HAITI EARTHQUAKE

ASCE/TCLEE RECONNAISSANCE PROJECT

Presented by:

William Bruin, P.E

Principal Engineer

Halcrow Inc., Oakland

&

Alex Augustin

Assistant Civil Engineer

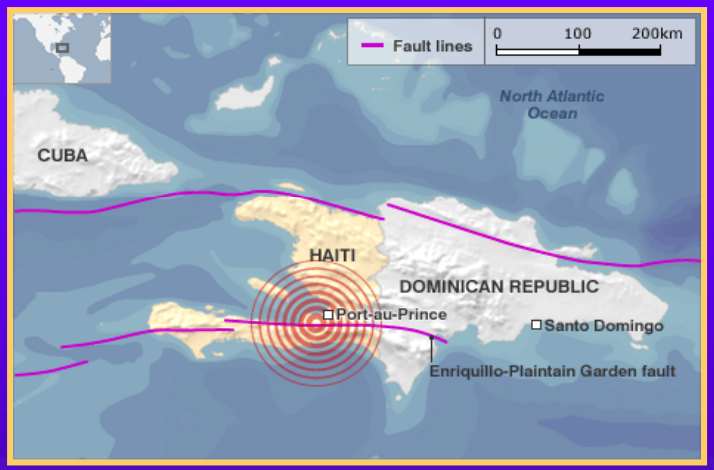
California State Lands Commission (MFD)

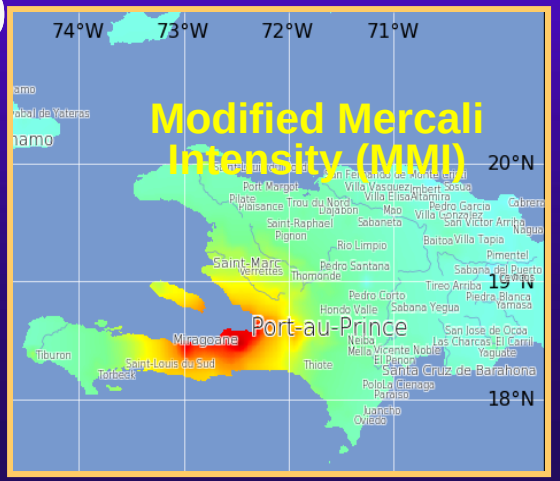
Haiti Earthquake Reconnaissance

- February 28 to March 6, 2010
- Two Groups: ASCE TCLEE and EERI
- 11 Lifeline Engineering Professionals
- Ports Team:
  - Stu Werner
    Seismic Systems
  - Nason McCullough
    CH2M-Hill
  - William Bruin
    Halcrow
  - Alex Augustin
    CSLC

January 12, 2010 M7.0 Haiti Earthquake

- Previous Major Earthquakes:
  - June 3, 1770
  - 1860
- Date: January 12, 2010
- Earthquake Magnitude: 7.0
- Location: Port-au-Prince
- Hypocenter: ~ 6 miles
- Impacted Population: ~ 3,000,000
- Death Toll to Date: ~ 300,000
- Injured: ~ 300,000





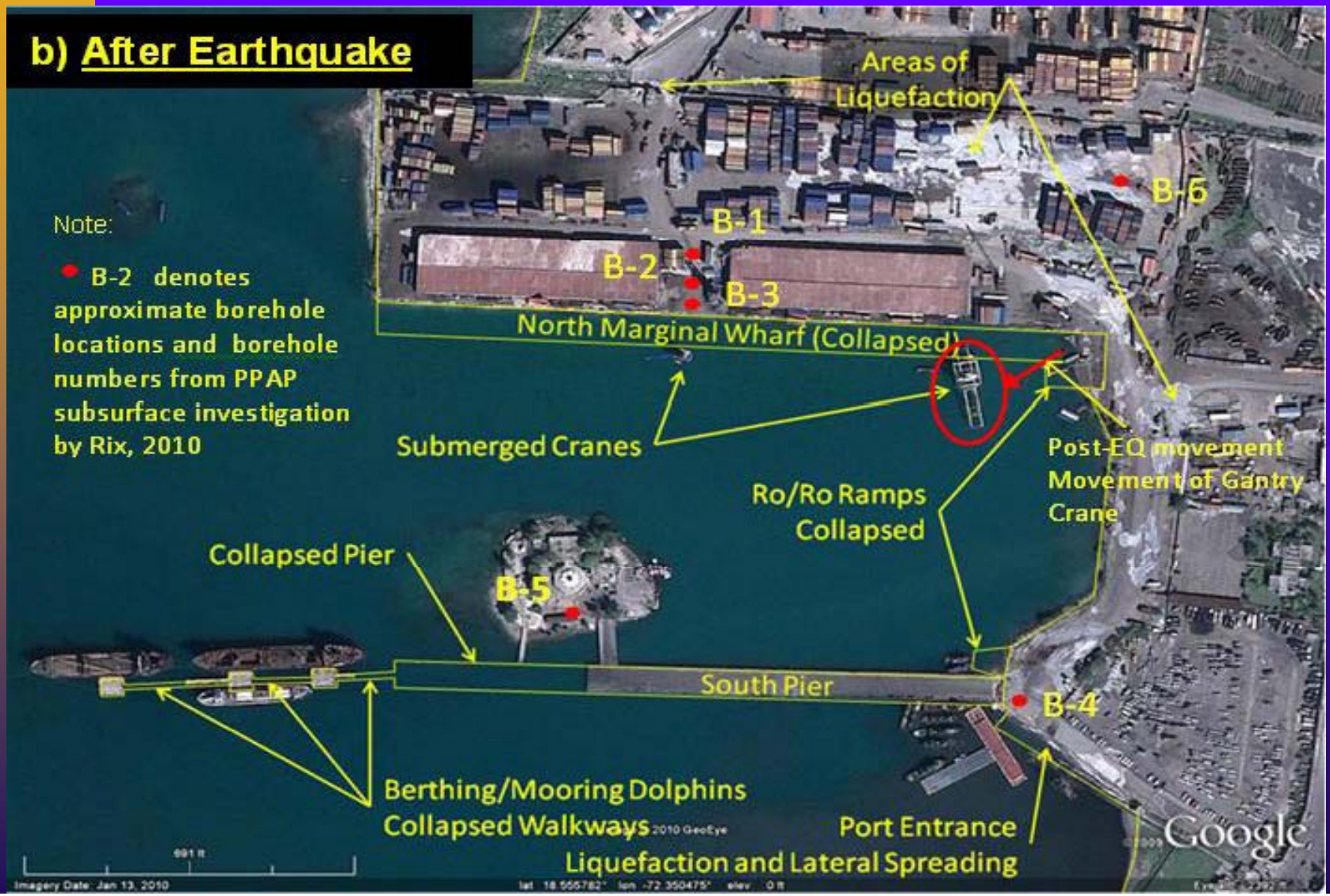
Port Sites Investigated

Authorité Portuaire Nationale (APN)

- National Port Regulators
- Owns & Operates Port of Port-au-Prince
- In process of becoming Regulators only
- Port of Port-au-Prince
  - Largest and Busiest Container Port
    - 1,200 containers/day
    - 170,000 TEU/year
- Construction 1978-1980

Authorité Portuaire Nationale (APN)

Authorité Portuaire Nationale (APN)

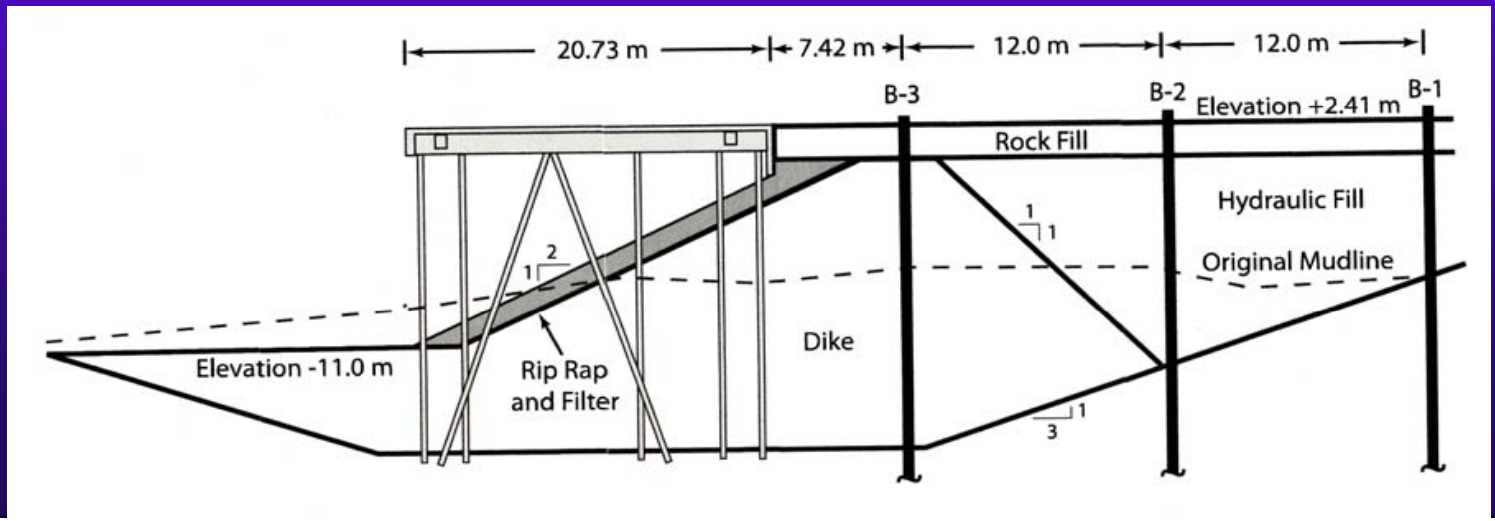


Authorité Portuaire Nationale (APN)

Authorité Portuaire Nationale (APN)

Condition Before Earthquake

- APN in process of Retrofitting both facilities
- Actual Condition Unknown (Assumed Poor)
- 18-in. Square Pre-stressed Concrete Piles
- Balanced Battered Pile Configuration
- Supported Gantry Container Crane, 2 mobile cranes
- **Configuration Similar to U.S**



Authorité Portuaire Nationale (APN)

What Really Happened?

Very Large Lateral Spreading

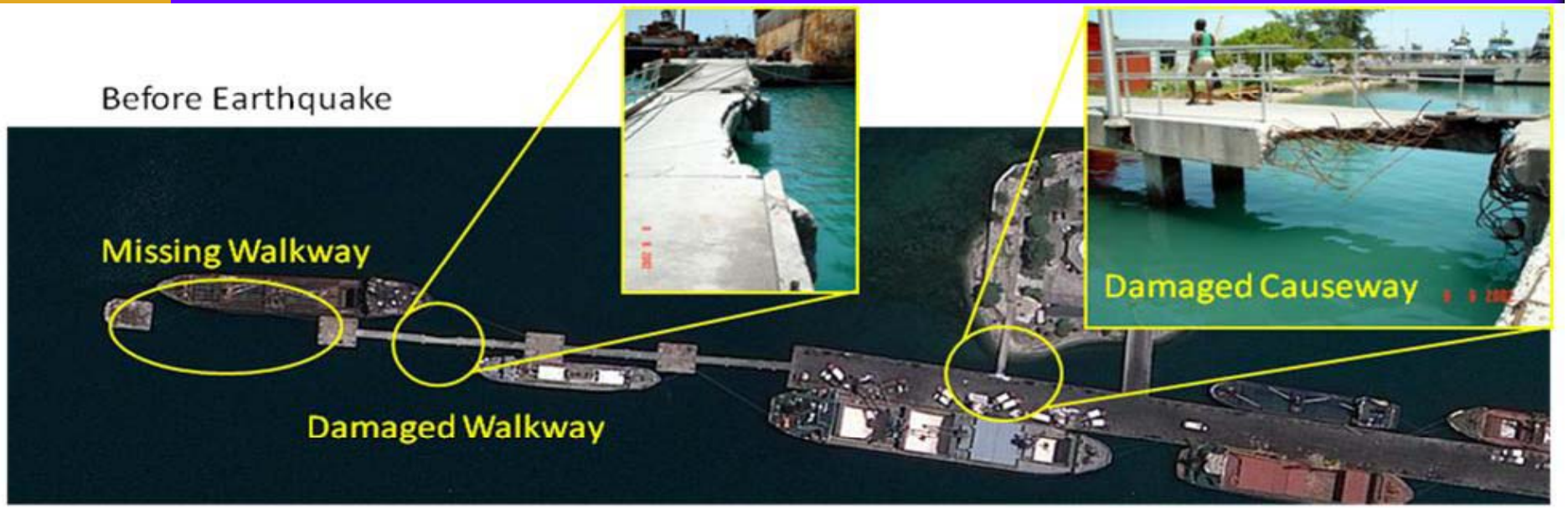
Liquefaction & Translation of Wharf

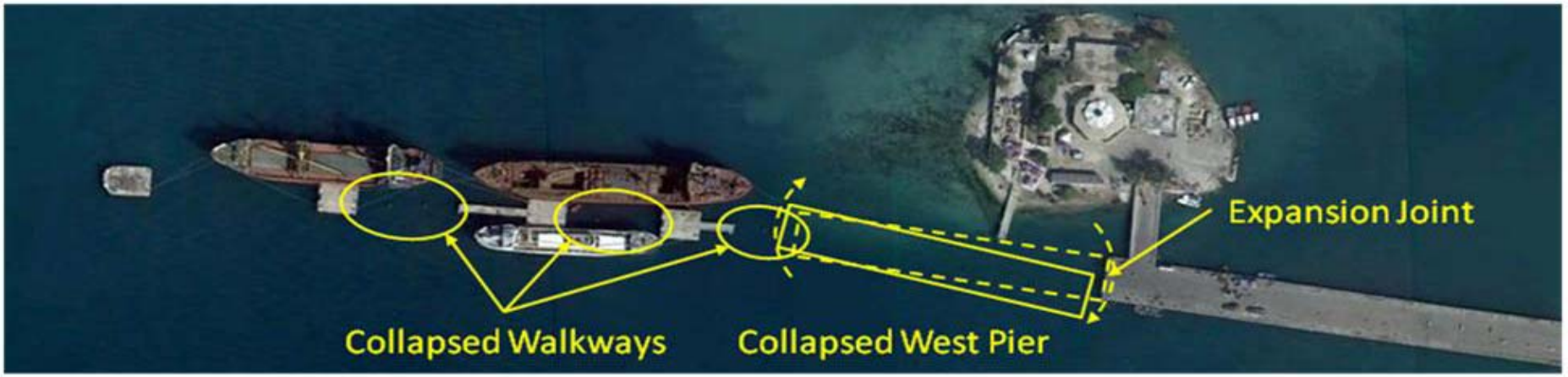
Authorité Portuaire Nationale (APN)

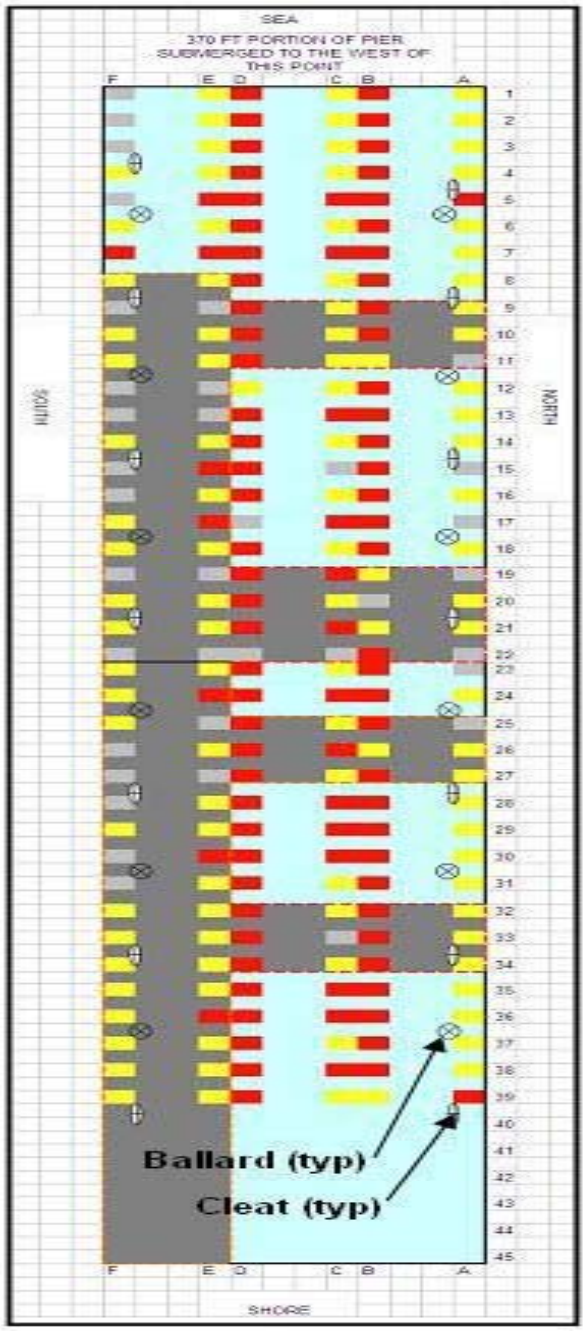
North Wharf Warehouse Damage

Authorité Portuaire Nationale (APN)

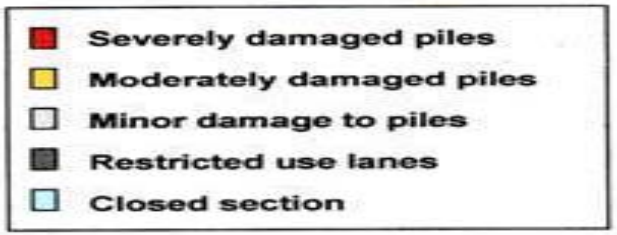
South Pier Condition







a) Pile Damage Map



b) Map Legend

c) Examples of Red-Coded and Yellow-Coded Piles

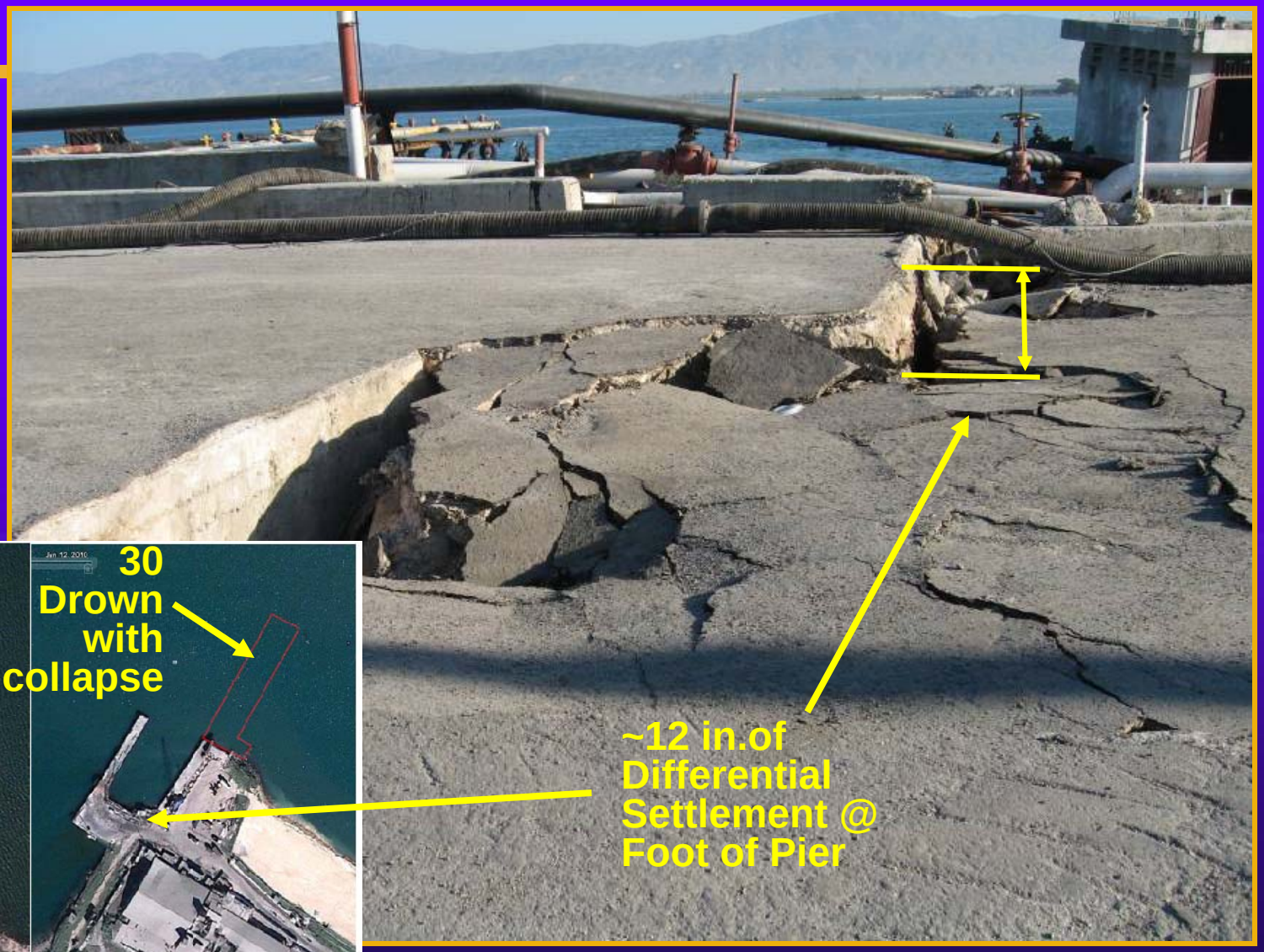
Authorité Portuaire Nationale (APN)

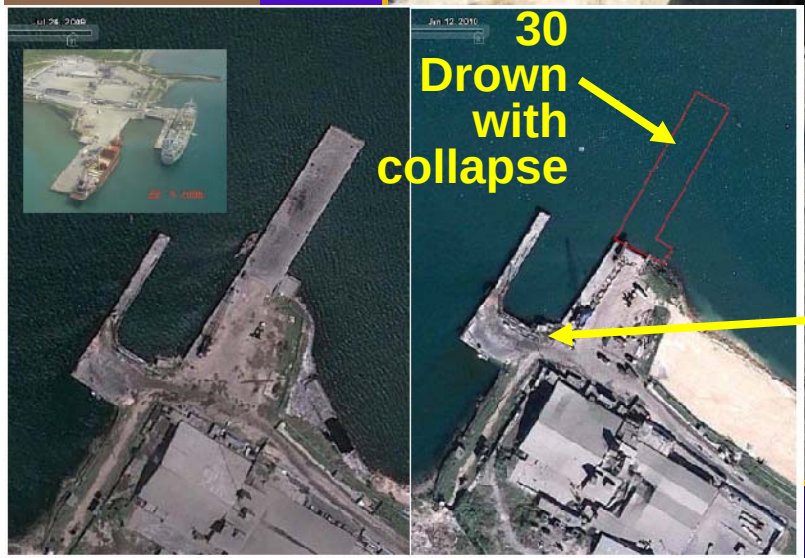
North Wharf Conclusion

- Severe Structural Condition prior to earthquake
- Was not designed for Inertial and kinematic loads

MOT Sites Investigated

MOT Observations – Settlement



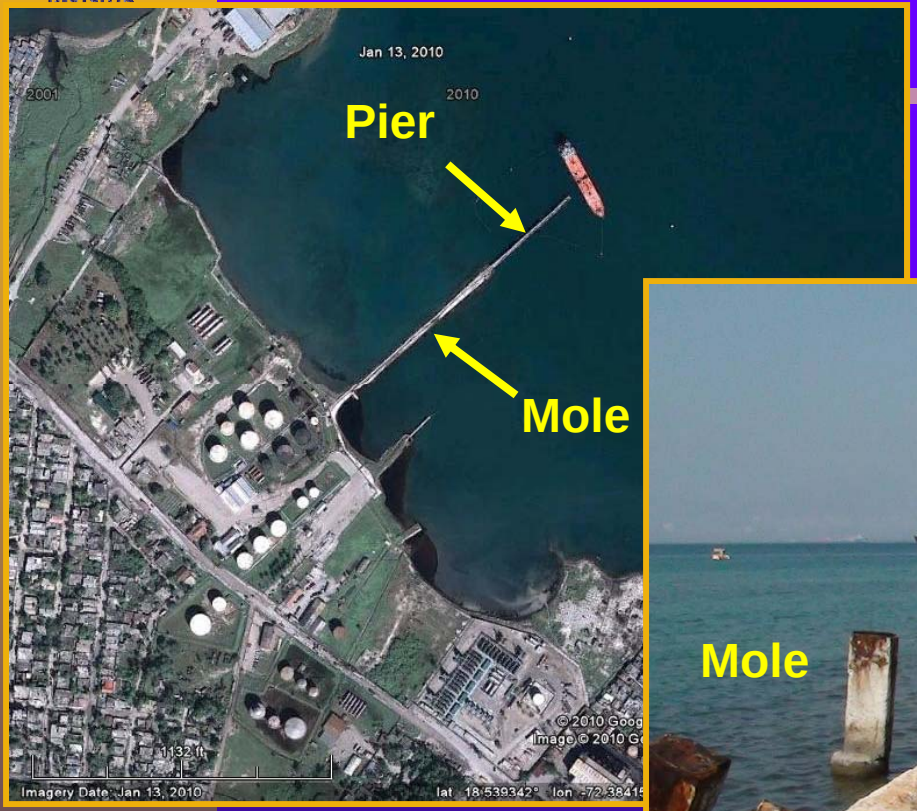


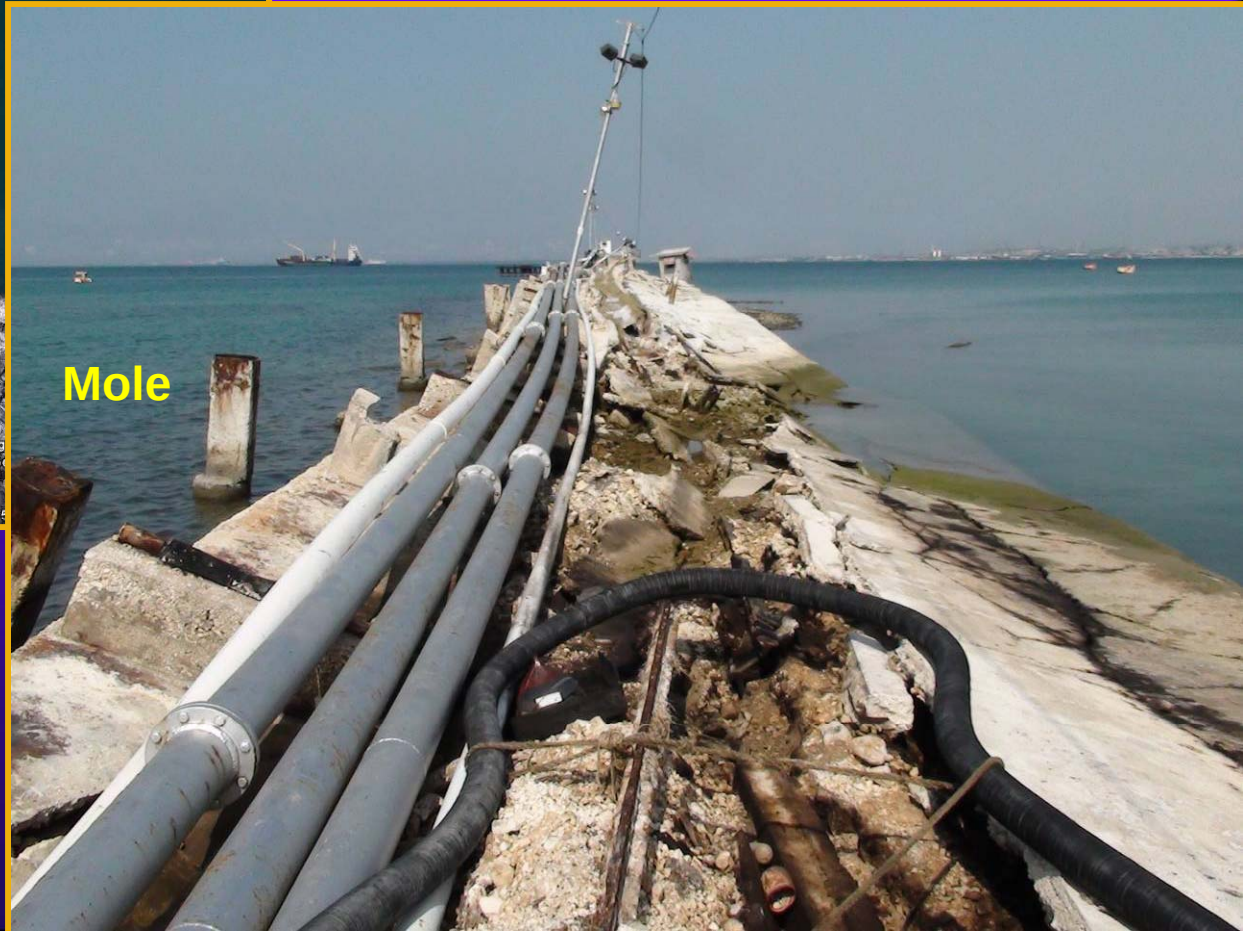
Photos Courtesy of CWO Lowell Schrader

MOT Observations - Piping

Severely Corroded Line Breaks with ~12 in. of Settlement

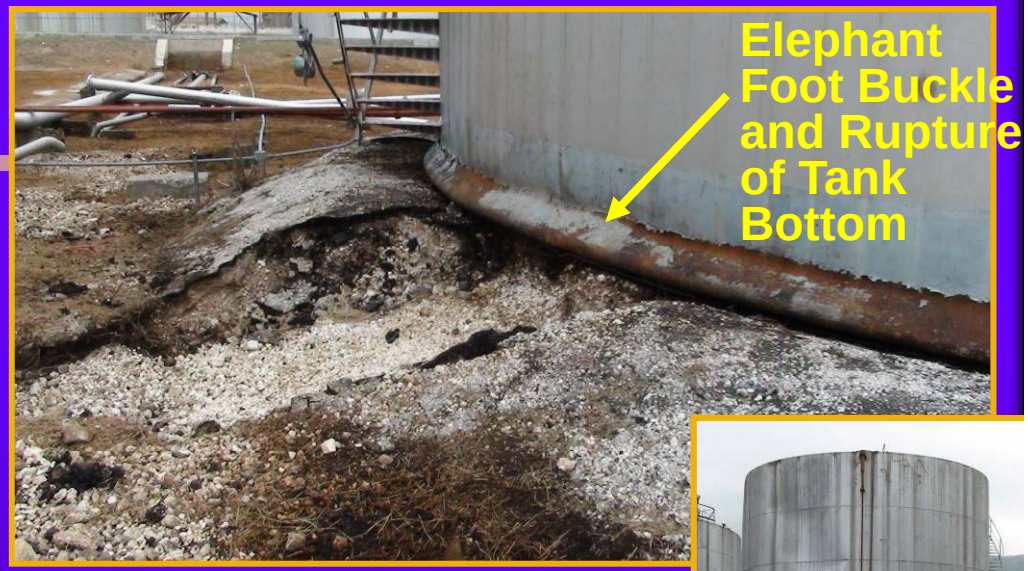
MOT Observations - Settlement

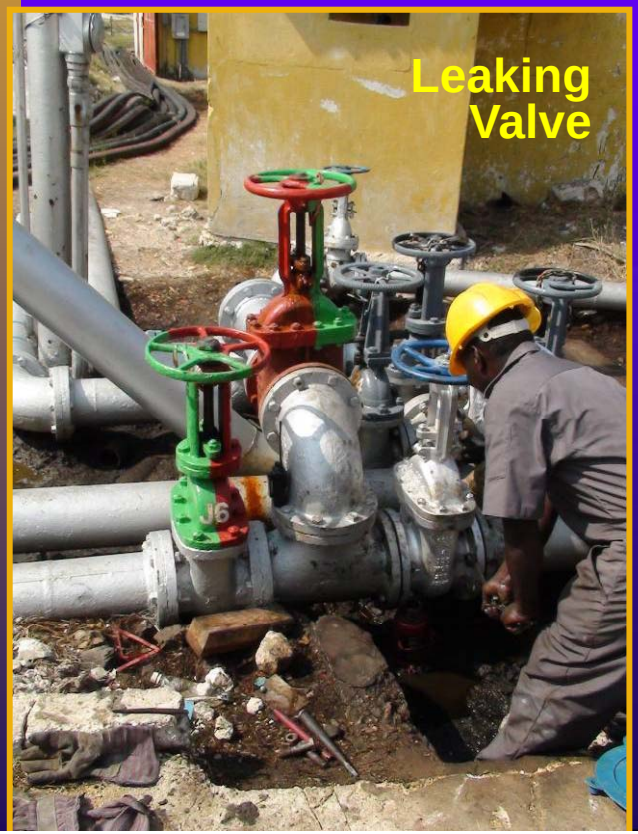


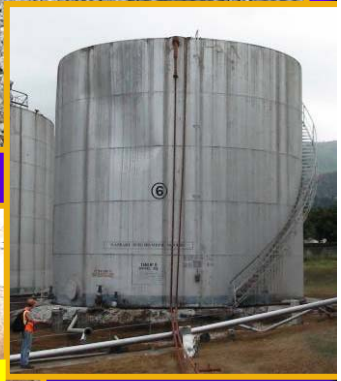


MOT Observations – Lateral Spreading

Tank Farm Observations







- Full, unanchored tank rocked, buckled

Tank Farm Observations

Anchorage Observations

- 15,000 gal. Diesel Tank
  - Partially Anchored (4 of 8 installed)
  - Anchor Uplift
  - Anchor Pullout
- Some anchorage better than nothing

Photos Courtesy of Eduardo Fierro

Haiti Lessons Learned

- Liquefaction & lateral spreading caused significant structural damage
  - Consider kinematic loads in design
- Structural condition impacts performance
- Wharf-to-shore transition critical - piping/utilities/access
- Anchored tanks/equipment performed well
- Maintained piping performed well
- Post-event response plans are critical