A DEEP FOUNDATION COMPARISON: DRIVEN vs BORED PILES

PILE DRIVING CONTRACTORS ASSOCIATION

Professor's Driven Pile Institute

Logan, UT

June 26, 2013

Presented By:

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S&ME

COMMON DEEP FOUNDATIONS (US Practice for Support of Structures)

DRIVEN

- Concrete
  - 10”, 12”, 14”, 18”, 24”, 30” and 36” square PSC
  - 36” to 66” Cylinder
- Steel
  - 10”, 12” and 14” HP (16” and 18” now being rolled)
  - 8” to 36”+ pipe (open or closed)
- Wood
  - 7” to 10” tip diameter, L<65’
- Composite
  - PSC top with HP, W, or Pipe section bottom

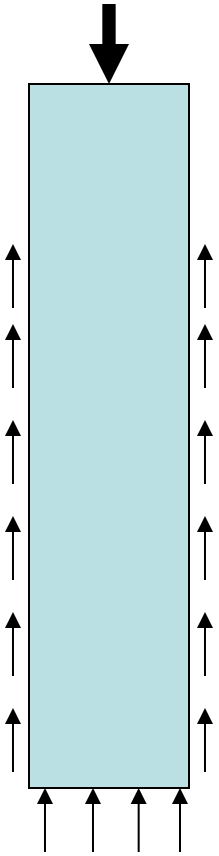
BORED

- Drilled Shafts
  - 3’ to 12’
- Micropiles
  - 5” to 12”
- Drilled Displacement
  - 14” to 18”
- Continuous Flight Auger (CFA)
  - 12” to 24”

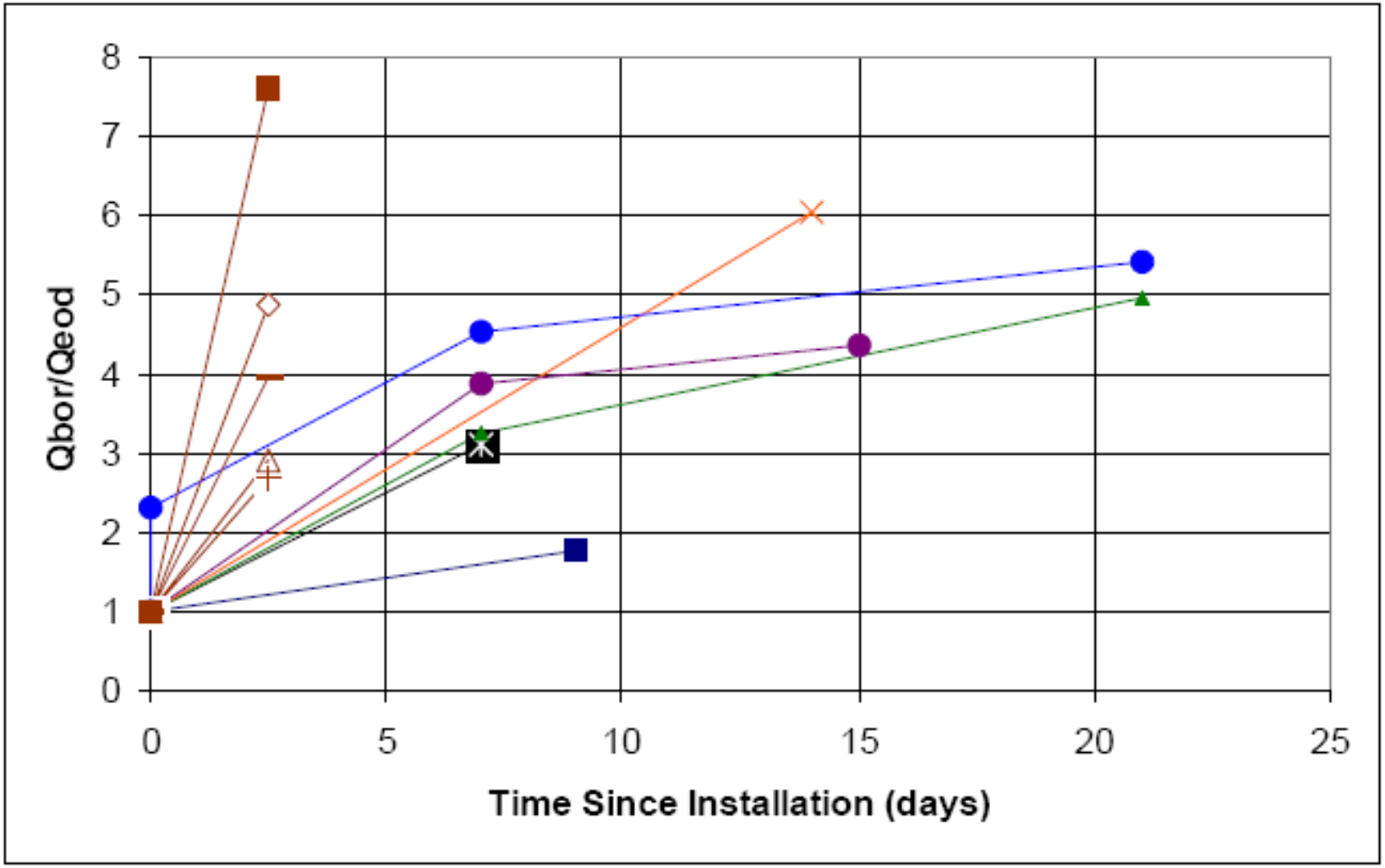
UNIT RESISTANCE

DRIVEN

- Displacement or Low Displacement: Stress Increase – strength increase and stiffer response. ✓
- Disturbance: setup - resistance increase with time. ✓



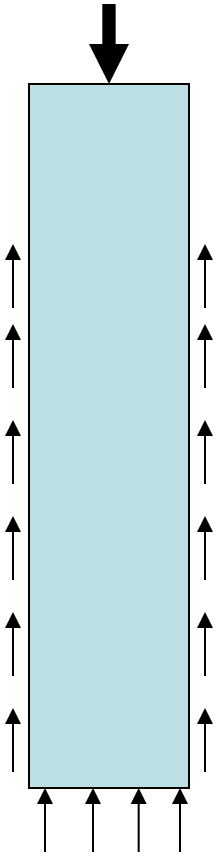
Driven Pile Time Dependency



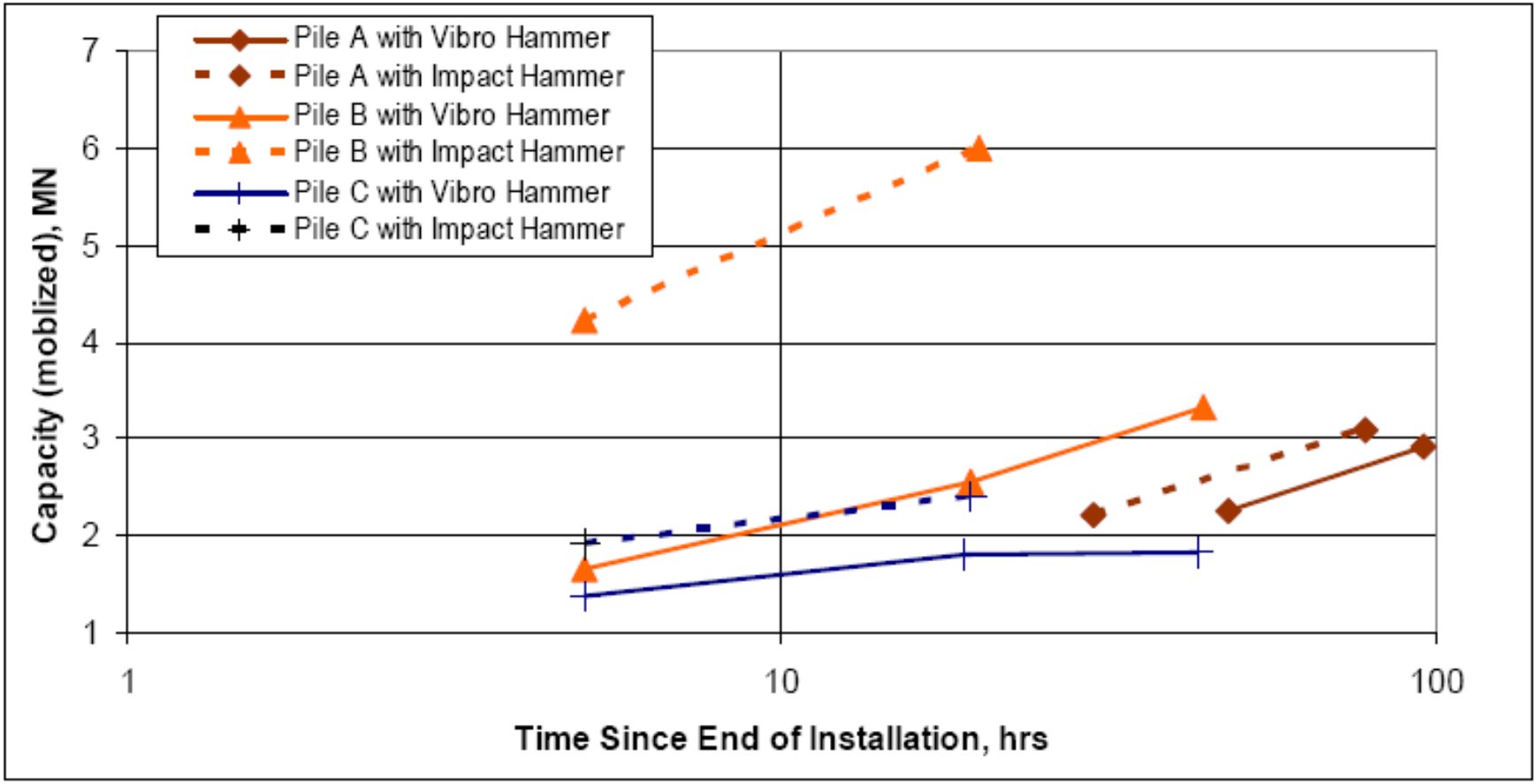
UNIT RESISTANCE

DRIVEN – Cont.

- Disturbance: relaxation – decreased resistance with time. –
- Disturbance: irrecoverable in some formations (e.g., calcareous sands) –
- Construction method effects rarely a factor. ✓



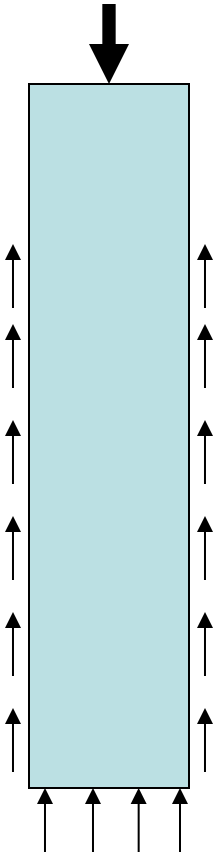
Driven Piles – Installation Method



UNIT RESISTANCE

DRILLED SHAFTS

- Excavation reduces stresses – strength decrease and softer response. —
- Roughness – small scale (concrete vs steel) and larger scale (irregular surface). ✓

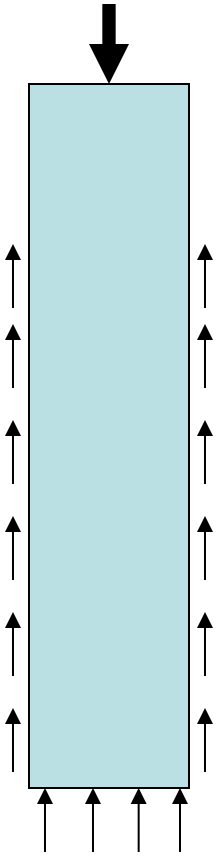



02/24/2005

UNIT RESISTANCE

DRILLED SHAFTS – Cont.

- Reduced Disturbance: beneficial in some formations (e.g., calcareous sands) ✓
- Construction method effects can be very important. –



Drilled Shaft – Polymer vs Mineral Slurry

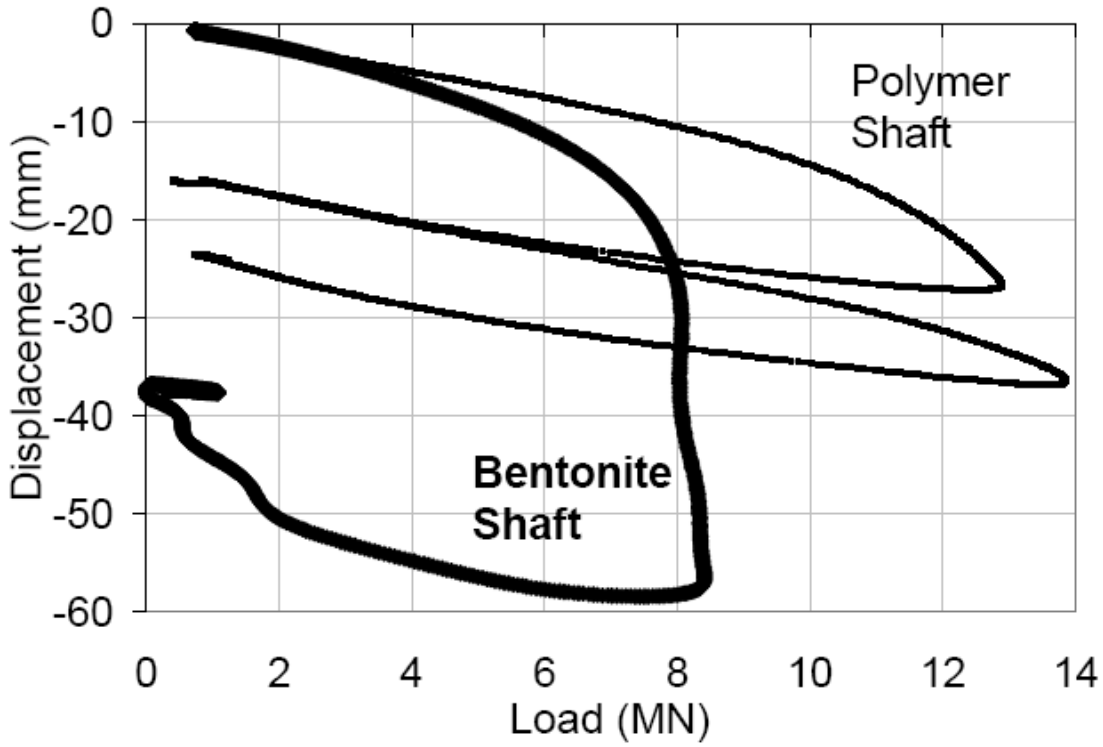


Figure 4 Static Load Deflection Response

From Brown et al 2002

Fundamental Difference

- Point of Manufacture
  - Driven Piles: at steel mill, prestressed yard, or wood yard under factory controlled conditions
    - Uniform, consistent product delivered to the site
    - Highly efficient
  - Drilled Shafts: manufactured on site and in place
    - Complex construction process
    - Significant QA/QC requirements in the field

Driven Pile Manufacturing

Driven Pile Construction Equipment

- Crane
- Hammer & Leads
- Powerpack (hydraulic or air hammer)
- Helper Crane (opt.)

Pile Driving Equipment

Drilled Shaft Manufacturing

- Excavation
- Excavation Stability
- Excavation Cleaning
- Steel Reinforcement Fabrication
- Placement of Reinforcing Cage
- Concrete Delivery
- Concrete Placement

Drilled Shaft Construction Equipment

- Drill Rig
- Helper Crane
- Spoil Handling (loader, skip pan, etc.)
- Casing (opt)
- Slurry Handling (opt)
- Cage Erection Template
- Concrete Truck
- Concrete Pump Truck (opt)

Drilled Shaft Construction Process

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Consequently…

- Driven piles are generally less expensive
- General contractors can often self-perform with driven piles
- Drilled shafts usually require a specialty foundation subcontractor
- Since drilled shaft QA/QC is all done in the field, oversight & inspection is more complex but critical

Constructability Issues

Driven Piles

- Length revisions are relatively easy (splicing or cut-off of steel piles, cut-off of PSC piles). ✓
- Minimum penetration requirements (e.g., consideration of scour and liquefaction potential, fixity, uplift) may be hard to meet –

Drilled Shafts

- Length revisions are feasible but take time (cage modifications) –
- Minimum penetration requirements are typically not an issue ✓

Construction Feedback

Driven Piles

- Driving resistance
- Transferred hammer energy/hammer performance
- Driving stresses
- Pile integrity
- Capacity

Drilled Shafts

- Auger cuttings
- Observation of bottom cleanliness (sometimes)
- Concrete volume
- Shaft profile/geometry (possible but not widely done)

Redundancy & Loading Issues

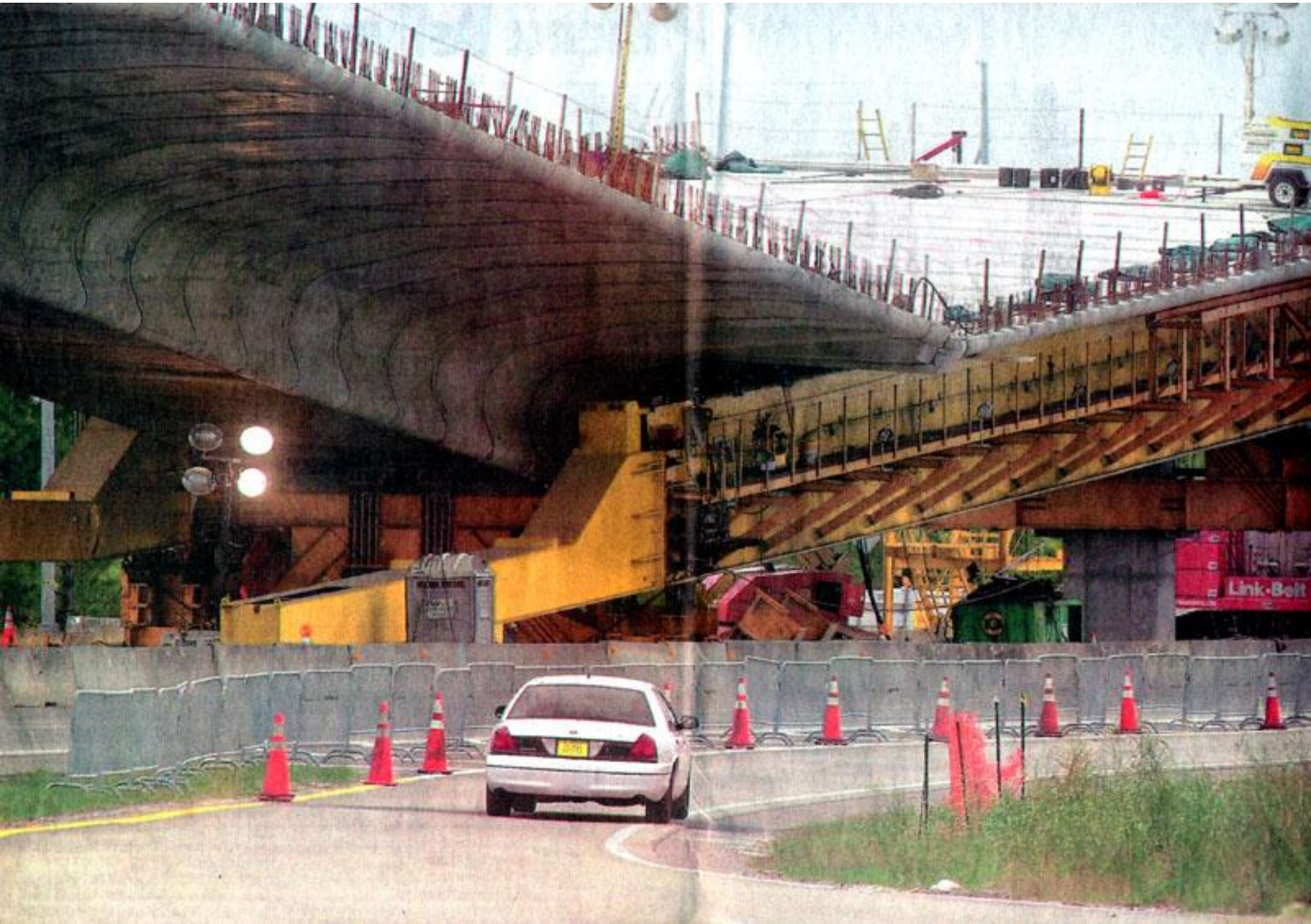
Driven Piles – in general

- Smaller elements
- Lower capacity
- Lower cost
- More elements used
- Highly redundant

Drilled Shafts – in general

- Bigger elements
- Higher capacity
- Higher cost
- Fewer elements used
- Little to no redundancy


EXIT
11
TOLL PLAZA
AHEAD


Link-Belt


DEERE
644H

Integrity & Reliability Issues

Driven Piles

- Delivered free of defects
- May be damaged during or infrequently, after installation
- Damage is typically easily detectable – *A Driven Pile is a Tested Pile*
- Repair generally consists of adding a new pile

Drilled Shafts

- Defects may occur during construction
- Damage after construction is possible but rare
- Defects are not easily quantified
- Repair is generally very complex

Driven Pile Damage

- Handling

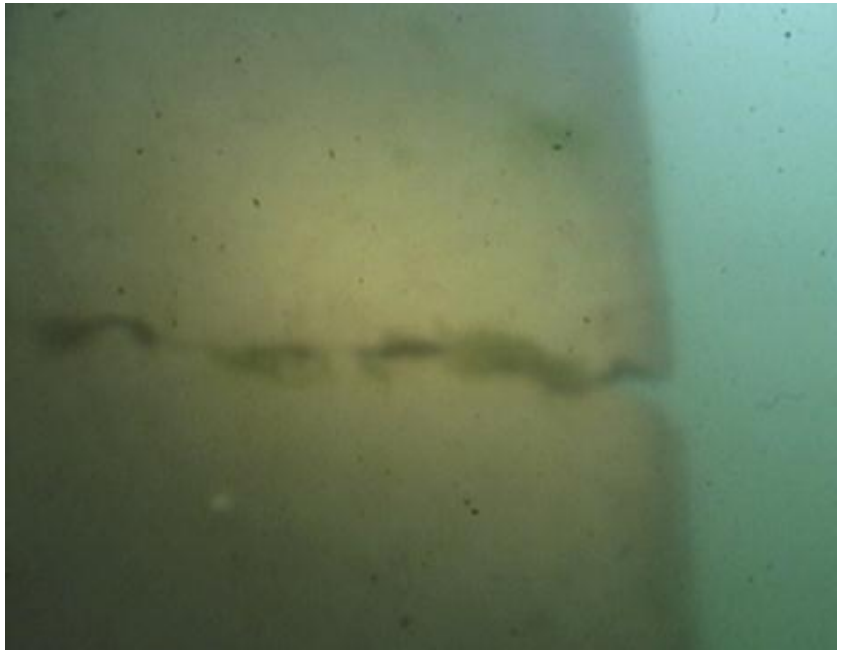
Fix – replace with new pile

Driven Pile Damage

- Driving

Pipe pile toe damaged when trying to penetrate limestone – identified during installation via dynamic testing

Fix – spud through caprock, switch hammers



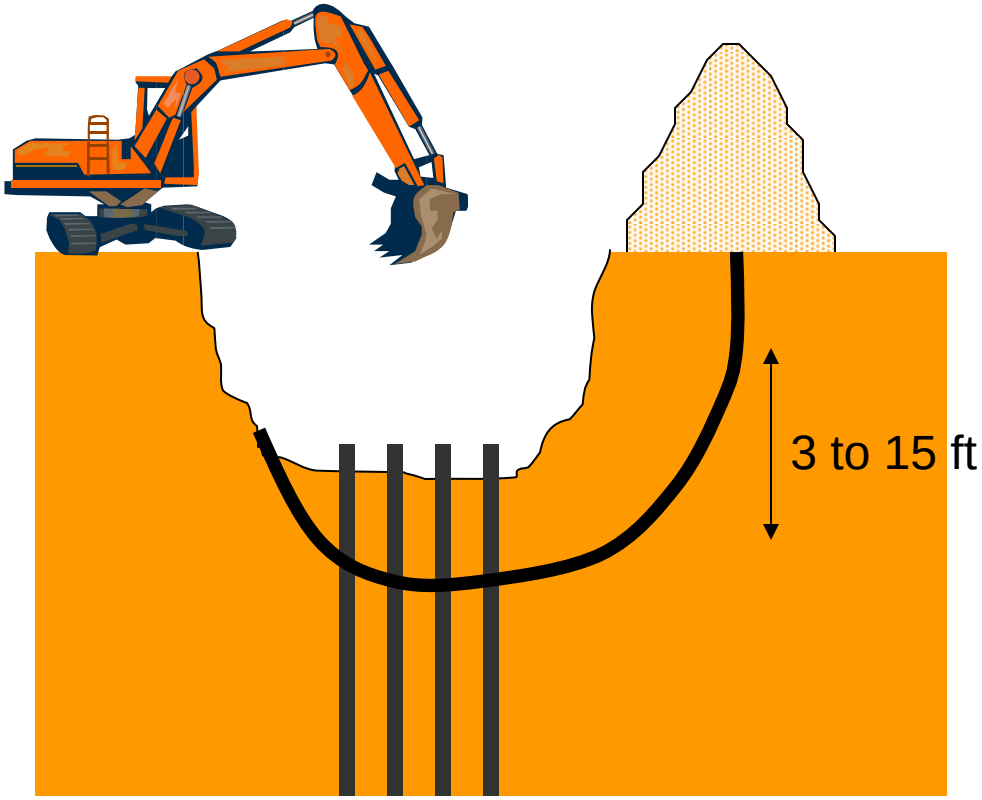
Crack in PSC pile between mudline and water surface – identified during installation via dynamic testing

Fix – underwater patching w epoxy grout, switch hammers

Driven Pile Damage

- Post-Installation

Pipe group damaged due to ground movement – confirmed via low strain dynamic testing

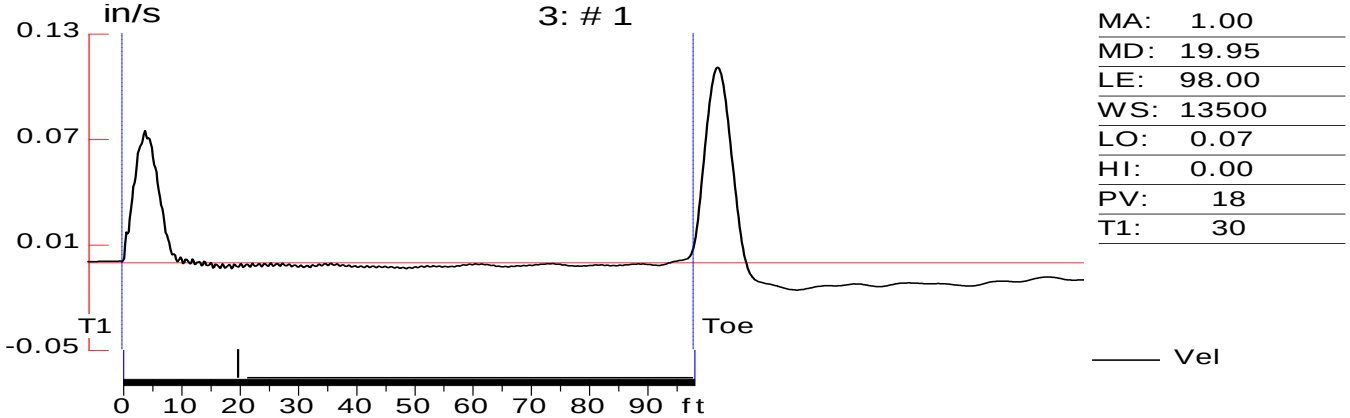


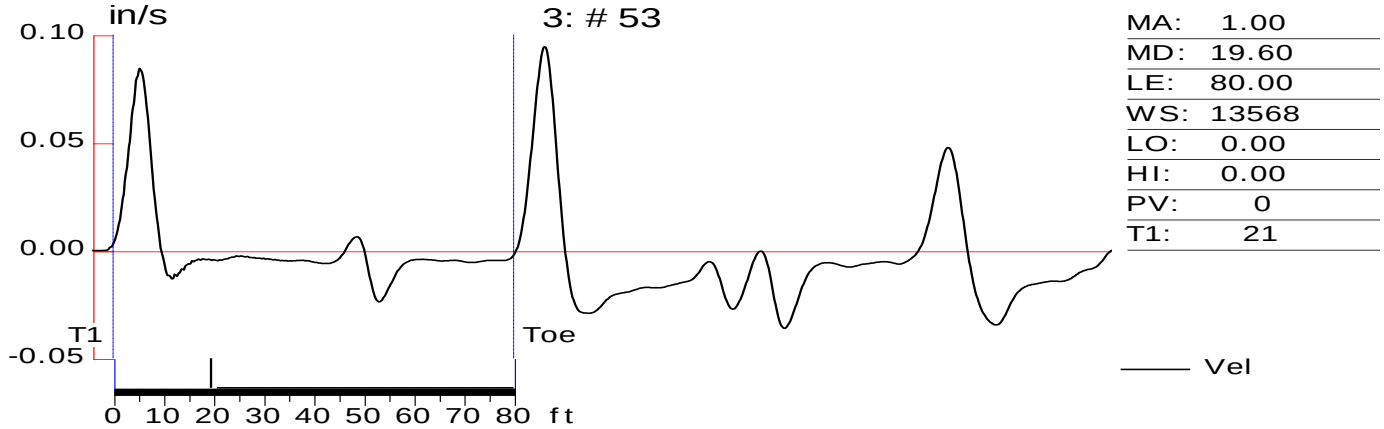
Fix – drive H-piles in between broken piles

Low Strain Integrity Testing

Sample PIT Data

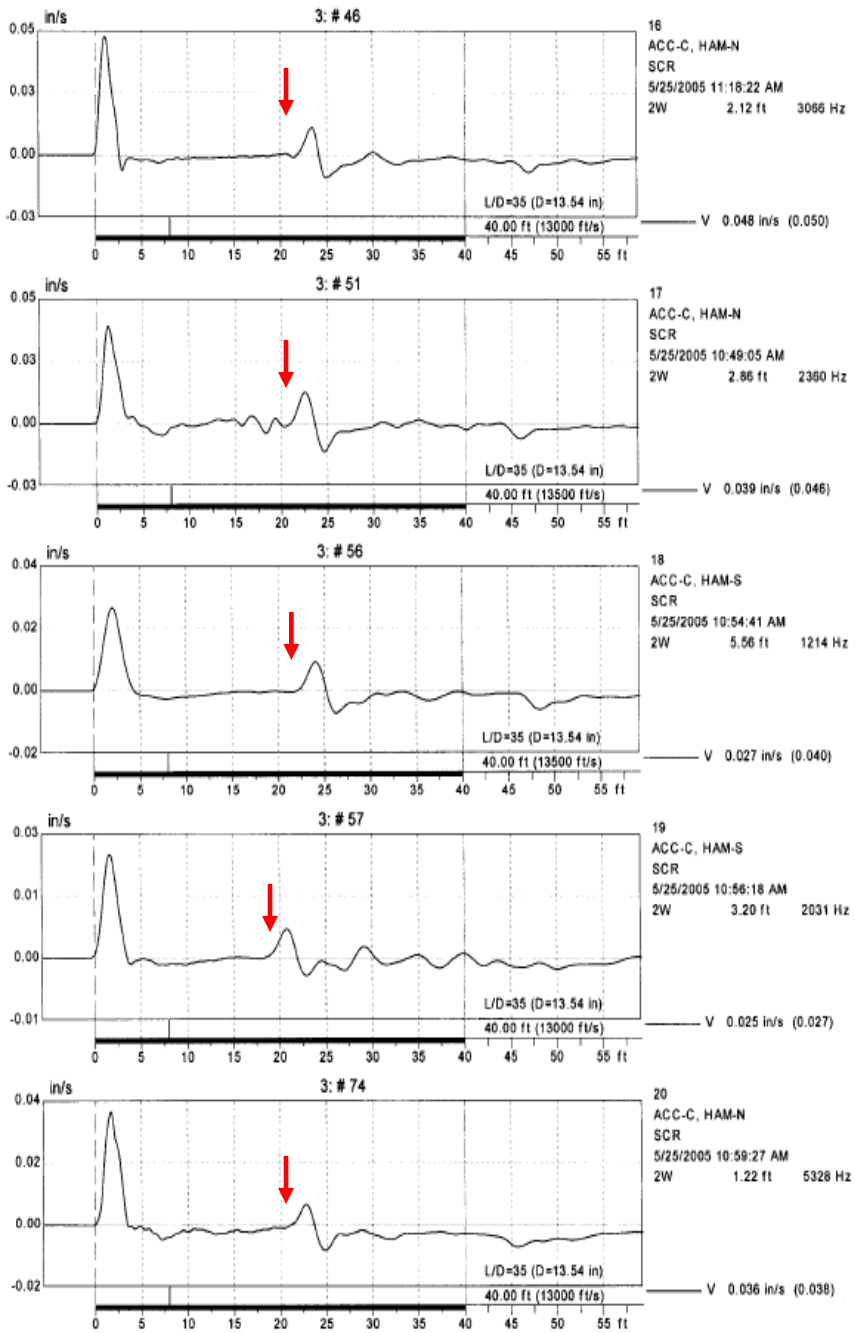
PIT Record from a 98-ft long production pile stored on-site (supported on blocks).





PIT Record from a pile laying on the ground with a break at 46 ft.

Records from Broken Pile Group

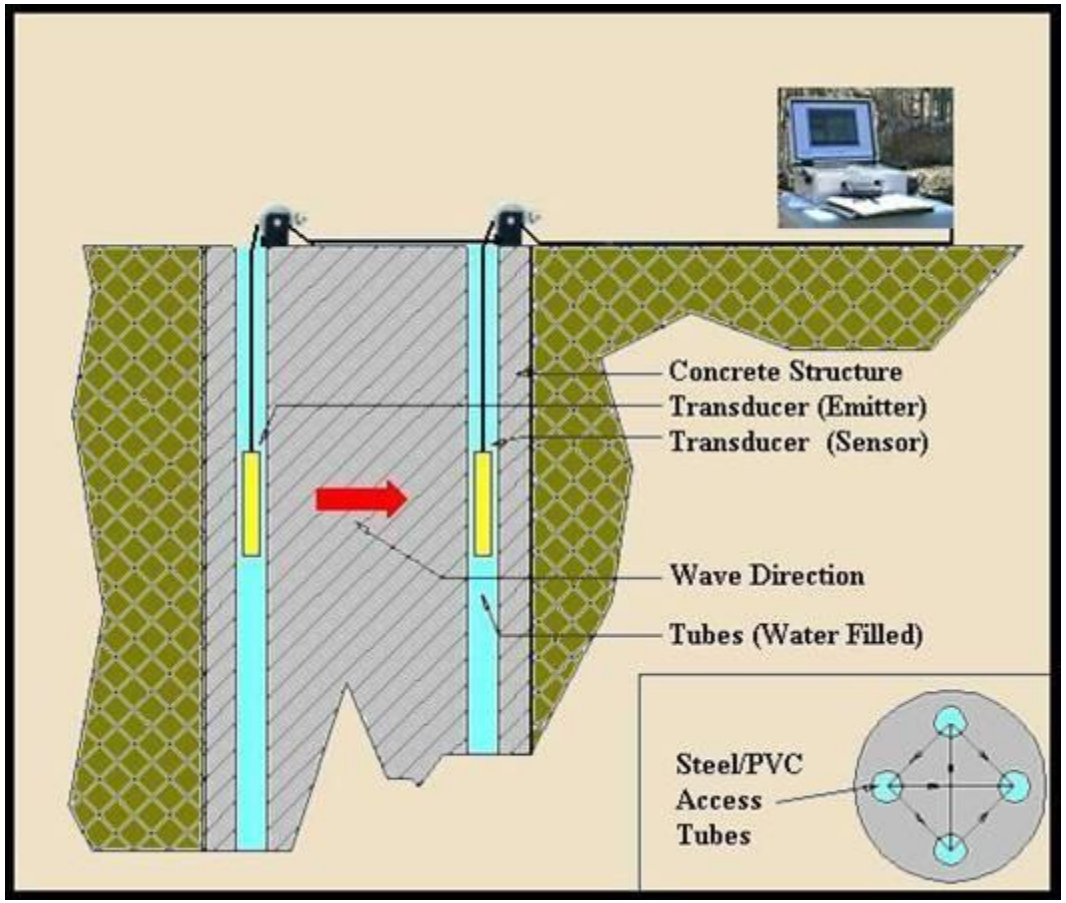


↓ Break

If unbroken, no velocity increase before 98 ft, which is the pile toe location

Drilled Shaft Defects

Crosshole Sonic Logging

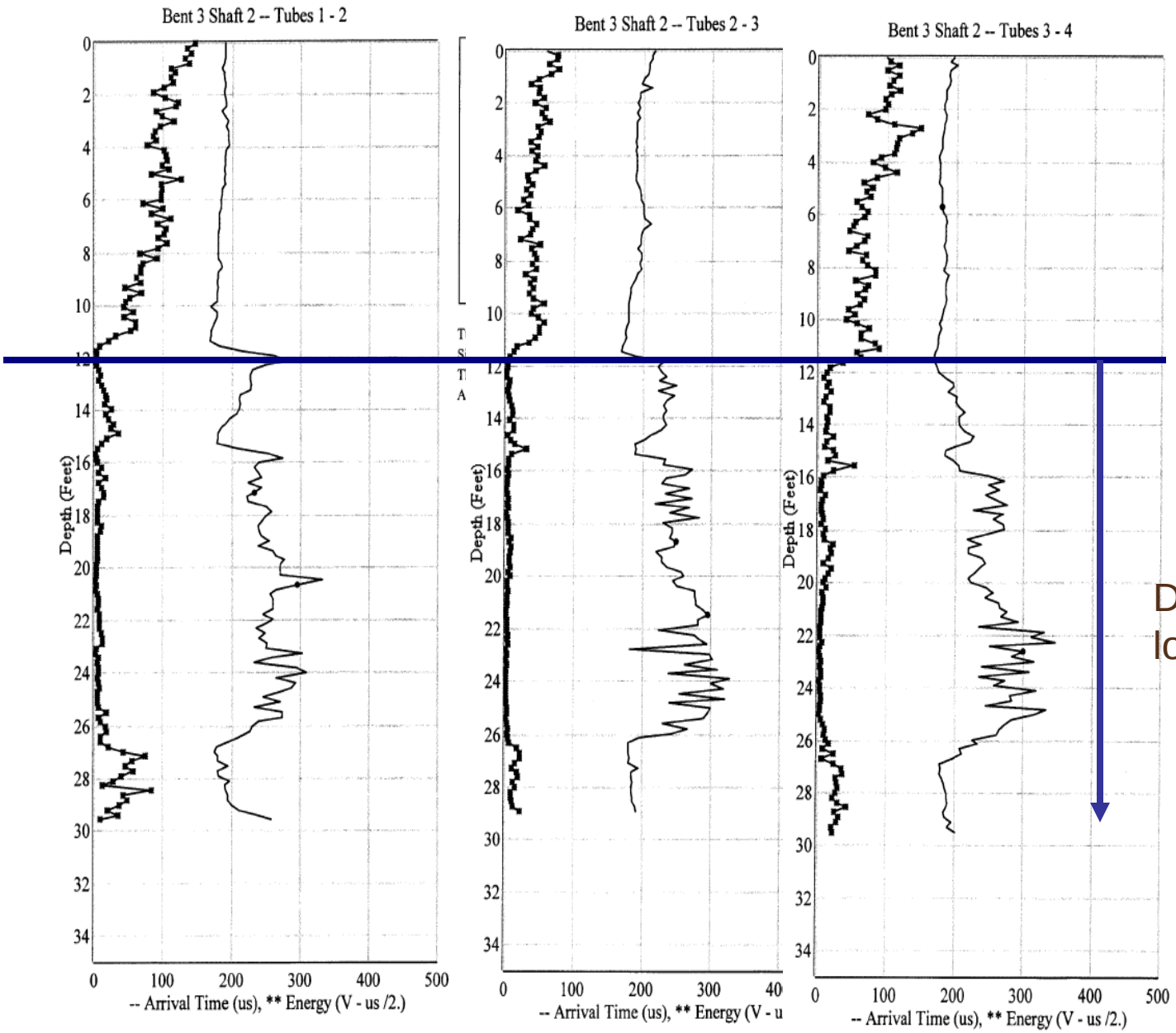


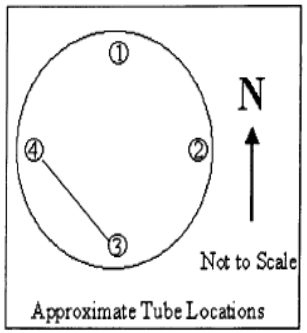
$E=\rho V^2$

$F'_c \approx \text{Constant} * E^2$

Defect or Anomaly

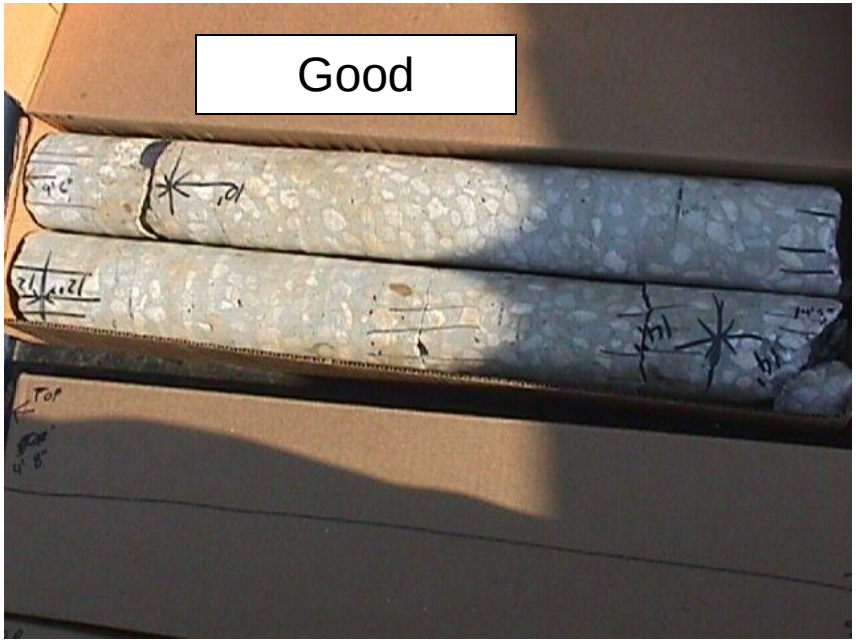
- Drilled Shaft Case History – DOT Project
  - 4.5 ft diameter, 28 ft long shaft (approx 16 cy vol)
  - Dry Method (but Wet)
  - No problems reported on construction logs





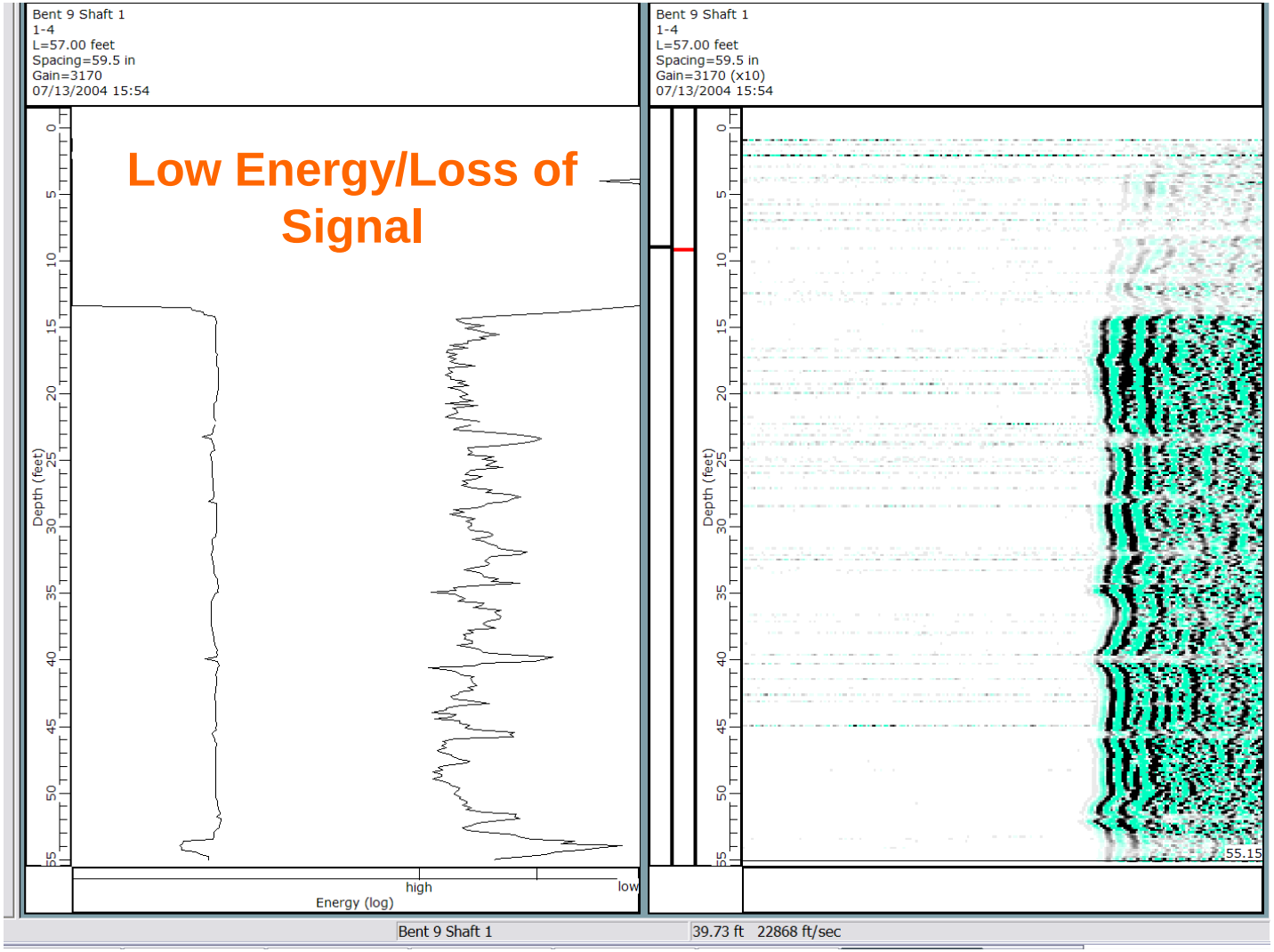
Tube Spacing :	26.00	inches
Signal Gain :	1	
Threshold :	1.50	
At Depth of	29.48	ft
Velocity	15600	ft/sec
First Arrival Time	202	us
Signal Energy	84.81	V-us

Delayed velocity and low energy



Defect: Segregation caused by free-fall placement of concrete through 10 ft of water (as noted by inspector)

Defect or Anomaly



Anomaly: Minor segregation/channelization due to bleed water – inconsequential with respect to shaft performance

Detectable by CSL?

Example 4 of Shaft Defects due to the Loss of Workability (Caltrans)

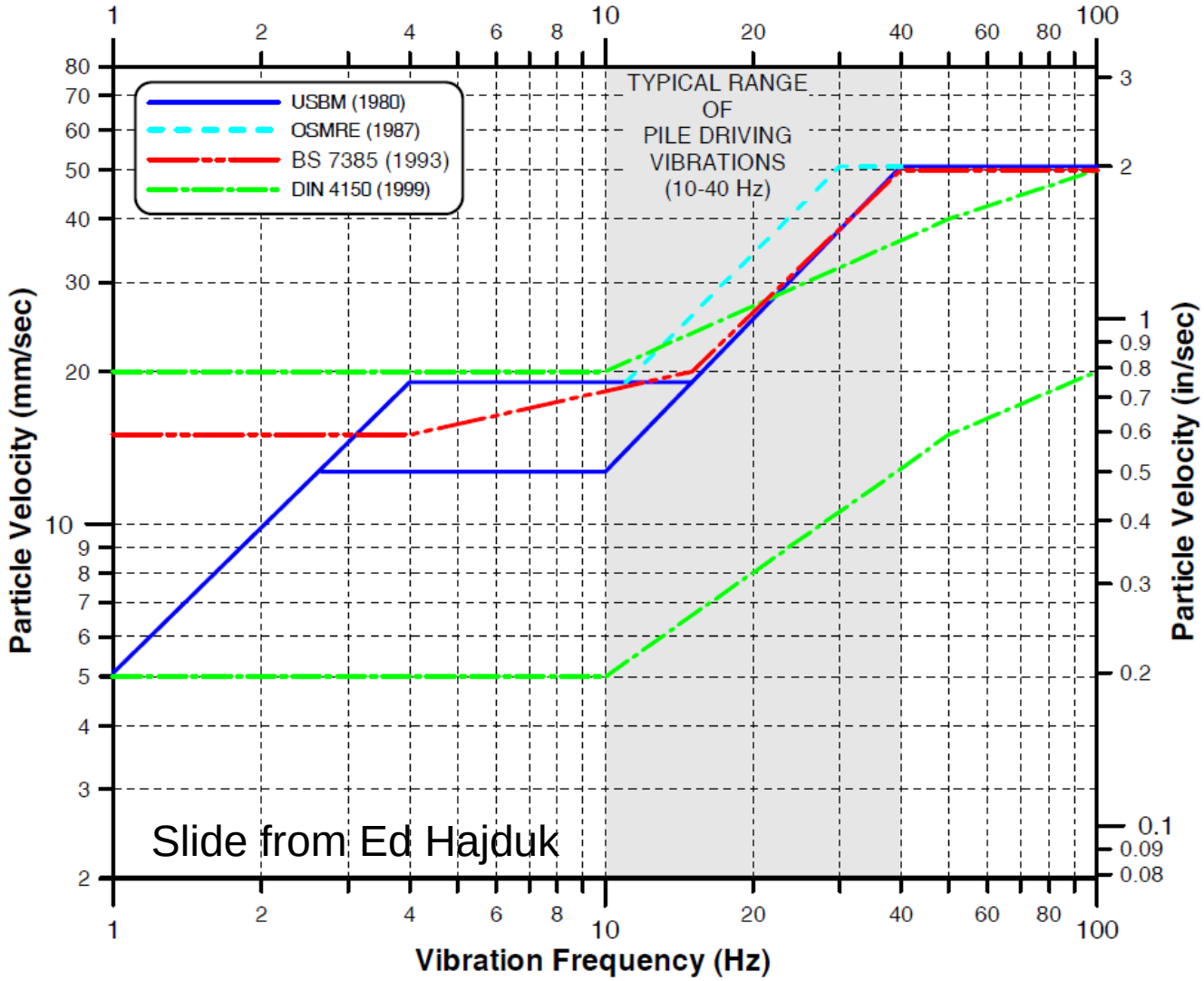
Integrity & Reliablity Summary

- Pile problems easily identified via testing
- Repair generally possibly via replacement/supplementation
- Shaft problems often hard to quantify
- Remedy of shaft problems may be very difficult

Vibration Misconception

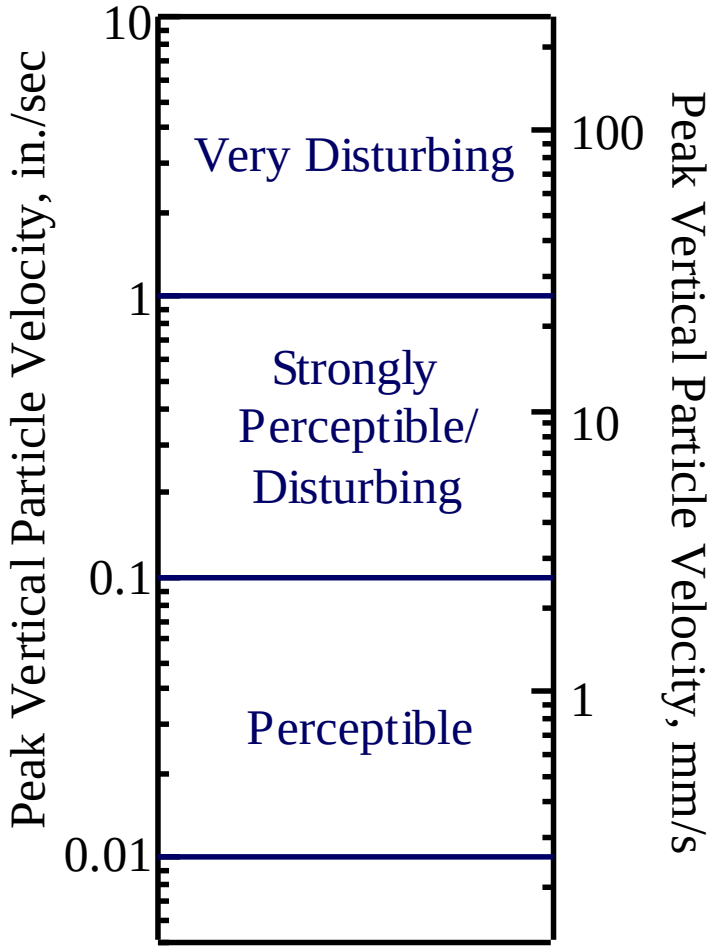
- *Construction Activities* generate vibrations
- Pile driving often inappropriately penalized because of its consistent auditory alert
- Structures and soil are much more tolerant of vibrations than people

Vibration Criteria

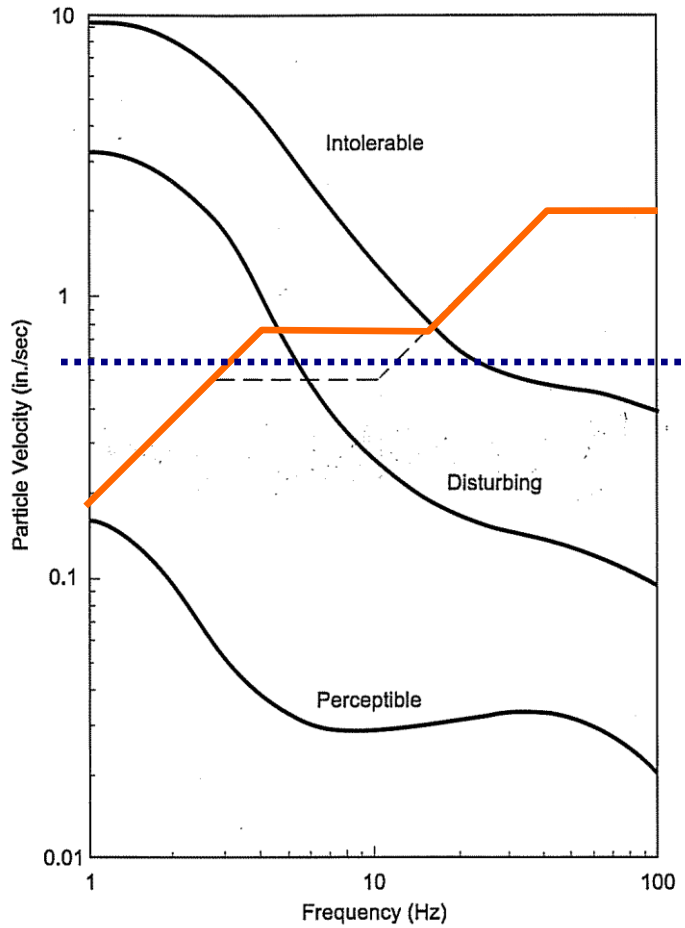


Upper blue line is most commonly used

Human Perception Thresholds



Formation of hairline cracks in plaster and drywall joints

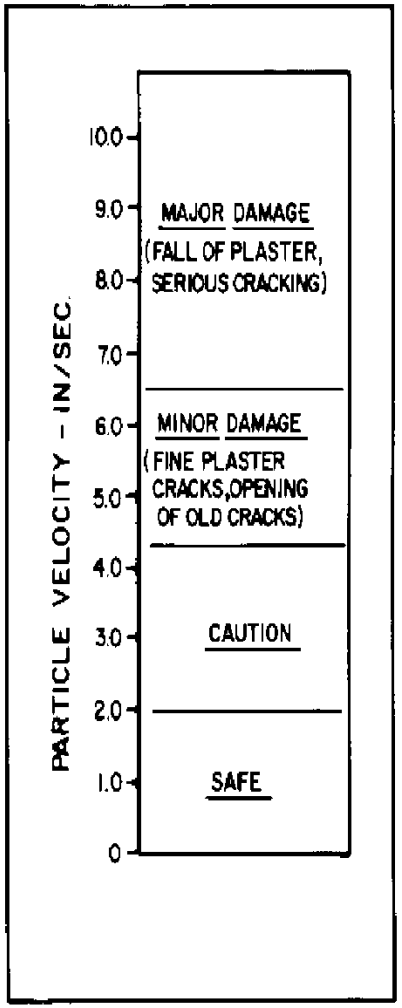


Approx PPV that will induce 0.01% strain in a very loose sand (Vs of 500 fps)

Oriard's and NAVFAC Criteria

Range of Common Residential Criteria and Observed Side Effects	
0.5 ips (1.27 cm/s) (12.7 mm/s)	Bureau of Mines recommended guideline for plaster-on-lath construction near surface mines (long-term, large-scale blasting operations, low-frequency vibrations (RI 8507).
0.75 ips (1.91 cm/s) (19.1 mm/s)	Bureau of Mines recommended guideline for sheetrock construction near surface mines (RI 8507).
1.0 ips (2.54 cm/s) (25.4 mm/s)	OSM regulatory limits for residences near surface mine operations at distances of 301-5000 ft. (long-term, large-scale blasting).
2.0 ips (5.08 cm/s) (50.8 mm/s)	Widely accepted limit for residences near construction blasting and quarry blasting (BuMinBulletin 656, BuMin RI 8507, various codes, specifications and regulations). Also allowed by OSM for frequencies above 30 Hz.
5.4 ips (13.7 cm/s) (137 mm/s)	Minor damage to the average house subjected to quarry blasting vibrations. (BuMin Bulletin 656).
9 ips (22.9 cm/s) (229 mm/s)	About 90% probability of minor damage from construction or quarry blasting. Structural damage to some houses. Depends on vibration source, character of vibrations and the house.
20 ips (50.8 cm/s) (508 mm/s)	For close-in construction blasting, minor damage to nearly all houses, structural damage to some. A few may escape damage entirely. For low-frequency vibrations of long duration, major damage to most houses.

(from Oriard, 1999)



(from NAVFAC DM-7, 1986)

Largest Vibration-Related Claims in Charleston, SC

St. Philips Church: Extraction of drilled shaft temporary casing with vibratory hammer

French Huguenot Church: Pavement demolition with large track-hoe

Driven Piles vs Drilled Shaft Foundation Selection Case Histories

Indian Inlet River Replacement Bridge Design Build

Scour concerns – no foundations in inlet

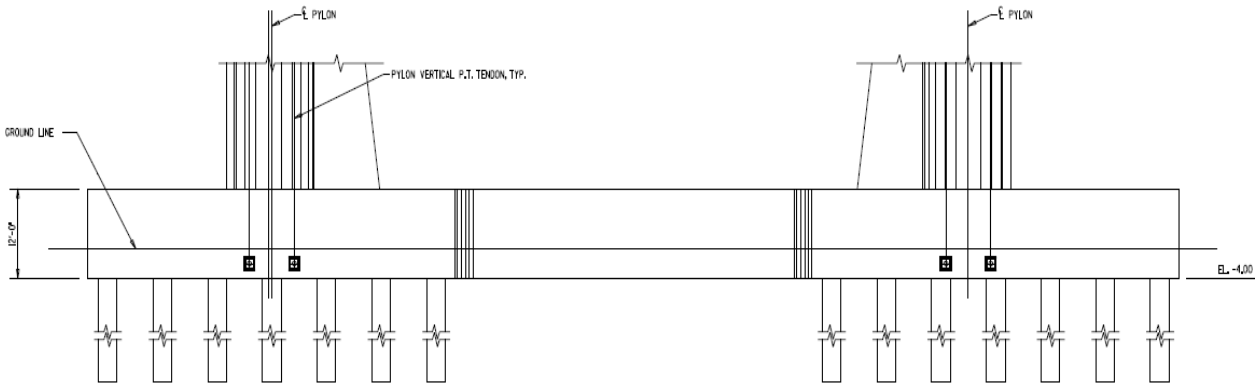
Larger main pier footings = longer span length (expensive)

Two DB teams: winning team used all driven piles, other team used drilled shafts

Indian Inlet River – Cont.

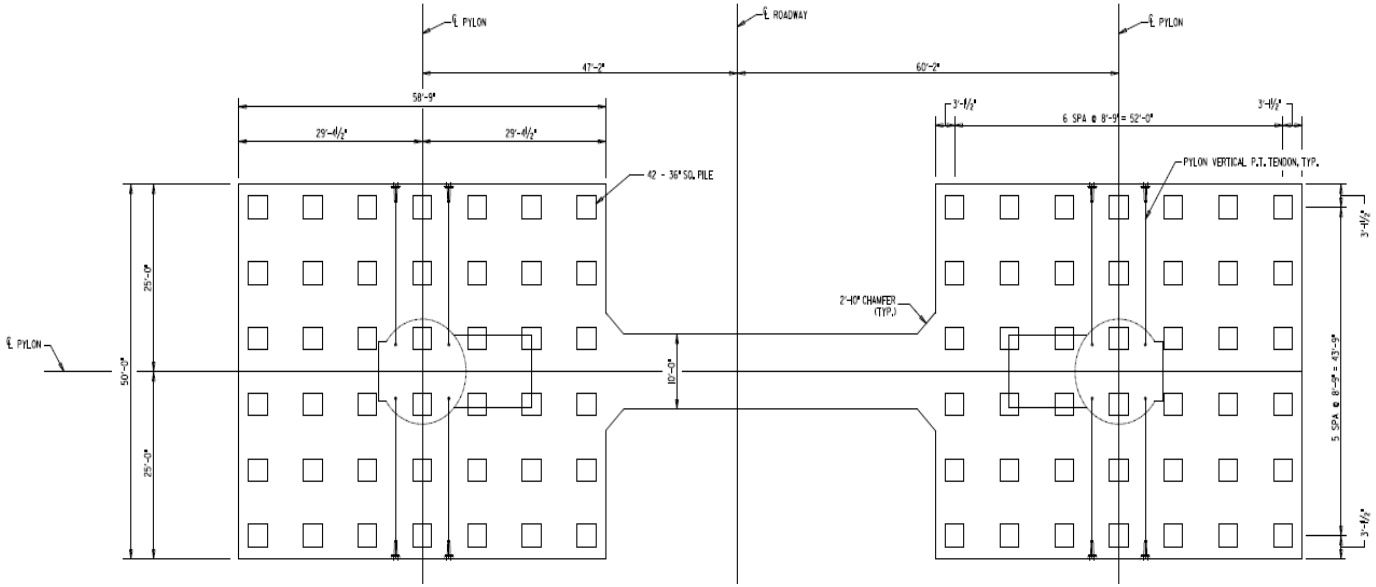
- Skanska: voided 36” sq. PSC piles
- Self-performed
- Higher resistance factor
- Faster
- Less expensive

Main Piers



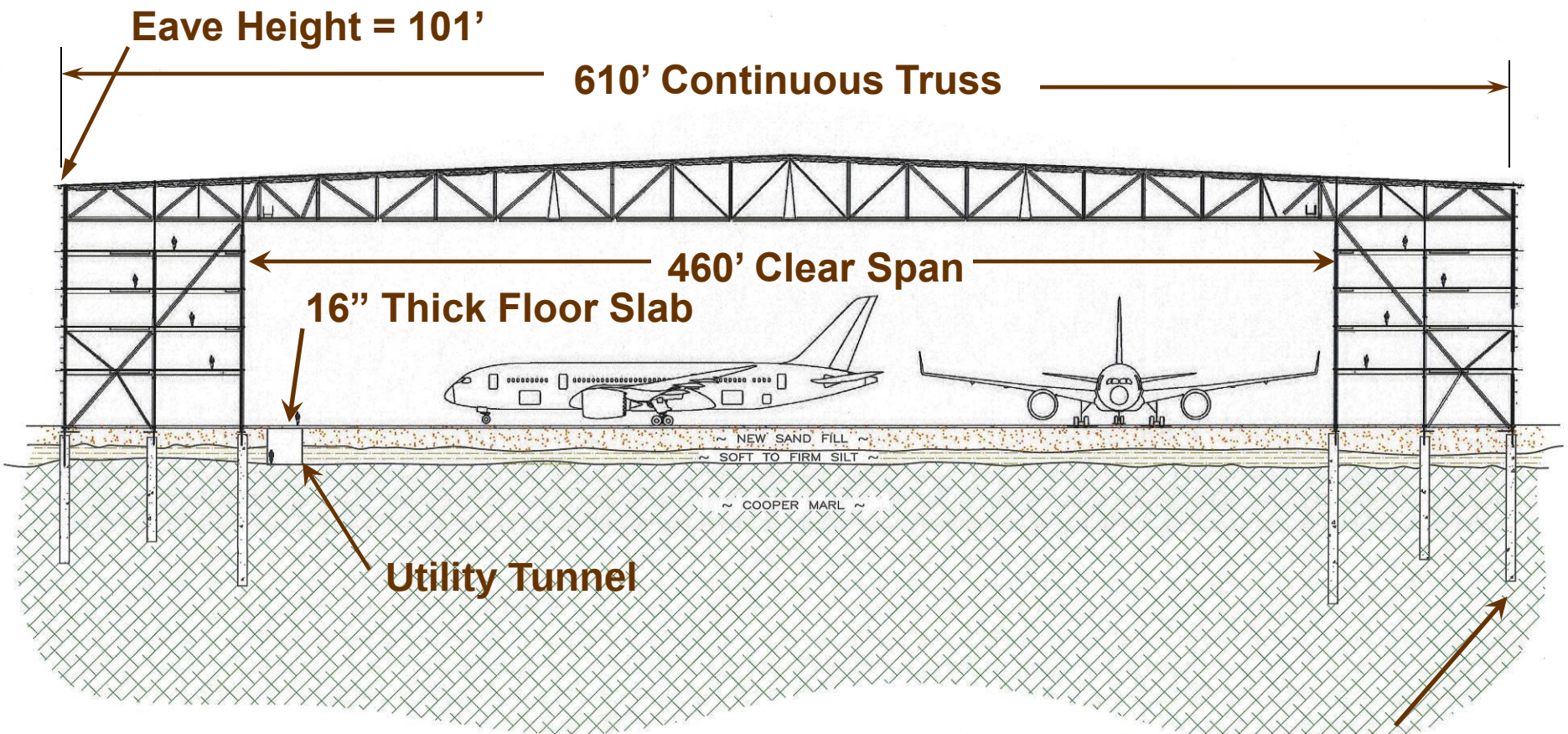
TRANSVERSE ELEVATION

1/8" = 1'-0"



Boeing 787 Second Assembly Line

MAIN BUILDING



Foundation Alternates in Bid Documents

24" Pipe Piles - 2, 3, 4 and 5 pile groups

HP 14 x73 – 2, 4, 5, and 7 pile groups

Lowest Cost Foundation

4' & 5' dia. Drilled Shafts

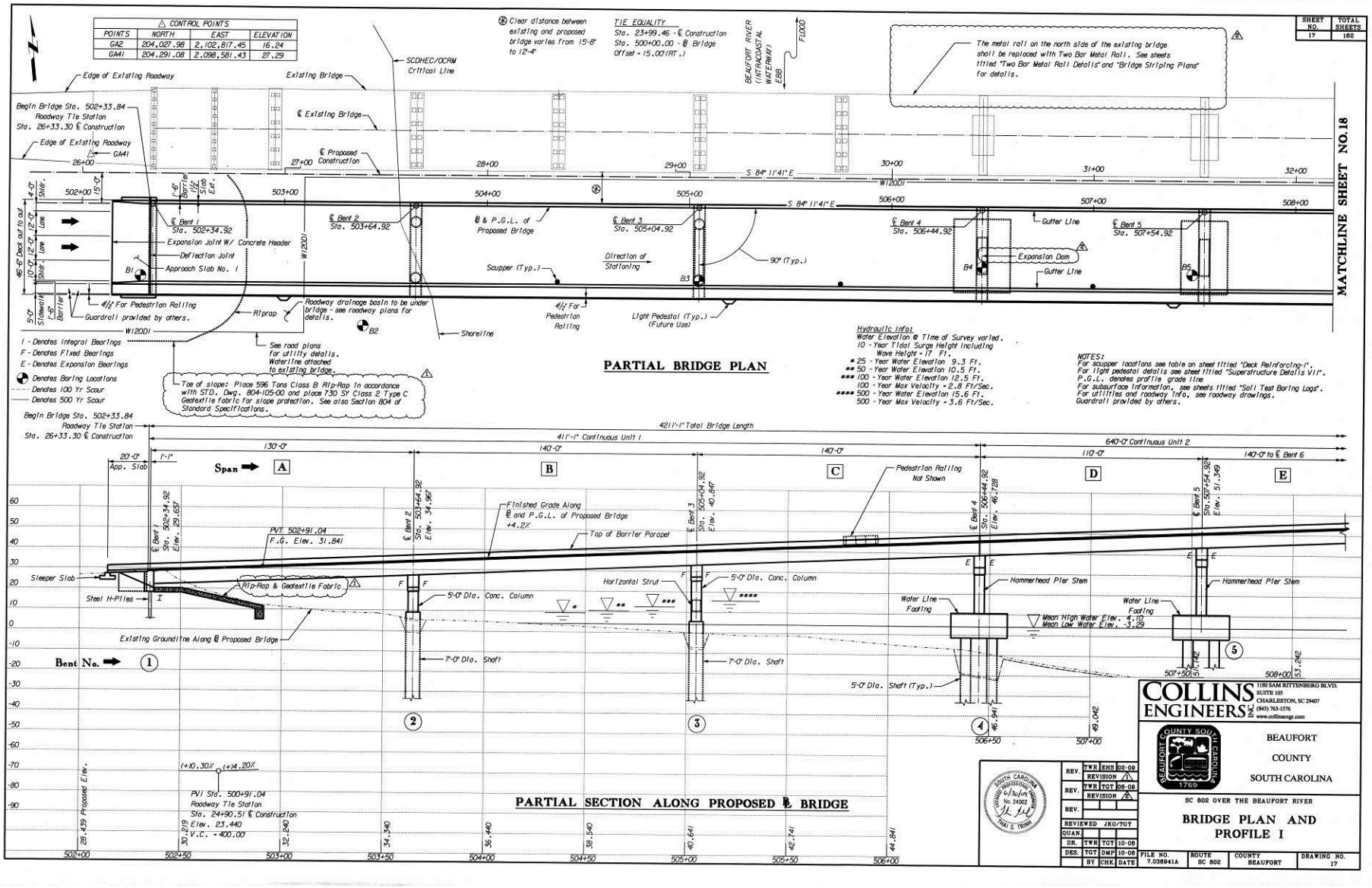
- **compressive load ≤ 2300 kips**
- **uplift ≤ 547 kips**
- **lateral load ≤ 350 kips**

SC 802 – Bridge over Broad Creek Beaufort, SC

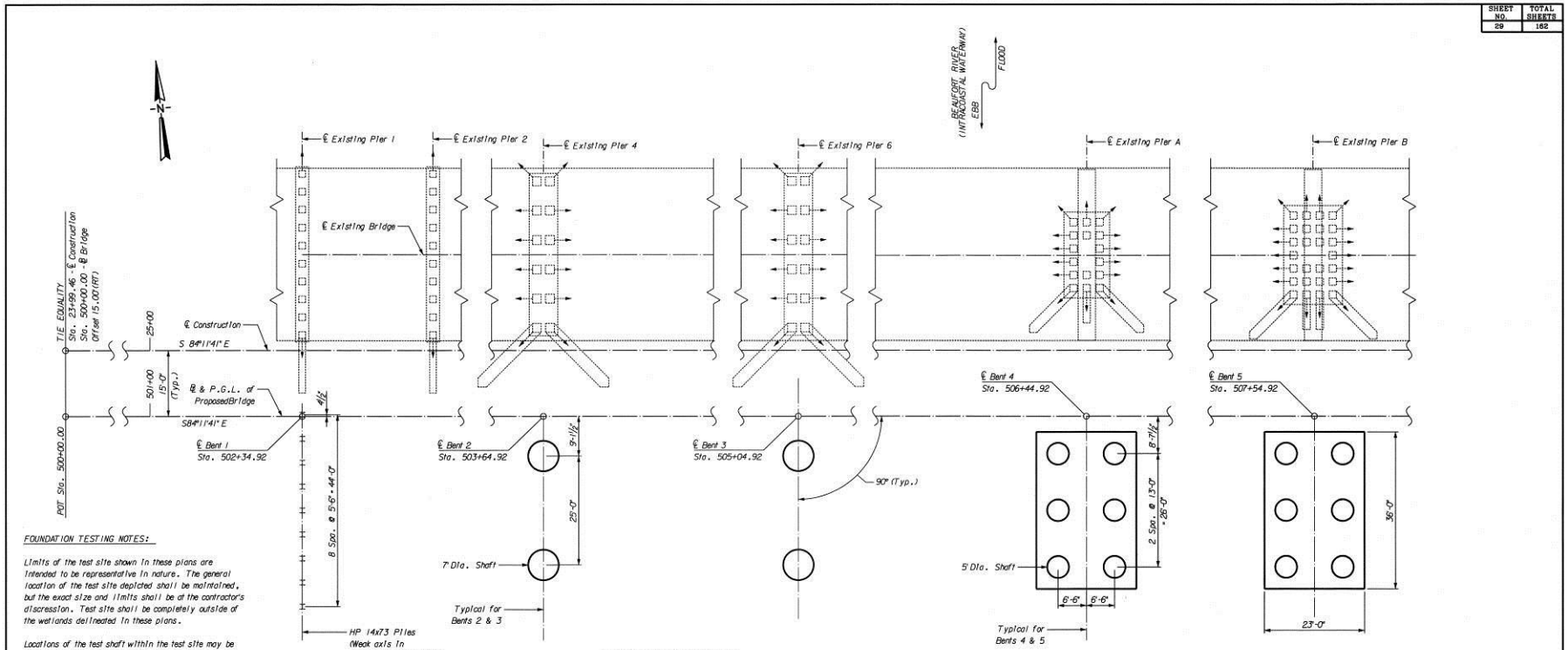
- New bridge adjacent to existing bridge (c. 80s)
- Existing bridge on driven H-Piles and PSC piles
- New bridge design requirements
  - Much larger seismic hazard
- New bridge foundations
  - Driven PSC piles on approaches
  - Drilled shafts at higher bents

Existing Bridge

Existing Bridge


PARTIAL BRIDGE PLAN
PARTIAL SECTION ALONG PROPOSED ℄ BRIDGE
MATCHLINE SHEET NO.18
SHEET NO. 17
TOTAL SHEETS 102
△ CONTROL POINTS
POINTS NORTH EAST ELEVATION
GA2 204,027.98 2,102,817.45 16.24
GA41 204,291.08 2,098,581.43 27.29
TIE EQUALITY
Sta. 23+99.46 - ℄ Construction
Sta. 500+00.00 - ℄ Bridge
Offset = 15.00'(RT.)
BEAUFORT RIVER (INTRACOASTAL WATERWAY)
FLOOD
EBB
SCDHEC/OCRM Critical Line
Existing Bridge
Proposed Construction
Edge of Existing Roadway
Begin Bridge Sta. 502+33.84
Roadway Tie Station
Sta. 26+33.30 ℄ Construction
S 84° 11'41" E
W120D1
Bent 1 Sta. 502+34.92
Bent 2 Sta. 503+64.92
Bent 3 Sta. 505+04.92
Bent 4 Sta. 506+44.92
Bent 5 Sta. 507+54.92
Expansion Joint W/ Concrete Header
Deflection Joint
Approach Slab No. 1
Scupper (Typ.)
Direction of Stationing
90° (Typ.)
Gutter Line
Expansion Dam
Light Pedestal (Typ.) (Future Use)
Shoreline
Rip-rap
Guardrail provided by others.
Roadway drainage basin to be under bridge - see roadway plans for details.
See road plans for utility details. Waterline attached to existing bridge.
Toe of slope: Place 596 Tons Class B Rip-Rap in accordance with STD. Dwg. 804-105-00 and place 730 SY Class 2 Type C Geotextile fabric for slope protection. See also Section 804 of Standard Specifications.
The metal rail on the north side of the existing bridge shall be replaced with Two Bar Metal Rail. See sheets titled "Two Bar Metal Rail Details" and "Bridge Striping Plans" for details.
I - Denotes Integral Bearings
F - Denotes Fixed Bearings
E - Denotes Expansion Bearings
Denotes Boring Locations
Denotes 100 Yr Scour
Denotes 500 Yr Scour
Hydraulic Info:
Water Elevation @ Time of Survey varied.
10 - Year Tidal Surge Height Including Wave Height = 17 Ft.
* 25 - Year Water Elevation 9.3 Ft.
** 50 - Year Water Elevation 10.5 Ft.
*** 100 - Year Water Elevation 12.5 Ft.
100 - Year Max Velocity = 2.8 Ft/Sec.
**** 500 - Year Water Elevation 15.6 Ft.
500 - Year Max Velocity = 3.6 Ft/Sec.
NOTES:
For scupper locations see table on sheet titled "Deck Reinforcing-I".
For light pedestal details see sheet titled "Superstructure Details VII".
P.G.L. denotes profile grade line
For subsurface information, see sheets titled "Soil Test Boring Logs".
For utilities and roadway info, see roadway drawings.
Guardrail provided by others.
411'-1" Total Bridge Length
411'-1" Continuous Unit 1
640'-0" Continuous Unit 2
Span
Bent No.
Sleeper Slab
Steel H-Piles
Rip-Rap & Geotextile Fabric
Existing Groundline Along ℄ Proposed Bridge
PVI 502+91.04
F.G. Elev. 31.841
Finished Grade Along ℄ and P.G.L. of Proposed Bridge
Top of Barrier Parapet
Pedestrian Railing Not Shown
Horizontal Strut
5'-0" Dia. Conc. Column
7'-0" Dia. Shaft
5'-0" Dia. Shaft (Typ.)
Hammerhead Pier Stem
Water Line Footing
Mean High Water Elev. 4.10
Mean Low Water Elev. -3.29
PVI Sta. 500+91.04
Roadway Tie Station
Sta. 24+90.51 ℄ Construction
Elev. 23.440
V.C. = 400.00
COLLINS ENGINEERS INC.
1180 SAM RITTENBERG BLVD.
SUITE 105
CHARLESTON, SC 29407
(843) 763-1576
www.collinsengr.com
BEAUFORT COUNTY SOUTH CAROLINA
BEAUFORT COUNTY SOUTH CAROLINA
SC 802 OVER THE BEAUFORT RIVER
BRIDGE PLAN AND PROFILE I
FILE NO. 7.036941A
ROUTE SC 802
COUNTY BEAUFORT
DRAWING NO. 17

SHEET NO.	TOTAL SHEETS
29	162



FOUNDATION TESTING NOTES:

Limits of the test site shown in these plans are intended to be representative in nature. The general location of the test site depicted shall be maintained, but the exact size and limits shall be at the contractor's discression. Test site shall be completely outside of the wetlands delineated in these plans.

Locations of the test shaft within the test site may be selected at the contractor's discression with approval by the Engineer, provided the following criteria are met:

1) The shaft shall be located at least 25 feet from any existing bridge foundation and shall be positioned such that construction and testing operations do not adversely affect the existing bridge.

2) The shaft shall be located a minimum of 25 feet from any future bridge foundation location as shown on this sheet.

3) Location shall avoid conflicts with construction staging, necessary work trestle, and utilities nearby.

See special provisions for load test requirements. Testing shall generally be conducted as follows:

60" Diameter Drilled Shaft - Statnamic testing with a minimum test load of 1900 tons.

After completion of all testing and data collection, test shaft shall be removed in accordance with special provisions.

NOTES:

All existing bridge foundation information is shown for information only. As built conditions of bridge may vary from what is shown from existing bridge plans.

Limits of Battered Piles shown on this sheet is based on as assumed 100 ft long piling, or actual information from the as built pile driving record.

It is not anticipated that the contractor will have conflicts with existing bridge foundations during installation of proposed shaft and piles.

Contractor may encounter debris on channel bottom from previous construction of bridge and will be responsible for any measures necessary to work around or remove such debris.

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BEAUFORT COUNTY SOUTH CAROLINA 1769

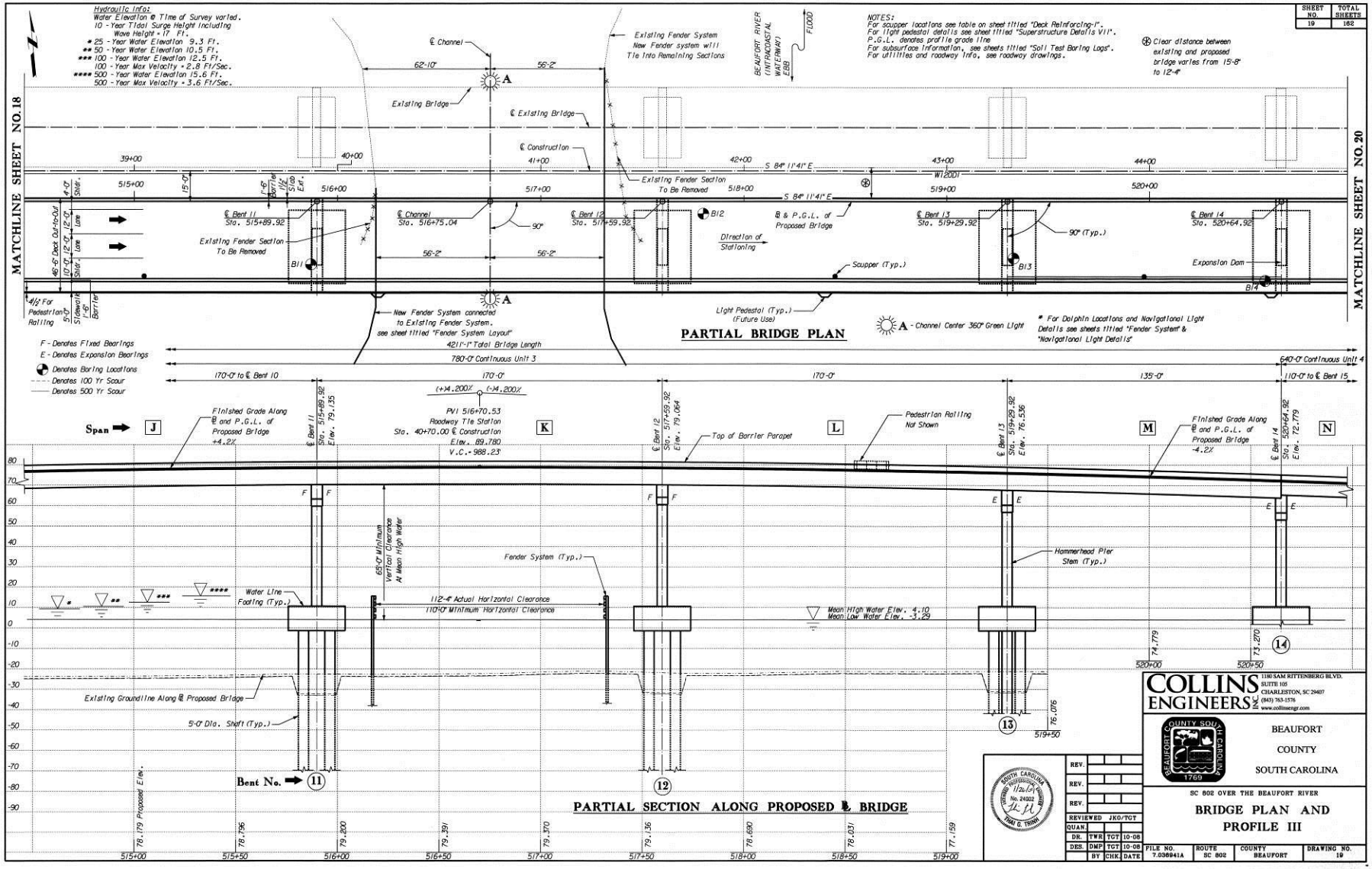
BEAUFORT
COUNTY
SOUTH CAROLINA

SC 802 OVER THE BEAUFORT RIVER
FOUNDATION LAYOUT
PLAN - I
BENTS 1 THRU 5

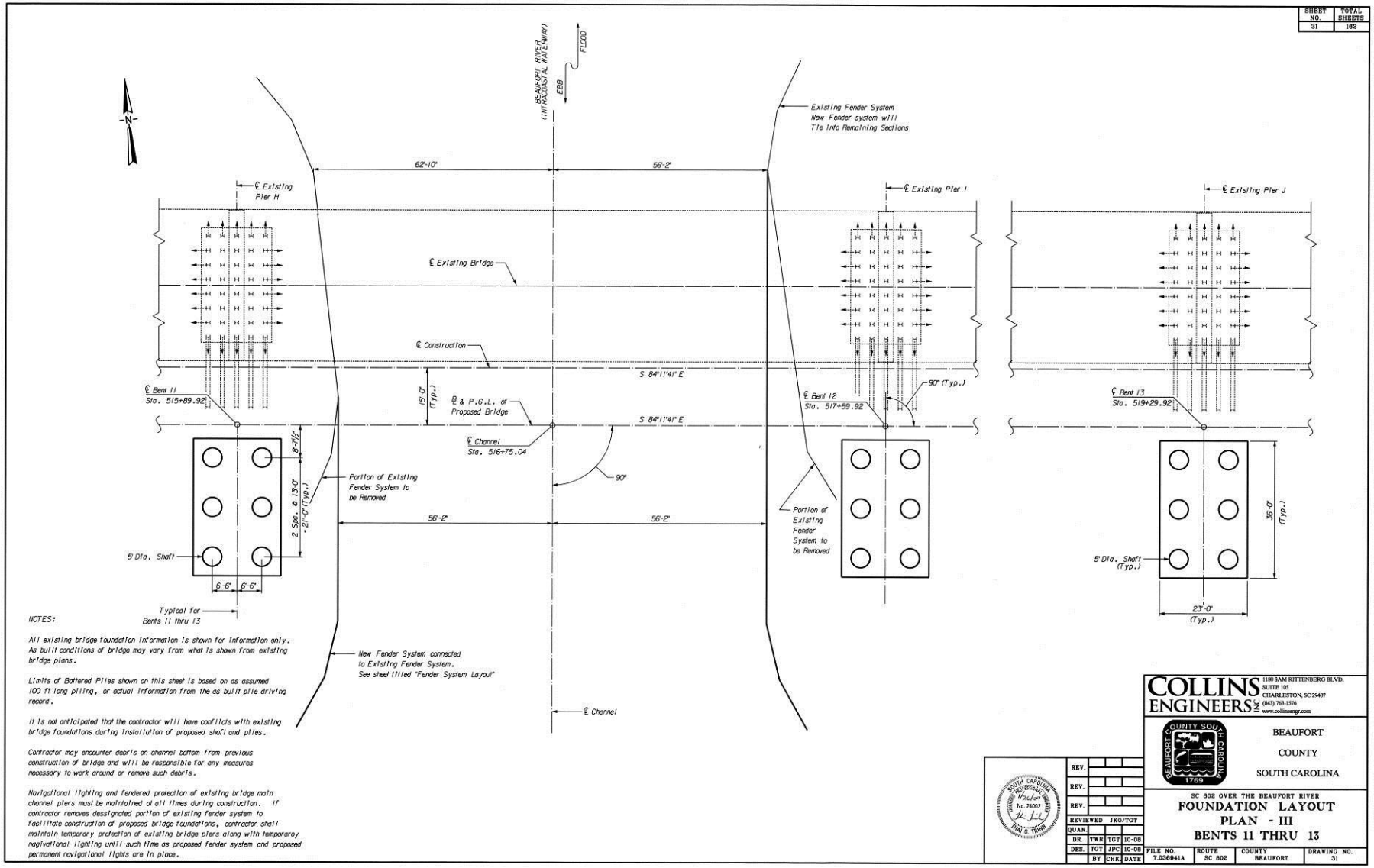
SOUTH CAROLINA PROFESSIONAL ENGINEER 1/24/01 No. 24032 RICHARD G. TRIBBLE

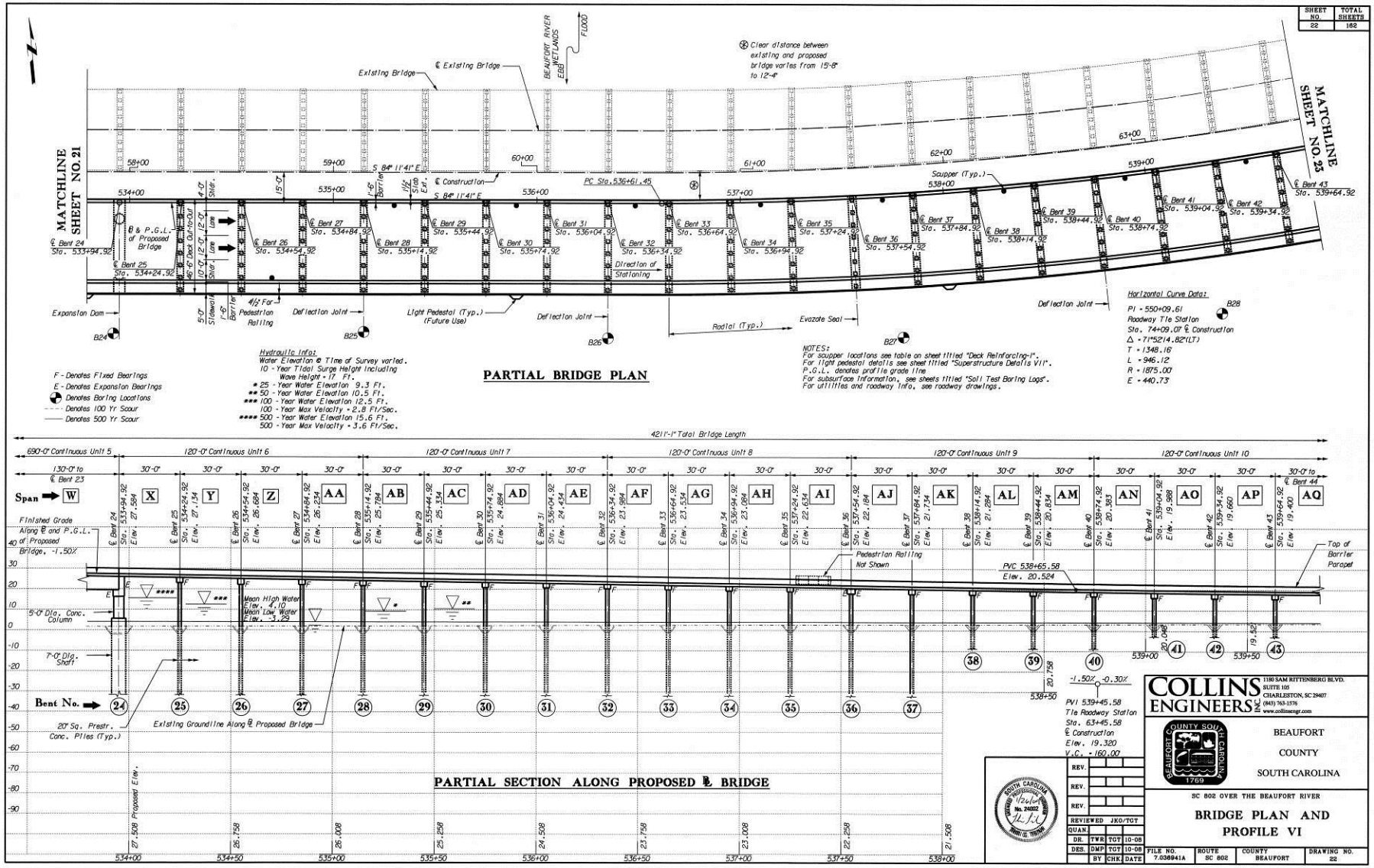
REV.				
REV.				
REV.				
REVIEWED	JKO/TGT			
QUAN.				
DR.	TWR	TGT	10-08	
DES.	TGT	JPC	10-08	
	BY	CHK	DATE	

FILE NO.	ROUTE	COUNTY	DRAWING NO.
7.036941A	SC 802	BEAUFORT	29



PDPI
June 26, 2013 – Logan, UT


SHEET NO. 31
TOTAL SHEETS 162
BEAUFORT RIVER (INTRACOASTAL WATERWAY)
EBB
FLOOD
N
Existing Fender System
New Fender system will
Tie Into Remaining Sections
62'-10"
56'-2"
℄ Existing Pier H
℄ Existing Pier I
℄ Existing Pier J
℄ Existing Bridge
℄ Construction
S 84°11'41" E
℄ Bent 11
Sta. 515+89.92
15'-0" (Typ.)
℄ & P.G.L. of
Proposed Bridge
℄ Bent 12
Sta. 517+59.92
90° (Typ.)
℄ Bent 13
Sta. 519+29.92
℄ Channel
Sta. 516+75.04
90°
8'-7½"
2 Spa. @ 13'-0"
21'-0" (Typ.)
Portion of Existing
Fender System to
be Removed
56'-2"
56'-2"
Portion of
Existing
Fender
System to
be Removed
35'-0" (Typ.)
5' Dia. Shaft
6'-6"
6'-6"
Typical for
Bents 11 thru 13
5' Dia. Shaft
(Typ.)
23'-0"
(Typ.)
NOTES:
All existing bridge foundation information is shown for information only. As built conditions of bridge may vary from what is shown from existing bridge plans.
Limits of Battered Piles shown on this sheet is based on as assumed 100 ft long piling, or actual information from the as built pile driving record.
It is not anticipated that the contractor will have conflicts with existing bridge foundations during installation of proposed shaft and piles.
Contractor may encounter debris on channel bottom from previous construction of bridge and will be responsible for any measures necessary to work around or remove such debris.
Navigational lighting and fendered protection of existing bridge main channel piers must be maintained at all times during construction. If contractor removes designated portion of existing fender system to facilitate construction of proposed bridge foundations, contractor shall maintain temporary protection of existing bridge piers along with temporaroy navigational lighting until such time as proposed fender system and proposed permanent navigational lights are in place.
New Fender System connected
to Existing Fender System.
See sheet titled "Fender System Layout"
℄ Channel
COLLINS ENGINEERS INC
1180 SAM RITTENBERG BLVD.
SUITE 105
CHARLESTON, SC 29407
(843) 763-1576
www.collinsengr.com
BEAUFORT COUNTY SOUTH CAROLINA
1769
BEAUFORT
COUNTY
SOUTH CAROLINA
SC 802 OVER THE BEAUFORT RIVER
FOUNDATION LAYOUT
PLAN - III
BENTS 11 THRU 13
REV.
REV.
REV.
REVIEWED JKO/TGT
QUAN.
DR. TWR TGT 10-08
DES. TGT JPC 10-08
BY CHK DATE
FILE NO. 7.036941A
ROUTE SC 802
COUNTY BEAUFORT
DRAWING NO. 31


PARTIAL BRIDGE PLAN
PARTIAL SECTION ALONG PROPOSED ℄ BRIDGE
MATCHLINE SHEET NO. 21
MATCHLINE SHEET NO. 23
4211'-1" Total Bridge Length
Existing Bridge
BEAUFORT RIVER WETLANDS
EBB FLOOD
Clear distance between existing and proposed bridge varies from 15'-8" to 12'-4"
Expansion Dam
Deflection Joint
Light Pedestal (Typ.) (Future Use)
Radial (Typ.)
Evazote Seal
Scupper (Typ.)
Direction of Stationing
Hydraulic Info:
Water Elevation @ Time of Survey varied.
10 - Year Tidal Surge Height Including Wave Height = 17 Ft.
* 25 - Year Water Elevation 9.3 Ft.
** 50 - Year Water Elevation 10.5 Ft.
*** 100 - Year Water Elevation 12.5 Ft.
100 - Year Max Velocity = 2.8 Ft/Sec.
**** 500 - Year Water Elevation 15.6 Ft.
500 - Year Max Velocity = 3.6 Ft/Sec.
F - Denotes Fixed Bearings
E - Denotes Expansion Bearings
Denotes Boring Locations
Denotes 100 Yr Scour
Denotes 500 Yr Scour
NOTES:
For scupper locations see table on sheet titled "Deck Reinforcing-I".
For light pedestal details see sheet titled "Superstructure Details VII".
P.G.L. denotes profile grade line
For subsurface information, see sheets titled "Soil Test Boring Logs".
For utilities and roadway info, see roadway drawings.
Horizontal Curve Data:
PI = 550+09.61
Roadway Tie Station
Sta. 74+09.07 ℄ Construction
Δ = 71°52'14.82"(LT)
T = 1348.16'
L = 946.12
R = 1875.00'
E = 440.73'
690'-0" Continuous Unit 5
120'-0" Continuous Unit 6
120'-0" Continuous Unit 7
120'-0" Continuous Unit 8
120'-0" Continuous Unit 9
120'-0" Continuous Unit 10
Finished Grade Along ℄ and P.G.L. of Proposed Bridge, -1.50%
Mean High Water Elev. 4.10
Mean Low Water Elev. -3.29
5'-0" Dia. Conc. Column
7'-0" Dia. Shaft
20" Sq. Prestr. Conc. Piles (Typ.)
Existing Groundline Along ℄ Proposed Bridge
Pedestrian Railing Not Shown
PVC 538+65.58
Elev. 20.524
Top of Barrier Parapet
PVI 539+45.58
Tie Roadway Station
Sta. 63+45.58
℄ Construction
Elev. 19.320
V.C. = 160.00'
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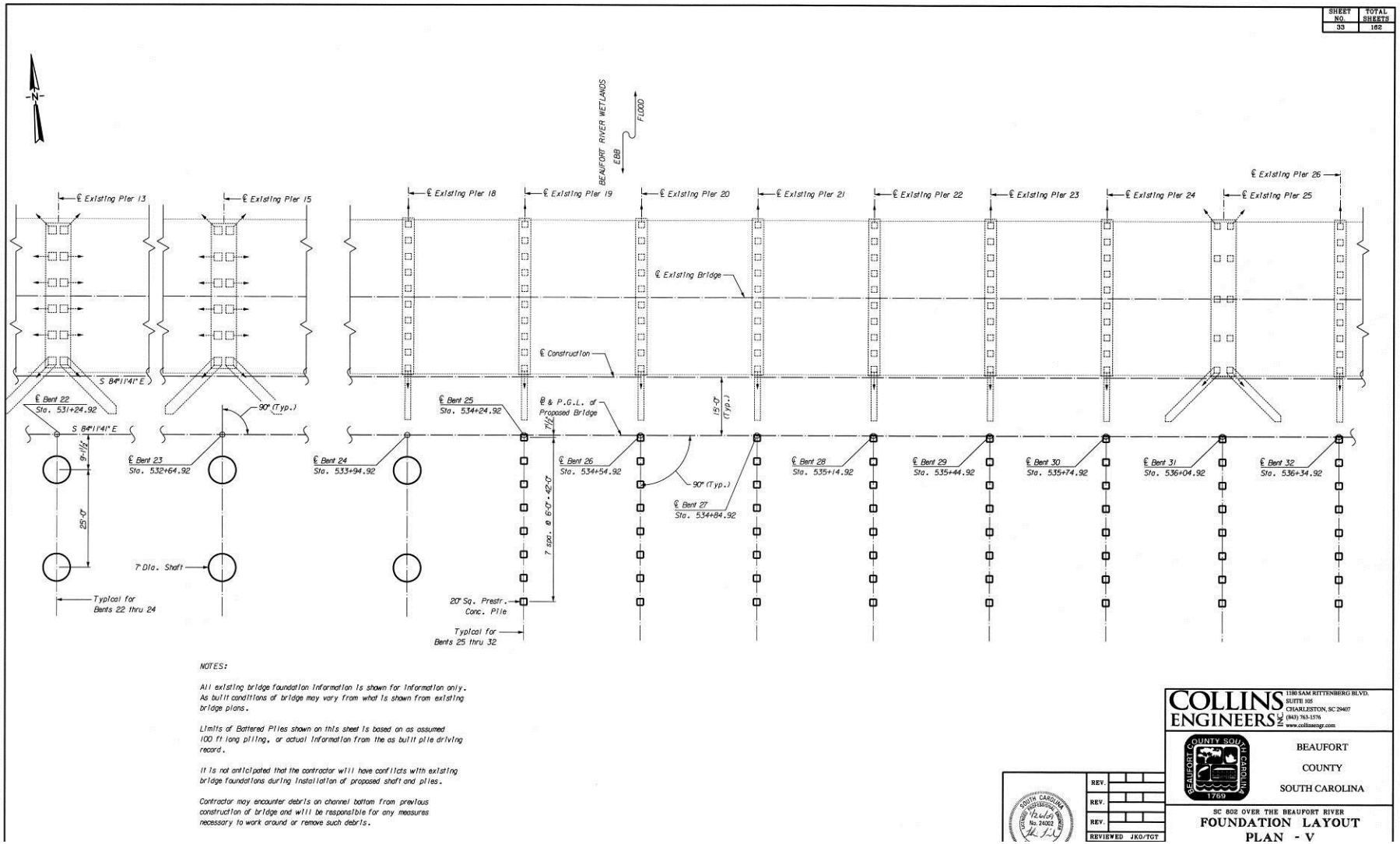
BEAUFORT COUNTY SOUTH CAROLINA
SC 802 OVER THE BEAUFORT RIVER
BRIDGE PLAN AND PROFILE VI
FILE NO. 7.036941A
ROUTE SC 802
COUNTY BEAUFORT
DRAWING NO. 22
SHEET NO. 22
TOTAL SHEETS 162


SHEET NO. 33
TOTAL SHEETS 182
N
BEAUFORT RIVER WETLANDS
EBB
FLOOD
℄ Existing Pier 13
℄ Existing Pier 15
℄ Existing Pier 18
℄ Existing Pier 19
℄ Existing Pier 20
℄ Existing Pier 21
℄ Existing Pier 22
℄ Existing Pier 23
℄ Existing Pier 24
℄ Existing Pier 25
℄ Existing Pier 26
℄ Existing Bridge
℄ Construction
S 84°11'41" E
℄ Bent 22
Sta. 531+24.92
90° (Typ.)
℄ Bent 25
Sta. 534+24.92
℄ & P.G.L. of
Proposed Bridge
7½"
15'-0"
(Typ.)
S 84°11'41" E
9'-1½"
℄ Bent 23
Sta. 532+64.92
℄ Bent 24
Sta. 533+94.92
℄ Bent 26
Sta. 534+54.92
90° (Typ.)
℄ Bent 27
Sta. 534+84.92
℄ Bent 28
Sta. 535+14.92
℄ Bent 29
Sta. 535+44.92
℄ Bent 30
Sta. 535+74.92
℄ Bent 31
Sta. 536+04.92
℄ Bent 32
Sta. 536+34.92
25'-0"
7 spa. @ 6'-0" = 42'-0"
7' Dia. Shaft
Typical for
Bents 22 thru 24
20" Sq. Prestr.
Conc. Pile
Typical for
Bents 25 thru 32
NOTES:
All existing bridge foundation information is shown for information only. As built conditions of bridge may vary from what is shown from existing bridge plans.
Limits of Battered Piles shown on this sheet is based on as assumed 100 ft long piling, or actual information from the as built pile driving record.
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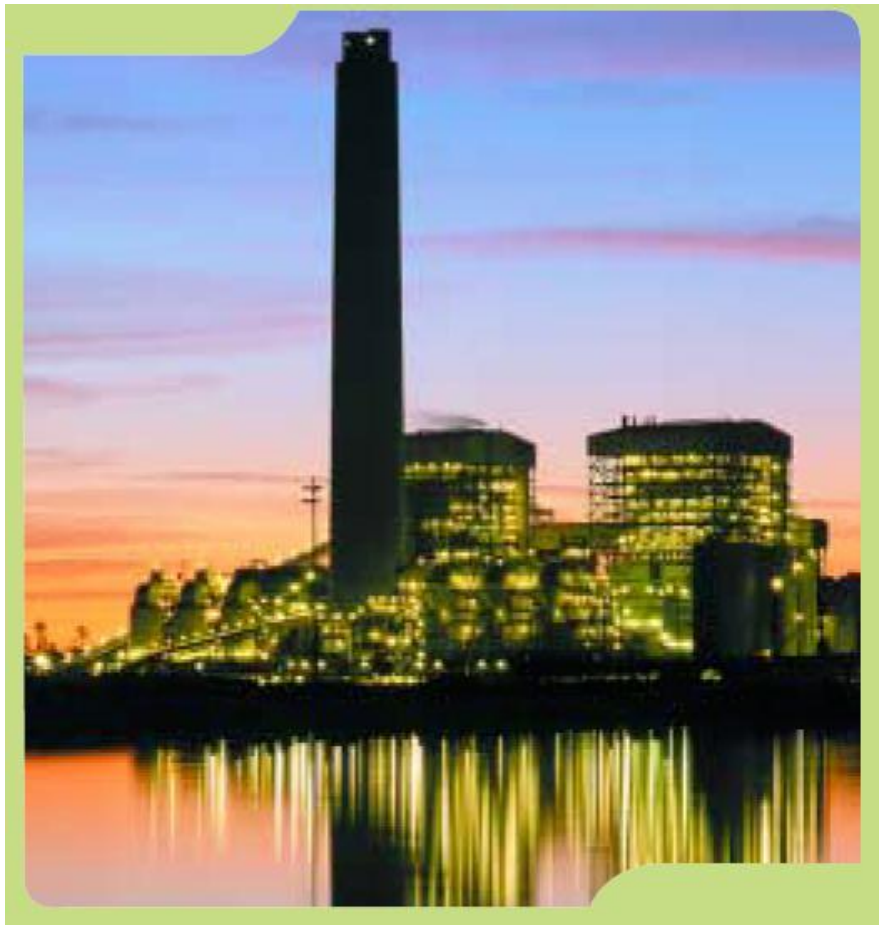
1769
BEAUFORT
COUNTY
SOUTH CAROLINA
SC 802 OVER THE BEAUFORT RIVER
FOUNDATION LAYOUT
PLAN - V
REV.
REV.
REV.
REVIEWED JKO/TGT
No. 24002

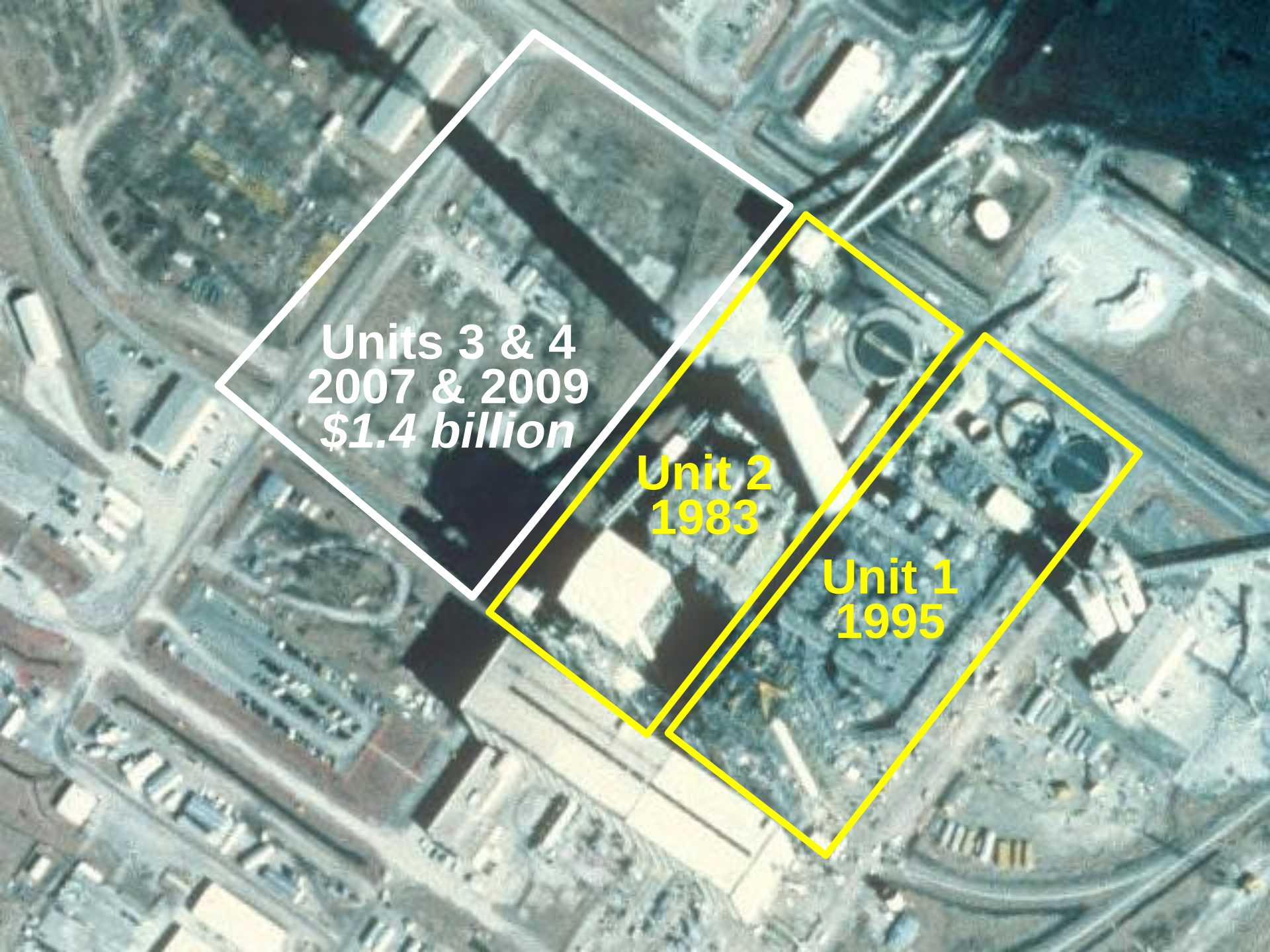

JAN 11 2010


JAN 11 2010

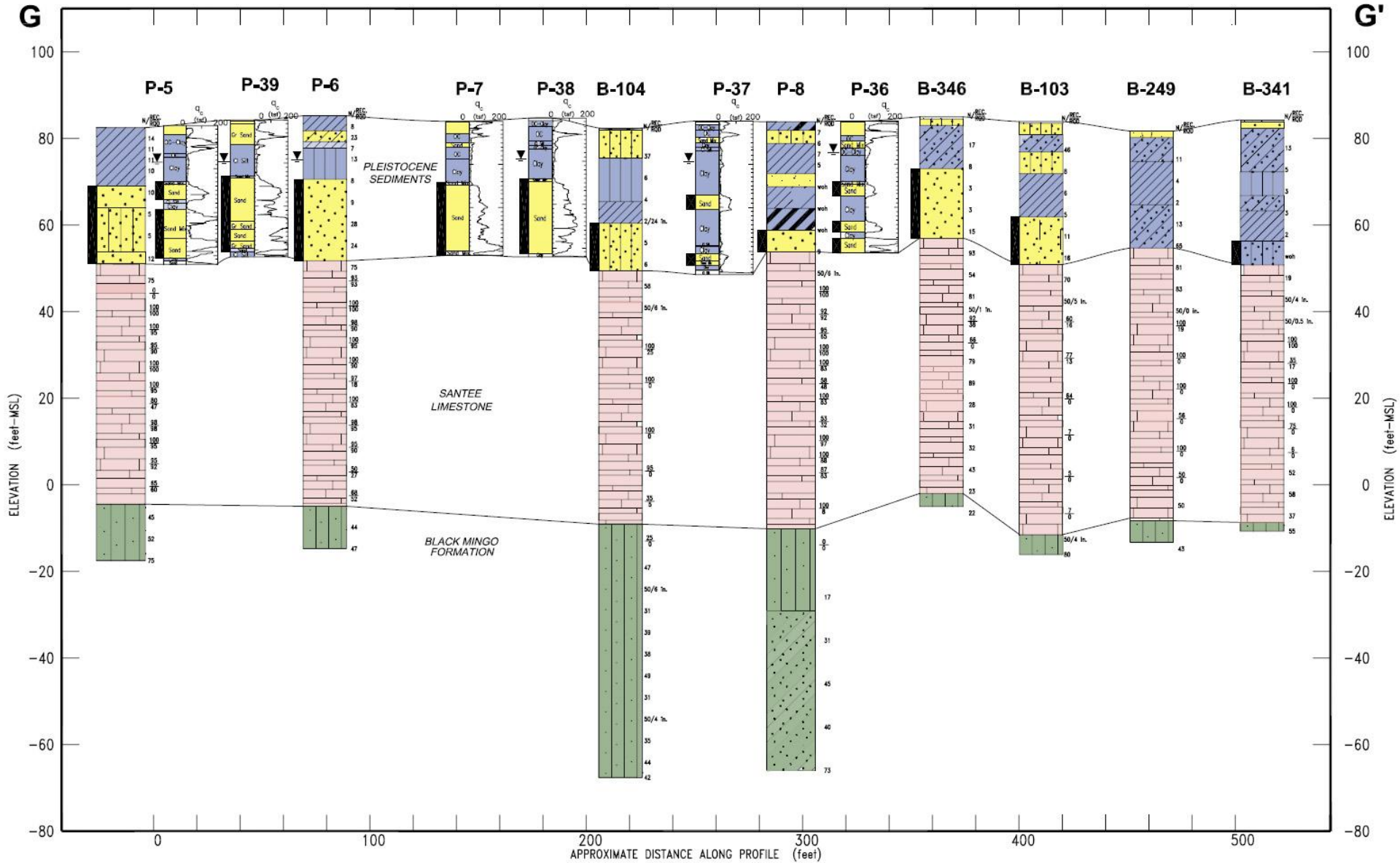
Power Plant Expansion

- Major expansion of existing power plant
- All original structure supported on 3’ or 4’ diameter drilled shafts (due to karst concern)

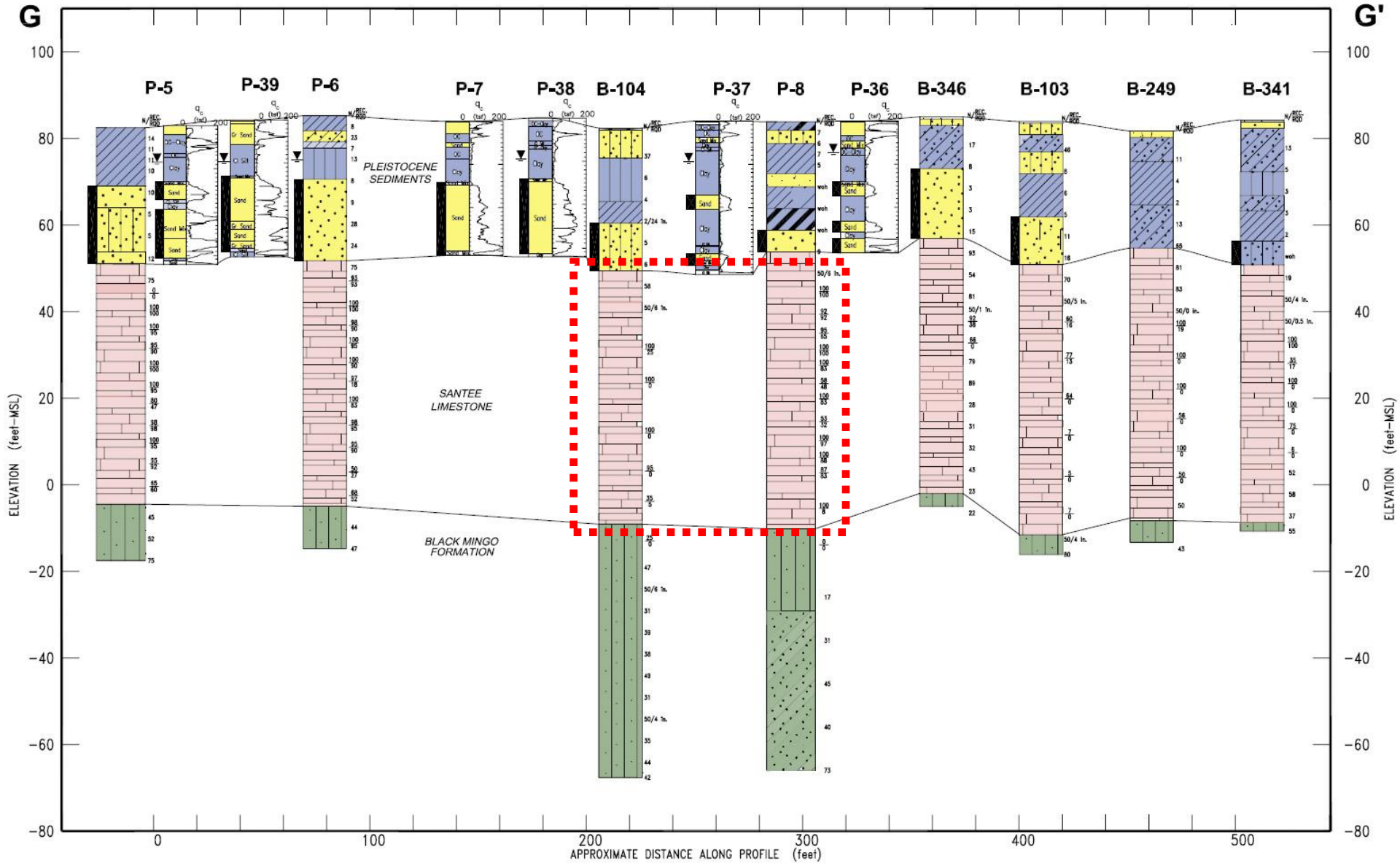



Units 3 & 4
2007 & 2009
$1.4 billion
Unit 2
1983
Unit 1
1995

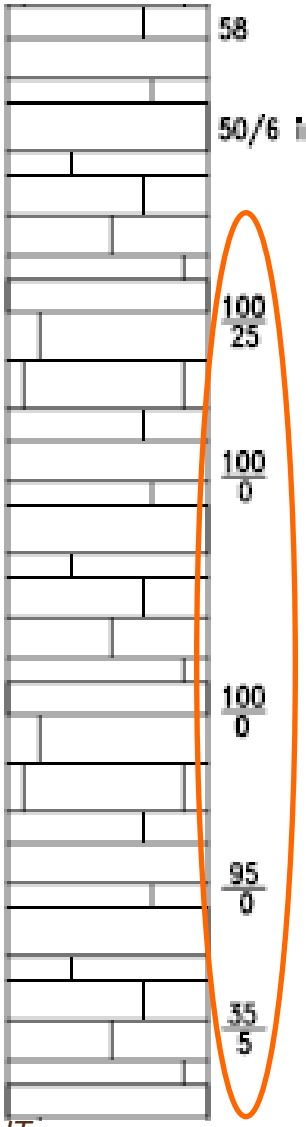
Sample Profile



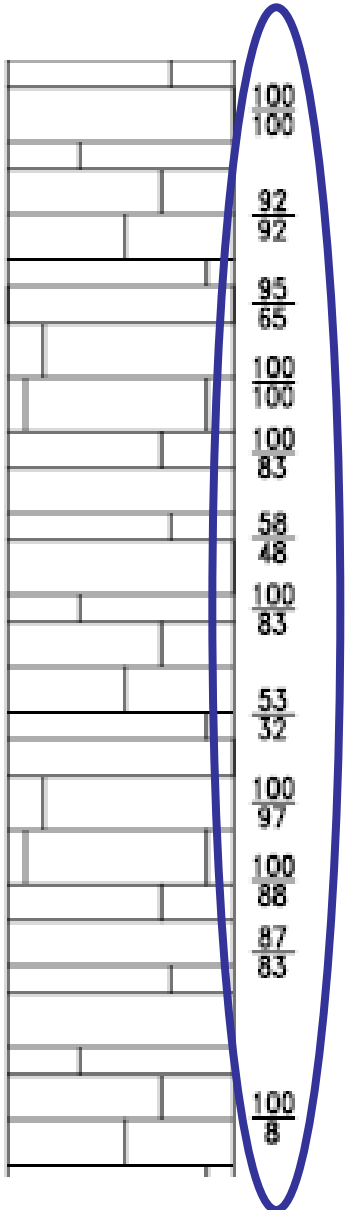
Sample Profile



Coring Comparison

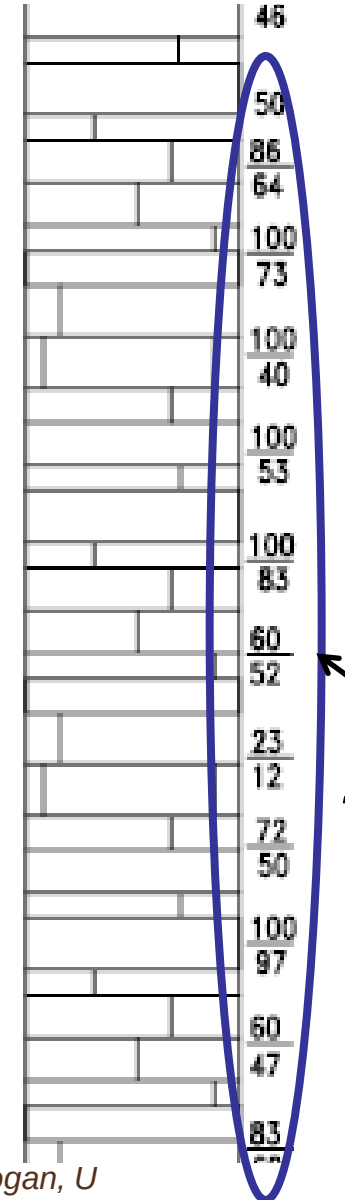


Previous Methods

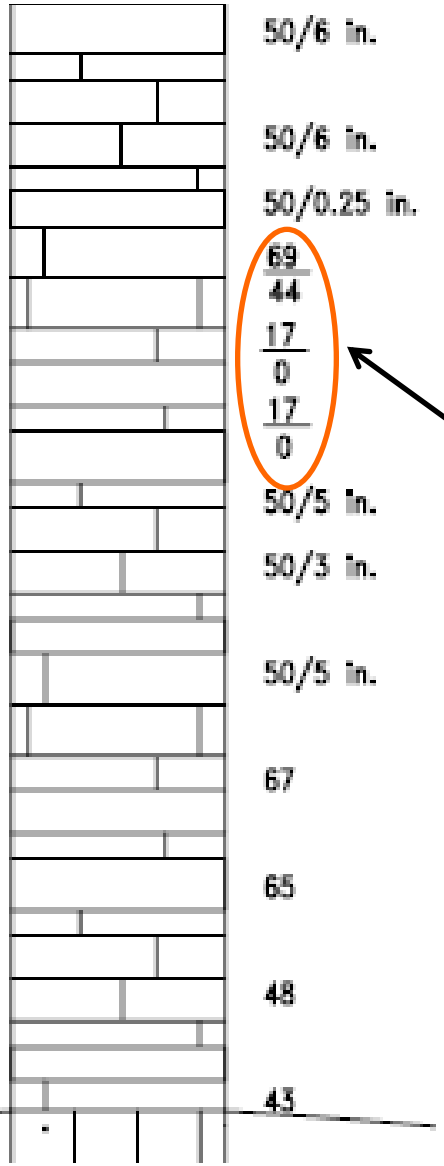


Triple-Tube Coring

Coring Comparison – Cont.



Triple-Tube Coring



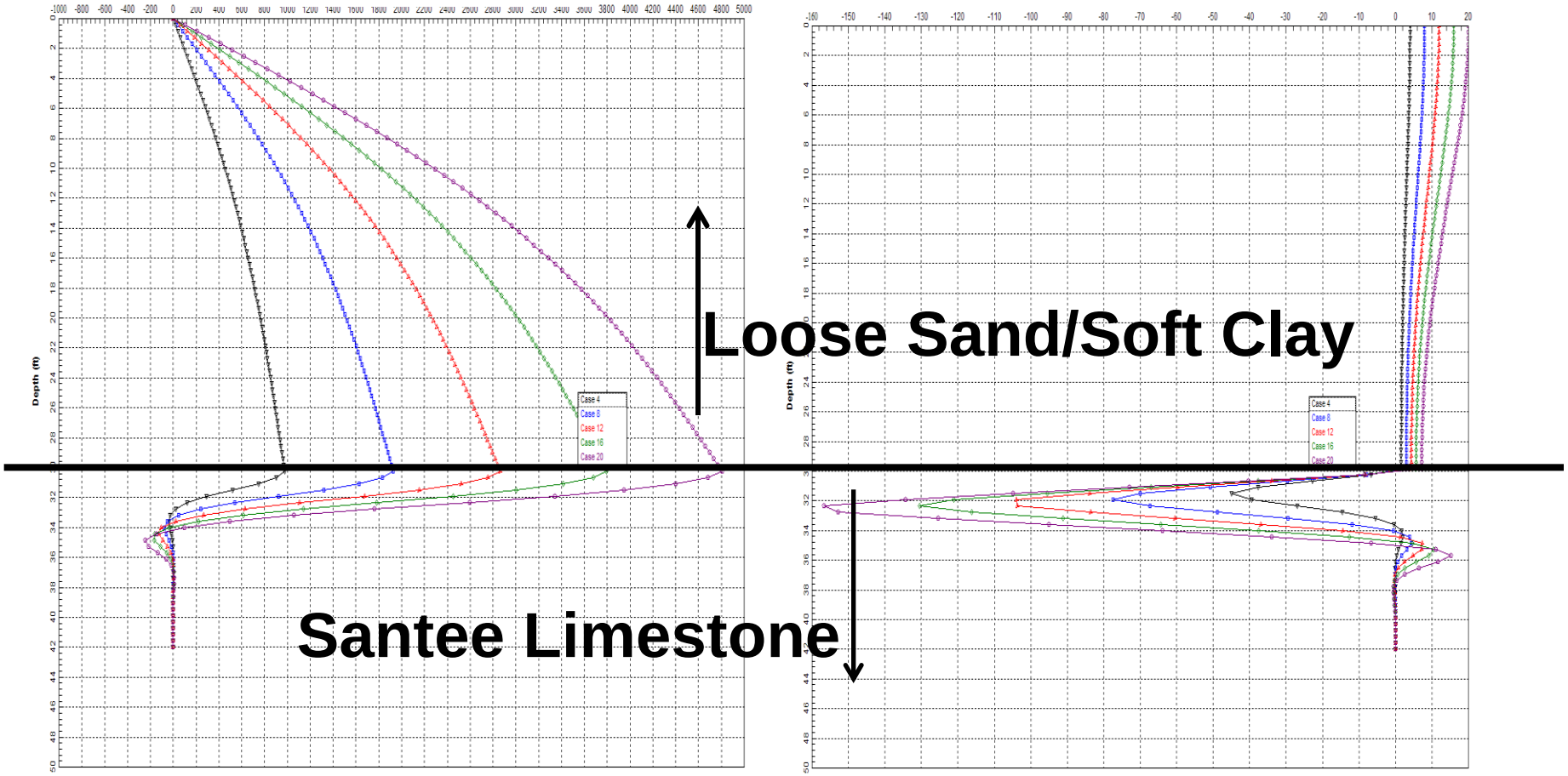
Previous Methods

Foundation Design – Part 1

- 3’ or 4’ Diameter Drilled Shafts
- Rock Sockets: fs=12ksf
- 300 ton Design Load

Drilled Shaft Lateral Response

Moment ***Shear***

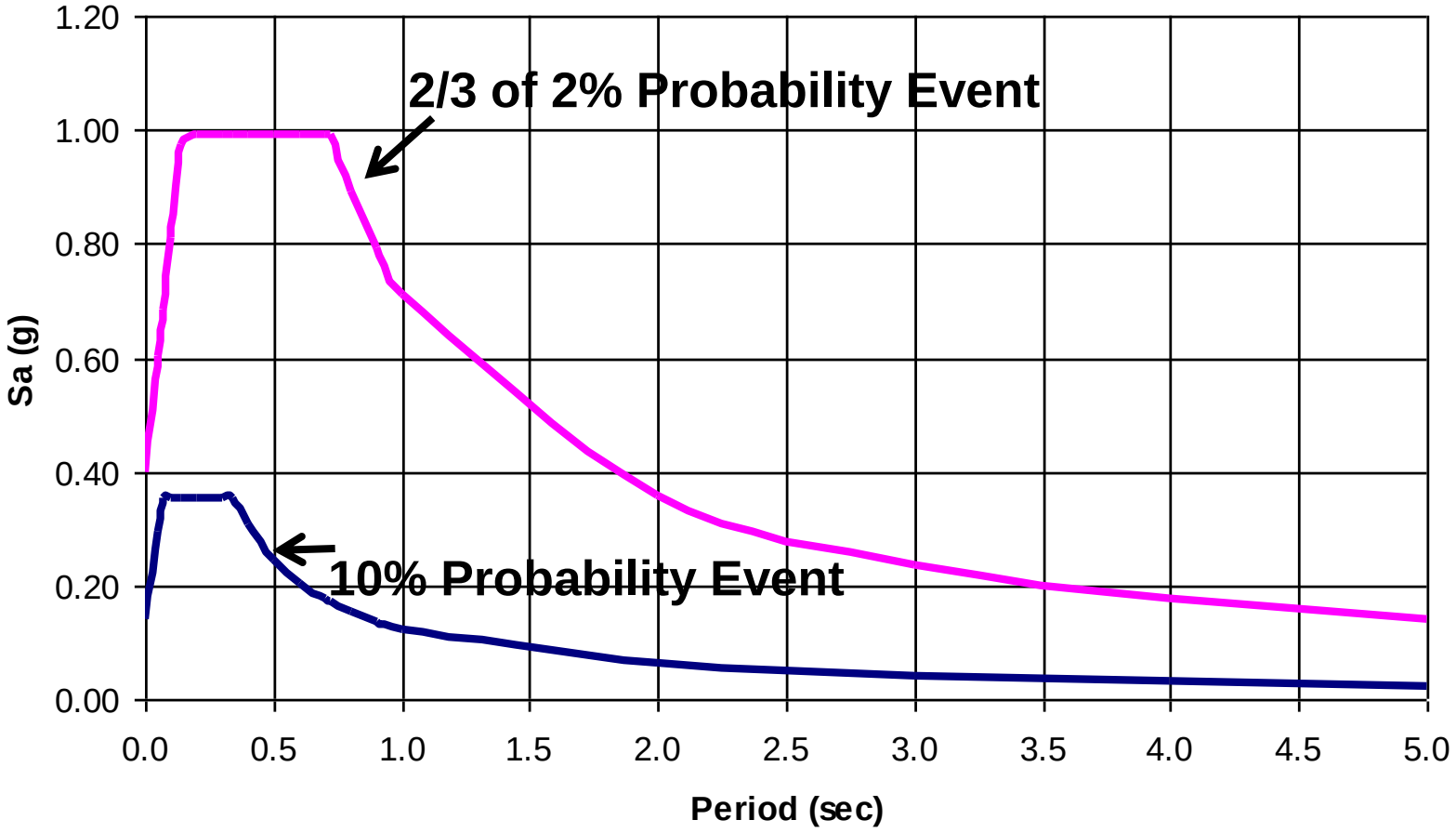


Change Since Units 1 & 2 Design

- New Design Event in Building Code
  - Prior Codes: 10% prob of exceedance in 50 yrs
  - IBC: 2% prob of exceedance in 50 yrs (w 2/3 factor)

Seismic Hazard Differences

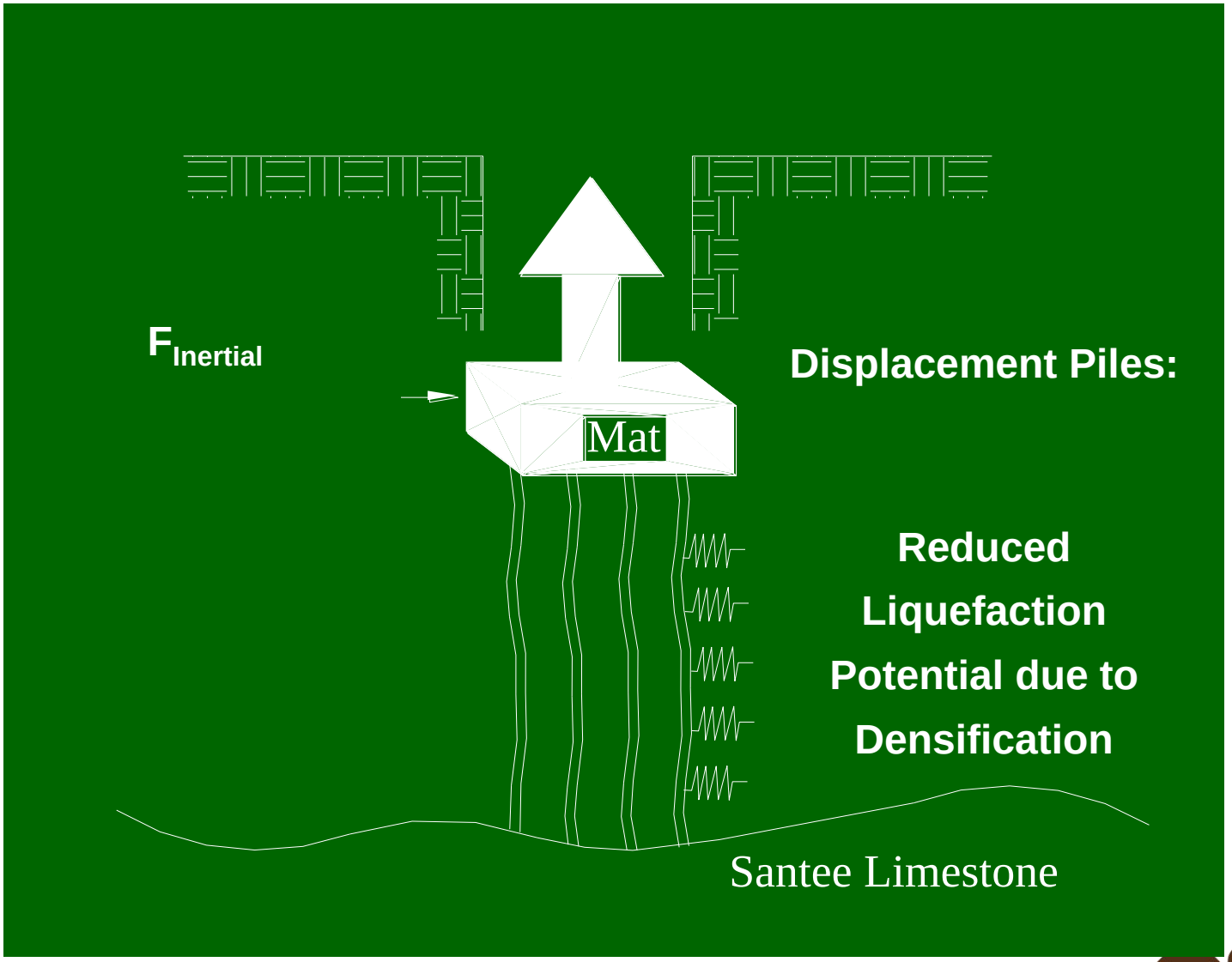
Pineville Response Spectra



Foundation Alternatives

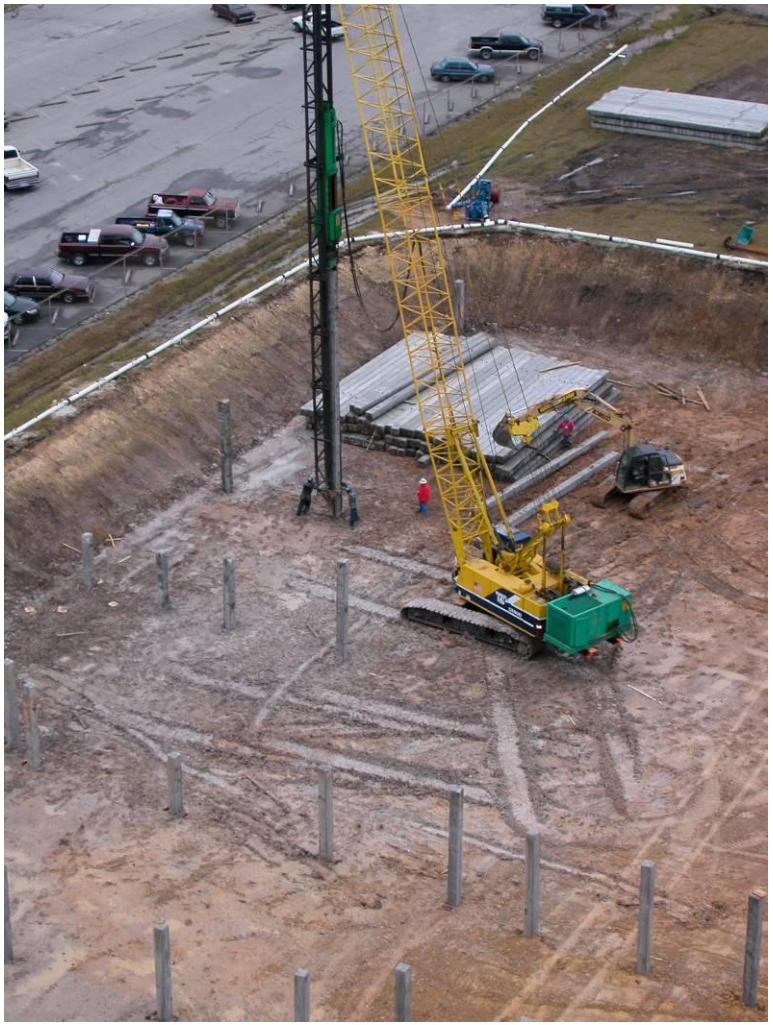
- Larger Shafts
- Ground Improvement
- Driven Piles
  - “Flexible”
  - Reduced Liquefaction Potential

Driven Pile Model



Foundation Design – Part 2

- Driven Piles Bearing on the Santee Limestone
- 14-in. square PSC Piles: 100 Ton Design Load
- 12-in. square PSC Piles: 70 Ton Design Load
- Savings of $6 to $8 million on Unit 3
- Savings of 1 to 2 months on Unit 3



Construction

- 20,000+ PSC piles driven
- 30 piles per rig per day
- PSC Pile Manufacturers: Tekna & Palmetto Pile Driving
- Foundation Costs > $100 million

Summary

Driven Piles

- Simplicity
- Cost
- Reliability

Drilled Shafts

- Capacity
- Geologic Versatility

Thanks for Listening

????

Billy Camp, PE, D.GE
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843-884-0005