Observations From The Instrumentation of a Micropiled and Tied Back Reticulated Grid

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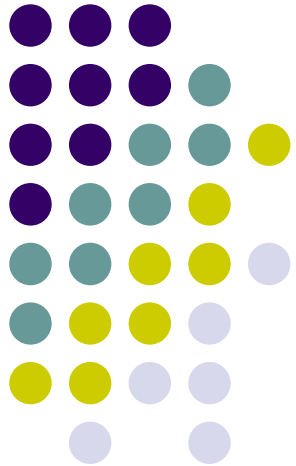
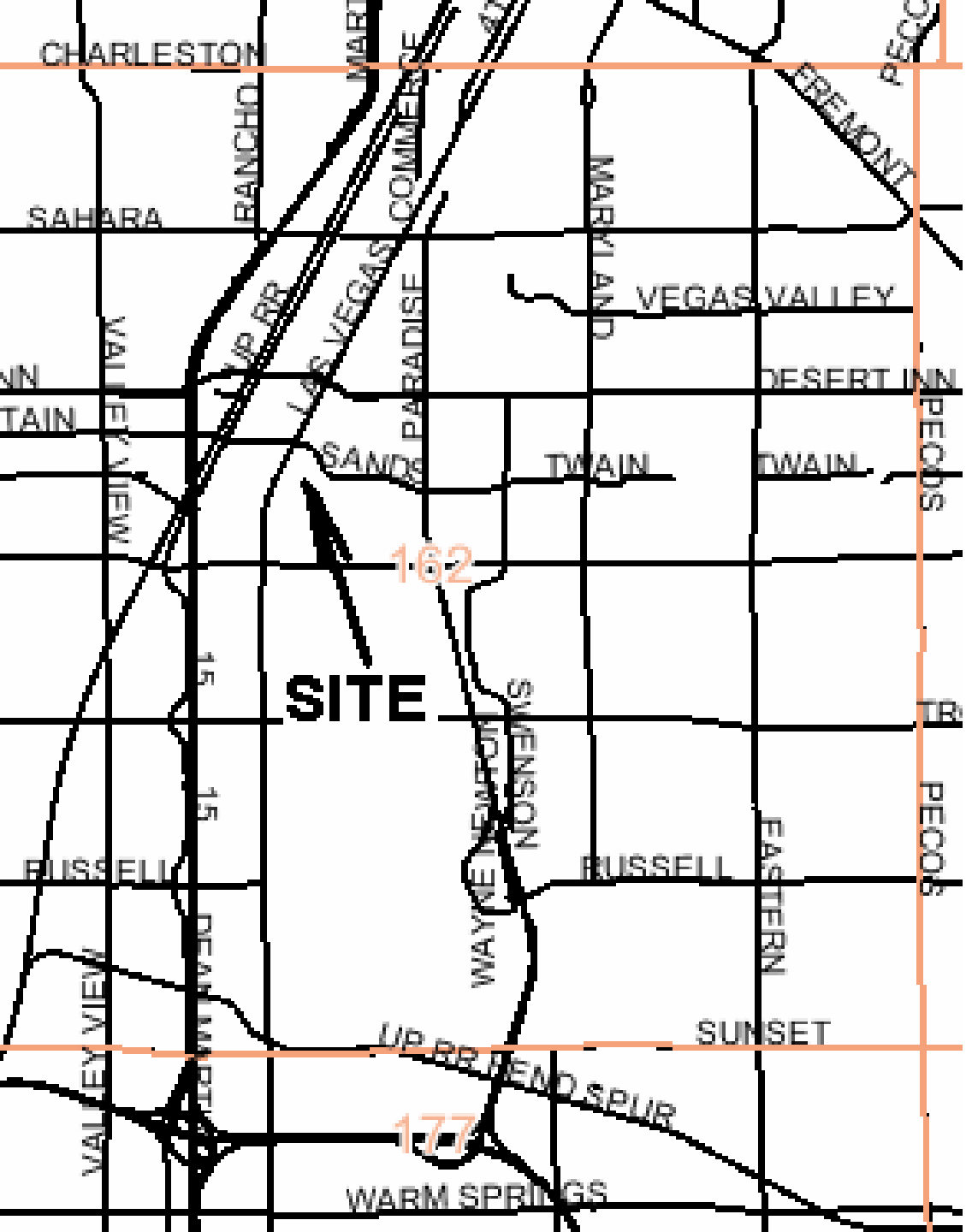
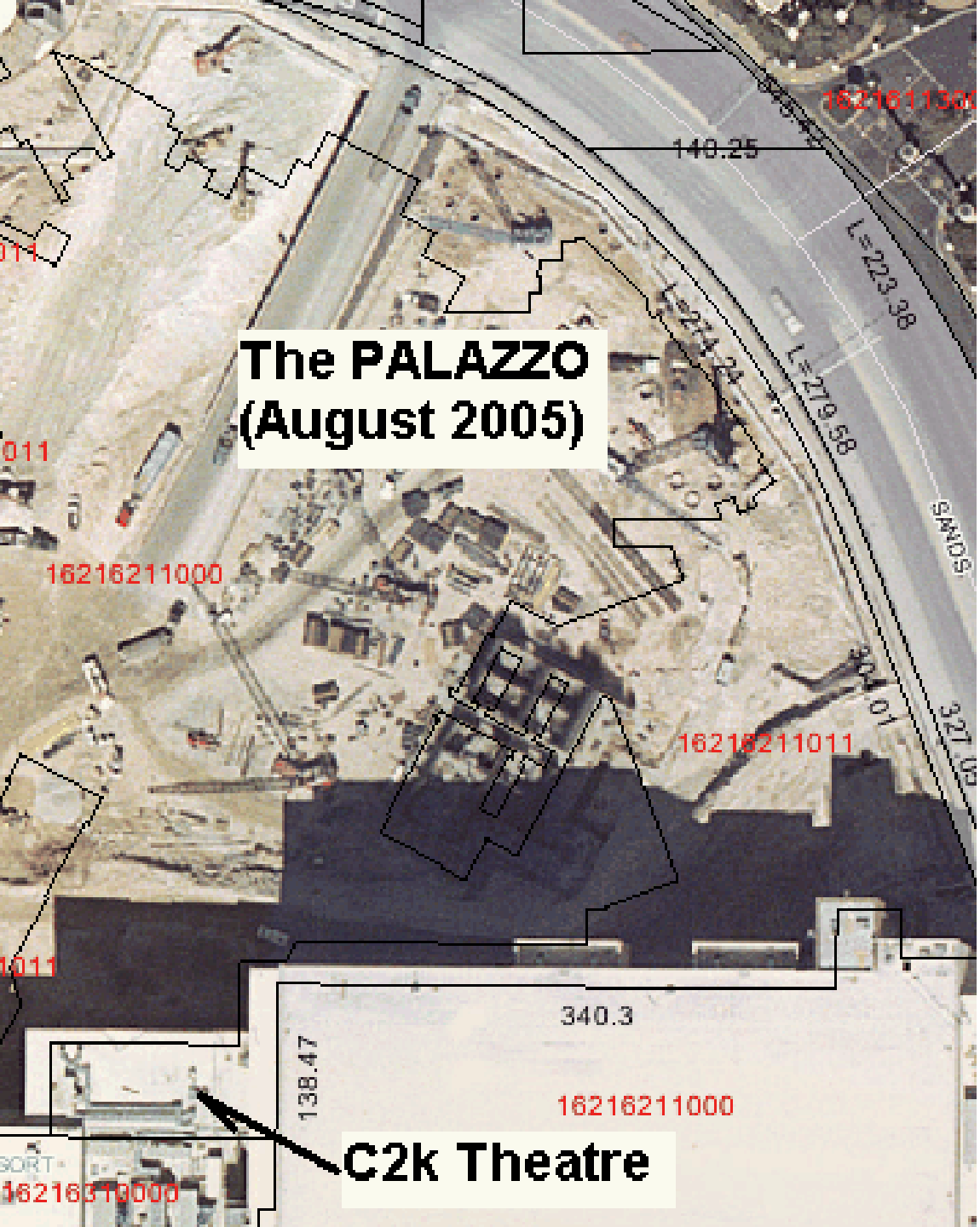
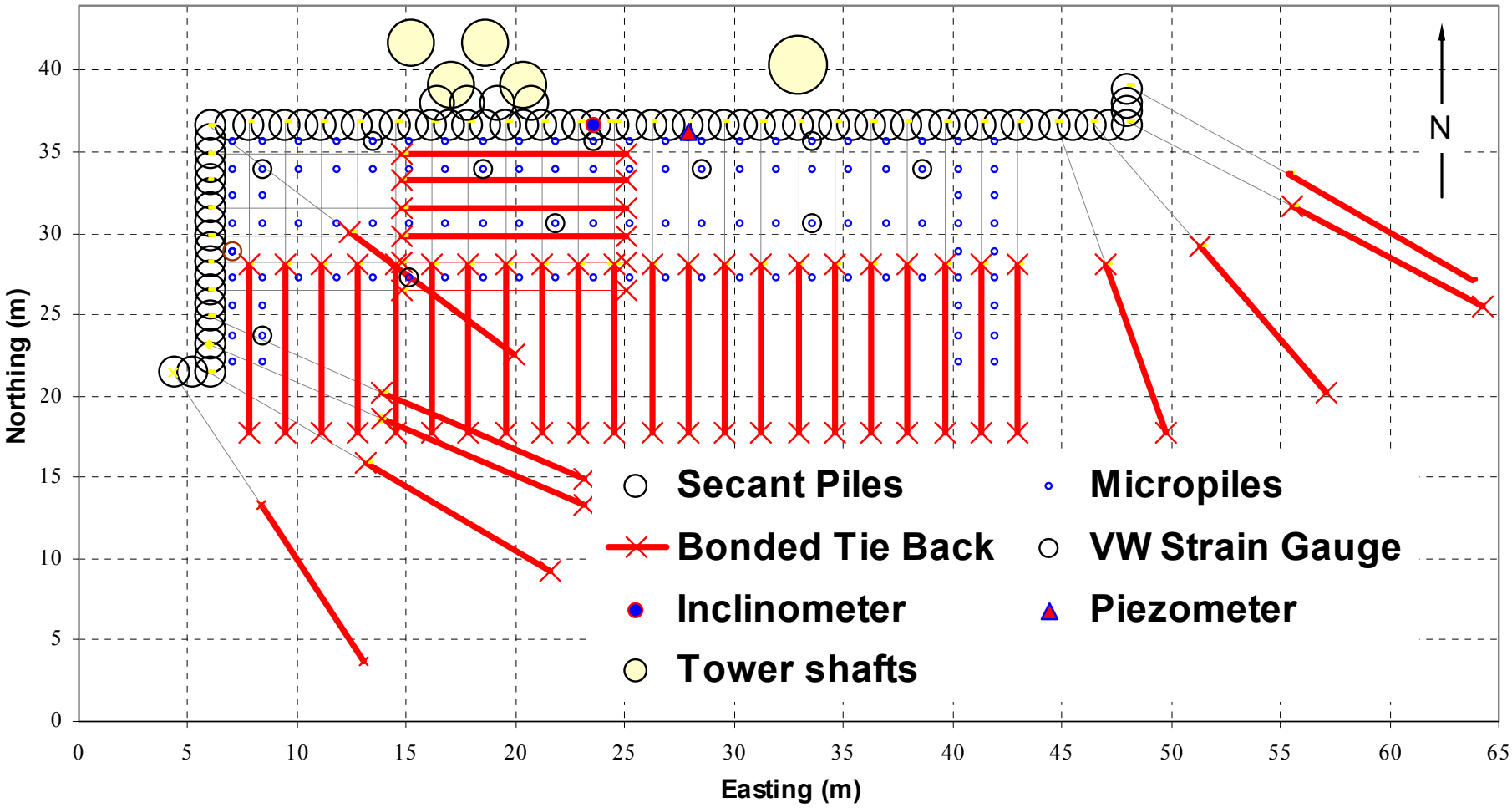




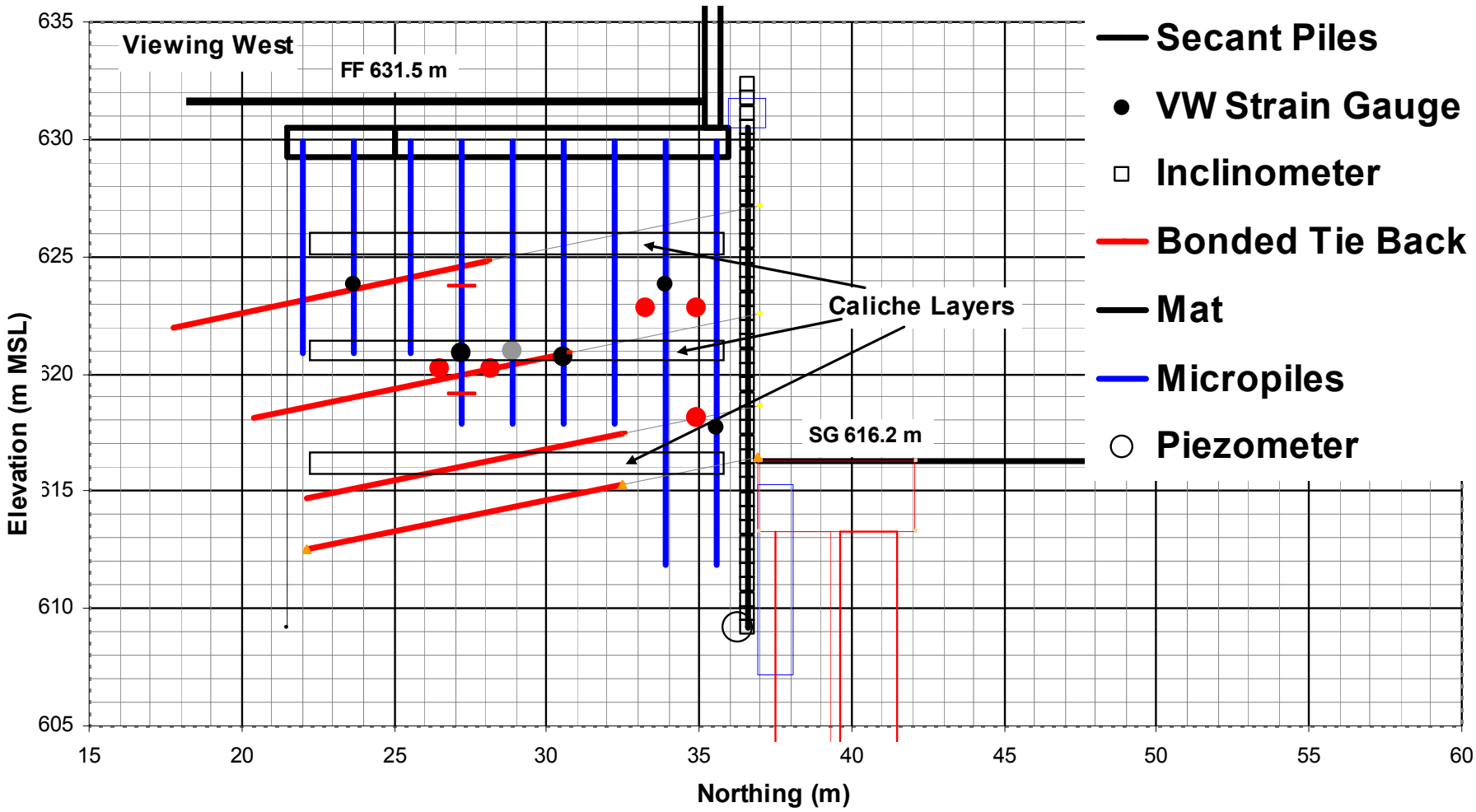
- Site: The C2K Theatre at the Palazzo
- 370 kN wall load at the crest of a 15.3 m excavation
- Theatre construction concurrent with excavation and tower construction



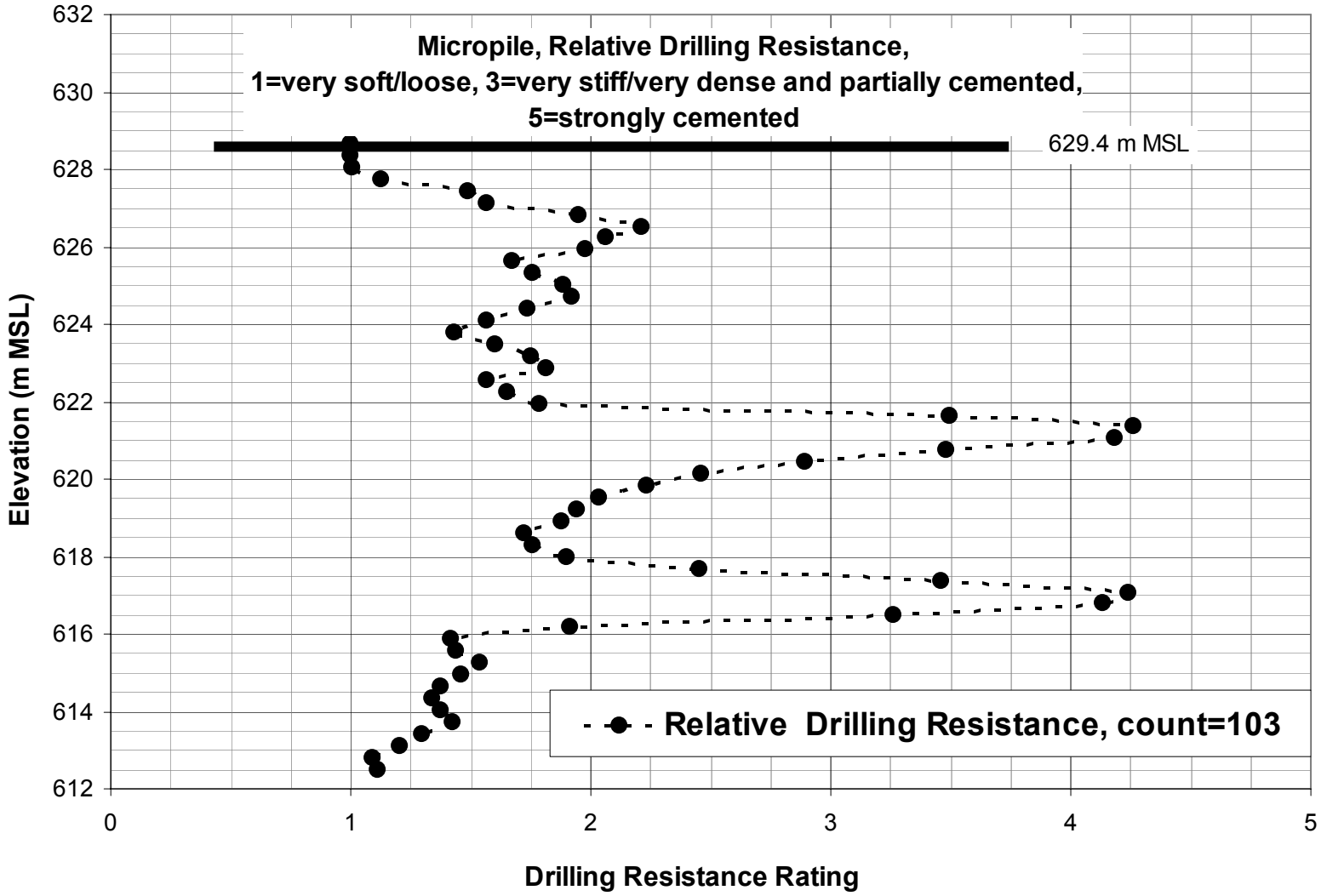
- Site excavation began 9/1/04
- Theatre construction began 11/25/04
- Secant pile installation began 12/6/04
- Underpinning installed 12/11/04
- Secant piling complete 12/16/04
- Theatre structure frame complete 3/14/05



- Reticulated group plan
- VW gauge locations
- Micropile locations
- Tieback locations
- Foundation shafts for cantilevered tower

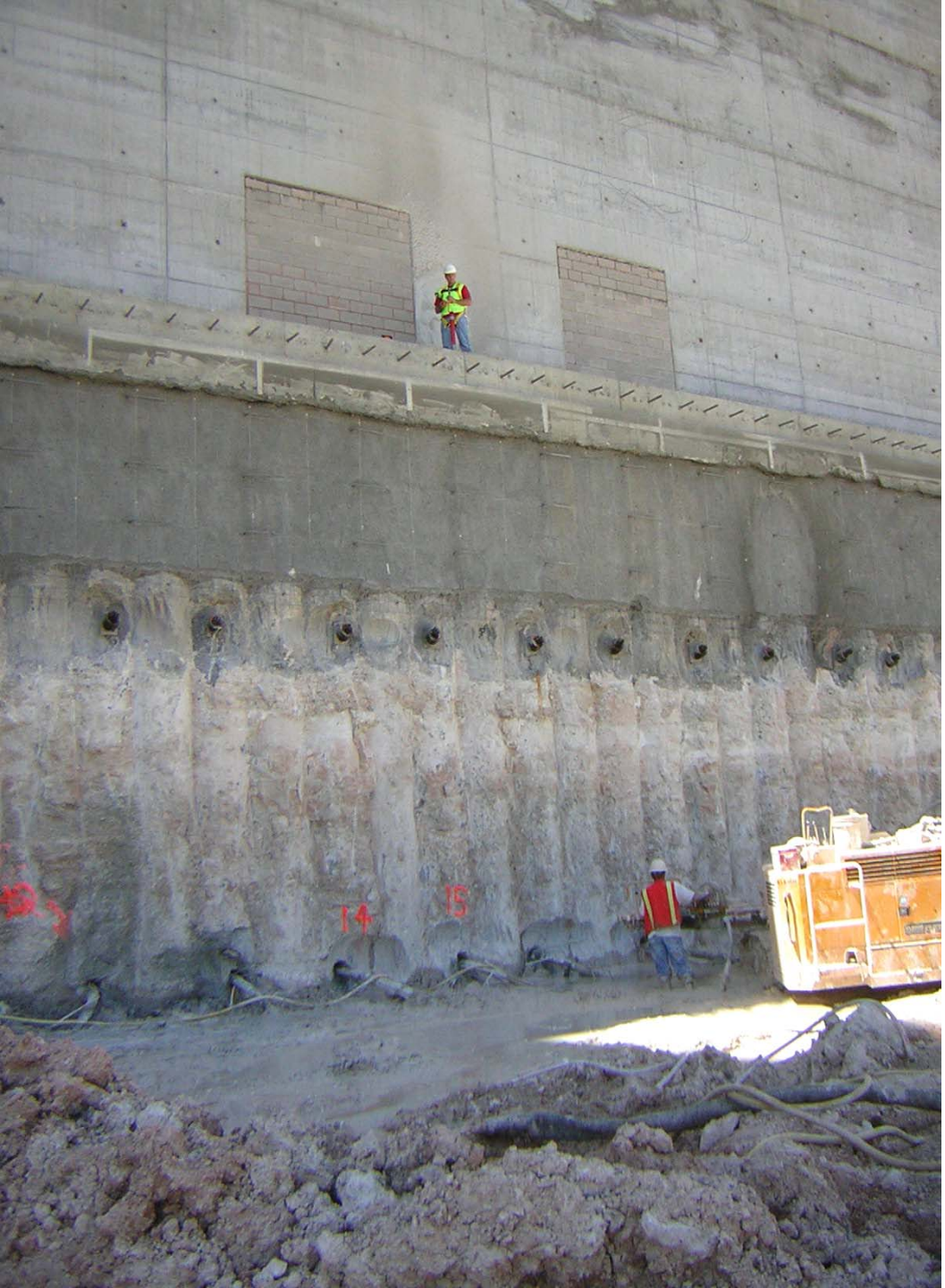


- Reticulated group profile
- VW gauge locations
- Micropile locations
- Tieback locations
- Reticulated tieback intersections
- Cemented beds
- Piezometer location



- Relative top-drive hammer drilling resistance
- Measured by rate of advance
- Subjectively interpreted relative to geotechnical logging

- Flush grout injection drilling
- VW strain gauge
- Insertion by fiberglass rod



- Inclinometer at P1-015NS
- Piezometer at P1-013S
- Cemented layer at approximately elevation 626.5 m to 625 m MSL

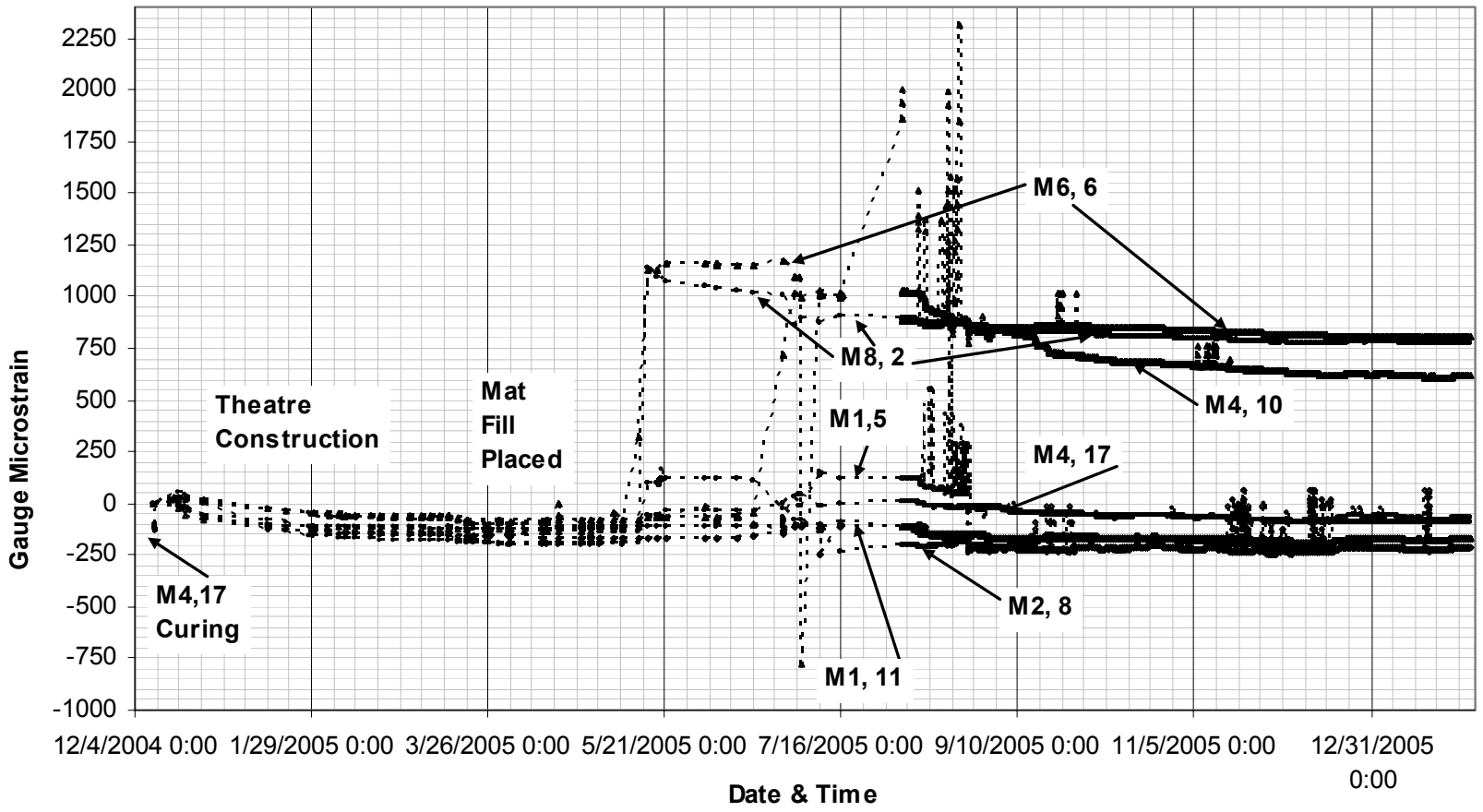
- Notch at tower cantilever
- Theatre wall

  36.3 m - wide by

  32 m - high by

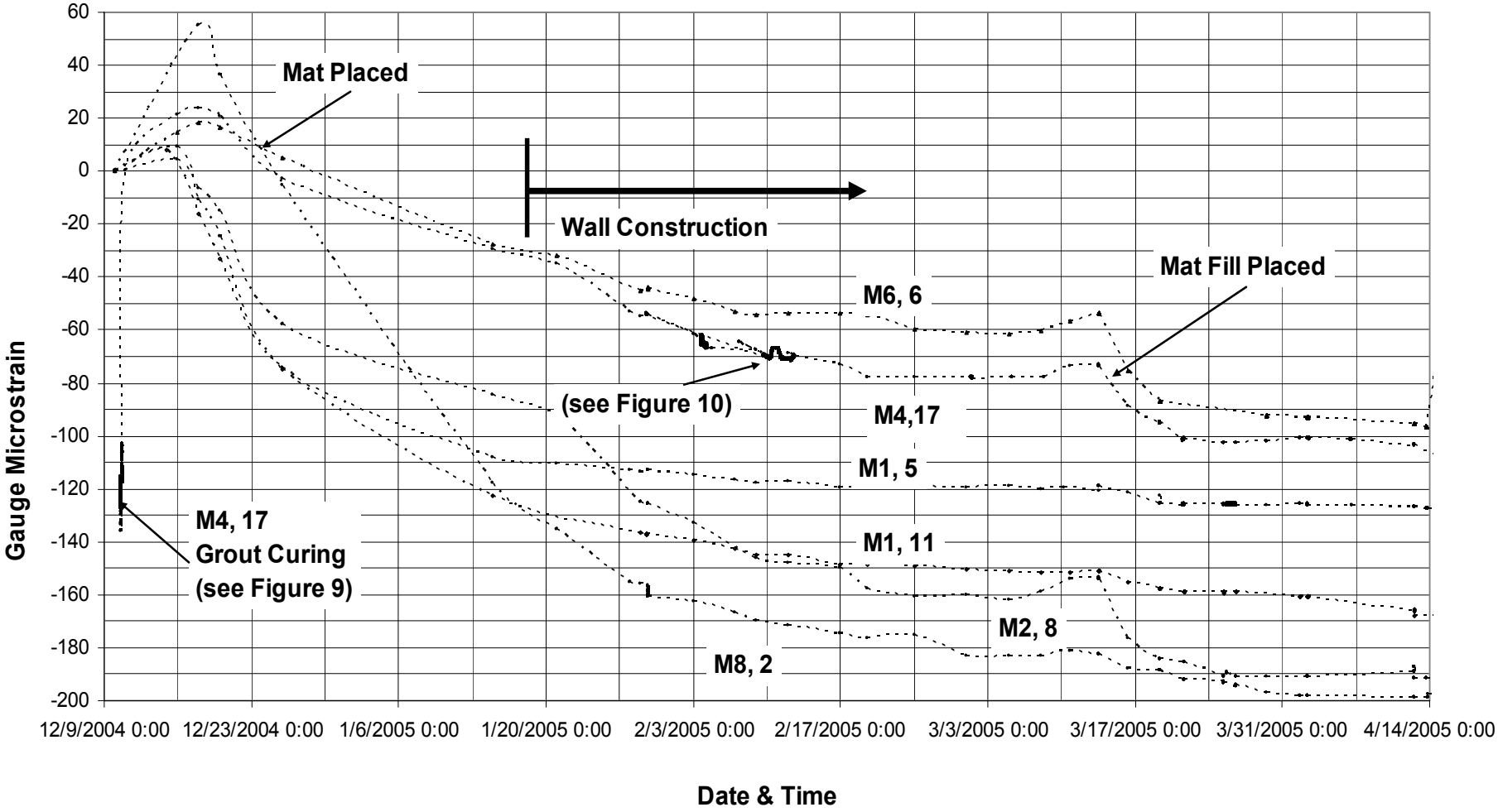
  457mm - thick
- Carbonate precipitate at tie-backs

- Tower shaft group at cantilever

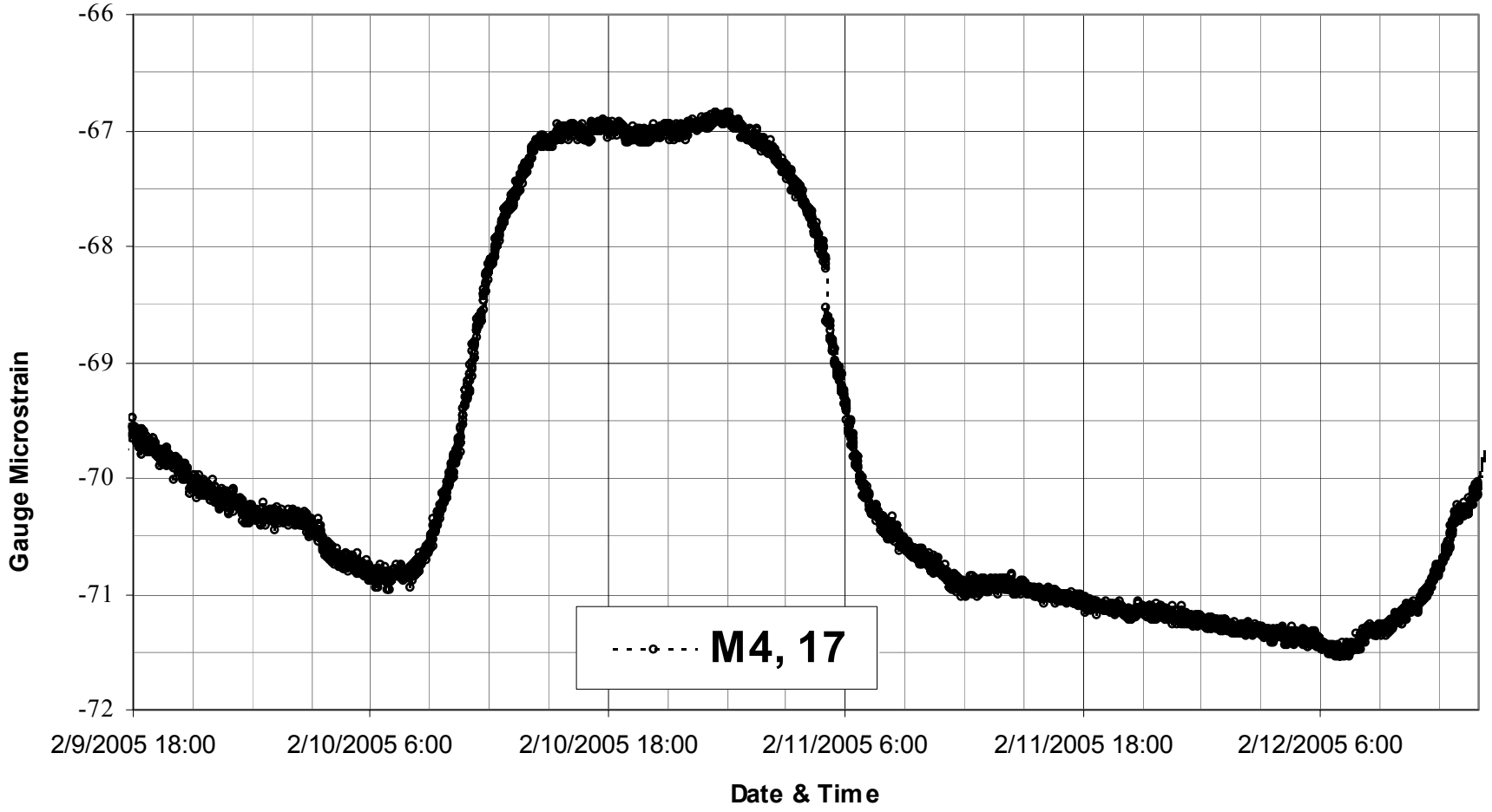


- Micropile strain history
- VW strain gauge data record

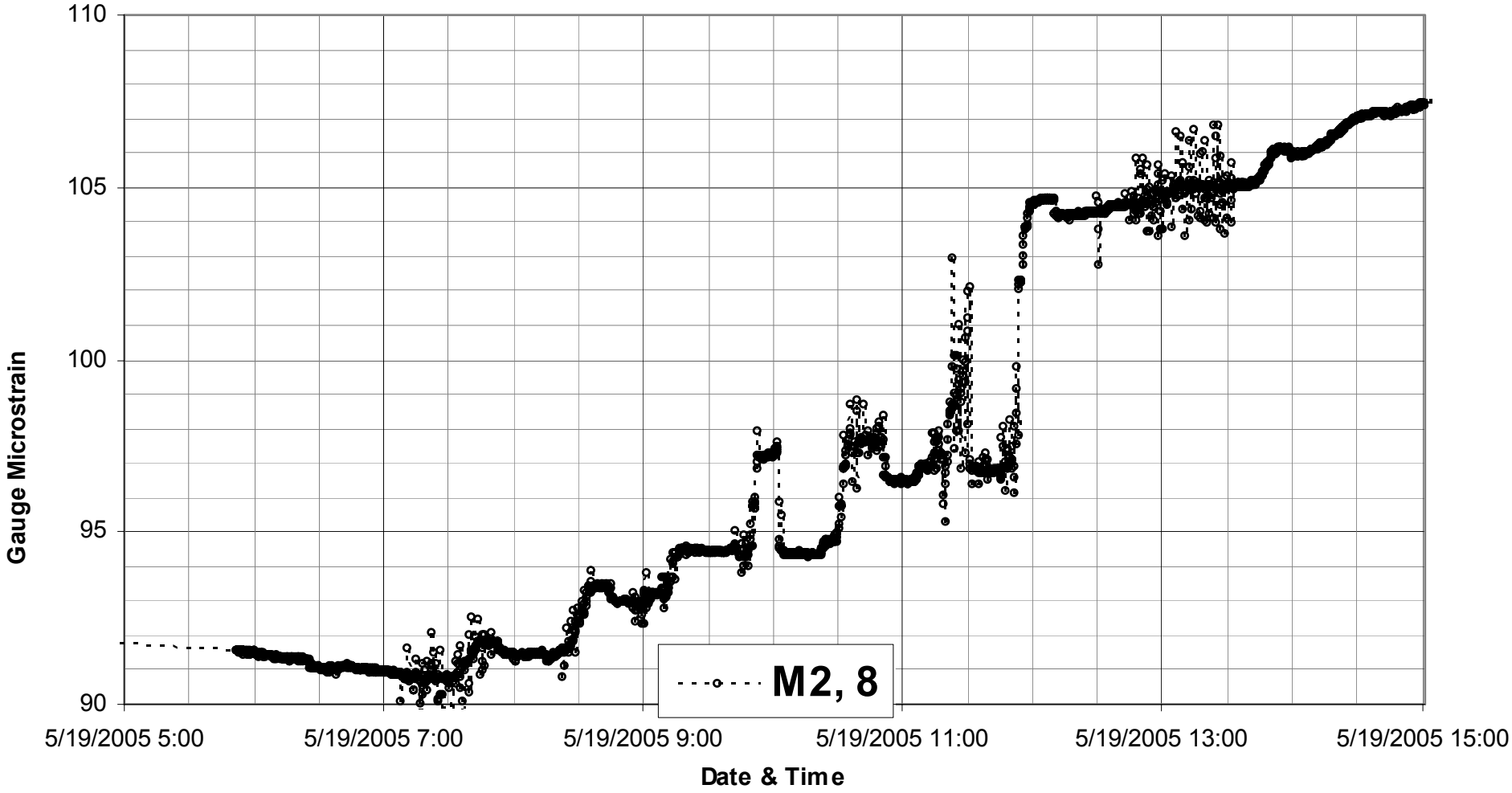
- Installation 12/04 through completion 1/06



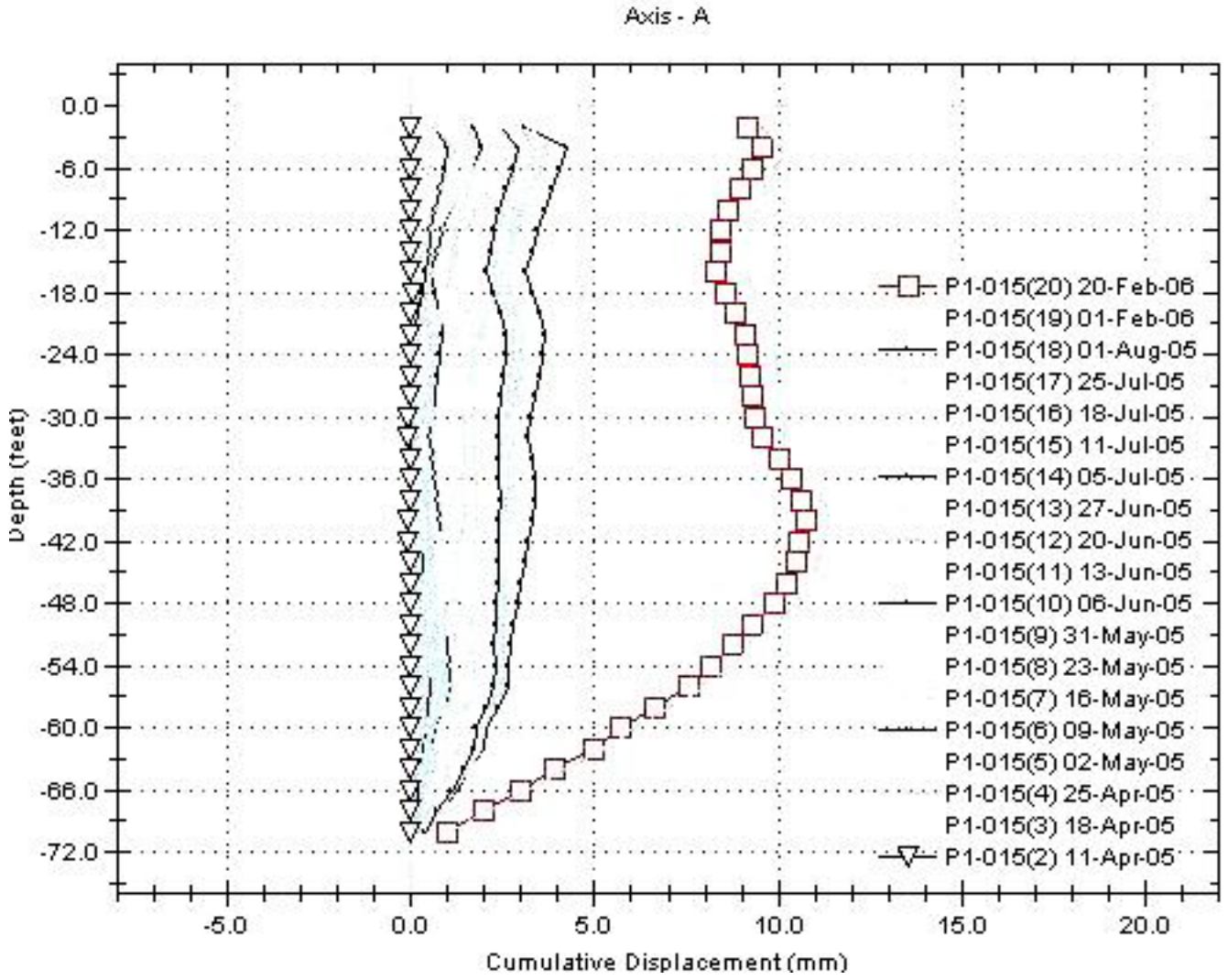
- Initial tension during curing and excavation to subgrade 12/11/04 – 12/18/04
- Mat placement 12/24
- Theatre construction 1/05 – 3/05
- Fill placement 3/14/05 – 3/20/05



- Forming and concrete placement load/unload at interior location on mat

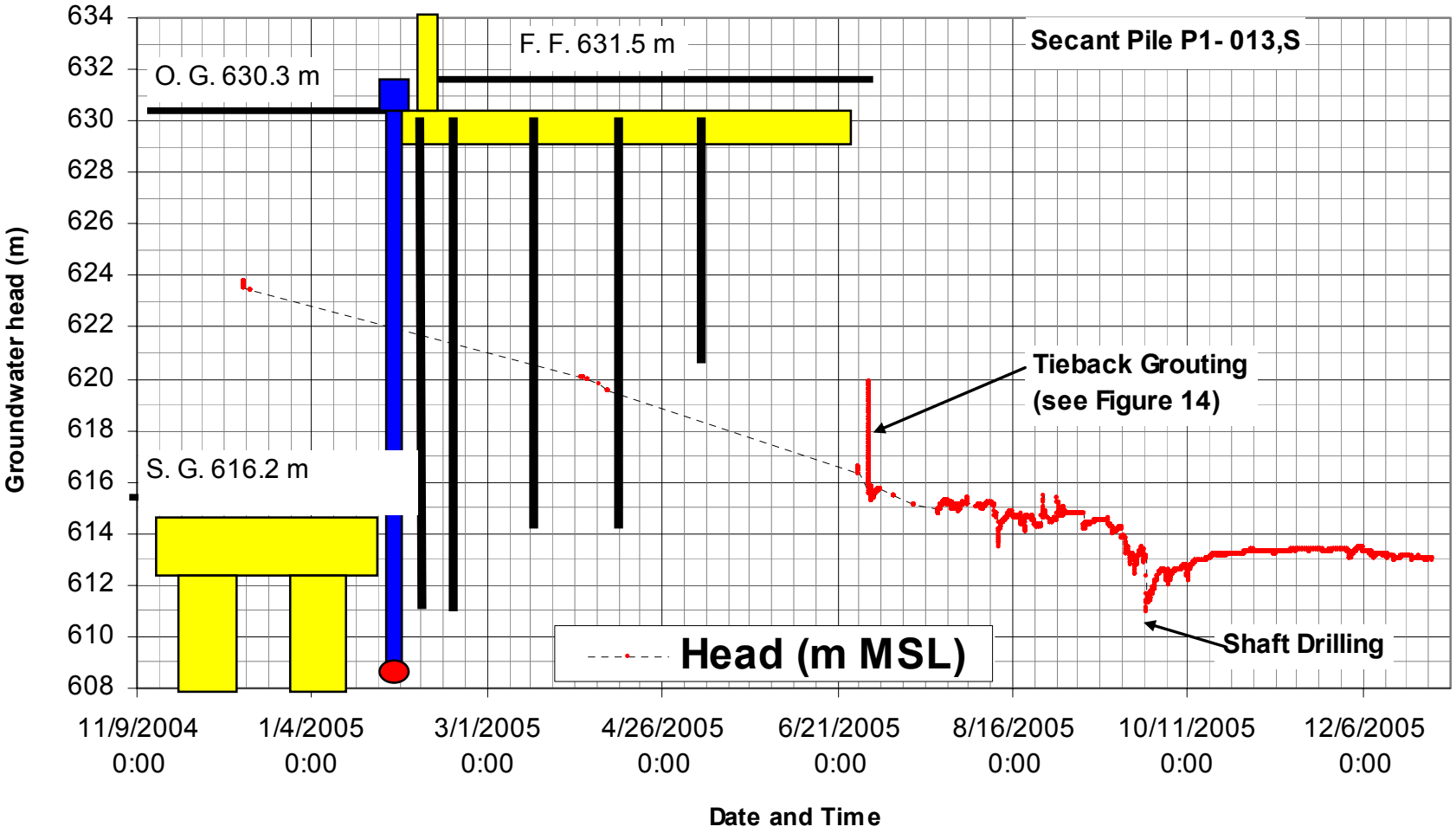


- Tieback stressing effects
- 15 Tiebacks at Level -1 stressed



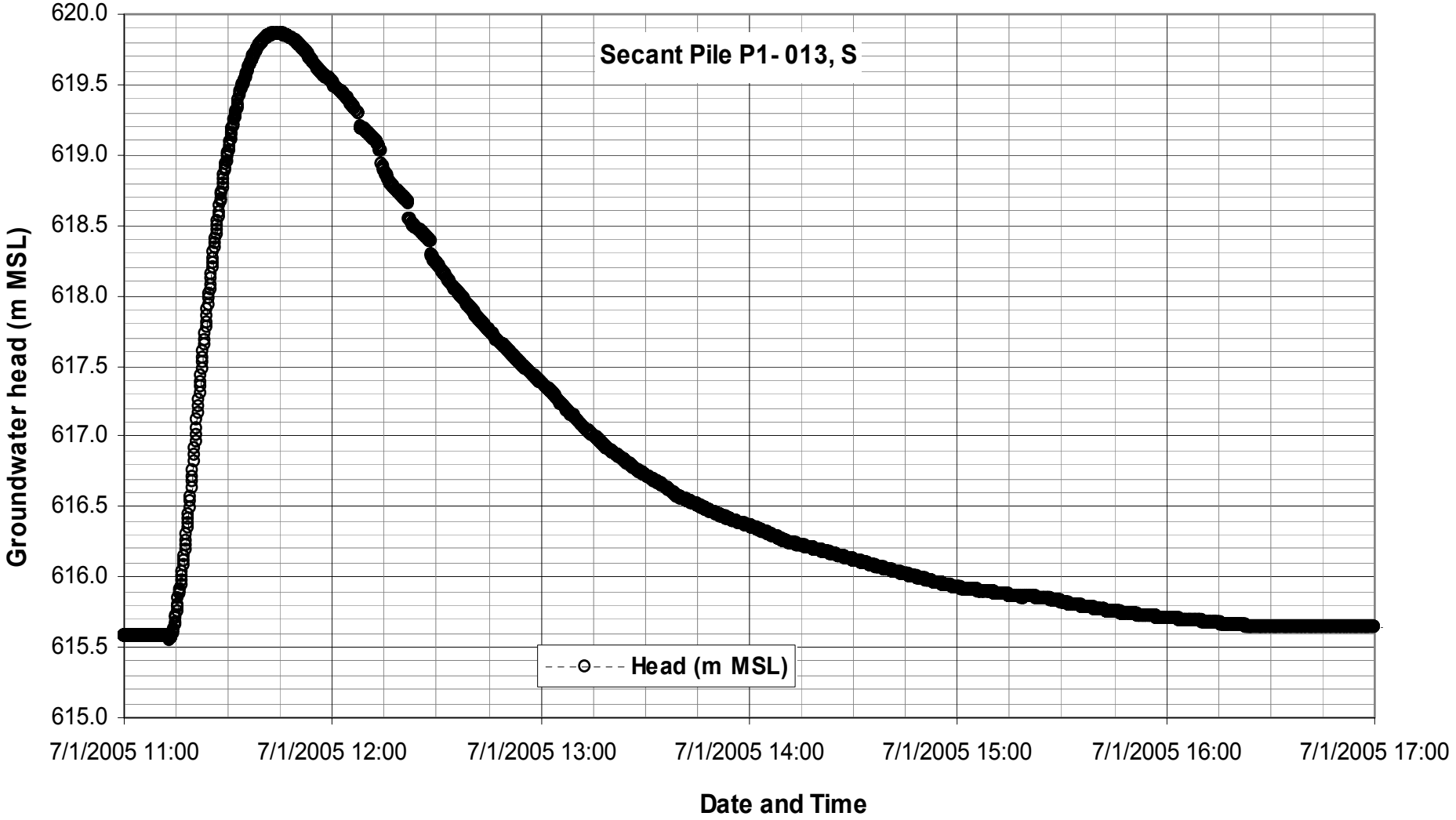
- Inclinometer data record
- Weekly record 4/05 to 8/05 and 2/06

- Hourly data by IPI system 8/05 – 12/05 not included



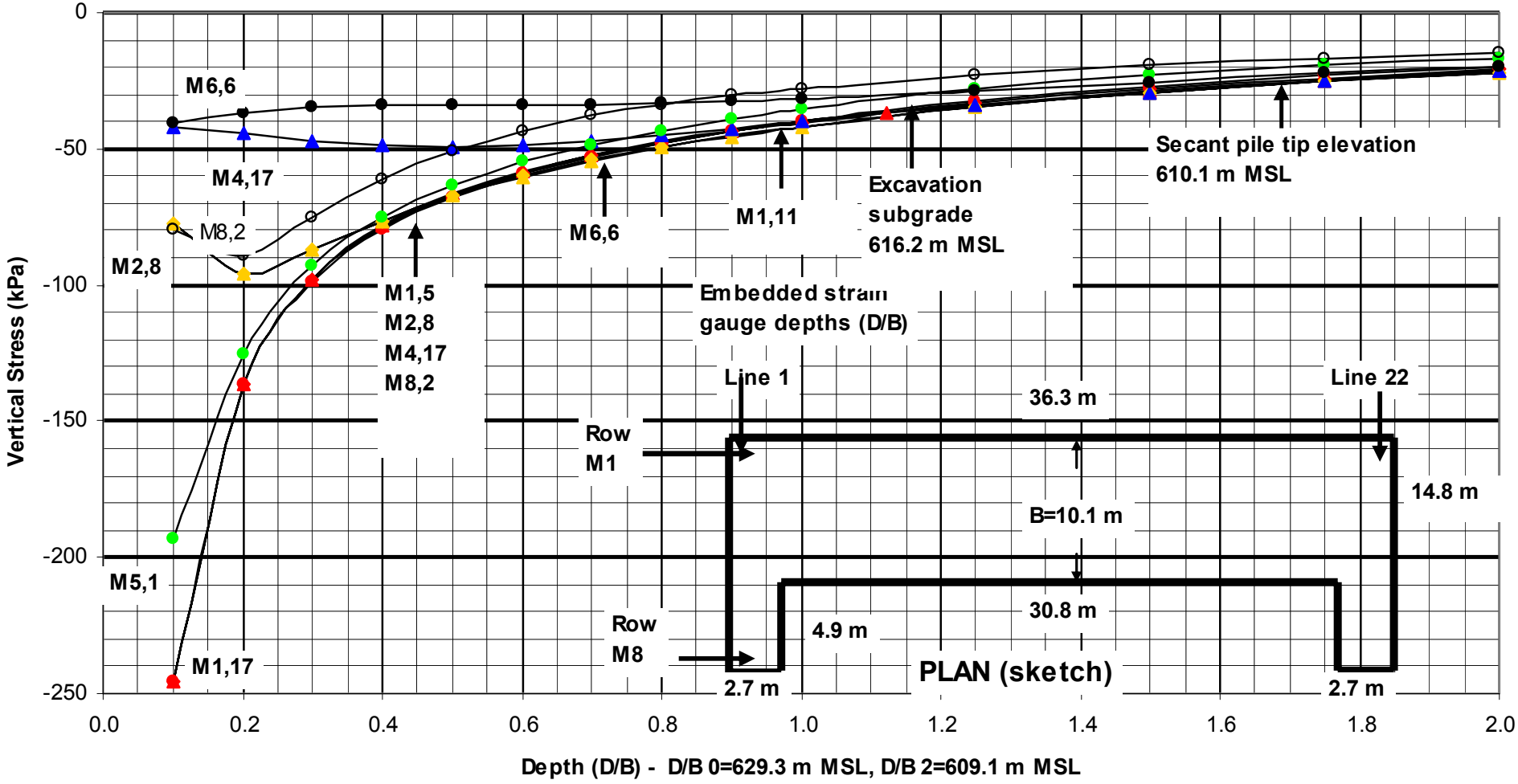
- Piezometer data record 12/04 – 1/06

- Head rise during tieback grouting
- Head drop during drilled shaft construction



- Tieback grout placement at Level – 2

Elastic Analyses vs. Observations



- Boussinesq elastic analyses by superposition
- Instrumented micropile locations and depths

Ground/Micropile Load Sharing Pre-Excavation, April 1, 2004

Location	D/L	D/B	4/1/05 Load (kN)	Boussinesq Stress (kPa)	Tributary Area (m^2)	Stress Ratio %
M1,5	0.30	0.5	-41.08	-67.5	1.62	37.6 %
M1,11	0.66	1.1	-52.41	-36.7	1.62	88.3 %
M1,17	0.30	0.5	-55.05	-58.7	1.62	50.9 %
M5,1	0.57	0.8	-42.62	-43.2	1.96	50.4 %
N2,2	0.66	1.1	-50.32	-34.0	2.02	73.2 %
M2,8	0.30	0.5	-14.02	-67.4	3.70	5.6 %
M2,14	0.30	0.5	-69.93	-67.3	3.70	28.1 %
M2,20	0.30	0.5	-50.00	-72.0	4.18	16.6 %
M8,2	0.47	0.5	-64.71	-50.9	2.70	47.0 %
M4,10	0.60	0.8	-26.55	-43.3	5.64	10.9 %
M4,17	0.37	0.5	-32.94	-49.4	5.64	11.8 %
M6,6	0.58	0.8	-30.26	-33.4	5.62	17.1 %

- 37.6% to 88.3% at perimeter
- 5.6% to 73.2% at 1st interior row
- 10.9% to 11.8% near middle of mat (row 4)
- 17.1% at back edge of mat (row 6)
- Prior to stressing

Ground/Micropile Load Sharing Post Construction January 31, 2006

Location	D/L	D/B	1/31/06 Load (kN)	Boussinesq Stress (kPa)	Tributary Area (m^2)	Stress Ratio %
M1,5	0.30	0.5	-22.77	-67.5	1.62	20.8 %
M1,11	0.66	1.1	-68.56	-36.7	1.62	115.5 %
M1,17	0.30	0.5	-25.22	-58.7	1.62	26.6 %
M5,1	0.57	0.8	-56.18	-43.2	1.96	66.4 %
N2,2	0.66	1.1	-59.43	-34.0	2.02	86.1
M2,8	0.30	0.5	-16.60	-67.4	3.70	6.7 %
M2,14	0.30	0.5	-198.27	-67.3	3.70	79.6 %
M2,20	0.30	0.5	-87.14	-72.0	4.18	29.0 %
M8,2	0.47	0.5	252.84	-50.9	2.70	184 % *
M4,10	0.60	0.8	201.22	-43.3	5.64	83.0 %*
M4,17	0.37	0.5	-31.71	-49.4	5.64	11.4 %
M6,6	0.58	0.8	261.76	-33.4	5.62	139.5 %*

- After tieback stressing
- 20.8% to 115.5% at perimeter
- 6.7% to 184% (tension) at 1st interior row
- 11.4% to 83.0% (tension) near middle of mat (row 4)
- 139.5% (tension) at back of mat (row 6)

CONCLUSIONS

- The micropiles accumulated 10 to 90 percent of the load as it was applied in proportion to the relative stiffness between the soils and the micropiles.
- Instrumented micropiles responded with strains consistent with their location within the group and the forces applied.
- The micropiles provided confinement and resistance to axial deformation during tieback stressing.
- Tie back stressing caused micropiles to act in tension at the tieback bond zone.