



# Crescent City, CA

## Tsunami Damage and Lessons Learned

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Oakland, CA



Project Location

- **Crescent City**
  - Project Location & Tsunami History

Project Overview & Approach

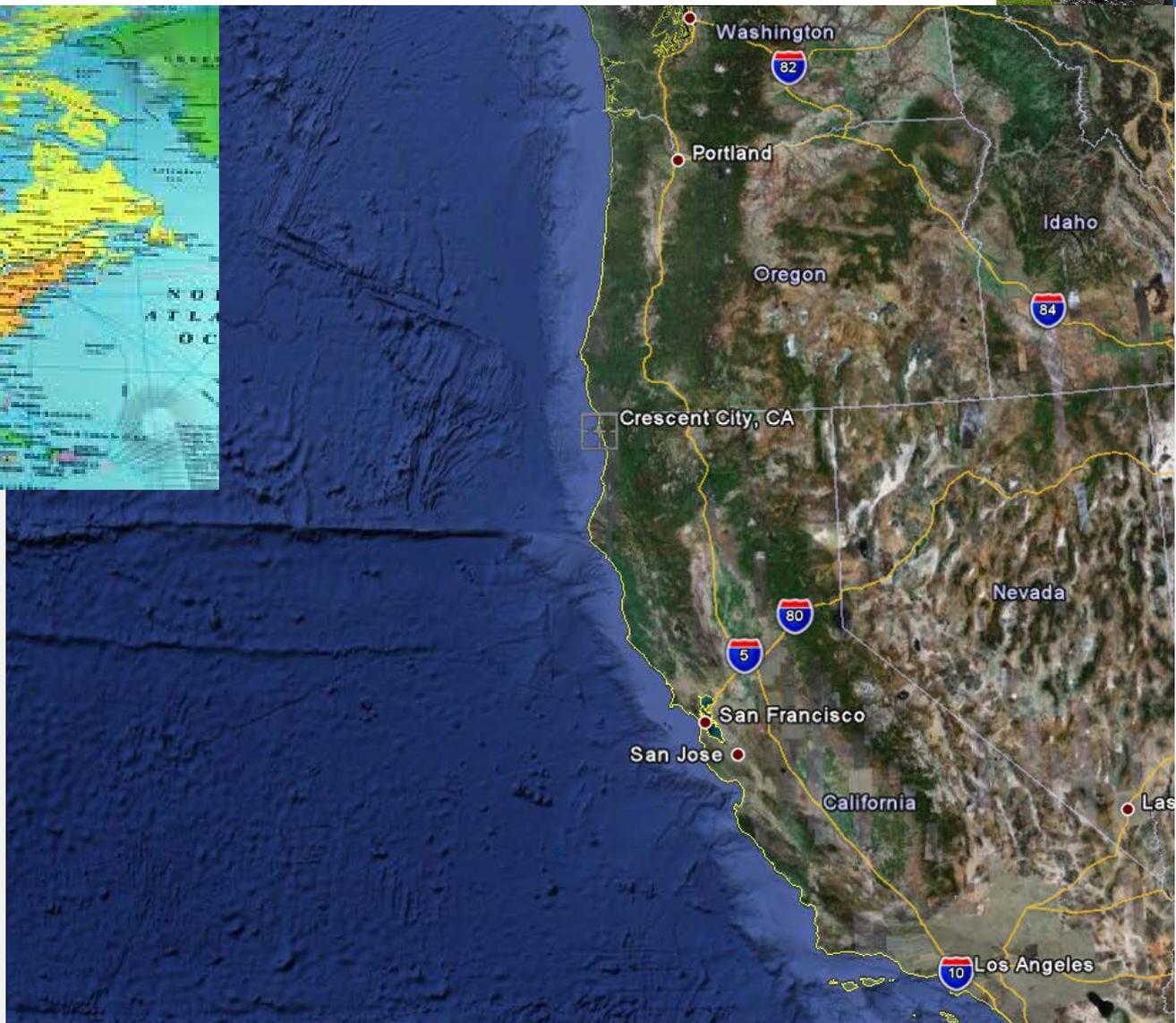
- **Tsunami Damage and Lessons Learned**
  - Tsunami Damage
  - Emergency Response & Recovery
  - Marina Replacement Project
  - Lessons Learned

Questions and Answers

- **Questions and Answers**



# Project Location



# Tsunami History



Crescent City has a history of tsunamis

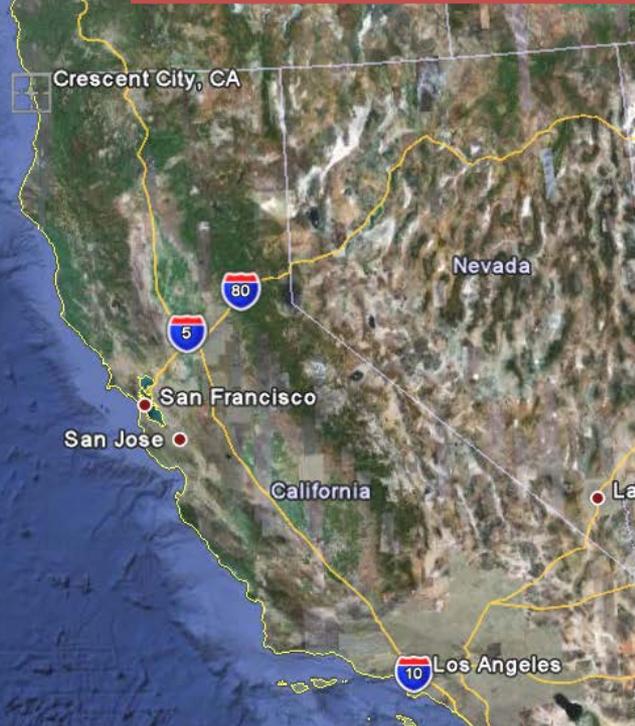
- 1964 Alaska
- 2005 Eureka
- 2006 Kuril Islands
- 2011 Tohoku

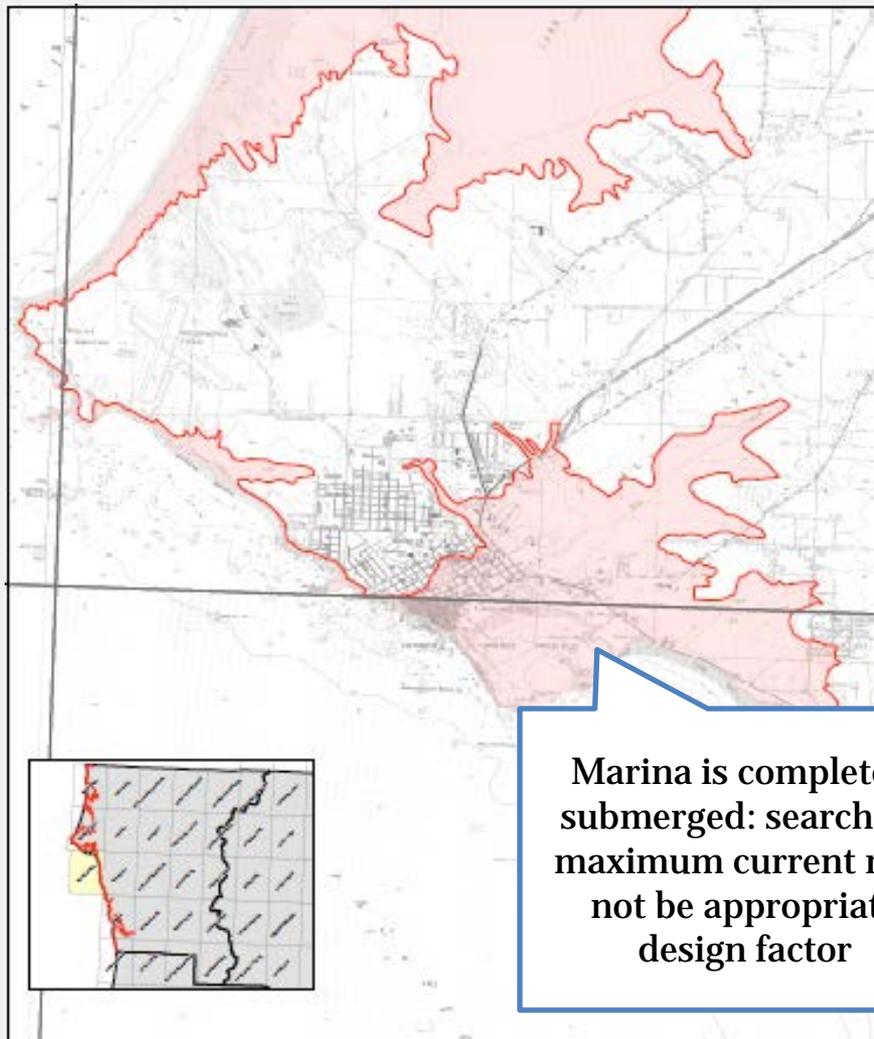
Two primary factors

**Factor 2** Wave amplification in the 20-min range



**Factor 1** Presence of the Mendocino escarpment





FEMA Map  
Design Tsunami

Marina is completely submerged: search for maximum current may not be appropriate design factor



# Project Location



## Crescent City Harbor Waterfront





## Hydrodynamic Model of 15-ft Tsunami

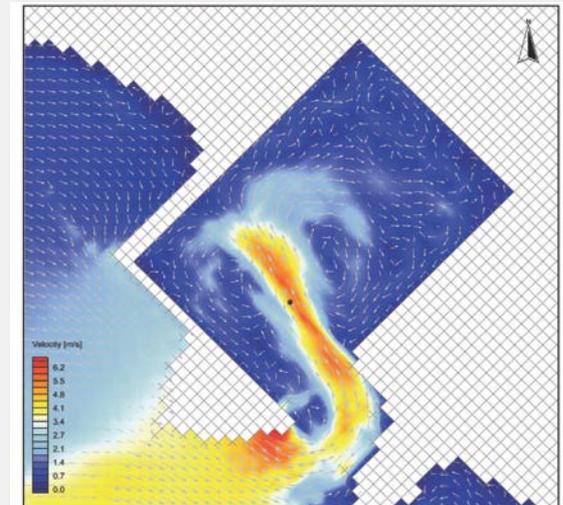
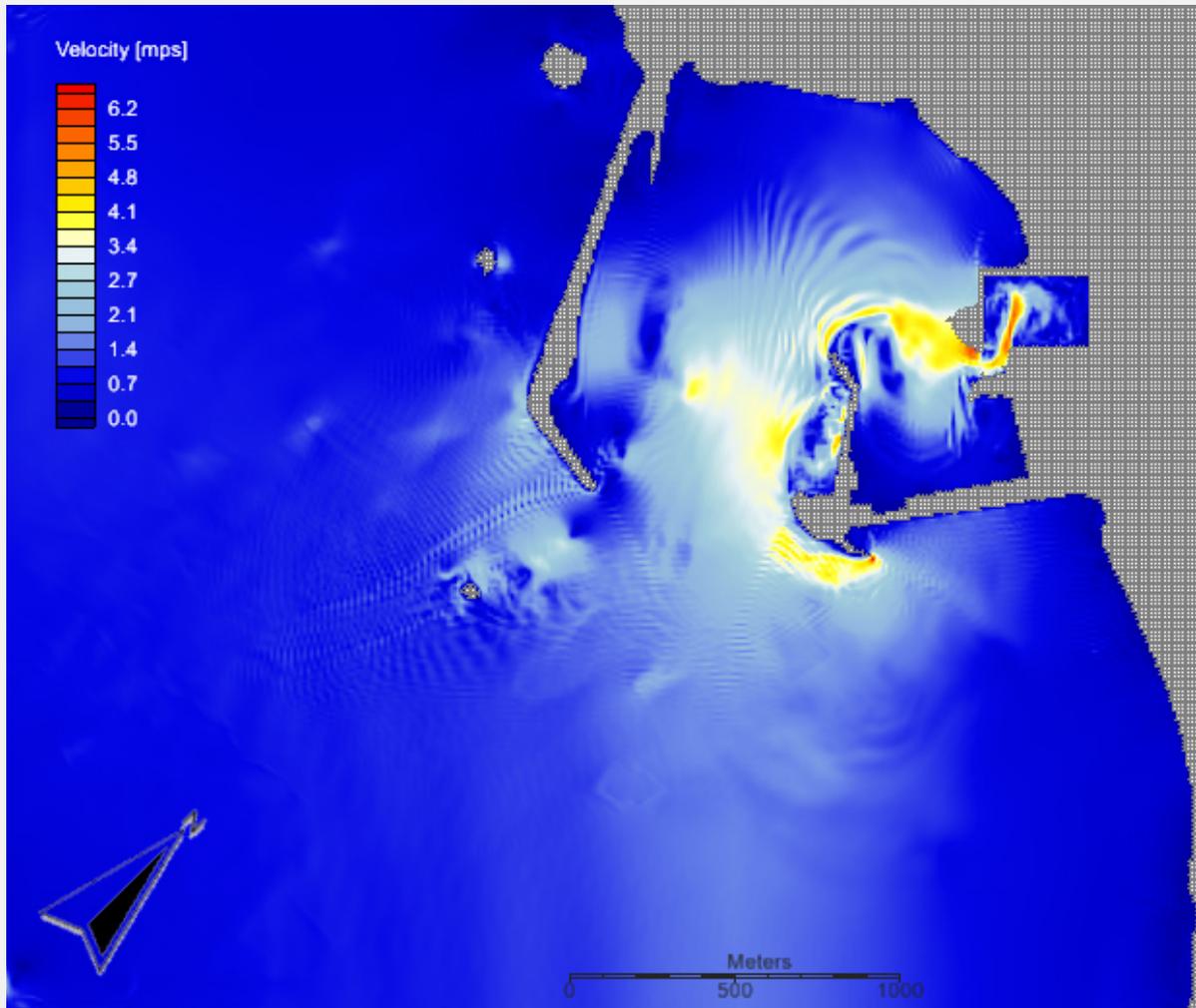


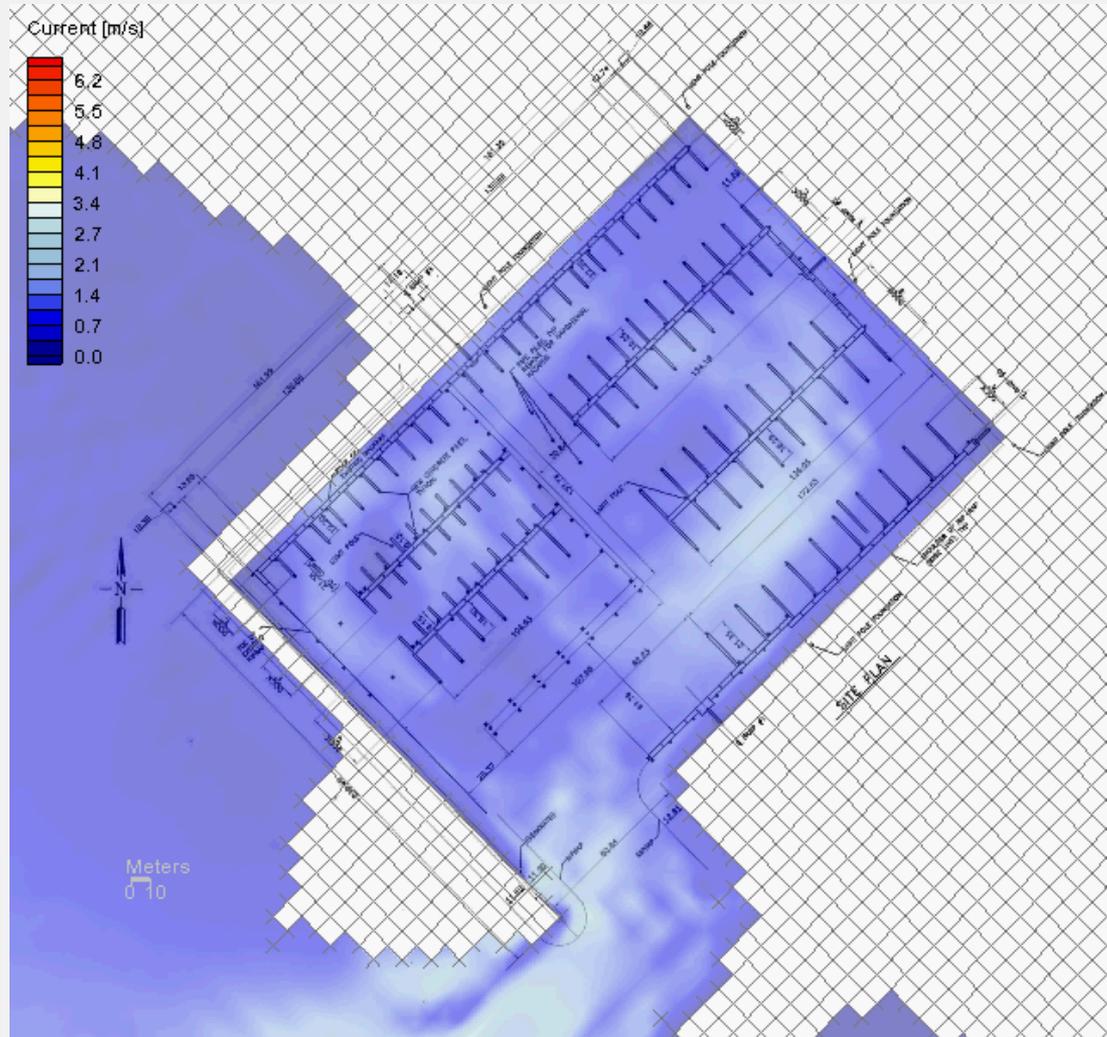
Figure 7.2 Velocity field, MHHW during inflow phase at timestamp 00 50:00 (hh:mm:ss).



# Tsunami Damage



## Hydrodynamic Model of 15-ft Tsunami





# Tsunami Damage

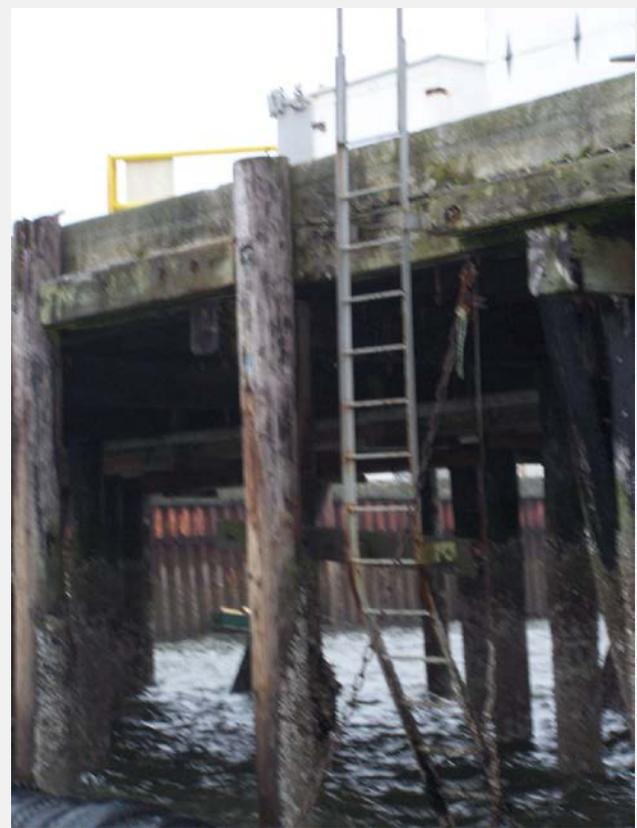


## B Street Pedestrian Pier





## Citizens Dock





## Inner Harbor Marina





# Tsunami Response Plan



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## Memorandum

Subject CCHD Marina Replacement Marina Recovery Plan BCG Job 2009-40  
Date March 12, 2011  
To Ward Stover  
From Ted Trenkwalder *TWT*

We (Gerwick Team) have monitored and reviewed the news and video describing yesterday's Tsunami that hit Crescent City. Our hearts go out to the boaters and residents that have been affected by the devastation.

Although the shock has not worn off from the impact of the tsunami, I wanted to develop a draft recovery plan for the Marina Replacement Team and Harbor District to consider for development of a path forward to restore the fishing community and rebuilding the marina. This memorandum is an attempt to start the recovery process and move forward from the effects of the tsunami.

There are immediate, intermediate, and long term phases for the boaters and marina with different objectives. The phases include the following:

1. The Immediate Phase objective would be to survey the present damage, develop vessel salvage plans, and develop and construct immediate repair plans for allowing boaters to moor and have access to their vessels in the harbor. The amenities (power, water, and sanitation) will most likely be limited during this phase and may not occur until the new floats can be furnished and installed in the Inner Harbor.
2. The Intermediate Phase objective would be to design and construct the replacement berths for the boaters to moor and provide service to their vessels in the Inner Harbor. This phase would include design of more standard floats (not Tsunami resistant floats and walkways) that could be furnished and installed in a more timely manner in the marina.
3. The Long Term Phase objective would be to complete the design and construction of the remainder of the replacement berths for the Inner Harbor Marina. This phase would include design of remainder of floats (standard and Tsunami resistant) that could be furnished and installed in the future.

This will take full involvement from the Harbor District, Design Team, and local agencies to meet the goals and objectives to restore the fishing community and marina replacement.

### Immediate Phase Recovery Phase (6-8 weeks)

The immediate phase requires planning to determine a reasonable path forward for the marina recovery. Some options to consider:

## Three Phases:

### Immediate (6-8 weeks)

Assess Damage

Marina Temporary Float Outreach

Contractor Outreach

Permitting Issues & Restrictions

Temporary Moorings

Intermediate Plan Development

### Intermediate (8-12 weeks)

Dredging Contract

Temporary Float Furnish & Install

Power & PW Access

### Long Term (12 weeks)

Marina Replacement Design

Contractor Qualification & Selection



# Marina Replacement Project



## Why build a tsunami resistant marina?

"We do not want to simply replace what was there." Dr. Richard Young (CCHD)

Before March 2011



March 12, 2011

All Photographs Courtesy Ernie Perry (CCHD Permit Specialist)





# Marina Replacement Project



**History of  
Tsunami  
Activity**

**Major source of  
revenue for Del  
Norte County**



## How do you design a tsunami resistant marina?

Determine key design parameters

- Determine Peak wave heights and velocities
  - 14-ft above astronomical tide
  - 20.3 ft/s (6.2 m/s)

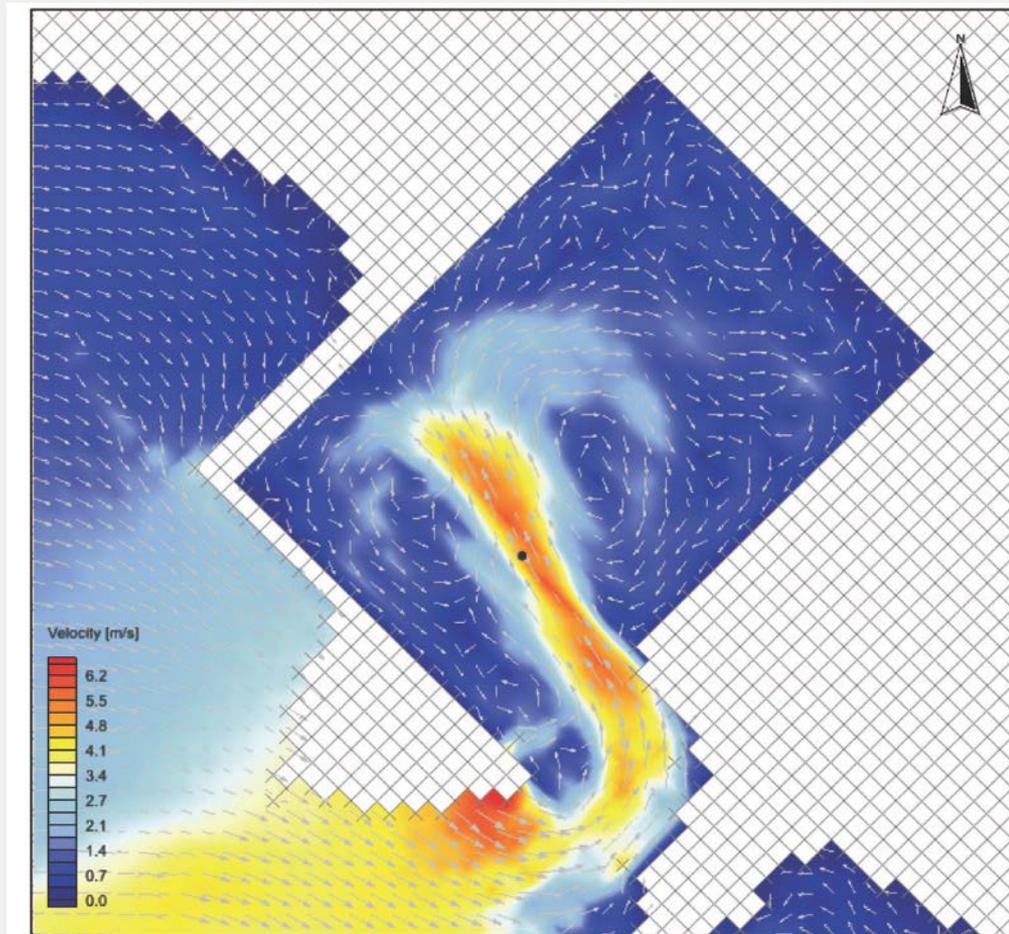
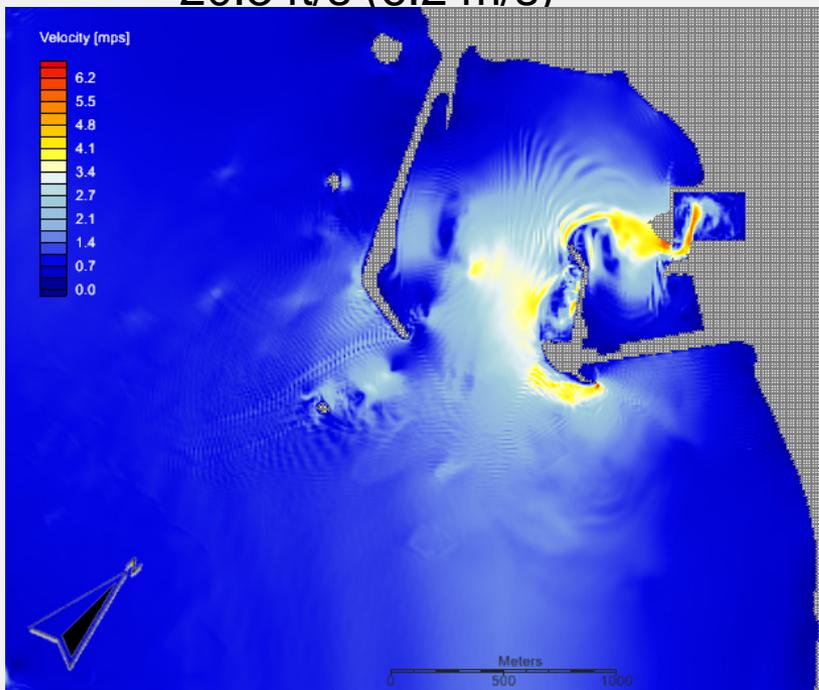


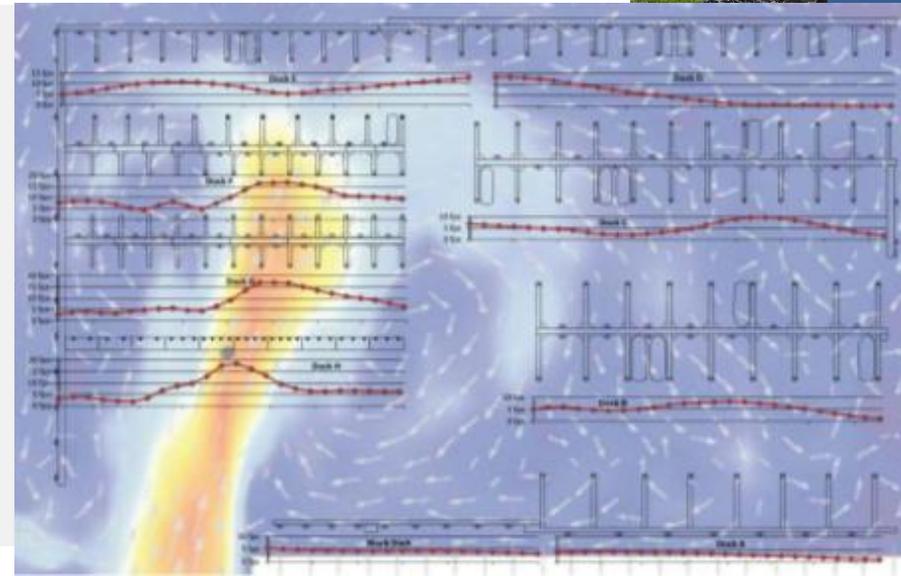
Figure 7.2 Velocity field, MHHW during inflow phase at timestamp 00 50:00 (hh:mm:ss).



## Calculate tsunami loads

- Extreme High Water + tsunami = +14.3

$$F_{float} \text{ or } F_{pile} = LF \times \frac{1}{2} \times \frac{\gamma_{design}}{g} \times V^2 \times C_D \times A_{below}$$



where

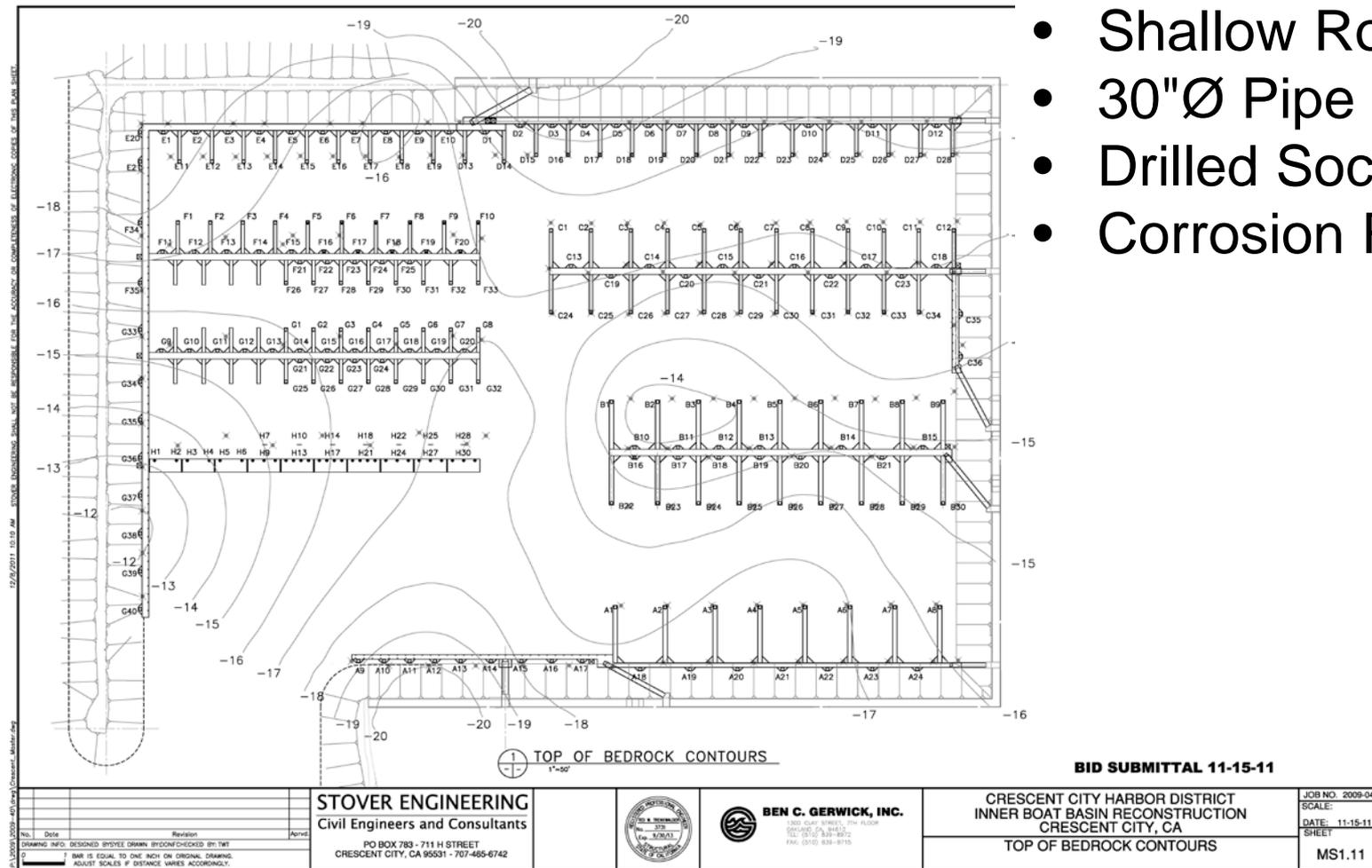
- LF = design load factor of 1.0 for strength design
- $\gamma_{design}$  = density of seawater with 1.05 factor to account for suspended sediment =  
 $1.05 \times 64 \text{ pcf} = 67.2 \text{ pcf}$
- g = gravitational acceleration
- V = design velocity due to design tsunami event
- $C_D$  = drag coefficient
- $A_{below}$  = below water projected area of potential berthed craft and floating docks or guide pile





# Construction Considerations

- Shallow Rock
- 30"Ø Pipe Pile
- Drilled Sockets
- Corrosion Resistance



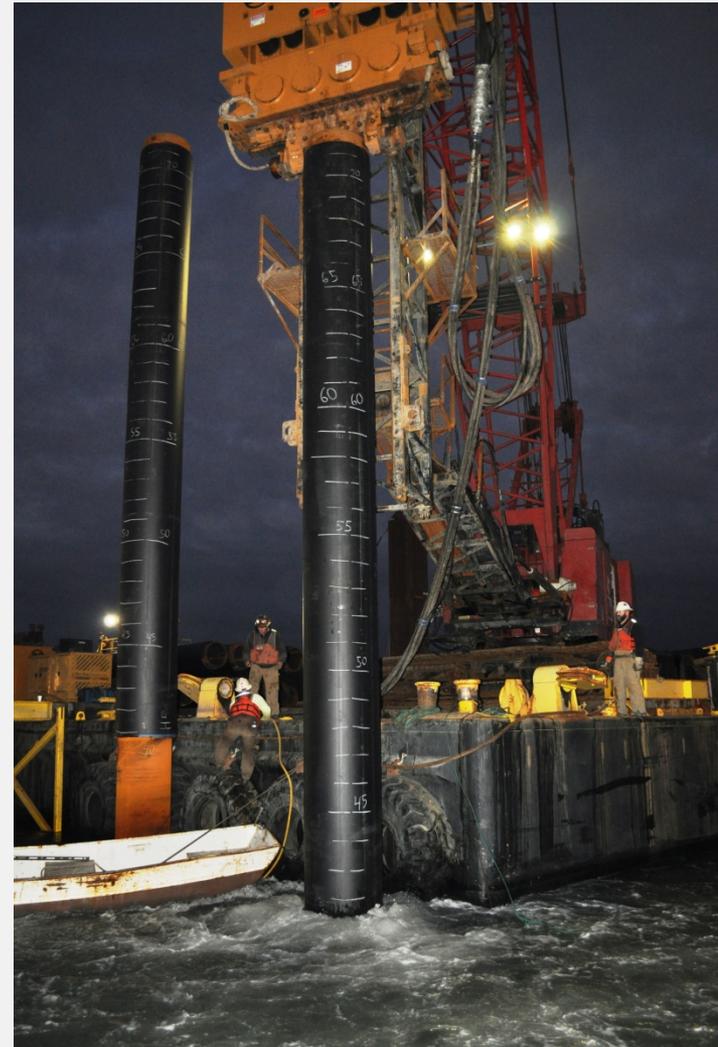


# Marina Replacement Project



## Permitting Considerations

- Pinnipeds & Salmon
- Construction Windows
- Mitigation Measures







# Marina Replacement Project



## Larger Rock Slope Protection





# Marina Replacement Project



Larger piles



# Marina Replacement Project



## Larger Floats



# Marina Replacement Project



## Larger Floats





- Critical Financial Asset for Community & County
- Do not simply replace waterfront asset
- Have a Tsunami Response Plan
- Define design goals and understand critical elements
- Pre ASCE 7 Tsunami Loads & Effects Subcommittee





# Questions and Answers

