Climate Vulnerability Assessment - Decision making for climate robust infrastructure

March 19, 2013

ECCA

INCAH TNO

Massachusetts Institute of Technology

AECOM

Overview of Presentation

– The Challenge: Uncertainty. Barriers to behavior change and proactive planning/decision making processes

– The Harboring Uncertainty Project

– Adapting to Rising Tides Project

– Lessons learned and discussion

Hi!

We are: Nienke Maas, Yanna Badet, Todd Schenk

And who are you?

1) What professions are represented in the audience?
   Please raise your hands:
   - Scientists & Researchers? Planners & other practitioners?
   - Private Sector? Public Sector? NGO representatives?

2) How many of you are working on Infrastructure projects?

3) Have you ever done a SLR vulnerability assessment for a project?

4) Do you have a project that you are considering doing a SLR vulnerability assessment on?

5) Is ‘uncertainty’ a factor in your decision making processes?

The Challenge

for Adaptation in a regional and local planning context:

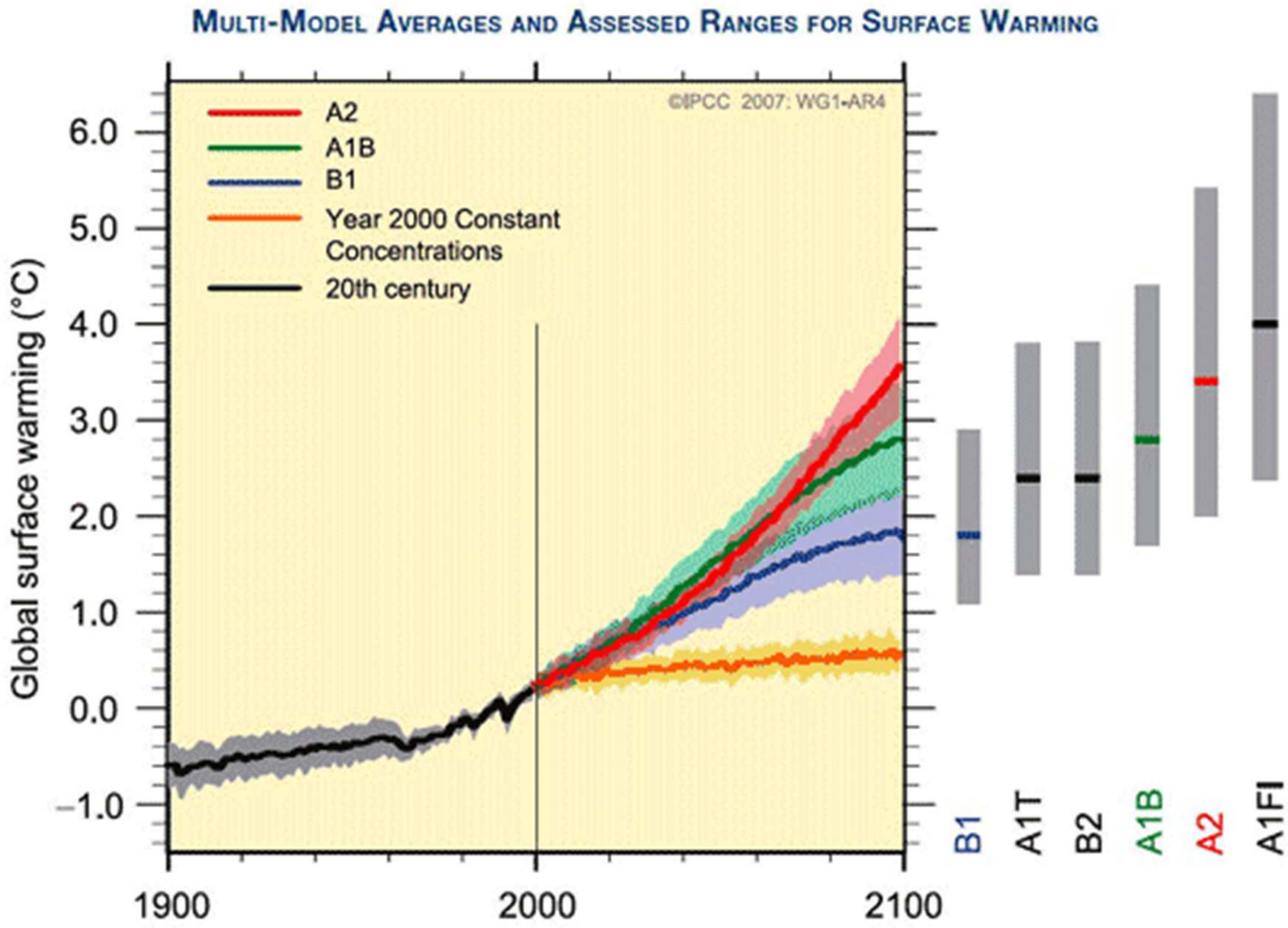
Uncertainty – when, where and how exactly

Other Barriers – that kept us from having planned (read: low-cost) responses already

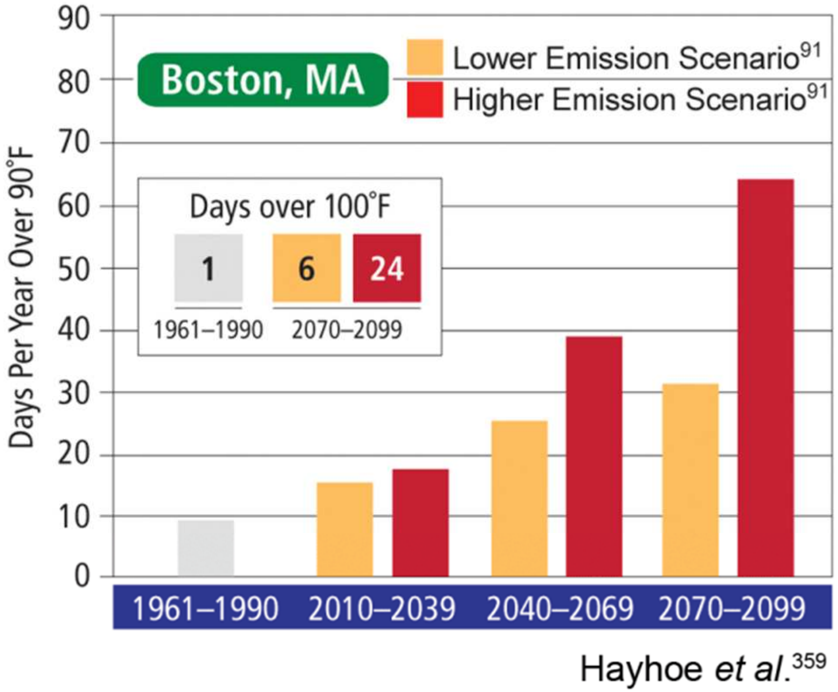
- Politics and competing interests
- Short-term focused versus long-term
- Cost of adaptation strategies (esp big infrastructure)
- Ineffective public processes

Barriers: Real Uncertainty

MAKE MORE UP-TO-DATE

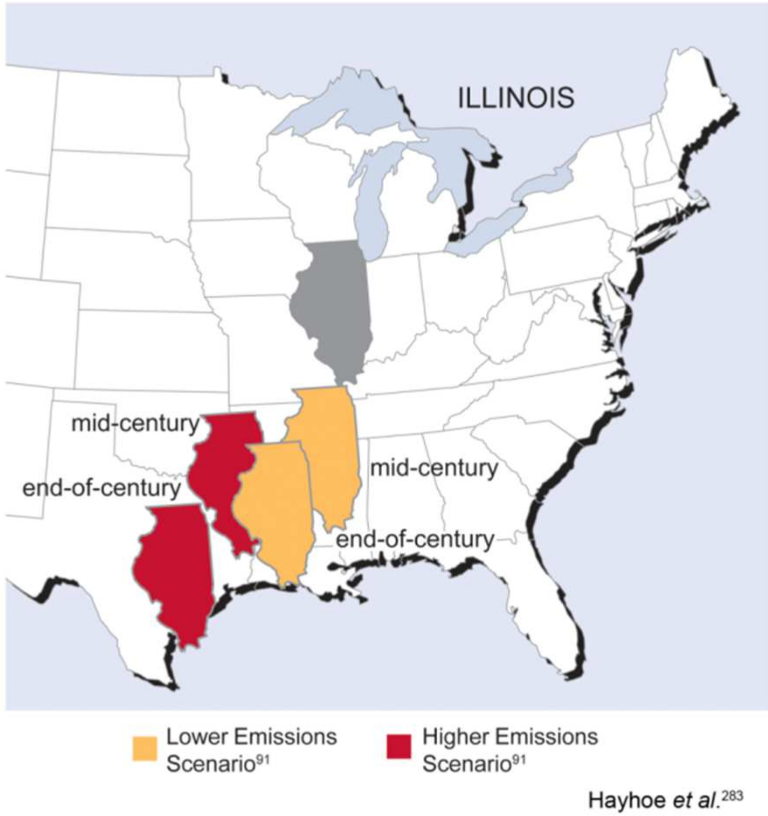


Barriers: Real Uncertainty



The graph shows model projections of the number of summer days with temperatures over 90°F in Boston, Massachusetts, under lower and higher (referred to as "even higher" on page 23) emissions scenarios.91 The inset shows projected days over 100°F.[359]

Source: http://www.globalchange.gov/images/cir/hi-res/10-northeast-pg-108_bot.png



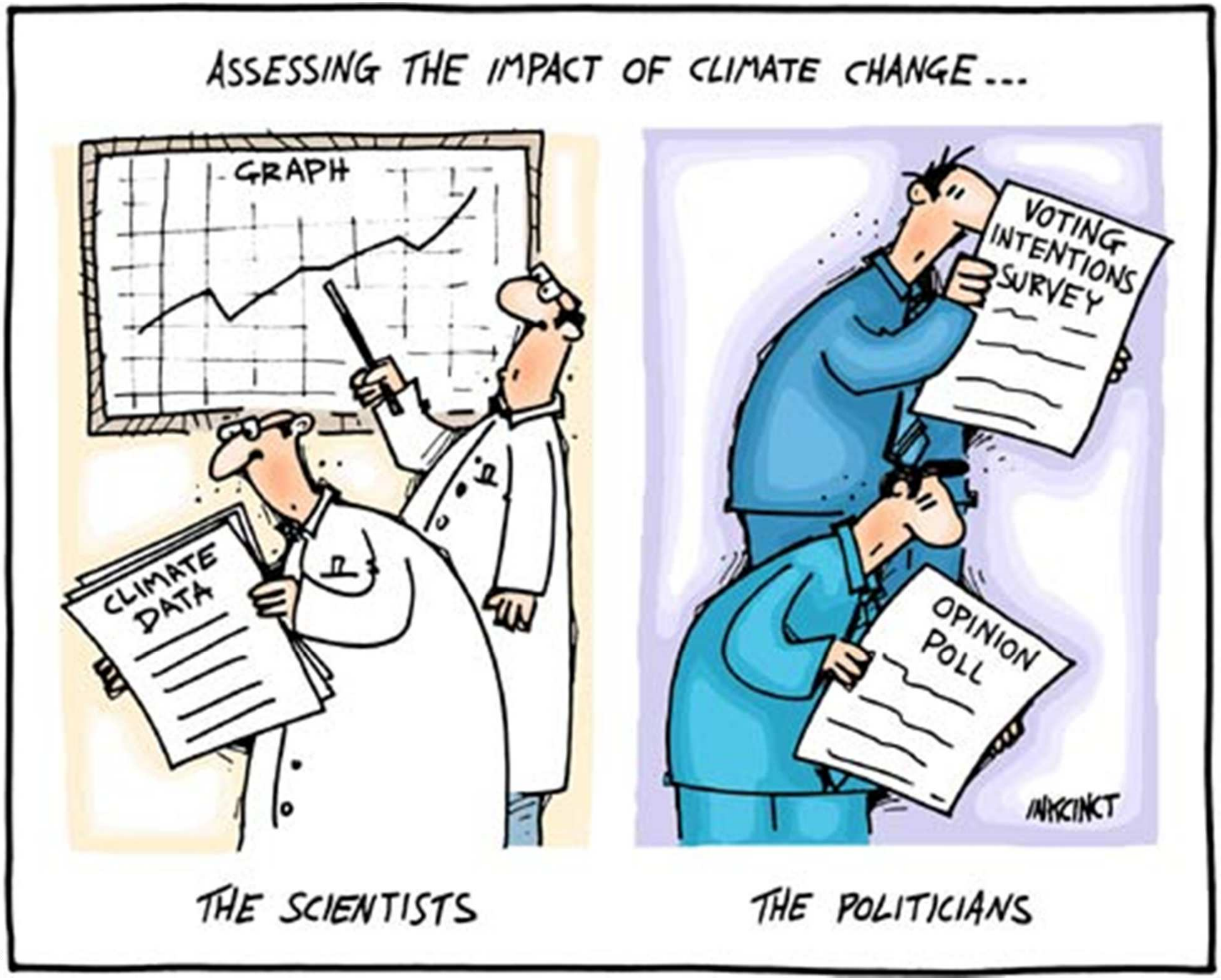
Model projections of summer average temperature and precipitation changes in Illinois for mid-century (2040-2059), and end-of-century (2080-2099), indicate that summers in this state are expected to feel progressively more like summers currently experienced in states south and west. Illinois is projected to get considerably warmer and have less summer precipitation.

Source: http://www.globalchange.gov/images/cir/hi-res/12-midwest-pg-117_ilonly.png

Barriers: Real Uncertainty

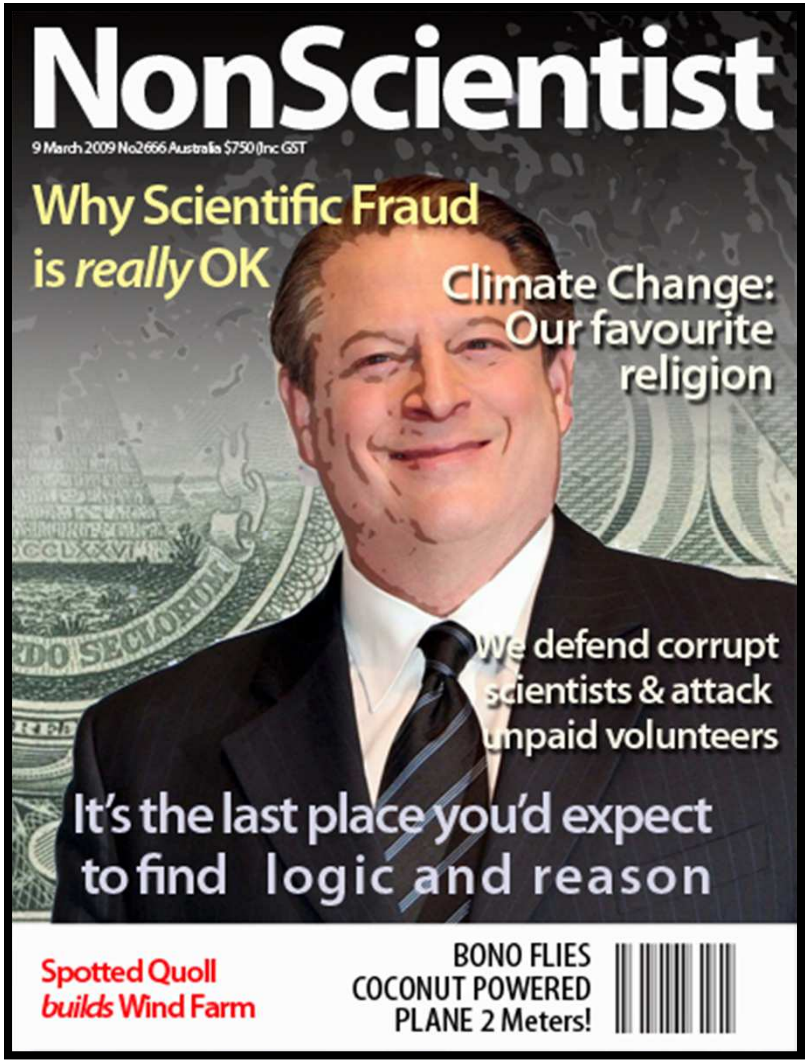
National Research Council (NRC) (2012) Regional SLR Projections near San Francisco, CA

Year	*Projection*	*Range*
2030	15.25 cm ± 2.0	5 – 30 cm
2050	28 cm ± 3.6	12 – 60 cm
2100	91 cm ± 10.0	42 – 166 cm


ASSESSING THE IMPACT OF CLIMATE CHANGE...
GRAPH
CLIMATE DATA
THE SCIENTISTS
VOTING INTENTIONS SURVEY
OPINION POLL
INKCINCT
THE POLITICIANS

Barriers: Manufactured Uncertainty

Source: http://www.globalchangeblog.com/2009/11/why-dont-people-engage-climate-change-part-5-a-perfect-storm-of-climate-change-denial/



Source: http://wattsupwiththat.com/2009/12/15/news-on-the-new-non-scientist/

Barriers: Competing Interests

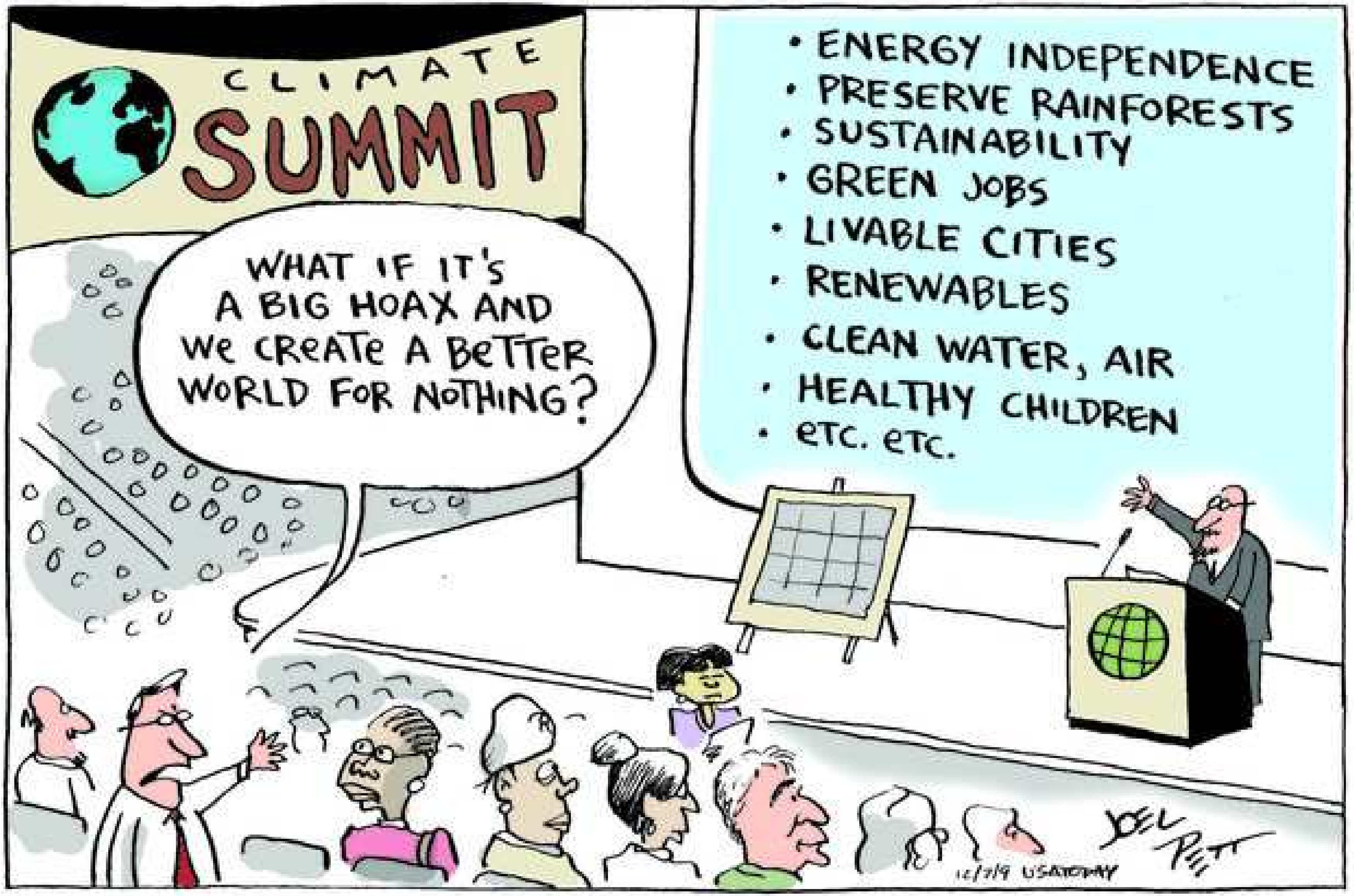
Photo courtesy of U.S. Army Corps of Engineers
Superstorm Sandy levee repair in Montoloking, New Jersey *:*

AECOM

Barriers: Poor Public Processes

Sources: http://www.southernfriedscience.com/?p=8179 (above); Source:http://www.earthisland.org/journal/index.php/eij/article/whos_to_blame_for_the_impasse_in_global_climate_talks (top-right); http://www.telegraph.co.uk/earth/copenhagen-climate-change-confe/6843154/Copenhagen-climate-conference-global-warming-talks-meltdown.html (bottom right)


HORSEY
IT'S SETTLED...
WE AGREE TO SIGN A PLEDGE TO HOLD ANOTHER MEETING TO CONSIDER CHANGING COURSE AT A DATE YET TO BE DETERMINED.
CLIMATE CHANGE
WORLD LEADERS


CLIMATE SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• etc. etc.
JOEL PETT

Barriers: High Cost of Adaptation

450 million EUR Maeslantkering storm surge barrier in Rotterdam

Credit: Quistnix (http://en.wikipedia.org/wiki/File:Schip_dat_de_Maeslantkering_passeert.jpg)

Objective: Overcoming these barriers to advance effective adaptation in infrastructure planning

Strategies:

#*1* Multiple scenarios

(Todd)

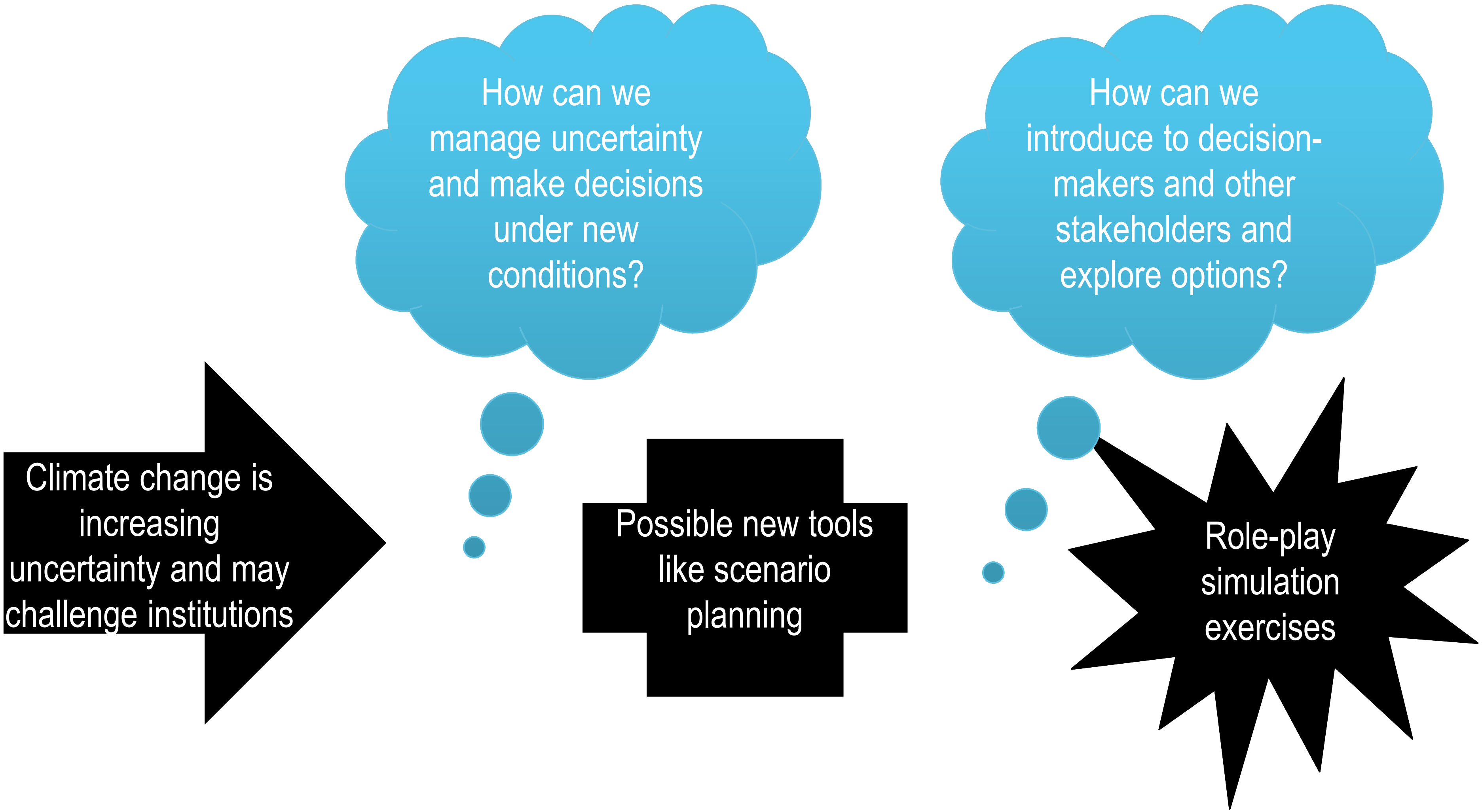
#2 Effective stakeholder engagement

(Todd)

#3 Risk and vulnerability assessment

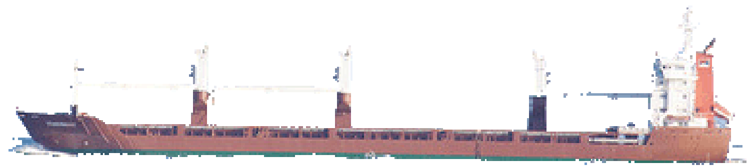
(Yanna)

Experimental framework:
Role-Play Simulation Exercise



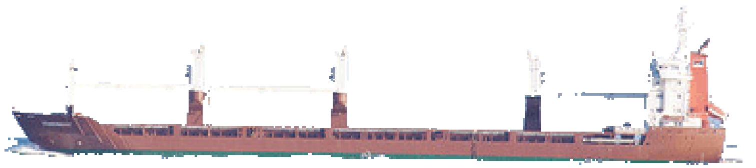
Role-Play Simulation Exercise:
A New Connection in Westerberg

- –Westerberg is a *major port city* in the fictional country of Palgrond
- –Major *congestion on existing A3 highway*, impacting both the port and broader city
- –*New highway (A39) proposed* as a solution to the congestion problems
- –<u>However</u>, a new report – the Westerberg Climate Impacts Assessment – suggests that *the proposed A39 could be vulnerable*

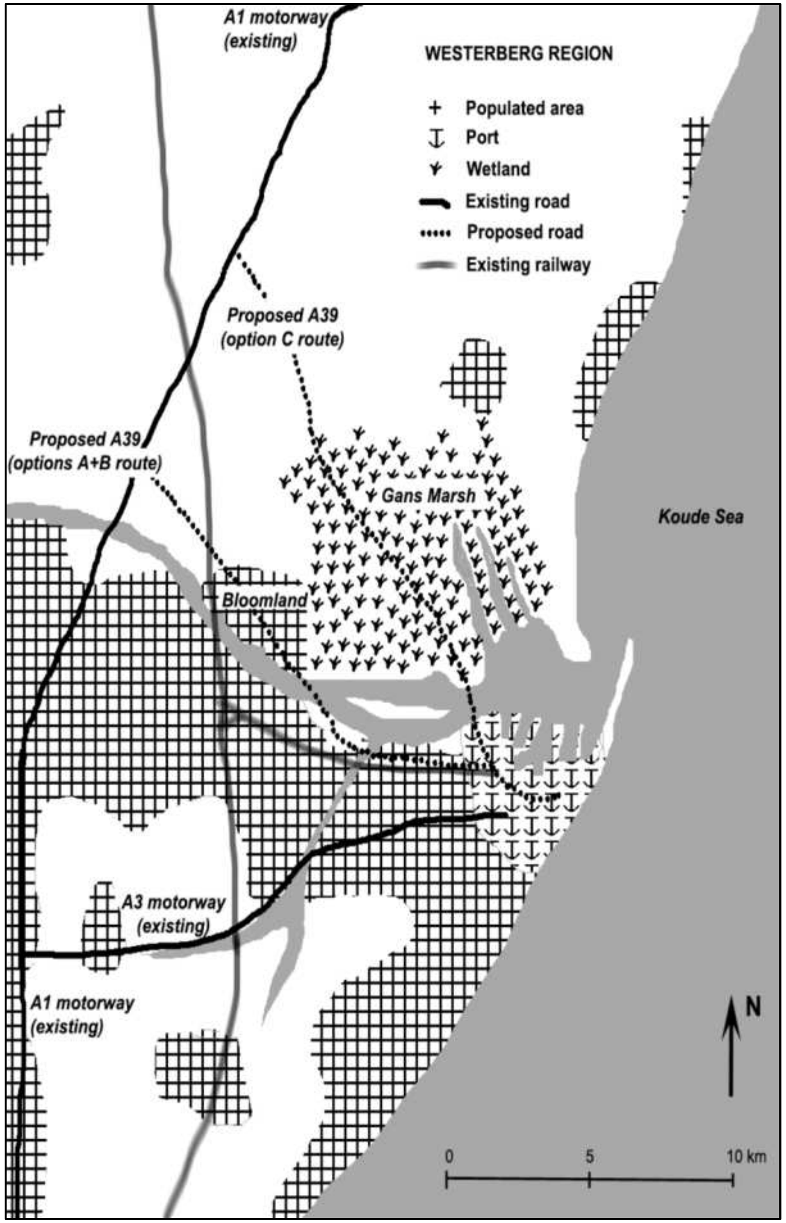


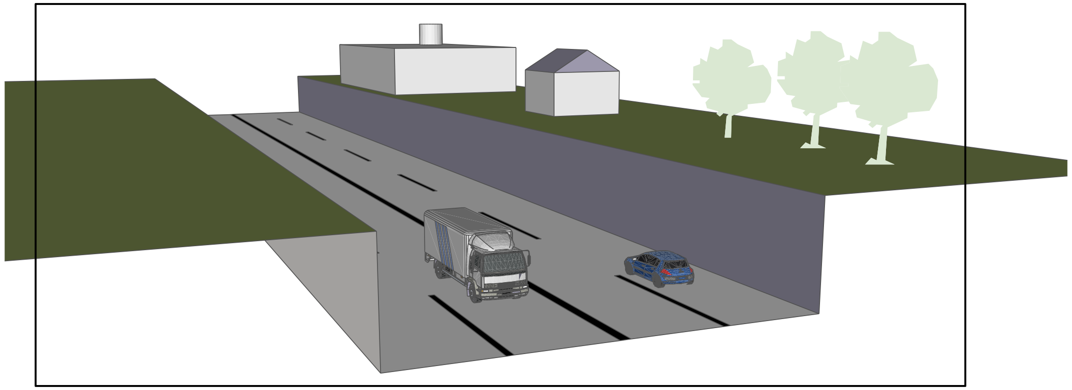
Role-Play Simulation Exercise:
A New Connection in Westerberg

- –The Transportation Agency has pulled together a multi-stakeholder group to evaluate the threats and possible responses: *The A39 Climate Change Evaluation Group (A39-C)*
  - Municipal traffic agency, port, national agencies, environmental group, Alderman's rep
- –The group is tasked with evaluating *various options for the A39,* considering potential climate change

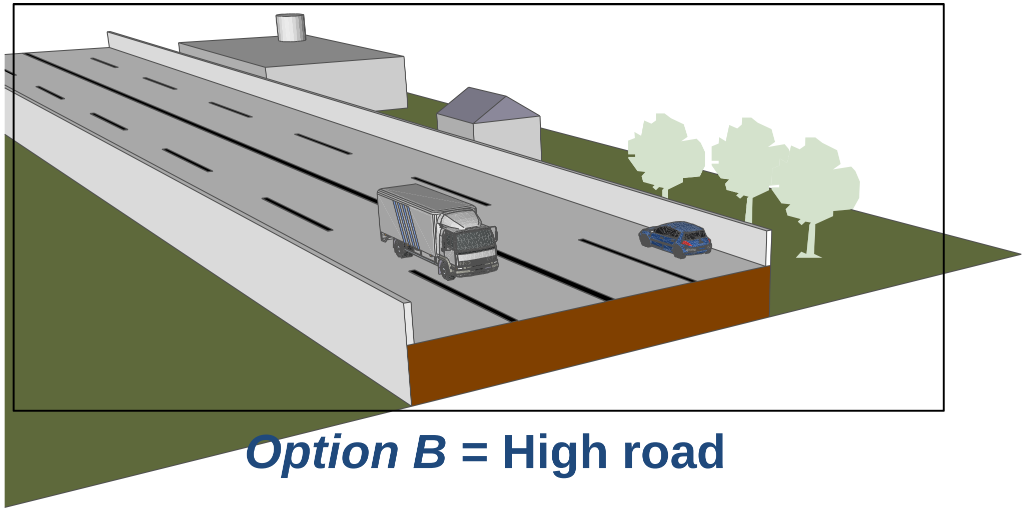


A New Connection in Westerberg *(RPS)*

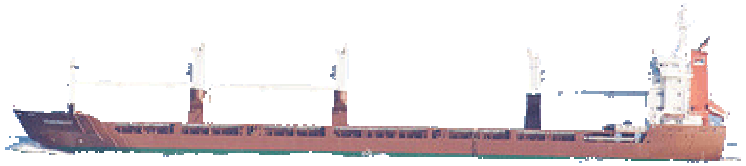




Option A **= Low road**



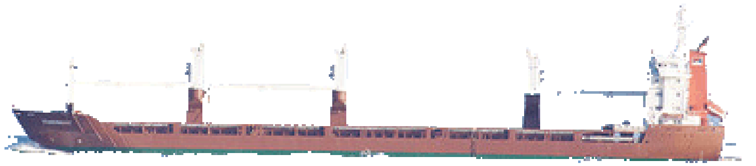
Option B **= High road**



Strategy #1: Multiple Planning Scenarios
A New Connection in Westerberg

Wet and Quiet	*Wet and Busy*
• Precipitation and/or riverine flooding leads to higher water levels in the near future • Vehicular traffic volume remains constant or declines in the coming years	• Precipitation and/or riverine flooding leads to higher water levels in the near future • Vehicular traffic increases steadily and substantially in the coming years
Dry and Quiet • Slow or no increase in precipitation and flooding risks • Vehicular traffic volume remains constant or declines in the coming years	***Dry and Busy*** • Slow or no increase in precipitation and flooding risks • Vehicular traffic increases steadily and substantially in the coming years

No probabilities, qualitative in nature…
Looking for options that are robust in various possible futures



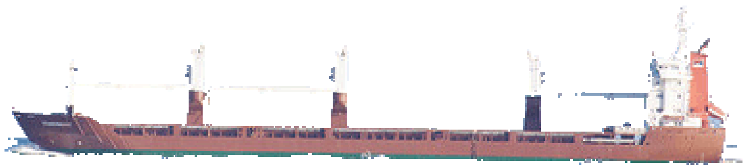
Strategy #1: Multiple Scenarios
A New Connection in Westerberg

Risk assessment version:

Warming is very likely. Mean annual temperatures are projected to increase by: 0.75 – 1.5 °C by 2030; 1.5 – 3 °C by 2050; and 2.5 – 4 °C by 2080

Changes in **precipitation** are not as certain, but are forecasted to increase by: 0 – 5% by 2030; 3 – 10% by 2050; and 6 – 15% by 2080

– *Anything over a ~7% increase in precipitation would cause major problems for low-lying infrastructure, requiring major reconstruction or significant dependence on pumping. This could be particularly problematic with option A*

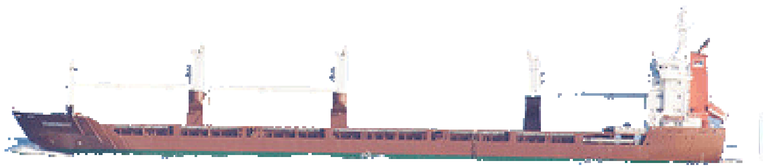


Strategy #1: Multiple Scenarios
A New Connection in Westerberg

Risk assessment version:

Understanding changes in **storm intensity and associated flooding** is even more challenging, but the frequency of what are *currently* 500-storms (meaning the probability of a storm of that intensity occurring in any given year is 1:500) is projected to increase to: 1:400 (i.e., once every 400 years on average) by 2030; 1:250 (i.e., once every 250 years on average) by 2050; and 1:150 (i.e., once every 150 years on average) by 2080

– *Current regulations for A-class roadways stipulate that they should be built to the 500-year storm threshold and older roads vulnerable to 200-year storms are flagged for attention. All four road options would be protected from 500-year storms using current storm patterns and flood maps, but their vulnerability – particularly of options A and D (at current road level and design) – is expected to increase under climate change*

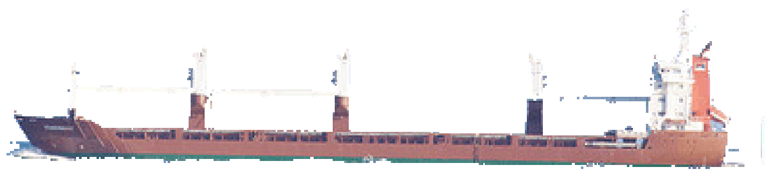


Strategy #1: Multiple Scenarios
A New Connection in Westerberg

Risk assessment version:

Sea level rise and **water level rise in the river and harbor** - insofar as they are tidal and will also be impacted by upstream precipitation - are extremely likely. The projected rise from current levels is: 5 to 12 cm by 2030; 15 to 30 cm by 2050; and 30 to 60 cm 2080

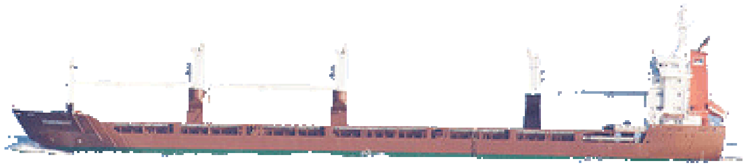
– *Coupled with high tides, a rise of more than 30 cm would flood parts of the existing A3, causing catastrophic traffic problems. Unless addressed during reconstruction, these impacts would extend to option D. Sections of the proposed A39 under option A may also be vulnerable to flooding with a water level rise of more than 30 cm*



Strategy #1: Multiple Scenarios
A New Connection in Westerberg

Lessons learned:

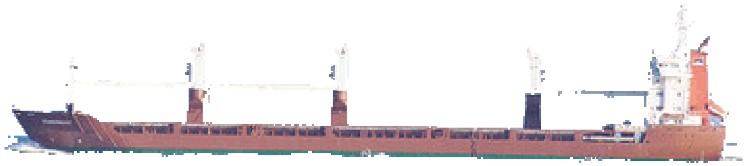
- Scenarios make uncertainty more explicit
- This may lead to more robust decisions, but can also be a reason to delay action
- Strong preference towards single forecasts or probabilities. Hard to use scenarios
- Flexibility is an alternative that many suggest may be an appropriate way to deal with uncertainty



Strategy #2: Stakeholder Engagement
A New Connection in Westerberg

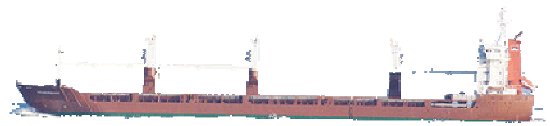
– *Challenge:* Traditional institutions are not aligned for managing significant uncertainty and emerging threats like *climate change*

– *Solution:* Bring decision-makers and other stakeholders together for face-to-face dialogue. Collaboratively evaluate the situation and options, seeking consensus on a plan to move forward



Strategy #2: Stakeholder Engagement

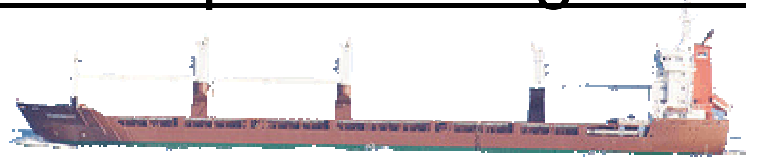
A New Connection in Westerberg



Strategy #2: Stakeholder Engagement
A New Connection in Westerberg

Lessons learned:

- Decision-making is traditionally fairly informal, with familiar actors interacting in various ways
- Divide between the technical and the political - Interests dominate the political, while data dominates the technical. Lack of mutual understanding and appreciation
- Benefits in bringing technical and political together



Governance Regimes
A New Connection in Westerberg

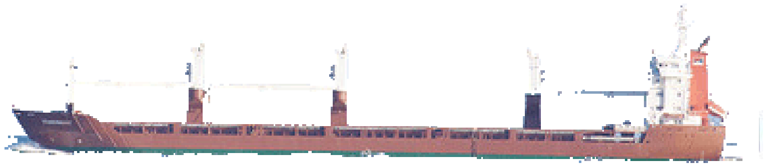
Variation based on governance regime:

– Neo-corporatist (Rotterdam)

– Neo-pluralist/neo-liberal (New York)

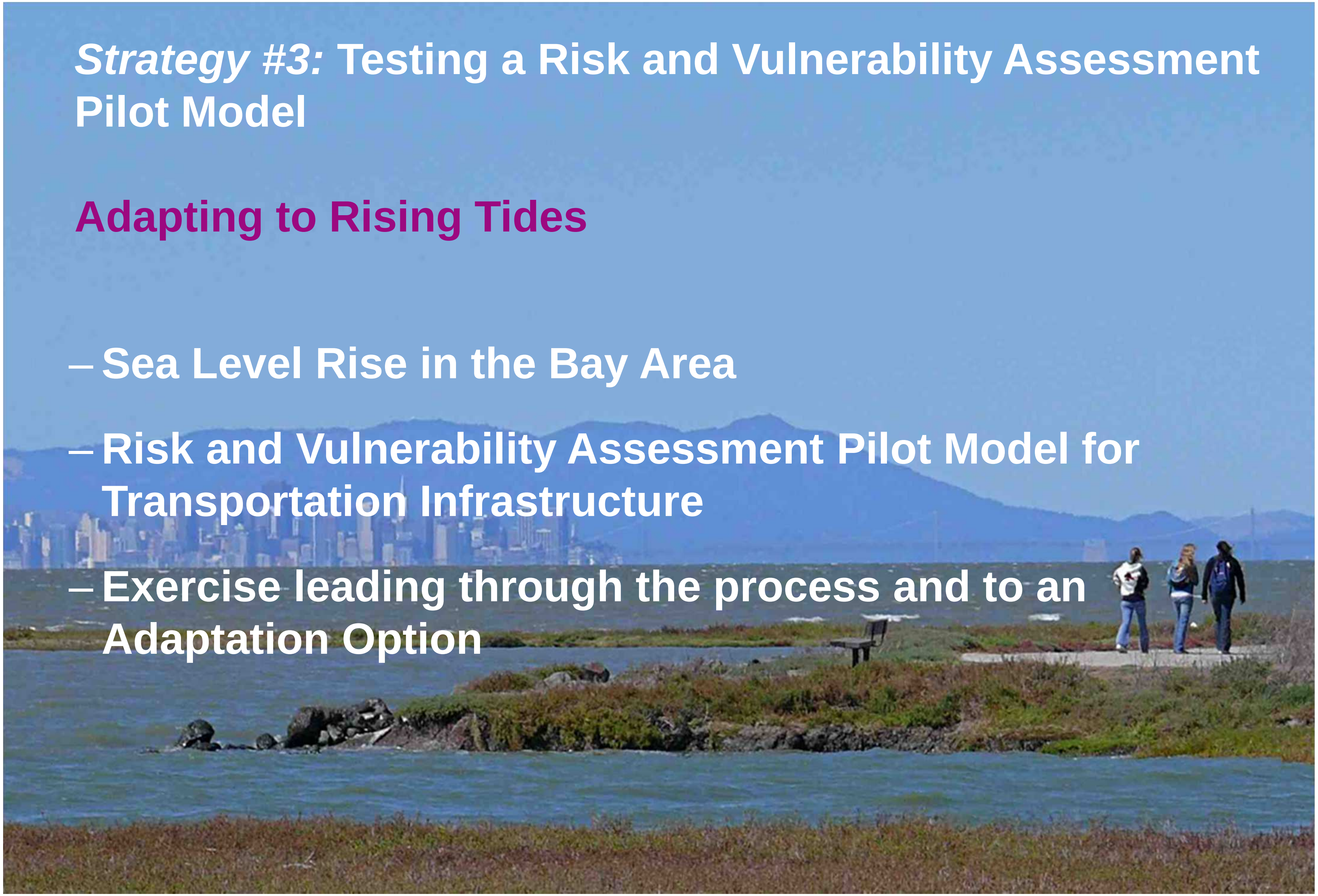
– Technocratic/Authoritarian (Singapore)

How does climate change adaptation and the use of these strategies in infrastructure planning vary across regimes?



Strategy #3: Testing a Risk and Vulnerability Assessment Pilot Model

Adapting to Rising Tides



- Sea Level Rise in the Bay Area
- Risk and Vulnerability Assessment Pilot Model for Transportation Infrastructure
- Exercise leading through the process and to an Adaptation Option

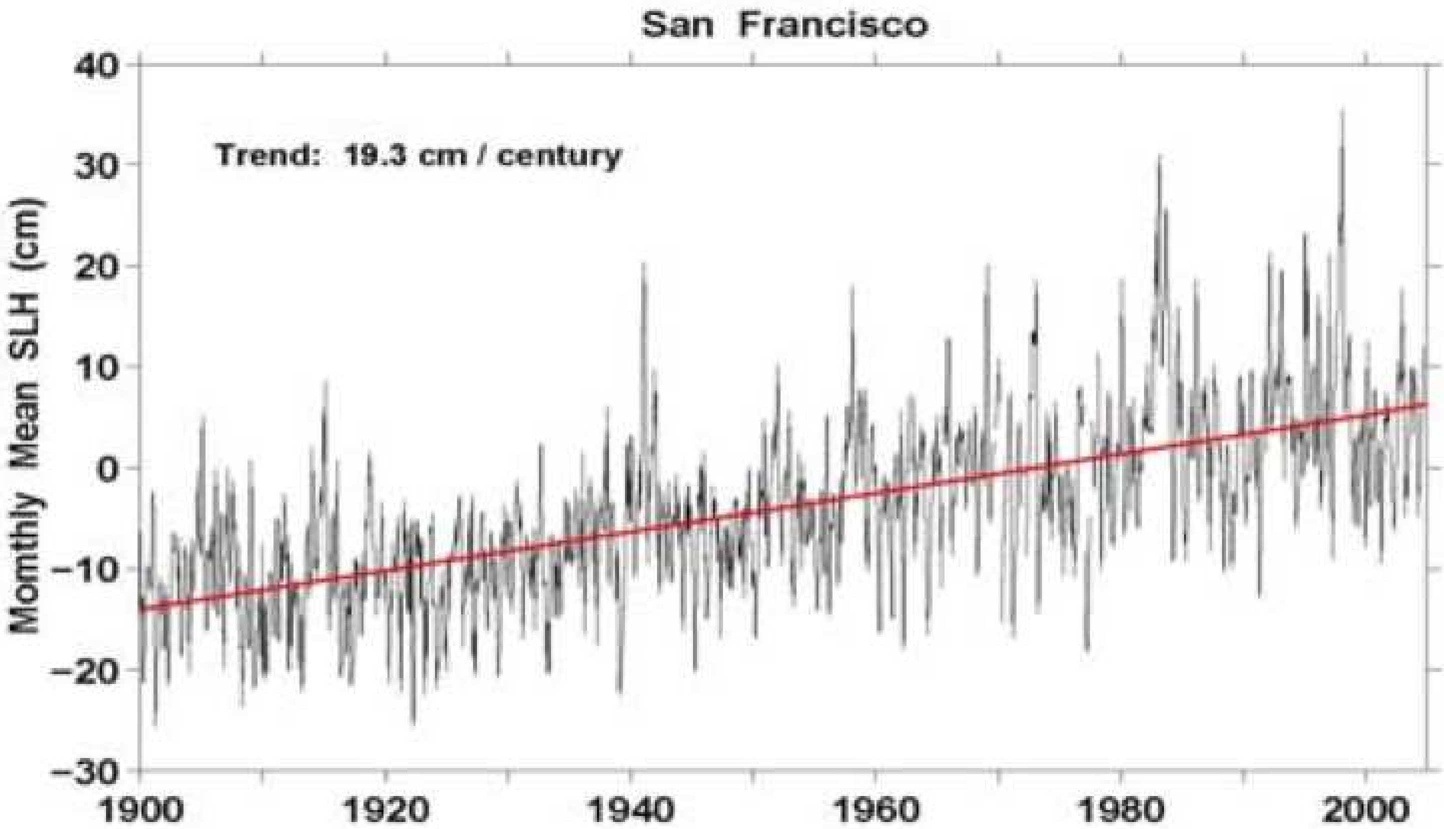
AECOM

The San Francisco Bay today

1/3 smaller than in the 1850s

because it's shallow and was filled to create more land

San Francisco-observed sea level with trend of 19.3 cm (0.63 feet) rise per century



Source: California Climate Action Team Report 2006

This is a graph of sea level rise in San Francisco Bay.
The most important thing to note about this graph is that it is not a prediction.
This is history.

Sea Level Rise in the San Francisco Bay Area

http://www.californiakingtides.org/ - King Tides are providing a glimpse of the future

AECOM

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 – What are Californians doing about Sea Level Rise?

State guidance

- Executive Order S-13-08
- California Sea Level Rise Interim Guidance Document
  - > 16 inches/ by 2050
  - > 55 inches/ by 2100
- California Climate Adaptation Strategy
- Caltrans Guidance on Incorporating Sea Level Rise

Local guidance

- San Francisco BCDC Bay Plan Amendment No. 1-08
- Local government: Solano County Sea Level Rise Strategic Plan; Marin Countywide Plan; Contra Costa General Plan; Napa County County General Plan

Then-Governor Arnold Schwarzenegger addressing Sea Level Rise in the SF Bay in 2008

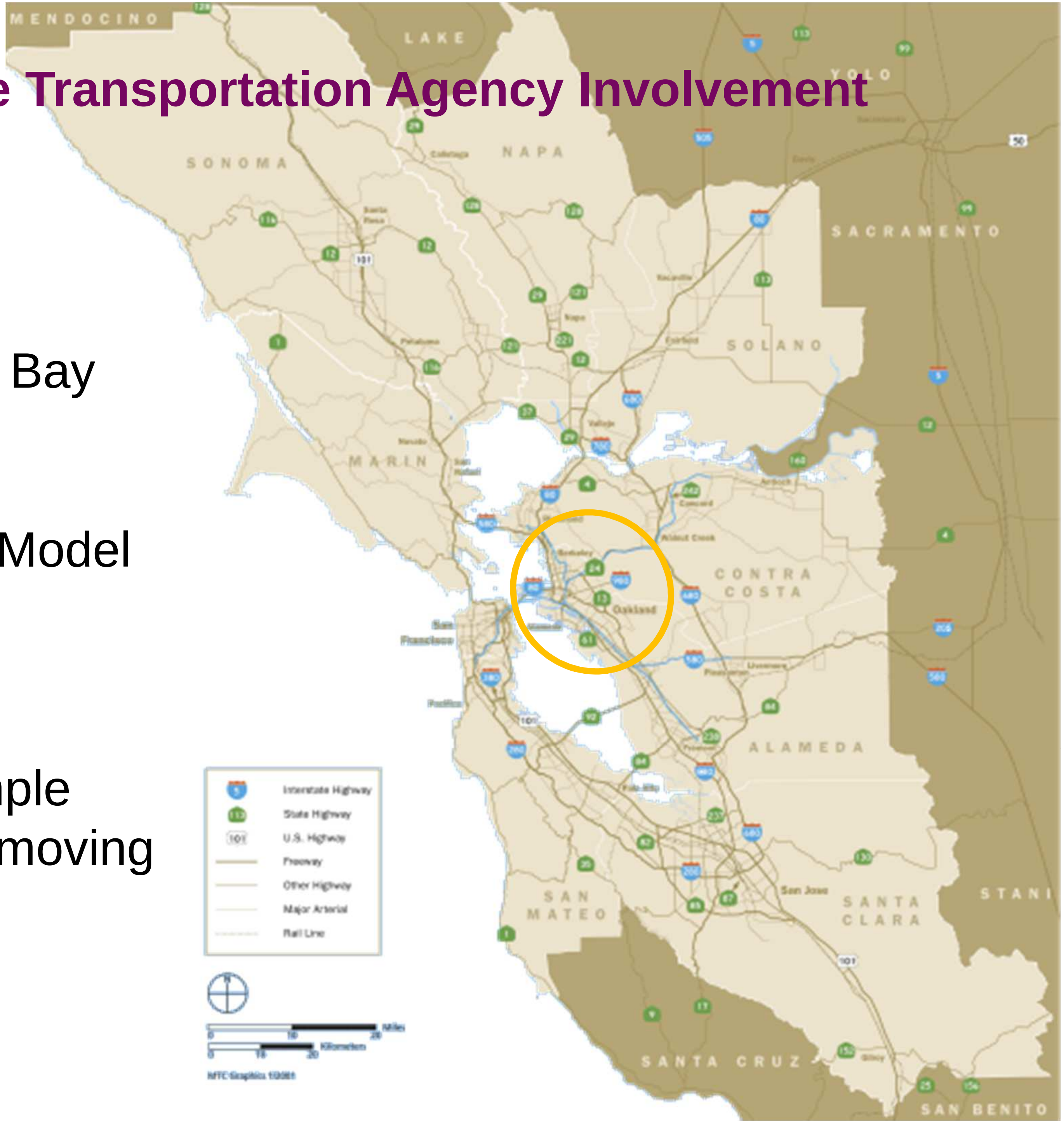
AECOM

Local and State Transportation Agency Involvement

Lots of critical transportation infrastructure in Bay Area

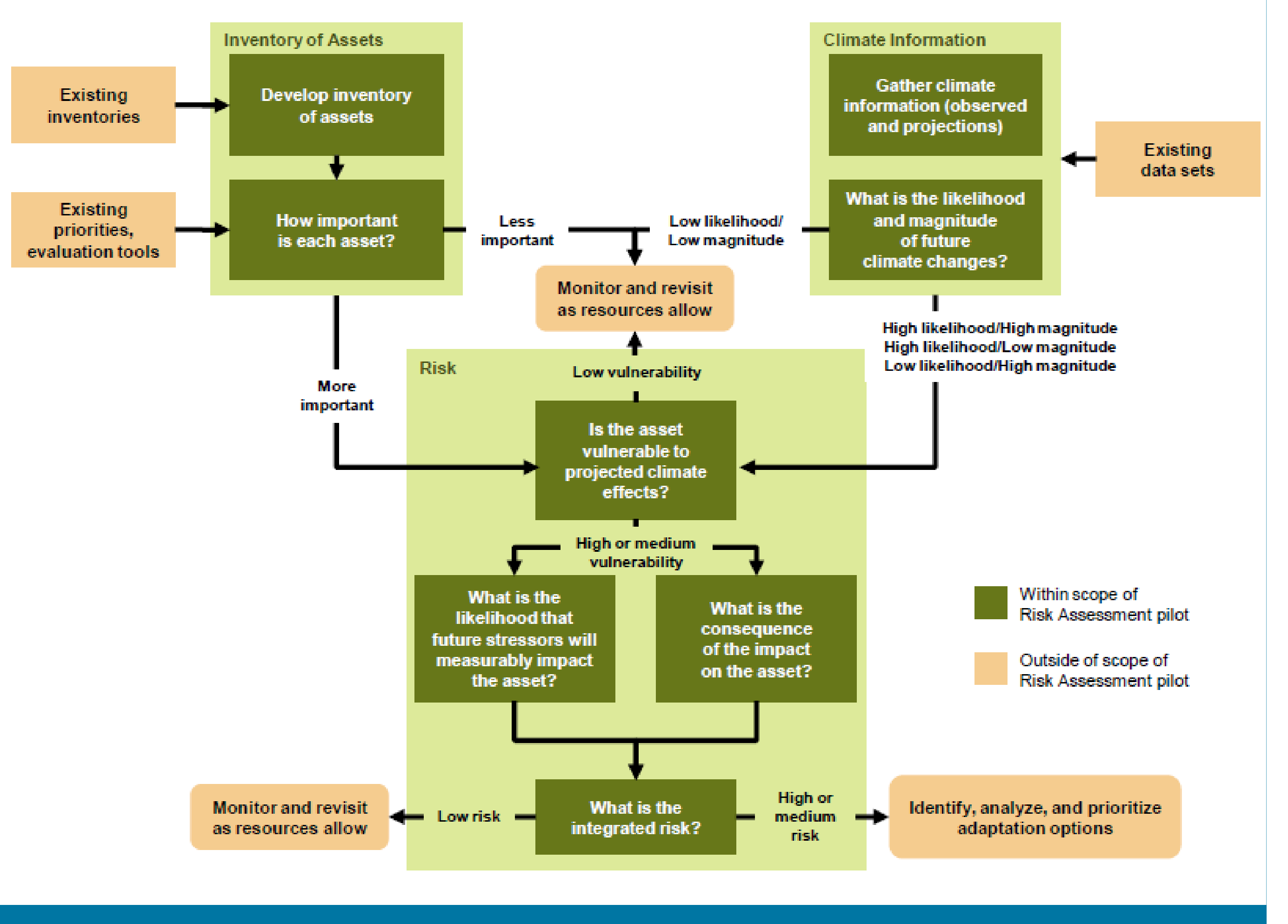
Interest in Pilot Model to:

- invest wisely
- lead by example
- keep people moving



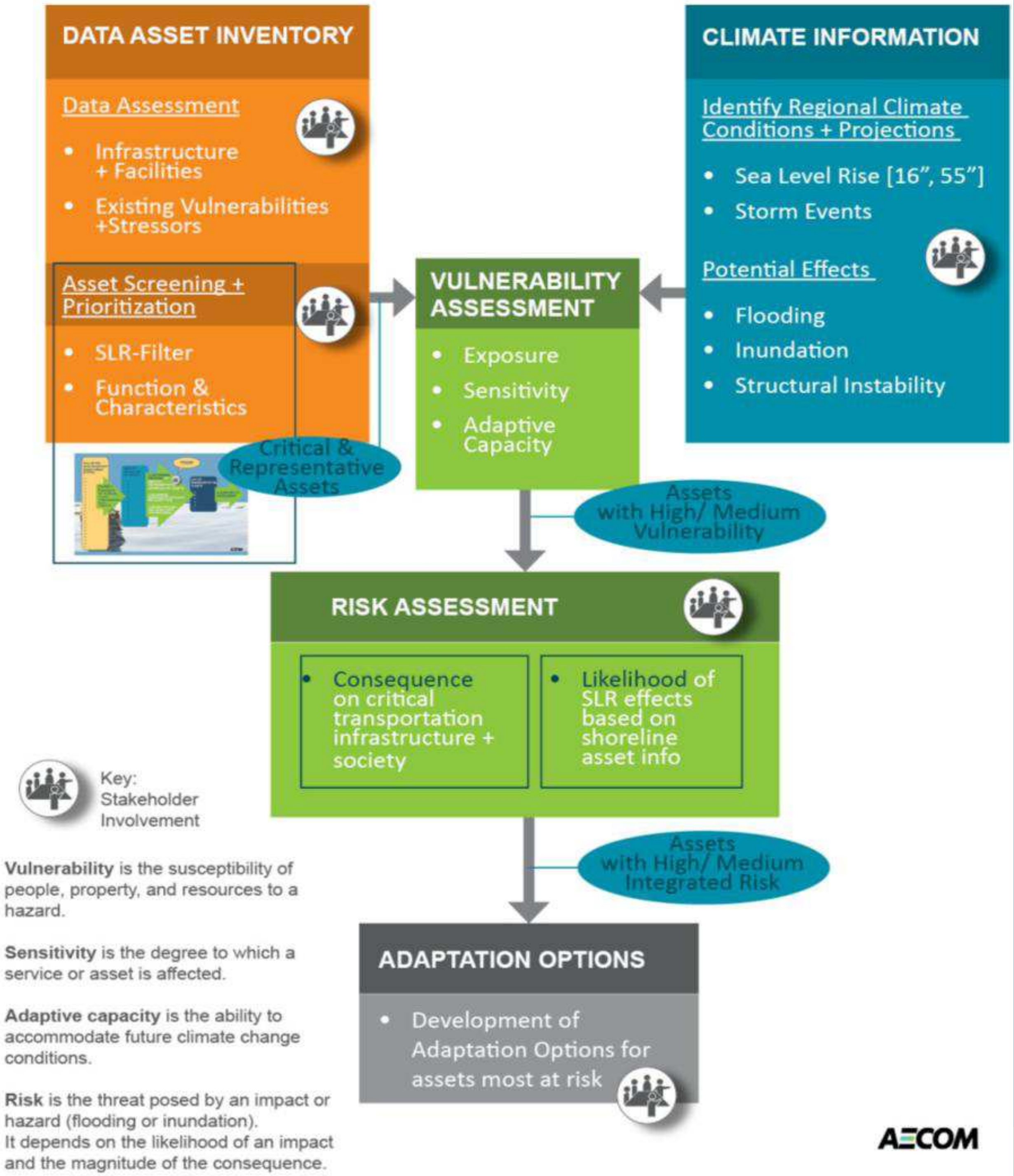
Federal Highway Administration Vulnerability and Risk Pilot Model

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



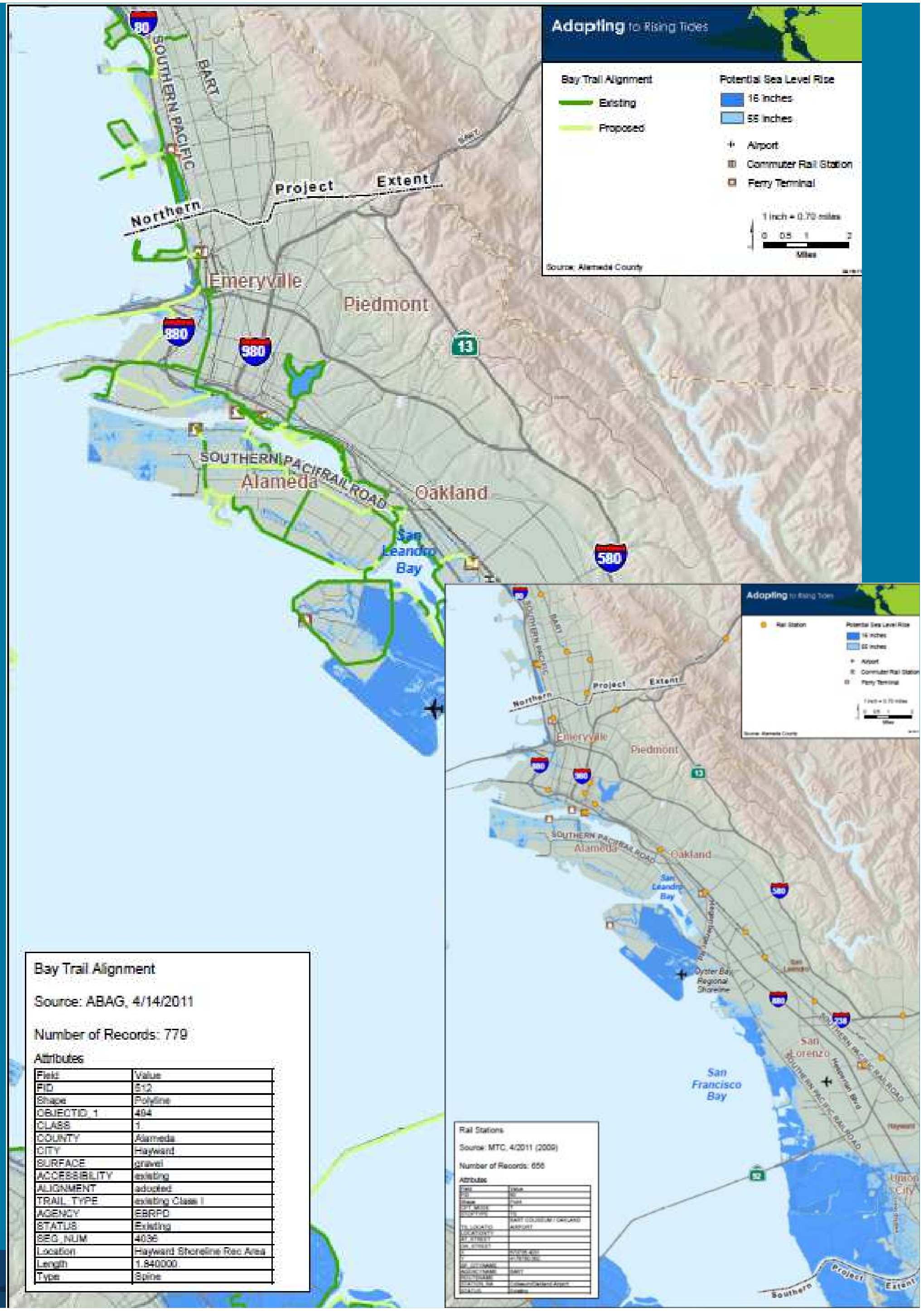
The Pilot Model

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



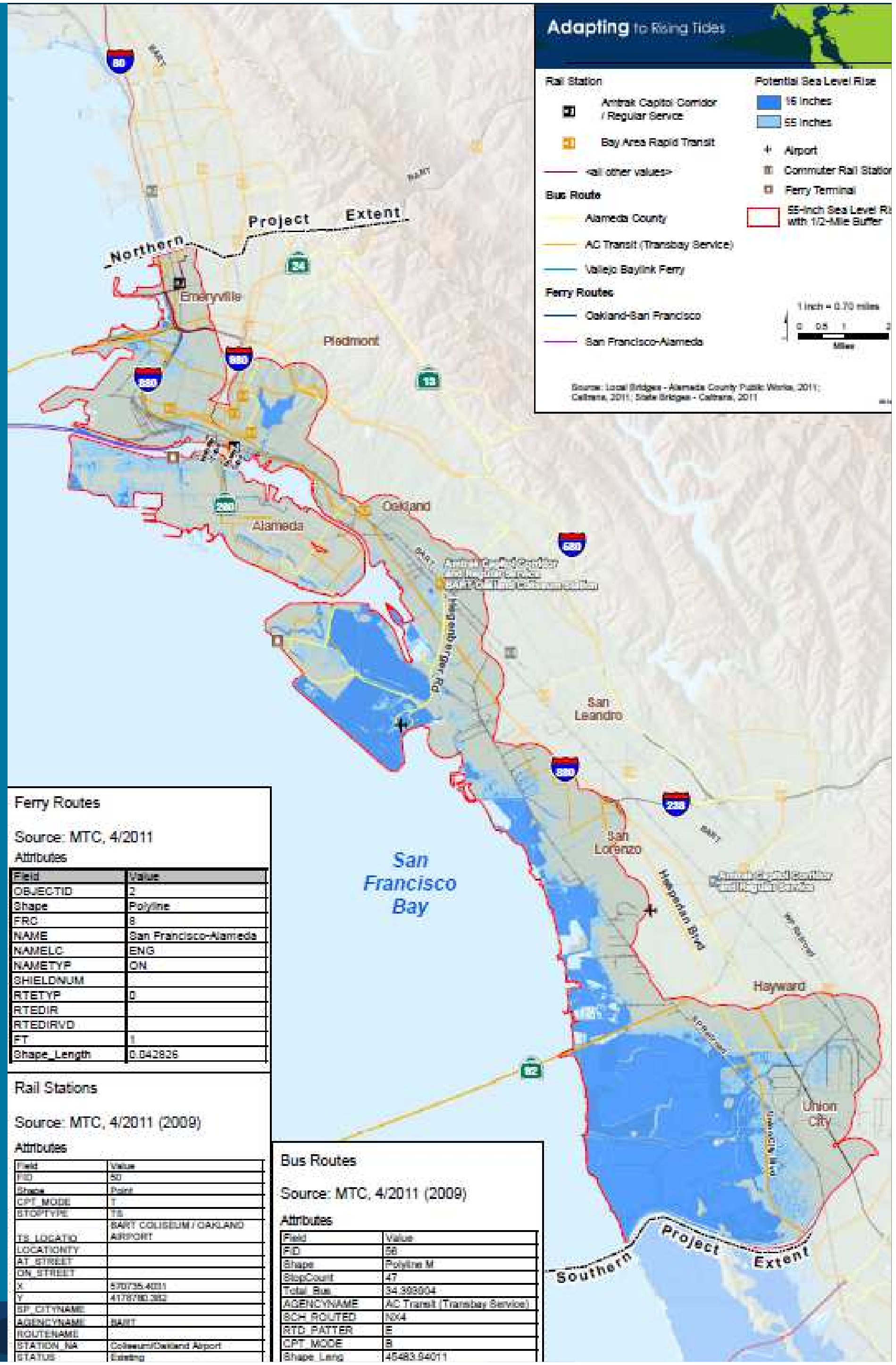
Transportation Assets

- 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

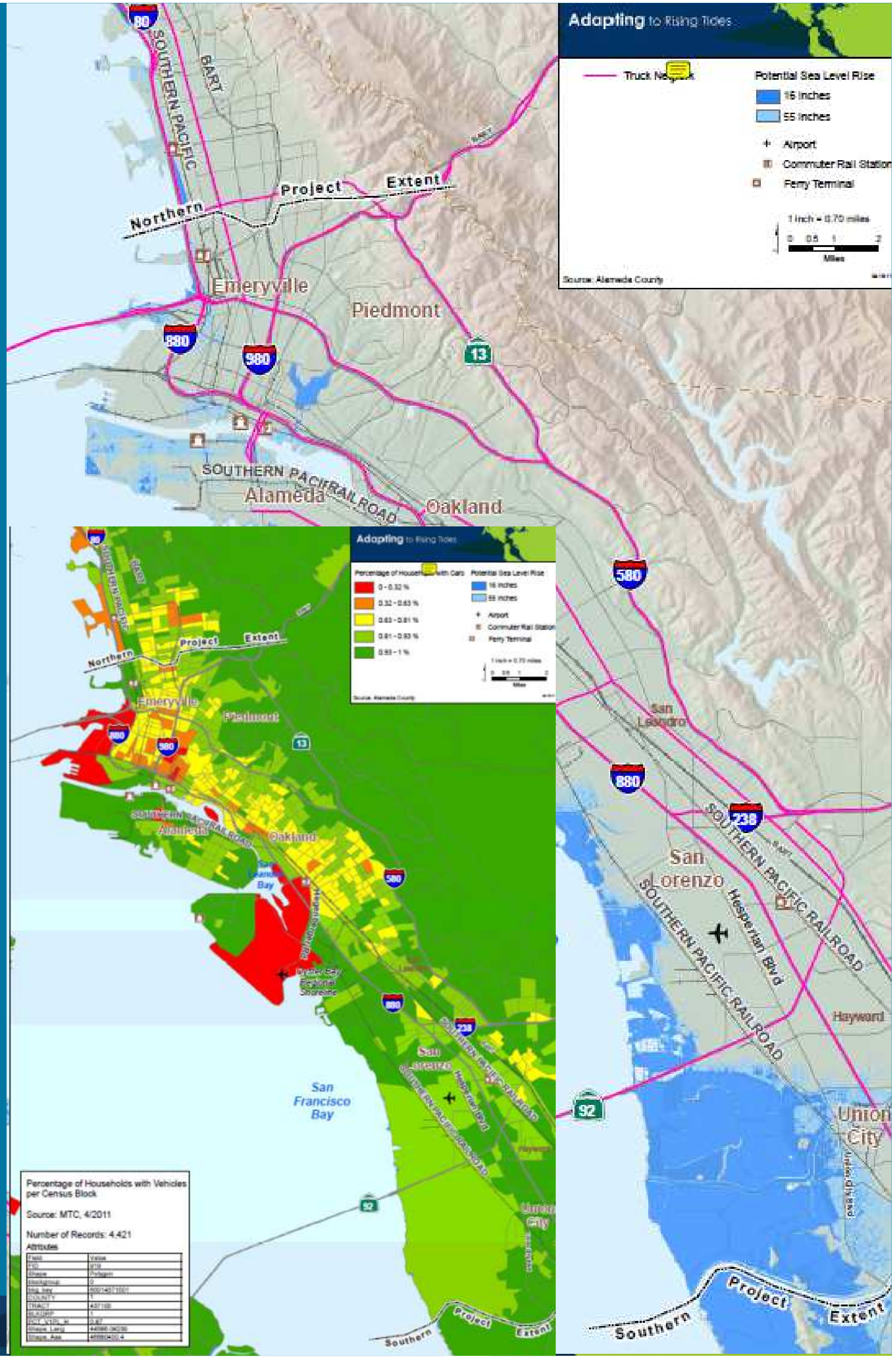
- Organized assets into asset categories:
  - Road
  - Transit
  - Facilities
  - Bike / Pedestrian

- First Filter= SLR plus buffer;



Characteristics

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



3. Climate and Shoreline Information

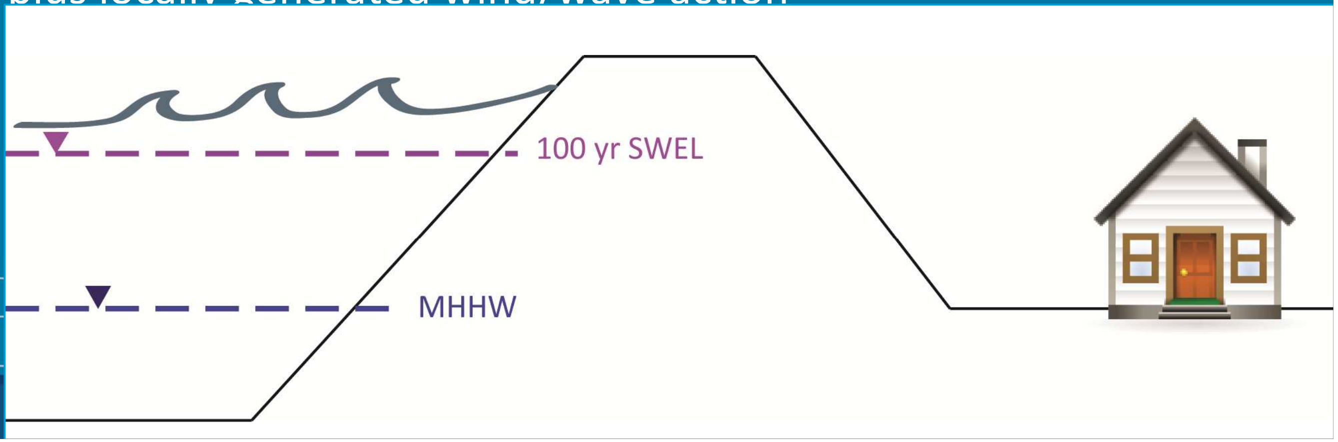
- Reviewed Climate Information; Mid-century 16 inches, end-of century 55 inches SLR
- Developed simple/distinct shoreline categories based on primary function and potential to protect against inland inundation
- Using shoreline categories in combination with new inundation maps to understand vulnerability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

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)

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?

Vulnerability Assessment

Vulnerability

=

exposure + sensitivity + adaptive capacity

AECOM

EXPOSURE

SLR Maps

“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

Sensitivity:

- **Sensitivity** *"is the degree to which a system is affected by a climate impact"*

- **Physical characteristics**
- **Management status**
- **Community characteristics**
- **Ecological health**

Adaptive Capacity

- *"the ability of a system to adjust to climate change, to moderate potential damages, to take advantage of opportunities or cope with the consequences*

http://www.freefoto.com/index.jsp

http://news.bbc.co.uk/2/hi/in_pictures/6237100.stm

Adaptive Capacity: San Francisco – Oakland Bay Bridge Approach

Sensitivity: High	
Year Built	1936; widened 1962 New span under construction
Level of Use	
Peak Hour	16,300
AADT	251,000
AADTT	6,476
Seismic Retrofit	New span under construction
Annual O&M	$721,000
Liquefaction Susceptibility	Very High
Exposure: Medium	
Maximum Inundation Depths	
16" + MHHW	0 ft
16" + 100-yr SWEL	2 ft
16" + 100-yr SWEL + wind waves	YES
55" + MHHW	2 ft
55" + 100-yr SWEL	5 ft
55" + 100-yr SWEL + wind waves	YES
Inadequate Adaptive Capacity (16" SLR): Medium BART and ferries provide alternate routes	
Vulnerability Rating (mid century): High	

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?

6. What about Adaptation Strategies?

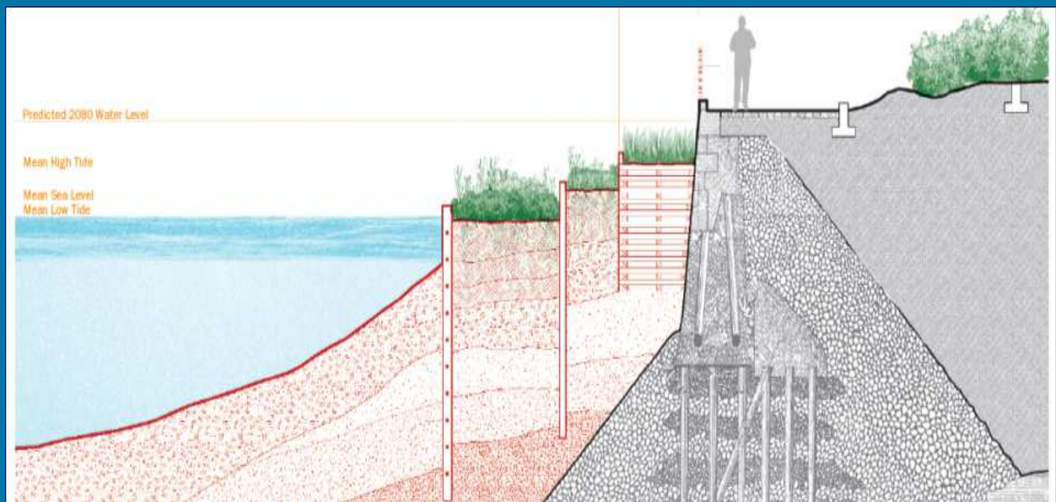
- Adaptation strategies flow from Vulnerabilities, Risks and Consequences
- Use Risk Profile to identify options
- Develop strategies using criteria

San Francisco – Oakland Bay Bridge Approach Adaptation Strategies

Sensitivity: High	
Year Built	1936; widened 1962 New span under construction
Level of Use	
Peak Hour AADT AADTT	16,300 251,000 6,476
Seismic Retrofit	New span under construction
Annual O&M	$721,000
Liquefaction Susceptibility	Very High
Exposure: Medium	
Maximum Inundation Depths	
16" + MHHW 16" + 100-yr SWEL 16" + 100-yr SWEL + wind waves	0 ft 2 ft YES
55" + MHHW 55" + 100-yr SWEL 55" + 100-yr SWEL + wind waves	2 ft 5 ft YES
Inadequate Adaptive Capacity (16" SLR): Medium BART and ferries provide alternate routes	
Vulnerability Rating (mid century): High	

Strategy Options

- Improve drainage
- Create berm or floodwall
- Wetland enhancement
- Raise wetland edge
- Raise Road Surface, build perched wetlands at edge or if slower rate of rise and adequate sediment supply, sustain tidal wetland



Conclusion: Adaptive Capacity

– Regardless of the strategy chosen, we need to increase *adaptive capacity:*
  - If *scenario planning*, new ways of dealing with multiple possible futures rather than single forecast status quo
  - If *multi-stakeholder,* new ways of reconciling competing interests and uncertain information
  - If….

Discussion: Multi-stakeholder Planning + Decision-Making

– What experiences do you have with collaborative planning?

– What are the keys to success?

– Do you use neutral facilitators and process experts? Why or why not?

Discussion: Uncertainty

- Are single forecasts sufficient?
- Are scenarios an effective way to deal with uncertainty? Do they enrich or overly complicate decision-making?
- Are there alternative ways of reconciling with uncertainty?
- How do we maintain flexibility in practice?

Discussion: Governance Regimes + Institutions

– What constraints do existing governance regimes and traditional institutional environments present?

– How do we work with or effectively alter institutions, given emerging and dynamic threats like climate change?

Discussion: Adaptive Capacity

- Is decision-making for climate change really so different, challenging existing capacities?
- How do we assess and strengthen adaptive capacity?
- What are the primary limitations/needs currently?

Questions

Other barriers?

Suggestions Re: Strategies?

Pilot Model?