

# Adapting to Rising Tides



## Adapting to Rising Tides - Transportation Vulnerability and Risk Assessment Pilot

Wednesday, September 28, 2011 at SPUR



# Adapting to Rising Tides

The goal of the Adapting to Rising Tides Project is to increase the preparedness and resilience of Bay Area communities to sea level rise and other climate change impacts while protecting ecosystem and community services



Photo: Ingrid Taylor

# ART Project Management

- San Francisco Bay Conservation and Development Commission
- NOAA Coastal Services Center
- U.S. Department of Transportation Federal Highway Administration
- Metropolitan Transportation Commission
- California Department of Transportation
- ICLEI Local Governments for Sustainability



# ART Project Objectives

**The Adapting to Rising Tides project is a collaborative effort to address two specific questions:**

- How will sea level rise and storm events affect the future of Bay Area communities, infrastructure, ecosystems and economy?
- What approaches can we pursue, both locally and regionally, to assess these challenges, and to reduce and manage these risks?



# ART Subregional Partners



- ABAG
- Bay Trail
- Caltrans
- City of Alameda
- Alameda County
- BART
- California Coastal Conservancy
- Capitol Corridor JPA
- East Bay Dischargers Authority
- East Bay Municipal Utility District
- East Bay Regional Park district
- City of Emeryville
- City of Hayward
- Hayward Area Rec. and Park District
- City of Oakland
- MTC
- Port of Oakland
- City of San Leandro
- City of Union City

# Local Climate Projections

**Two sea level rise scenarios will be used:**

- 16" (40 cm) of sea level rise  $\approx$  mid-century
- 55" (140 cm) of sea level rise  $\approx$  end-of-century

**Exposure to tidal action (inundation), flooding, and storm events will be evaluated for:**

- New spring tide (MHHW)
- New 100-year extreme tide, e.g., a King Tide
- Wind waves and wave overtopping during a 100-year extreme tide

# Climate Impacts

**Exposure to five impacts related to changes in storm events and sea level rise:**

- More frequent floods
- Flooding lasts longer
- Frequent or permanent inundation in new areas
- Overtopping of shoreline protection and erosion
- Elevated groundwater and salinity intrusion



# ART Asset Inventory

**Assets in twelve categories will be evaluated:**

- Airport
- Community Land Use
- Contaminated Lands
- Energy, Gas/pipelines, Telecom
- **Ground Transportation**
- Hazardous Materials
- Natural Shorelines
- Parks and Recreation
- Seaport
- **Structural Shorelines**
- Stormwater
- Wastewater



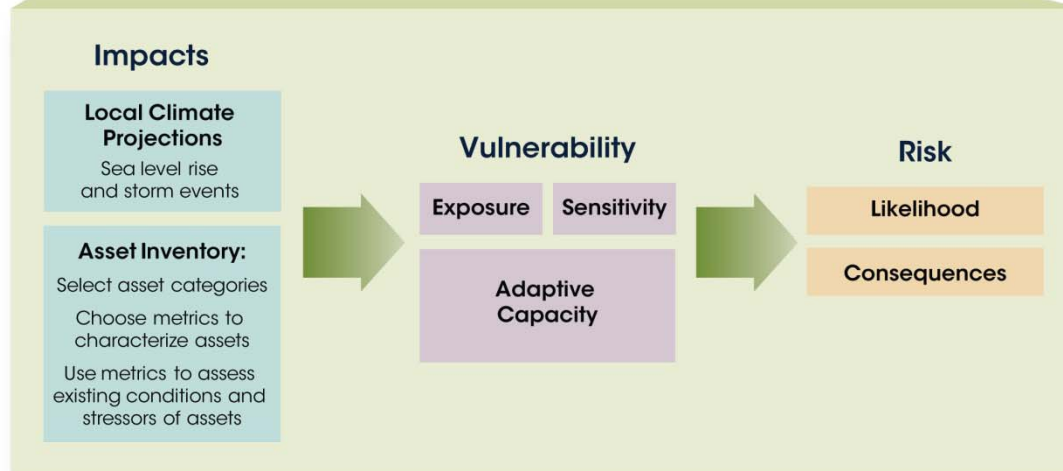


# Adapting to Rising Tides

## The Assess Step: Understanding Vulnerability and Risk of the Natural and Built Environment



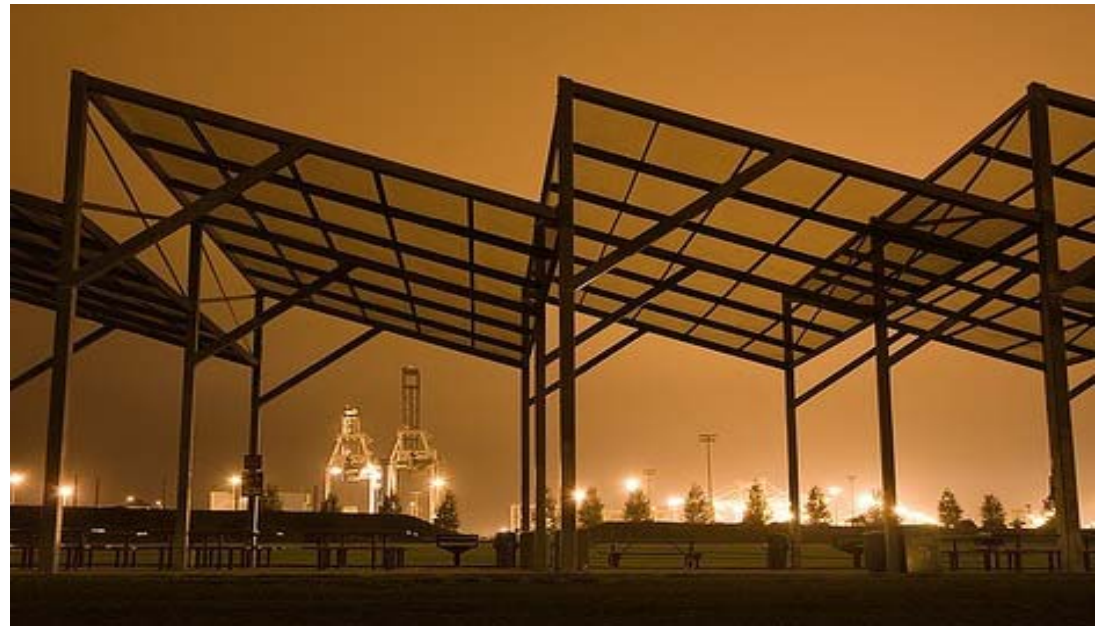
RESILIENCE



# Asset Characteristics

**Existing conditions and stressors will be evaluated based on:**

- Physical characteristics
- Management status
- Community characteristics
- Economic values
- Ecological values
- Public health & safety
- Public access & recreation



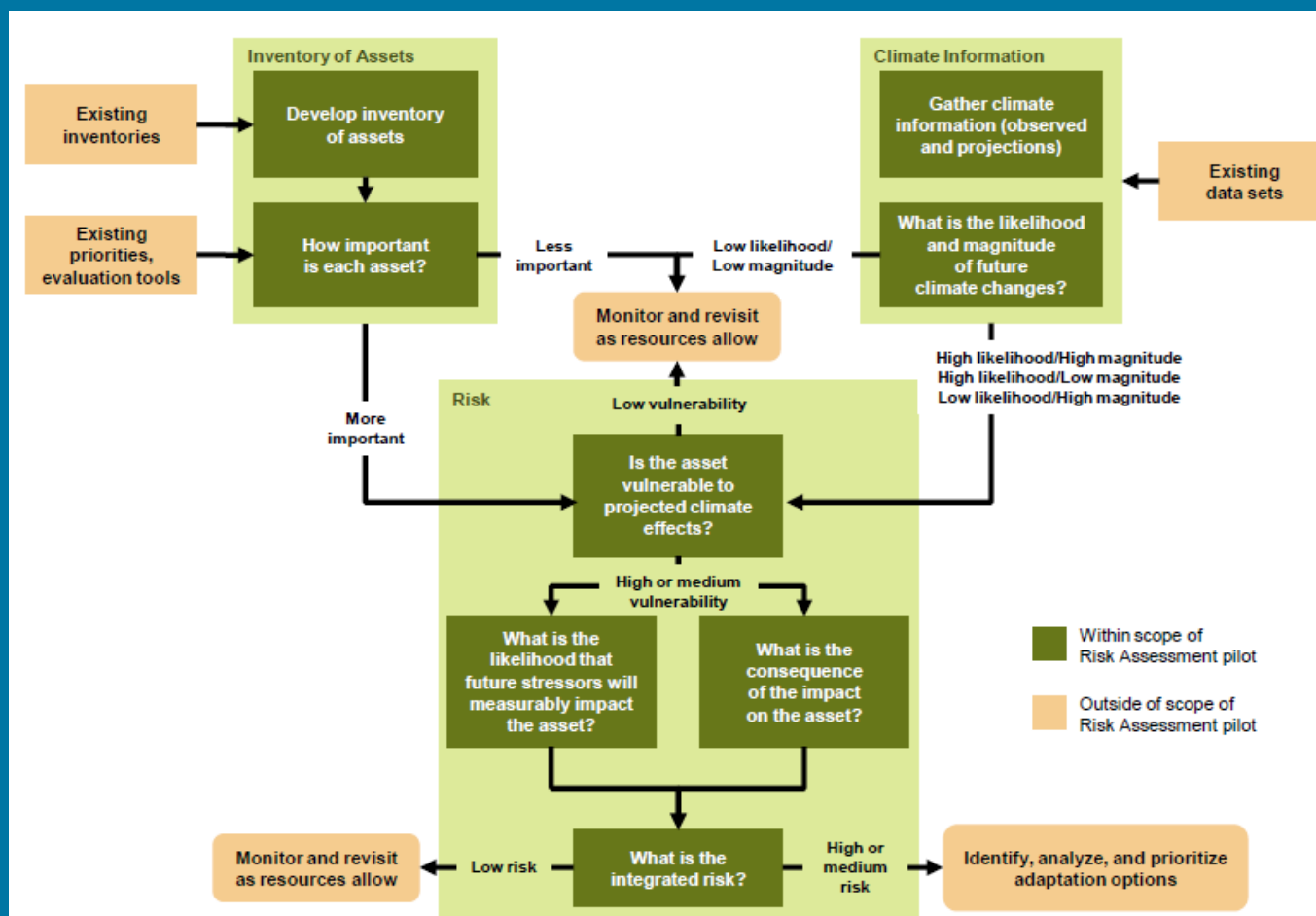
# Developing adaptation strategies & options

## Consideration of:

- Options for reducing vulnerability and risk
- Strategies to improve community resilience
- Opportunities to address governance, equity, environment and economic barriers
- Multi-sector, multi-jurisdictional solutions

# Federal Highway Administration Vulnerability and Risk Pilot Model

- MTC, BCDC, Caltrans
- Funded: Federal Highway Administration (FHWA)
- Budget: \$300,000
- Timeframe: approx 1 year



# The Pilot Model

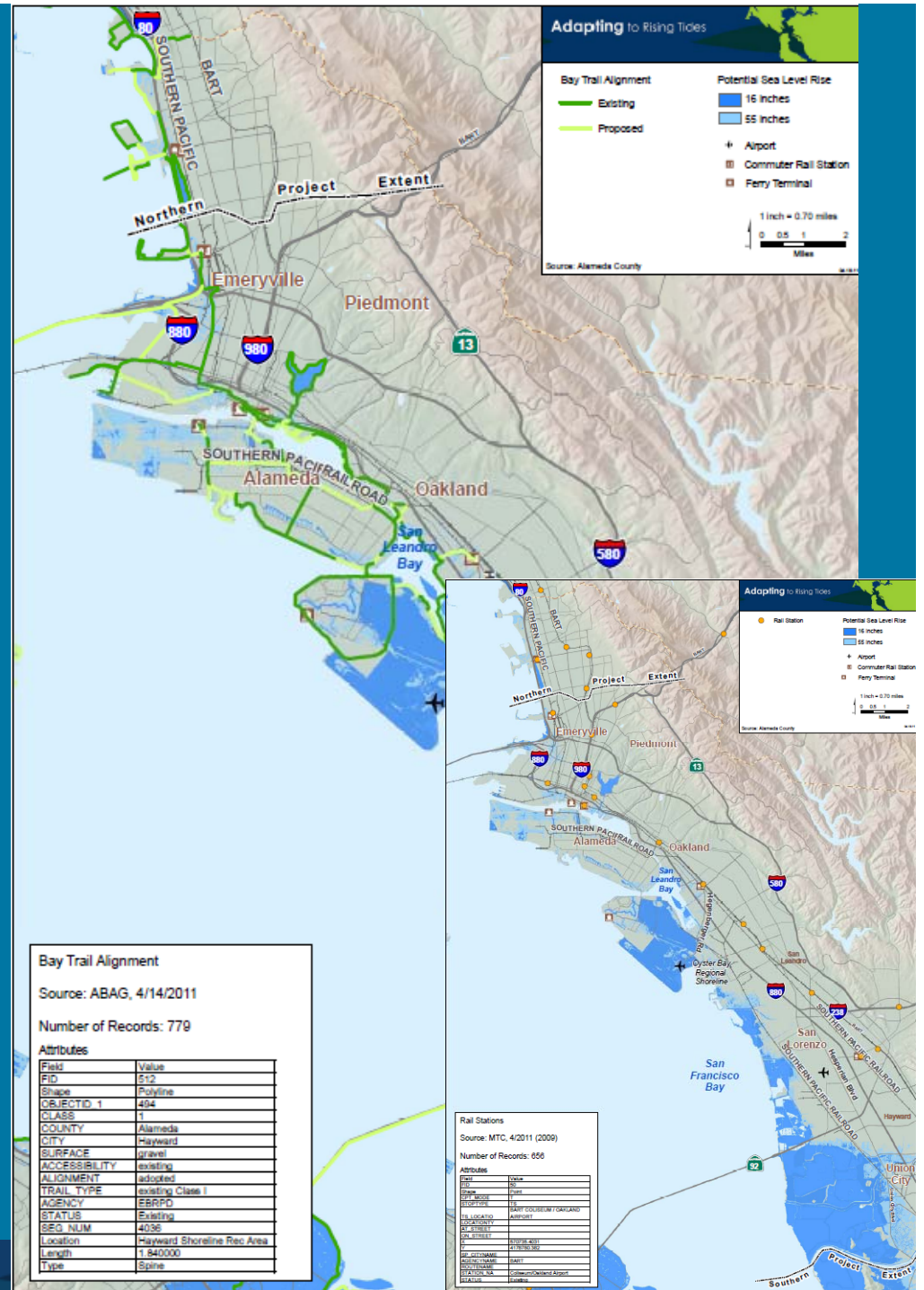
1. Data Asset Inventory
2. Asset Screening and Prioritization
3. Climate and Shoreline Information
4. Vulnerability Assessment
  1. =Exposure + Sensitivity + Adaptive Capacity
5. Risk Assessment
  1. = Likelihood + Consequence
6. Next Steps/ Adaptation Strategies





# 1. Asset Data Inventory

- Identified information we needed to collect about each asset
- Collaborated with MTC, BCDC, Caltrans and local agencies to collect it



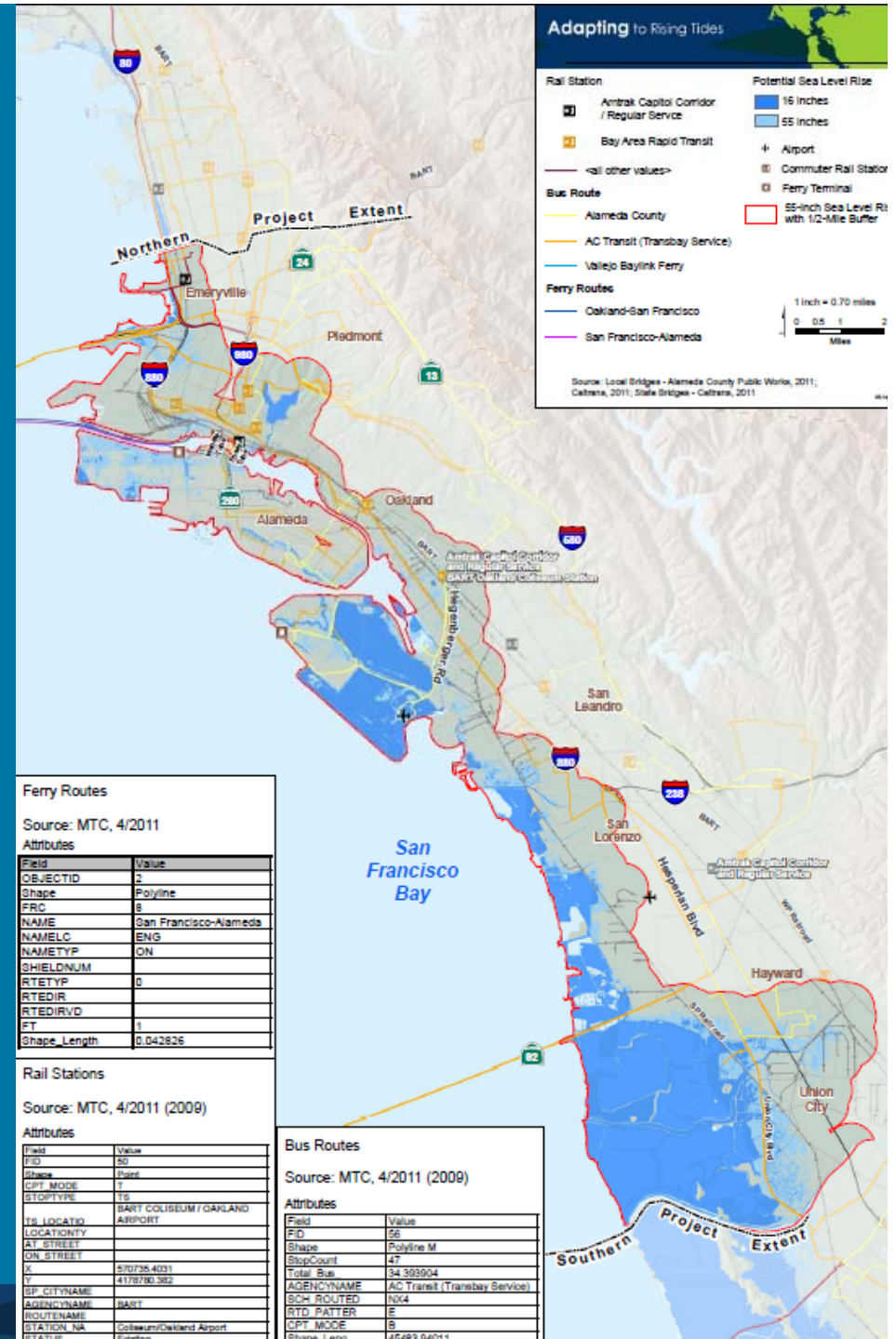
# Adapting to Rising Tides

## Transportation Assets

- Interstates/Freeways
- Arterial, collector and local streets
- Road tunnels/tubes
- Bay bridges
- Alameda bridges
- BART stations
- BART alignments
- Amtrak stations
- Passenger/freight rail alignments
- Ferry terminals
- Transportation Management Centers
- Bus Maintenance Facilities
- BART System Assets
- Passenger and Freight Yards and Depots
- Pedestrian/ Bicycle Facilities
- Transit associated with all road assets

## 2. Asset Screening and Selection

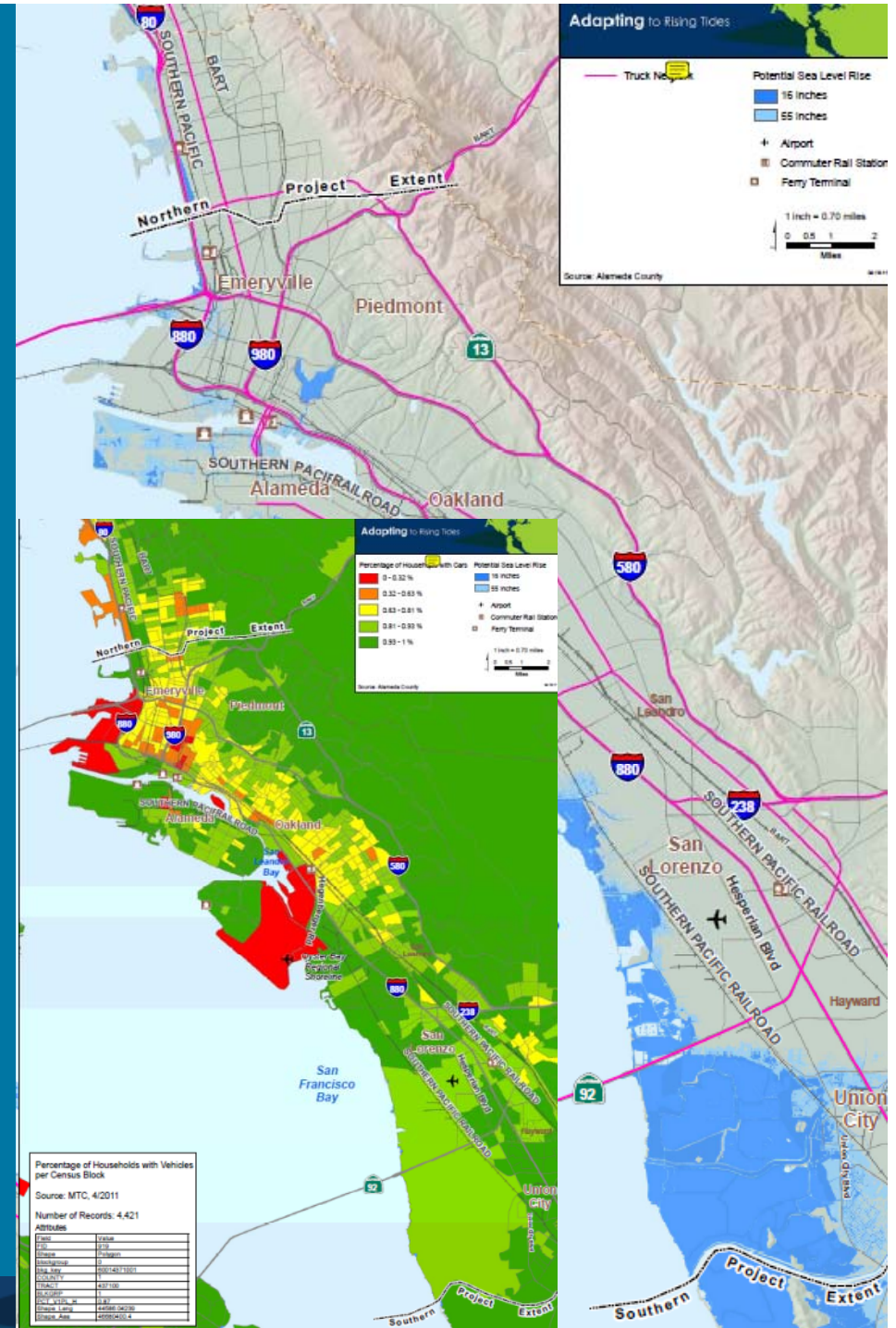
- Organized assets into asset categories:
  - Road
  - Transit
  - Facilities
  - Bike / Pedestrian
- First Filter= SLR plus buffer;





# Characteristics


- Physical Characteristics  
built at-grade, below grade, or elevated on embankments or structures;
- Functional Characteristics,  
lifeline routes, evacuation routes, goods movement routes, transit routes, and bike routes;
- Jurisdiction,  
agency, city or other entity with ownership and/or management responsibility for the asset;
- Social/Economic Functions,  
connecting to jobs, regional importance, and support of transit-dependent populations.



# Adapting to Rising Tides



## 3. Climate and Shoreline Information

- Reviewed Climate Information; Mid-century 16 inches, end-of century 55 inches SLR
  - Developed simple/distinct shoreline categories based on primary function and potential to protect against inland inundation
  - Using shoreline categories in combination with new inundation maps to understand vulnerability and risk
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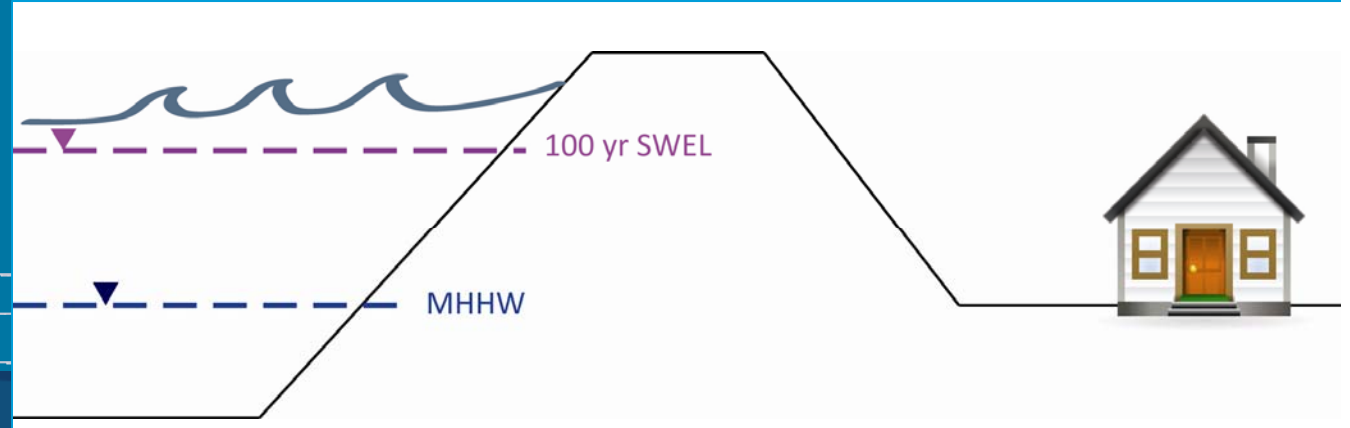


# Adapting to Rising Tides

## Shoreline Inundation and Flooding

### New Sea Level Rise Maps for the Study Area:

- ✧ Two Sea Level Rise Projections
  - 16" (40 cm) of sea level rise ≈ mid-century
  - 55" (140 cm) of sea level rise ≈ end-century
- ✧ Three scenarios - inundation, flooding, and storm events
  - MHHW
  - 100-year SWEL
  - 100-year SWEL plus locally generated wind/wave action



# Adapting to Rising Tides

## Shoreline Assets

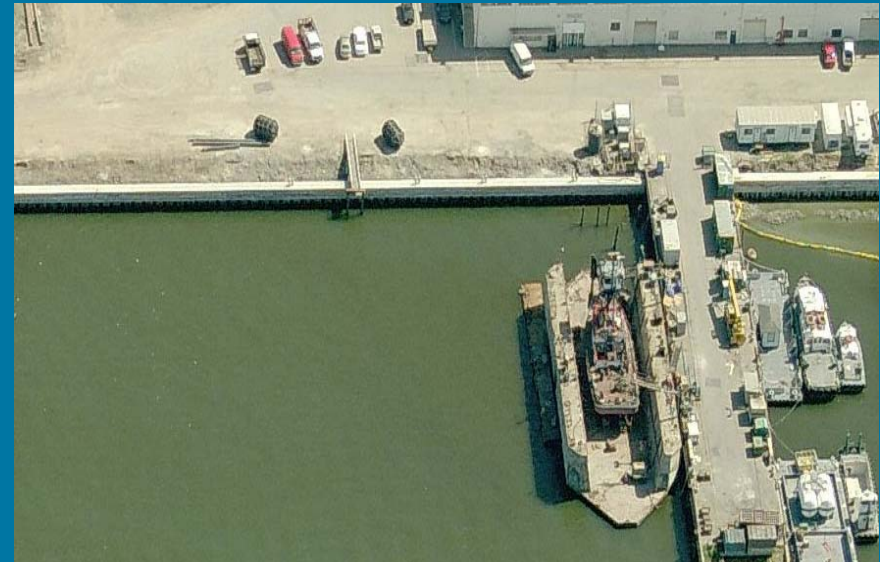
- ✧ Engineered Flood Protection Structures
  - Levees
  - Flood Walls
- ✧ Engineered Shoreline Protection Structures
  - Bulkheads
  - Revetments
- ✧ Non-Engineered Berms
- ✧ Wetlands
  - Natural
  - Managed
  - Tidal Flats
- ✧ Natural Shorelines/Beaches (non-wetland)

# Adapting to Rising Tides

## Engineered Shoreline Protection Structures



Engineered Revetment



Bulkhead



Non-Engineered Berm



# Adapting to Rising Tides

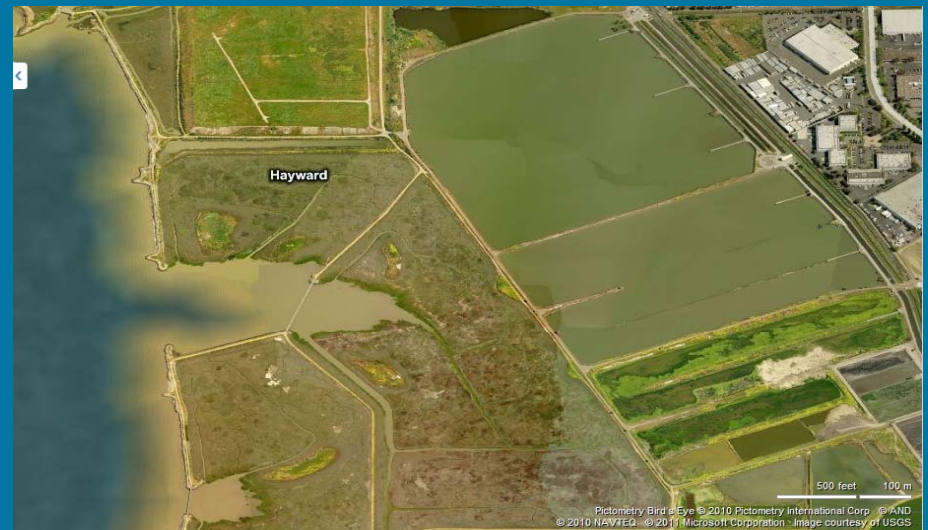


Wetland with natural marsh edge



Tidal flats

## Wetlands



Managed wetlands

# Adapting to Rising Tides



## New Sea Level Rise Maps Include:

- Existing shoreline protection – 2m DEM using 2010 CA Coastal LIDAR (USGS)
- Daily and extreme tide levels – USGS TRIM2D (Knowles, 2009)
- Storm wave scenarios – FEMA MIKE21 wind setup, wave setup, wave height
- Hydraulic Connectivity – resolved using NOAA CSC methodology (Marcy et al., 2011)
- Depth of Inundation



# Adapting to Rising Tides



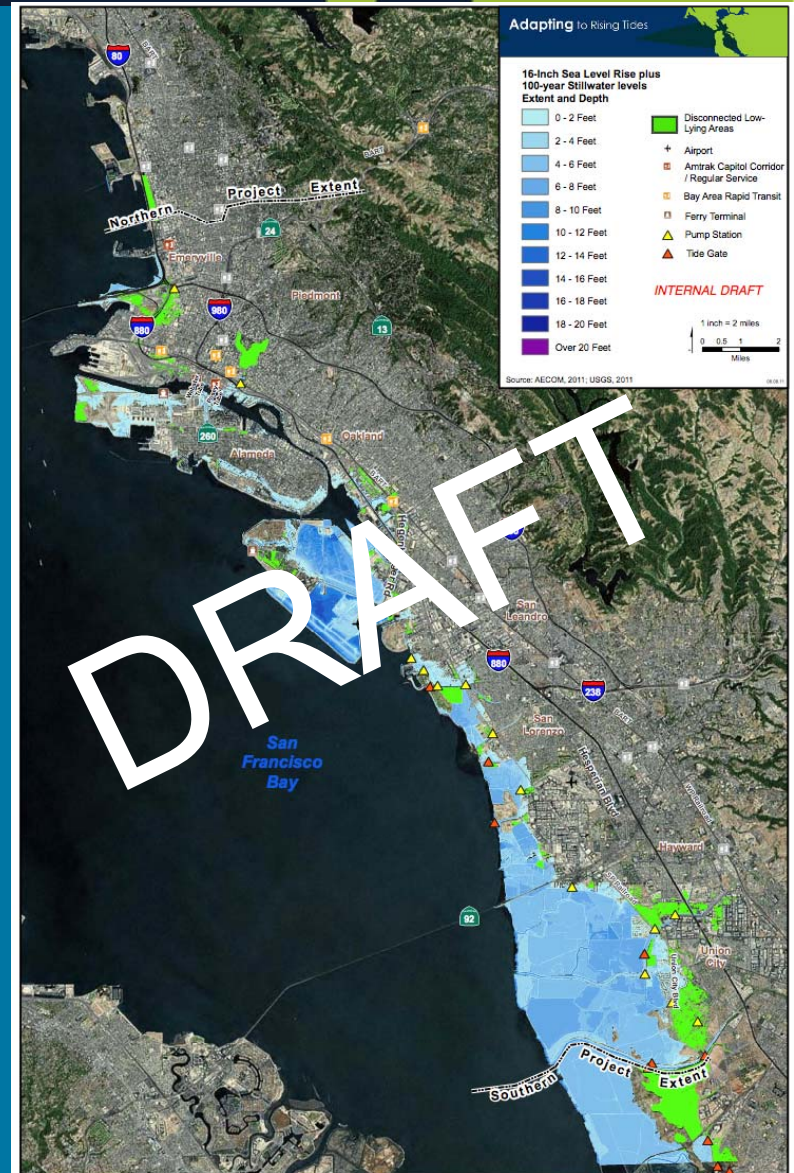
## NEW SLR Maps

Internal Drafts – Maps will  
be available in final report  
(December 2011)

# Adapting to Rising Tides

## “Weak links” Analysis

- Identify the locations in the shoreline protection system where **overtopping** and thus inundation and flooding is likely to occur in each scenario
- Determine the total amount (length) of shoreline overtopped in each scenario
- Consider if there are plans to improve shoreline protection in the identified weak link areas



# Adapting to Rising Tides

## Vulnerability and Risk Assessments

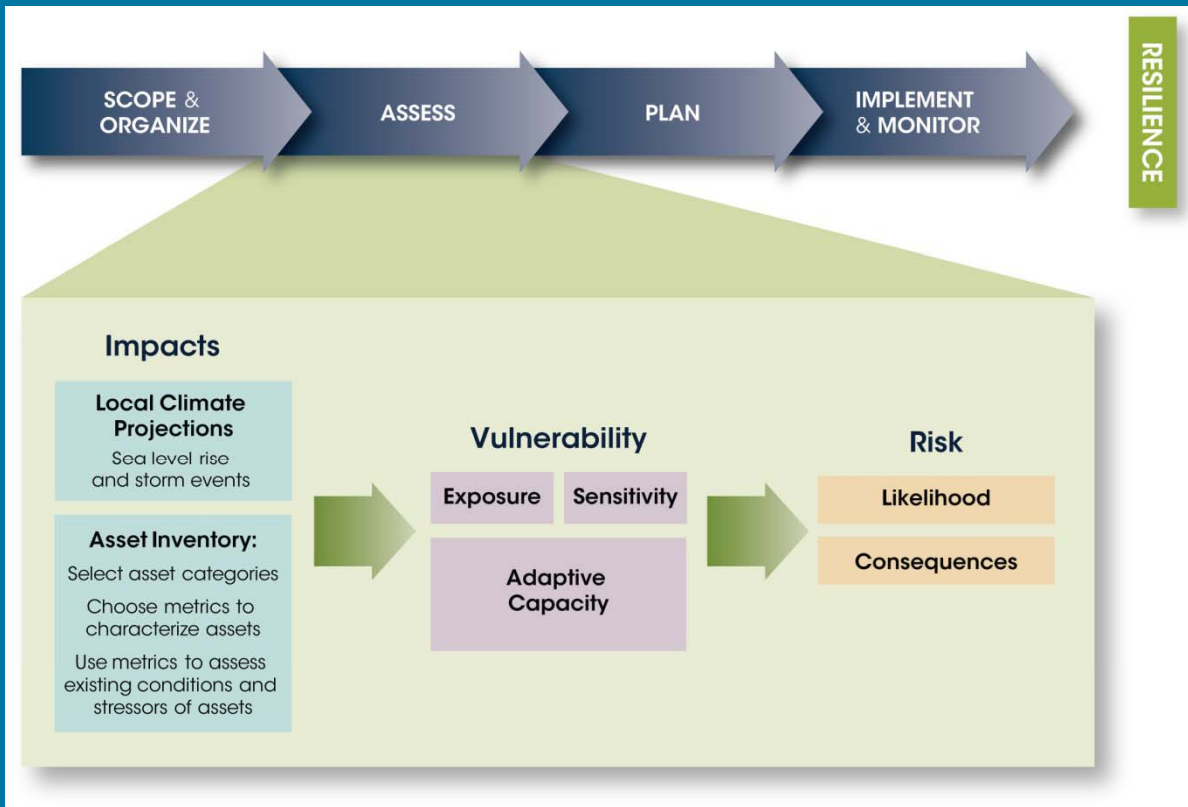


Photo: H. Bahr

## 4. Assessing Vulnerability

**Vulnerability is the susceptibility of people, property, and resources to a hazard. It depends on the type of impact, and the sensitivity and adaptive capacity of the impacted.**

Will the asset experience the climate change impacts?



If so, to what degree will that asset be impaired?



Can the asset adjust without significant intervention?



Photo: N. Girling

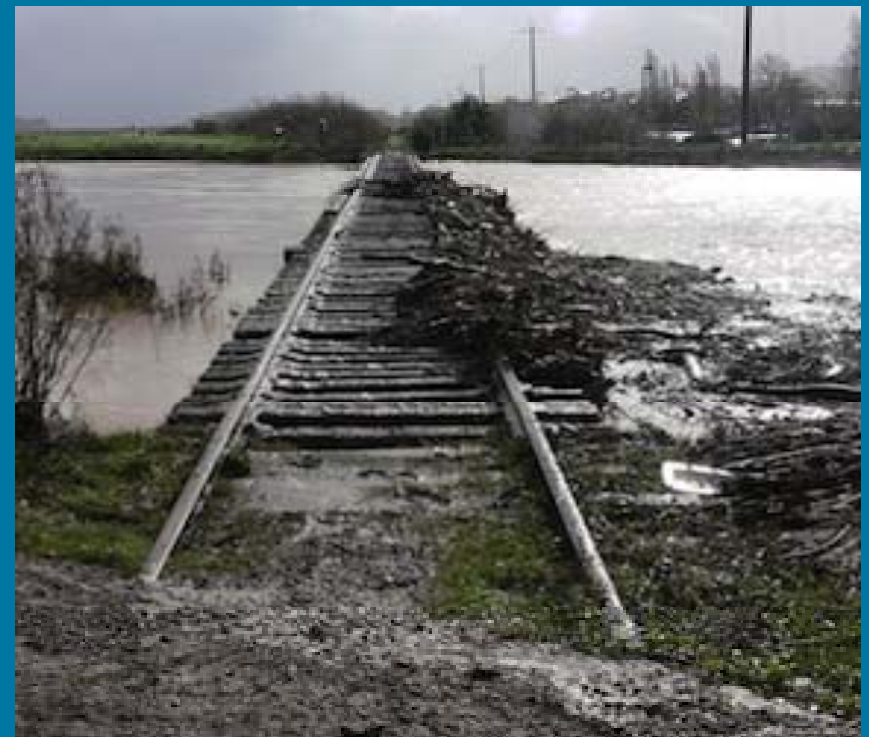
## 5. Determining Risk

**Risk is the threat posed by an impact or hazard. It depends on the likelihood of an impact and the magnitude of the consequence.**

What is the likelihood of the asset being impacted by sea level rise?



If so, what are expected consequences in terms of cost and time to replace asset, economic impact, socio-economic impact, public safety and degree of redundancy in the system?





# Draft Asset Risk Profile

- Includes information on:
- Characteristics
  - Vulnerability (condition, exposure, inundation depth)
  - Any nearby “Weak links” (levees that could be overtopped)

## Draft Asset Risk Profile

Asset Name		
Webster and Posey Tubes		
Asset Location		
Oakland - Alameda		
Sensitivity/Background Information		
Jurisdiction: Caltrans		
	Posey Tube	Webster Tube
Age:	Built-1927, Retrofit-2004;	Built-1963, Retrofit-2005 Level
Level of Use-Average Daily Traffic (ADT)	PH=1,850; AADT=22,300; AADTT=535	PH=1,850; AADT=22,300; AADTT=535
Seismic Retrofit	Yes	Yes
Maintenance Costs (O&M)	\$83,312	\$72,812
Liquefaction Suceptibility	Very High	Very High
<b>Importance Category:</b> Critical asset <ul style="list-style-type: none"><li>• Commuter Route,</li><li>• Goods movement,</li><li>• Transit Routes [O, W, 20, 31, 51A, 314, 851, Estuary Shuttle]</li><li>• Connects to Jobs</li></ul>		
<b>Vulnerability Rating mid century</b>		High
<b>Max. Inundation Depths</b>		
16 inch SLR		4 ft
16 inch +100 yr SWEL		22 ft
16 inch + 100 yr SWEL + wind waves		YES
55 inch SLR		23 ft
55 inch +100 yr SWEL		25 ft
55 inch + 100 yr SWEL + wind waves		YES
Shoreline "Weak Link" Analysis [shoreline assets responsible for flooding]		
<b>Consequences</b> [Description]		
<b>Potential to reroute</b>		
<b>Potential Adaptation Strategies</b>		



Webster Tube, Alameda



Posey Tube, Alameda



Projected Inundation Extent at Asset Location at 16 inch SLR + 100yr SWEL




Projected Inundation Extent at Asset Location at 55 inch SLR + 100yr SWEL

# Adapting to Rising Tides



## 6. Next Steps

- Complete the “weak links” analysis of the shoreline and verify with ART project partners
  - Use shoreline categories, sea level rise maps, and “weak link” analysis to inform vulnerability and risk of community and shoreline assets
  - Review Consequences with ART project partners
  - Develop Adaptation strategies and options
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# Discussion

- Implications for the larger Bay Area



Photo: Ingrid Taylor