





Schnabel
ENGINEERING

Emergency Repairs to the Jefferson Memorial Seawall

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Geo Virginia 2012. Williamsburg, Virginia

Virginia Geo-Institute



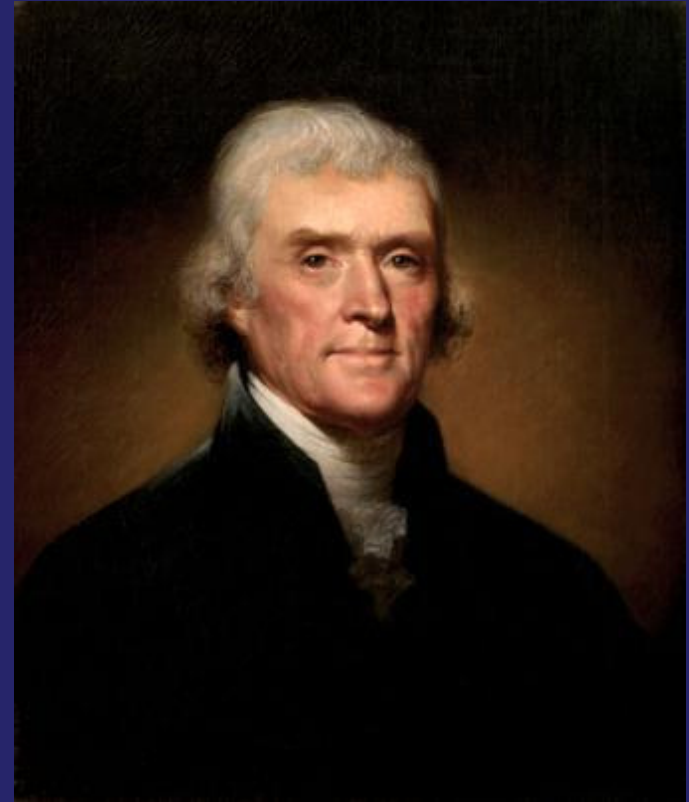
Outline

- Original construction
- Issues
- Investigations
- Findings
- Design
- Seawall reconstruction

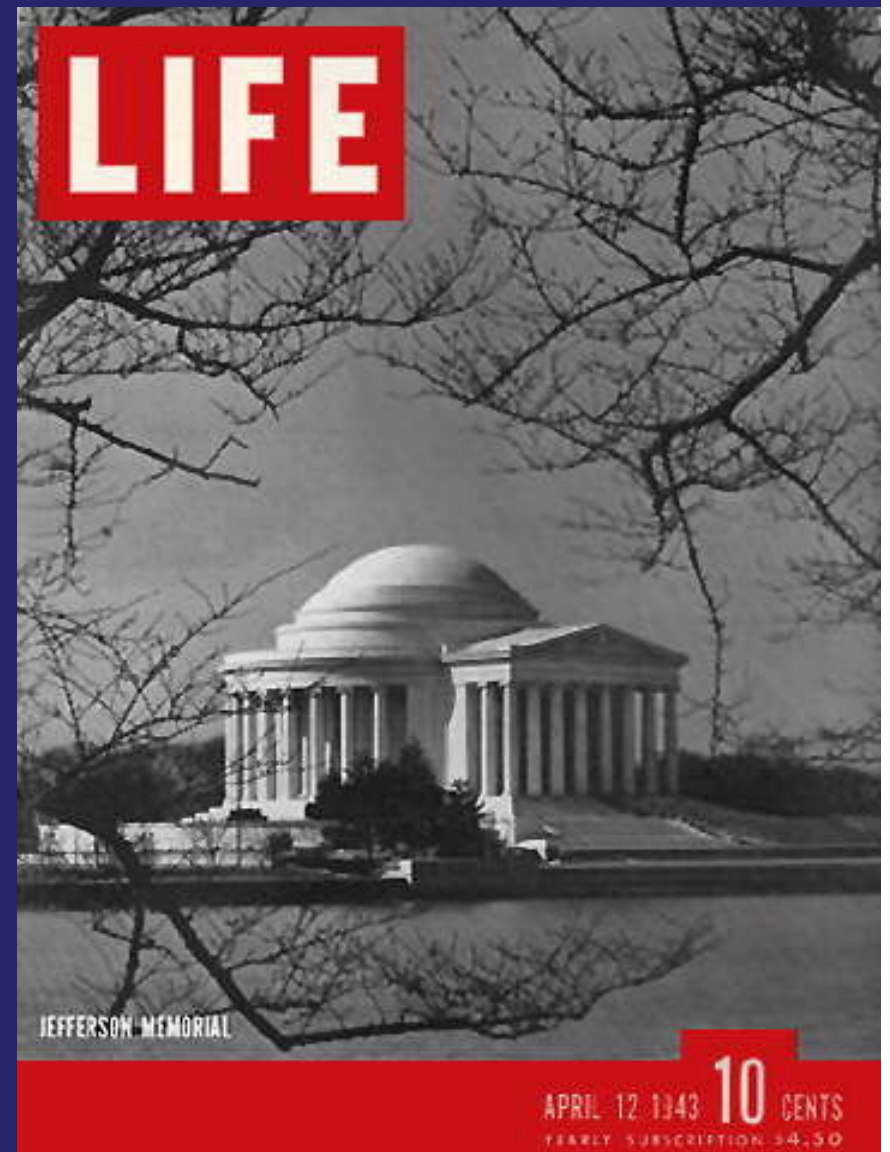


Introduction

- Tribute to 3rd President
- Groundbreaking 1938
- Dedicated April 12, 1943
- Original Statue was plaster, replaced by bronze 1947
- 2007: Fourth on the List of America's Favorite Architecture by the AIA



Introduction



Constructing the Memorial

- West Potomac Park on reclaimed land
- Bedrock is nearly 100 ft deep at the Memorial site
- Originally marshland and shoals
- Complex reclamation history throughout the 1800s
- Mostly intentional
- Reworked for construction of Memorial





Constructing the Memorial



Source: National Park Service Archives 1940

Constructing the Memorial



Source: National Park Service Archives 1941

Constructing the Memorial



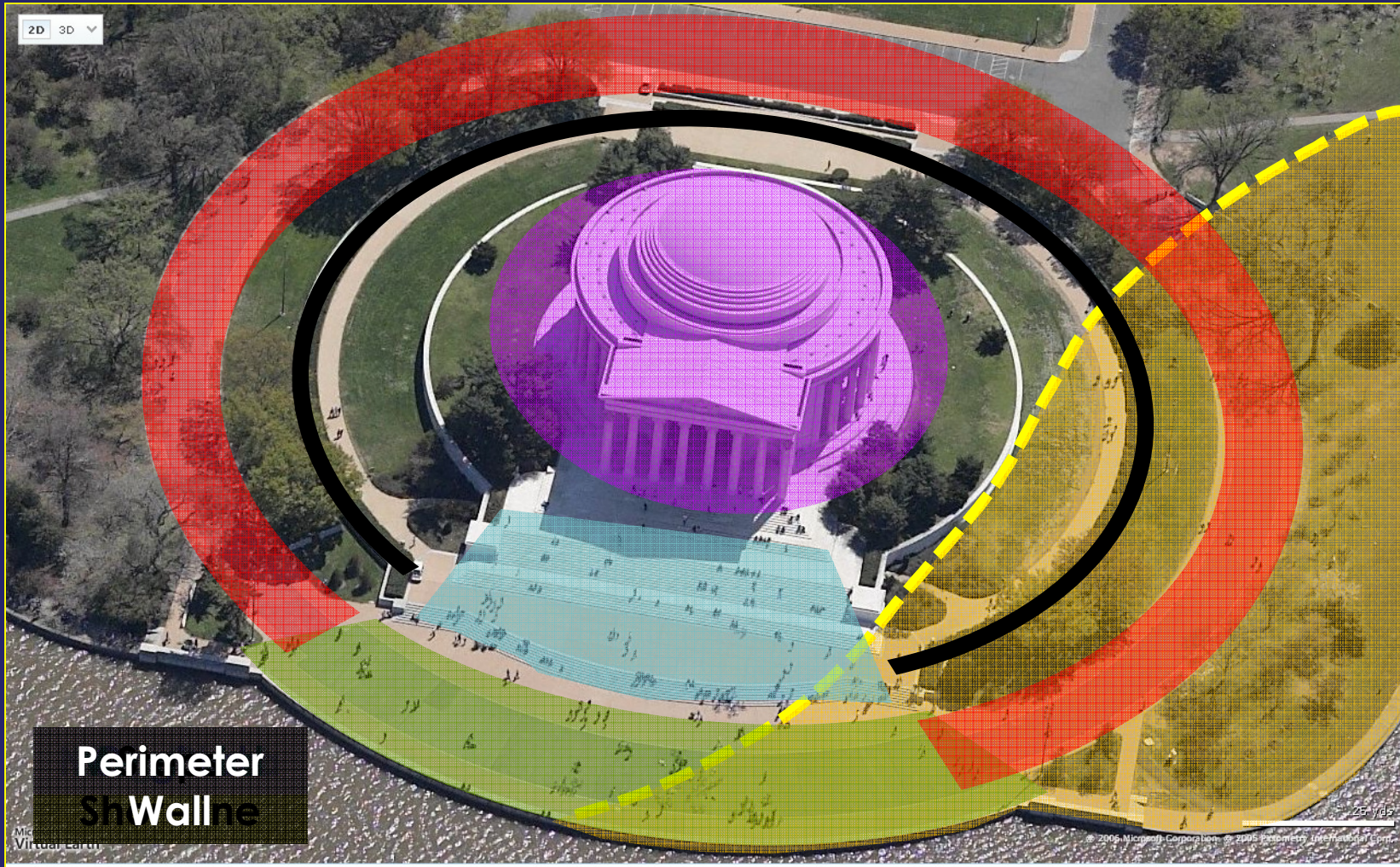
Source: National Park Service Archives 1940

Constructing the Memorial



Source: National Park Service Archives 1941

Nomenclature



Constructing the Memorial

- Memorial structure and steps supported on deep foundations
 - 443 cast-in-place Raymond piles
 - 88 24" caissons
 - 103 16" caissons
 - All bearing on rock
 - Detailed records of foundation work

Constructing the Memorial

- Seawall
 - No records on its construction
 - Original design was reinforced concrete wall on vertical and battered precast piles
 - Needed to investigate this further
- North Plaza, Perimeter Wall and Ring Road on Grade

Constructing the Memorial



Settlement issues

- Significant ground settlement was anticipated by designers
- “Let it happen then fix” approach
- Good historic monitoring data available
- Bench marks still accessible

Settlement issues

- By the 1960s, North Plaza had settled over 3 ft in places
- Perimeter walls sagged significantly
- Steps showed northward movement and structural damage
- Seawall settled but much less than North Plaza
- Memorial building not affected

Settlement issues



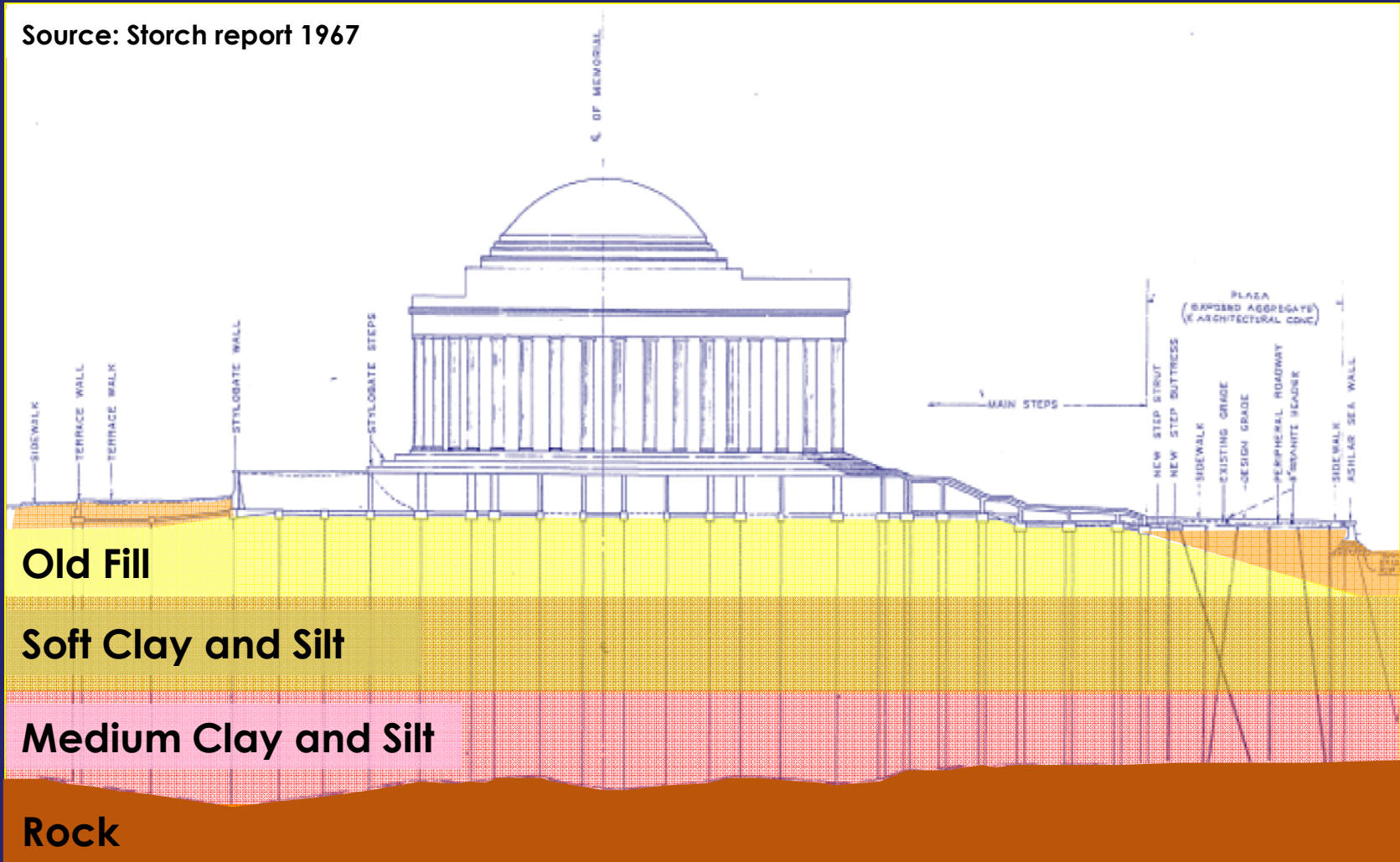
Source: National Park Service Archives

Settlement issues

- Study commissioned (Storch Report)
 - Reconstruction of North Plaza on piles
 - Buttressing of the steps
 - Repositioning of perimeter walls
 - No repair to seawall
 - Valuable information
- Repairs implemented by 1971

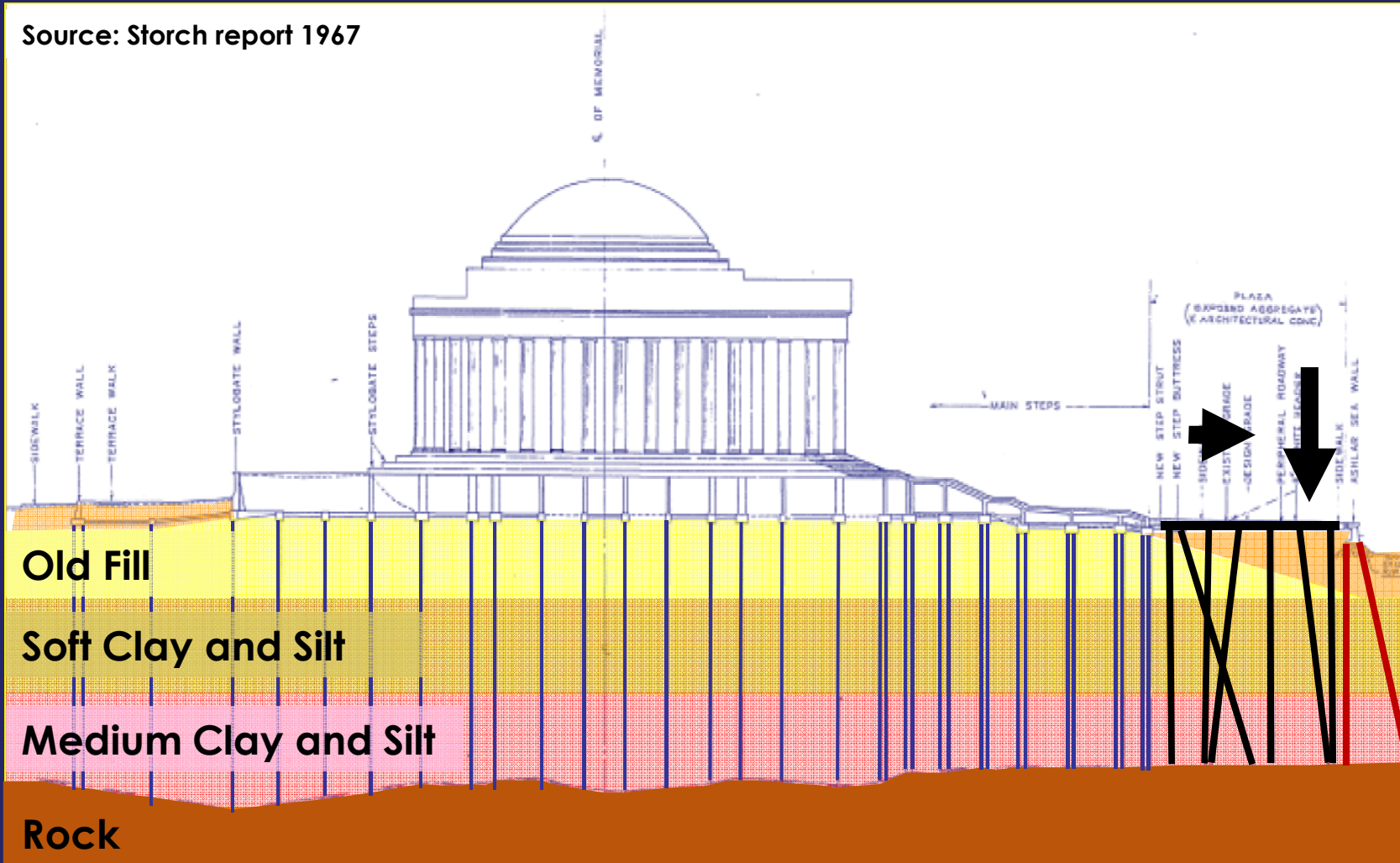
Settlement issues

Source: Storch report 1967



Settlement issues

Source: Storch report 1967



Old Fill

Soft Clay and Silt

Medium Clay and Silt

Rock

Time goes by so slowly...

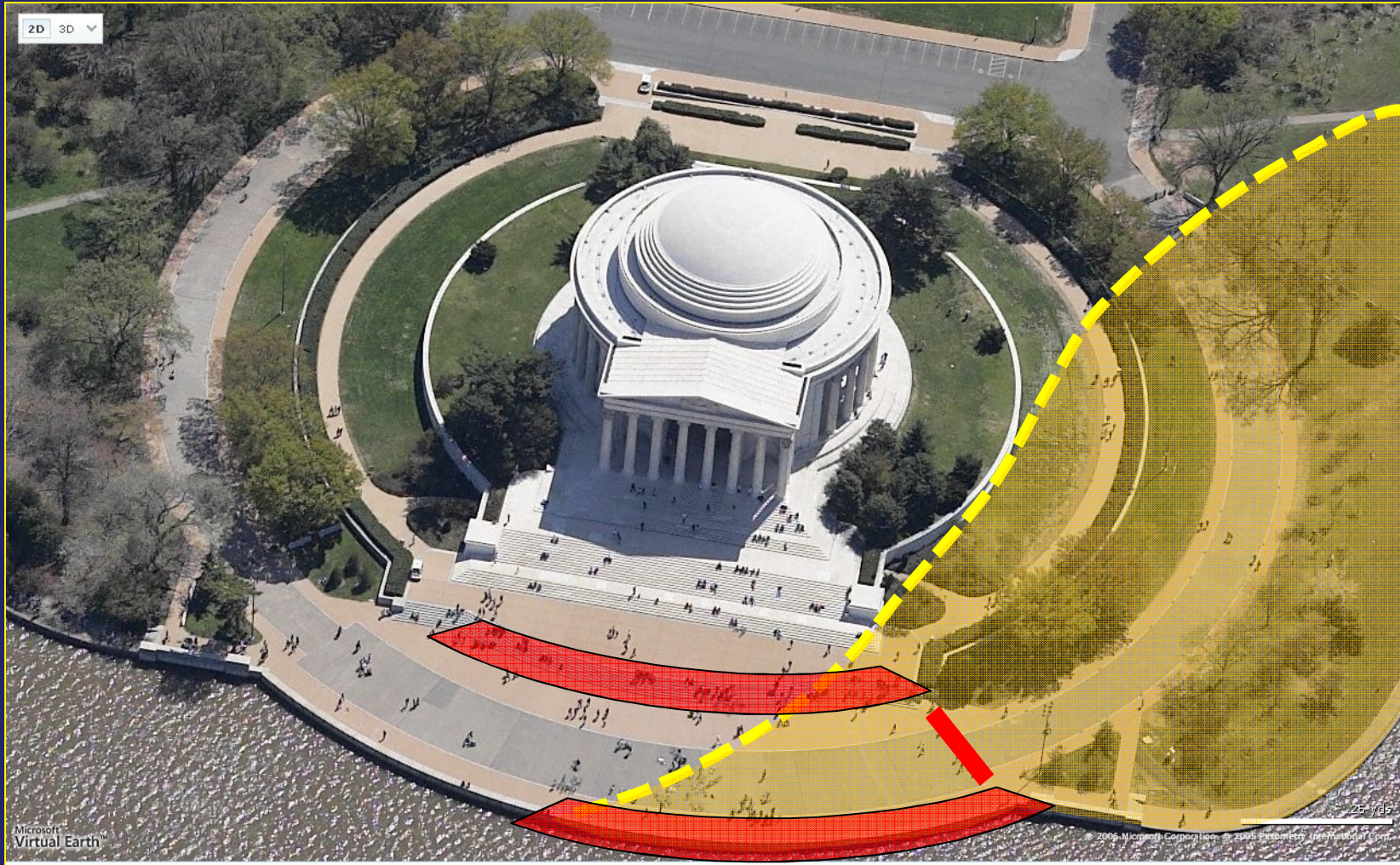
... and time can do so much

(Righteous Brothers)

Its Happening Again...

- 2005-2006
 - “Sudden” noticeable seawall settlement
 - North Plaza pulling away from Steps
- October 2006, NPS commissions investigation of movements

Settlement issues



Investigation



Investigation



Investigation



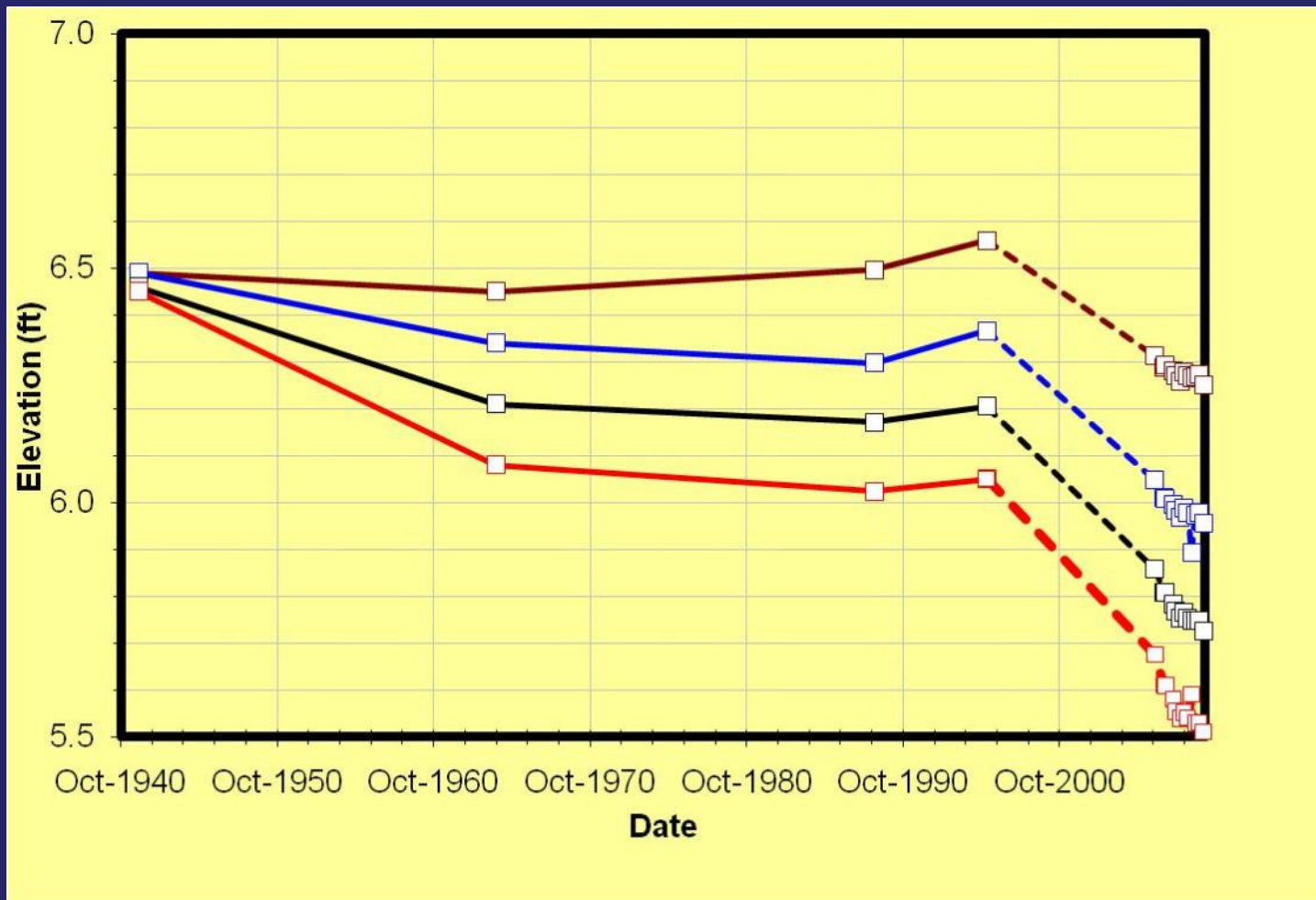
Questions that needed answers

- Was seawall on piles?
 - What type?
 - How deep?
- Were movements really sudden?
- If so, what was the cause?
- How much additional settlement? How much lateral movement?
- Was seawall safe?
- Was North Plaza safe?
- How about Memorial Building?

2006 Study

- Review historic information
- Exploration
- Instrumentation
- Survey
- Analyses

Findings



Was seawall on piles?



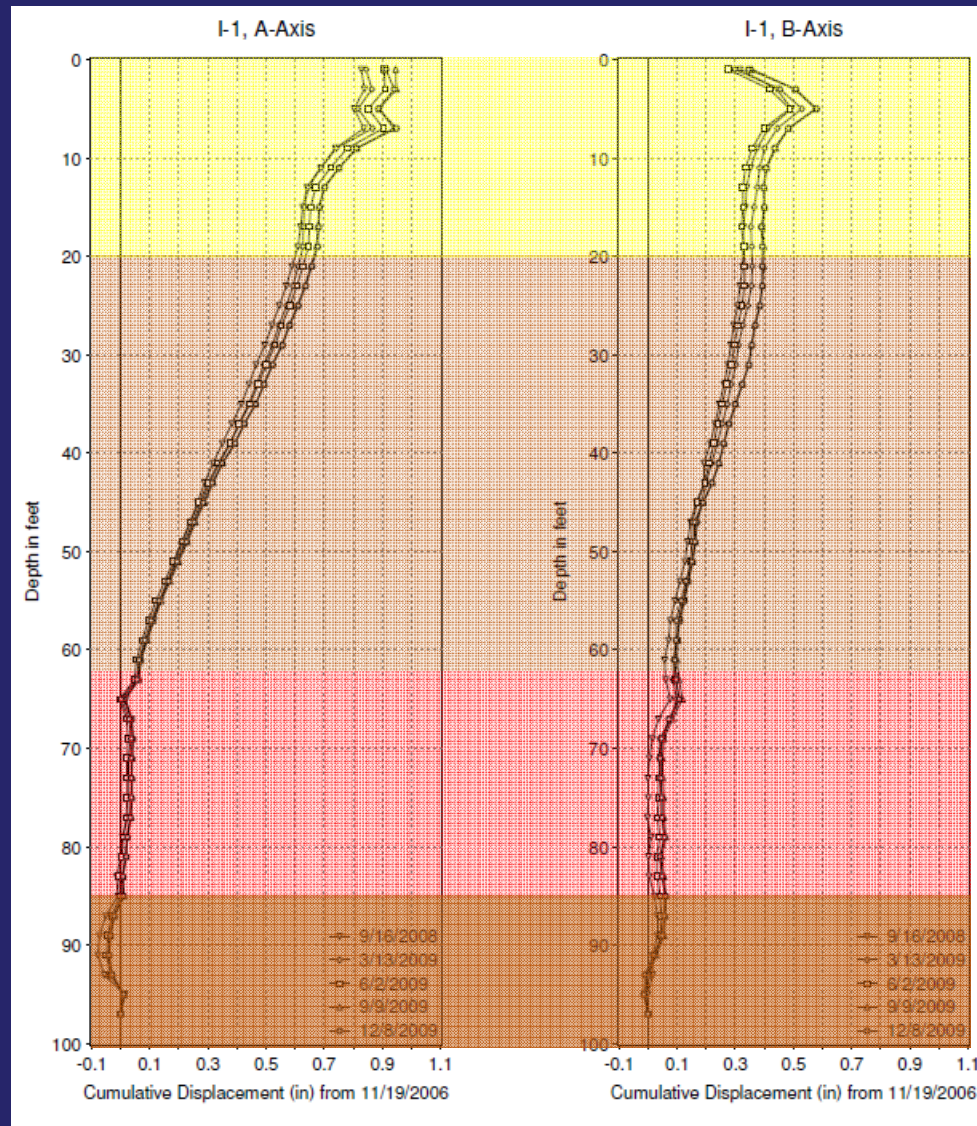
Source: National Park Service Archives 1939

Constructing the Memorial

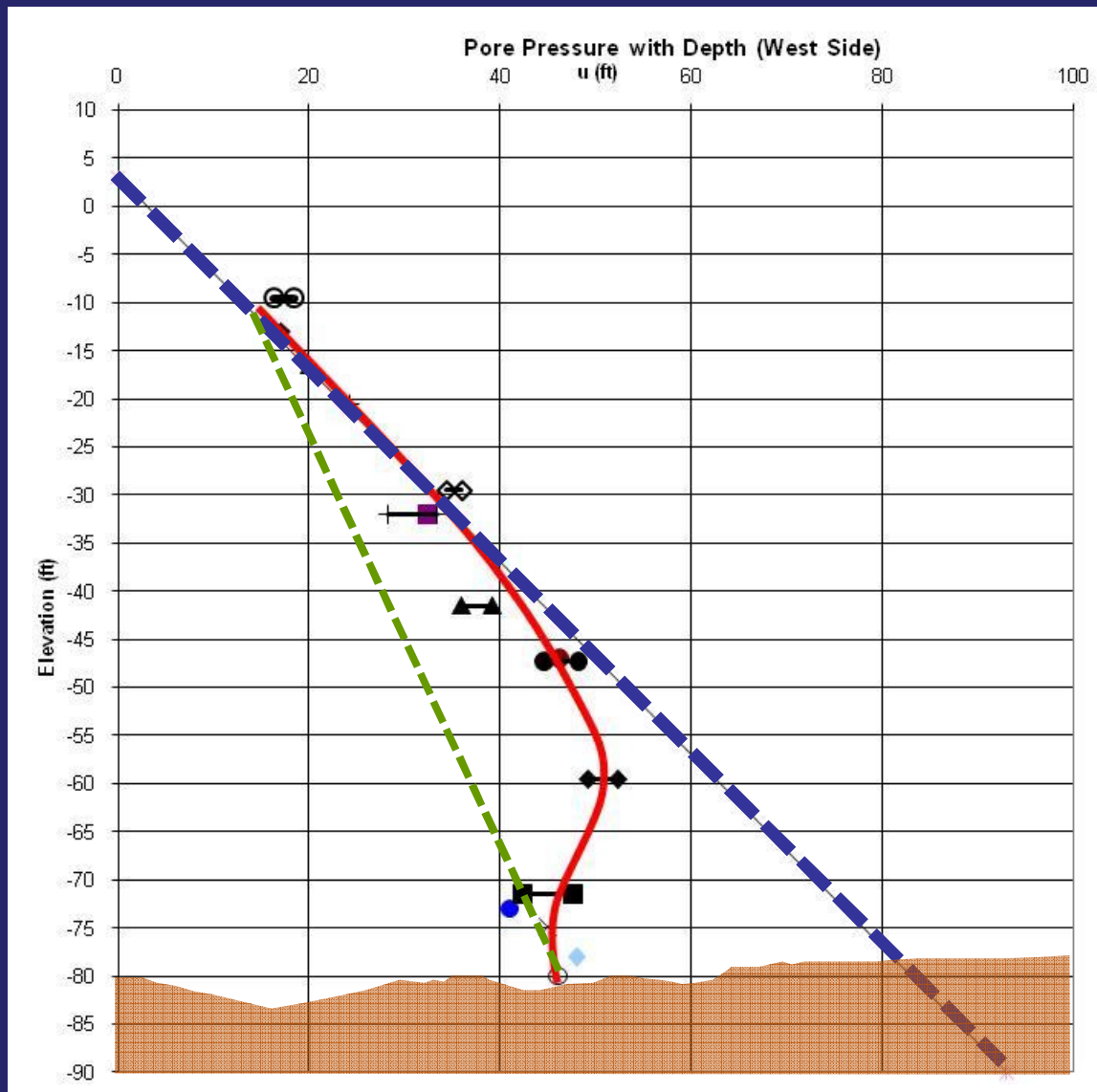


Source: National Park Service Archives 1939

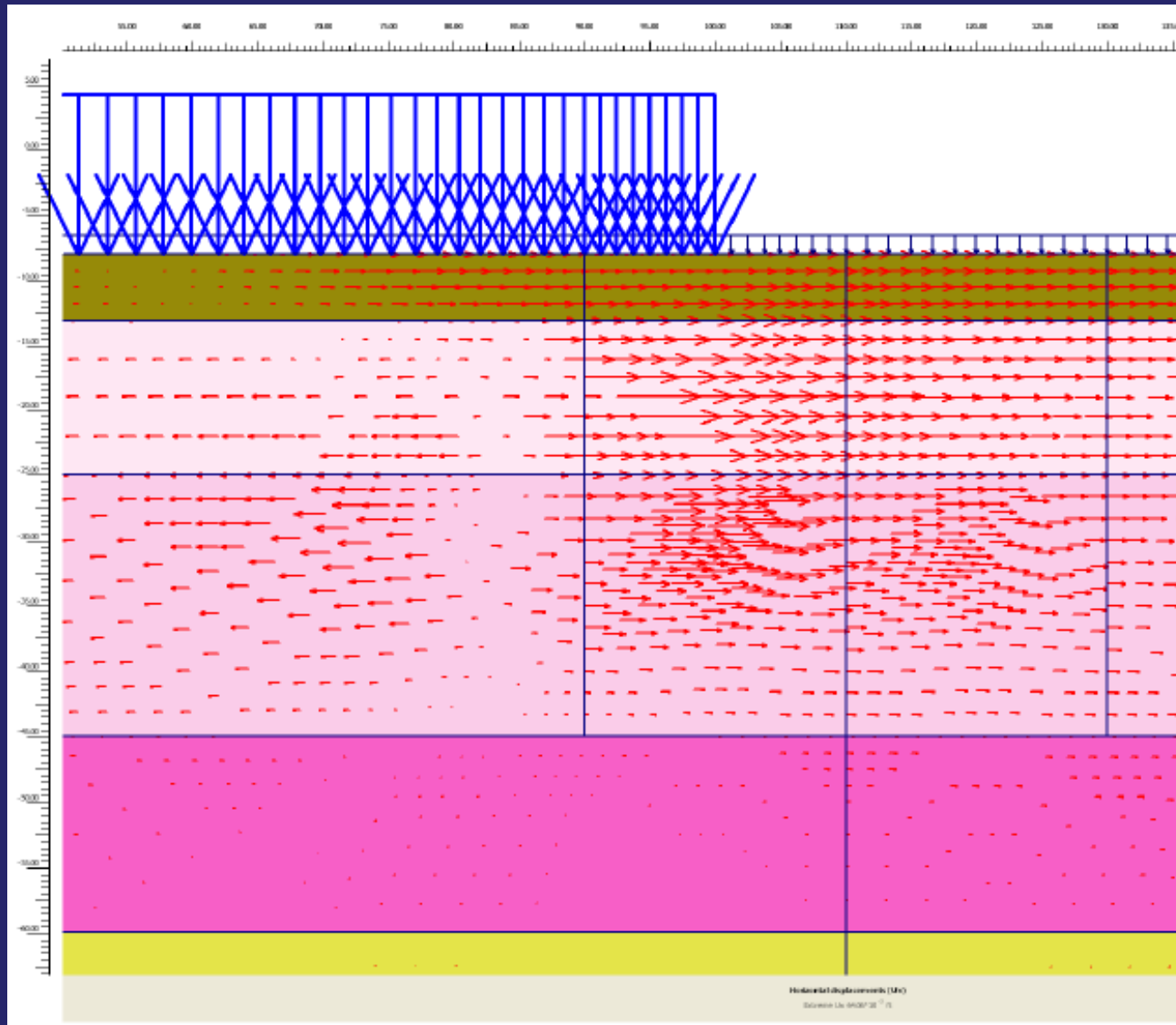
Findings



Findings



Findings



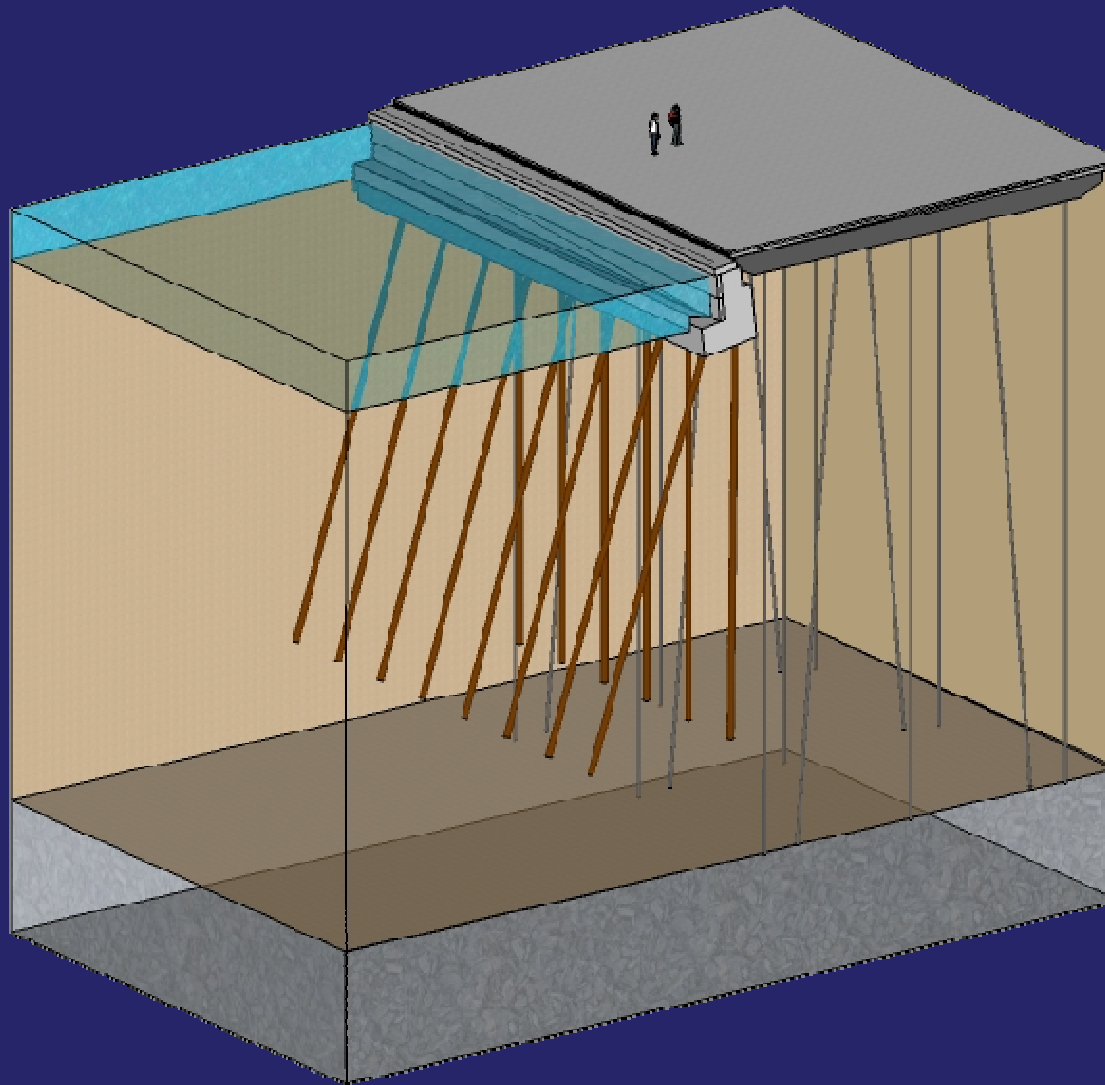
Remediation design

- Considered various alternatives
 - Deep Soil Mixing (DSM)
 - Treated root cause of problem
 - Spoils
 - Micropiles
 - Minimum disruption
 - Too flexible, required large number
 - Tied back diaphragm wall
 - Suitable stiffness
 - Conflict with North Plaza piles

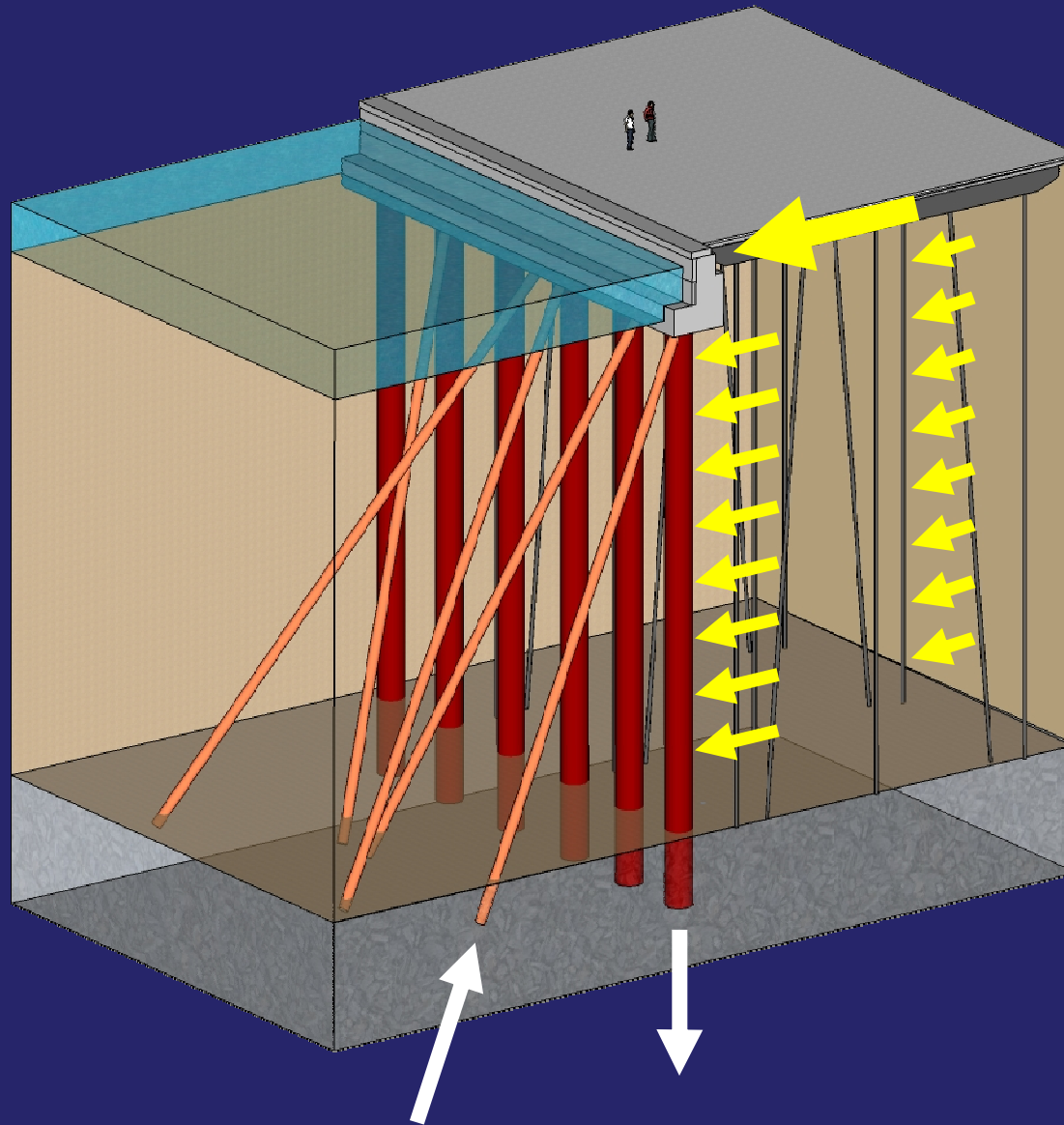
Remediation design

- Selected caissons and battered pipe piles
 - Suitable stiffness
 - No conflicts with existing piles
 - Visitor's experience

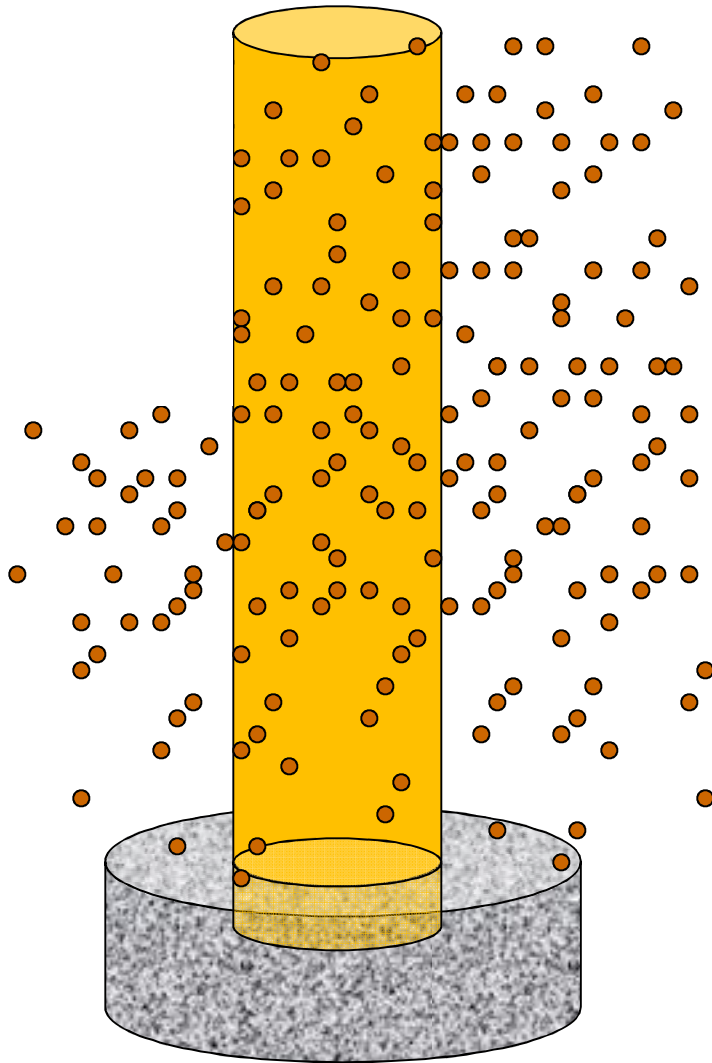
Remediation design



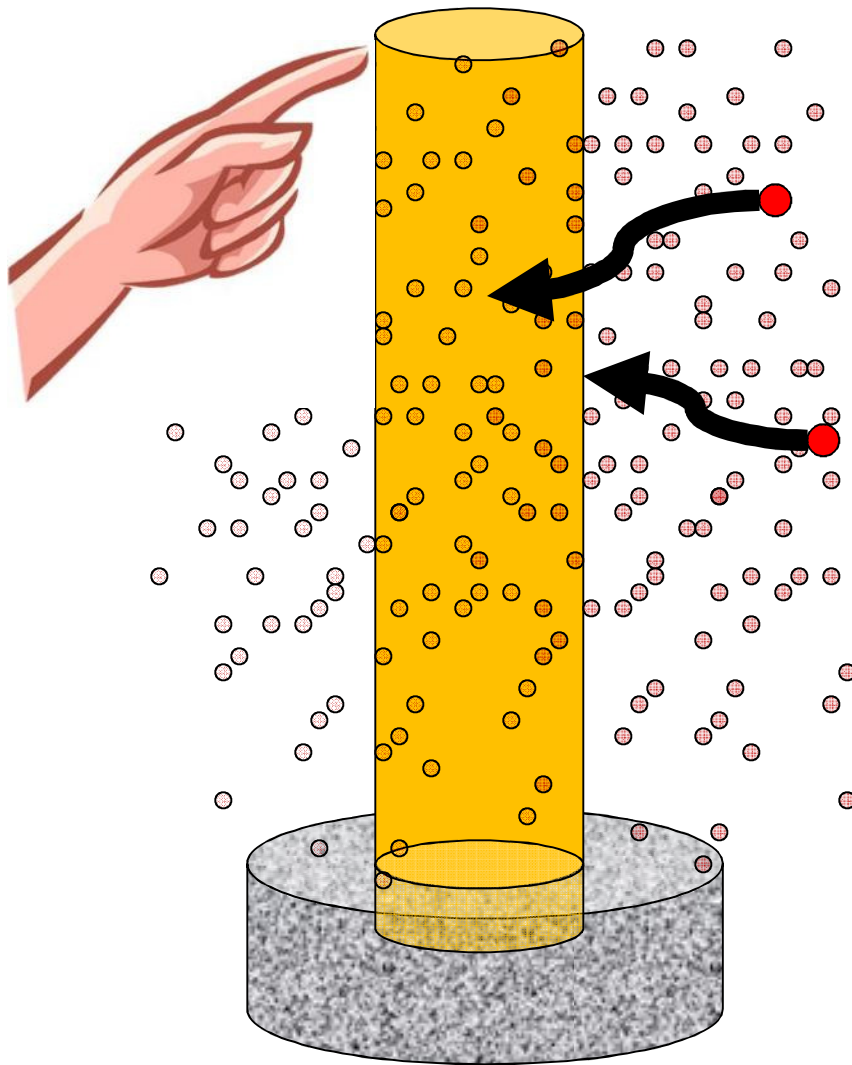
Remediation design



Lateral analyses



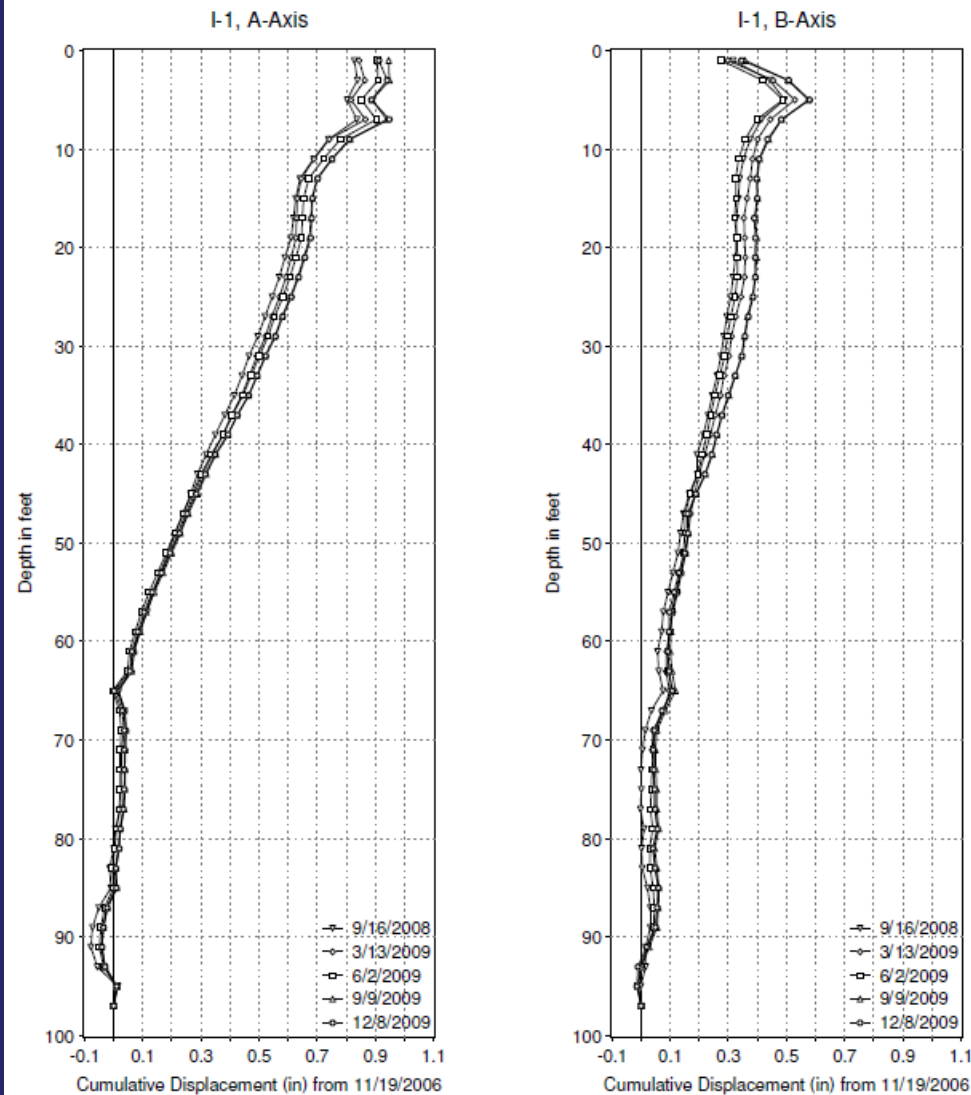
Lateral analyses of caisson and piles



- Apply soil movement profile
- Apply given displacement at top
- Determine shear at top
- For piles consider batter

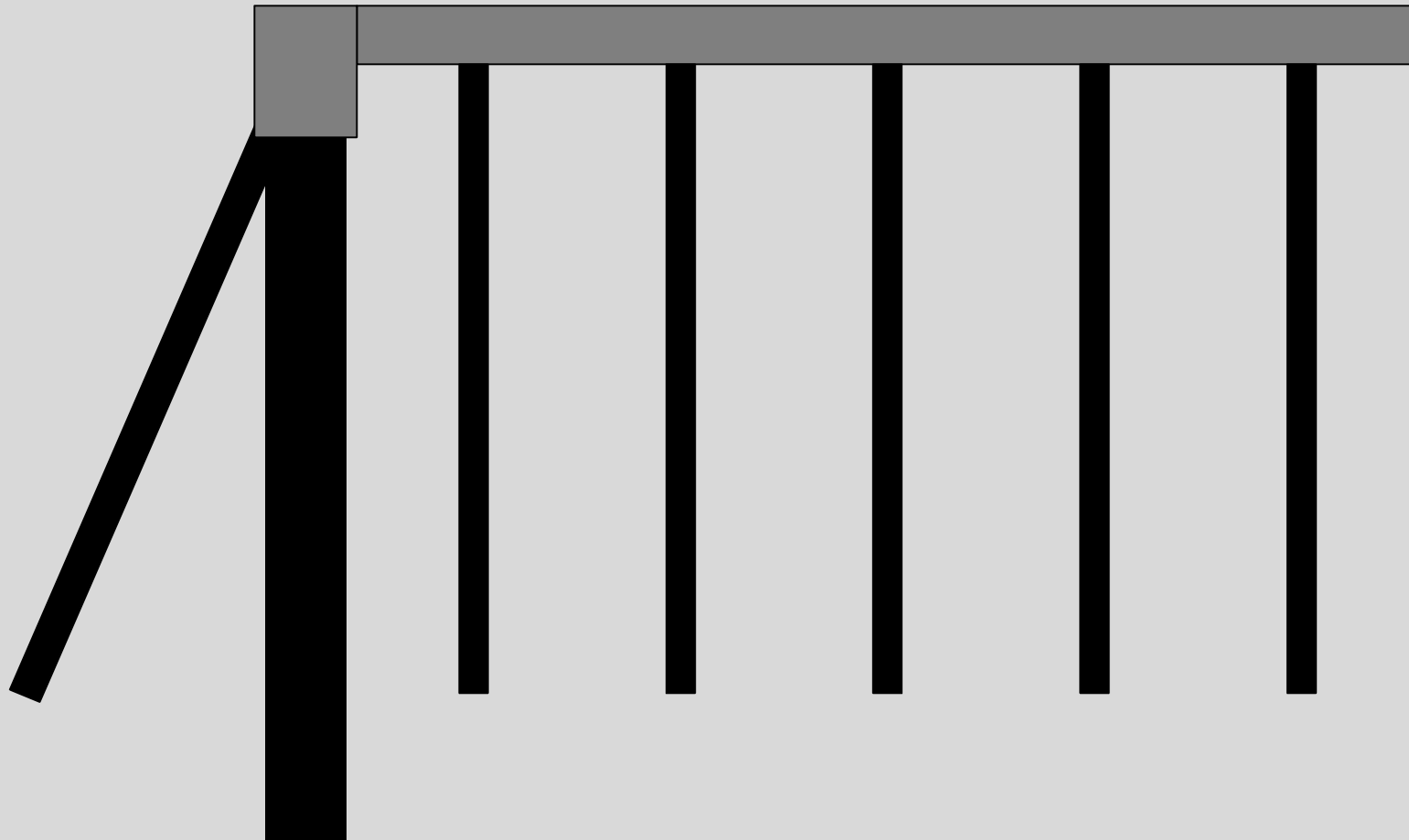


Soil movement profile

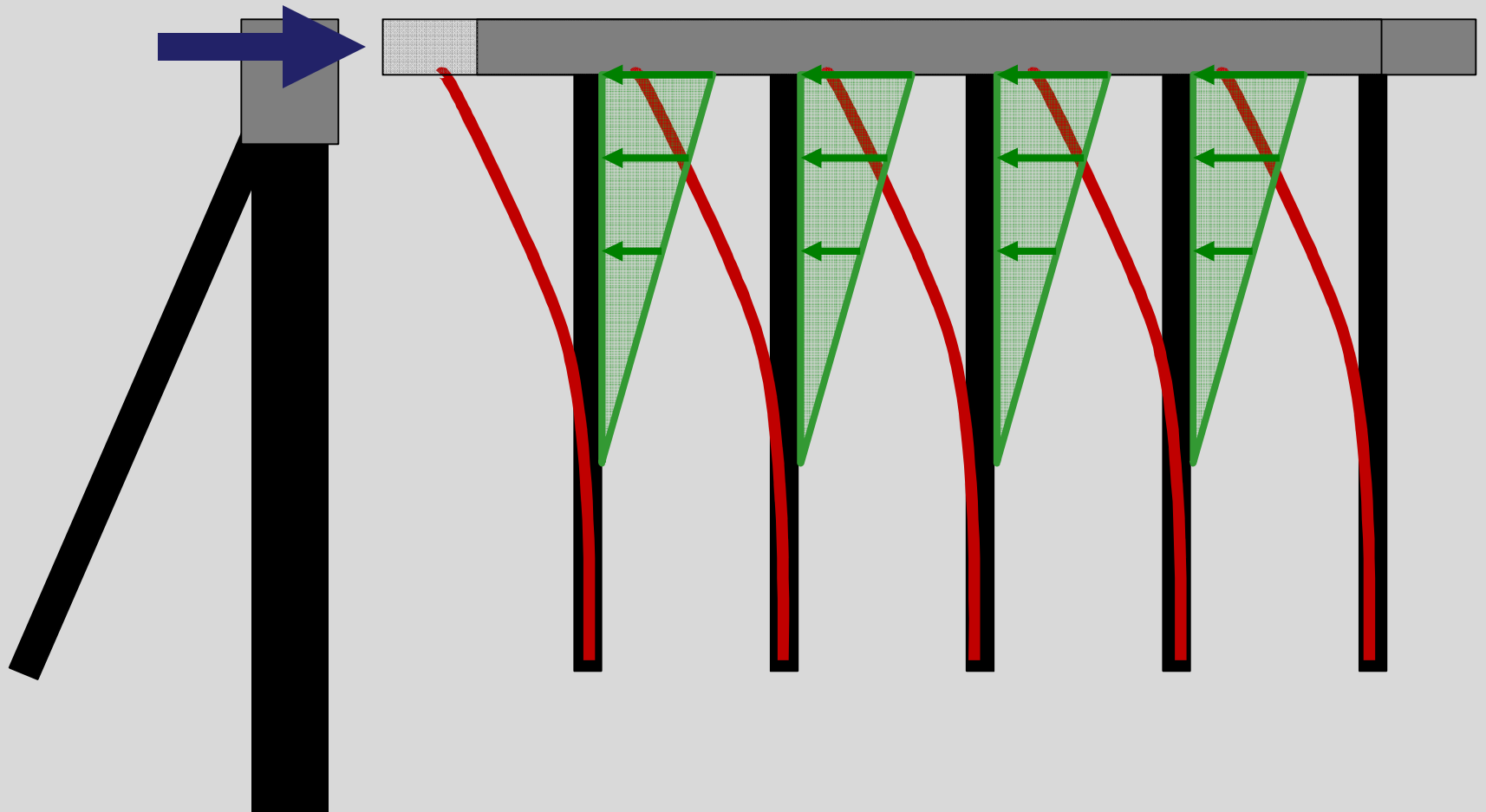


- Scaled from inclinometers
- Maximum displacement at top
- Zero at about 65 ft
- Used settlement/lateral displacement ratio from Plaxis

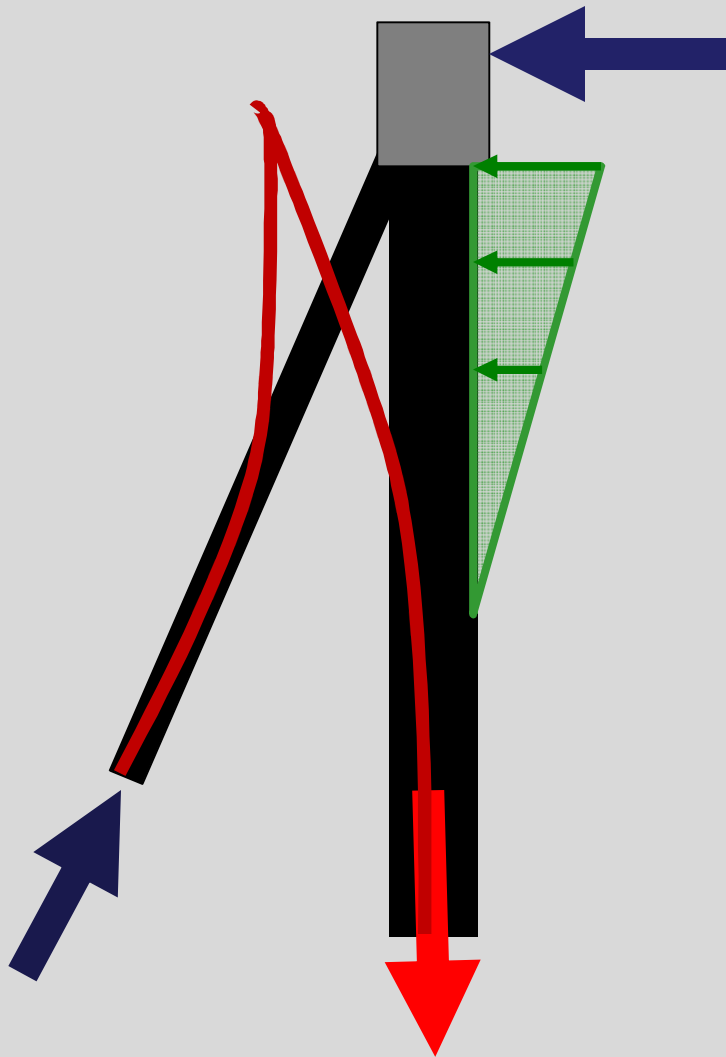
Lateral Analyses



Lateral Analyses

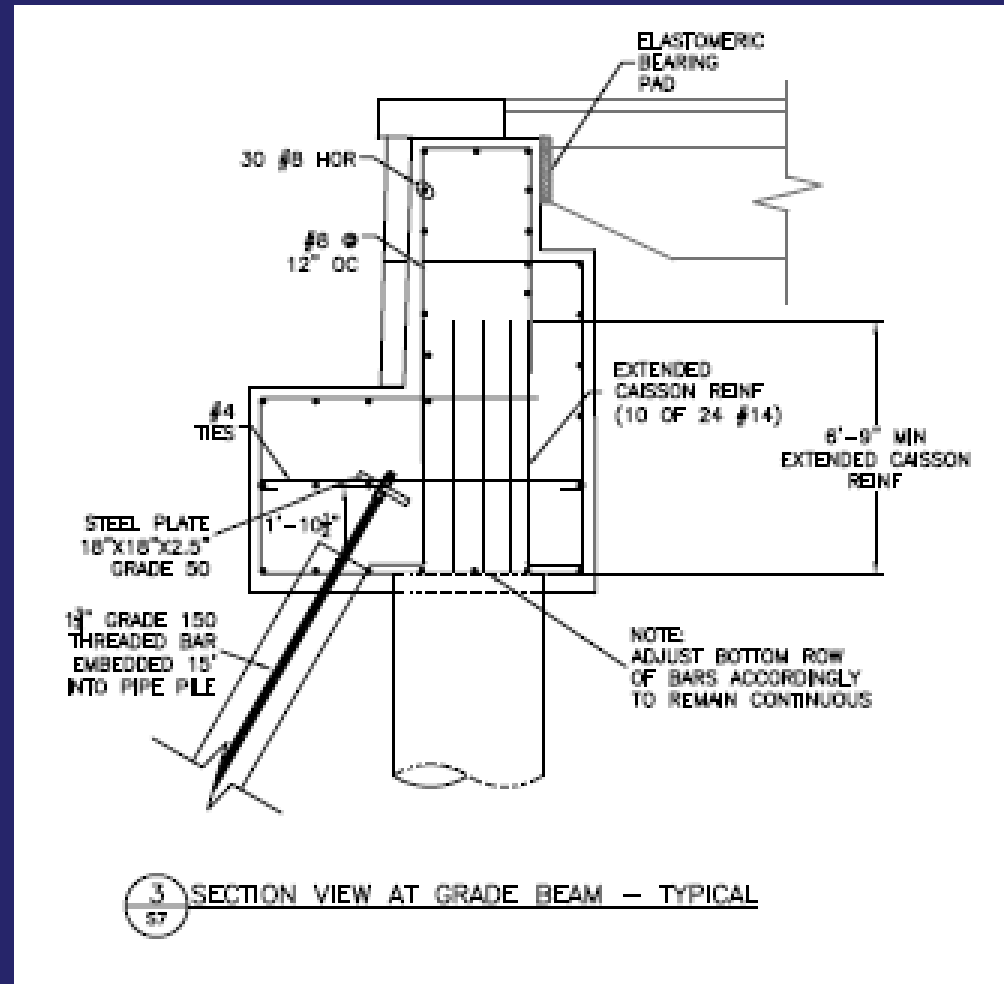


Lateral Analyses



- Iterative process
- Determine existing Plaza shear from Lpile analysis for various soil and head displacements
- Guess caisson and pipe pile sizes
- Use Lpile to determine shear forces, bending etc for zero head displacement
- Design caisson and piles
- Run structural analyses using framework or similar and determine head displacement
- Run next iteration

Remediation design



Seawall Reconstruction

- Contractor – Clark Construction
- Construction Management – Alpha
- CO/COR – NPS Denver
- Engineer – Schnabel Engineering



Seawall Reconstruction



Seawall Reconstruction



Seawall Reconstruction



Seawall Reconstruction



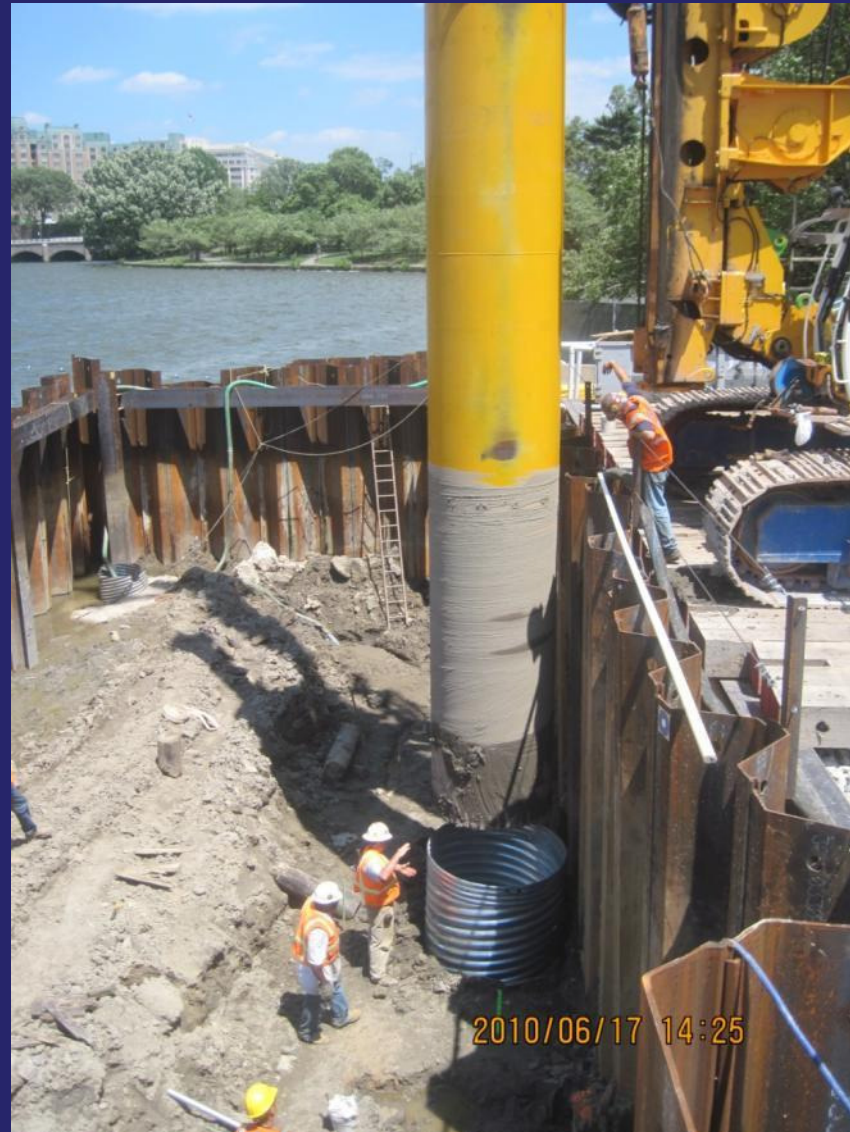
Seawall Reconstruction



Seawall Reconstruction



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Seawall Reconstruction



North Plaza Connection



Transition Zone



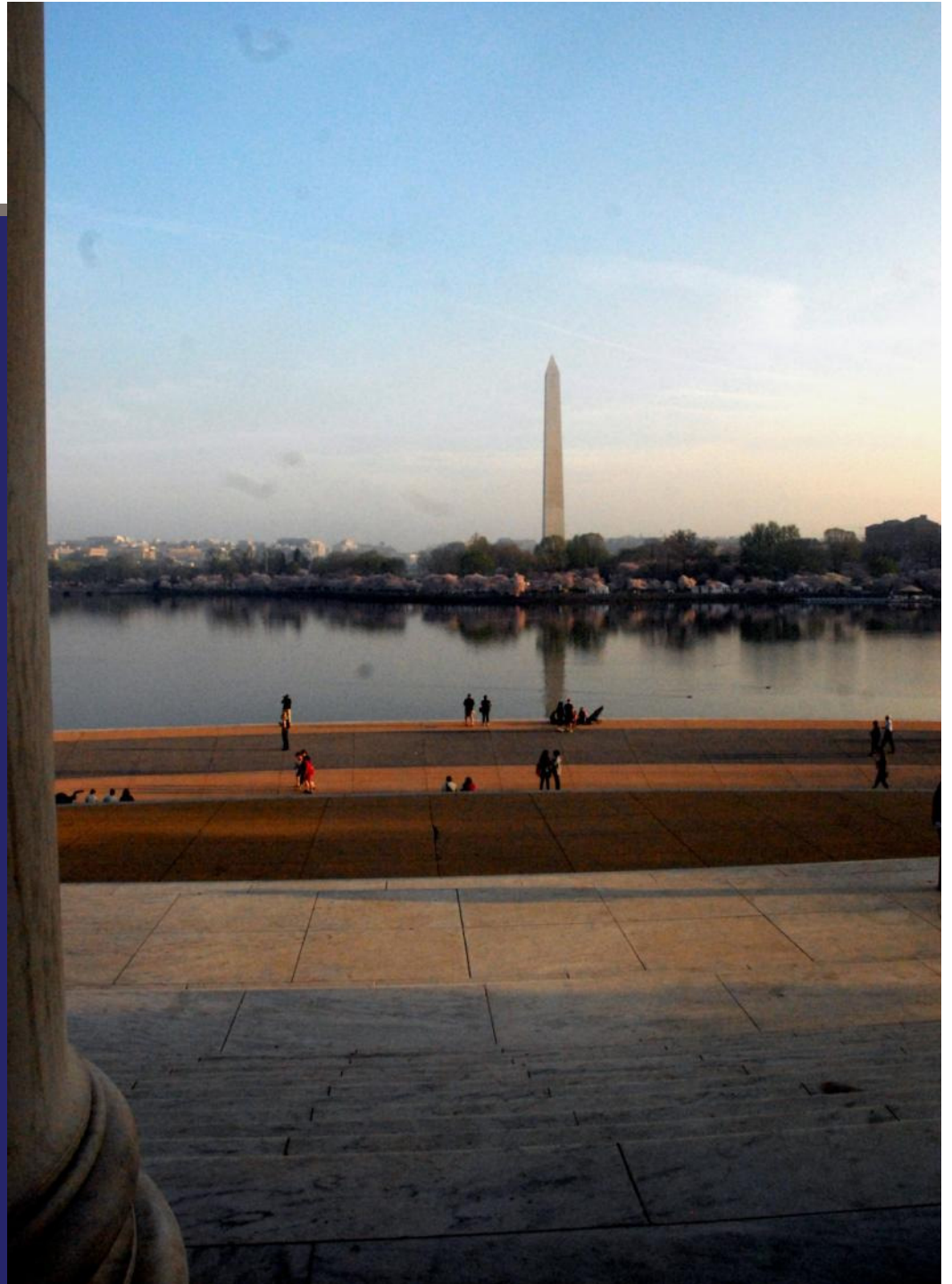
Transition Zone



North Plaza



North Plaza



Lessons learned

- Tidal Basin area around Jefferson Memorial may be subject to settlement over time
- Construction documentation is important
- Dewatering may have dramatic consequences even at considerable distance
- Current inclinometer data shows a change in direction and reduction of magnitude of movement
- Monitoring continues with periodic reporting to NPS

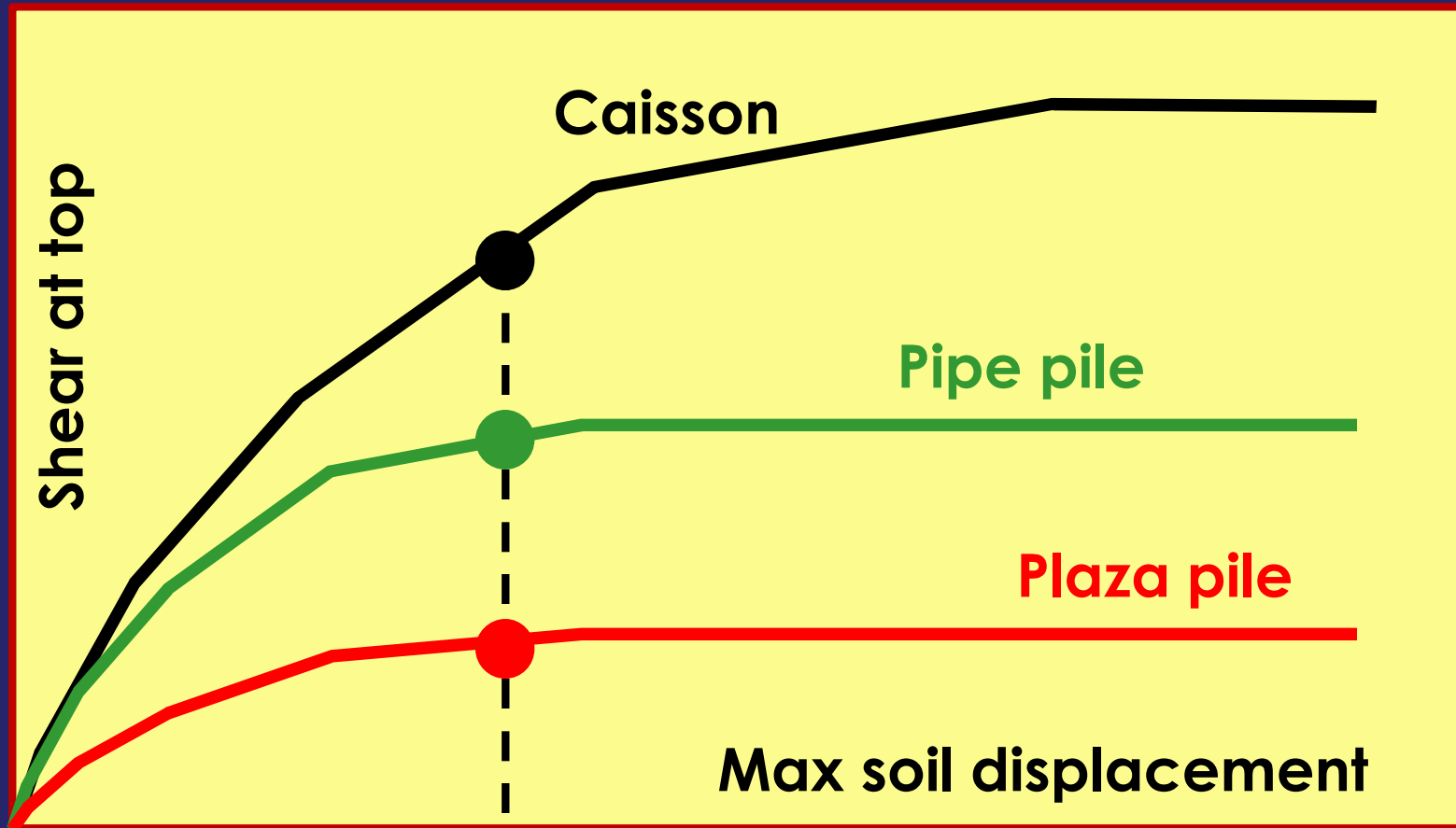


“thanks to a benevolent arrangement of things, the greater part of life is sunshine.”

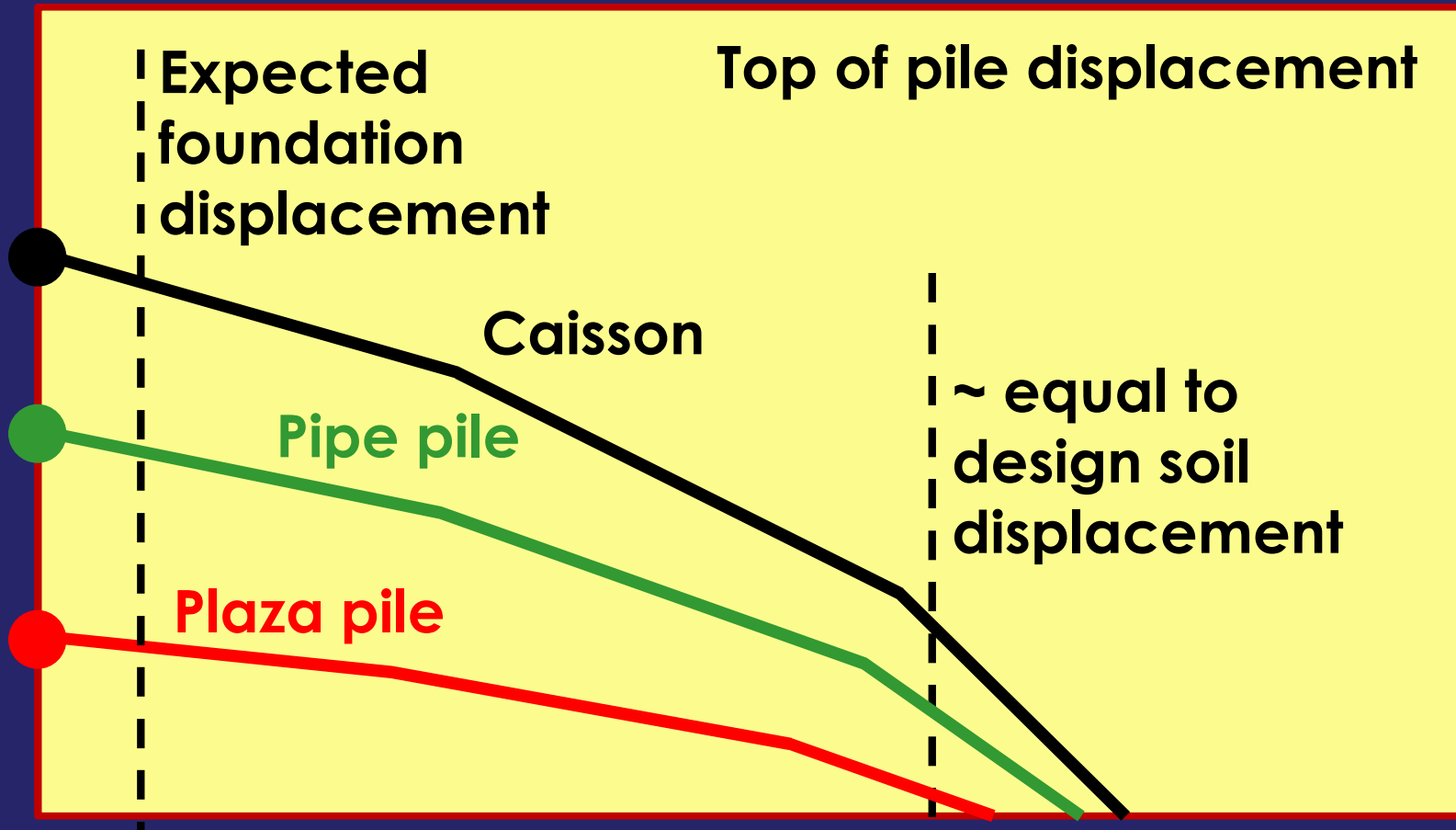
A handwritten signature in black ink, which appears to be "W. Edwards Deming".



Lateral Analyses



Lateral Analyses



Seawall Reconstruction



Seawall Reconstruction



Seawall Reconstruction



Lateral Analyses

- Modeled caisson and pile separately in Lpile Plus
- Applied various magnitudes of soil movement around foundations
- Movement profile scaled from inclinometer data
- Maximum settlement estimated from present pore pressure distribution
- Maximum lateral movement scaled from settlement based on Plaxis analyses

Seawall Reconstruction

