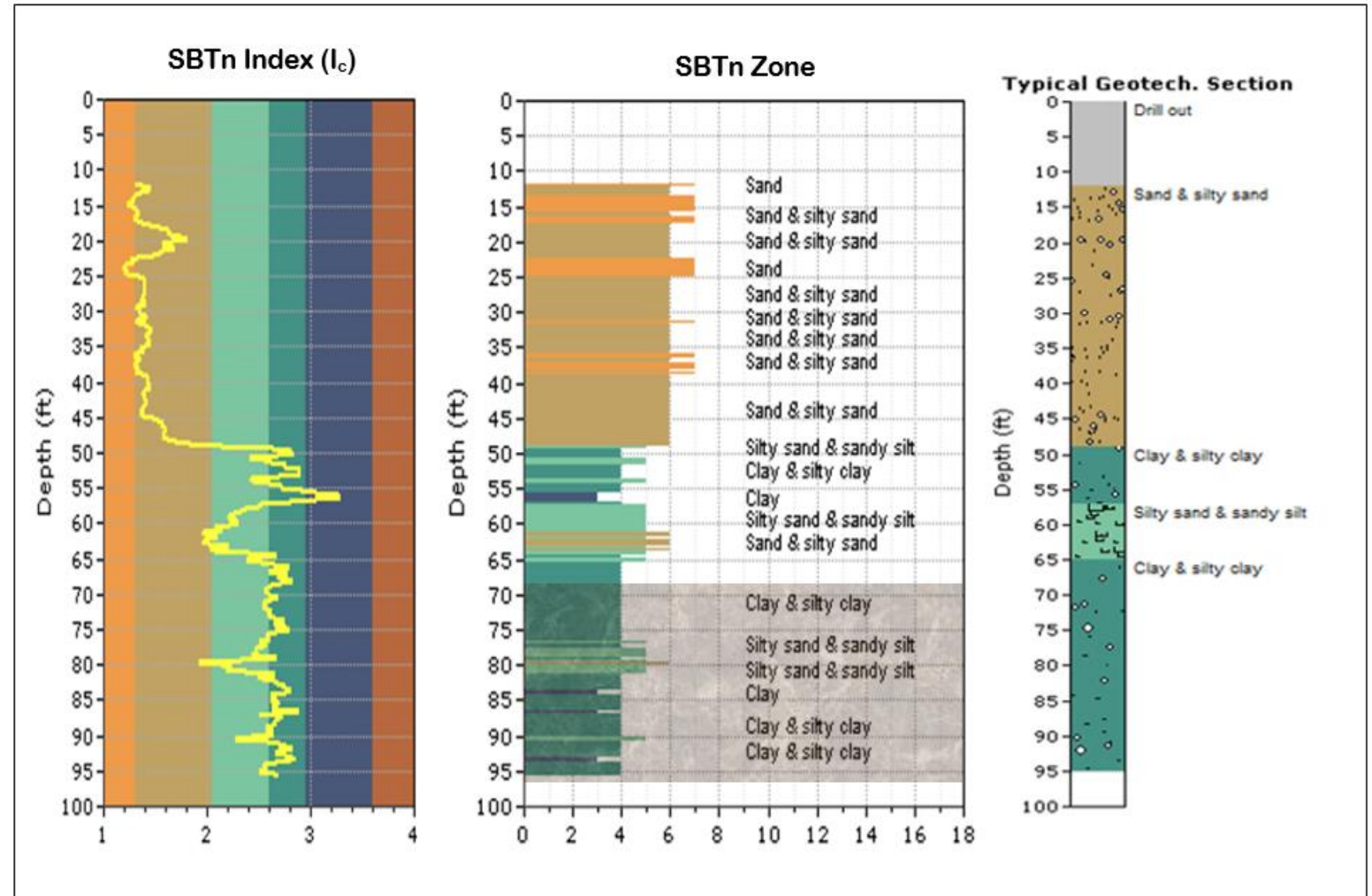
Robertson Modified SBTn Chart

Rebound plots above contractive-dilative boundary
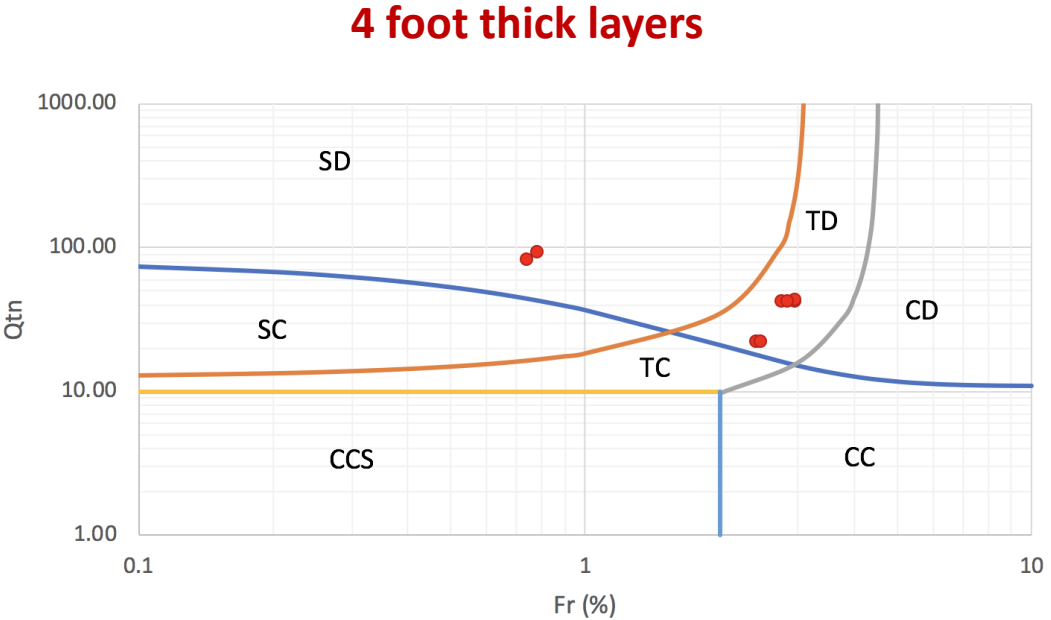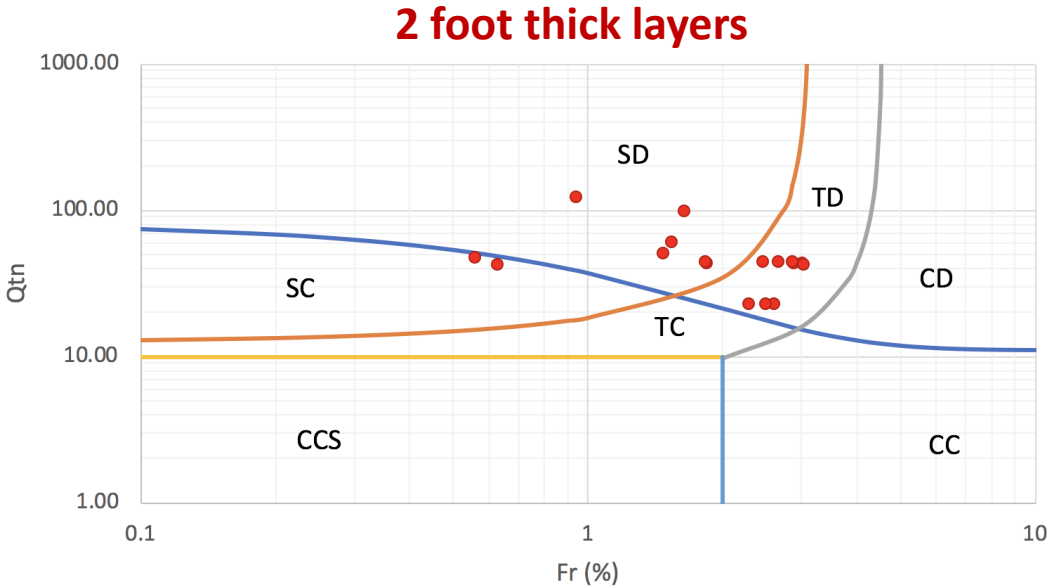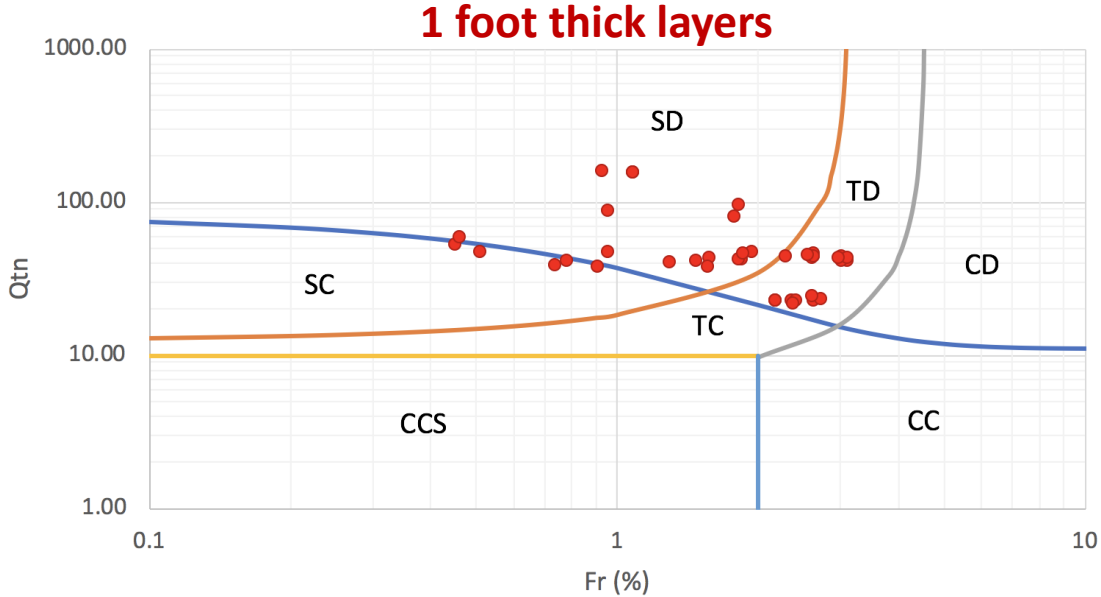
As layer thickness increases number of data points decreases

SPT N vs CPT N
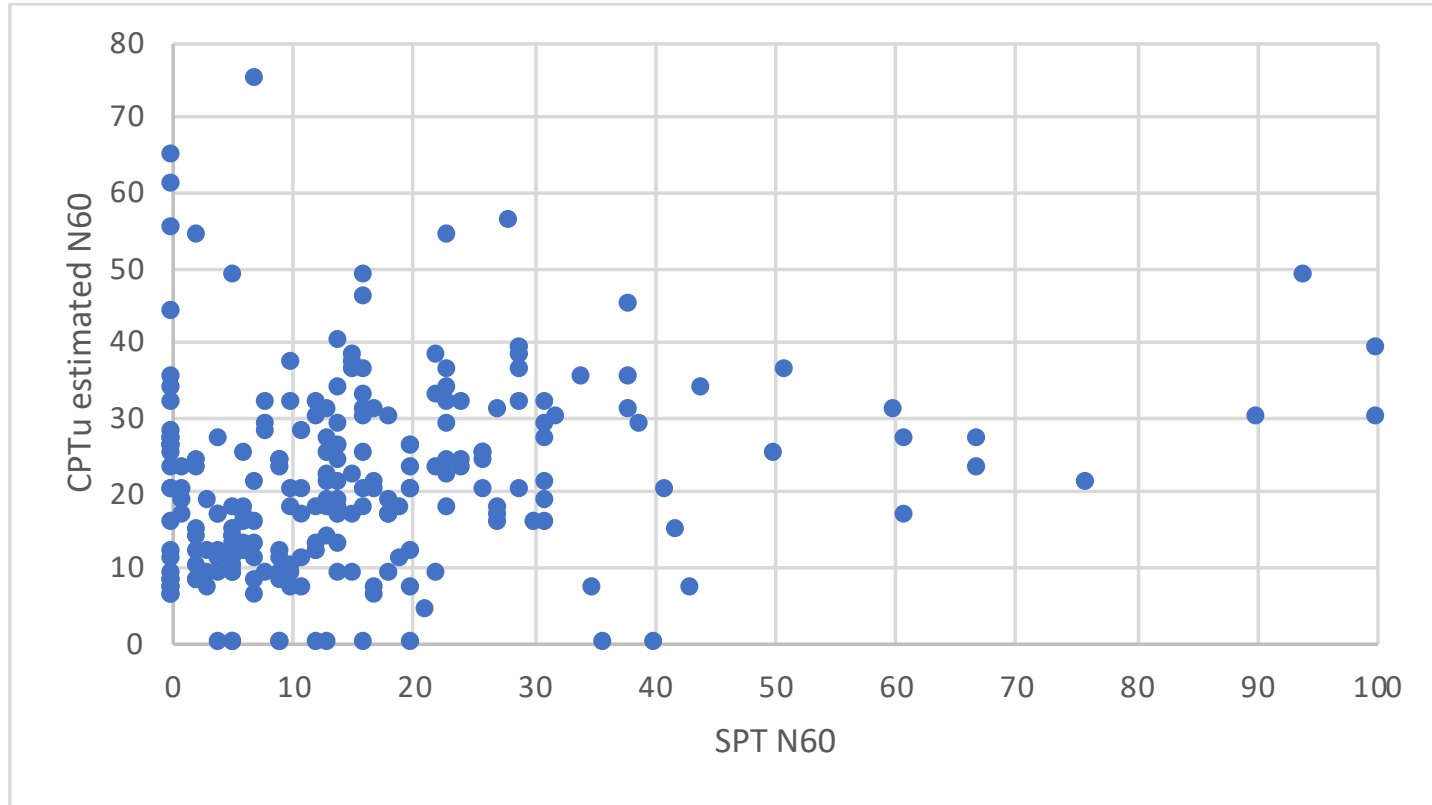
Matched CPT averaged over 1 foot intervals and elevation
No Correlation

Conclusions

- Based on ½ inch rebound
  - Predrilling and fuel setting 2 used to quantify data *to eliminate early driving conditions clarified findings*
  - FC < 12% rebound is below 1/2-inch: *sands do not produce rebound*
  - Dilative soils still causing rebound but more clearly defined based on new sites
  - Fines Content between 20 and 40 % or SM and ML/MH show similar trends
  - SPT averaged over 4 diameter intervals (layer thickness) also showed no clear trends in pile rebound and pile penetration into layer
  - SPT N versus CPTu N equivalent values produced no useable correlations

Questions