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HAMMER-GROUT PILES FOR THE BRONX-WHITESTONE BRIDGE

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INTERCOASTAL
FOUNDATIONS AND SHORING

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HAMMER-CAST-IN-PLACE PILES FOR THE BRONX-WHITESTONE BRIDGE

- *Background*
- *Subsurface Conditions*
- *Proposed Means & Methods*
- *Collaboration by Stakeholders*
- *Pre-Production Load Testing*
- *Production Results*

BRONX-WHITESTONE BRIDGE

- *Owned and operated by Tri-Borough Bridge and Tunnel Association (TBTA) – a division of the MTA*
- *Constructed in 1939*
- *Main span of 2,300 feet*
- *Carries 200,000 vehicles per day*
- *One of three bridges connecting The Bronx and Queens boroughs of New York City*

BRONX-WHITESTONE BRIDGE

REPLACEMENT OF BRONX APPROACH

- *General contract awarded to The Conti Group in January 2009*
- *Contract value $192 million*
- *Contract duration 48 months*
- *Complete replacement of 1,800 feet of approach ramp*
- *Maintain traffic throughout duration*
- *Install new foundations and support around the existing approach ramp*
- *Avoid settlement of existing foundations*

MINI-PILE FOUNDATIONS

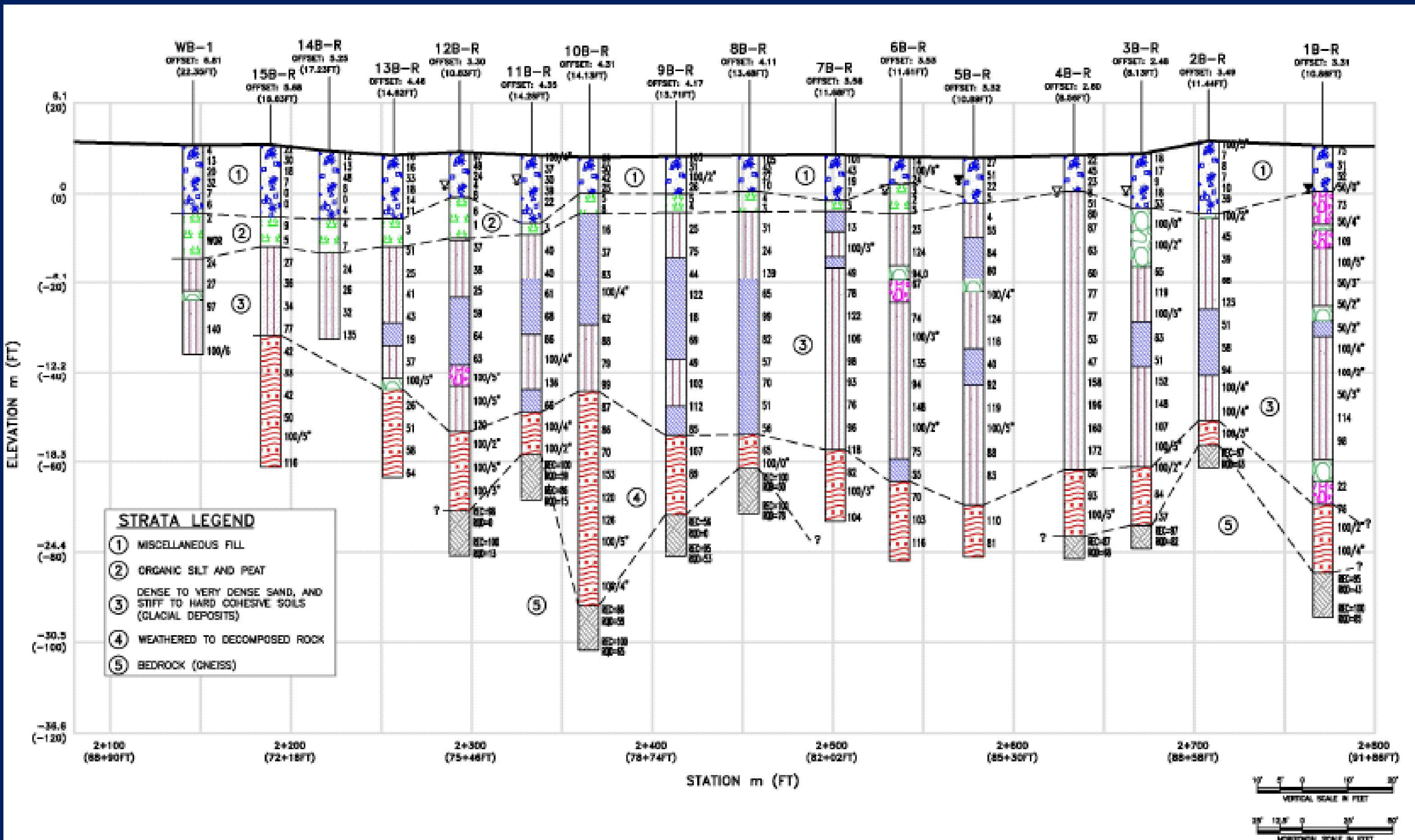
- *Mini-pile subcontract awarded to Intercoastal Foundations & Shoring*
- *Urkkada Technology hired as mini-pile design consultant to mini-pile subcontractor*
- *772 mini-piles*
- *Design loads from 120 to 150 US tons*
- *Anticipated minimum pile depth of 75 feet*
- *Perform 15 static axial compression load tests to 250% of design load*
- *Approximately 50% of mini-piles to be installed in restricted headroom as low as 15 feet*

SUBSURFACE CONDITIONS

- *Soil borings from the original bridge construction revealed varied soil conditions along the approach*

- *New soil borings were performed – 2 for each new bent – one on either side of the approach*

SUBSURFACE CONDITIONS

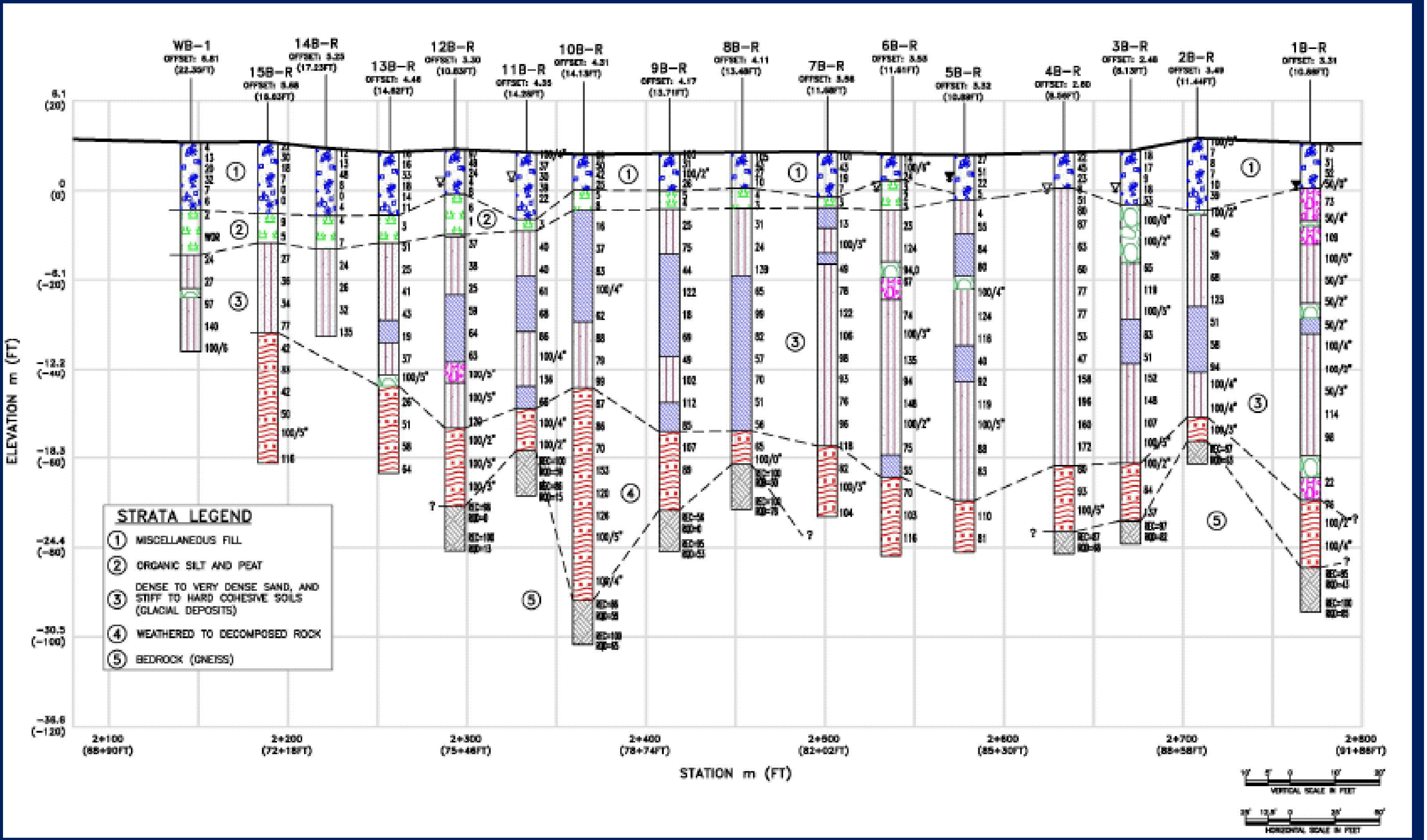


SUBSURFACE CONDITIONS

- *Bedrock at depths of 60 to 130 feet*
- *Thick layers of decomposed rock in some locations*
- *Glacial overburden - from Geotechnical Report:*

The glacial materials consist of dense to very dense stratified sand and gravel with boulders, cobbles, and silt, and clay. These strata are inter-bedded with fine-grained layers of very stiff to hard organic-rich silt and clay, dense fine sand and silt with varying amounts of gravel.

SUBSURFACE CONDITIONS



MINI-PILE DESIGN CHALLENGES

- *Owner's Engineer/Designer:*

  Find a single deep foundation type that is reasonably suited to varying soil conditions and can be installed in low headroom condition

- *Sub-contractor:*

  Find means and methods to drill efficiently through soils which normally call for different types of tooling

CONTRACT SPECIFICATIONS

- *Contractor design*
- *Follow the design methodology detailed in Geotechnical Report, including FHWA bond values:*

Table 5.6 Recommended Ultimate Ground/Grout Bond Strength

Stratum	Material Type	Estimated Ultimate Bond Strength, (ksf)
Glacial Deposits	Sand and Silt	4.5
	Sand and Gravel	6.2
	Clay and Silt	3.3
Decomposed Rock	Composite	4.5-6.2

- *Means and methods to be capable of drilling through cobbles, boulders, and sound rock*

PROPOSED MEANS AND METHODS

- *Risks*
  - *restricted headroom*
  - *stringent settlement criteria of ¼ inch maximum – existing approach supported on spread footings*
  - *schedule - large quantity of piles – how many rigs would be required?*
  - *difficult soil conditions leading to*
    1. *low productivity (long duration and high cost)*
    2. *dispute over use of DHH*

PROPOSED MEANS AND METHODS

The contract specifications restricted the use of down-hole-hammer (DHH) to drilling of obstructions and sound rock.

The sub-contractor would be expected to drill with casing, rotary bits (e.g. roller bits), and water flush until an obstruction was encountered, "trip-out", use a DHH to drill and extend the casing through the obstruction, "trip-out" again, and return to cased rotary drilling to the full depth.

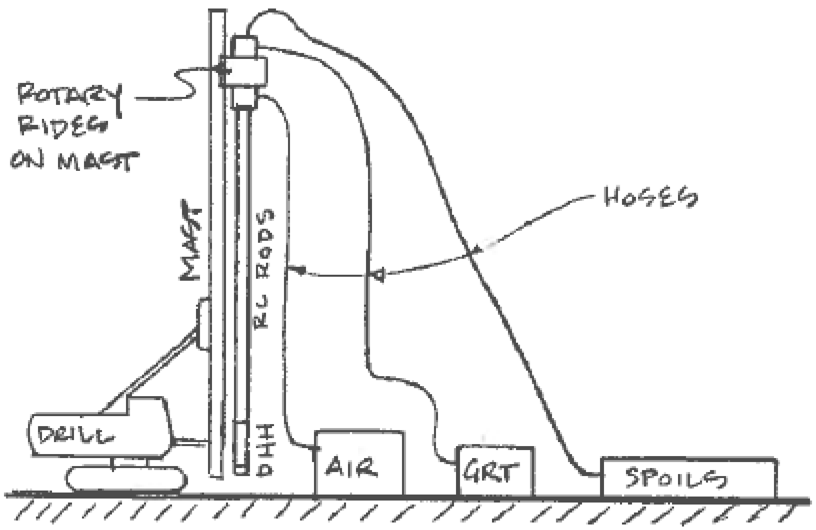
The pile was then to be tremie-grouted and pressure grouted as the casing is withdrawn.

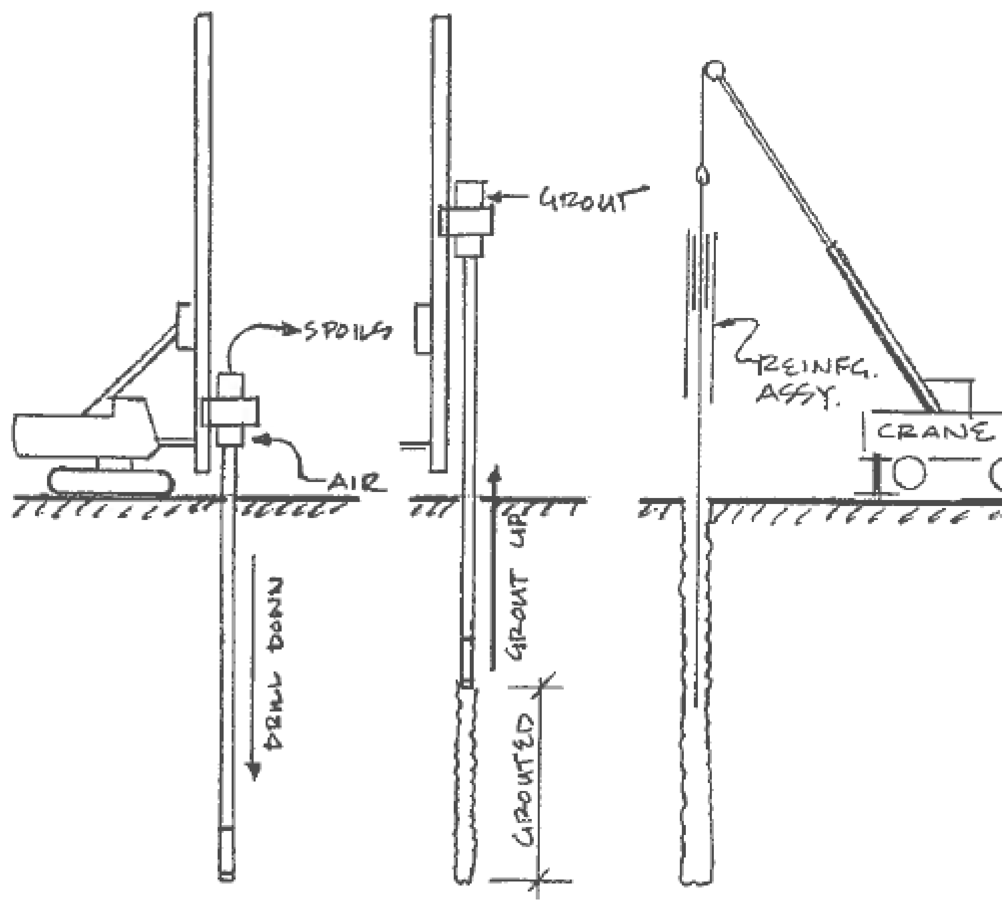
PROPOSED MEANS AND METHODS

- *Develop a single drilling method capable of drilling efficiently through the varied soil conditions.*
- *Take advantage of higher productivity of large fixed mast drill rigs, where possible, in order to reduce the need for a larger number of crews in order to meet the schedule.*
- *Eliminate the risk of obstruction claims by drilling with a down-hole-hammer (DHH) throughout the process.*
- *Reduce potential settlement by utilizing "true" reverse-circulation drill rods together with grouting through the DHH and bit.*

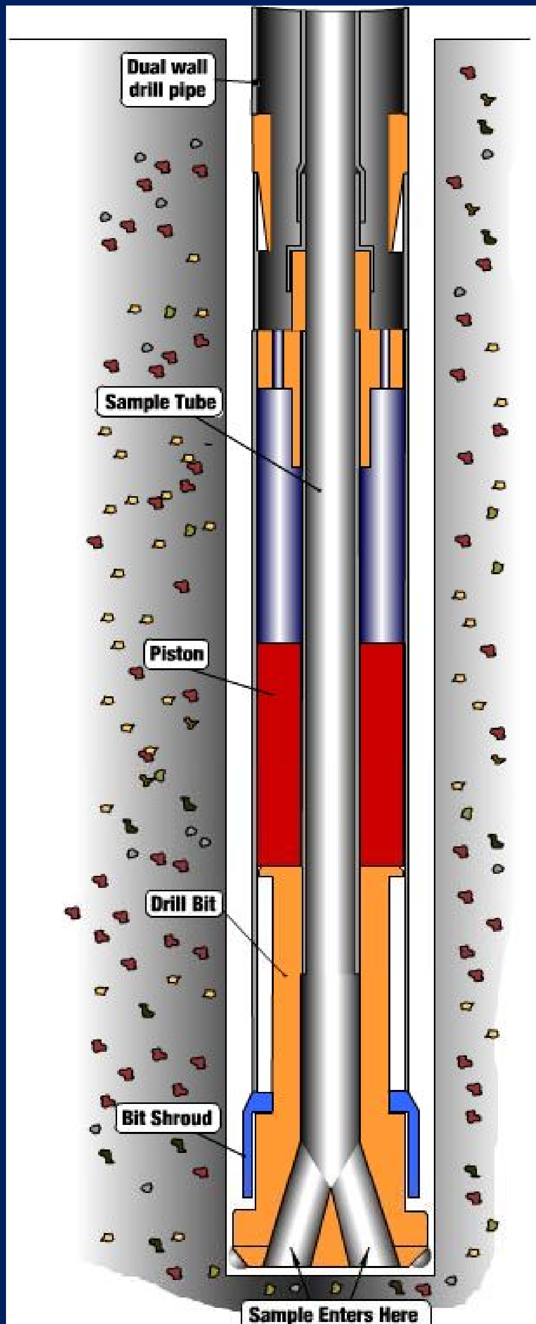
PROPOSED MEANS AND METHODS

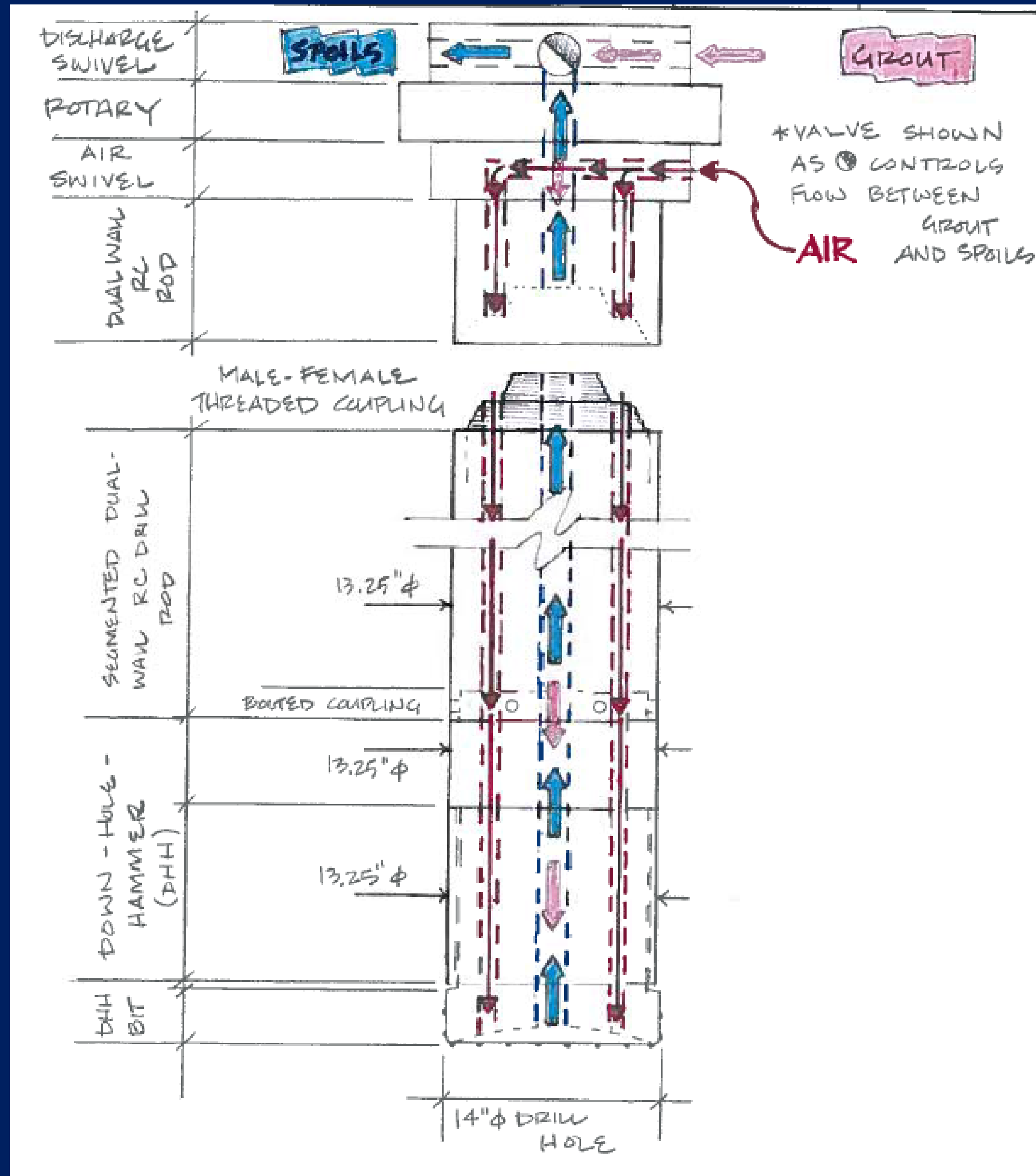
In general, the proposed method is most similar to a traditional auger-cast-in-place pile

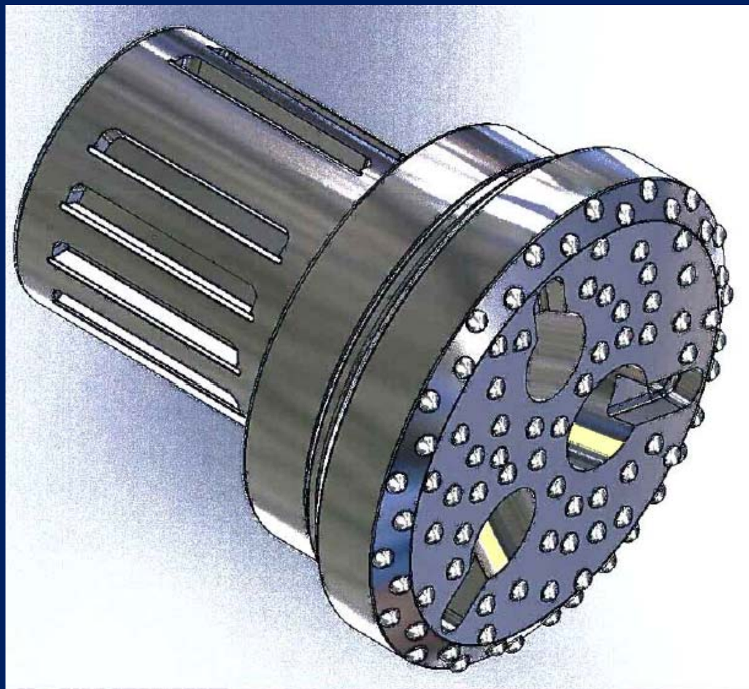


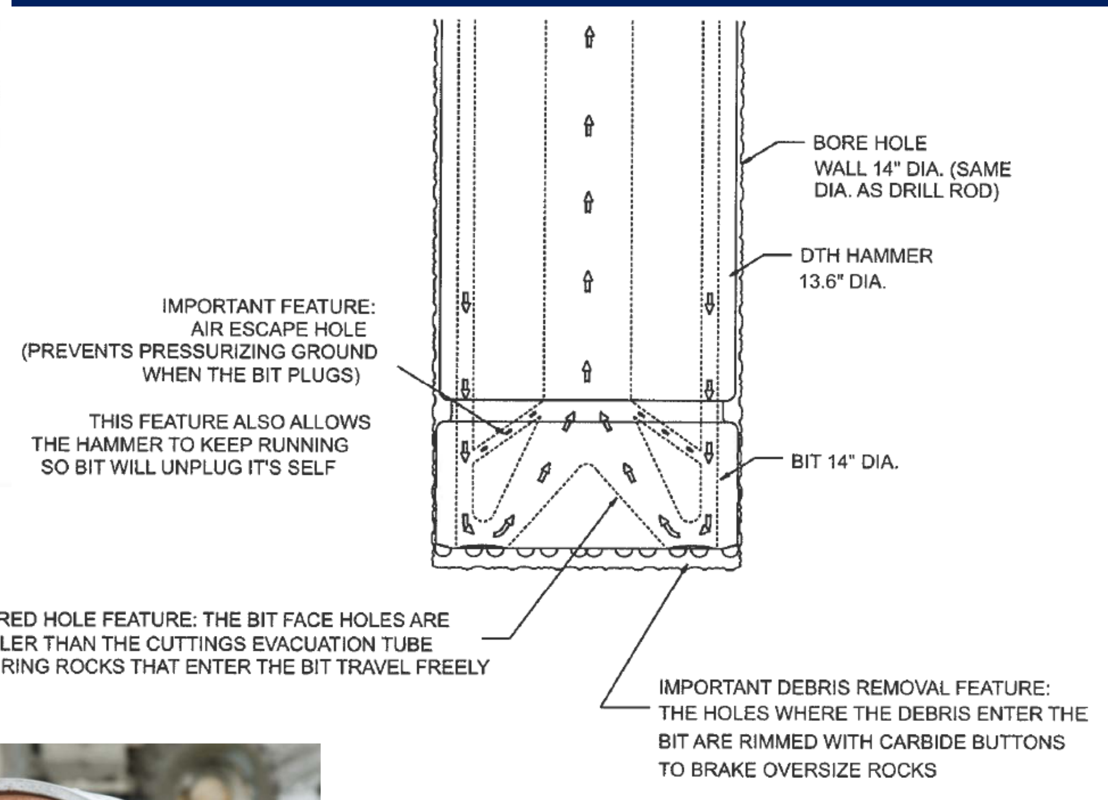


1. *Drill down*
2. *Grout up*
3. *Place reinforcing*


Dual wall drill pipe
Sample Tube
Piston
Drill Bit
Bit Shroud
Sample Enters Here

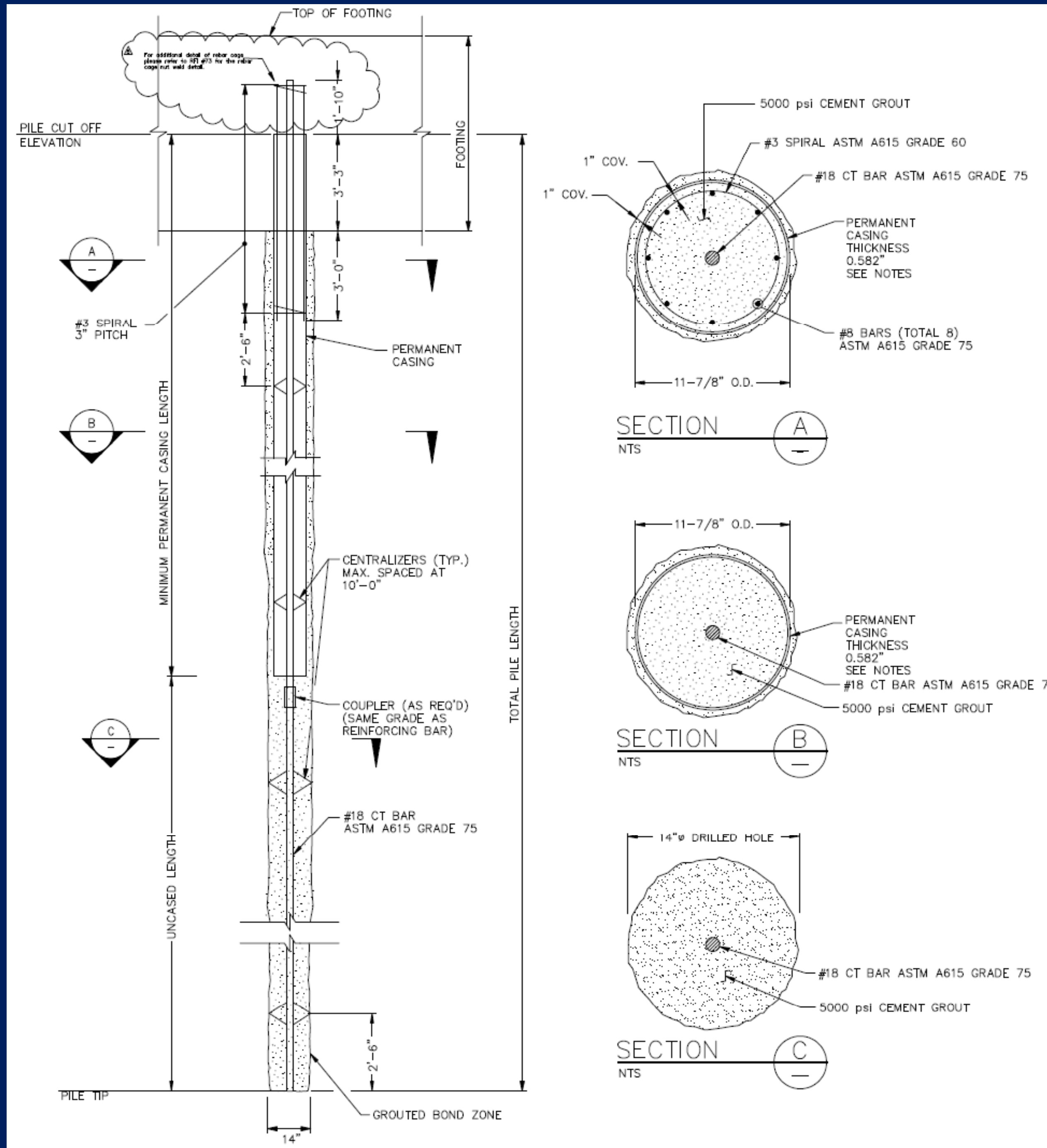

DISCHARGE SWIVEL
SPOILS
GROUT
ROTARY
AIR SWIVEL
*VALVE SHOWN AS CONTROLS FLOW BETWEEN GROUT AND SPOILS
AIR
DUAL WALL RC ROD
MALE-FEMALE THREADED COUPLING
SEGMENTED DUAL-WALL RC DRILL ROD
13.25"Φ
BOLTED COUPLING
13.25"Φ
DOWN-HOLE-HAMMER (DHH)
13.25"Φ
DHH BIT
14"Φ DRILL HOLE




BORE HOLE
WALL 14" DIA. (SAME
DIA. AS DRILL ROD)
DTH HAMMER
13.6" DIA.
IMPORTANT FEATURE:
AIR ESCAPE HOLE
(PREVENTS PRESSURIZING GROUND
WHEN THE BIT PLUGS)
THIS FEATURE ALSO ALLOWS
THE HAMMER TO KEEP RUNNING
SO BIT WILL UNPLUG IT'S SELF
BIT 14" DIA.
TAPERED HOLE FEATURE: THE BIT FACE HOLES ARE
SMALLER THAN THE CUTTINGS EVACUATION TUBE
ENSURING ROCKS THAT ENTER THE BIT TRAVEL FREELY
IMPORTANT DEBRIS REMOVAL FEATURE:
THE HOLES WHERE THE DEBRIS ENTER THE
BIT ARE RIMMED WITH CARBIDE BUTTONS
TO BRAKE OVERSIZE ROCKS


Discharge
Grout-Intake Swivel
Rotary Drill Head
Air-Intake Swivel
13-5/8” diam. RC rods

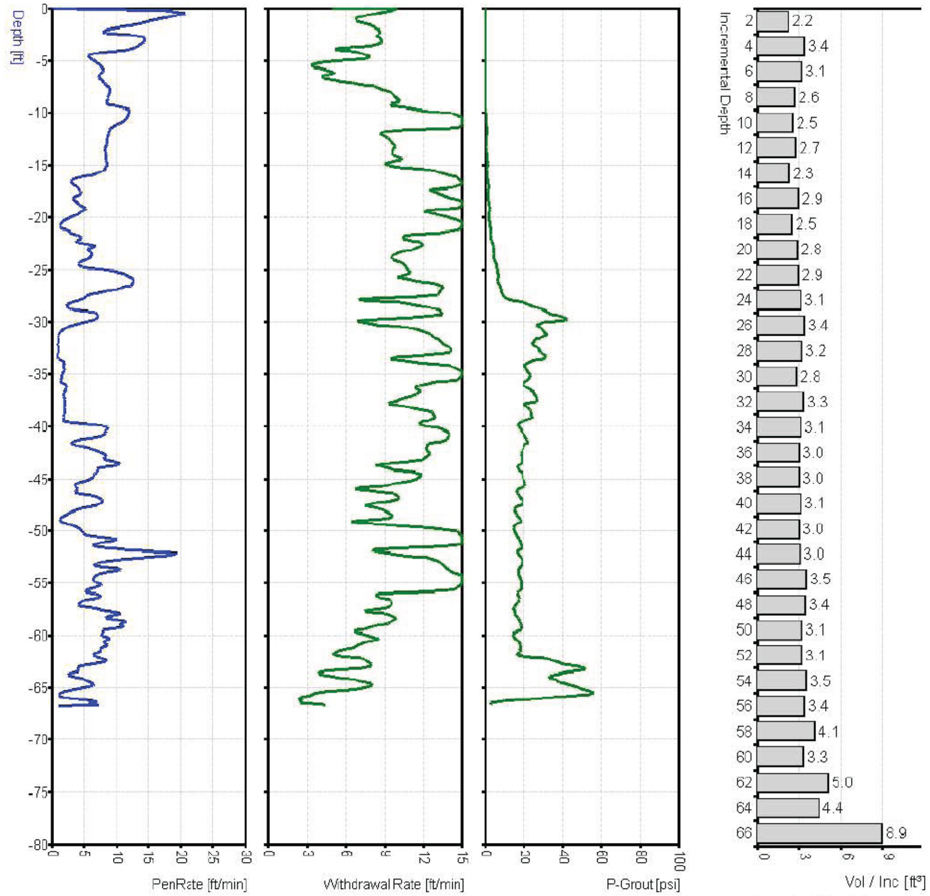

CAT
CAT
020902
V5C
HAMMER&STEEL


TOP OF FOOTING
For additional detail of rebar cage please refer to RFI #73 for the rebar cage nut weld detail.
PILE CUT OFF ELEVATION
1'-10"
3'-3"
3'-0"
FOOTING
2'-6"
#3 SPIRAL 3" PITCH
PERMANENT CASING
MINIMUM PERMANENT CASING LENGTH
CENTRALIZERS (TYP.) MAX. SPACED AT 10'-0"
COUPLER (AS REQ'D) (SAME GRADE AS REINFORCING BAR)
TOTAL PILE LENGTH
UNCASED LENGTH
#18 CT BAR ASTM A615 GRADE 75
2'-6"
PILE TIP
GROUTED BOND ZONE
14"
5000 psi CEMENT GROUT
#3 SPIRAL ASTM A615 GRADE 60
1" COV.
1" COV.
#18 CT BAR ASTM A615 GRADE 75
PERMANENT CASING THICKNESS 0.582" SEE NOTES
#8 BARS (TOTAL 8) ASTM A615 GRADE 75
11-7/8" O.D.
SECTION A
NTS
11-7/8" O.D.
PERMANENT CASING THICKNESS 0.582" SEE NOTES
#18 CT BAR ASTM A615 GRADE 75
5000 psi CEMENT GROUT
SECTION B
NTS
14"φ DRILLED HOLE
#18 CT BAR ASTM A615 GRADE 75
5000 psi CEMENT GROUT
SECTION C
NTS

Mini Pile

INTERCOASTAL FOUNDATIONS AND SHORING

Job Site Data:	Data for Pile No: tp9	
Project name: TBTA BW 89	DRILL DATE: 4/23/2009	GROUT DATE: 4/23/2009
Client: Conti Corp	DRILL START: 1:29:40 PM	GROUT START: 2:51:09 PM
Contractor: Intercoastal	DRILL END: 2:51:09 PM	GROUT END: 3:16:22 PM
Machine: TM20_25	DRILL TIME: 01:21:29	GROUT TIME: 00:25:13
	DRILL DEPTH: 66.8 ft	TOTAL VOLUME: 4.10 yd³



Inc: 0 - 64 = 2 ft
Inc: 66 = 2.8 ft

COLLABORATION BY STAKEHOLDERS

- *Owner: TBTA*
- *Owner's Engineer: PB/Sells*
- *Construction Manager and Resident Engineer: GPI/Parsons*
- *General Contractor: The Conti Group*
- *Subcontractor: Intercoastal*
- *Subcontractor's Design Engineer: Urkkada*

CHALLENGES TO ACCEPTANCE

- *Would continuous use of the DHH lead to unacceptable settlement of the existing structure?*
- *Could grout quality be assured when placing the grout through the center tube of the RC rods and DHH bit?*
- *Could grout-ground design bond values be achieved and verified during load tests?*
- *Could the reinforcing be placed with sufficient control so as not to slough the sides of the drilled and grouted hole?*
- *Could the procedures be monitored, inspected and controlled so as to provide assurance of continued performance throughout the production pile installation?*

PRE-PRODUCTION LOAD TESTING

- *Pre-production load test program:*
  - *- 4 bents*
  - *- a sacrificial test pile plus 4 sacrificial reaction piles at each of the 4 bents*
  - *- strain gages installed in test piles at 5 depths of interest: full reinforcing, casing and bar, immediately below casing, mid-depth of bond zone, and pile tip*
  - *- PIT testing of all test and reaction piles*
- *A successful pre-production load test on a sacrificial pile would be required at each bent prior to starting production at the given bent*

ADDITIONAL PRODUCTION QUALITY CONTROL

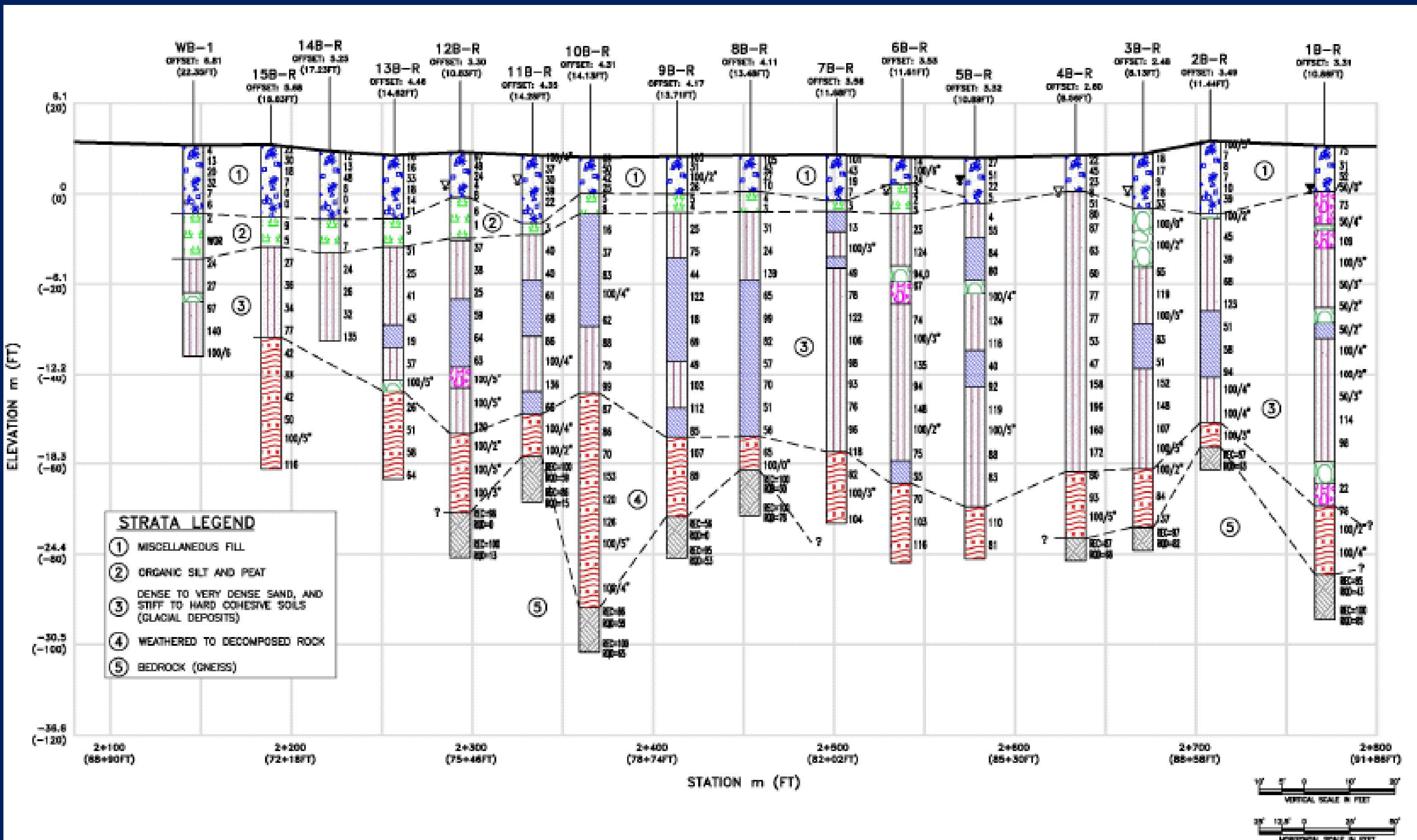
- *Pile Integrity Testing (PIT) to be performed on up to 5% of the production piles. Selection of these piles would be by PB/Sells.*

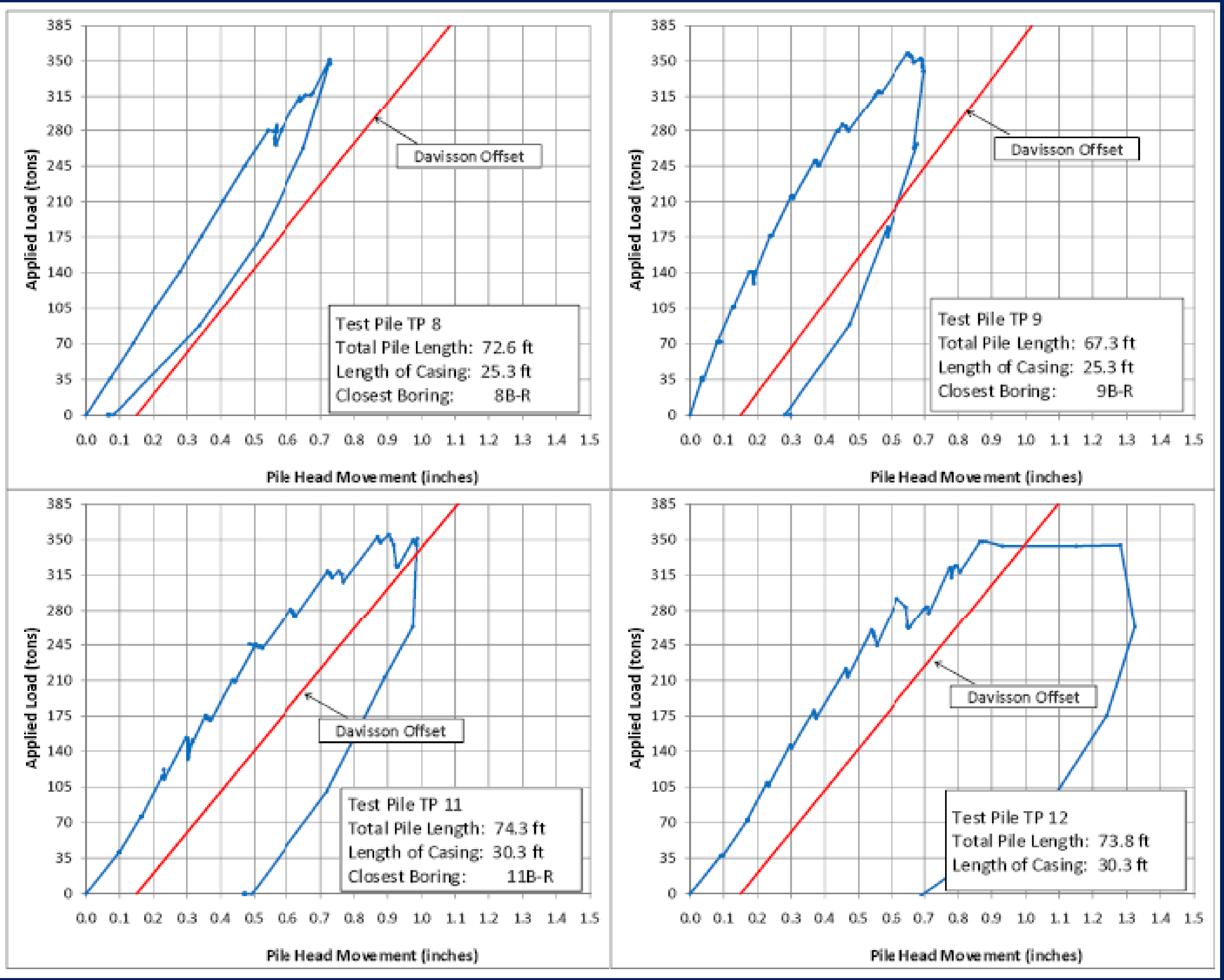
- *"Proof" static testing up to 2% of production piles to 200% of design load. Selection of these piles would be by PB/Sells.*

PRE-PRODUCTION LOAD TEST RESULTS

- *Successful load tests were performed at bents 8, 9, 11, and 12*
- *Acceptance based on the gross movement (Davisson Criteria) and creep (< 0.01"/hour and 0.03"/log cycle of time) during a 48-hour hold period at 100% of design load*
- *Test load was increased to 250% of design load (12-hour hold and < 0.01"/hour) to verify the achieved grout-ground bond values*

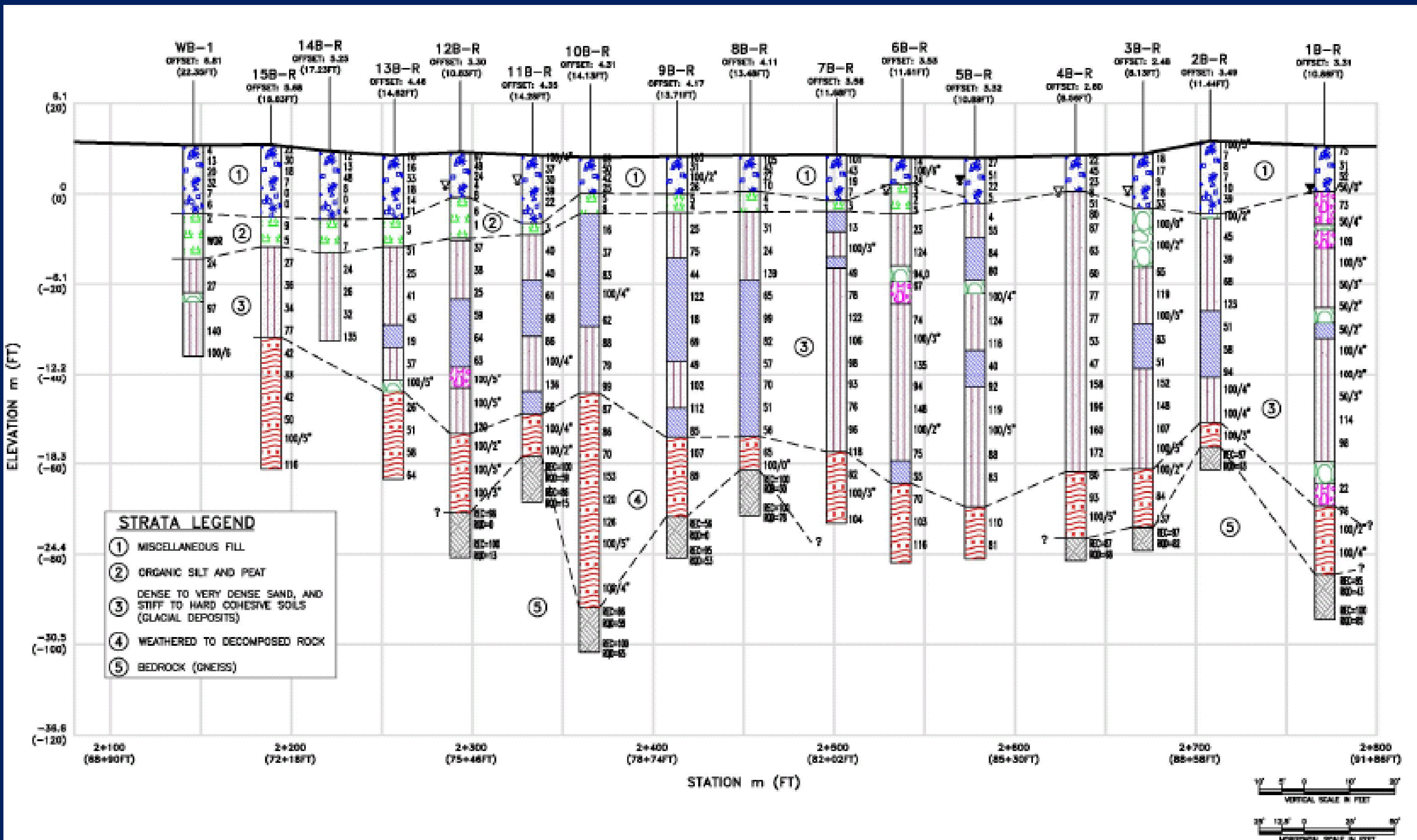
SUBSURFACE CONDITIONS





Davisson Offset
Test Pile TP 8
Total Pile Length: 72.6 ft
Length of Casing: 25.3 ft
Closest Boring: 8B-R
Davisson Offset
Test Pile TP 9
Total Pile Length: 67.3 ft
Length of Casing: 25.3 ft
Closest Boring: 9B-R
Davisson Offset
Test Pile TP 11
Total Pile Length: 74.3 ft
Length of Casing: 30.3 ft
Closest Boring: 11B-R
Davisson Offset
Test Pile TP 12
Total Pile Length: 73.8 ft
Length of Casing: 30.3 ft
Applied Load (tons)
Pile Head Movement (inches)

SUBSURFACE CONDITIONS



RESULTS

- *Pre-production testing did not result in any changes to means & methods or design lengths*
- *Some modifications were made to bit geometry to reduce air loss into soil formation*
- *All load tests (pre-production and production "proof" testing) were successful*
- *Maximum measured settlement of existing bridge structure was 1/8 inch*
- *Production Rates:*
  - *5 piles per rig-shift in unlimited headroom*
  - *2+ piles per rig-shift in 20-ft headroom*
- *No claims for obstructions*
- *20% reduction (conservative) in piling costs compared to conventional methods*

ACKNOWLEDGEMENTS

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- *William Picken, Gerard Maurer Nestor Martinez and Sean Blum of The Conti Group*
- *Art Holte of Holte Manufacturing*