

San Francisco Seawall: History, Performance and Future Challenges

**EERI Northern California Chapter Meeting
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San Francisco Seawall: History, Performance and Future Challenges

Steven Reel, PE Port of San Francisco



Port of San Francisco – History and Mission

- State of California (1863-1968)
- City of San Francisco (1969 – Present), Burton Act
- 7-1/2 Miles of Waterfront from Hyde Street Pier to Hunters Point.
- 39 piers and wharves
- 43 inland parcels (called "seawall lots")
- 245 commercial and industrial buildings that together comprise some 20 million square feet

San Francisco Seawall

- 4 Miles of the Bayside Northern Waterfront
- Pier 45 in Fisherman's Wharf (Jones Street) to Mission Creek & 500 feet South of at Pier 48
- Designed & Built from 1878 to 1915
- 21 Distinct Sections
- Continuous Bulkhead Wharf
- Finger Piers

History of the Seawall



Early Waterfront & Need for a Seawall

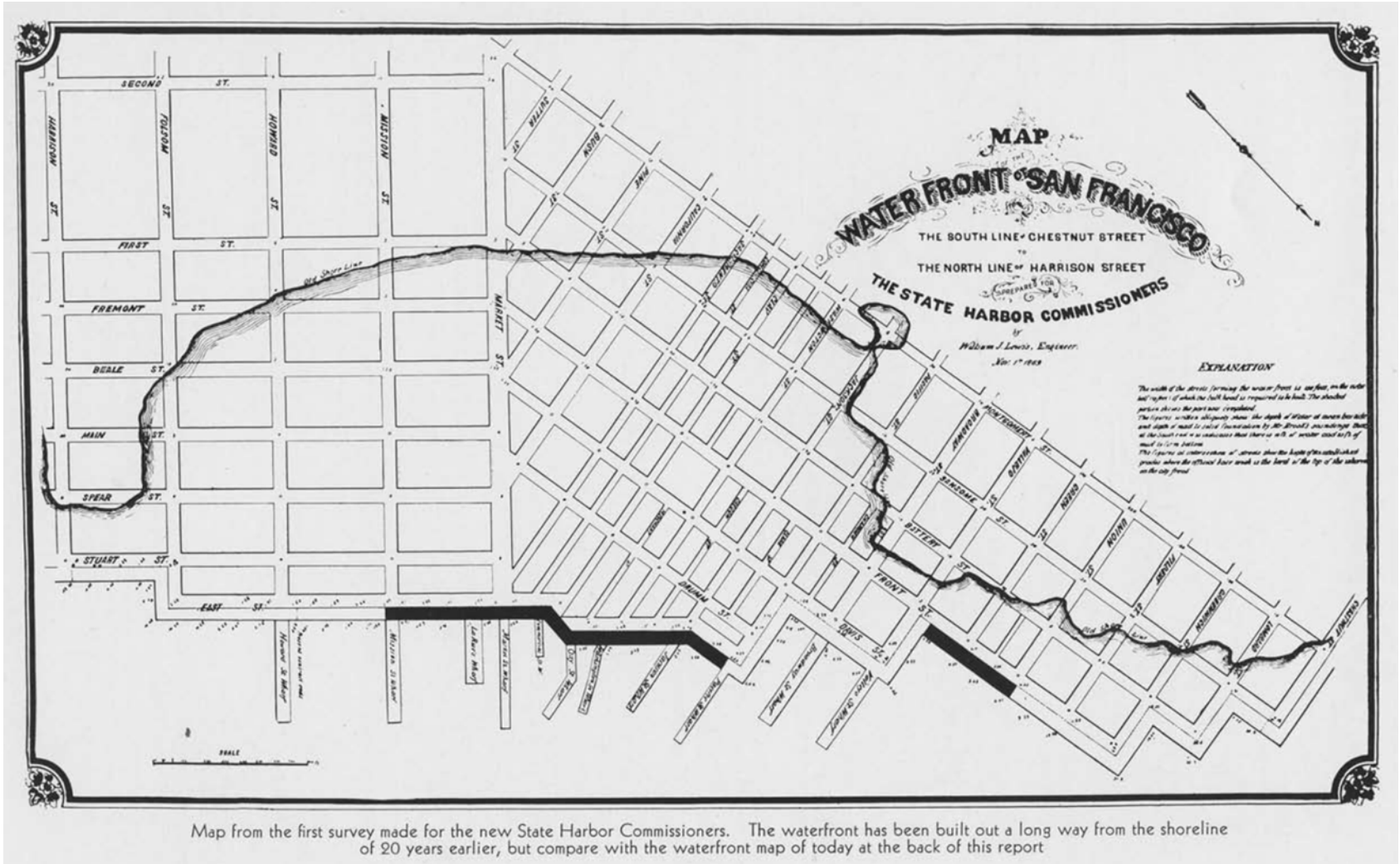


387. Ebb Tide, South Beach, San Francisco.

First Seawall (1867 – 1969)

- First Action of Harbor Commission
- William J. Lewis and G.F. Allardt, ZigzagPlan, 1866
- Plan and Specifications Completed 1867
- First 2 Sections completed in 1869 and third started
- Stopped due to lack of money
- Silting problems

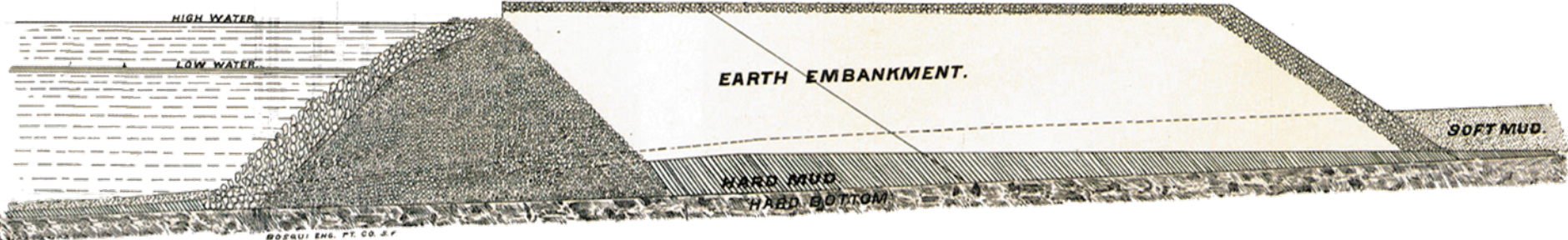
First Seawall (1867 – 1969)



Great Seawall 1878 - 1915

- 1870 Thomas J. Arnold, Engineer of Sea Wall
- 1873 Proposed new curved waterfront line
- 1877 New Waterfront Line Established
 - Continuous curved line
 - Wide enough for a 200 ft wide thoroughfare
 - Tide lands between owned by Harbor Commission

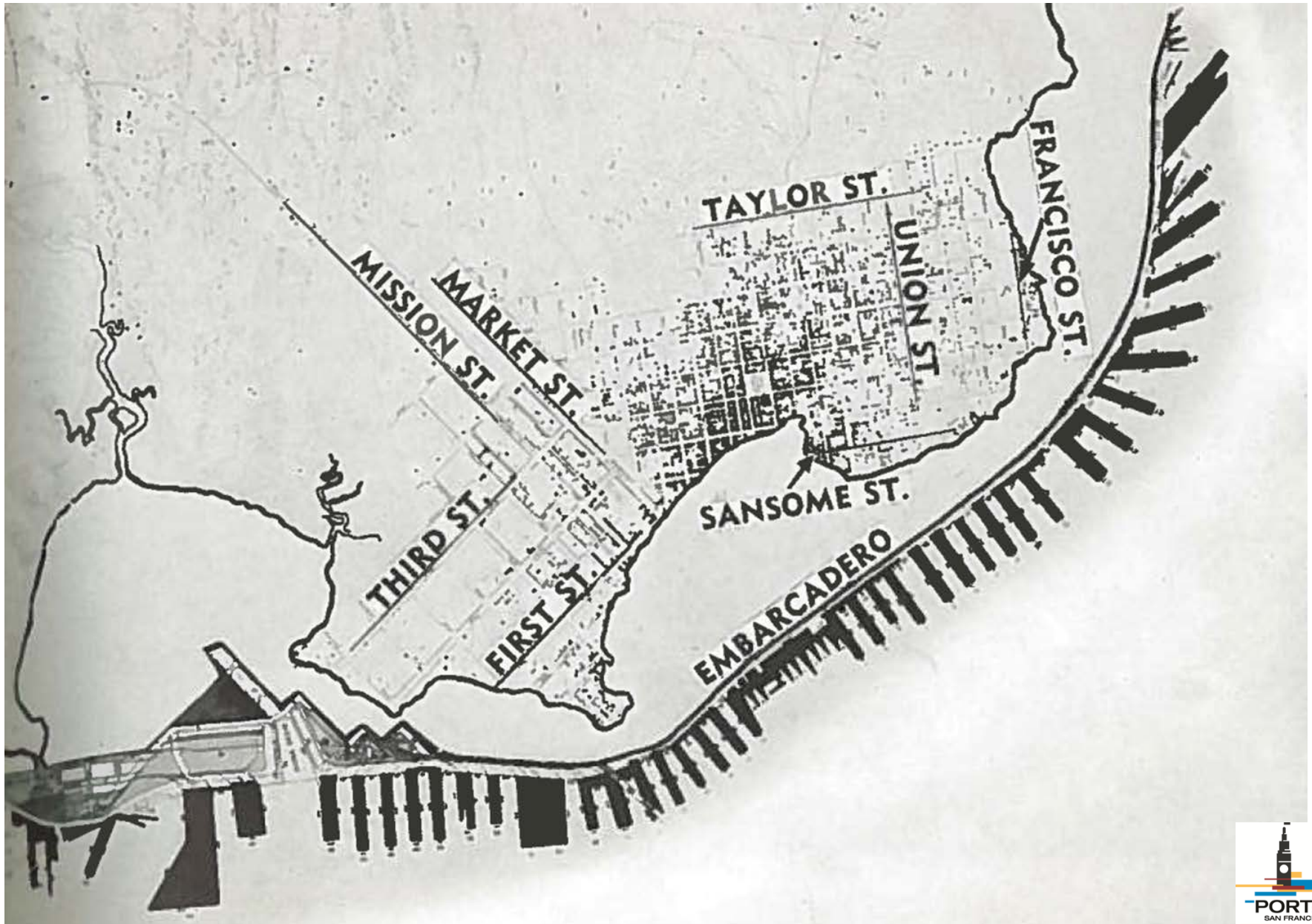
Great Seawall 1878 - 1915



TRANSVERSE SECTION of SEA WALL and THOROUGHFARE.

SCALE 20ft. = 1 INCH.

Great Seawall 1878 - 1915



Great Seawall 1878 - 1915

EXHIBIT 3

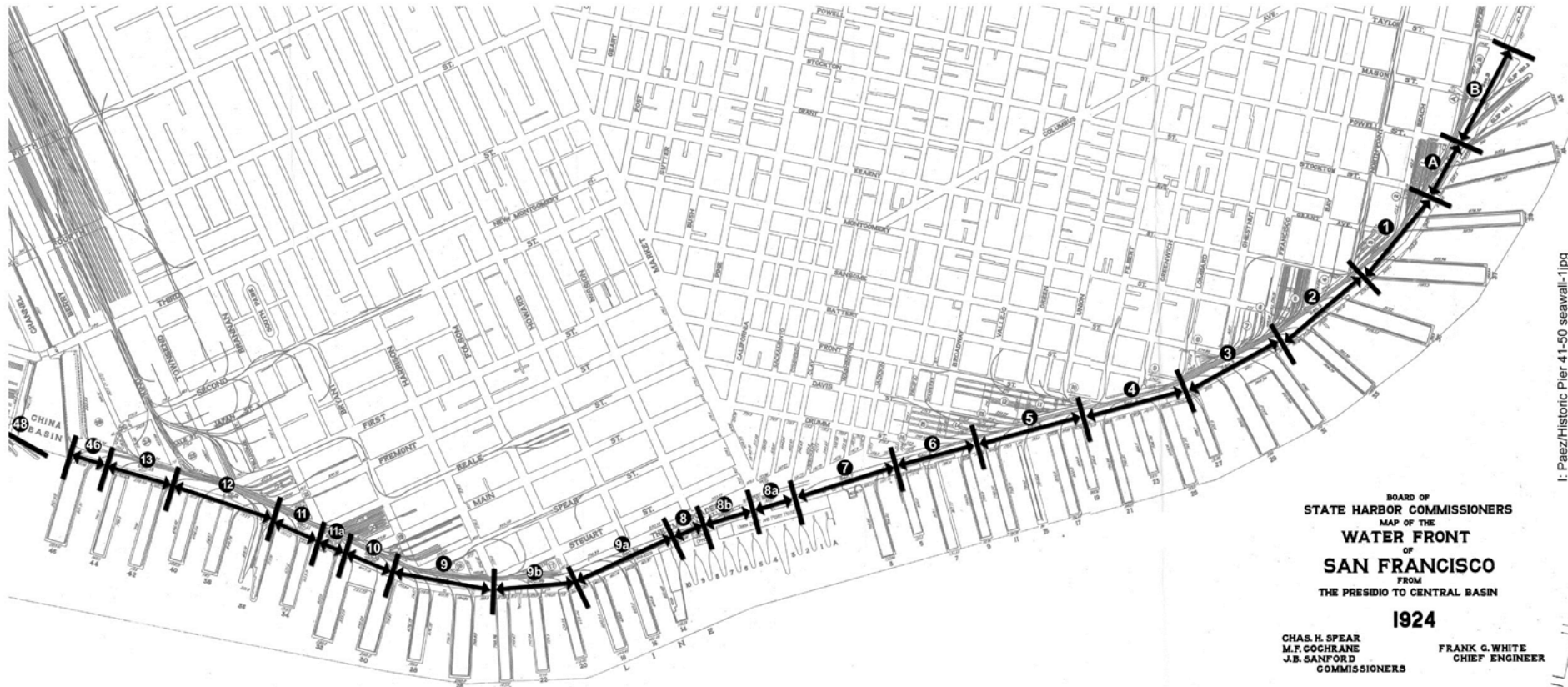
BULKHEAD WHARF AND SEAWALL LOCATION BY SECTION Embarcadero National Register Historic District (Pier 45 - 48 at China Basin)

Source: Board of State Harbor Commissioners 1924 Biennial Report

Legend

- Section B - 1000' between Taylor and Powell Streets - Constructed 1914.
- Section A - 561' between Powell and Stockton Streets - Constructed in two parts in 1914.
- Section 1 - 1000' between Stockton and Kearny Streets - Constructed in two parts in 1913-14 & 1914-15.
- Section 2 - 1000' between North Point and Francisco Streets - Constructed in two parts in 1914-16 & 1917-19.
- Section 3 - 1000' between Francisco and Lombard Streets - Constructed in three parts in 1915-16, 1917-18 & 1918-19.
- Section 4 - 1000' between Lombard and Union Streets - Constructed in two parts in 1920 and 1921-22.
- Section 5 - 1000' between Union and Vallejo Streets - Constructed in four parts in 1912-13, 1914-15, 1921-22 & 1930-31.
- Section 6 - 800' between Vallejo and Pacific Streets - Constructed in three parts in 1916-17, 1917 & 1920.
- Section 7 - 980' between Pacific and Clay Streets - Constructed in six parts in 1894-95, 1909, 1916, 1920, 1921-22 & 1929-30.
- Section 8a - 392' between Clay and Market Streets - Constructed 1894-95.

- Section 8b - 450' between Market and Mission Streets - Constructed 1915.
- Section 8 - 300' between Mission and point north of Howard Streets - Constructed 1915.
- Section 9a - 990' south of Mission to Folsom Street - Constructed 1913 and demolished in 1975 and 1983.
- Section 9b - 788' between Folsom and Harrison Streets - Constructed 1913, all but 60' was demolished in 1983.
- Section 9 - 990' south of Mission to Folsom Street - Constructed in two parts in 1909-10.
- Section 10 - 537' north of Beale to Main Street - Constructed 1910-11.
- Section 11a - 281' south of Main to Beale Street - Constructed 1912-14.
- Section 11 - 353' north of Beale to Fremont Street - Constructed 1909-10.
- Section 12 - 1167' between Fremont and King Streets - Constructed in two parts in 1909.
- Section 13 - 600' between King and Berry Streets - Constructed in two parts in 1917-18 & 1935-36.
- Pier 46 Section - 236' between Berry Street and China Basin Channel - Constructed in 1914.
- Pier 48 Section - 500' north side of Pier 50 to China Basin Channel - Constructed 1928-29.



BOARD OF
STATE HARBOR COMMISSIONERS
MAP OF THE
WATER FRONT
OF
SAN FRANCISCO
FROM
THE PRESIDIO TO CENTRAL BASIN
1924

CHAS. H. SPEAR
M.F. COCHRANE
J.B. SANFORD
COMMISSIONERS

FRANK G. WHITE
CHIEF ENGINEER

Great Seawall 1878 - 1915

- 12 Sections Constructed 1878 to 1905 (A,1,2,3,4,5,6,7,8b,B,8a,13).
- All similar in design, 40 ft high rock embankment rising from a trench 20 ft deep and 100 feet wide)
- Wooden piles driven on bayside of embankment to support a timber bulkhead wharf, 27ft to 60 ft wide.
- Earth Embankment to create 200 ft wide thoroughfare.

Great Seawall 1878 - 1915

- 7 Sections Constructed 1909 to 1915 (8,9a,9b,10,11,11a & 12).
- Slightly different construction, designed by H.J. Brunnier, to be especially strong.
- Trench partially filled with rock, concrete piles driven through base, reinforced concrete bulkhead wall integral with steel beam and concrete bulkhead wharf, rock and fill. Various bulkhead designs.
- Settlement repair of Sections 9a, 9b in 1917 and again in 1931. Also section 11.

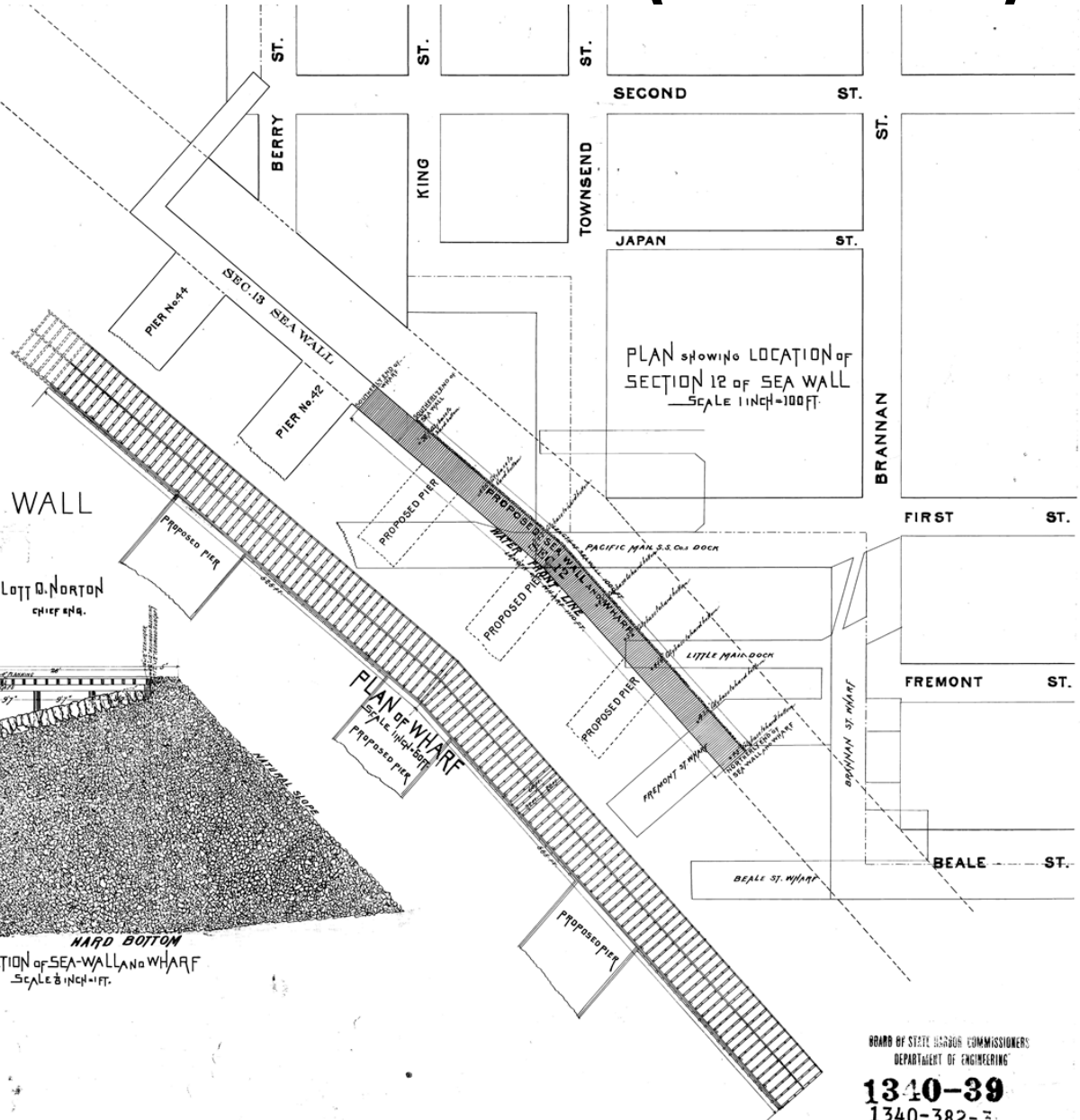
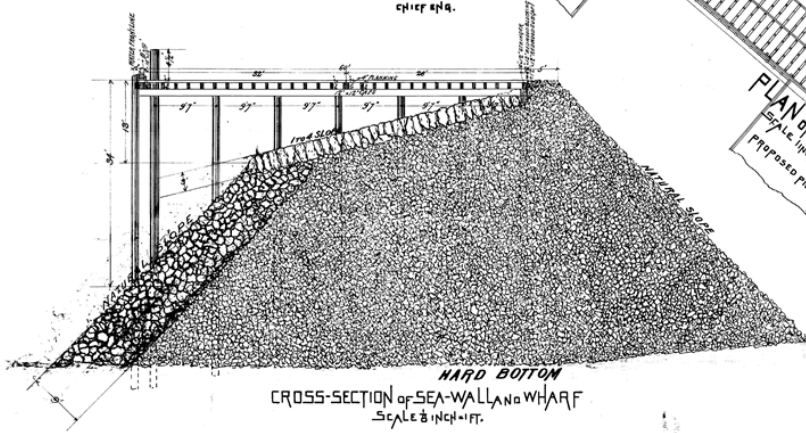
Great Seawall 1878 – 1915 (Section 12)

68-0781

PLAN
of
SECTION 12 OF THE SEA WALL

MAY 1, 1907.

LOTT O. NORTON
chief eng.



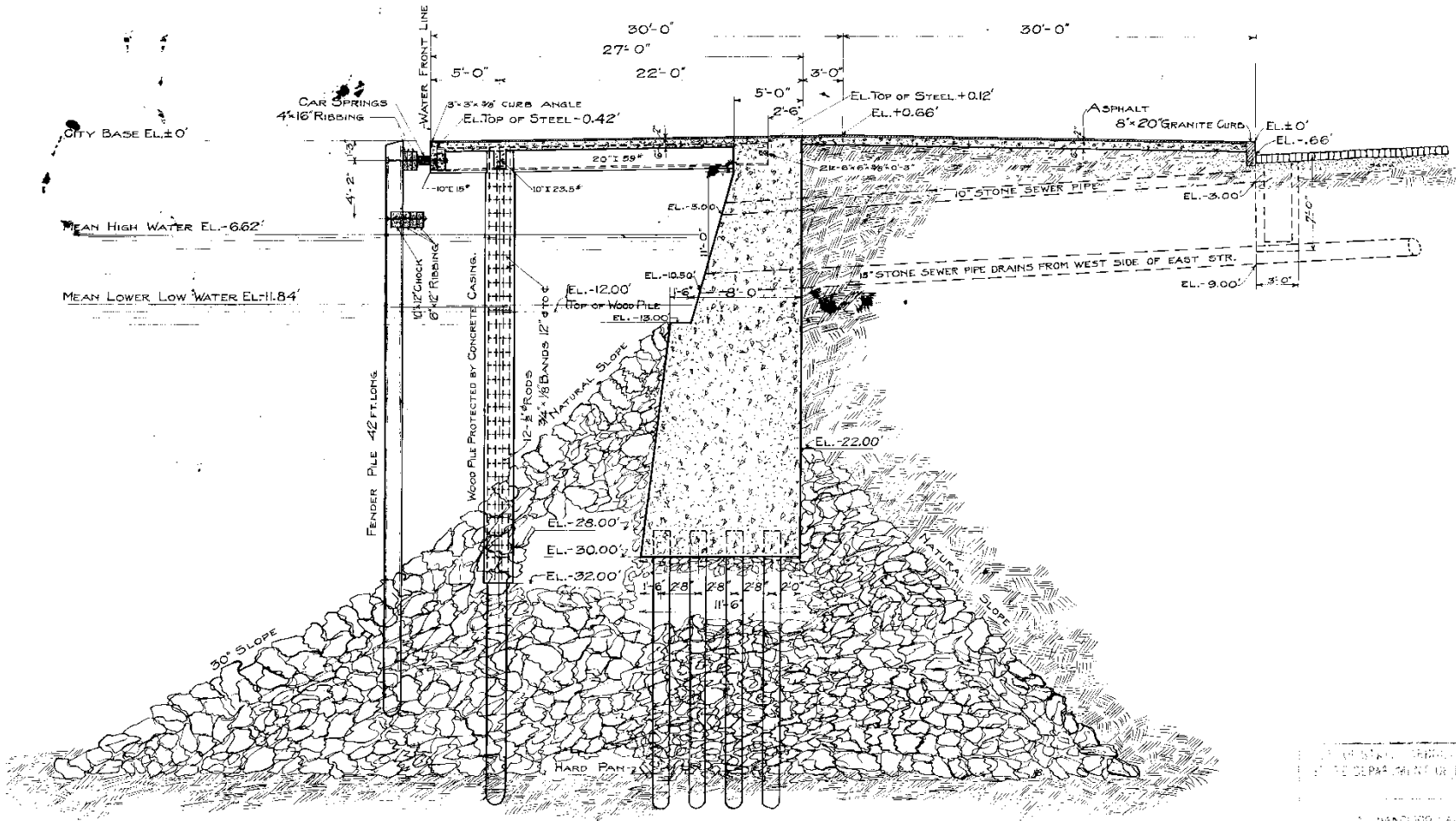
1340-382-3

BOARD BY STEVE HANCOCK, COMMISSIONERS
DEPARTMENT OF ENGINEERING

1340-39
1340-382-3



Great Seawall 1878 – 1915 (Section 10)

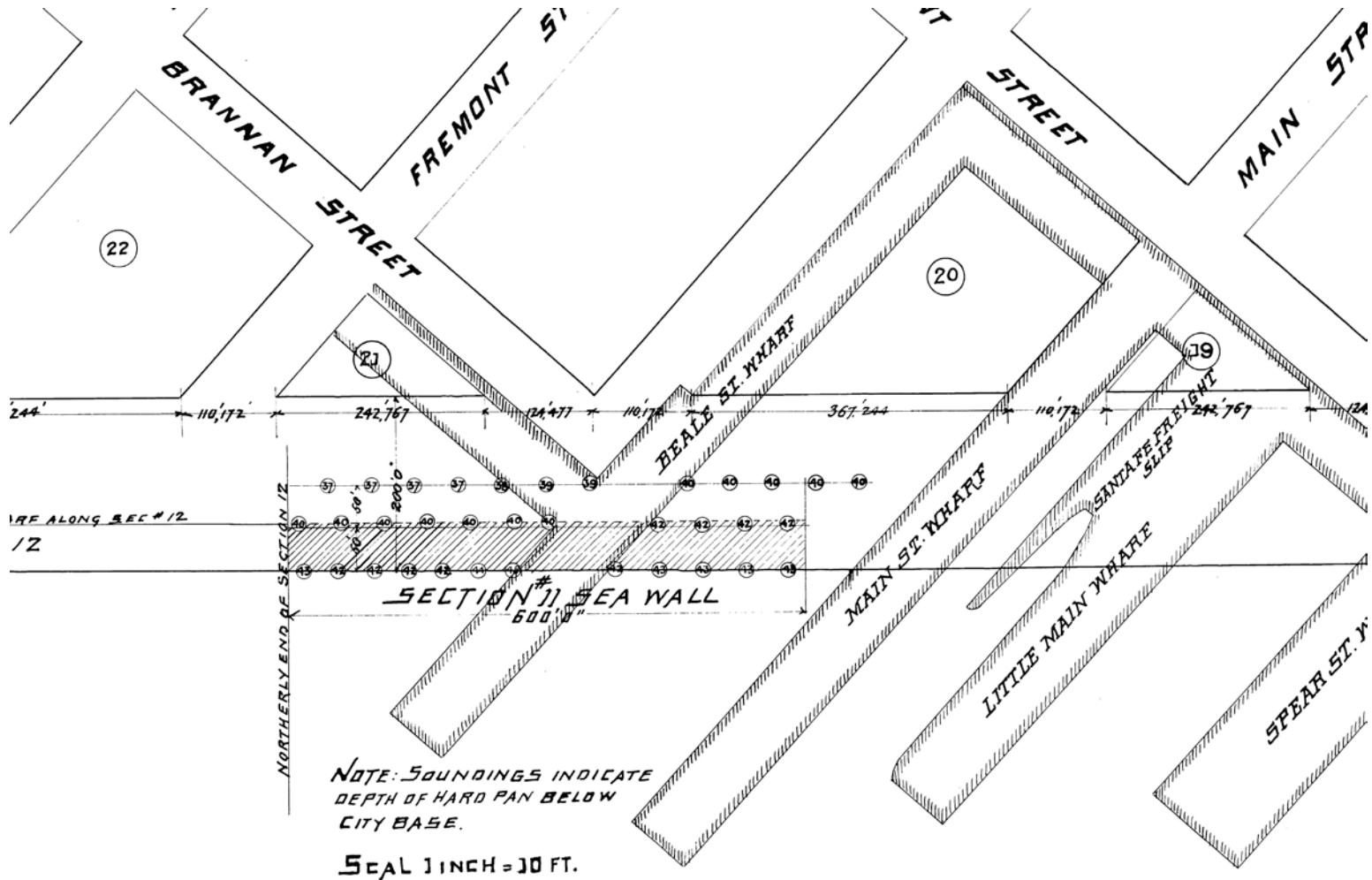


CROSS SECTION OF SEAWALL SECTION 10

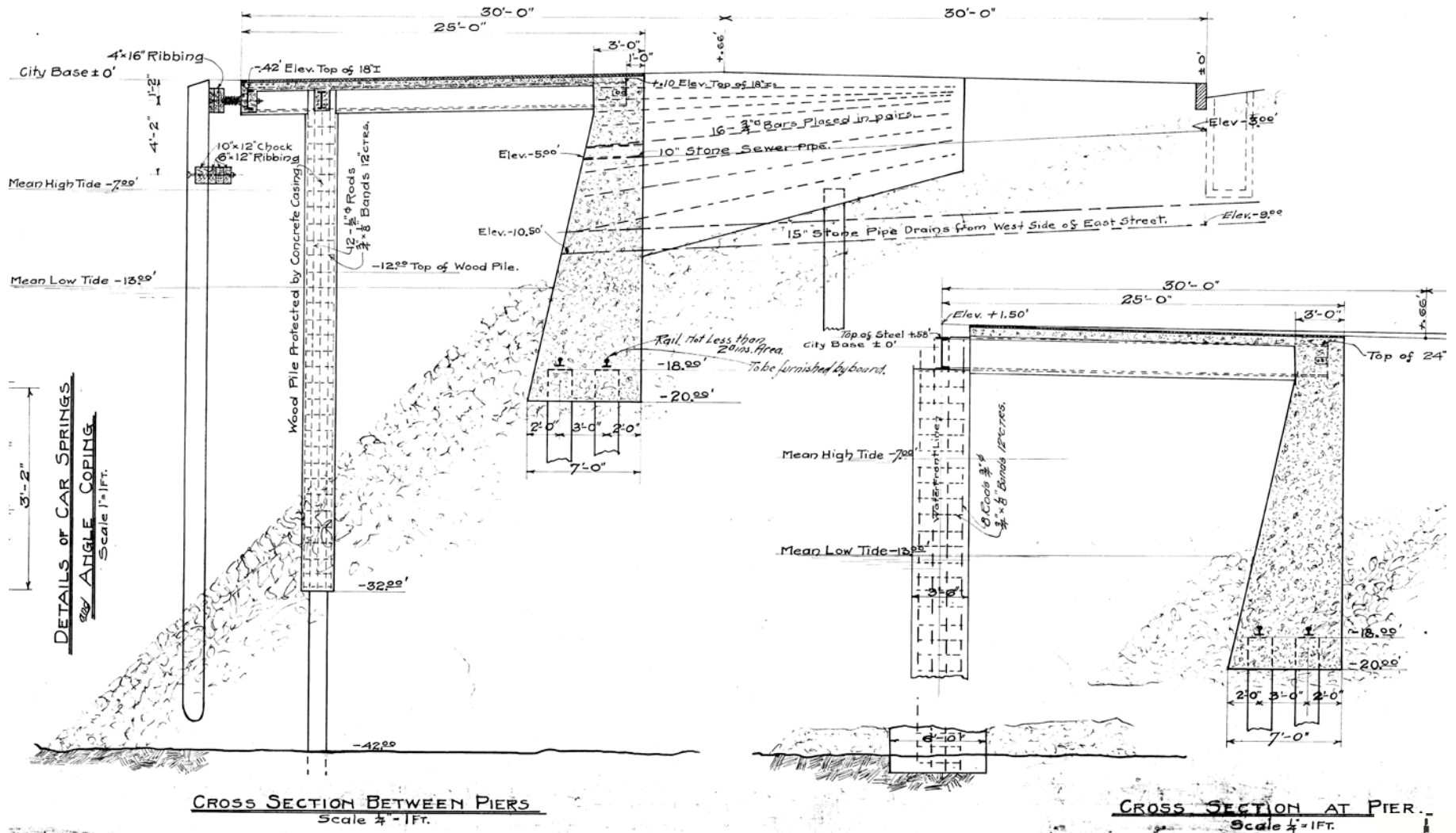
REPRODUCTION FROM
 THE DEPARTMENT OF LAND AND NATURAL RESOURCES
 SAN FRANCISCO, CALIF.

1993-39

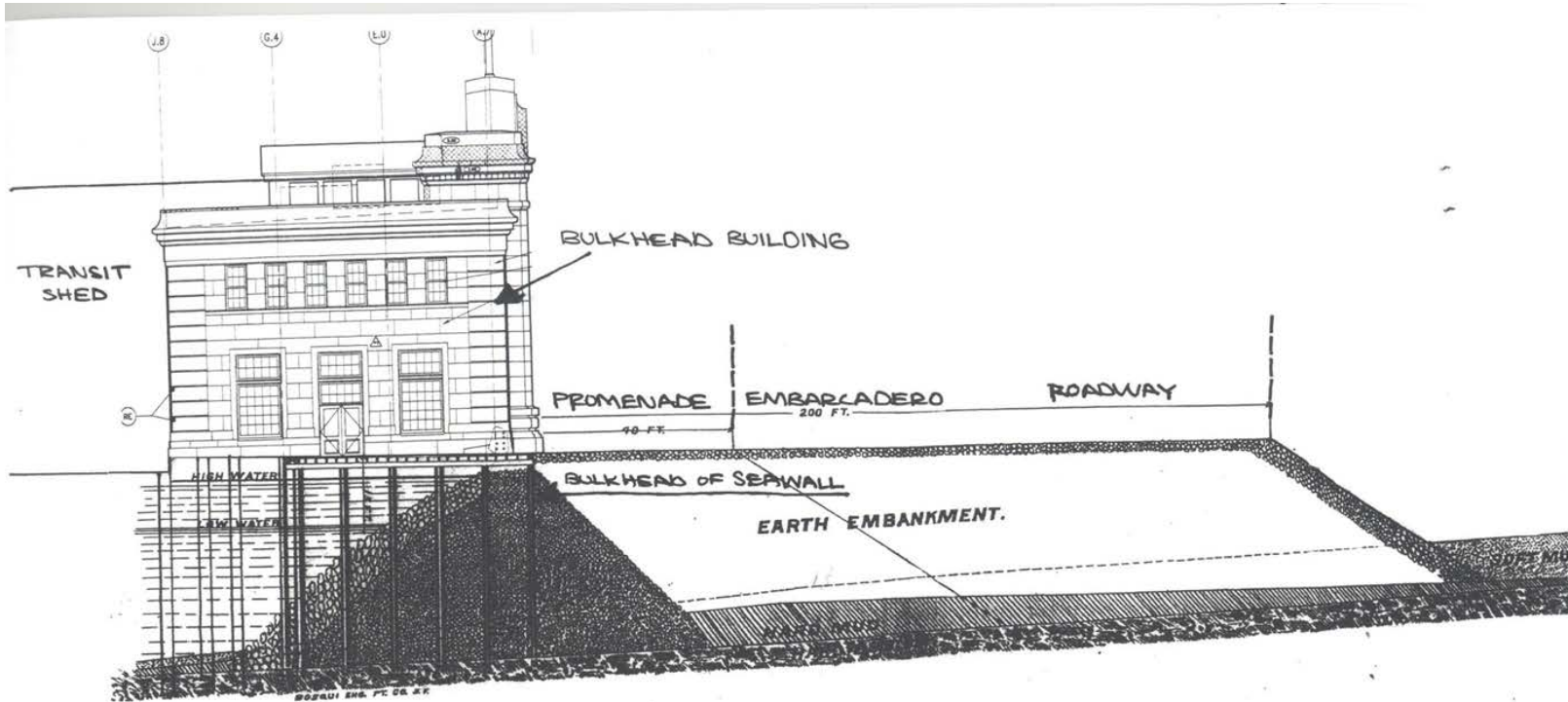
Great Seawall 1878 – 1915 (Sect 11 Soundings)



Great Seawall 1878 – 1915 (Section 11)



Great Seawall 1878 – 1915 (Bulkhead Bldg)



TRANSVERSE SECTION of SEA WALL and THOROUGHFARE.

SCALE 20ft = 1INCH.

BULKHEAD WHARF CONDITIONS
WITH A PIER

Figure 1. Original design of seawall, construction begun 1878. T.J. Arnold, Engineer of Seawall. Source: Crane 1882:n.p.

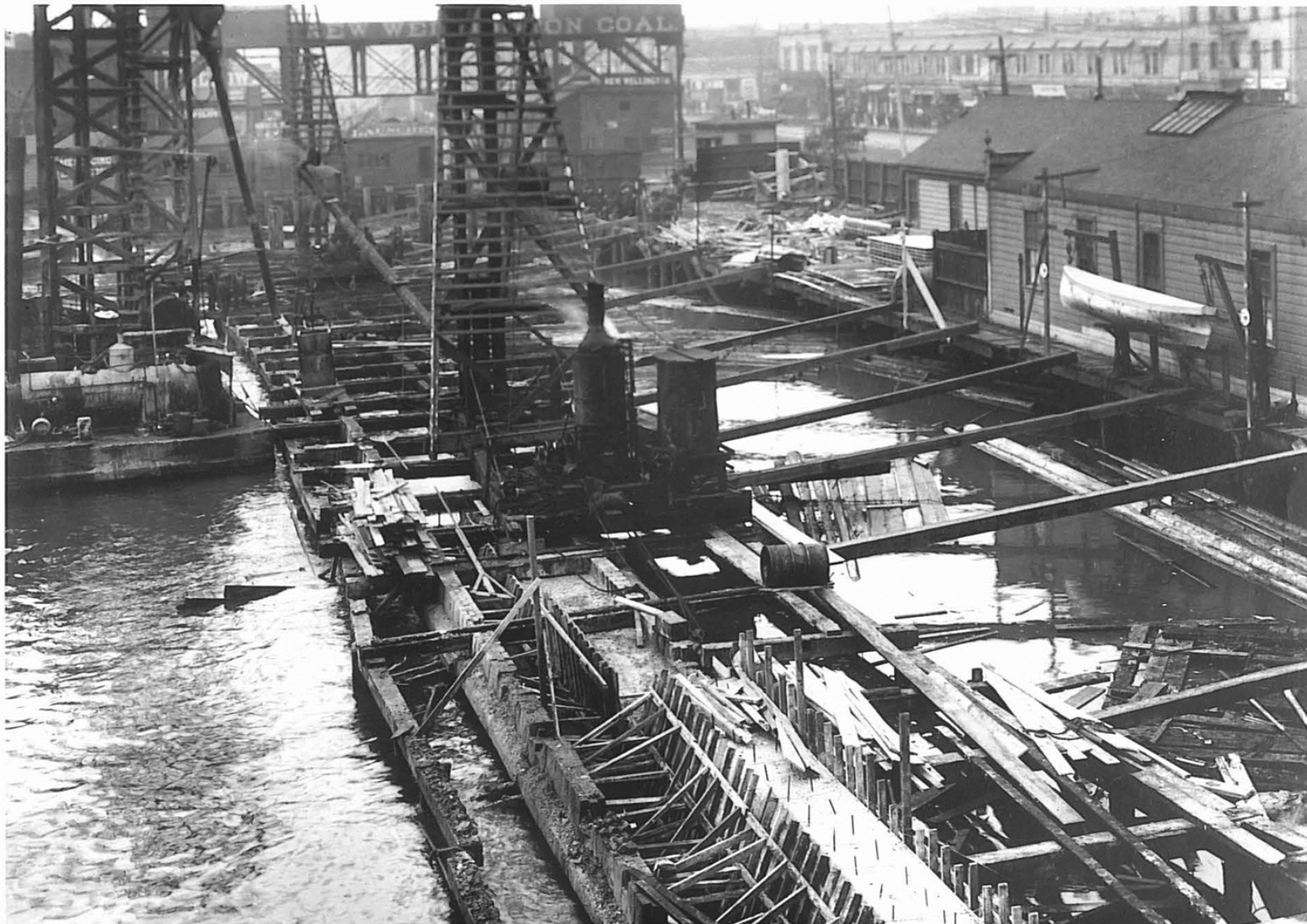
Great Seawall 1878 – 1915 (Typical Const.)



Great Seawall 1878 – 1915 (Typical Const.)



Great Seawall 1878 – 1915 (Section 8)



Great Seawall 1878 – 1915 (Section 8)



Great Seawall 1878 – 1915 (Section 12)



Great Seawall 1878 – 1915 (Section 11, 1910)



Great Seawall 1878 – 1915 (Sect. 9A, 1915)



Great Seawall 1878 – 1915 (Pier 29, 1916)



- Most bulkhead and Piers north of Ferry Bldg replaced 1915 to approx 1930.

Great Seawall 1878 – 1915 (Pier 31, 1917)



Great Seawall 1878 – 1915 (1932 Waterfront)



Earthquake Performance & Vulnerabilities

- 1906 Earthquake
- 1989 Loma Prieta Earthquake
- 1992 Harding Lawson Study
- 2012 Pier 43 Bay Trail Link
- 2013 Brannan Street Wharf

1906 Earthquake (View from Ferry Bldg)



1906 Earthquake



- Ferry Building Complete
- Seawall Sections Complete from Ferry Bldg to Fisherman's Wharf (B, A, 1, 2, 3, 4, 5, 6, 7, 8a, 8b)
- Seawall Section 13 near Mission Creek

1906 Earthquake



PHOTOGRAPH OF
SAN FRANCISCO IN RUINS
FROM LAWRENCE CAPTIVE AIRSHIP
2000 FEET ABOVE SAN FRANCISCO BAY
OVERLOOKING WATER FRONT.
SUNSET OVER GOLDEN GATE.

1906 Earthquake



1906 Earthquake



1906 Earthquake

- 1906-1908 Board of State Harbor Commissions Biennial Report: No Mention of Earthquake
- 1908 “Lawson” EQ Report: Noted substantial movement of filled lands, 6 feet near Mission Creek, but little damage to Port.
- Approx. $\frac{1}{2}$ of seawall in place, however, bulkhead and wharf for this portion modified/replaced later.

1989 Loma Prieta Earthquake



1989 Loma Prieta Earthquake

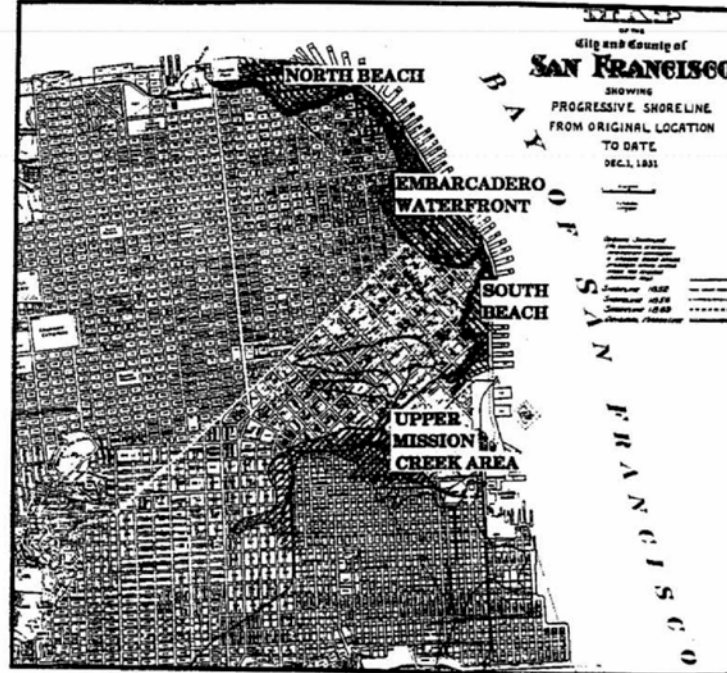
- Little damage to Seawall, bulkhead wharves and Piers of northern waterfront.
- Embarcadero Freeway torn down.
- Rebirth of Waterfront with Embarcadero Promenade and Roadway.

1992 Harding Lawson Study

Harding Lawson Associates
Dames & Moore
Kennedy/Jenks/Chilton
EQE Engineering

1992

January 1992



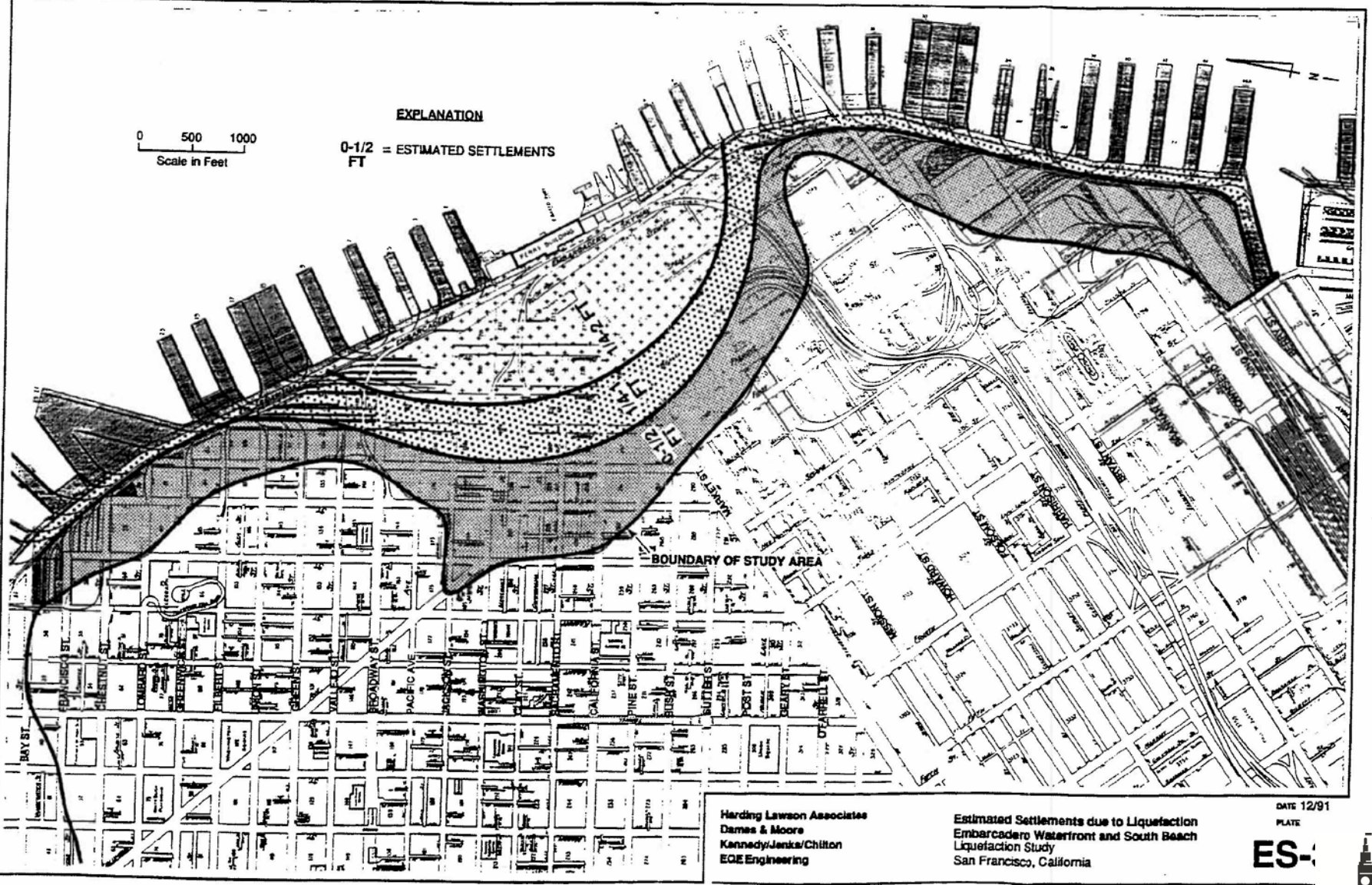
Final Report
Liquefaction Study
North Beach, Embarcadero Waterfront,
South Beach, and Upper Mission Creek Area
San Francisco, California

Prepared for:

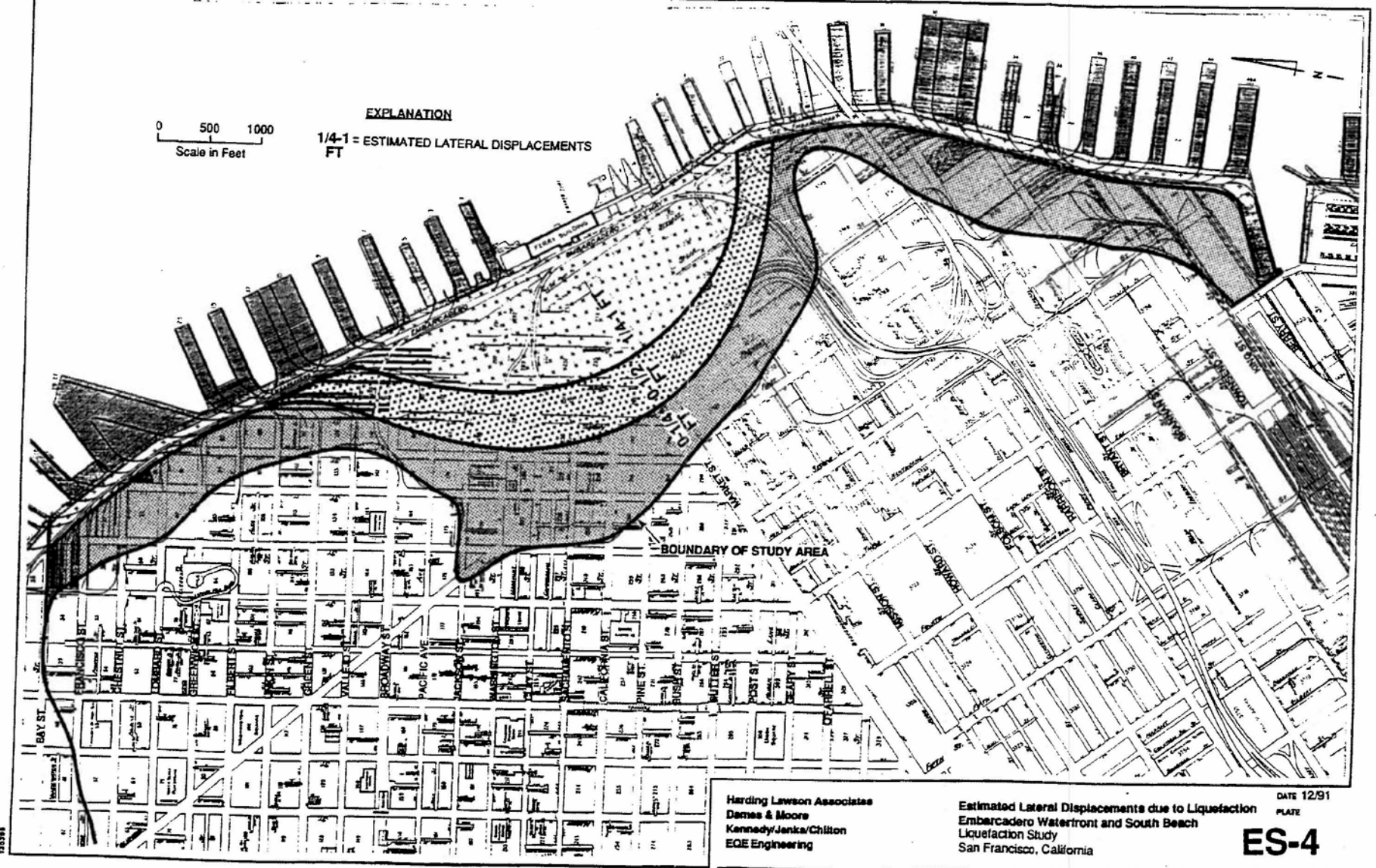
CITY AND COUNTY OF SAN FRANCISCO
DEPARTMENT OF PUBLIC WORKS
CITY HALL, ROOM 260
SAN FRANCISCO, CALIFORNIA 94102



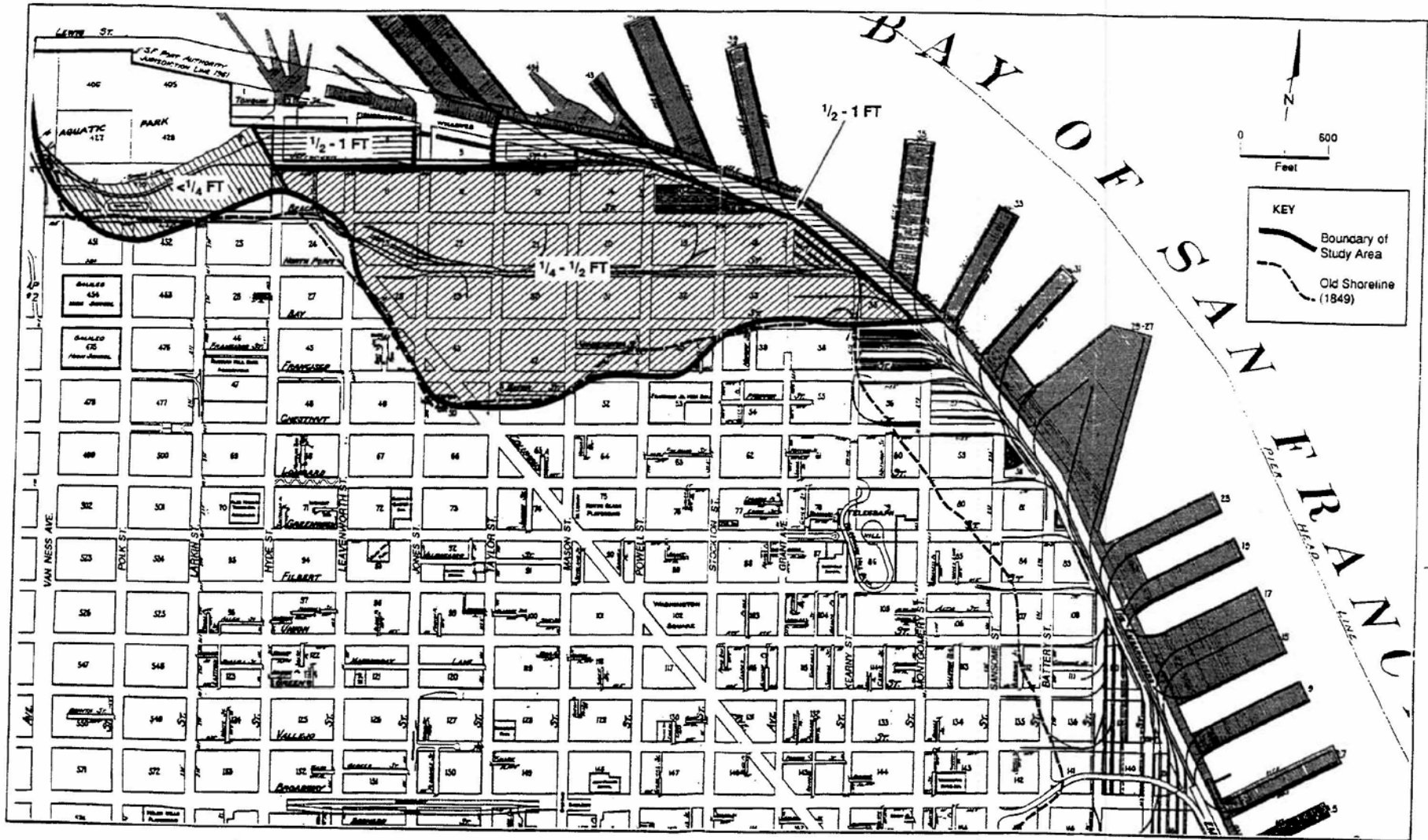
1992 Harding Lawson Study (Settlement South)



1992 Harding Lawson Study (Spread South)

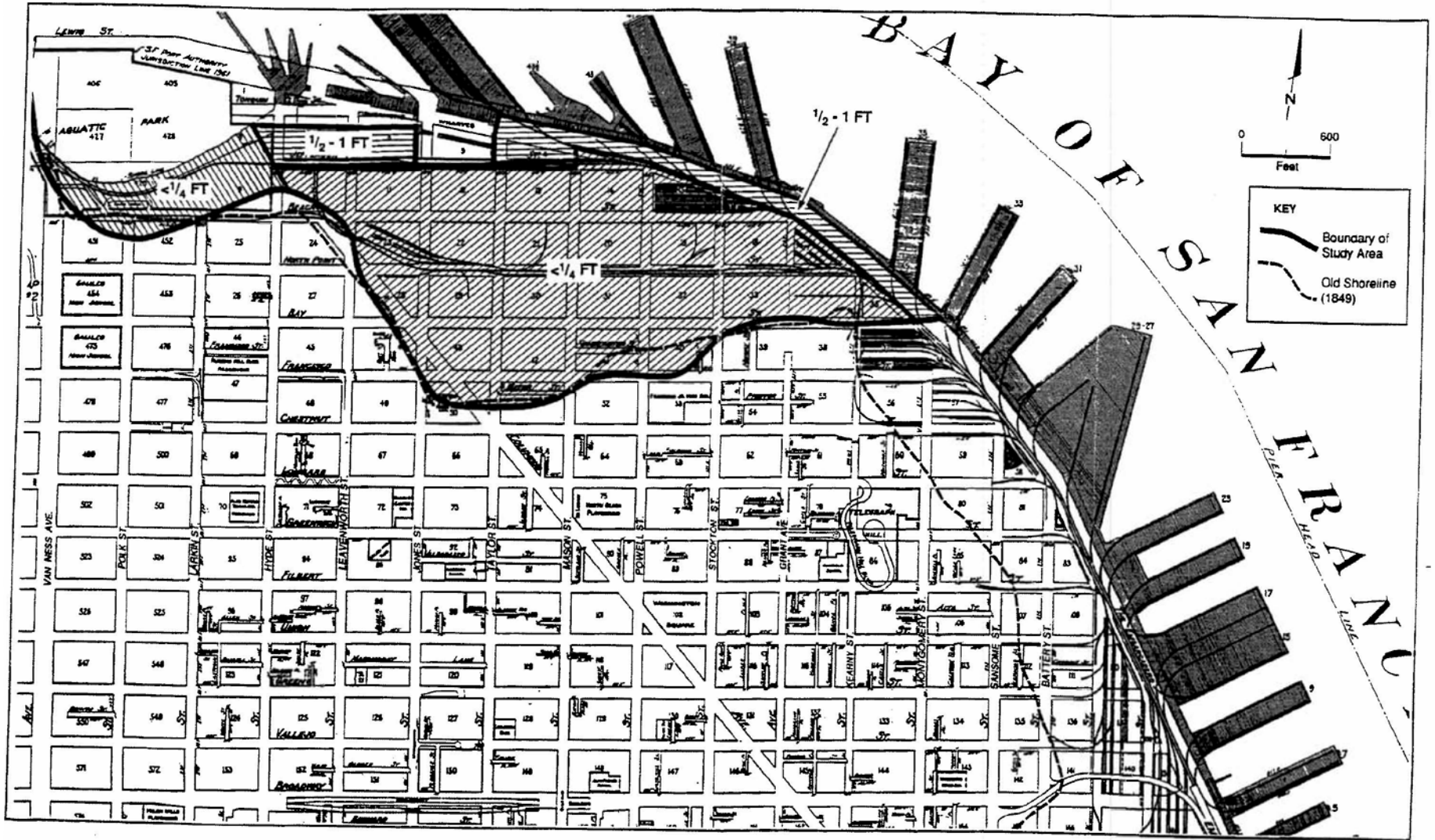


1992 Harding Lawson Study (Settlement North)



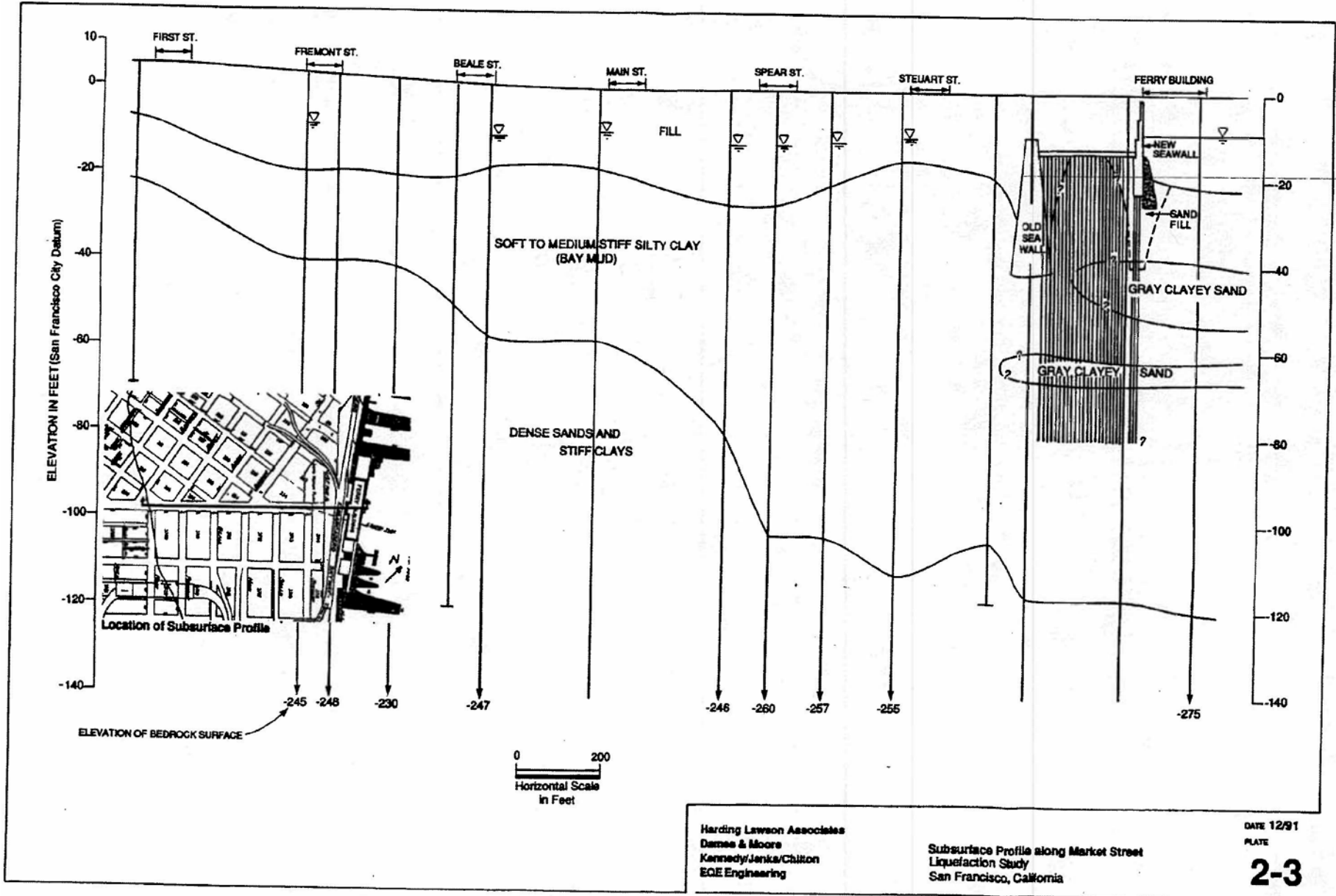
Harding Lawson Associates Dames & Moore Kennedy/Jenks/Chilton EGE Engineering	ESTIMATED SETTLEMENTS DUE TO LIQUEFACTION; NORTH BEACH Liquefaction Study San Francisco, California	DATE 9/91 PLATE ES-5
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1992 Harding Lawson Study (Spread North)



Harding Lawson Associates Dames & Moore Kennedy/Jenks/Chilton EQE Engineering	ESTIMATED LATERAL DISPLACEMENTS DUE TO LIQUEFACTION; NORTH BEACH Liquefaction Study San Francisco, California	DATE 9/91 PLATE
		ES-6

1992 Harding Lawson Study (Section Market St)



Harding Lawson Associates
 Dames & Moore
 Kennedy/Jenks/Chilton
 EQE Engineering

Subsurface Profile along Market Street
 Liquefaction Study
 San Francisco, California

DATE 12/91
 PLATE

Pier 43 Bay Trail Link Project (2012)

- Fisherman's Wharf Area
- Demolish Timber Pier
- Replace Timber Bulkhead Wall Section B with Reinforced Concrete Stemwall on Spread Footing
- Construct New Wharf Promenade over Existing Rock Dike (New Bulkhead Wharf)
- Disconnect Seawall & Wharf
- Pinned Head Piles for Displacement Capacity 3ft +

Pier 43 Bay Trail Link Project (2012)



Pier 43 Bay Trail Link Project (2012)



Pier 43 Bay Trail Link Project (2012)



Pier 43 Bay Trail Link Project (2012)



Brannan Street Wharf Project (2013)

- Southbeach Area, btwn P30/32 & P38
- Demolish Pier 36 & Portion of Bulkhead Wharf 11A
- Reinforce Seawall Section 11A with Rip Rap
- New 58,000 SF Public Wharf
- Disconnect Wharf from Seawall
- Steel Piles within Rock Embankment to survive significant lateral spreading movement.

Brannan Street Wharf Project (2013)



Brannan Street Wharf Project (2013)



Brannan Street Wharf Project (2013)



Brannan Street Wharf Project (2013)



Brannan Street Wharf Project (2013)

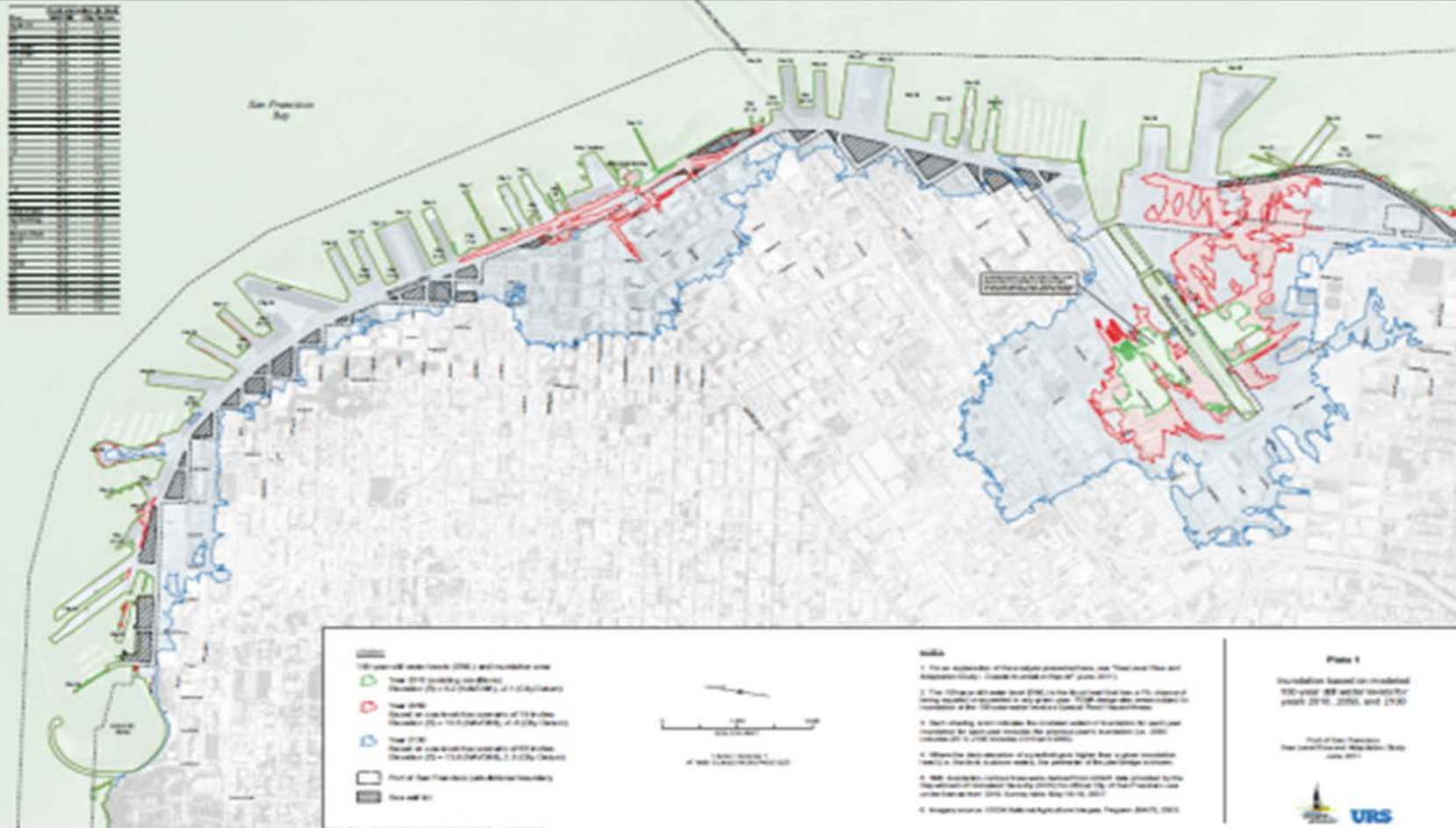


Sea Level Rise

- Current Guidance
- 2050 and 16" of Rise
- 2100 and 55" of Rise (17" to 66" NRC 2012)
- Beyond 2100
 - Pine Island Glacier, Greenland, 10 feet

Sea Level Rise

- Green: existing conditions
- Red: inundation predicted at 2050
- Blue: inundation predicted at 2100



Sea Level Rise



Next Steps

- Earthquake Vulnerability Study & Conceptual Retrofits
- USACE CAP Section 103 Project
- Evaluate, Develop and Fund Interim Improvements, 2015-2018
- Design & Construct Interim Improvements, 2017-2025
- New Vision for Waterfront, 2015 - 2030

