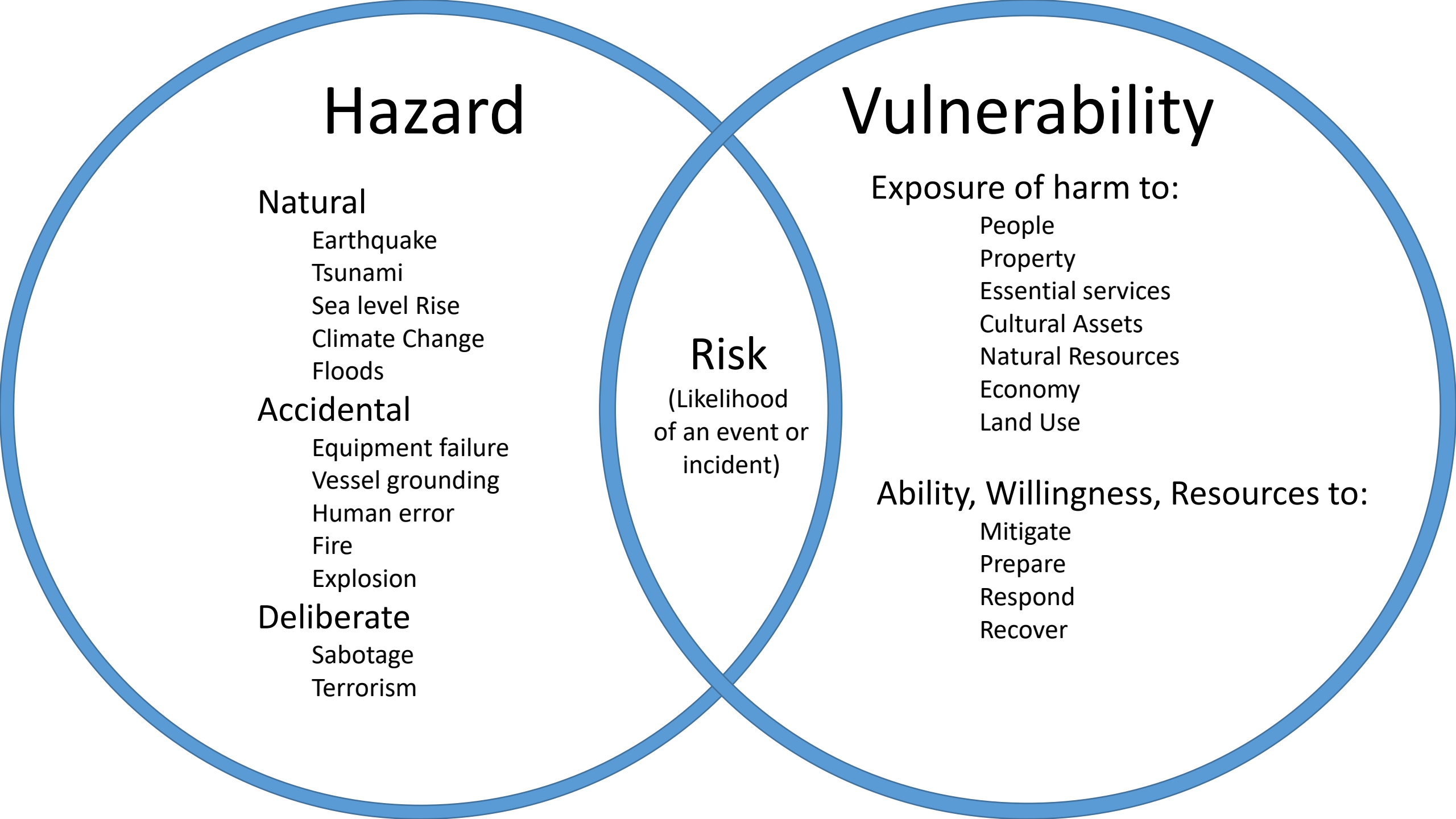
Hazard and Risk Considerations

THE JORDAN COVE TERMINAL AND LNG SHIPS

Presentation by Mike Graybill **League of Women Voters forum April 18, 2019**


Hazard
Natural
Earthquake
Tsunami
Sea level Rise
Climate Change
Floods
Accidental
Equipment failure
Vessel grounding
Human error
Fire
Explosion
Deliberate
Sabotage
Terrorism
Risk
(Likelihood of an event or incident)
Vulnerability
Exposure of harm to:
People
Property
Essential services
Cultural Assets
Natural Resources
Economy
Land Use
Ability, Willingness, Resources to:
Mitigate
Prepare
Respond
Recover

Key Message #1: Natural Gas is a Hazardous Material

Hazards of Gas Phase Methane (Natural Gas):

Heat from flames and fireballs causes burns and ignites flammable materials

Vapor Cloud Explosions in confined spaces creates overpressures/shock waves

Asphyxiation in high concentrations

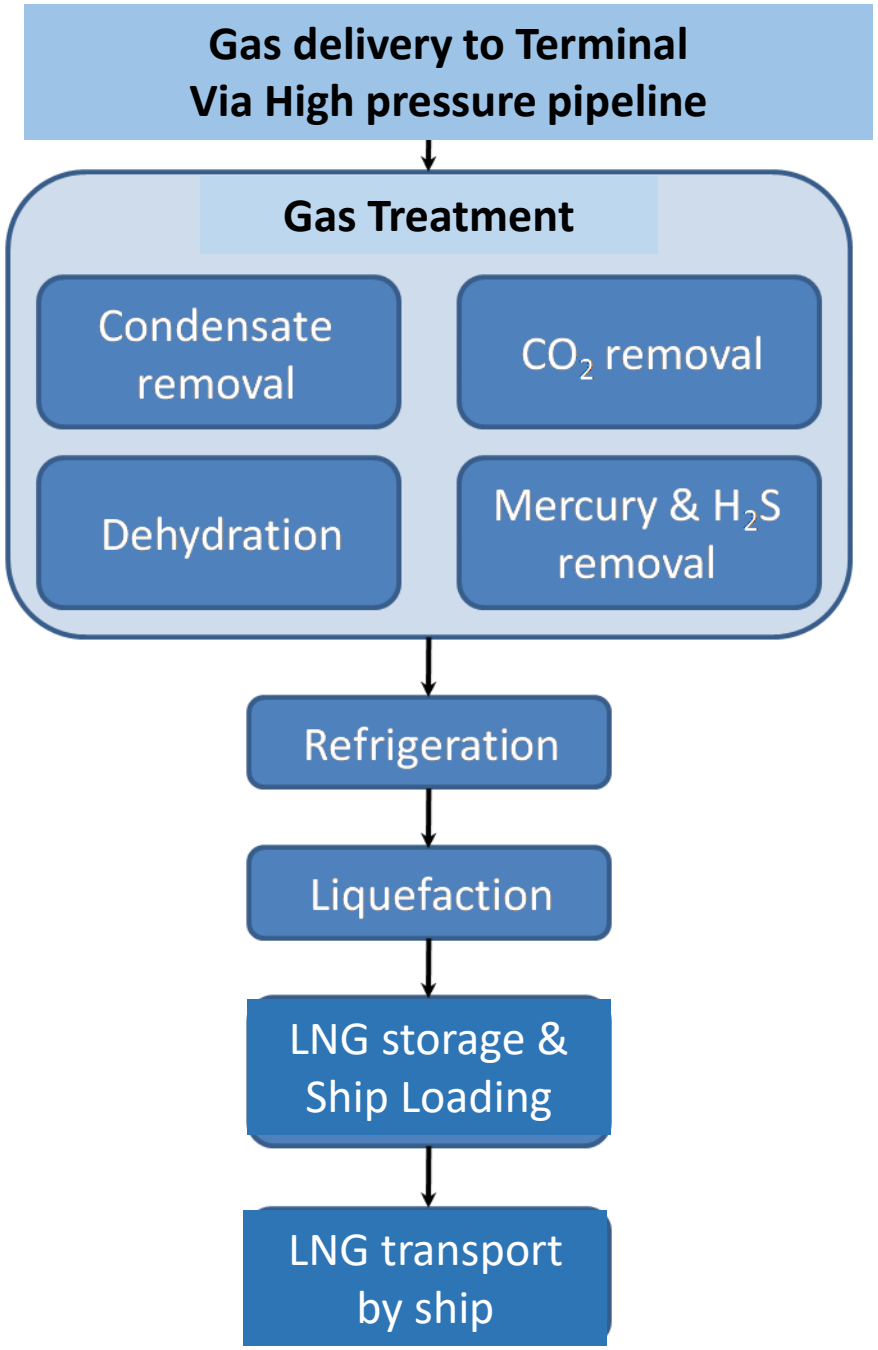
Carbon Monoxide poisoning from the byproducts of combustion

Hazards of Liquid Phase Methane (LNG) :

Freezing upon exposure

Cryogenic failure of structural material

A Rapid Phase Transition LNG spilled onto water boils so fast it can behave like an explosion without burning.



JORDAN COVE LNG TERMINAL BASICS

- Huge volumes of Gas to be processed: Enough to supply 5 million US households.
- High gas pressures (1,900 psi = scuba tank pressures)
- Flammable and toxic refrigerants & treatment by-products
- Large volumes of super cold (- 260 degrees) LNG stored on land (160,000 cubic meters per tank)
- Rapid transfer of LNG to Ships (20,000 gallons per minute)
- 120 ships per year

Key Message #2 Manufacturing and Shipping LNG is a complex, hazardous process

Three, 30 megawatt gas turbine compressors to refrigerate gas
Specialized training; emergency preparation & response plans
Security exclusion zones
Emergency gas flare systems
Remote sensors, surveillance & safety systems
Dedicated on site emergency response personnel at all times
- **Fire station**
- **Security and anti terror operations**

Key Message #3 Complex hazardous processes are highly regulated to limit known risks

Dozens of state, federal, local agencies are involved in regulation:

Multiple laws & regulations address specific hazards and risks

Tanker design and operation
Pipeline and hazardous materials
Worker safety
Structural materials safety
Anti Terror and sabotage
Noise
Water and air emissions
Ground water and storm water
Etc…etc….etc….

Key Message #4: Regulations are often developed in response to failure events & accidents

- **Physical layout and vapor dispersion zones**
- **Characteristics of steel exposed to cryogenic liquids**
- **Design tsunami and earth shaking events**
- **Penetration by projectiles from wind and explosions**
- **Fires and explosions**
- **Emergency response procedures**
- **Terrorism**

Key Message #5: Highly regulated processes can and do fail

Estimating of the likelihood of extreme events is difficult because of the lack of data: They are events that have not yet happened or have happened only very rarely, so relevant data are scarce. Standard statistical methods generally don't apply

Key point #6 Failures at highly regulated hazardous facilities include low probability high consequence events that exceed design standards

Tsunami Protection Barrier Overtopped during the 2011 Japan event.

Key message #7: LNG safety involves Risks from Low Probability High Consequence Events

Natural Hazards

- Ocean storms
- High wind
- Earthquake
- Tsunami
- Floods

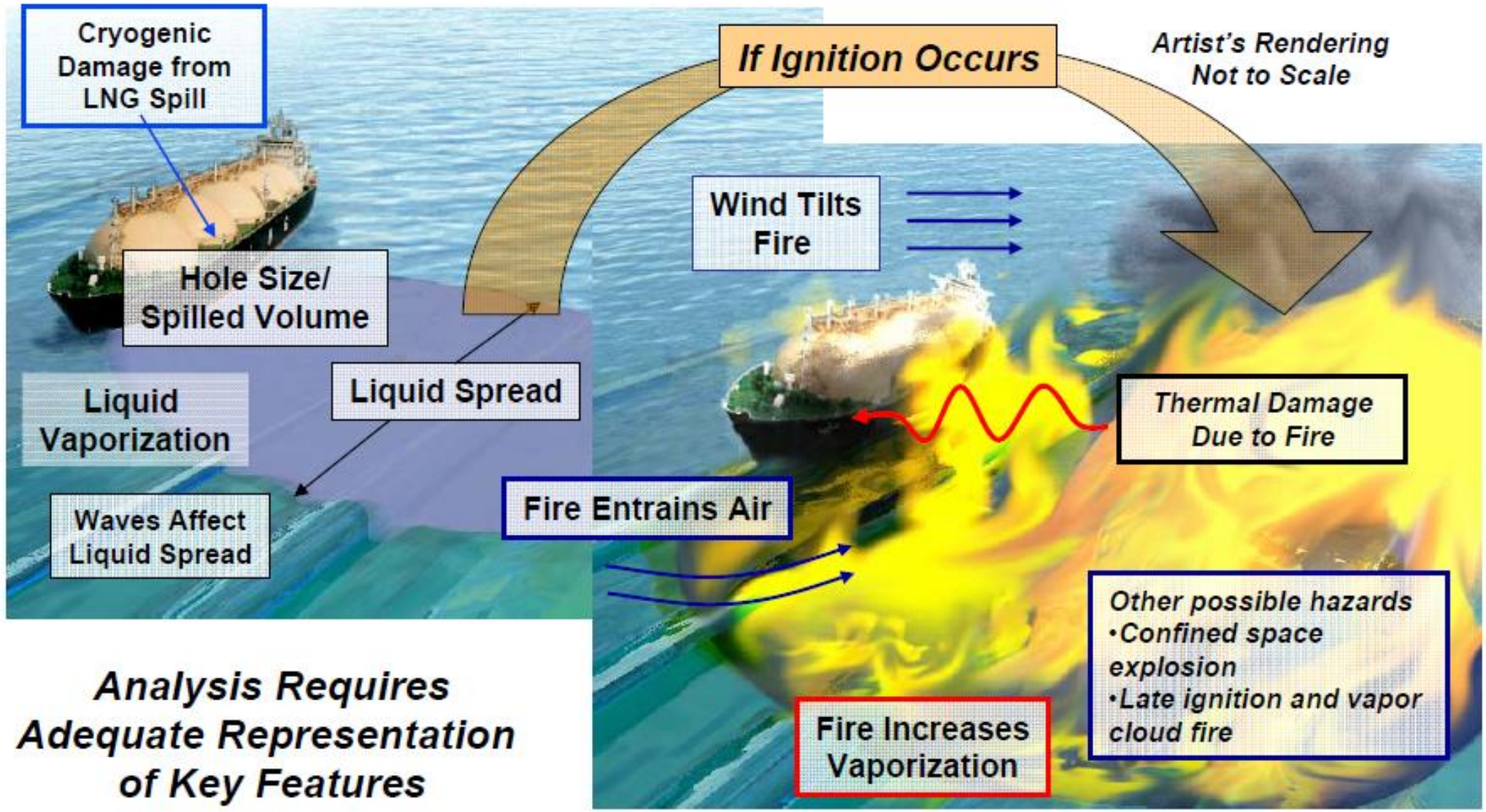
Accidental Hazards

- Equipment failure
- Vessel grounding
- Human error
- Fire
- Explosion

Deliberate Hazards

- Sabotage
- Terrorism

Key Features of LNG Spills Over Water



Analysis Requires Adequate Representation of Key Features

Vulnerability to an LNG spill

Zone 1 (yellow) –

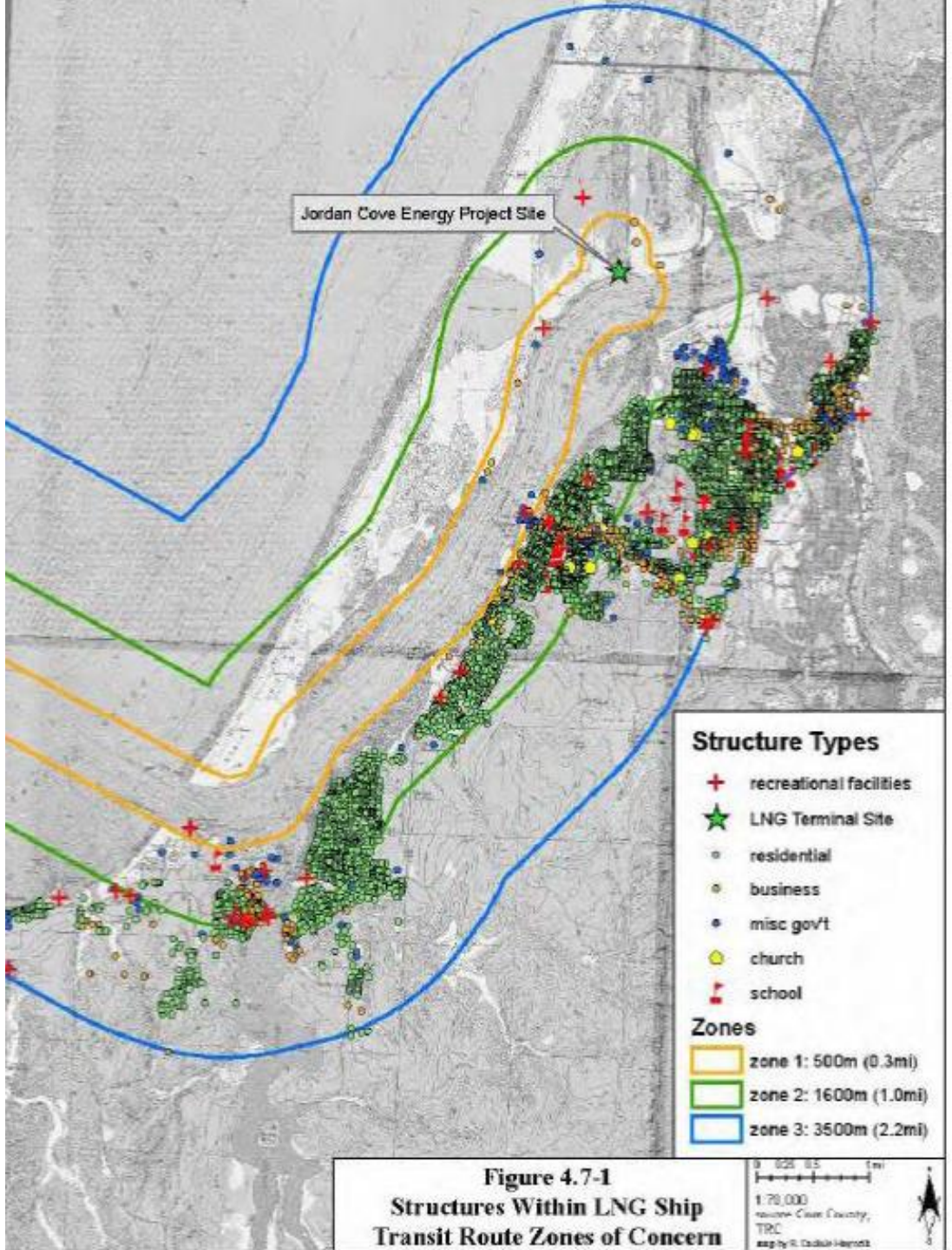
No one is expected to survive in this zone. Structures will self ignite just from the heat.

Zone 2 (green) –

People will be at risk of receiving 2nd degree burns in 30 seconds on exposed skin in this zone.

Zone 3 (blue) –

People still at risk of burns if they don't seek shelter but exposure time is longer than Zone 2



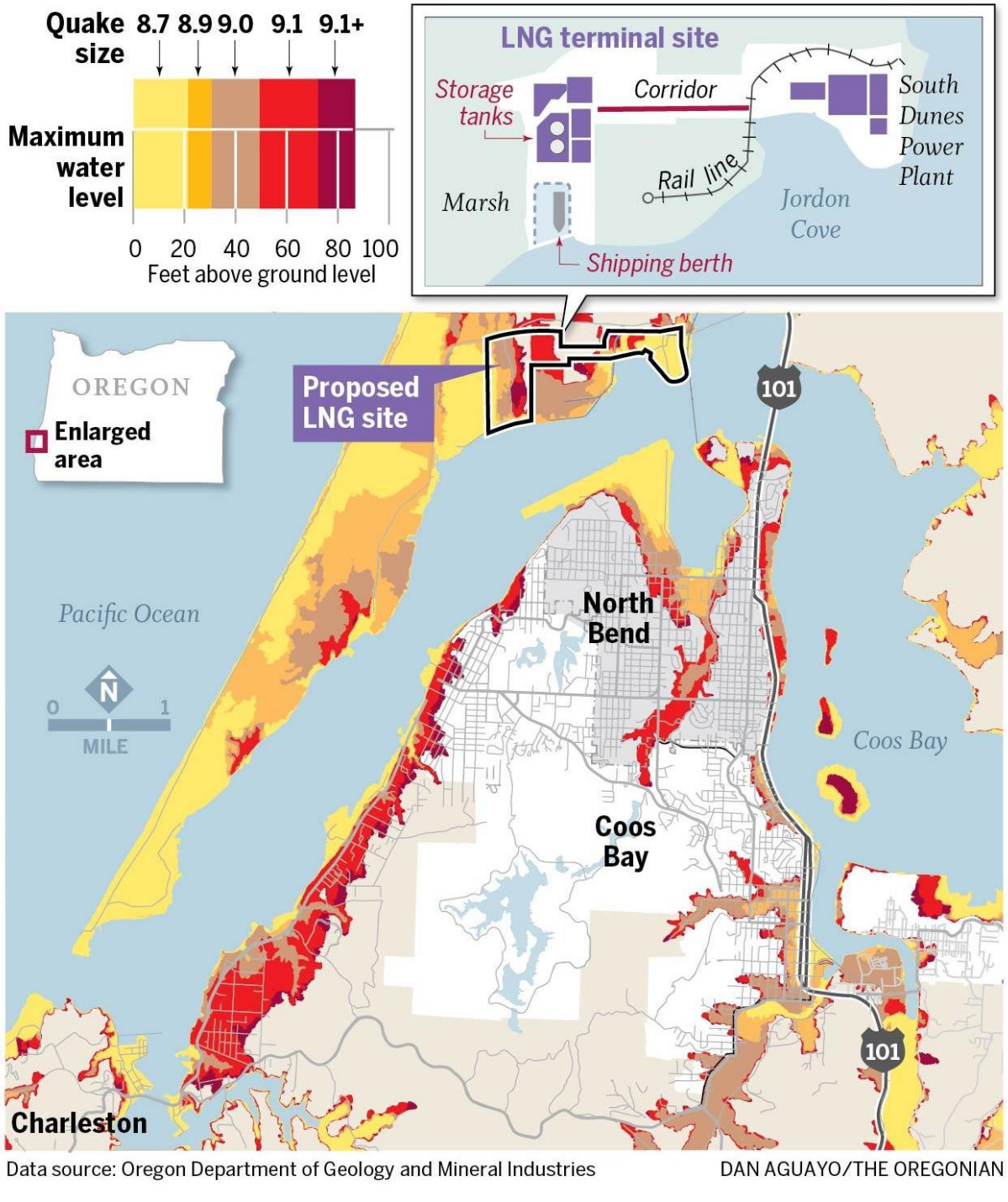
Vulnerability to Tsunami Inundation:

Tsunami Risk reduction strategies:

Elevate LNG site above 46‘ design tsunami inundation level.

Tsunami wall on west side of vessel berth.

Tugboats to hold LNG vessels in place during event.

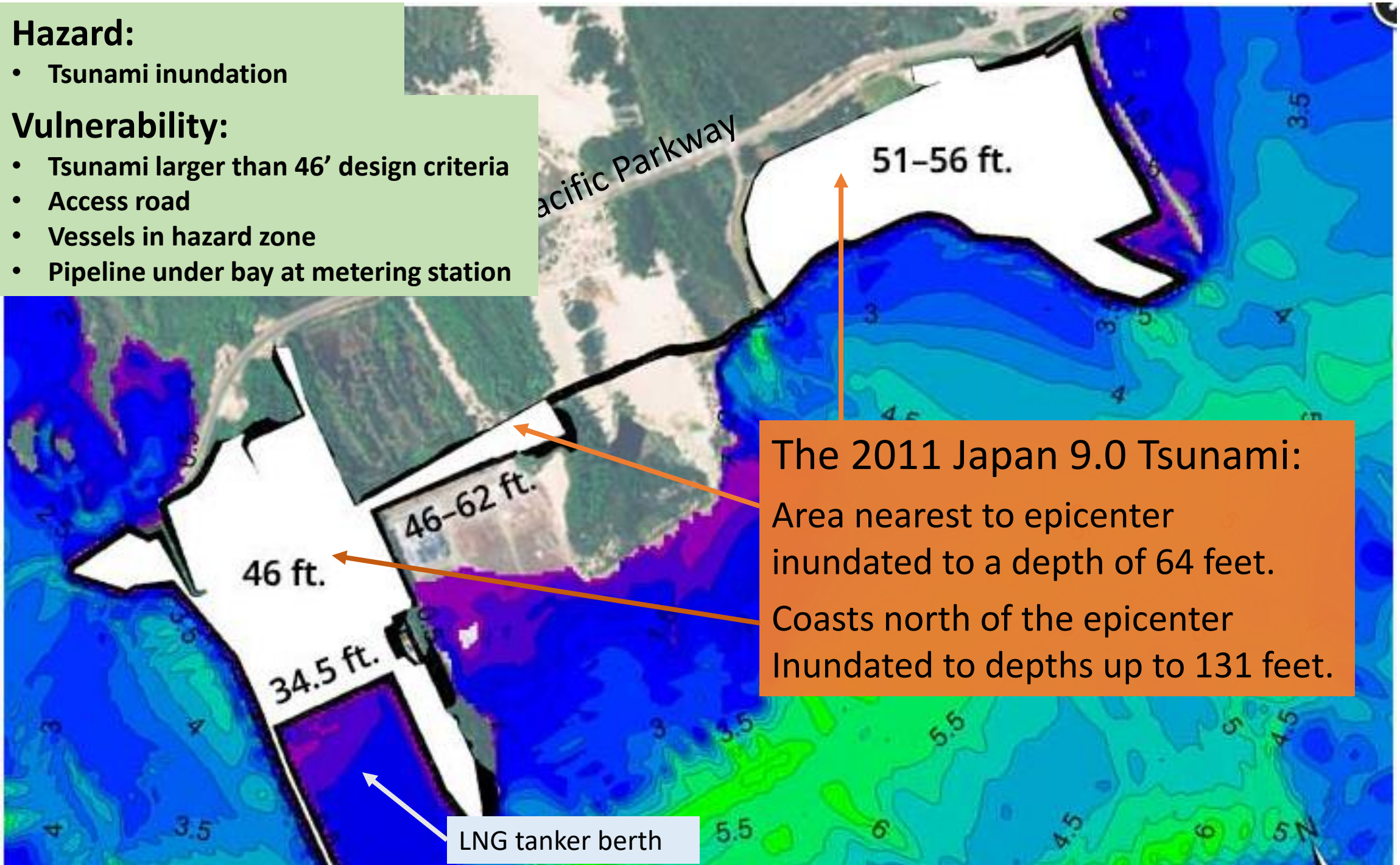


Hazard:

- Tsunami inundation

Vulnerability:

- Tsunami larger than 46’ design criteria
- Access road
- Vessels in hazard zone
- Pipeline under bay at metering station



The 2011 Japan 9.0 Tsunami:

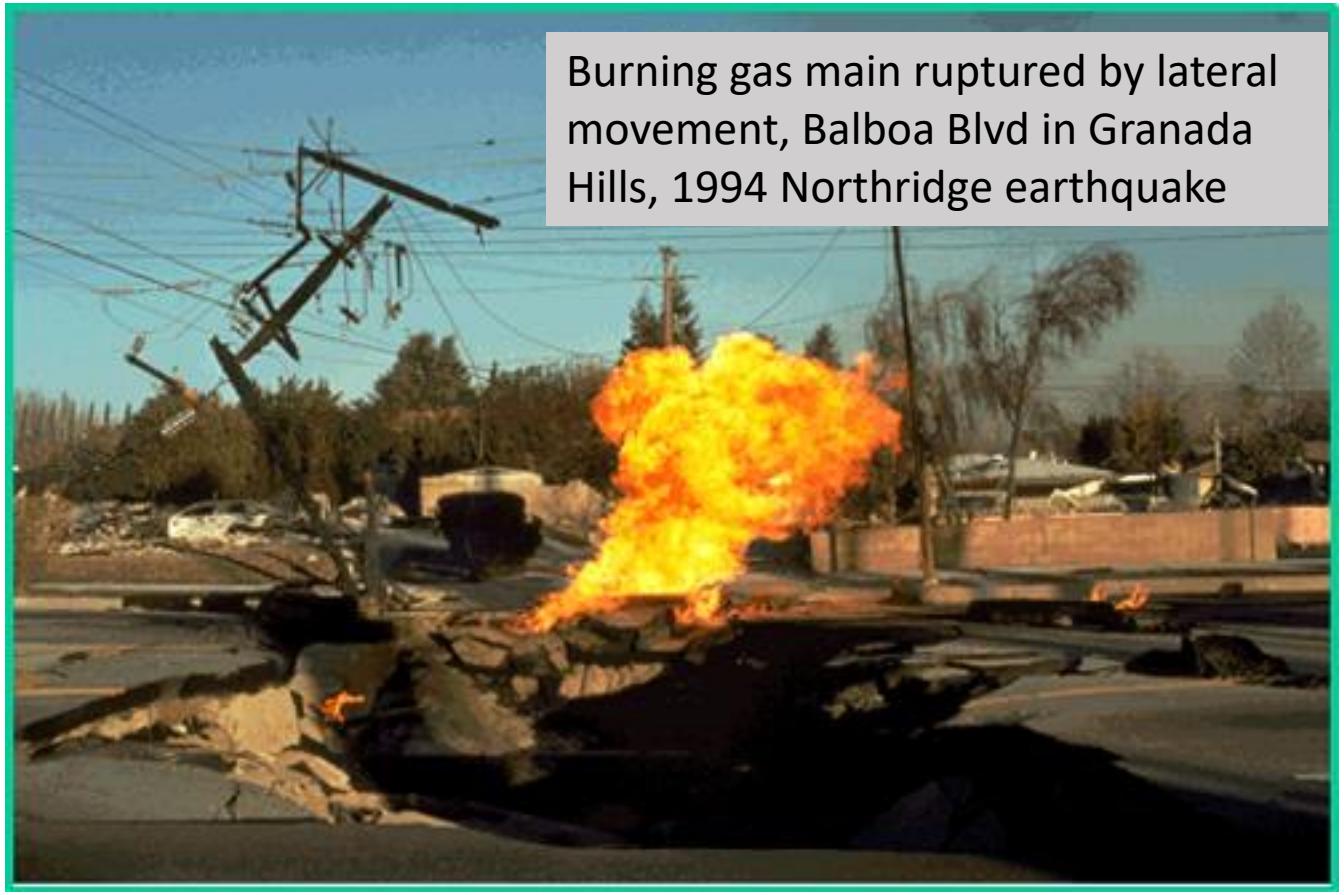
Area nearest to epicenter inundated to a depth of 64 feet.

Coasts north of the epicenter Inundated to depths up to 131 feet.

Earthquake Soil liquefaction Hazards:

Flotation — structures buried in the ground (e.g. pipelines, sewers and fuel tanks) can float to the surface when soil liquefies

Lateral Spreading – soil slides down gentle slopes or toward stream banks riding on a buried liquefied layer.



Burning gas main ruptured by lateral movement, Balboa Blvd in Granada Hills, 1994 Northridge earthquake

Earthquake Hazards: Flow Failures and Ground Oscillations: Vulnerability: North Spit access Road

Flow Failure — earth moves down steep slope with large displacement

The Marina District of San Francisco 1989 Loma Prieta earthquake. Soft bay and marsh soils covered by dredged sand amplified earthquake shaking. The sandy fill material liquefied, causing disruption of streets, sidewalks

Ground Oscillation — the surface layer, riding on a buried liquefied layer, is thrown back and forth by shaking


Thank you Very much for your attention!