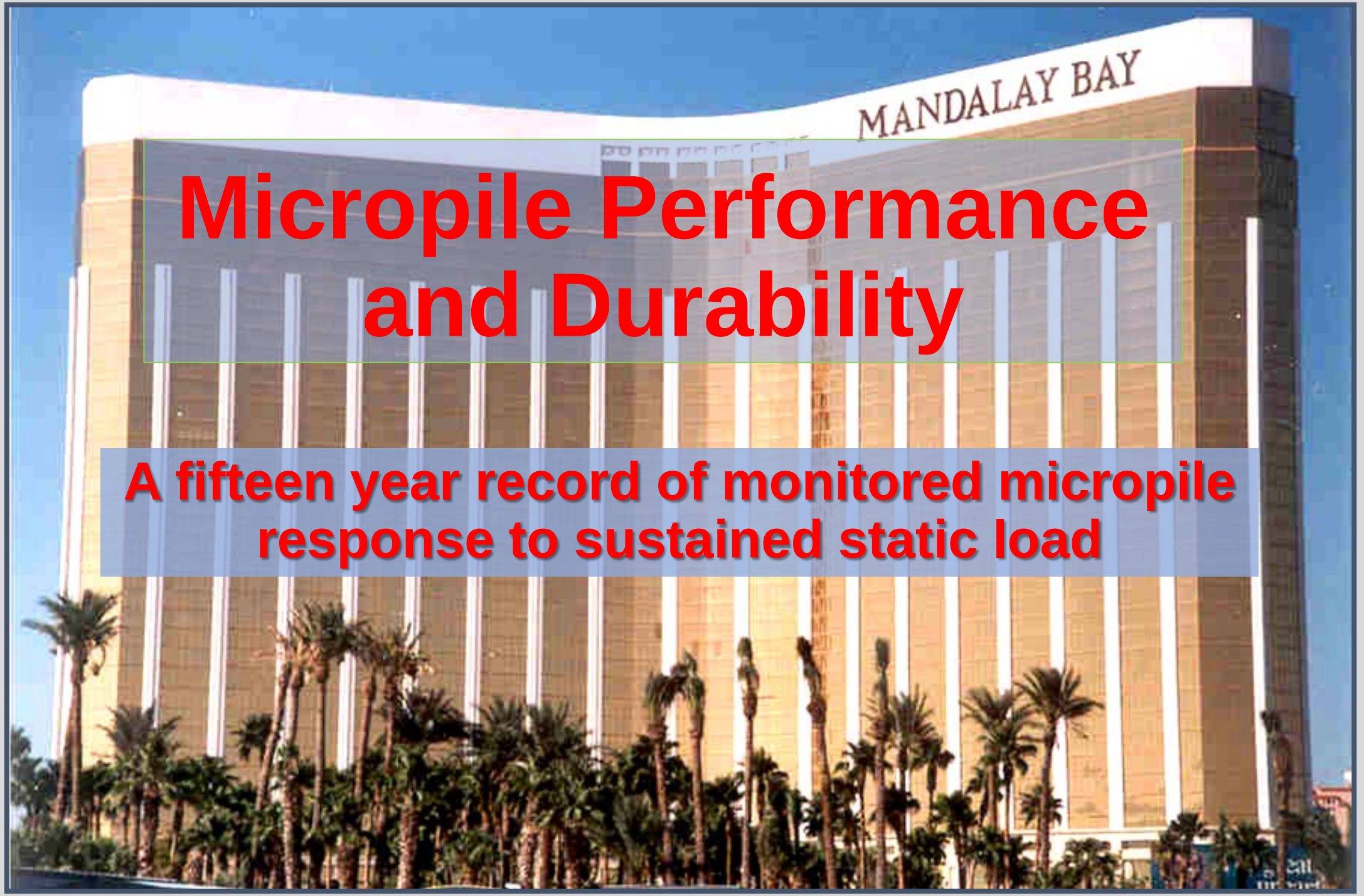
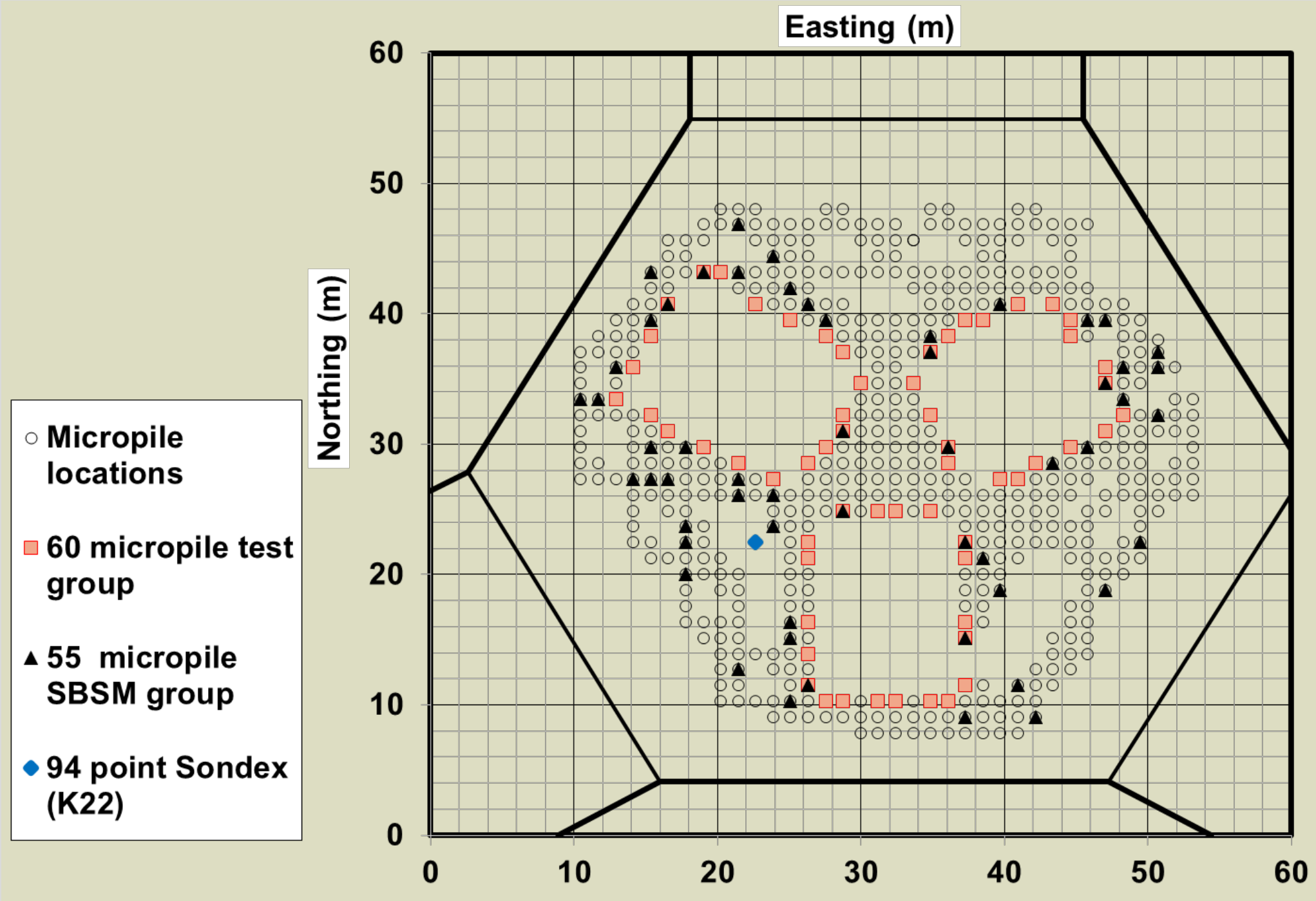
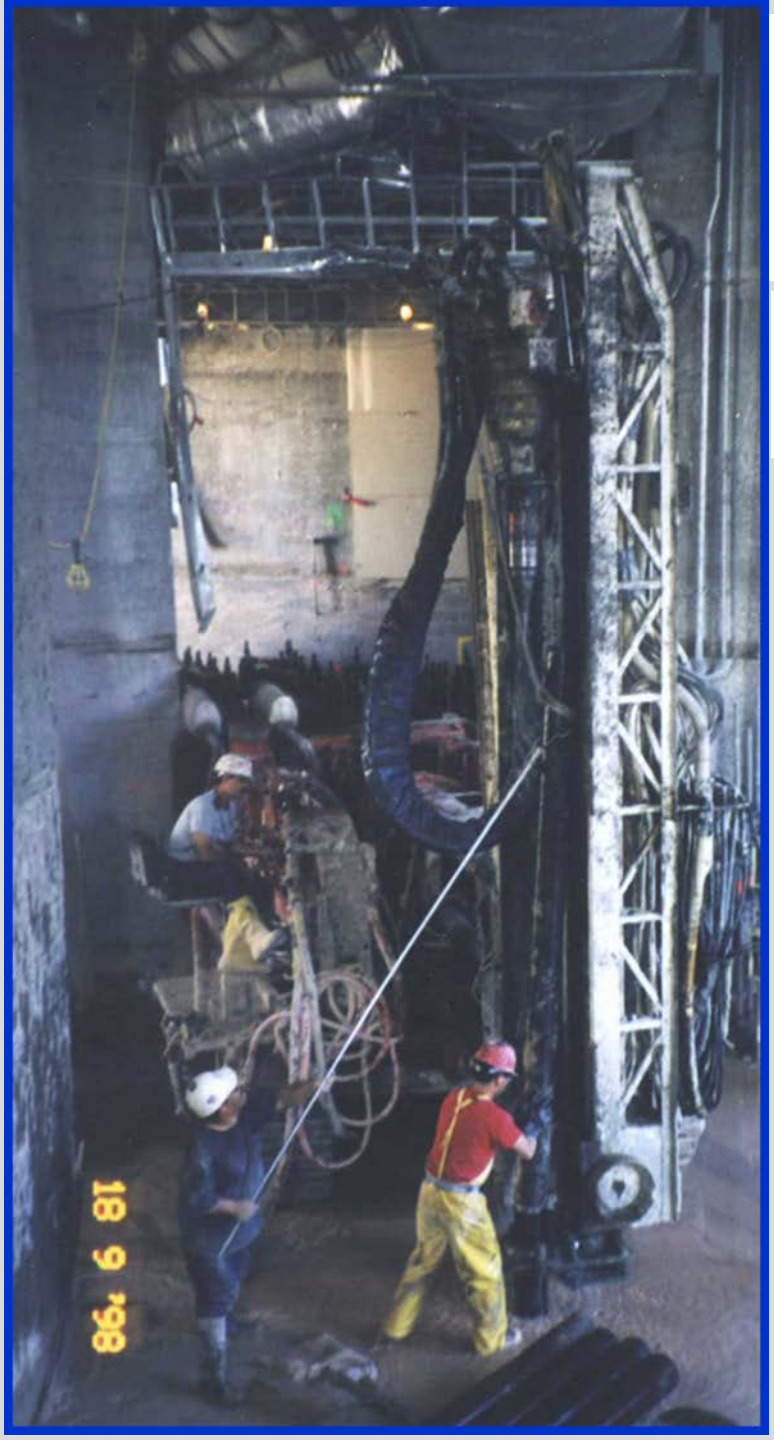


Micropile Performance and Durability

A fifteen year record of monitored micropile response to sustained static load


Easting (m)
Northing (m)
0
10
20
30
40
50
60
Micropile locations
60 micropile test group
55 micropile SBSM group
94 point Sondex (K22)

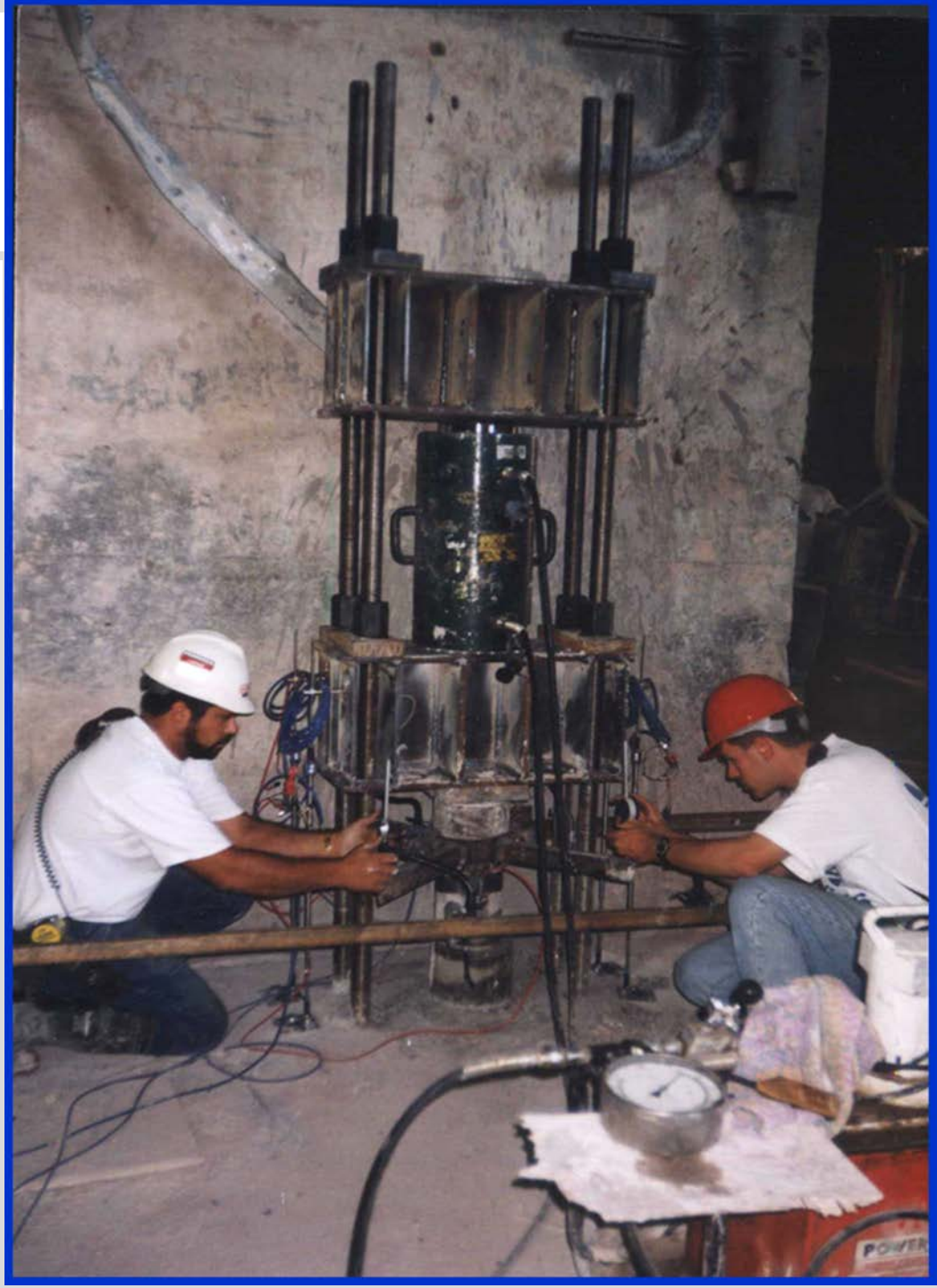


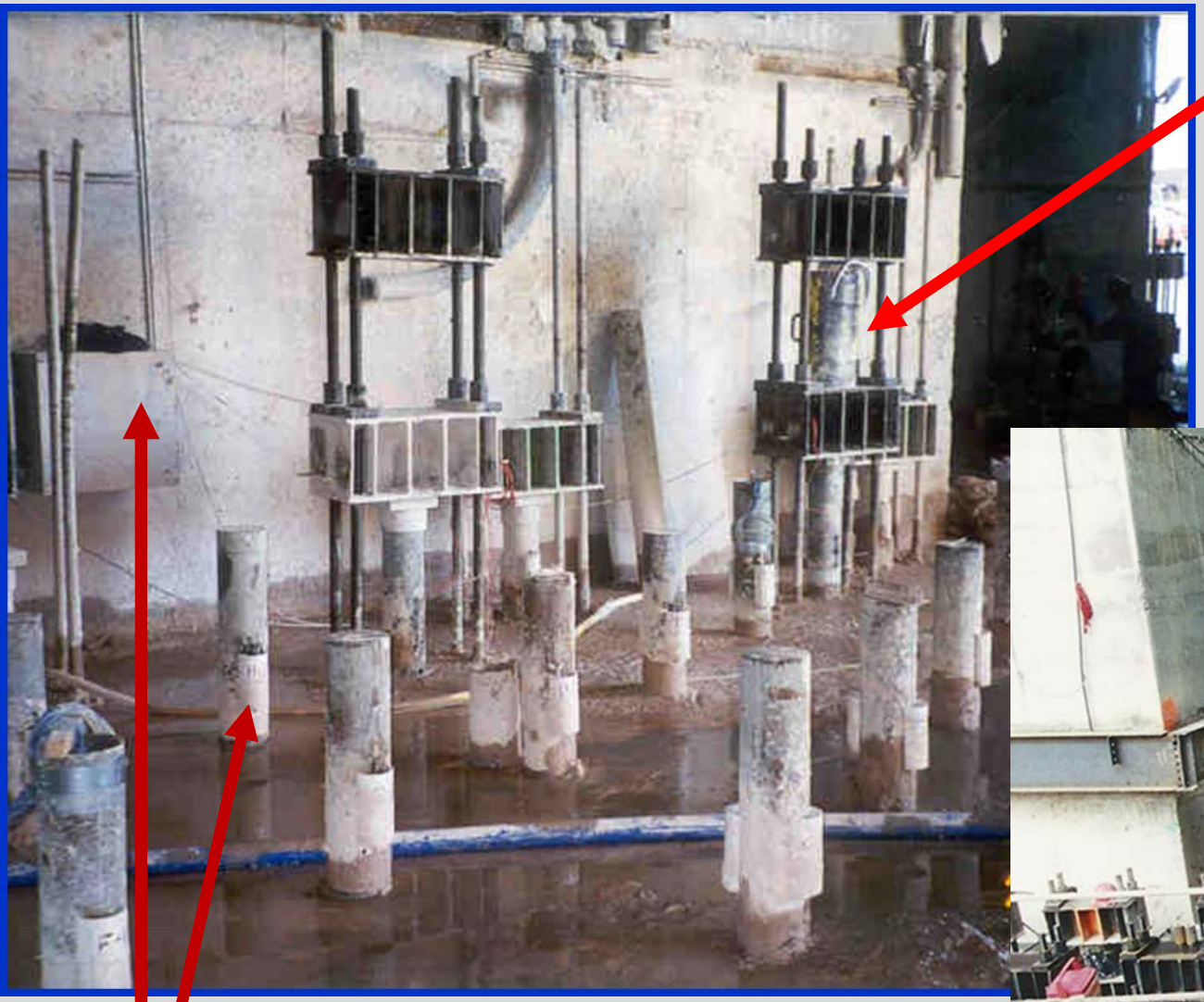
ISM 2014
Krakow, Poland

Walter E. Vanderpool
P.E.

- Installation @
MP C19, Sept.18, 1998

- Load test @ MP BB7
August 11, 1998



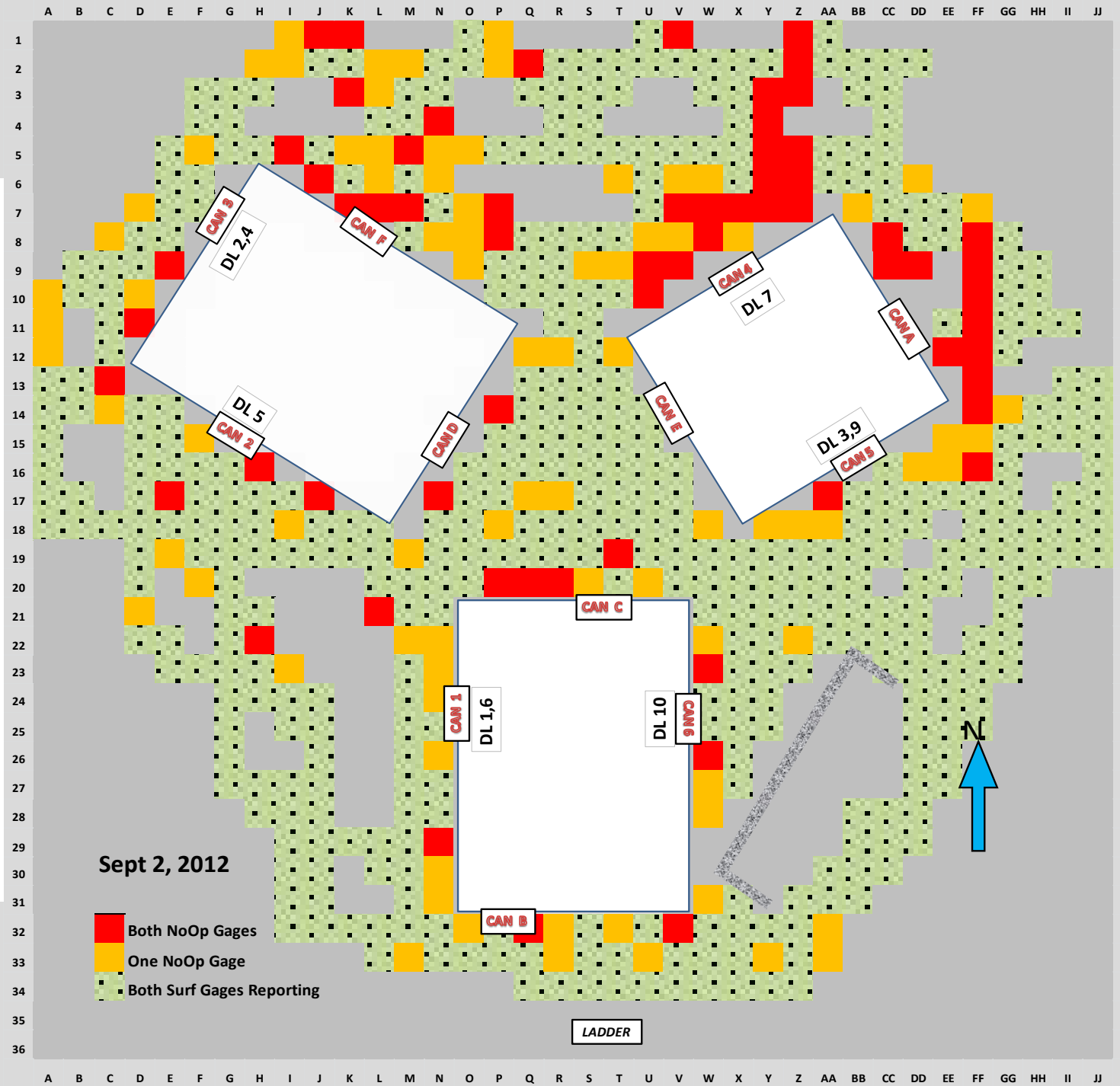


- Micropile L18 8/27/1998

- Installation complete 10/30/1998

- Temporary data logger mount & cables
- SMSG's with PVC covers

- By September 2012, 210 gauges had failed
- Both gauges on 64 micropiles
- One of two on 82 additional micropiles
- Maintenance in 2013 restored both SMSG's on 58 micropiles and recovered one gauge on 25 additional micropiles.



Micropile N31
Installed7/24/1998
Load tested 8/4/1998
Conditions 12/12/2013

- Micropile grid lines 27 – 28 from row A (west side)10/28/1998

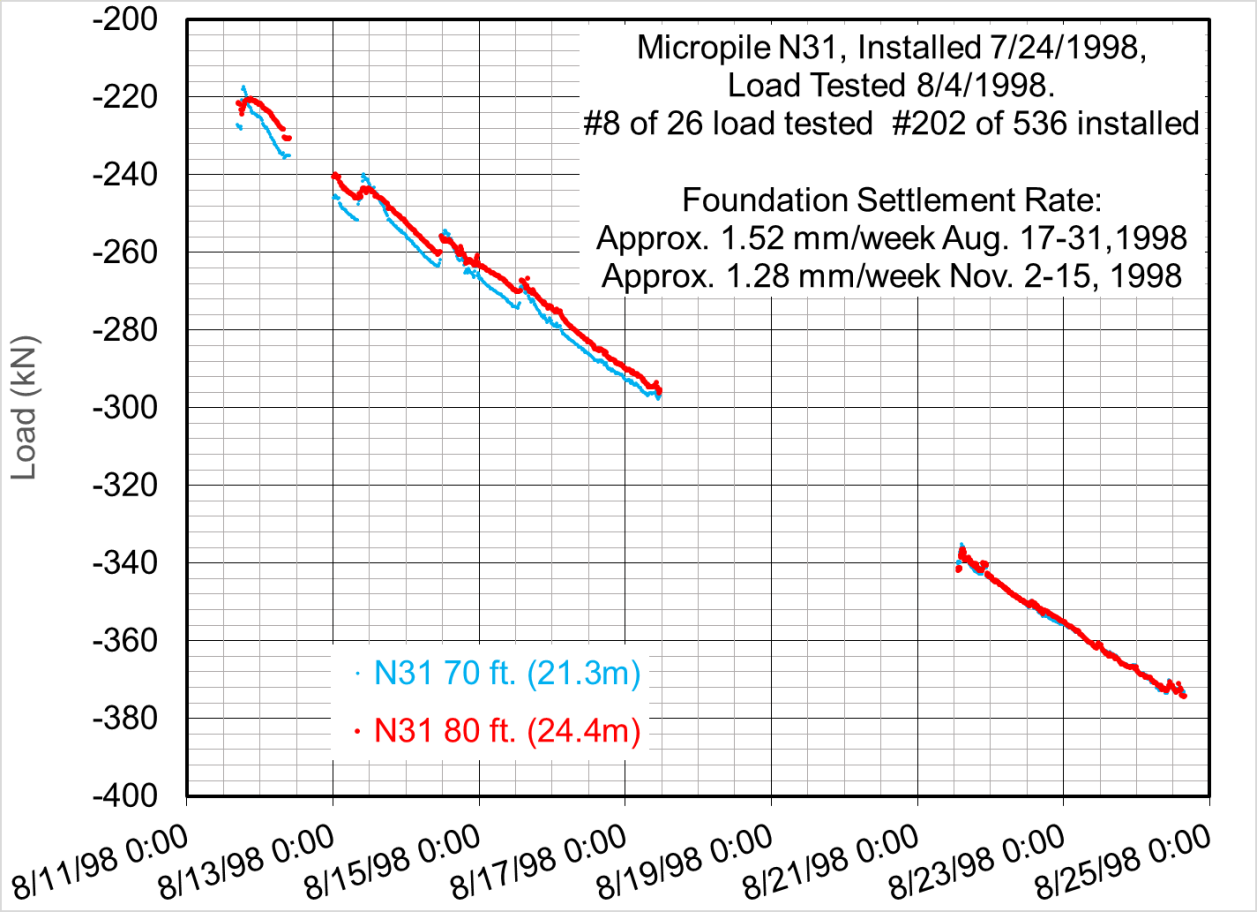
- Condition at micropile grid Q32 on 12/12/2013

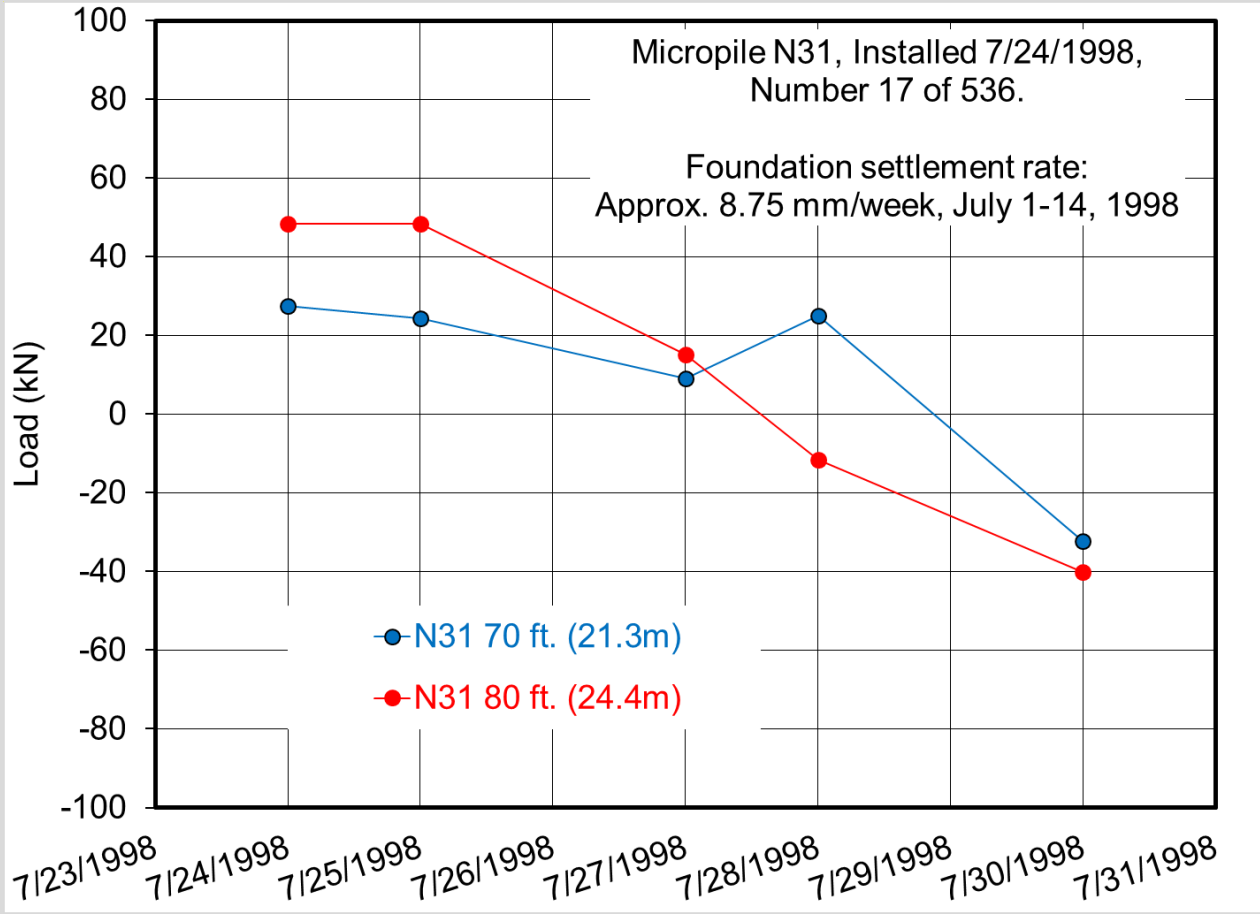
- Conduit conditions 12/12/2013 at grid lines 27 - 28

Conditions 12/12/2013 at cable box on north wall of NW elevator

- Micropile plan, grid line J 12/12/2013

- Micropiles began taking on load as soon as the grout set.
- Load development of approximately 15 kN/day before load test and 10 kN/day by 8/25/1998.





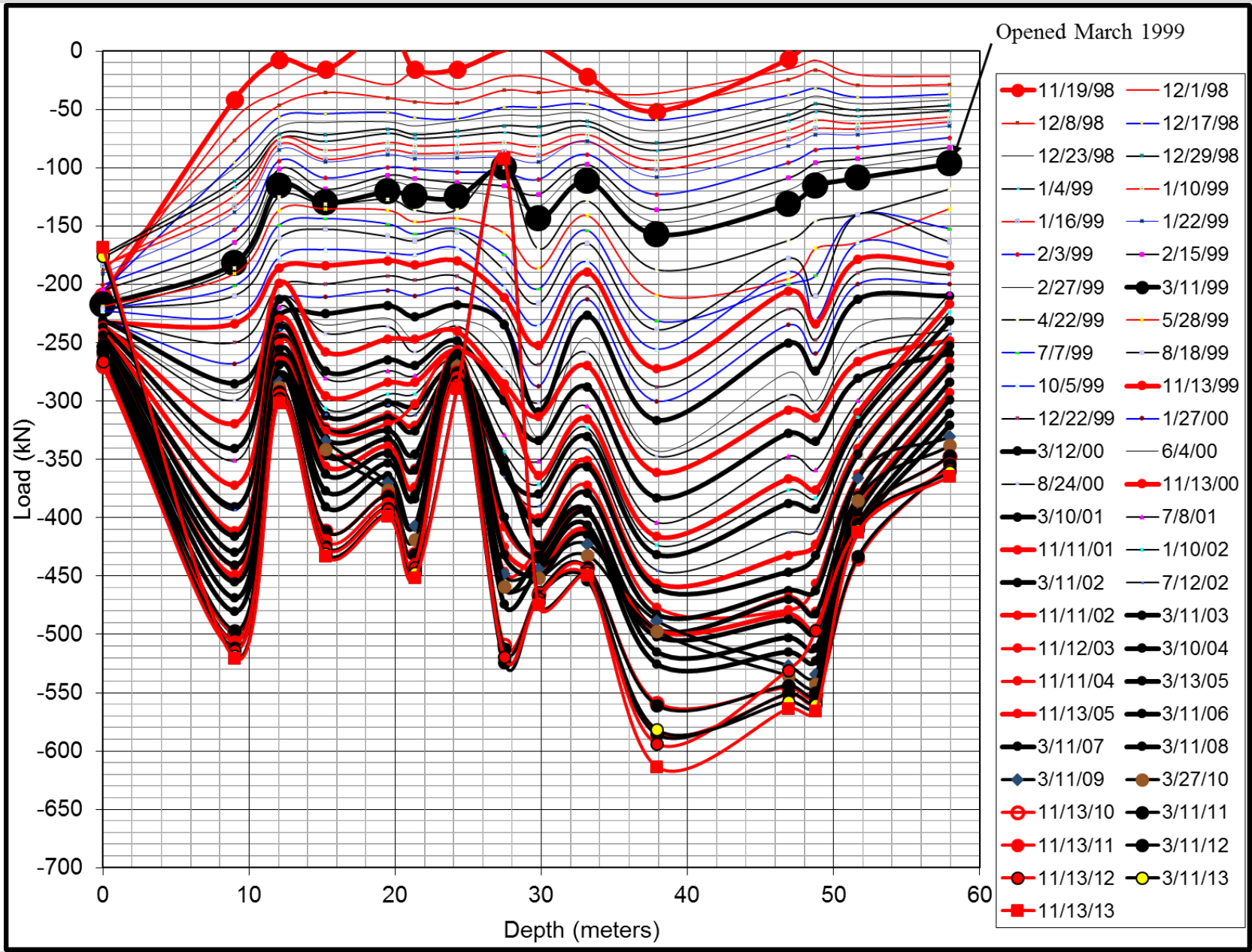
- Data only collected from one micropile (N31) between the load test (8/4/1998) and the 11/13/1998 load application due to site congestion.

Micropile load by depth interval in time domain

- Typical load pattern for 14 depth intervals.
- Fifty dates from the 15 year period

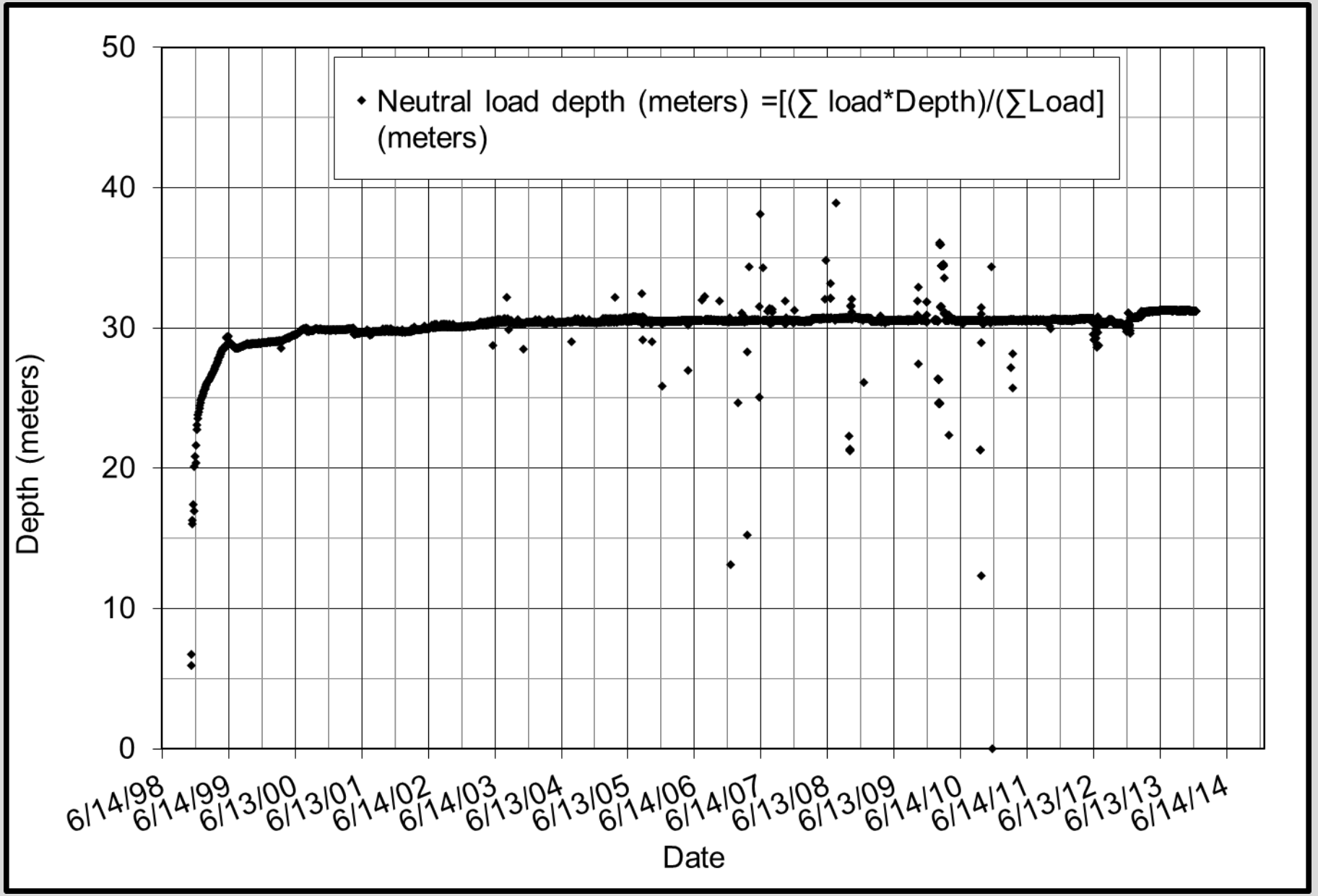
- November 13, 1998 load applied to top of each micropile - 222 kN/pile
- January 1, 2014 average load at top of each micropile 270 kN/pile

- Higher loads consistent with soft/compressible layers
- Lower loads consistent with cemented/strong layers



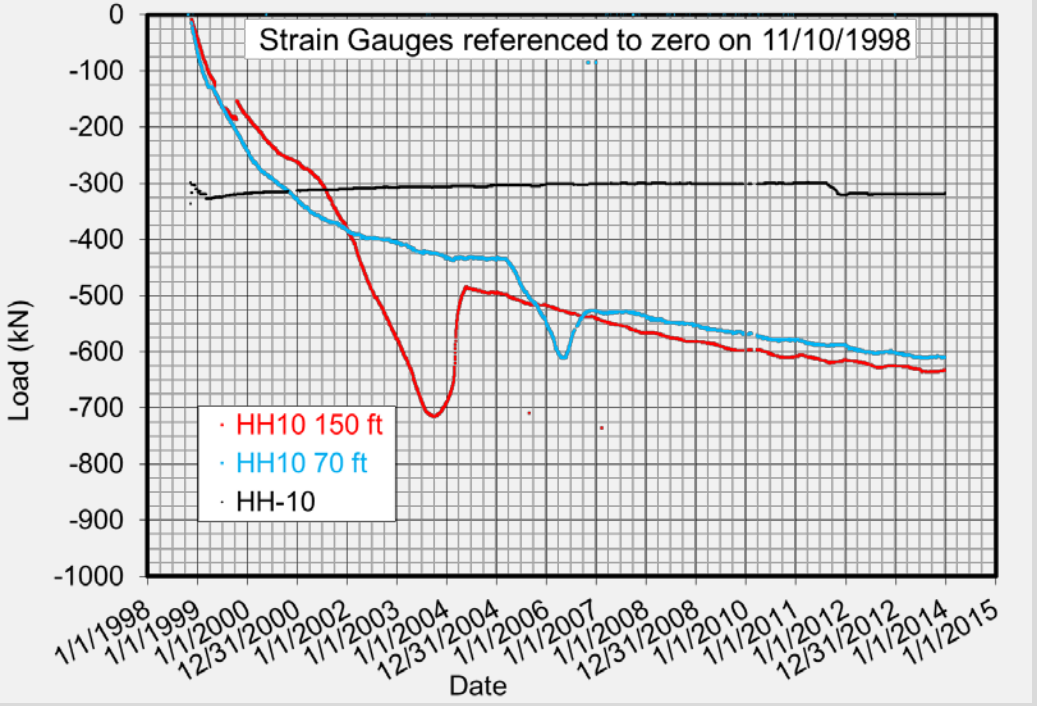
Micropile load centroid in time domain

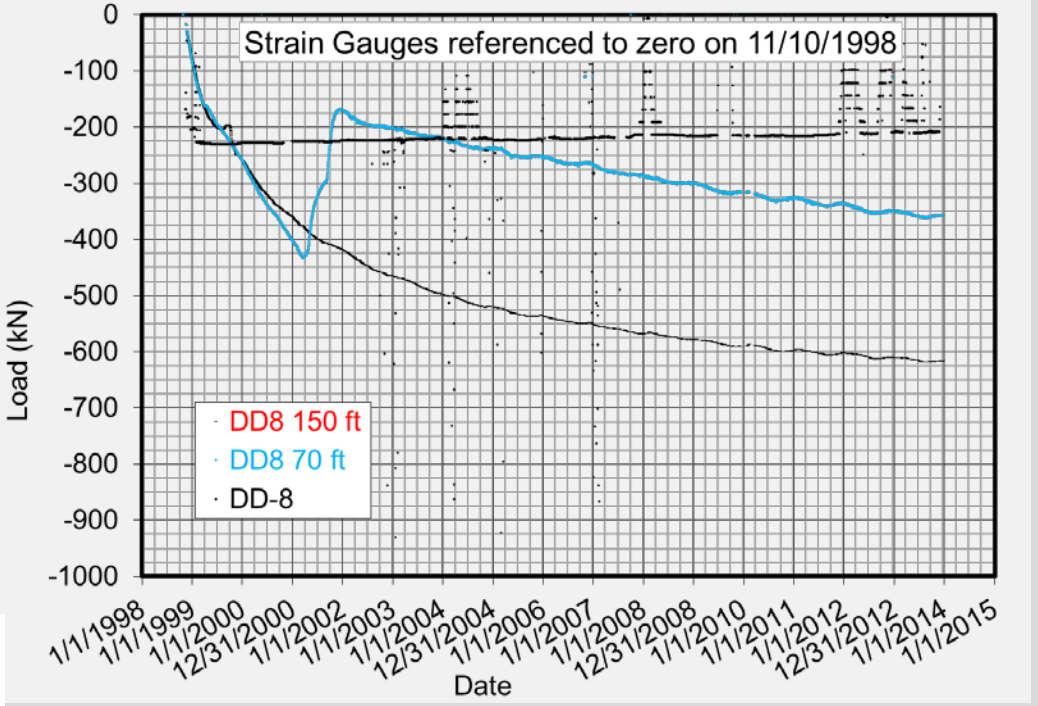
- Daily observations 11/13/98 to 12/28/2012
- Pile load migrated down the piles from 11/1998 to 6/2000
- Load centroid depth has remained nearly constant for past 14 years



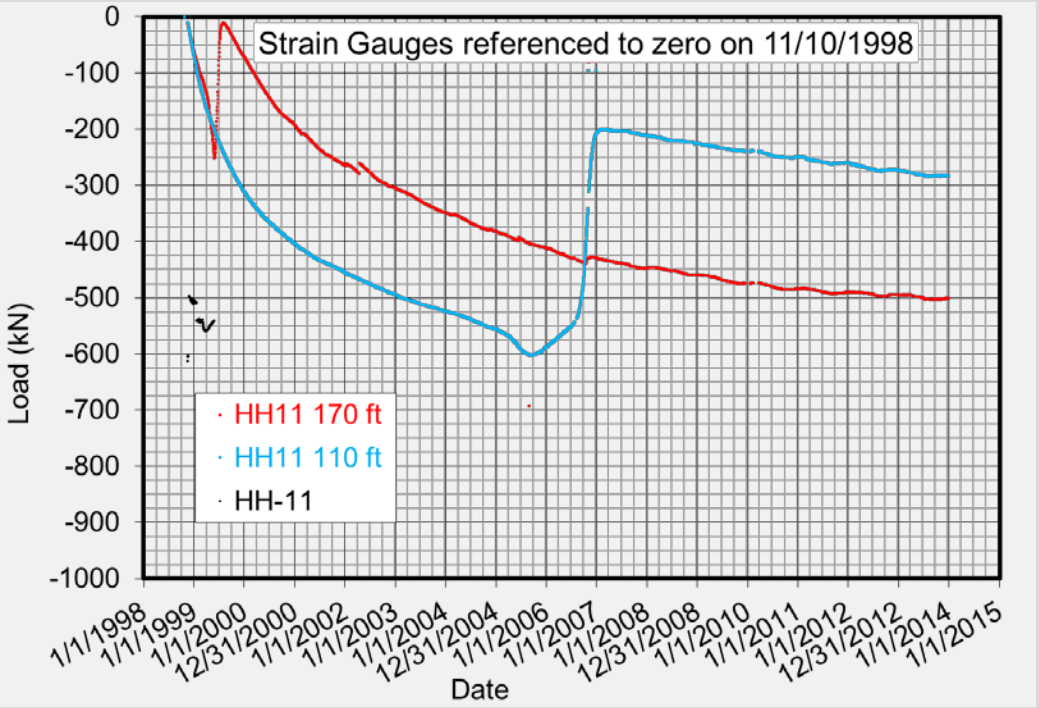
Conclusions

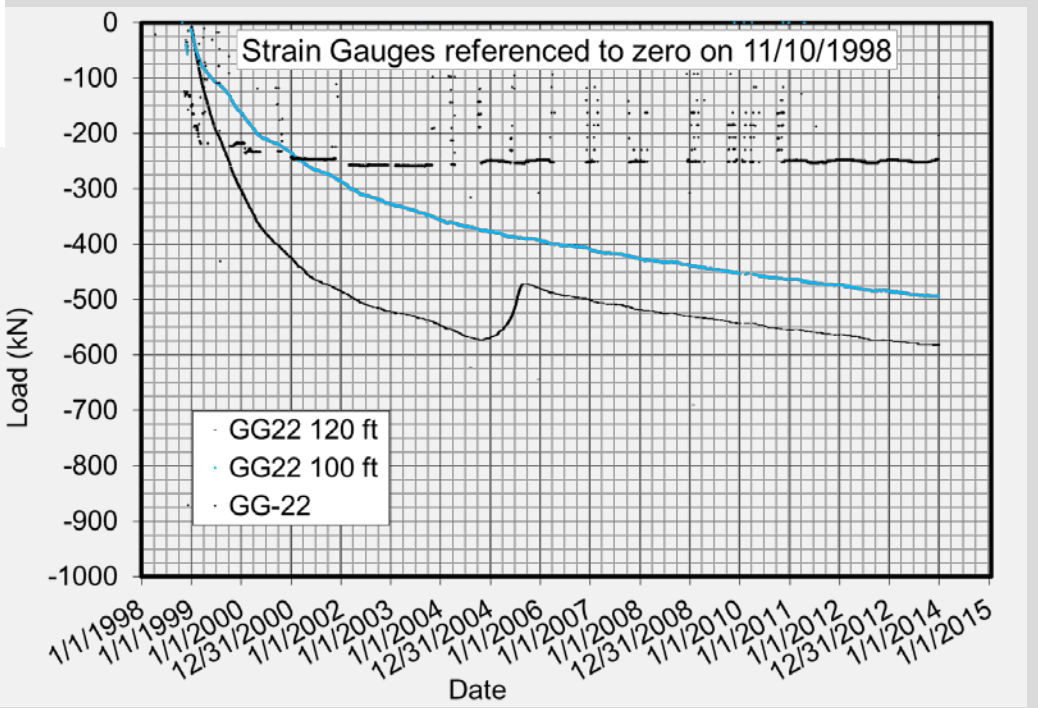
- “Steady State” is a little like “uniform, homogeneous, isotropic, normally consolidated, immediate elastic settlement, all in an infinite half-space”.
- The simplifying assumptions may be completely adequate for “geotechnical engineers” where “close enough for government work” meets the test.
- The equations of design have no basis in reality if the loads and material properties are not compliant with the design assumptions.
- And then there is the future…… The load? Load case? Construction sequence? Soil chemistry? Water levels? Climate cycles?
- **And then the rest of the story.**



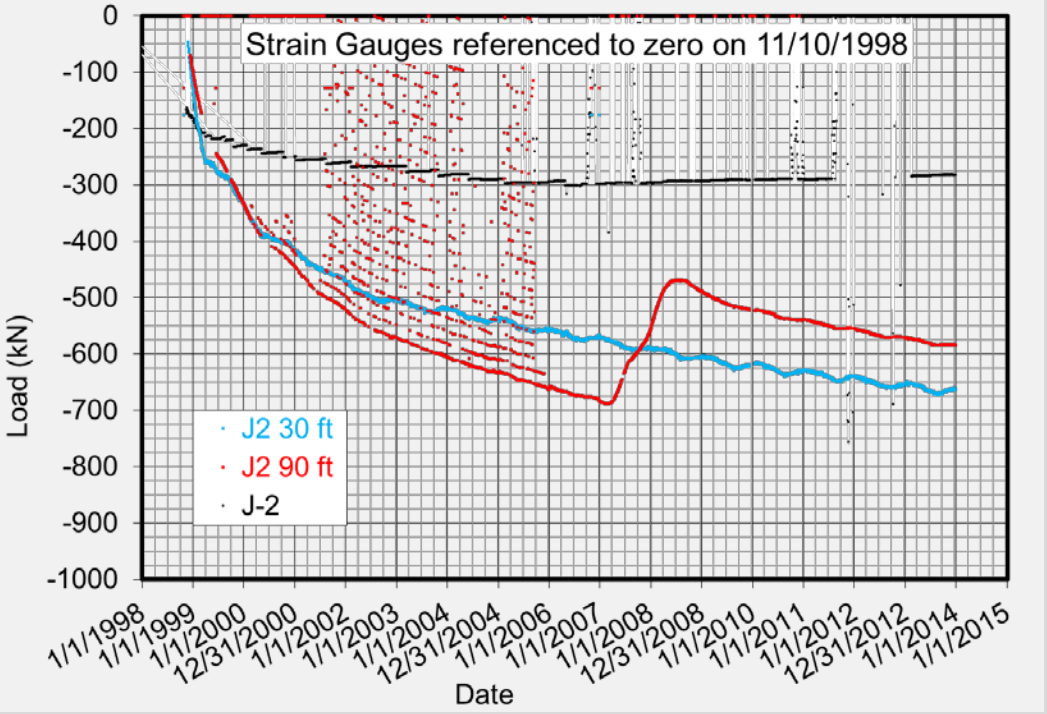


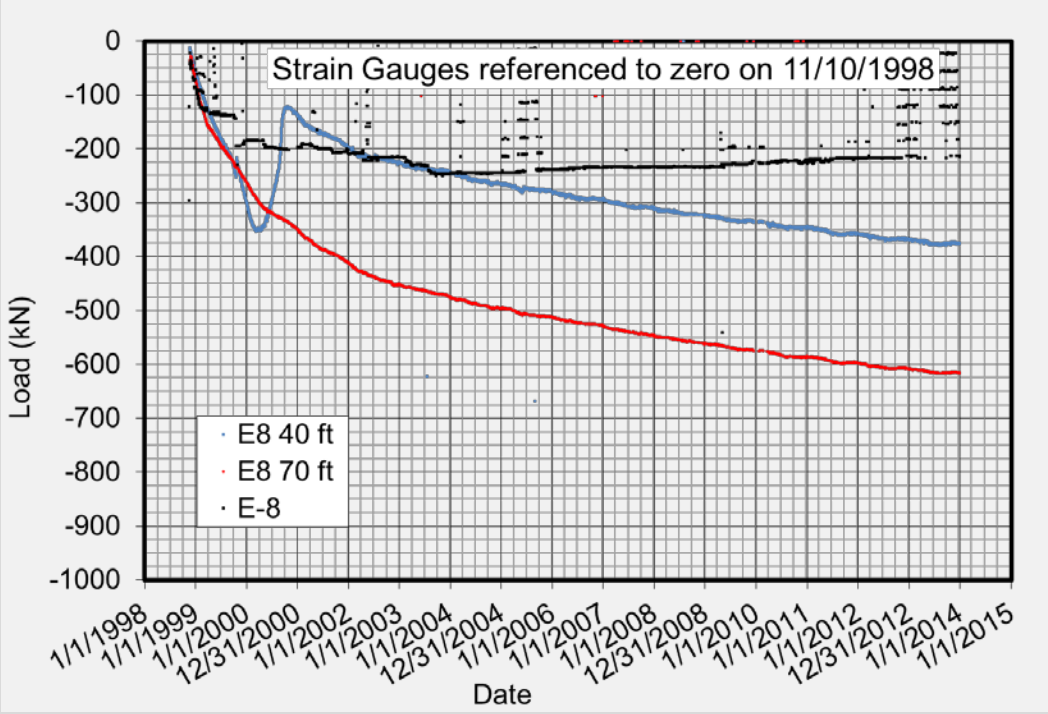
HH10 & HH11
Separated by
1.2 meters c/c

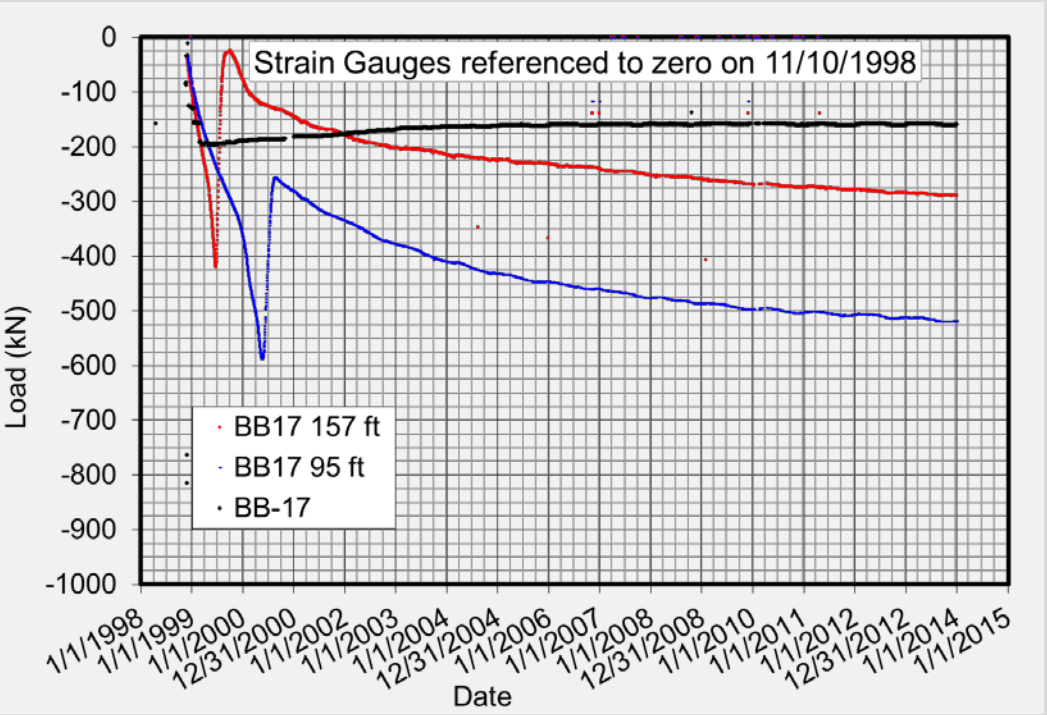


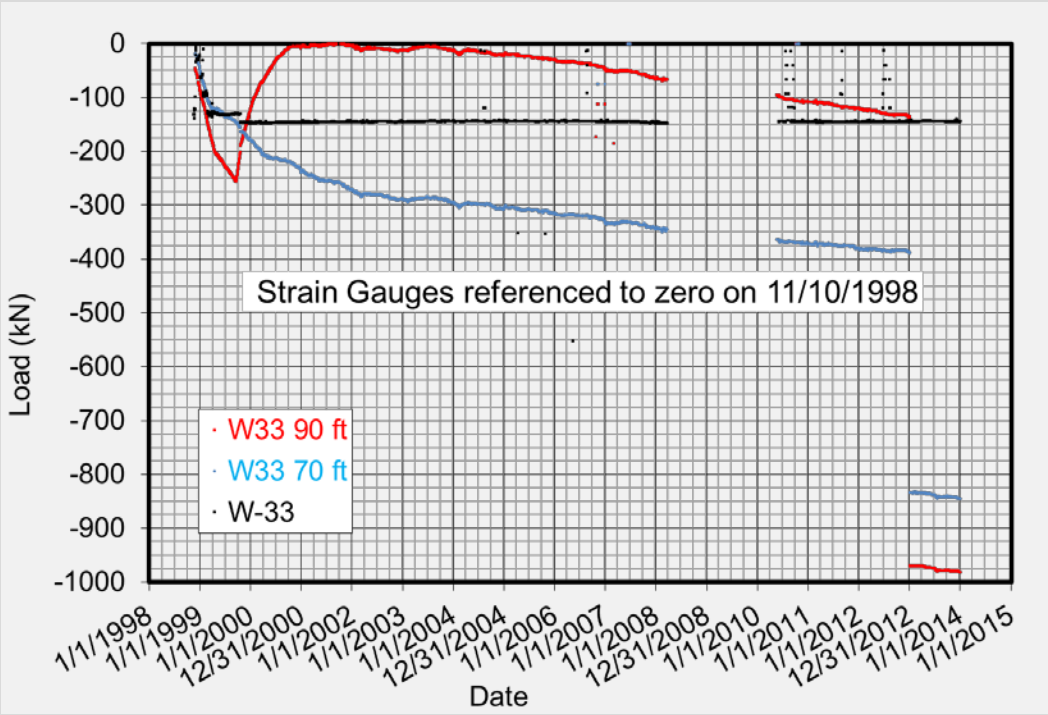


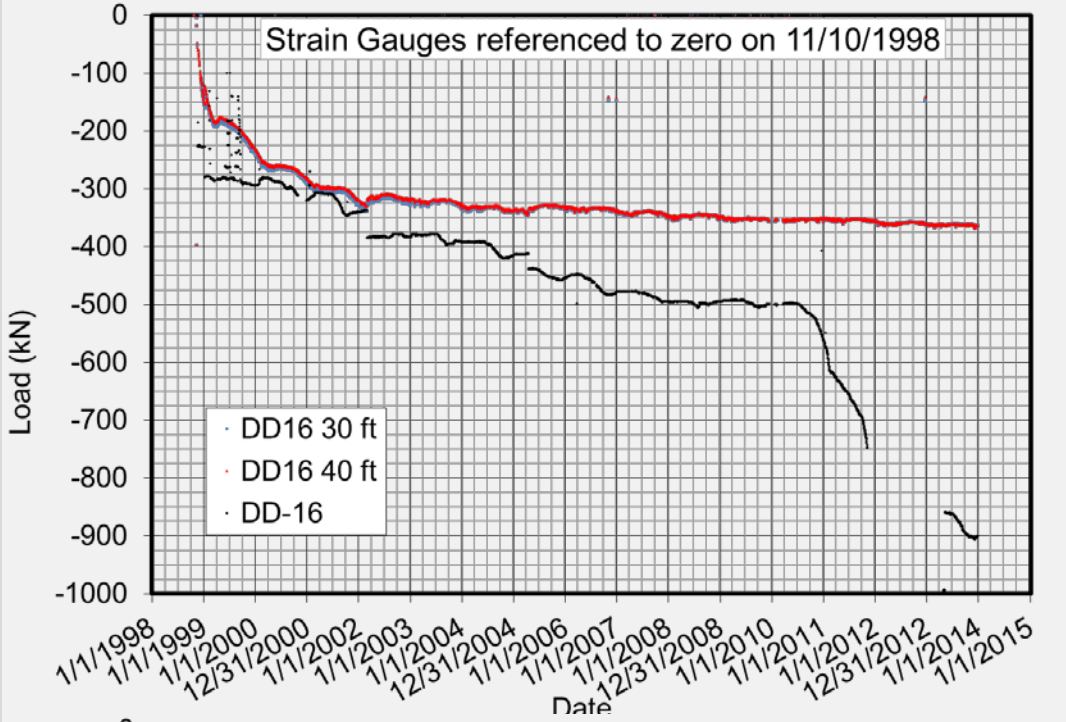
All data are discrete daily (11 to 12 PM) observations

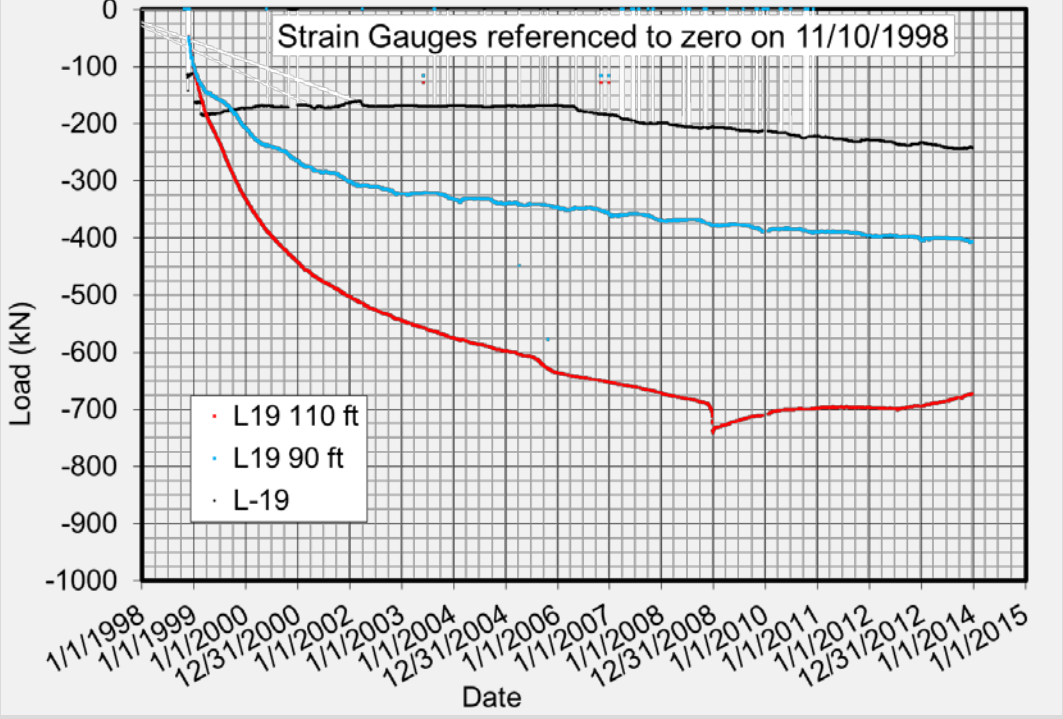


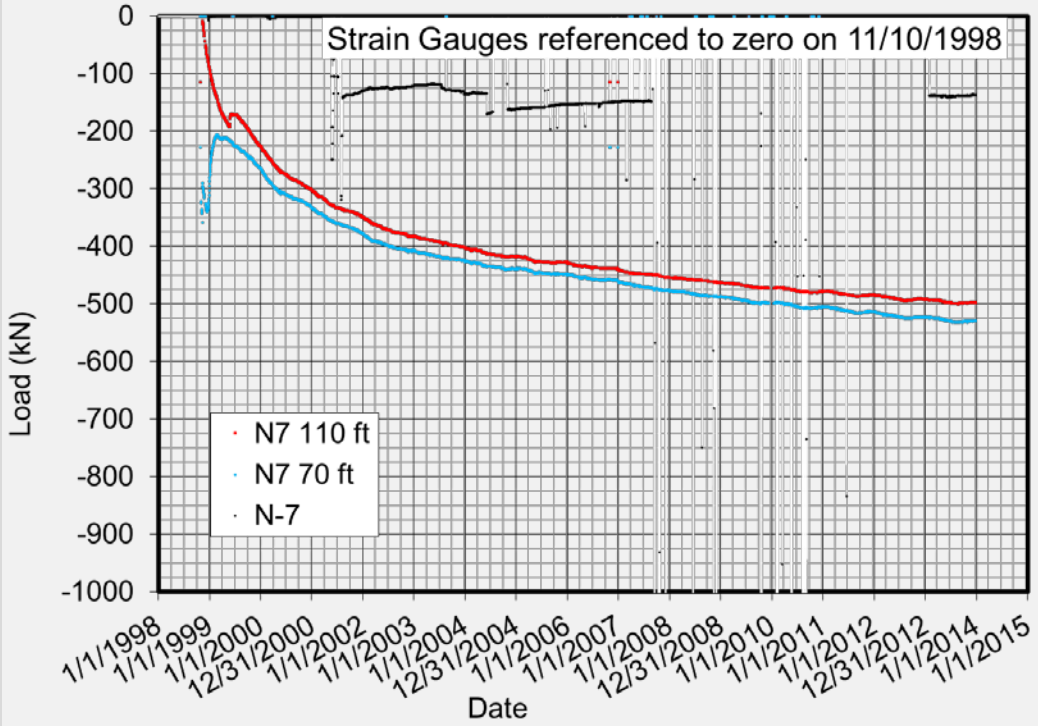






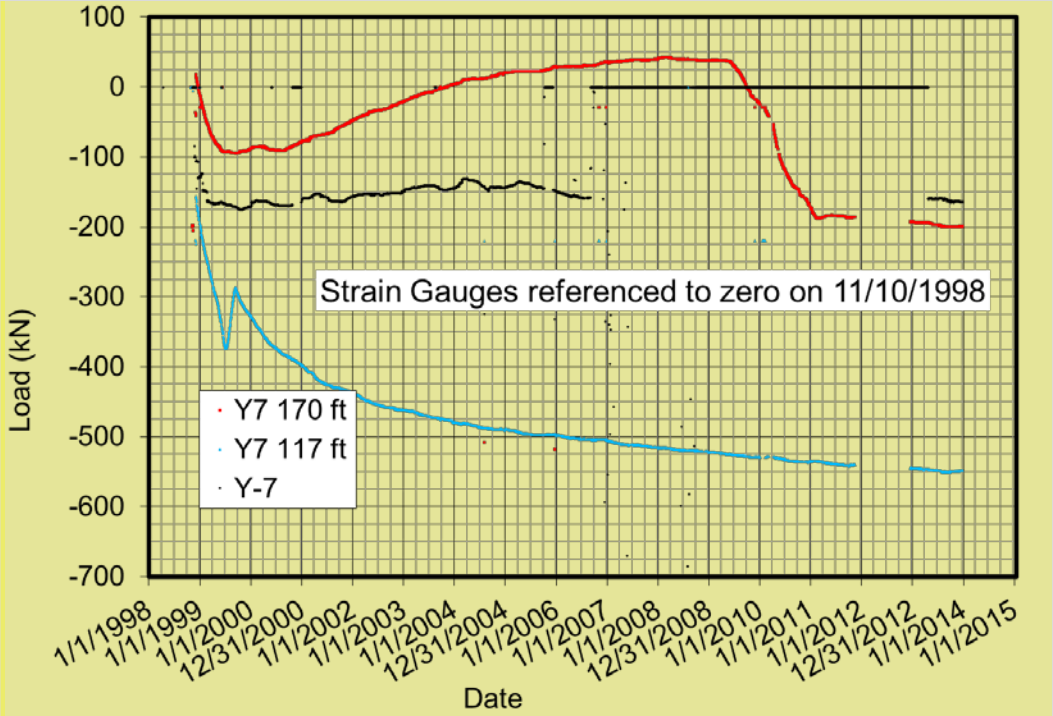


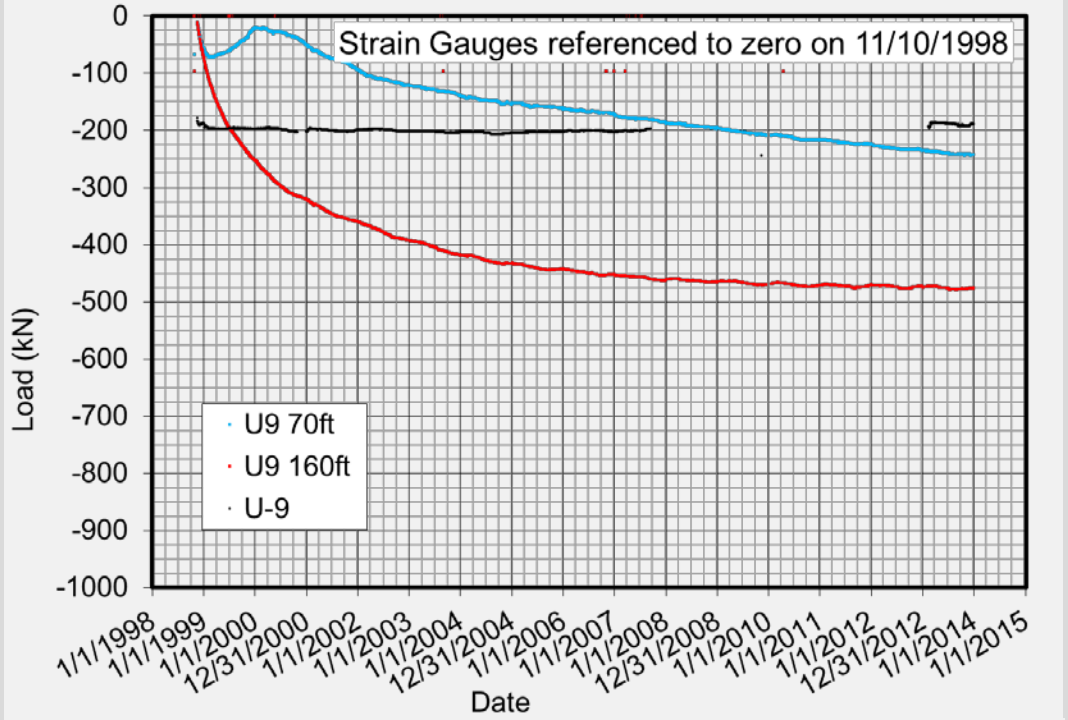


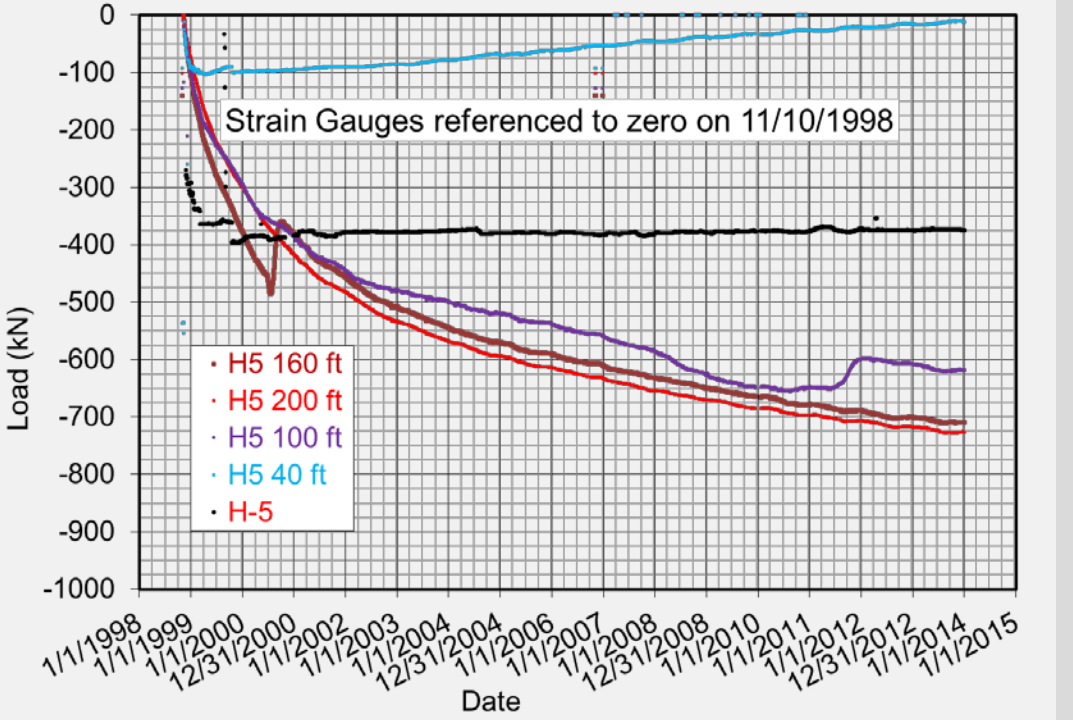


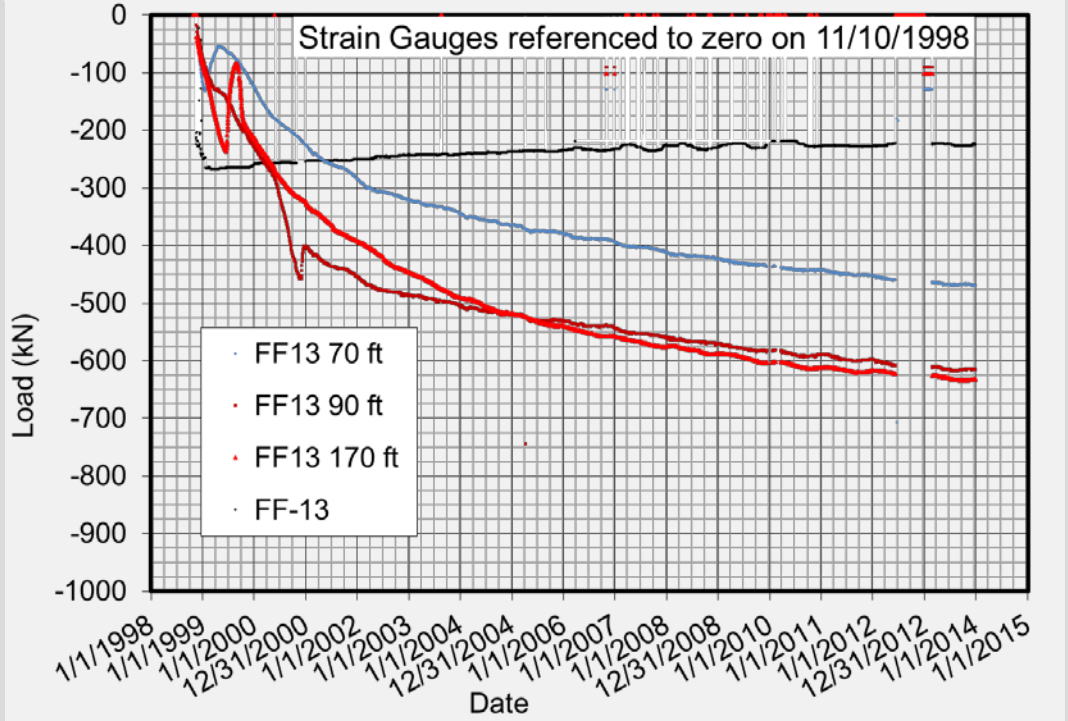
Implied tension based on the gauge zero reference established 11/10/1998

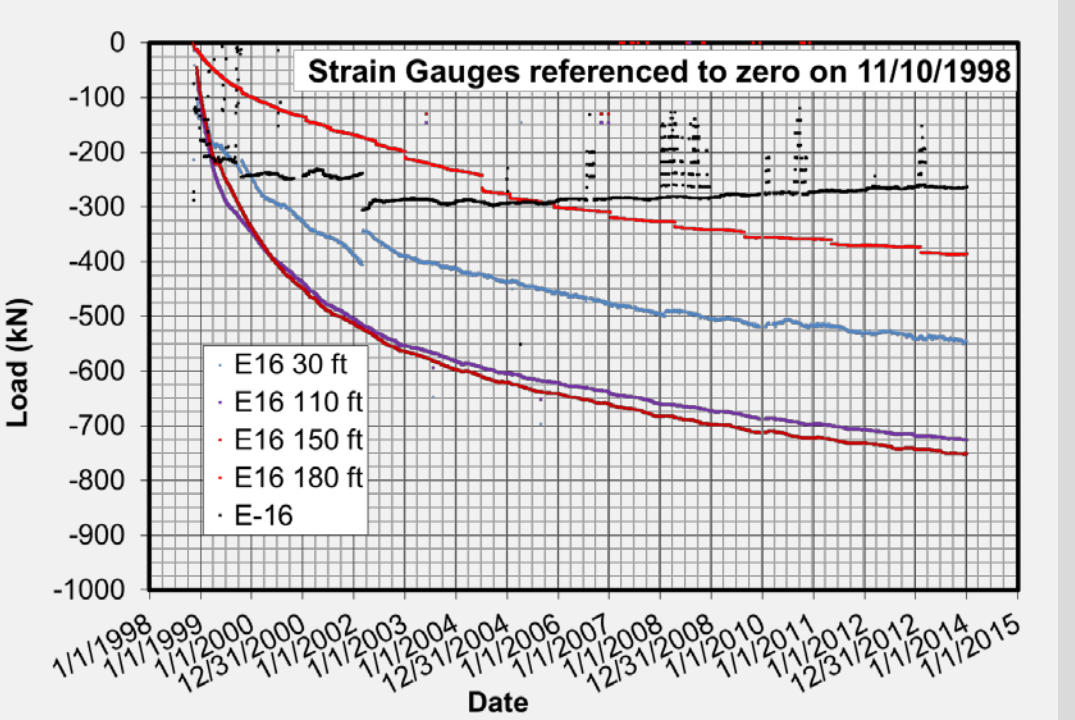
Note scale

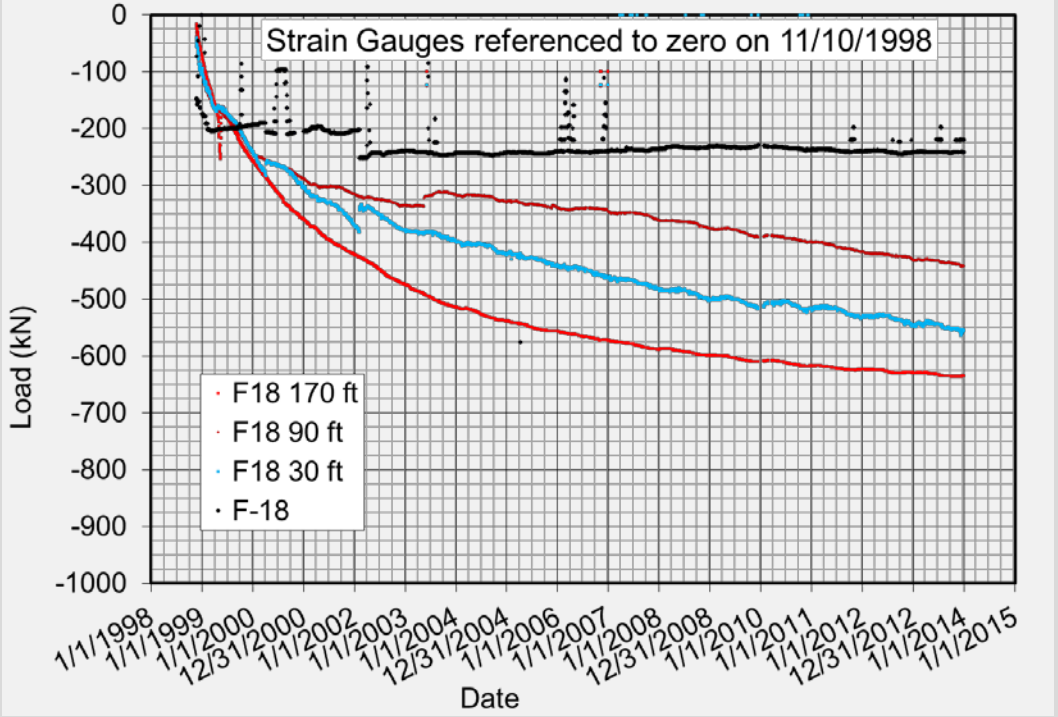


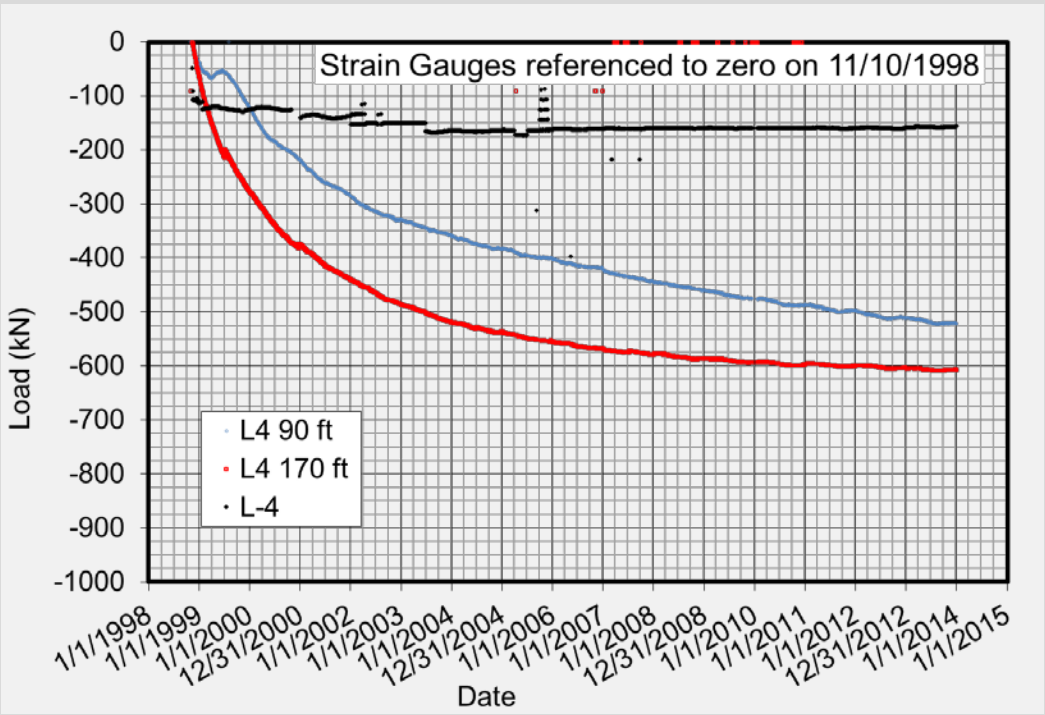

Strain Gauges referenced to zero on 11/10/1998
Load (kN)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
U9 70ft
U9 160ft
U-9
1/1/1998
1/1/1999
1/1/2000
12/31/2000
1/1/2002
1/1/2003
1/1/2004
12/31/2004
1/1/2006
1/1/2007
1/1/2008
12/31/2008
1/1/2010
1/1/2011
1/1/2012
12/31/2012
1/1/2014
1/1/2015
Date

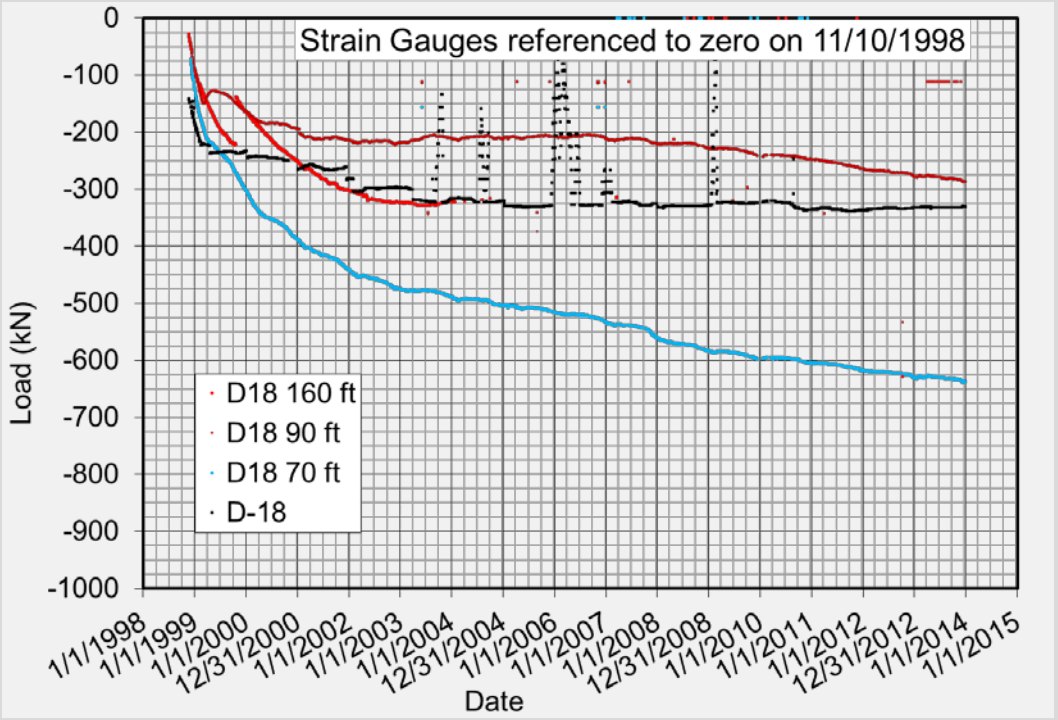

Strain Gauges referenced to zero on 11/10/1998
Load (kN)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
H5 160 ft
H5 200 ft
H5 100 ft
H5 40 ft
H-5
1/1/1998
1/1/1999
1/1/2000
12/31/2000
1/1/2002
1/1/2003
1/1/2004
12/31/2004
1/1/2006
1/1/2007
1/1/2008
12/31/2008
1/1/2010
1/1/2011
1/1/2012
12/31/2012
1/1/2014
1/1/2015
Date

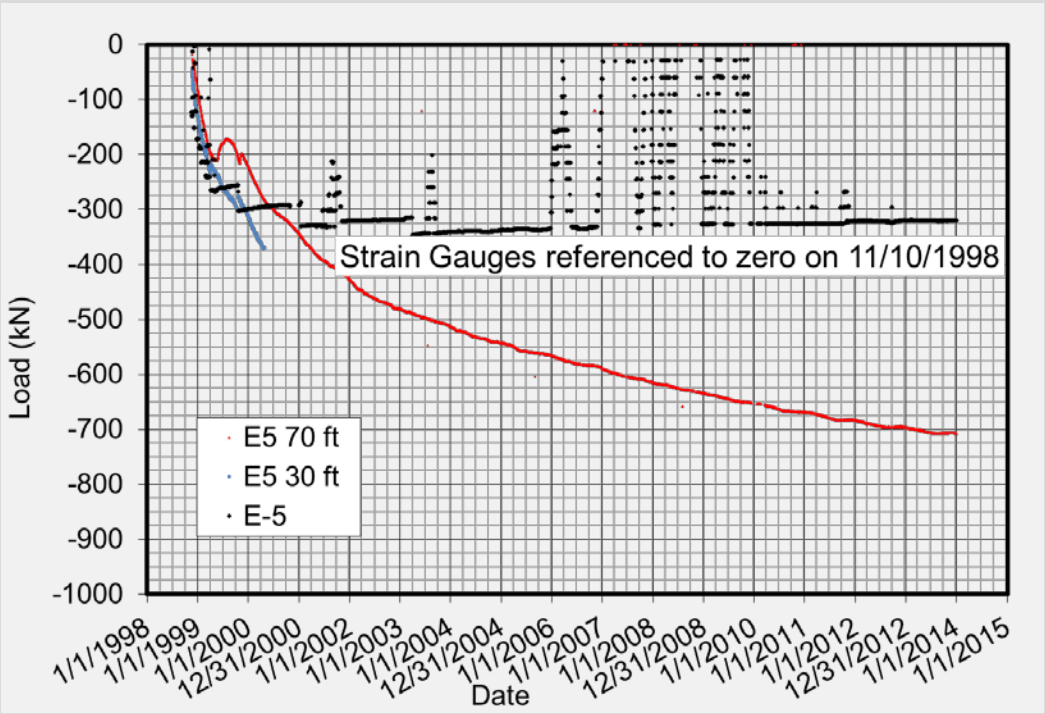

Strain Gauges referenced to zero on 11/10/1998
Load (kN)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
FF13 70 ft
FF13 90 ft
FF13 170 ft
FF-13
1/1/1998
1/1/1999
1/1/2000
12/31/2000
1/1/2002
1/1/2003
1/1/2004
12/31/2004
1/1/2006
1/1/2007
1/1/2008
12/31/2008
1/1/2010
1/1/2011
1/1/2012
12/31/2012
1/1/2014
1/1/2015
Date

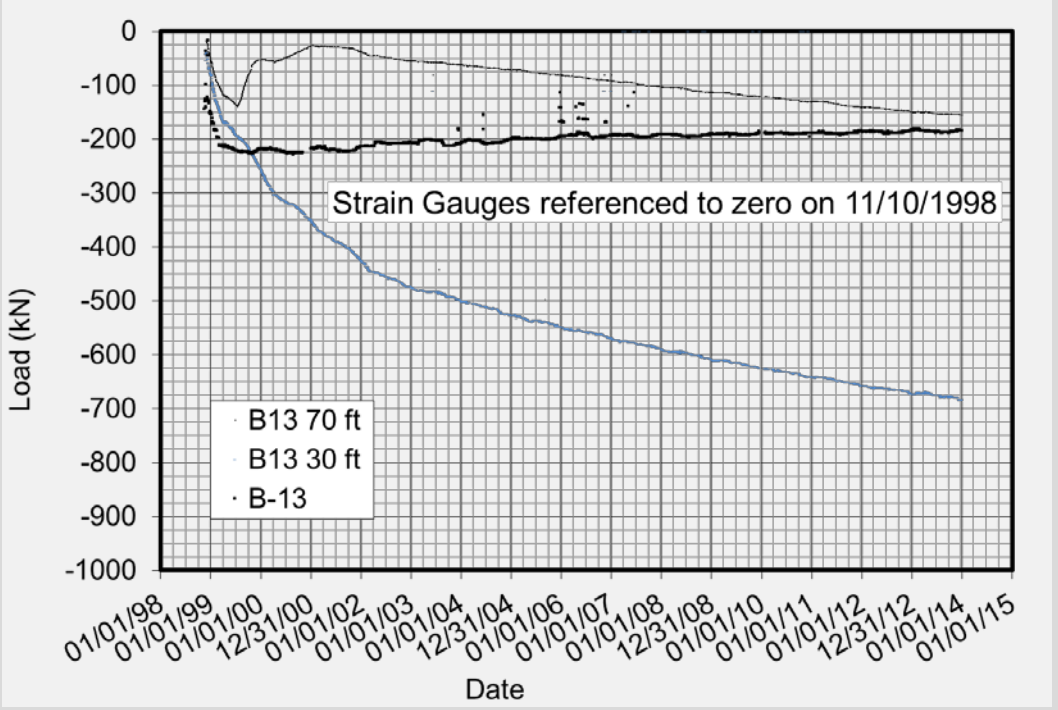

Strain Gauges referenced to zero on 11/10/1998
Load (kN)
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
E16 30 ft
E16 110 ft
E16 150 ft
E16 180 ft
E-16
1/1/1998
1/1/1999
1/1/2000
12/31/2000
1/1/2002
1/1/2003
1/1/2004
12/31/2004
1/1/2006
1/1/2007
1/1/2008
12/31/2008
1/1/2010
1/1/2011
1/1/2012
12/31/2012
1/1/2014
1/1/2015
Date


Strain Gauges referenced to zero on 11/10/1998
Load (kN)
Date
F18 170 ft
F18 90 ft
F18 30 ft
F-18

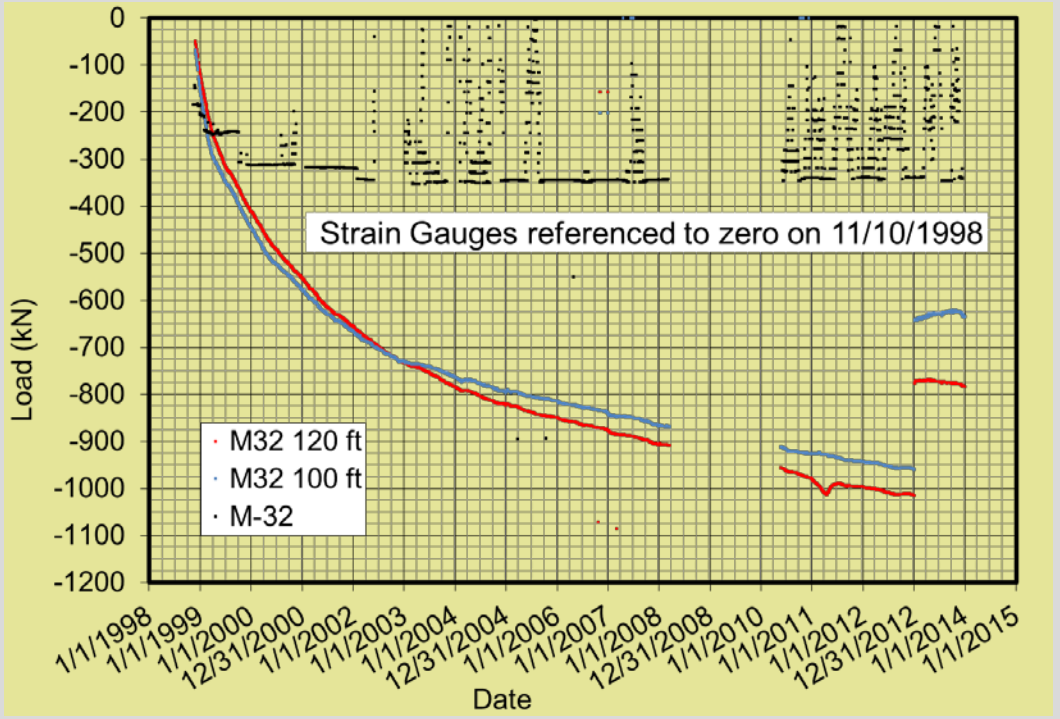

Strain Gauges referenced to zero on 11/10/1998
Load (kN)
Date
L4 90 ft
L4 170 ft
L-4

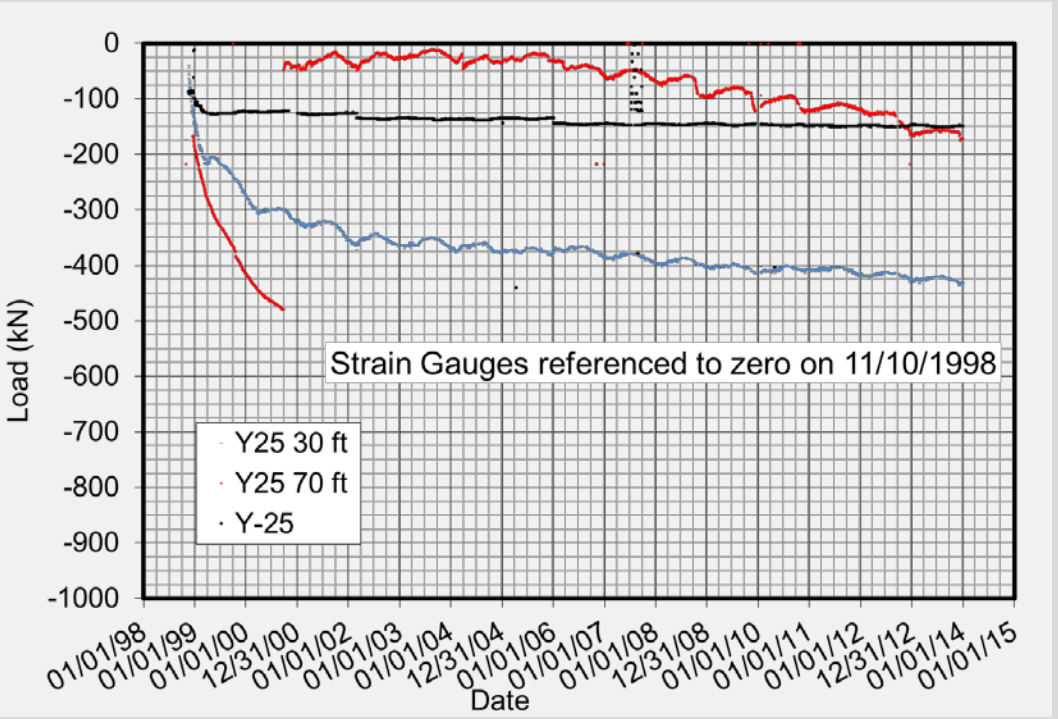

Strain Gauges referenced to zero on 11/10/1998
Load (kN)
Date
D18 160 ft
D18 90 ft
D18 70 ft
D-18

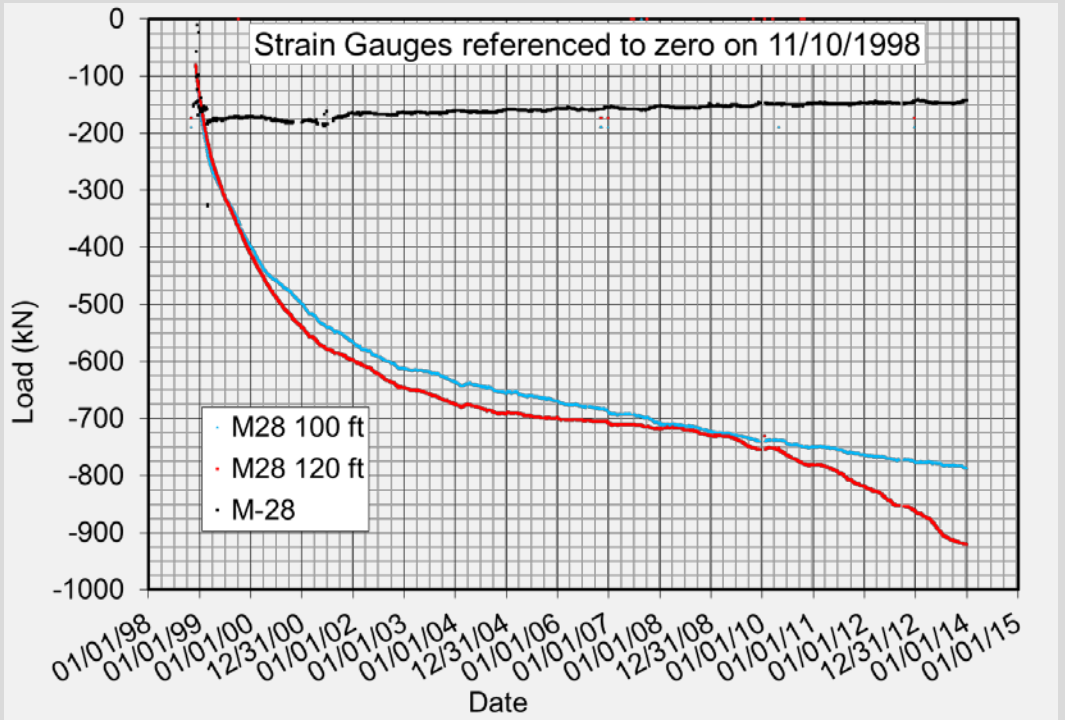

Strain Gauges referenced to zero on 11/10/1998
Load (kN)
Date
E5 70 ft
E5 30 ft
E-5


Strain Gauges referenced to zero on 11/10/1998
B13 70 ft
B13 30 ft
B-13
Load (kN)
Date

Note scale


Strain Gauges referenced to zero on 11/10/1998
M32 120 ft
M32 100 ft
M-32
Load (kN)
Date


Strain Gauges referenced to zero on 11/10/1998
Y25 30 ft
Y25 70 ft
Y-25
Load (kN)
Date


Strain Gauges referenced to zero on 11/10/1998
M28 100 ft
M28 120 ft
M-28
Load (kN)
Date

Questions and Discussion

Thank you for your time!

It was fun then
<u>And</u>
it's still fun