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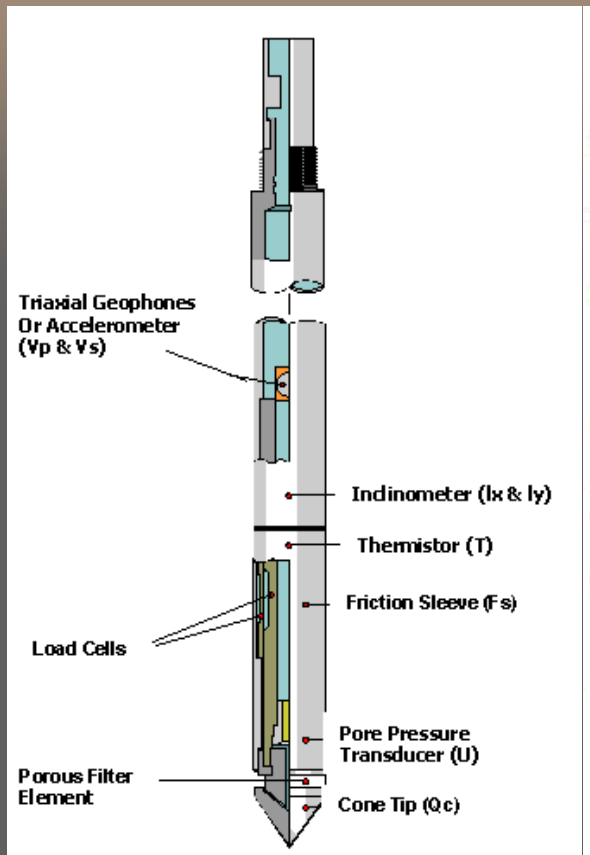
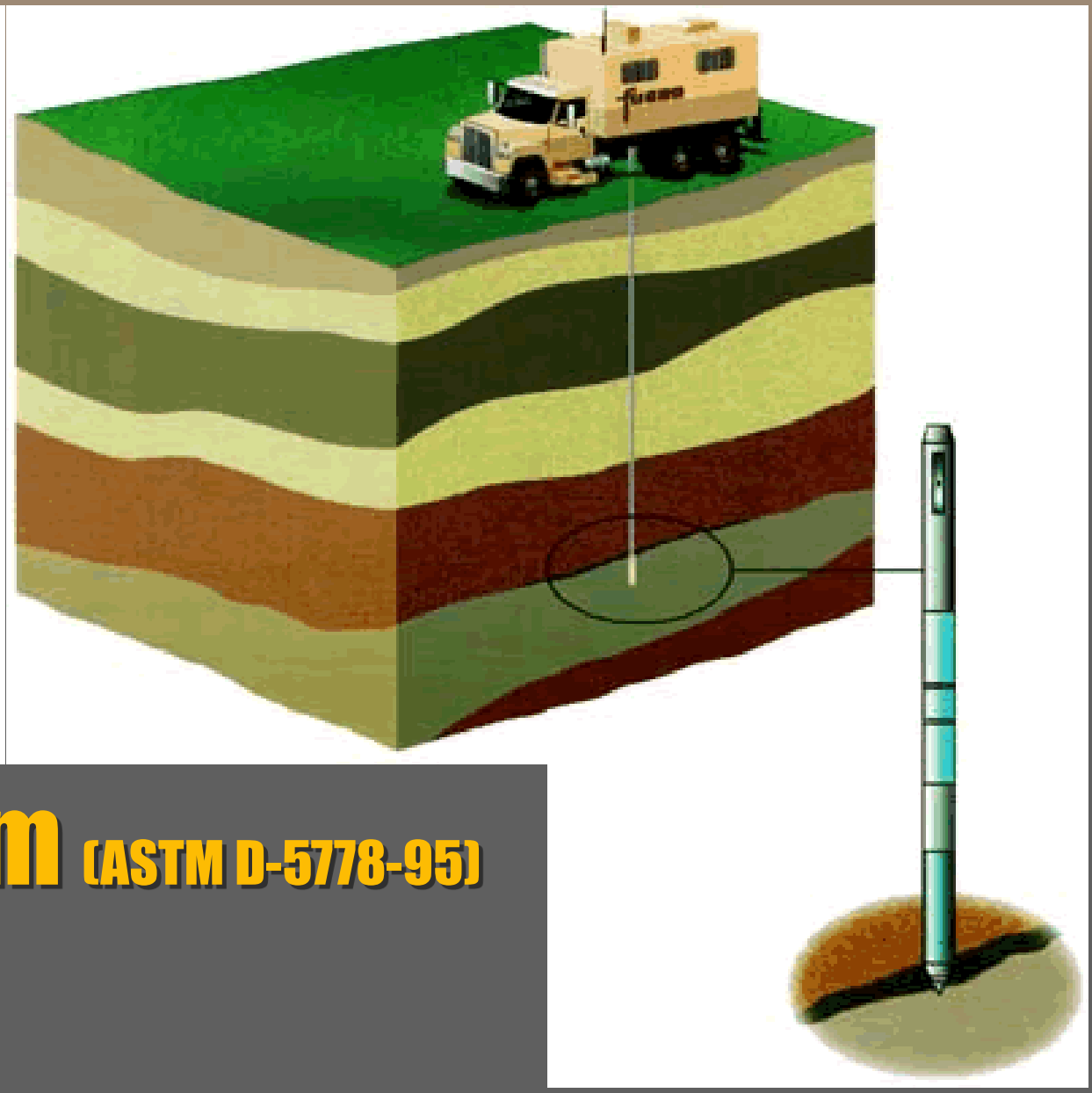
Bridge Foundation Investigations with the CPT

MnDOT CPT Units

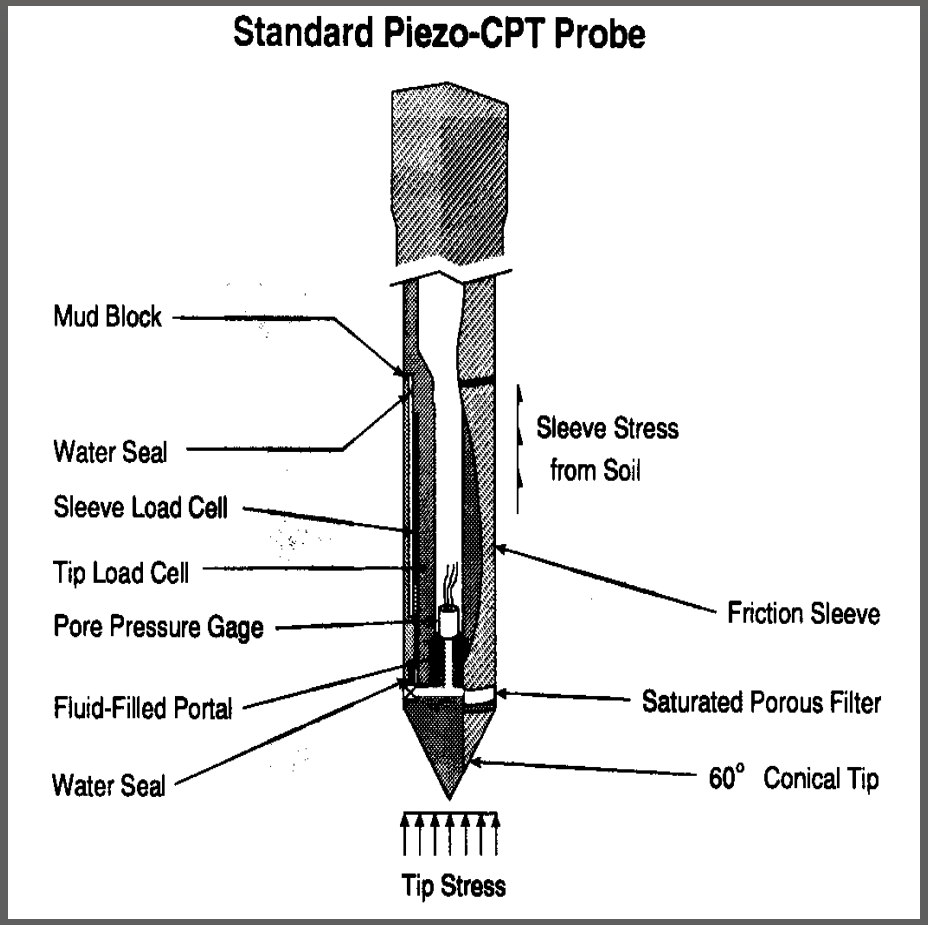




CPT System (ASTM D-5778-95)

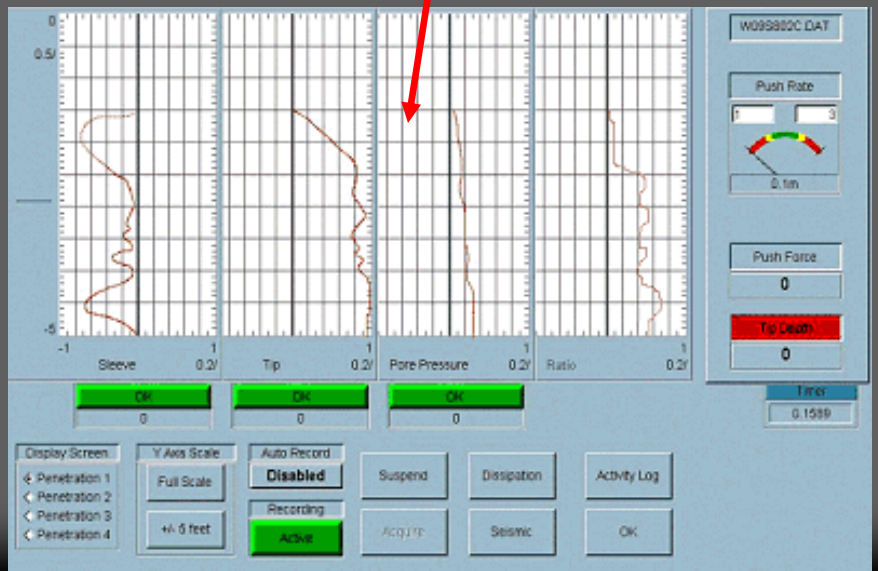
Instrumented Probe
Push System
Data Acquisition

Instumented Probe



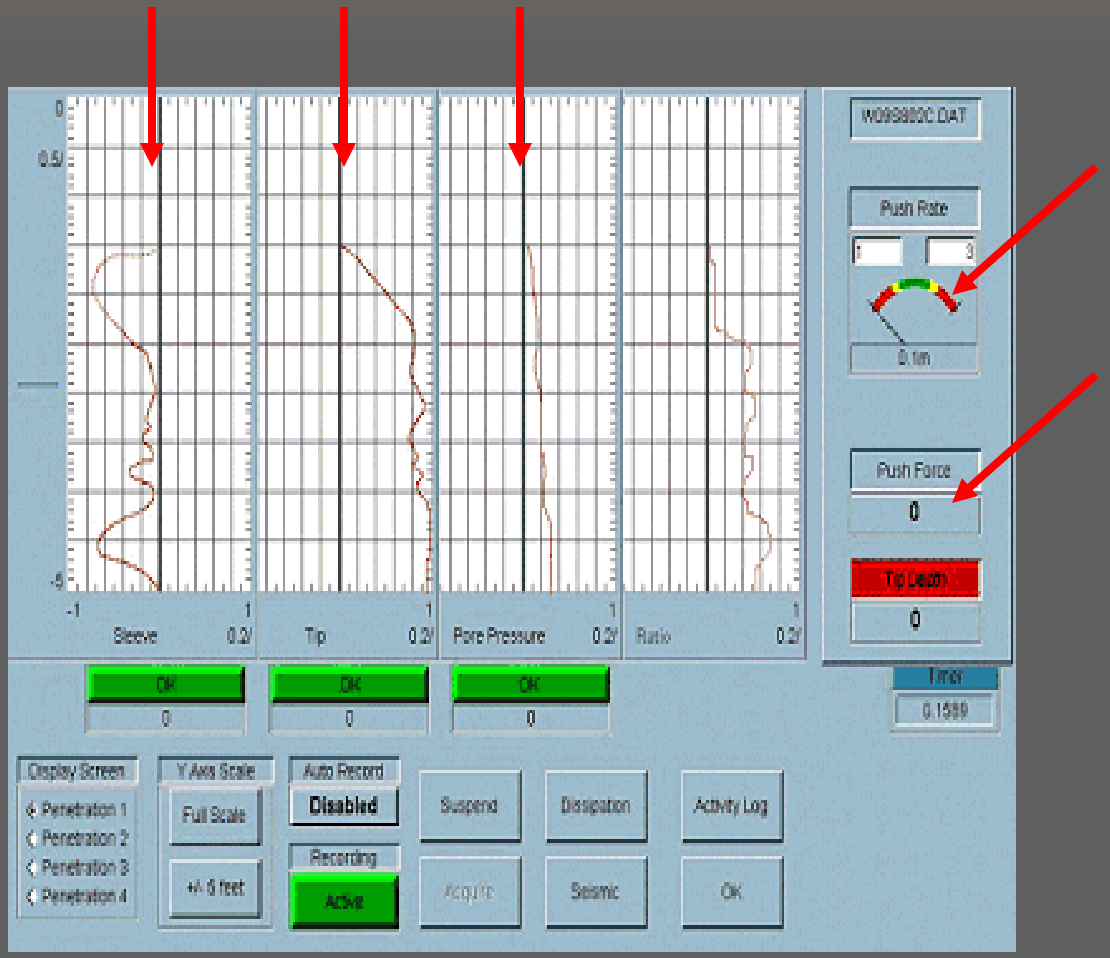
Push System (CPT Rig)

Data Acquisition

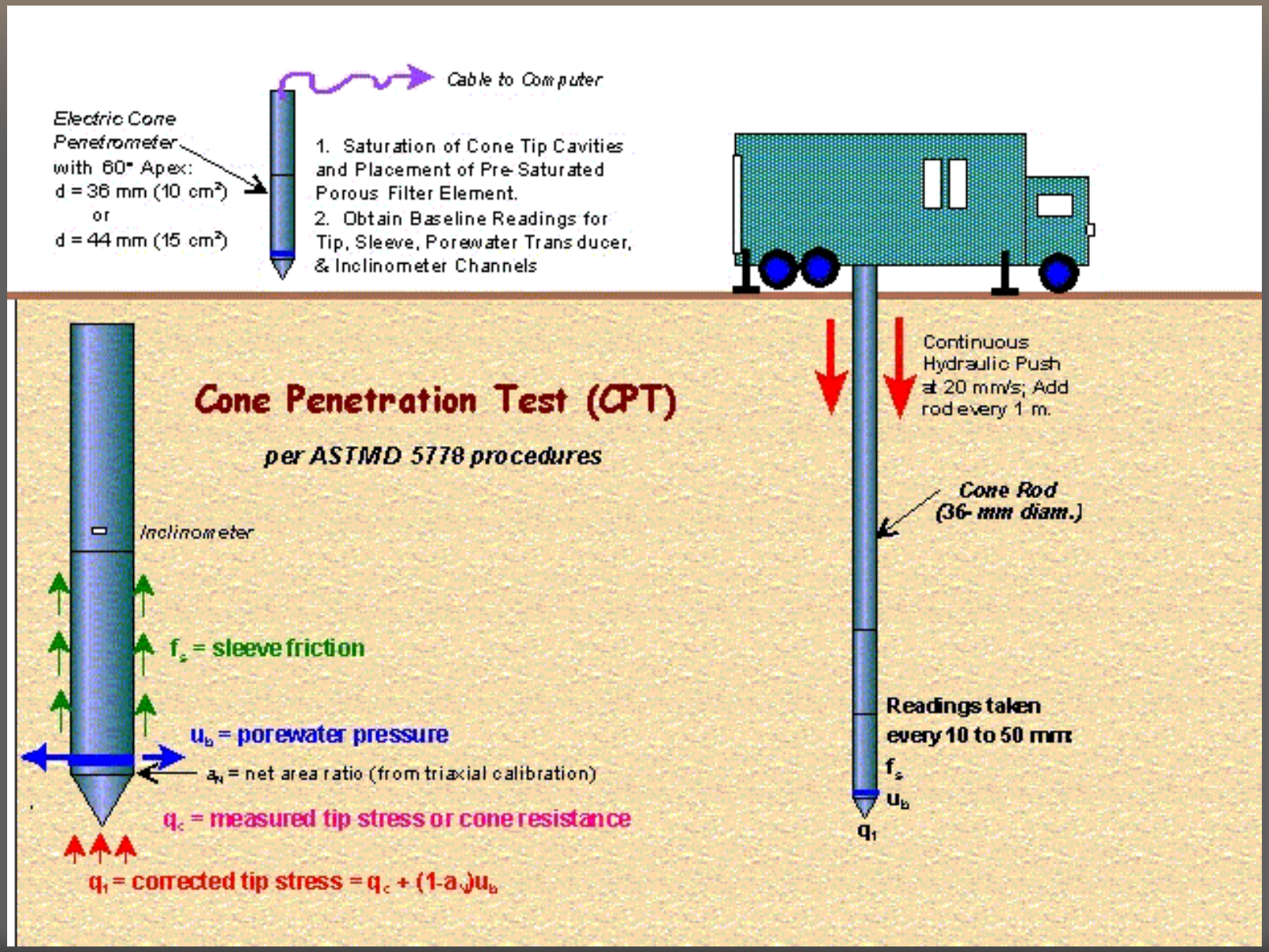


Data Acquisition

- Tip Stress
- Sleeve Friction
- Pore Pressure
- Push Rate
- Push Force



How the System Works



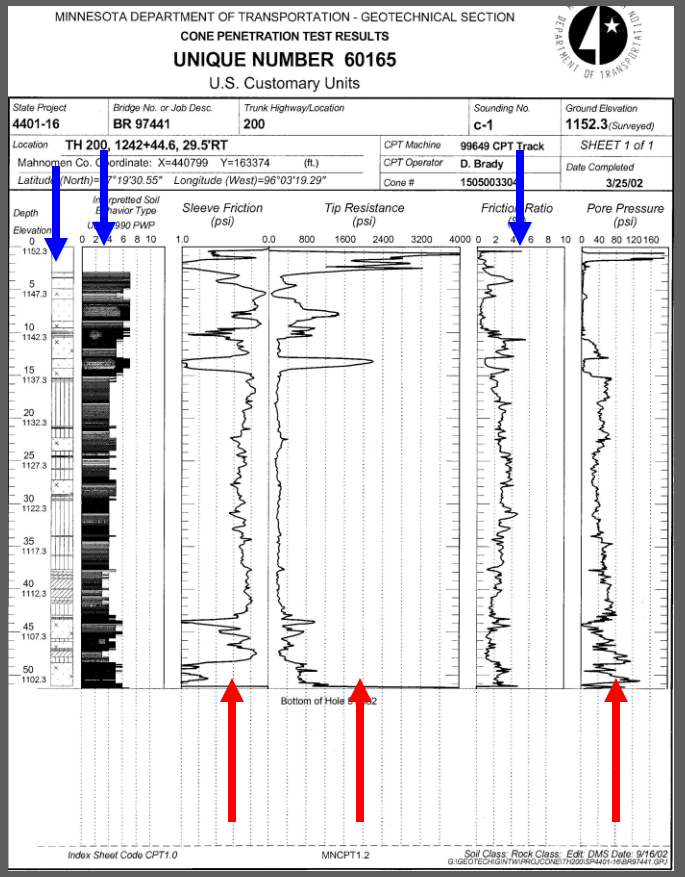

DANGER

Motivation for the "Cone"

- Speed of Investigations, 5x-10x faster, lab work eliminated
- The fall of "N60" as sufficient information to predict all things
- Less labor intensive; 2-person field crew and less wear/tear on personnel
- Continuous Soil Profile
- Fast response and results for "discoveries" at time of construction

Finished Product-CPT Log (pg 1)

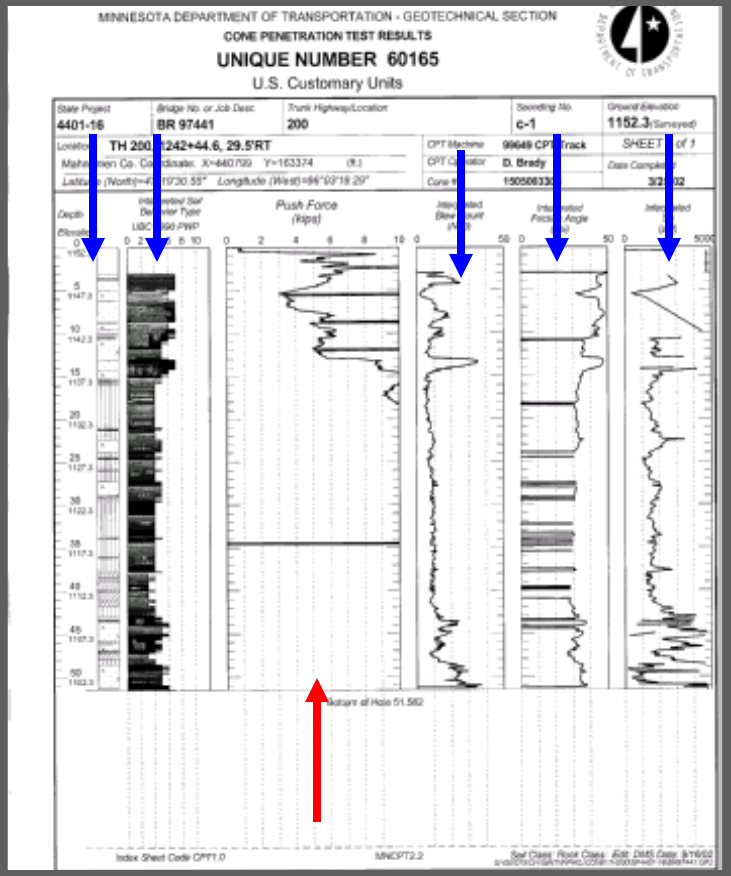
- Collected Data
  - Tip Stress
  - Sleeve Friction
  - Pore Water Pressure
- Interpreted Data
  - Soil Behavior Type
  - Lithology
  - Friction Ratio



Finished Product-CPT Log (pg 2)

This is where it gets tricky……..

- Collected Data
  - Push Force
- Interpreted Data
  - Soil Behavior Type
  - Lithology
  - Interpreted Blow Count
  - Interpreted Friction Angle
  - Interpreted Su



General Relationships

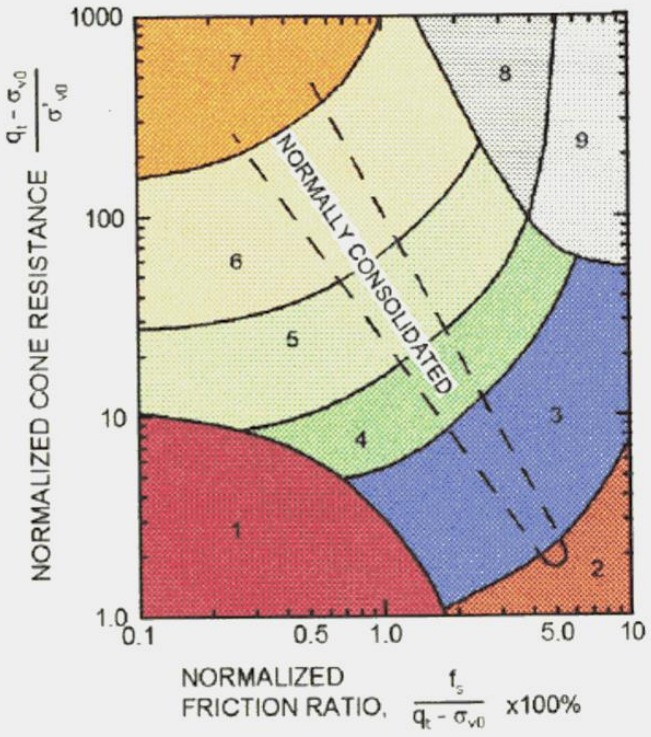
- Granular Soils - High tip resistance, high sleeve friction, low friction ratio
- Cohesive Soils - Low tip resistance, high sleeve friction, high friction ratio
- Organics - very low tip, very low sleeve, very high friction ratio

Soil Behavior Type

Zone	Q_t/N	Description
1	2	Sensitive, Fine Grained
2	1	Organic Soils-Peats
3	1.5	Clays-Clay to Silty Clay
4	2	Silt Mixtures-Clayey Siltto Silty Clay
5	3	Sand Mixtures-Silty Sand to Sandy Silt
6	4.5	Sands-Clean Sand to Silty Sand
7	6	Gravelly Sand to Sand
8	1	Very Stiff Sand to Clayey Sand *
9	2	Very Stiff, Fine Grained *
		Undefined Soil Layer

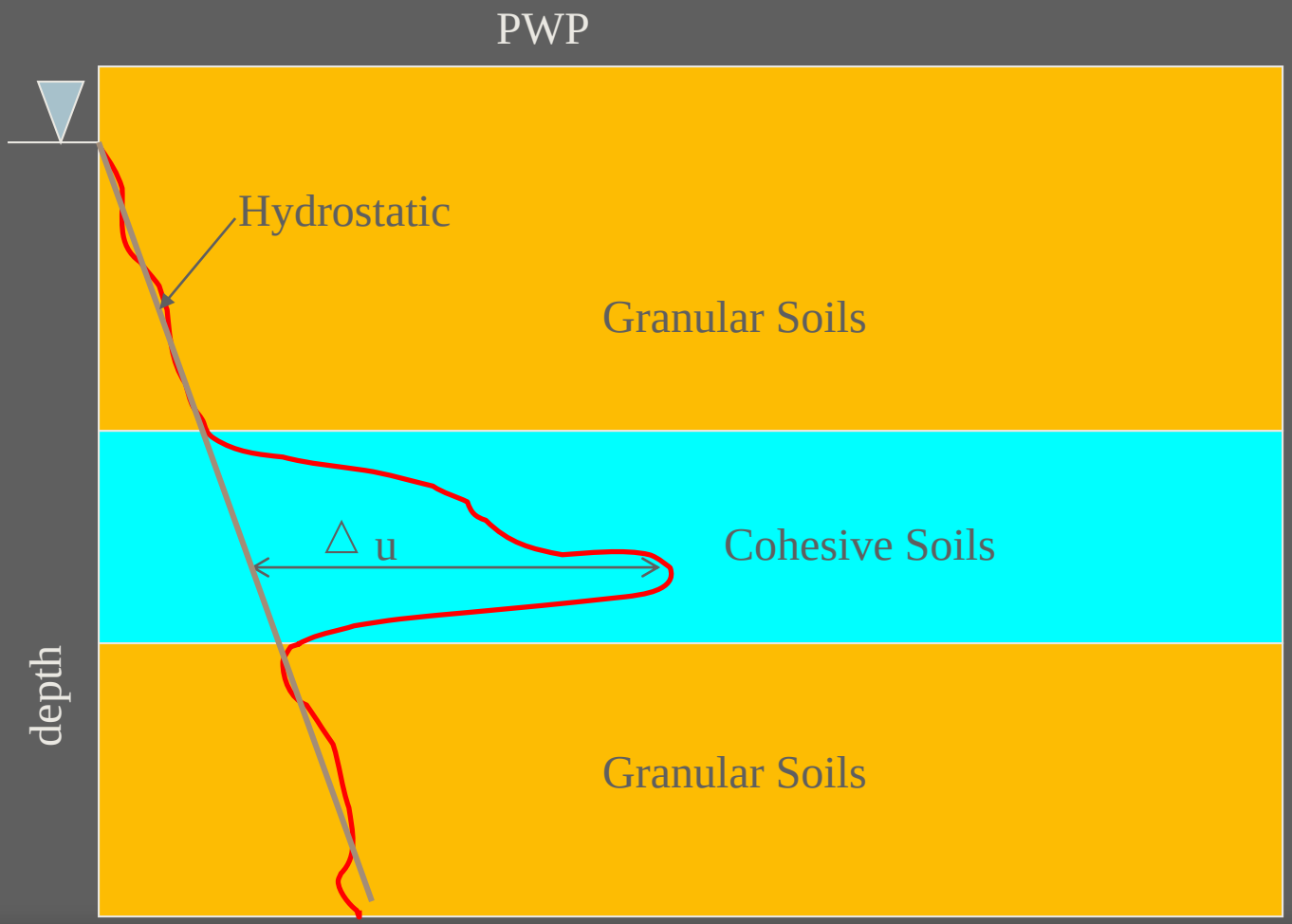
(*) *Heavily Overconsolidated or Cemented*

Normalized Friction Ration Classification Chart



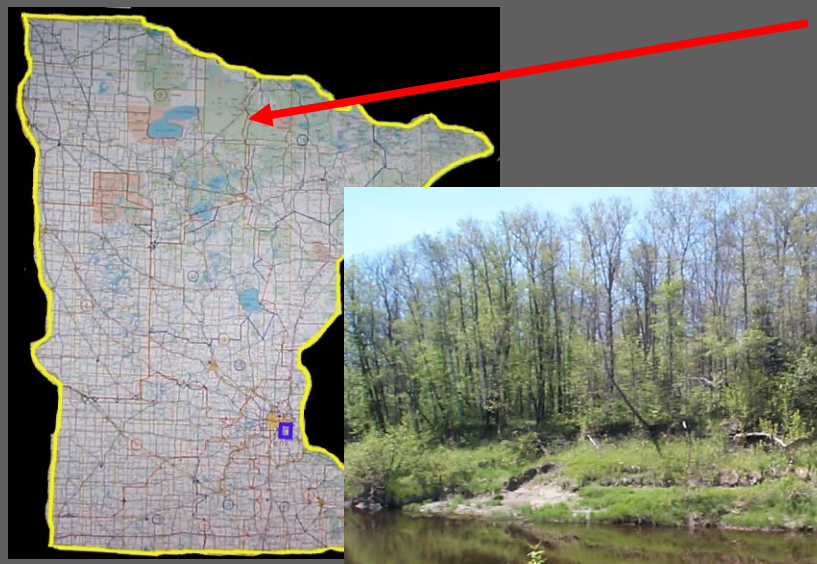
(Ref. Robertson, 1990)

Dynamic Pore Water Pressure (dU / PWP) Measurements



Case Study 1: Rural BR over Soft Clay

- Correlation in Normally Consolidated Clay, unstable slopes
- Compare time and end data with standard boring program
- MN Hwy 65 crossing the Littlefork River, multi span bridge
- SP 3609-30 T4, C4 (5 standard borings matched with 5 soundings)



MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 60180

U.S. Customary Units

COMBINED STANDARD/CPTU LOG

FOR DATA VALIDATION AND COMPARISON

AT ADJACENT BORINGS/SOUNDINGS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location		CPT Unit	Date Completed	Sounding	Ground Elevation
3609-30	east side span 2	65	SHEET 1 of 2	99649 CPT Track	6/4/02	c-4	1148.4 (Auto Level)

Location: TH 65, 1922+46.8, 24.1' Lt

Koochiching Co. Coordinate: X=561901 Y=232423 (ft.)

Latitude (North)=48°12'30.72" Longitude (West)=93°29'46.17"

Drill Rig: | Date Completed: | Boring: CS 5

DEPTH	Depth / Elev.	Lithology	Drilling Operation	Classification
	2.0 / 1146.4			slorg CL w/ some straw, dk gray-brn & damp
	4.5 / 1143.9			FS w/ thin seam pl SiL, lt gray-brn w/ lt gray, moist
				S w/ G & stone chips, seams F & FS; lt brn; wet to sat
	14.0 / 1134.4			fat C w/ some pebbles, gray, Vmoist to wet
	68.0 / 1080.4			fat C, some blocky or platey layers w/ Silt swirls to traces to pl SiL seams, evidence of slick-en-side faces; gray to lt gray; Vwet

Interpreted Soil Behavior Type — UBC 1990 PWP (0 2 4 6 8 10 12)

Sleeve Friction (psi) (1.0 0.0)

Tip Resistance (psi) (0 200 400 600 800)

Friction Ratio (%) (0 2 4 6 8)

Depth

MC % (0 60 120 180 240)

Pore Pressure (psi)

Coh (psf)

Interpreted Undrained Shear Strength Su (0 5000)

SPT N_{60}

Interpreted Blow Count (N60) (0 50)

Interpreted Friction Angle (phi) (0 50)

Depth

MNCPTSPT1.2

(Continued Next Page)

Soil Class: Rock Class: Edit: DMS Date: 10/14/02

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Case Study 2: Bridge 27V35 – W. Bush Lake Road over TH494

- New construction
- Geotechnical design based on SPT
- CPT soundings taken to compare with existing SPT data
- Sounding C10 taken adjacent to Boring B10

MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 60349

U.S. Customary Units

COMBINED STANDARD/CPTU LOG

FOR DATA VALIDATION AND COMPARISON

AT ADJACENT BORINGS/SOUNDINGS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	SHEET 1 of 2	CPT Unit	Date Completed	Sounding	Ground Elevation
2785-327	27V35	494		99649 CPT Track	11/20/01	C10	837.0 (CPT-GPS)

Location **at boring B-10**

Hennepin Co. Coordinate: X= Y= (ft.)

Latitude (North)= Longitude (West)=

Depth	Elev.	Classification
0.8	836.3	TOPSOIL
		SANDY LOAM with trace of fine Gravel - Brown - Fine to Medium Grain - Medium Dense - Moist
10.0	827.0	
		SAND, POORLY GRADED with trace of Fine Gravel - Gray to Brown - Fine to Medium Grain - Coarse Beyond 18' - Wet
21.0	816.0	
		SANDY CLAY LOAM - Gray - Fine Grained - Medium to Soft - Wet
45.0	792.0	
		SANDY LOAM with trace of Clay & fine Gravel - Brown - Fine to Medium Grain - Loose to Medium Dense - Moist

Interpreted Soil Behavior Type — UBC 1990 PWP — 0 2 4 6 8 10 12

Sleeve Friction (psi) — 1.0 0.0

Tip Resistance (psi) — 0 1000 2000 3000 4000

Friction Ratio (%) — 0 2 4 6 8

Depth

MC % — Pore Pressure (psi) — 0 36 72 108 144

Coh (psf) — 910 300 890 800

Interpreted Undrained Shear Strength Su — 0 3000

SPT N 60 — 25 11 15 10 15 14 11 9 5 5 8 8 3 17 35 15 30 30 20 44

Interpreted Blow Count (N60) — 0 50

Interpreted Friction Angle (phi) — 0 50

Depth

MNCPTSPT1.2

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Soil Class: Rock Class: Edit: Date: 10/24/02

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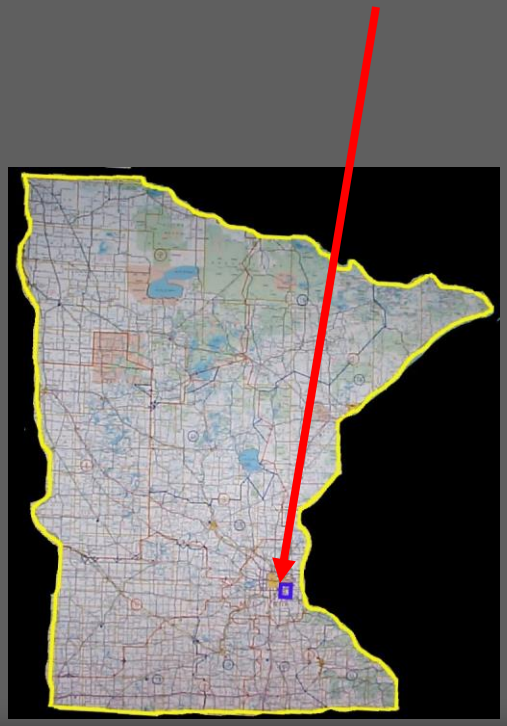
Case Study 3: I-494 "Wakota" Bridge

- Initial Correlation and Training; Lateral Pile Loads for Consultant
- I-494 in the SE Twin Cities (St. Paul, Newport, MN)
- Crossing the Mississippi River, multi span bridge, high profile project
- SP 8285-79 T44, C44-1



MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER

U.S. Customary Units

COMBINED STANDARD/CPTU LOG FOR DATA VALIDATION AND COMPARISON AT ADJACENT BORINGS/SOUNDINGS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	SHEET 1 of 2	CPT Unit	Date Completed	Sounding	Ground Elevation (CPT-GPS)
8285-99	82855/56	494		99649 CPT Track	10/31/01	c44-1	CS 1

Location

Washington Co. Coordinate: X= Y= (ft.)

Latitude (North)= Longitude (West)=

Drill Rig | Date Completed | Boring

DEPTH	Depth Elev.	Lithology	Drilling Operation	Classification
	3.5			slorg S w/ some G, thin seam LS; lt brn & damp
	22.0			S & FG w/ thin seam LS @ 3.0m, lt brn w/ brn, damp
	27.0			slorg pl SiL, a few traces Silt, a few shell pieces; gray to gray-brn; wet
			PD	S w/ a few thin seams LS @ 10.5m, a little G @ 11.9m; lt brn to 9.1m, gray; sat
	47.0		PD	slpl SL w/ seams & thin seams CL, lt gray w/ gray, sat
	57.0		PD	Seams & thin seams S, LS & slpl SL w/ a layer of horg CL; lt gray & gray w/ gray; sat w/ Vmoist
	67.0		PD	S w/ thin seams LS, gray & sat
	72.0		PD	CrS w/ a few shell fragments, gray & sat
	74.5		PD	S w/ a few shell fragments to 25.9m, seam of CrS @ 25.8m; grays & sat

Interpreted Soil Behavior Type — UBC 1990 PWP — 0 2 4 6 8 10 12

Sleeve Friction (psi) — 1.0 0.0

Tip Resistance (psi) — 0 1000 2000 3000 4000

Friction Ratio (%) — 0 2 4 6 8

Depth

MC % — Pore Pressure (psi) — 0 30 60 90 120

Coh (psf)

Interpreted Undrained Shear Strength Su — 0 2500

SPT N_{60} — 0 50

Interpreted Blow Count (N60) — 0 50

Interpreted Friction Angle (phi) — 0 50

Depth

MNCPTSPT1.2

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Soil Class: Rock Class: Edit: Date: 10/14/02

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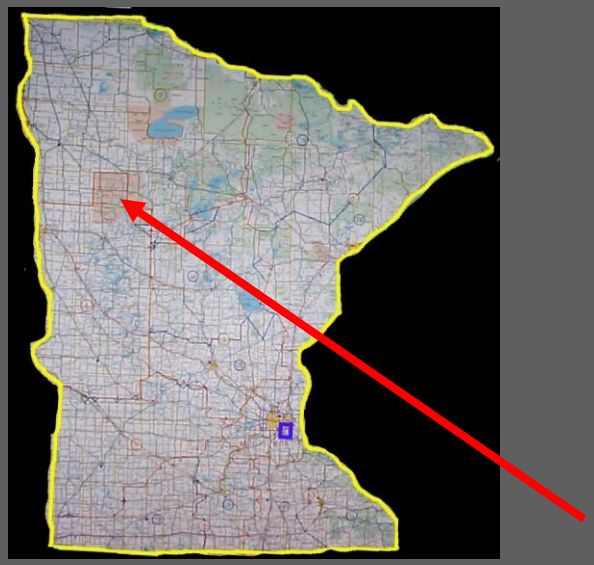
Case Study 4: Bridges/Culverts, MN Hwy 200

- Series of 3 culverts in NW District; CPTU correlation effort (lab tests)
- Mixed soils known to exist, normally and overconsolidated materials
- MN Hwy 200, Mahnomen, MN
- SP 4401-16 T1, C1 also T2, C2 at BR 97441 (replacing 4370)



MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

UNIQUE NUMBER 60165

U.S. Customary Units

COMBINED STANDARD/CPTU LOG

FOR DATA VALIDATION AND COMPARISON

AT ADJACENT BORINGS/SOUNDINGS

State Project	Bridge No. or Job Desc.	Trunk Highway/Location		CPT Unit	Date Completed	Sounding	Ground Elevation
4401-16	BR 97441	200	SHEET 1 of 2	99649 CPT Track	3/25/02	C-1	1152.3 (Surveyed)

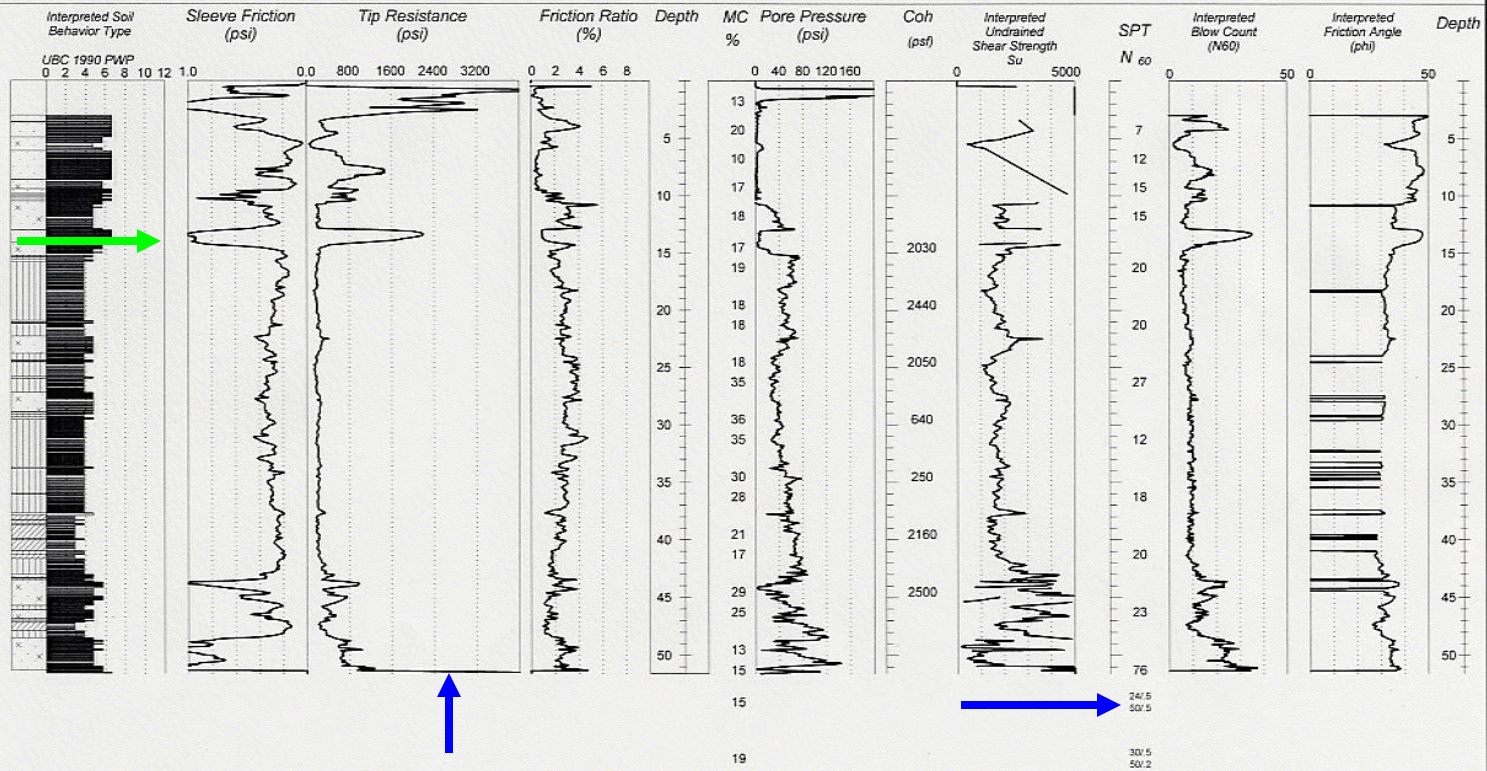
Location: TH 200, 1242+44.6, 29.5'RT

Mahnomen Co. Coordinate: X=440799 Y=163374 (ft.)

Latitude (North)=47°19'30.55" Longitude (West)=96°03'19.29"

CS 3 A

DEPTH	Depth / Elev.	Lithology	Drilling Operation	Classification
5	6.2 / 1146.1			LFS, gray-brn to gray, moist
	8.0 / 1144.3			S & G, lt gray & sat
10	10.5 / 1141.8			slpl FSL w/ CL pockets, lt gray w/ gray, moist
	15.8 / 1136.5			C w/ a few pebbles, Silt trace; gray w/ lt gray; moist
15	18.0 / 1134.3			mixed FS & CL, lt gray & gray, Vmoist
	21.0 / 1131.3			C w/ a few pebbles, small pockets and streaks Silt; gray w/ lt gray; moist
20	23.0 / 1129.3			LS, lt gray & wet
	25.5 / 1126.8			mixed C & CL w/ some pebbles, some Silt marbled in, slick-en-side face; gray w/ lt gray; moist
25	28.0 / 1124.3			C w/ traces Silt & FS, gray w/ lt gray, Vmoist
	34.0 / 1118.3			C, some blocky w/ a few pebbles, layer of pl SiL @ 30.6', some Silt pockets and slick-en-side faces; gray w/ lt gray; moist
30	35.0 / 1117.3			marbled pl SiL & Silt, lt grays & moist
	36.5 / 1115.8			C w/ slick-en-side face, gray & moist
35	43.0 / 1109.3			mixed C, SiCL, pl SiL & Silt w/ pebbles, a few S traces; gray & lt gray; moist
	44.5 / 1107.8			pl SiL w/ C seam, lt gray w/ gray, moist
40	45.0 / 1107.3			S & LS w/ some G, gray & moist
	48.0 / 1104.3			pl SiL w/ a few pebbles, traces & thin seam C; lt gray & damp
45	50.5 / 1101.8			pl & slpl SL w/ pebbles, some Silt mixed in; gray w/ lt gray; damp
	51.0 / 1101.3			S w/ some G, lt gray & Vmoist
50	61.0 / 1091.3			pl SL w/ pebbles, traces of Silt, a few thin seams LS; gray w/ lt gray; damp
	64.0 / 1088.3			S w/ a little G, thin seam pl SL; lt gray w/ gray; wet
				Bottom of Hole - 64.0'
				Water measured at 7.8' while sampling and/or drilling with augers
				Water measured at 28.4', hole depth



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Soil Class: Rock Class: Edit: DMS Date: 10/14/02

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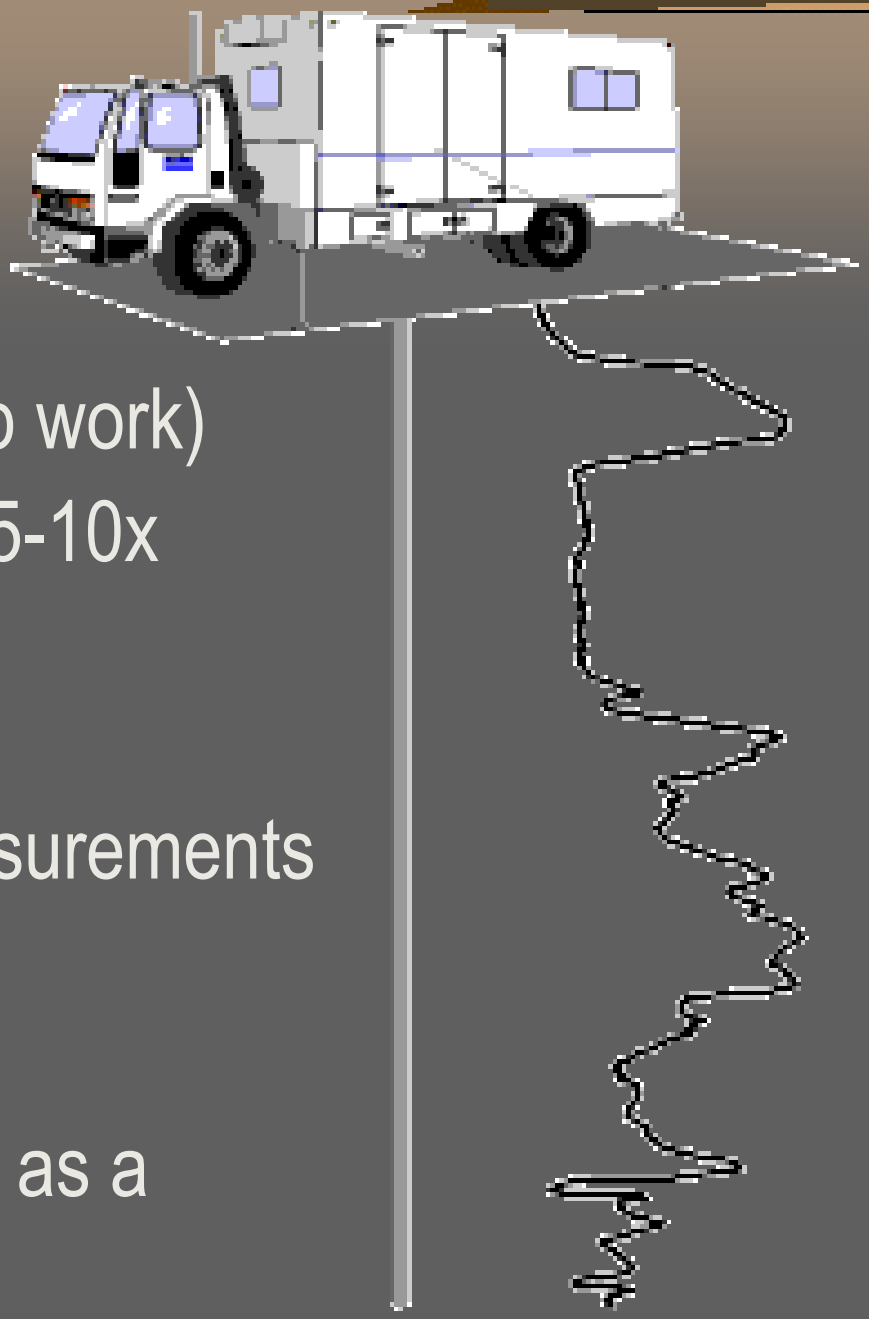
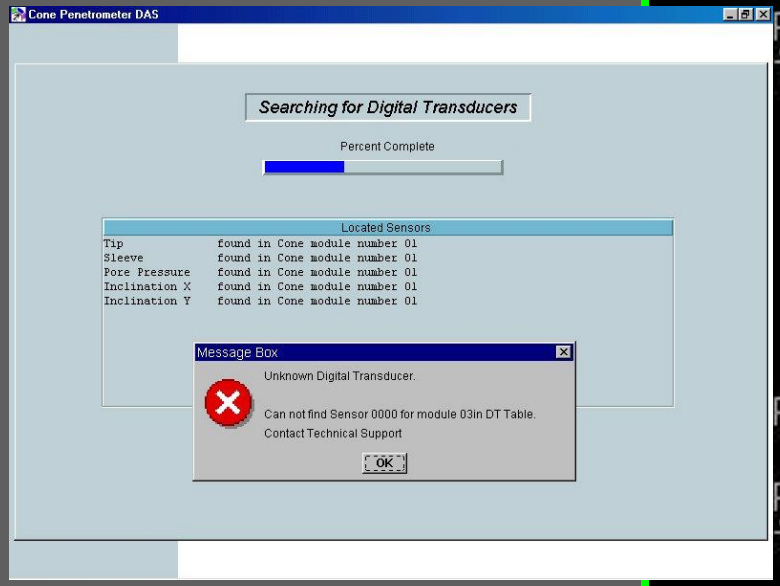
Advantages

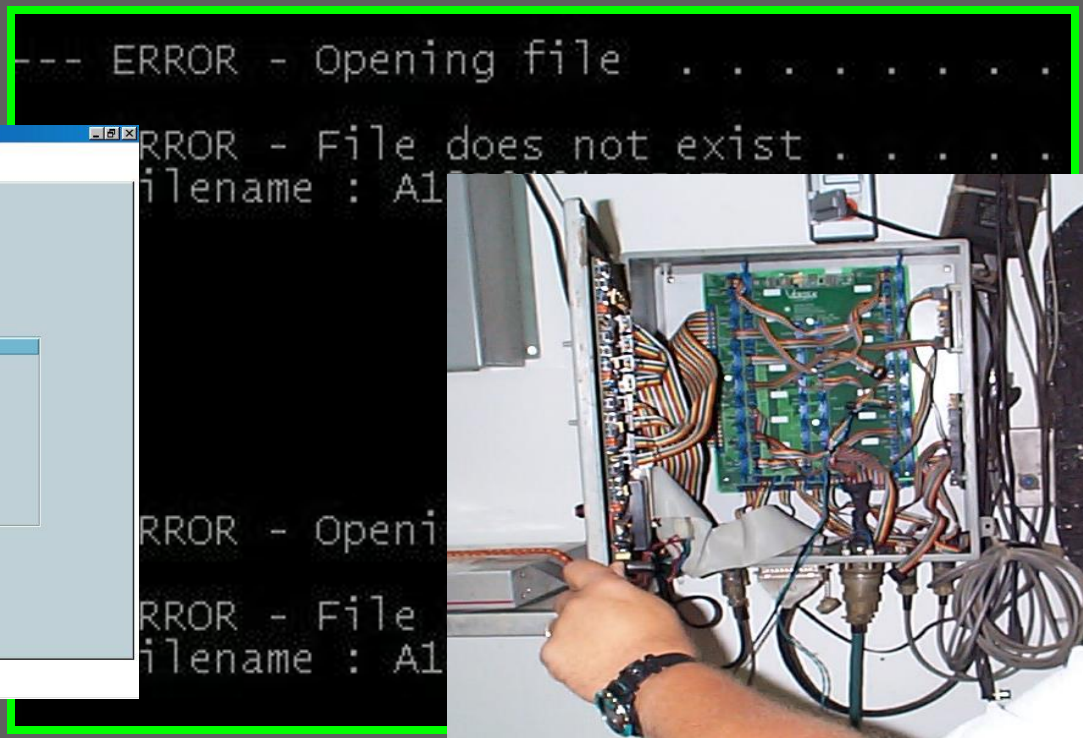


- Immediate Results (no lab work)
- Footage (150-500 ft/day, 5-10x faster)
- Continuous Soil Profile
- Pore water pressure measurements
- Great tool for preliminary investigations
- Can define a ‘Hard Layer’ as a supplement to SPT

Disadvantages

- No samples
- Rocks, concrete, rubble
- Depth Limitations (friction, tip, buckling)
- Electronics!





Any Questions?

Thanks for your attention, and participation in the seminar.