Adapting to Rising Tides

SF Bay Area Sea Level Rise

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APA WA OR Conference

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Questions?
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Adapting to Rising Tides

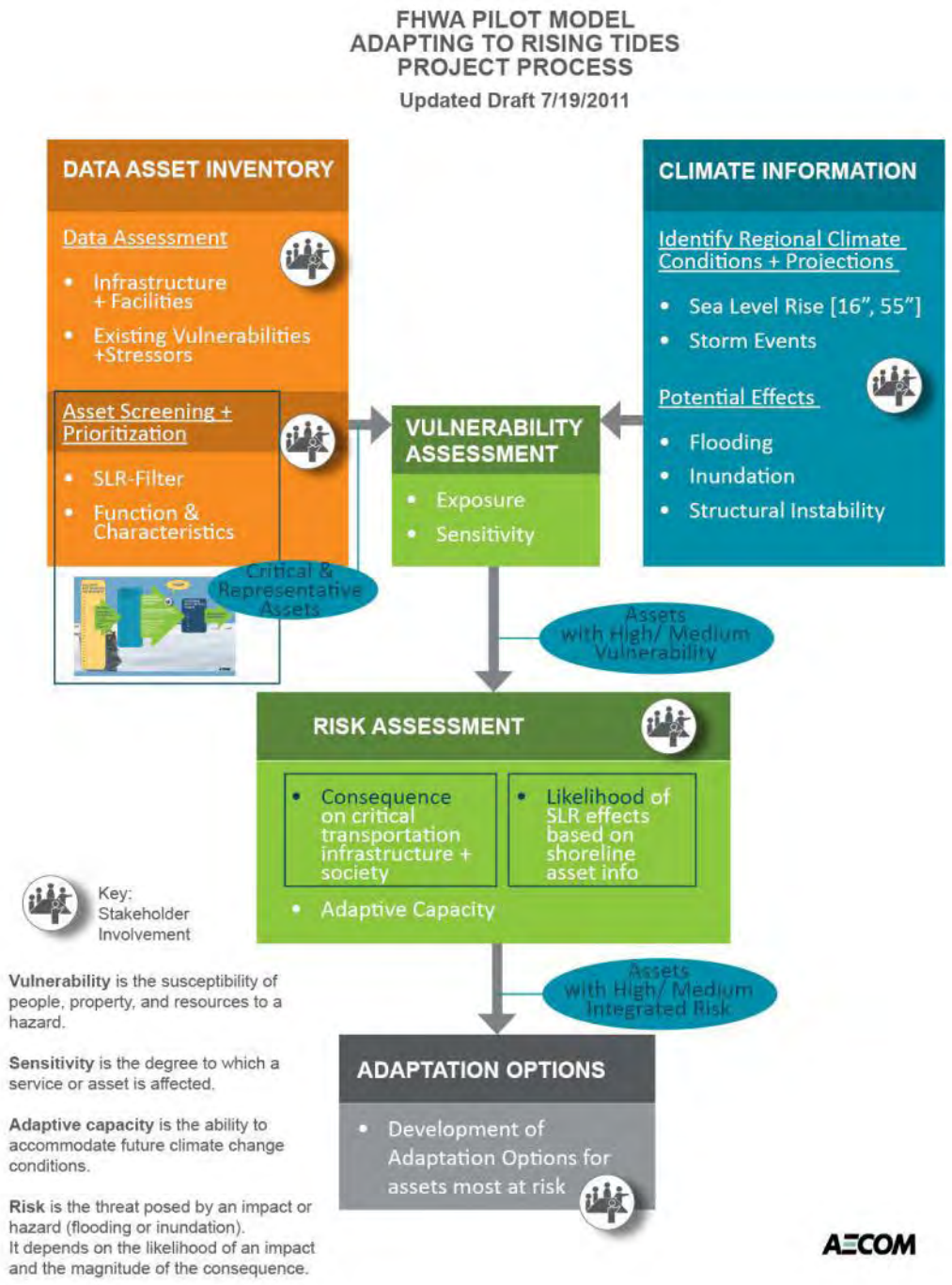
- Climate change vulnerability and risk assessment of transportation assets in a subregion of the San Francisco Bay Area: coastal area of Alameda County
- Client: Metropolitan Transportation Commission (MTC), Bay Conservation and Development Commission (BCDC) and California Department of Transportation (CalTrans)
- Funder: Federal Highways Administration (FWHA)

The Context

- Bay is predicted to rise
  - by 16” by midcentury
  - by 55” by end of century
- 9 county San Francisco Bay Area is home to approx 7 Million people
- Neighborhoods, businesses, industries will be subject to flooding
- 250,000 residents will be directly affected
- Many others will be indirectly affected

Project Objectives

- Test the FHWA model: can it be applied at regional scales?
- Assess the vulnerability of key transportation infrastructure for pedestrian, bicyclists, motorists, transit riders and goods movement.
- Develop approaches that can be applied consistently for similar shoreline typologies.
- Produce a detailed sub-regional vulnerability analysis of SLR impacts on regionally important transportation infrastructure.



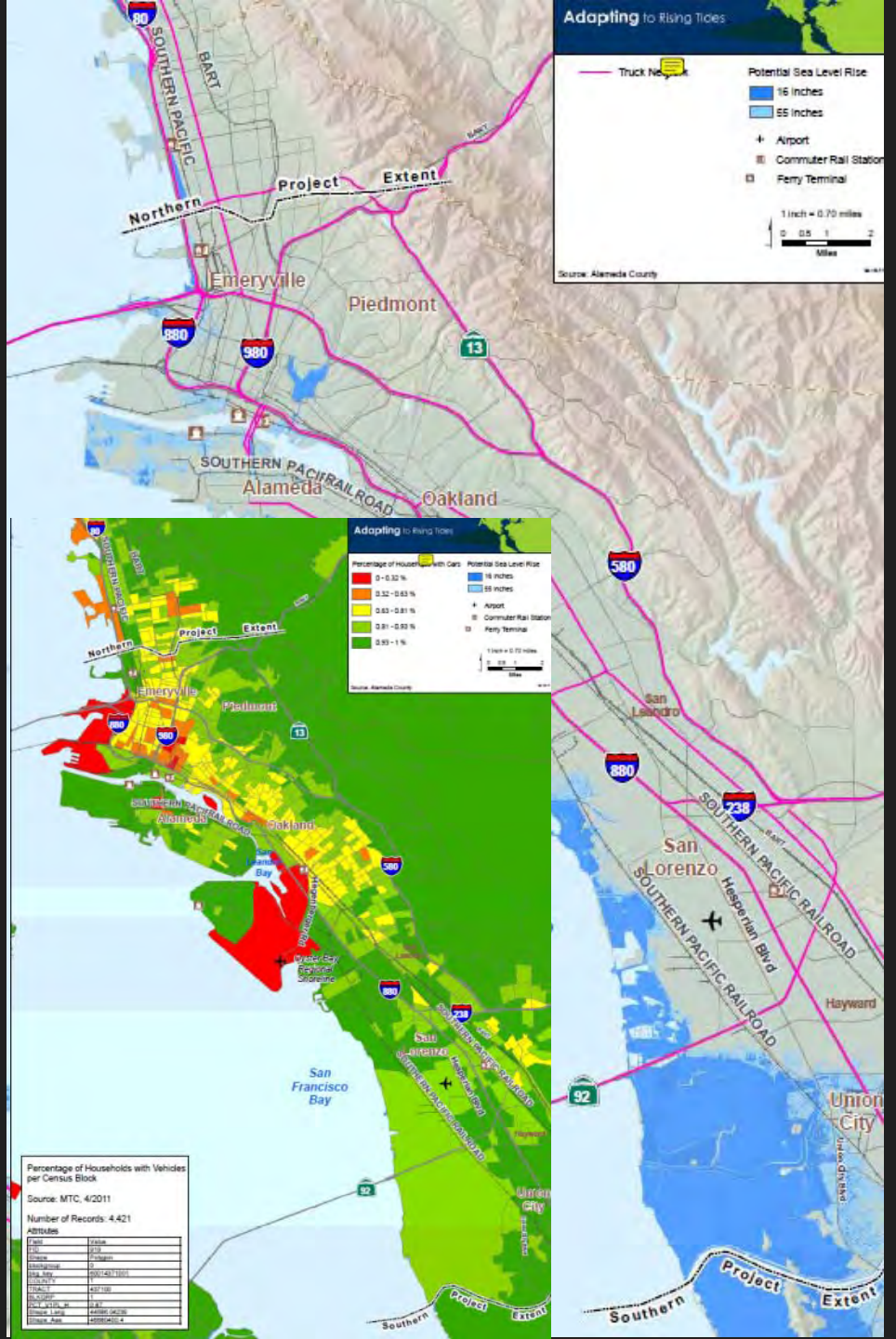
Asset Data Inventory

- Developed categories of transportation assets
- Identified information we needed to collect about each asset
- Information collected:

  Interstates/Freeways
  Arterial 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

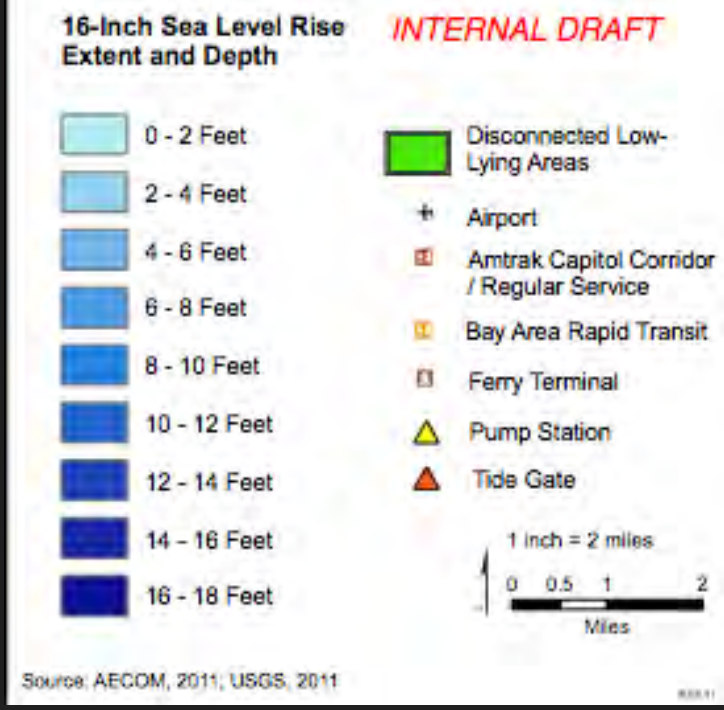
Physical Characteristics

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

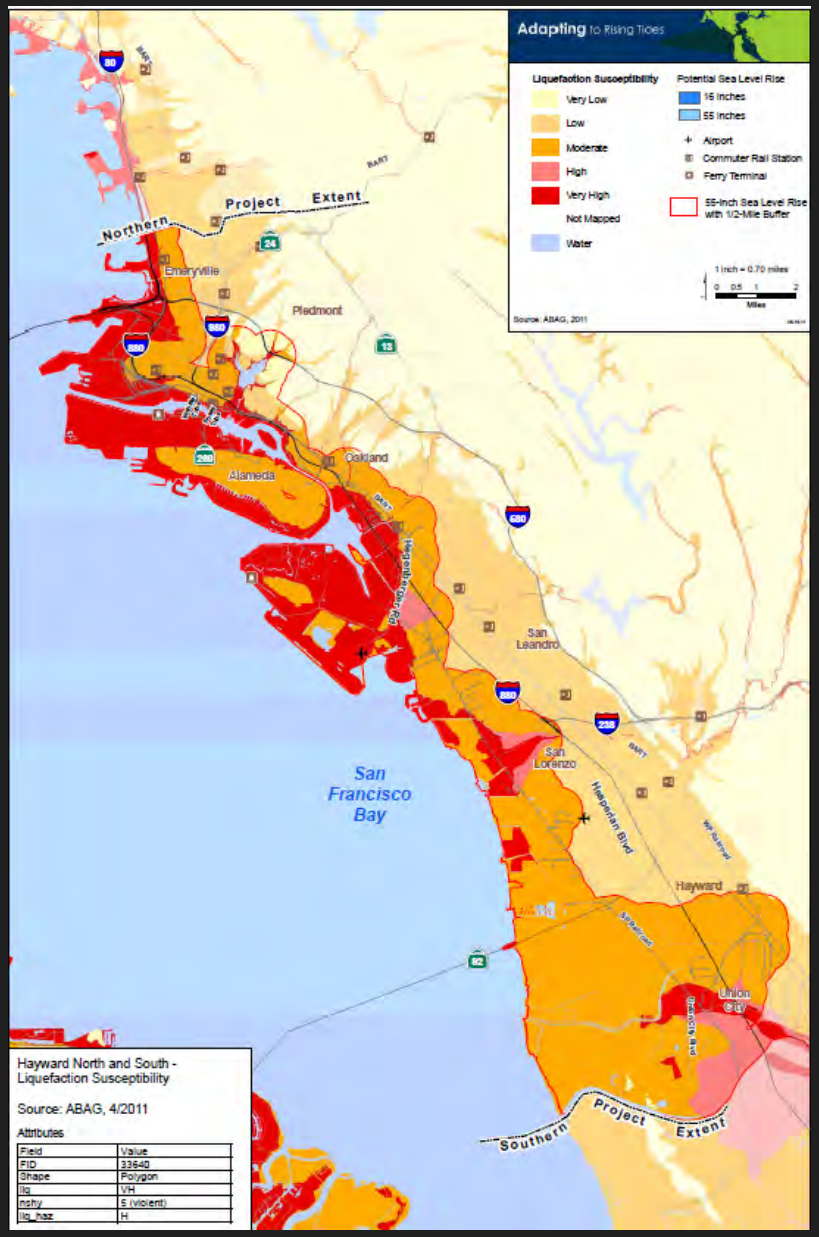


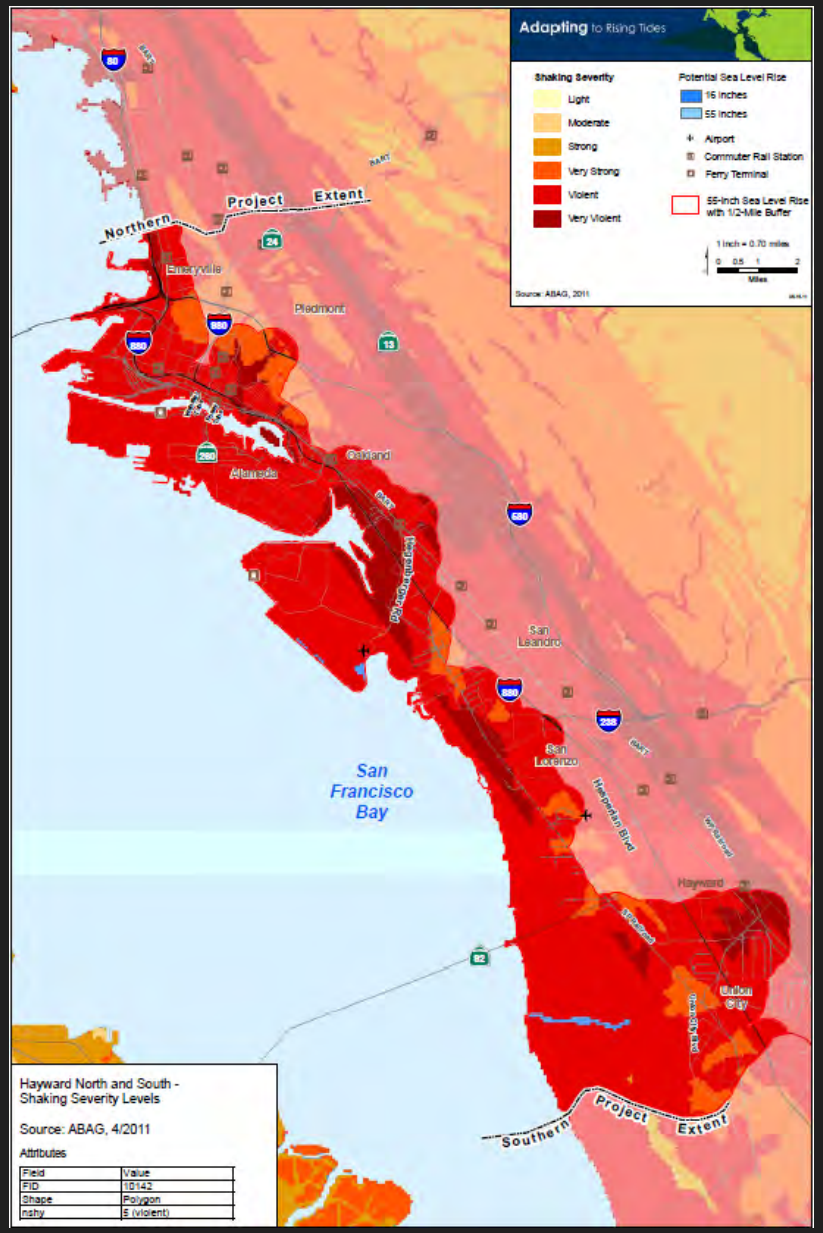
New Mapping

- Existing shoreline protection
- Daily and extreme tide levels
- Storm wave scenarios
- Hydraulic connectivity
- Depth of inundation



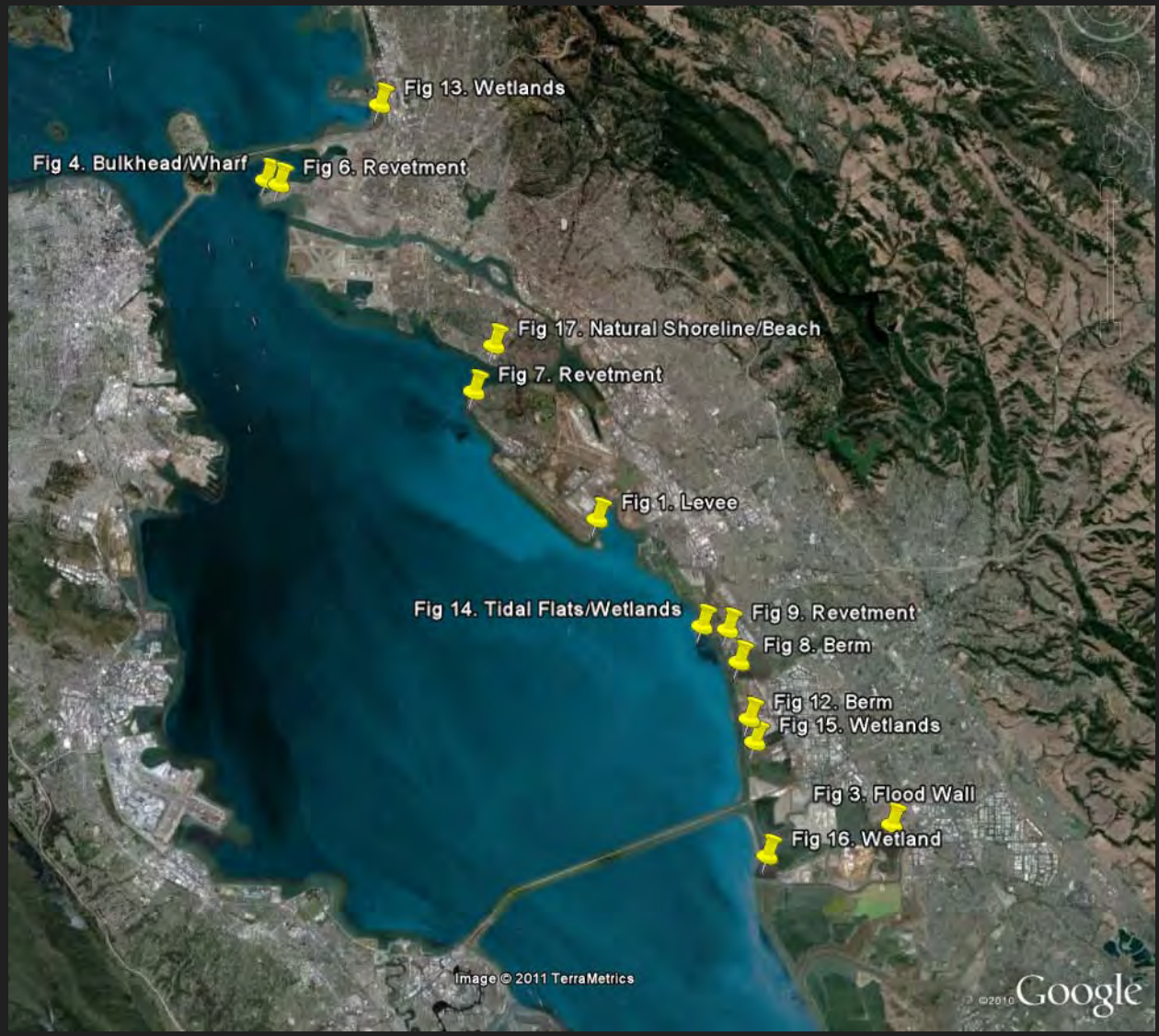
Impact of Earthquake – Shaking severity and Liquefaction Susceptibility





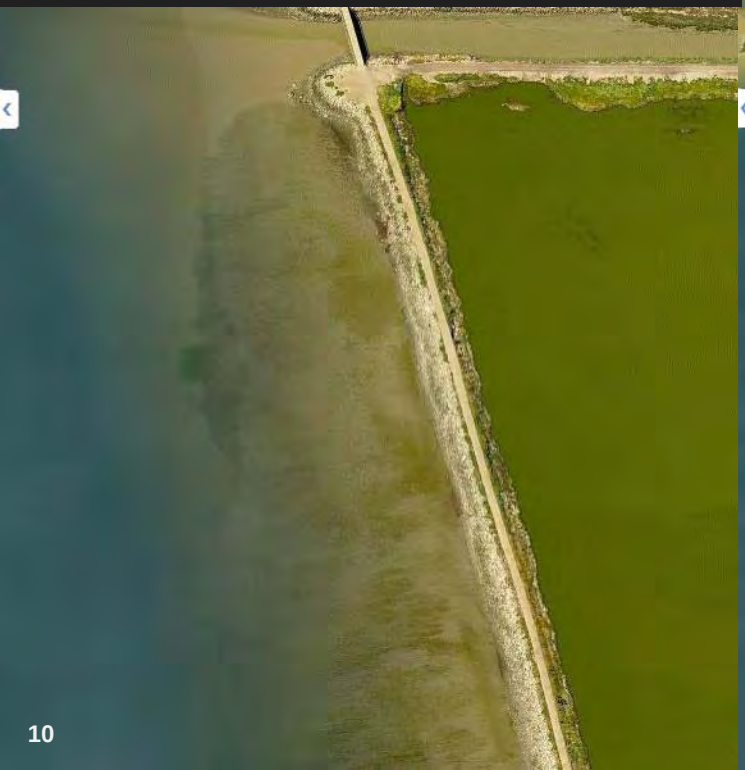
Shoreline Categorization

- Engineered Flood Protection Structures
  - Levees
  - Flood Walls
- Engineered Shoreline Protection Structures
  - Bulkheads
  - Revetments
- Non-Engineered Berms
- Wetlands
  - Natural
  - Managed
  - Tidal Flats
- Natural Shorelines (Non-Wetland)



Types of Shoreline Assets

- Revetment, Port of Oakland
- Berm along old salt pond
- Managed wetland

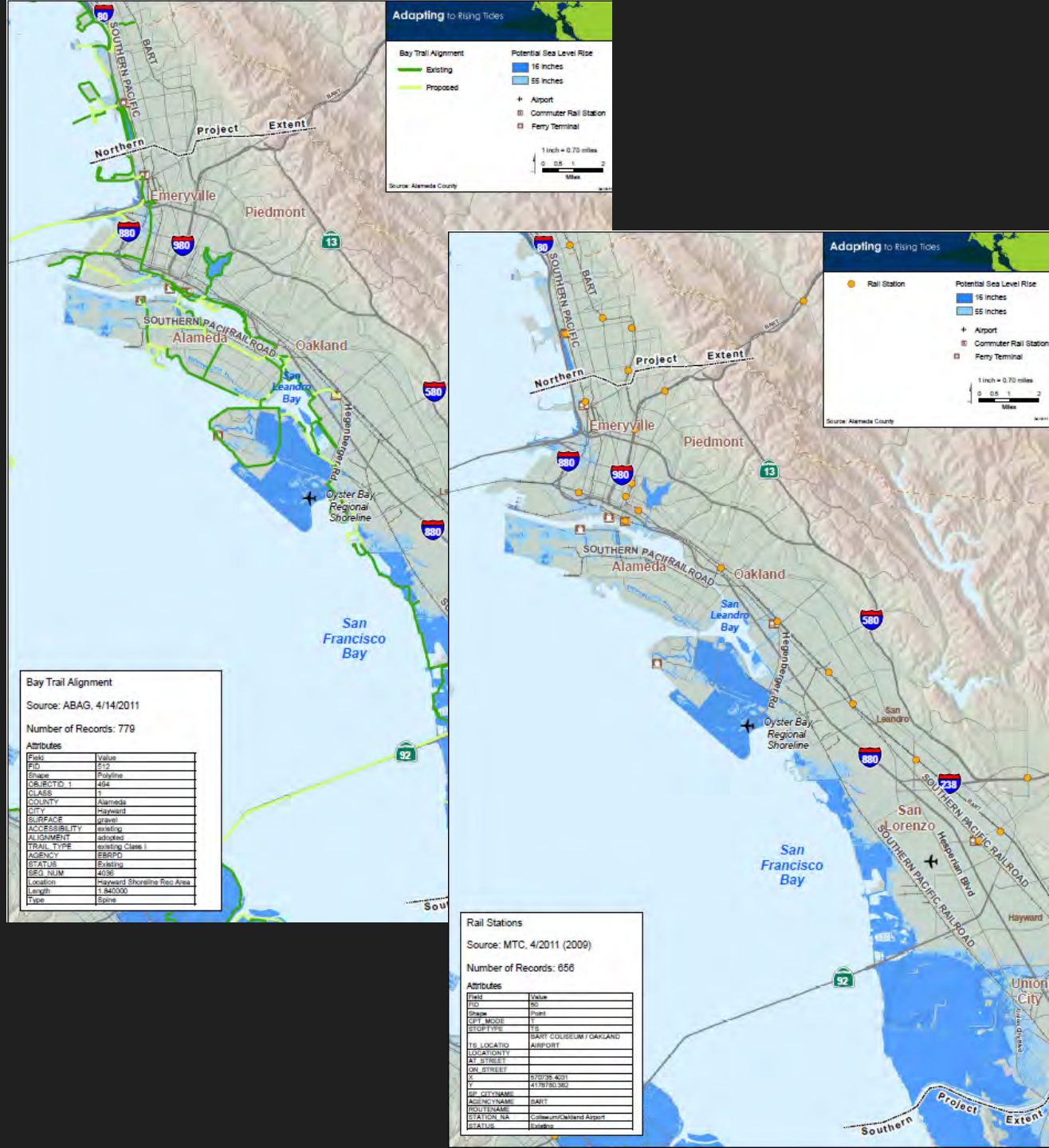


Wetlands

- Natural marsh edge
- Tidal flats
- Managed wetlands

How to Select Transportation Assets

- Politically challenging
- Every asset has important value
- Decided to move forward on representative asset categories :
  - Road
  - Transit
  - Facilities
  - Bike / Pedestrian



What makes an Asset Vulnerable?

Vulnerability to SLR =
exposure (how deep?)
+ sensitivity (physical condition)
+ adaptive capacity (partial use/reroute)

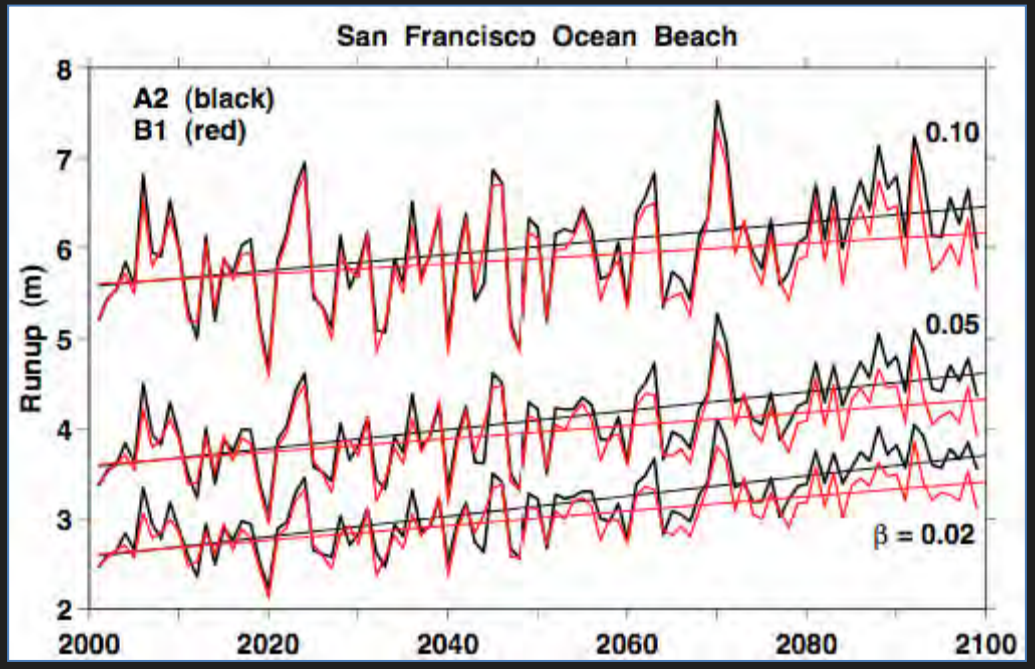
What makes an Asset Vulnerable?

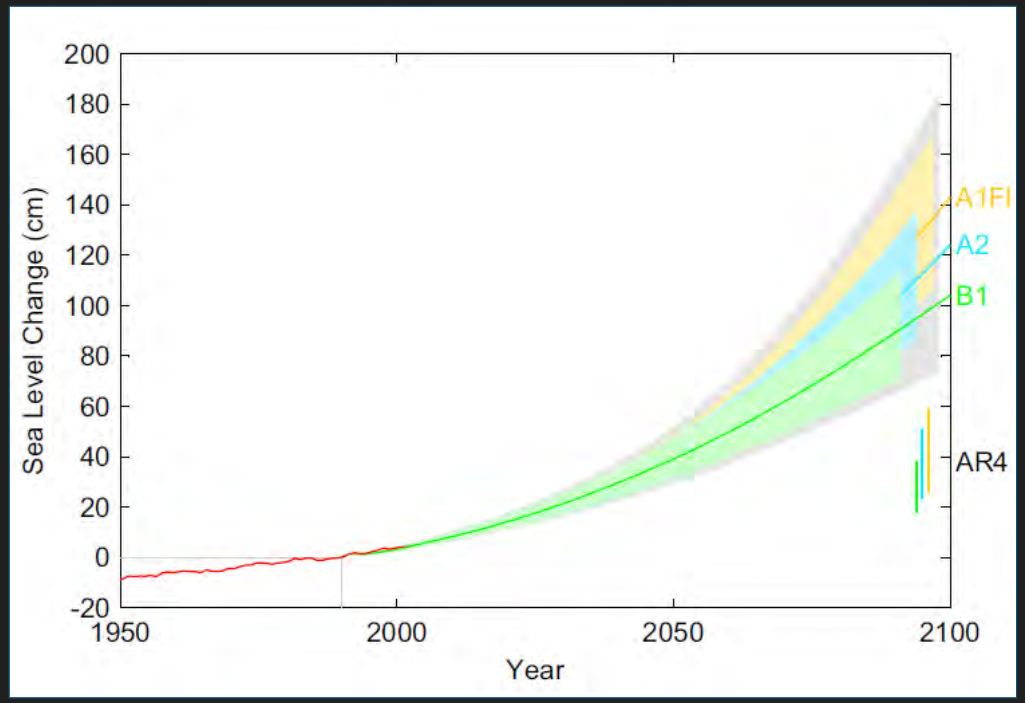
Condition data

Asset (Segment)	Level of Use - Average Daily Traffic (ADT) Volume	Operations & Maintenance Cost	Remaining Service Life	Liquefaction Susceptibility	Overall Sensitivity H/M/L
West Grand Avenue (I-80 to Adeline St.)	22,912 3 pts.	$2.0 M (30 yrs.) 2 pts.	14 yrs. 2 pts.	Very High 3 pts.	Point total: 10 **H**
Hegenberger Road (San Leandro St. to Doolittle Dr.)	18,000 2 pts.	$6.3 M (30 yrs.) 3 pts.	21 yrs. 1 pt.	Very High, Medium 2 pts.	Point total: 8 **M**
I-80 Frontage Road (Ashby Ave. to Powell St.)	15,830 2 pts.	$0.9 M (30-yr. equiv.) 1 pt.	18 yrs. 2 pts.	Very High 3 pts.	Point total: 8 **M**
Powell Street (west of I-80)	26,520 3 pts.	$1.2 M (30-yr. equiv.) 2 pts.	25 yrs. 1 pt.	Very High 3 pts.	Point total: 9 **H**
Mandela Parkway (West Grand Ave. to I-580)	8,030 2 pts.	$1.0 M (30 yrs.) 1 pt.	28 yrs. 1 pt.	Very High, Medium 2 pts.	Point total: 6 **L**
Third Street (Mandela Pkwy. to Market St.)	12,000 2 pts.	$0.5 M (30 yrs.) 1 pt.	5 yrs. 3 pts.	Very High, Medium 2 pts.	Point total: 8 **M**
Cabot Boulevard	524 1 pt.	$2.3 M (30 yrs.) 2 pts.	16 yrs. 2 pts.	Medium 1 pt.	Point total: 6 **L**

Risk Assessment Likelihood and Consequence

- **Likelihood:** What is the likelihood that the asset will be impacted by SLR?
- Depends on the certainty of climate projections
- We have selected one set of projections relating to one impact
- Likelihood will not play a differentiating role in our risk assessment





Risk Assessment Likelihood and Consequence

Consequence: what is the expected impact or consequence to society if the asset is inundated?

Criteria selected:

- Cost of and time to replace asset
- Economic impact (goods movement, commuter route)
- Socio-economic impact (transit dependent communities)
- Public safety

Integrated Risk Assessment

		Consequence				
Likelihood		1	2	3	4	5
	1	2	3	4	5	6
	2	3	4	5	6	7
	3	4	5	6	7	8
	4	5	6	7	8	9
	5	6	7	8	9	10

Risk	Low	Moderate	High

High Risk (Red)

Unacceptable, major disruption likely; different approach required; priority management attention required

Moderate Risk (Orange)

Some disruption; different approach may be required; additional management attention may be needed

Low Risk (Green)

Minimum impact; minimum oversight needed to ensure risk remains low

Draft Risk Profile

Includes information on:

- Characteristics
- Vulnerability (condition, exposure, inundation depth)
- Overtopping potential analysis

Draft Risk Profile

Asset Name Webster and Posey Tubes		
Asset Location Oakland - Alameda		
Sensitivity/Background Information Jurisdiciton: 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
Importance Category: Critical asset • Commuter Route, • Goods movement, • Transit Routes [O, W, 20, 31, 51A, 314, 851, Estuary Shuttle] • Connects to Jobs		
Vulnerability Ranking mid century		High
Vulnerability Ranking end of century		High
Max. Inundation Depths		
16 inch SLR **16 inch +100 yr SWEL** 16 inch + 100 yr SWEL + wind & waves		(4 ft) **22 ft** YES
55 inch SLR **55 inch +100 yr SWEL** 55 inch + 100 yr SWEL + wind & waves		 **23 ft** **25 ft** YES
Weak Link Analysis [shoreline assets responsible for flooding]		

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

Next Steps

- Review shoreline assets and confirm overtopping potential
- Use shoreline categories, SLR maps, and weak link analysis to inform vulnerability and risk of community and shoreline assets
- Review consequences with project partners
- Develop adaptation strategies and options

Adapting to Sea Level Rise:
Land Use Tool Kit

WA/OR APA Conference
October 21, 2011

Presented by
Nicole Faghin, LEED AP, AECOM
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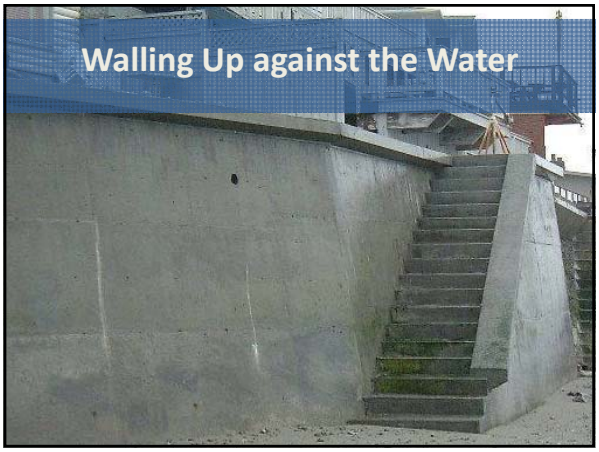
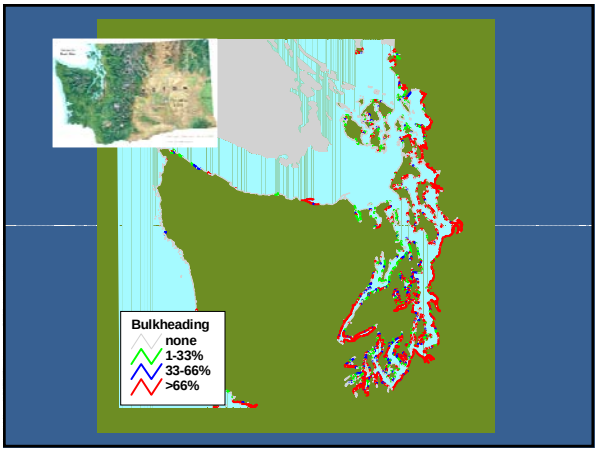
Which Way Should We Go?

- Our Choices..
  - –Reactive …
    - Structural Solutions

Walling Up against the Water





Which Way Should We Go?

…or Proactive
- Planning
- Regulations

Key Agency Players

- EPA (Clean Water Act)
- NOAA
- FEMA
- Coastal Zone Management (CZM) and State Programs
  - Shoreline Management Act (SMA) in Washington
  - Land Conservation and Development Commission (LCDC) in Oregon
- Association Of State Floodplain Managers:
  - NO ADVERSE IMPACT (NAI)

Planning Tools

- Comprehensive Plans
- Coastal Zone Management
- Shoreline Master Programs (WA)
- Floodplain Plans
- Stormwater Plans

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River Planning Context

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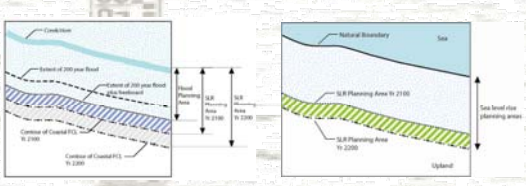
Coastal Planning Context



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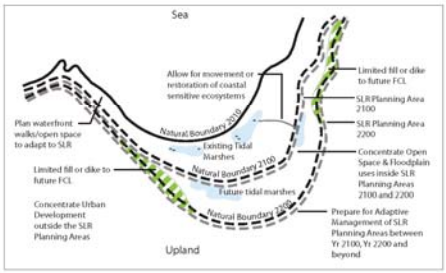
Taking the Long View



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Coastal Management Plans

Using Example of Washington State

1. Shoreline Jurisdiction
2. Inventory
3. Goals and Policies
4. Regulations
   - Shoreline Protects - Soft shore
   - Buffers
   - Setbacks
   - Non-conforming uses

- Resource: http://www.ecy.wa.gov/programs/sea/shorelines/smp/handbook/sea_level_guidance.pdf

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Regulatory Tools

- Zoning and Overlay
- Floodplain Regulations
- Building Codes
- Setbacks and Buffers
- Conditions, mitigation, dedications
- Subdivisions and cluster development
- Permit Conditions
  - Hard armoring vs. soft coastal protection
  - Rolling coastal easements

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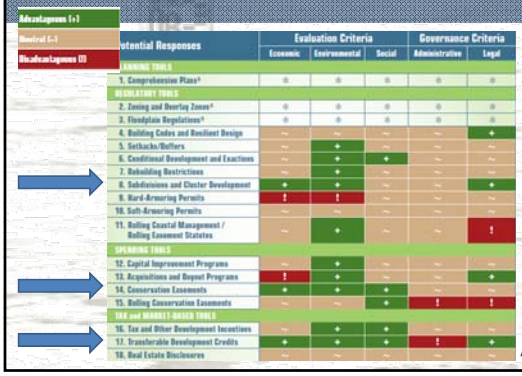
SLR Toolkit Evaluation



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Resources

- Georgetown Climate Center Adaptation Tool Kit
  http://www.georgetownclimate.org/sites/default/files/SLR_Toolkit.pdf
- Climate Adaptation Knowledge Exchange (CAKE)
  http://www.cakex.org/
- NOAA Climate Adaptation
  http://collaborate.csc.noaa.gov/climateadaptation/default.aspx

SLR Regulatory Toolkit
APA WA/OR Conference
October 21, 2011

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Adapting to Sea Level Rise:
Regulatory Tools

WA/OR APA Conference
October 21, 2011

Presented by
Nicole Faghin, LEED AP, AECOM
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- http://www.youtube.com/watch?v=k3i3UM7Z3ps

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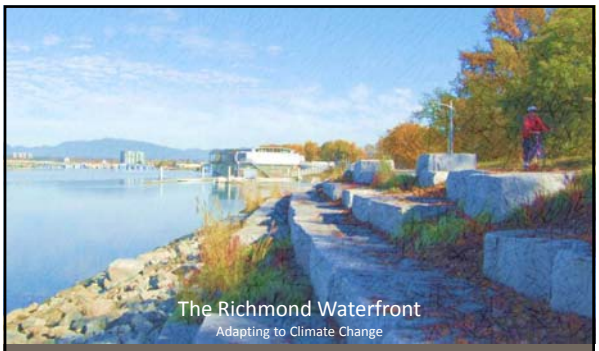


The Richmond Waterfront

Adapting to Climate Change

Todd Bronk, RLA, ASLA

berger

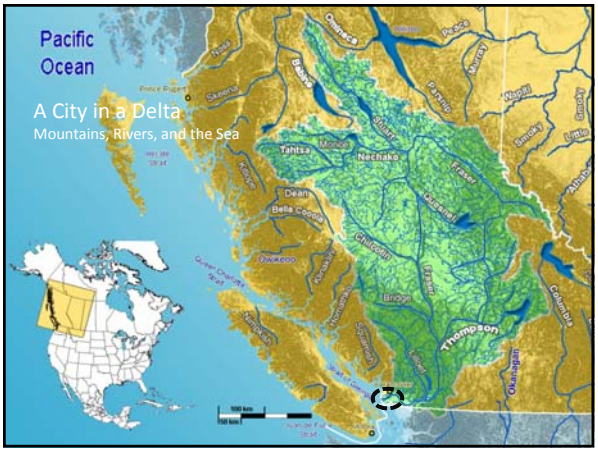
Adapting to Climate Change

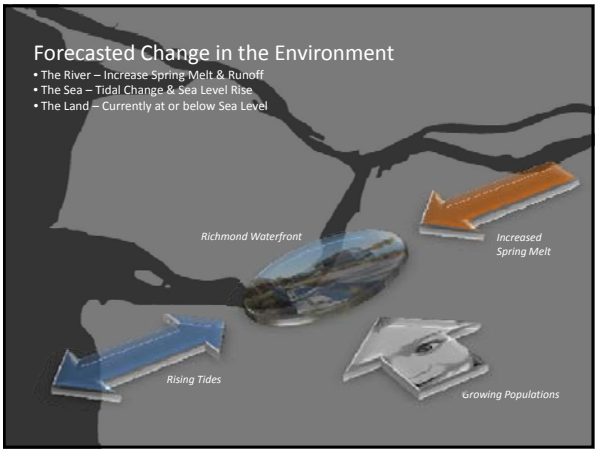
1 Contextual Overview
2 Understanding the Choices
3 Site Understanding
4 Master Plan Process
5 Designing the "first win"

Case Study: Richmond Waterfront
Richmond, British Columbia

1

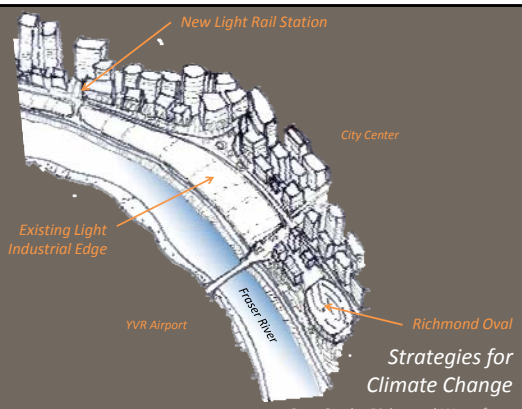
Contextual Overview





2

Understanding the Choices



Strategies for Climate Change

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Richmond, British Columbia

Protect & Armor Shoreline

Strategies for Climate Change

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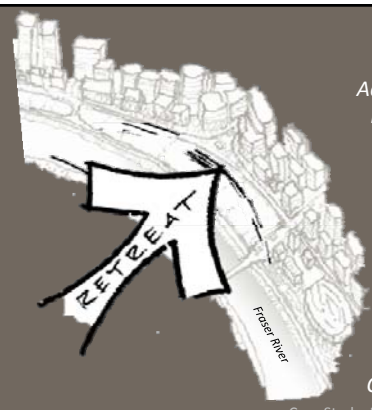
Richmond, British Columbia



Acceptance of a New Shoreline

Strategies for Climate Change

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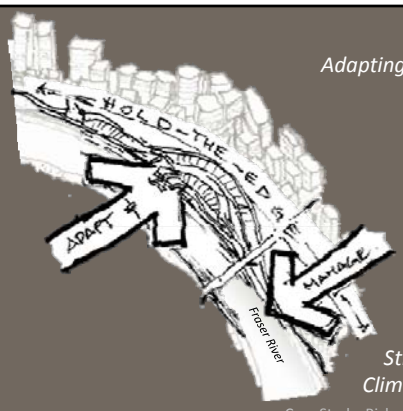
Richmond, British Columbia



Adapting to Change

Strategies for Climate Change

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Richmond, British Columbia

3

Site Understanding

Adapting to Change
Quick Facts

- 1.3 Kilometers in length
- On top of an existing dike
- Between Canada Line station & Olympic Speed Skating Oval
- 3 Plazas; UBC Boat House & racing; Navy League; private Marina; themed playground
- Raise dike to 4M & plan for 5M
- Completion of Phase 1 by 12/09
- $5.0 million Construction Budget – Phase 1

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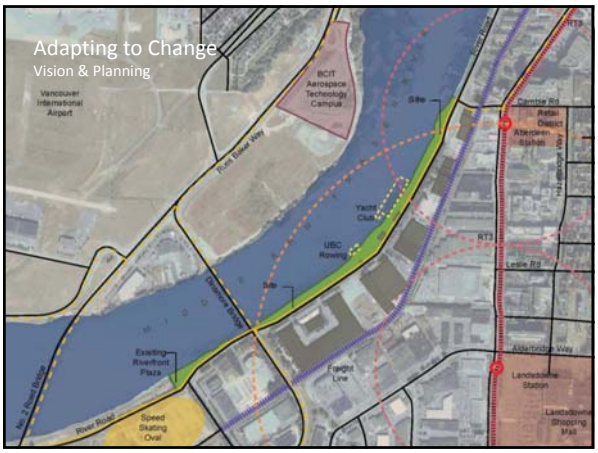
Richmond, British Columbia

Adapting to Change
Vision & Planning



Adapting to Change
Vision & Planning

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Richmond, British Columbia

4

Master Plan Process

Adapting to Change
Vision & Planning

The Big Ideas / Big Picture Goals

- Braided Delta System
- Flood Control / Sculptured engineering
- Sustainability & Ecology
- Engage Road in Phase one
- City / River Monuments
- Olympic Legacy

- Identify a “first win” to claim the bigger goals ahead

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Richmond, British Columbia

Adapting to Change
Vision & Planning

Restore the Shoreline

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Vision & Planning

Connect *the community*

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Vision & Planning

Integrate *form / function*

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Vision & Planning

Access *to public shoreline*

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Adapting to Change
Vision & Planning

Adapt *to Climate Change*

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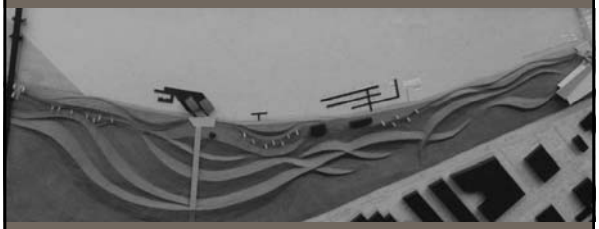
Adapting to Change
Letting nature take it's course



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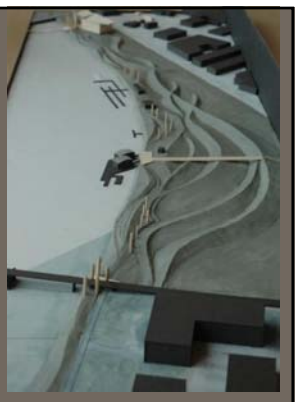
Adapting to Change
Sculpted Engineering



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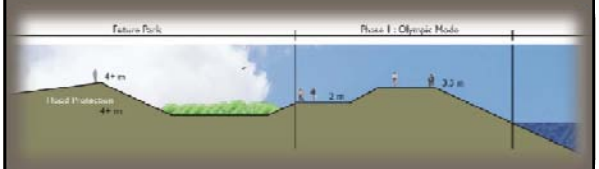
Adapting to Change
Engineering & Shoreline Protection

Typical Strategy



Adapting to Climate Factors

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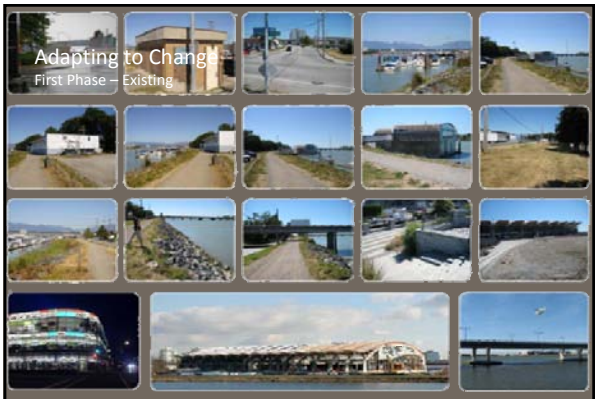
Richmond, British Columbia

5

"First win" design

Adapting to Change
First Phase – Existing



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Richmond, British Columbia

Adapting to Change
Environments that evolve

Capture Views

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Richmond, British Columbia

Adapting to Change
Designing in the age of climate change

Capture Views

Peel Back

Push Out

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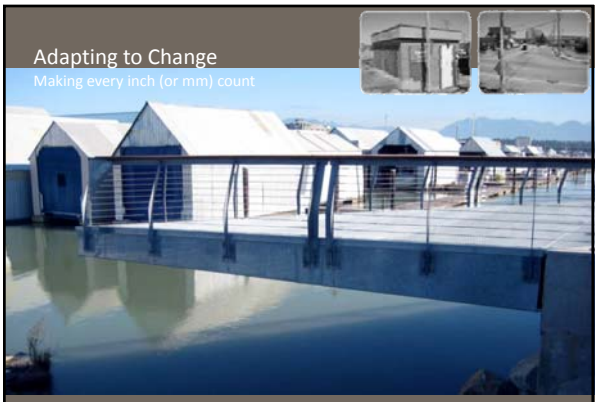
Richmond, British Columbia

Adapting to Change
Making every inch (or mm) count



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Adapting to Change
Making every inch (or mm) count
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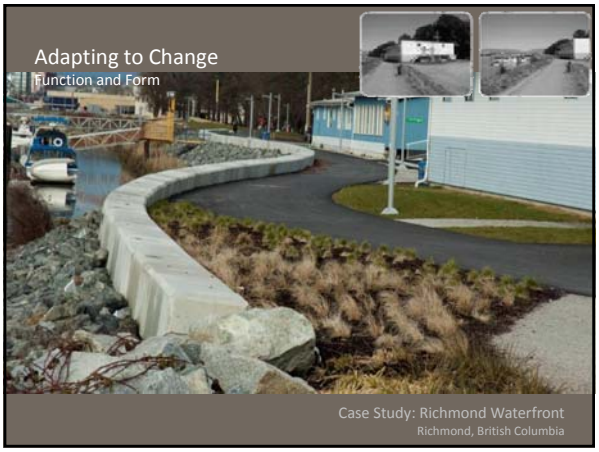
Adapting to Change
Function and Form
Case Study: Richmond Waterfront
Richmond, British Columbia


Adapting to Change
Function and Form
Case Study: Richmond Waterfront
Richmond, British Columbia


Adapting to Change
Communicating to future generations
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Richmond, British Columbia


Adapting to Change
Communicating to future generations
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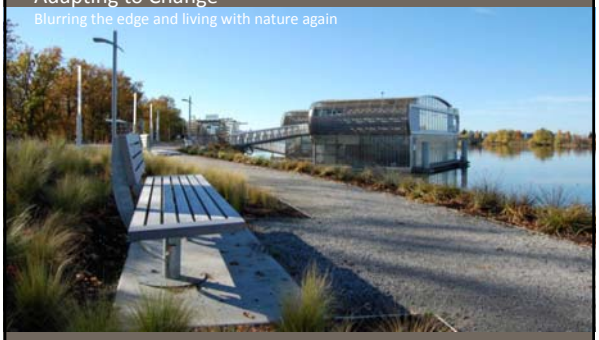
Richmond, British Columbia

Adapting to Change

Blurring the edge and living with nature again



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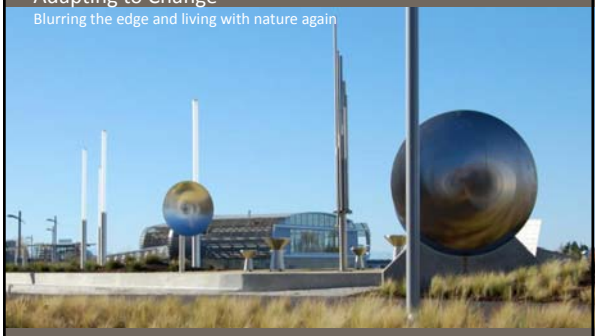
Adapting to Change

Blurring the edge and living with nature again



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Adapting to Change

Communicating to future generations

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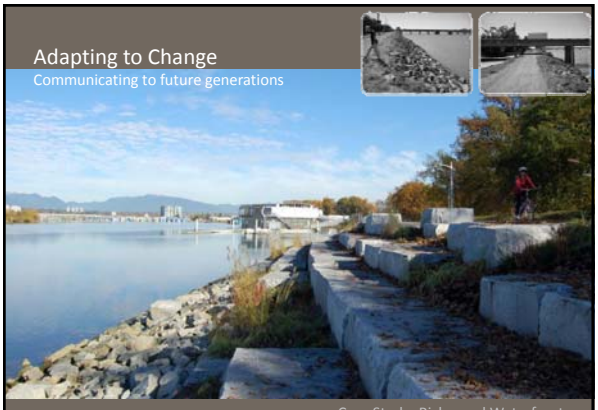
Communicating to future generations



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Adapting to Change

Communicating to future generations

Case Study: Richmond Waterfront
Richmond, British Columbia

Adapting to Change

Thank you

Preparing Washington State:
An update on Climate Change Response Efforts

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Secretary of Transportation

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Joint Oregon and Washington APA
October 21, 2011
Portland, OR

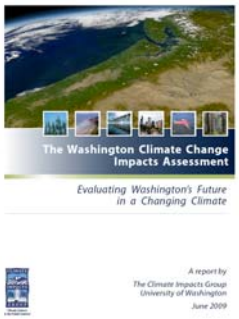
Governor and Legislative Direction

Climate Change challenge

State Law plus Executive Orders 07-02 (2007) and 09-05 (2009)
- Reduce emissions – referred to as "mitigation"
  - Improve vehicle technology and fuels
  - Reduce VMT
  - Create a more efficient transportation system
  - Conserve Energy and Resources
- Support our economy – create more sustainable economy
  - West Coast Green Highway
- "Adaptation" prepare for climate change impacts (esp. sea-level rise / coastal impacts)

Washington Climate Change Impacts Assessment

- Funded by the Washington State Legislature
- Comprehensive assessment of climate change impacts on Washington
- Downscaled from global climate models
- Products include comprehensive data sets

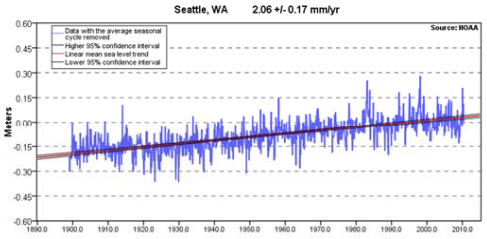


Regional Climate Impacts

UW Climate Impacts Group report covers more than Washington State

www.cses.washington.edu/cig/

Seattle Sea Level Rise



Climate Impact Areas of Concern

Western WA
- Sea level rise
  - Salt water intrusion
  - Landslides
  - Habitat loss
- Erosion, scour
- Flooding
- Extreme heat
- Drought

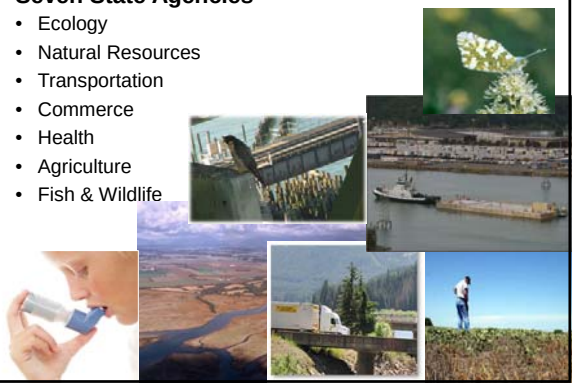
Eastern WA
- Heat and Drought
  - Toxic temps for fish
  - Habitat migration
- Rain dominant rivers
  - Water timing
  - Scour
  - Flooding
- Invasive Species

State Agency Climate Leadership Act, 2009

- Requires development of an *"integrated climate change response strategy…"* which must address "regional capacity to take action, existing ecosystem and resource management concerns, and health and economic risks."
- Requires state agencies *"… to incorporate adaptation plans of action as priority activities when planning or designing policies and programs. ..and funding infrastructure projects…"*
- Executive Order 09-05: requires focus on sea-level rise and water resources

Seven State Agencies

- Ecology
- Natural Resources
- Transportation
- Commerce
- Health
- Agriculture
- Fish & Wildlife



Broad Goals

- **Mainstream adaptation** into state agency planning, policies and investment decisions
- **Improve understanding & access to climate science**
- **Foster collaboration and coordination** between agencies, tribes, NGOs and all levels of government
- **Support efforts of local communities** to prepare for changing climate
- **Build awareness among decision-makers and public** through communication and engagement

Major elements of strategy

- Human Health and Security
- Ecosystems, Habitats and Species
- Coastal and Ocean Resources
- Water Management
- Agriculture
- Forestry
- Infrastructure
- Monitoring and Research
- Communication and Public Engagement
- Implementation Framework

Key Strategies - *DRAFT*

- Incorporate impacts and adaptation into long-range planning
- Consider climate projections when making public investments (all sectors)
- Strengthen state's emergency preparedness
- Protect human health by addressing impacts into existing public health activities
- Enhance monitoring (track emerging risks)

Key Strategies (cont.)

- Maximize mutual benefits: economic, social and environmental
- Protect ecosystem processes and services
- Encourage protection of conservation areas and avoid conversion of agriculture and forest lands
- Implement policies to achieve sustainable water resources management
- Improve availability & access to climate data



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Moving Washington –

Our framework for investing, maintaining, preserving and getting the most out of the transportation system

Sustainable:
Meet today's needs without compromising the ability of future generations to meet their own needs.

OPERATE EFFICIENTLY
MAINTAIN and KEEP SAFE
ADD CAPACITY STRATEGICALLY
MANAGE DEMAND
RELIABLE · RESPONSIBLE · SUSTAINABLE
MOVING WASHINGTON

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Preserving Assets in a Changing Environment

- Understand the climate forecast for PNW
- Be ready for severe weather events *and* long-term changes in site conditions
  - tides, streams, glacial melt and debris flows…
- Inform long-term decisions
- Build resilience where possible

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FHWA / WSDOT climate change vulnerability & risk assessment

- WSDOT Goals:
  - Informed decision-making
  - Assess our risks
  - Assist in prioritizing needs – feeds into planning and project development
  - Resilient and sustainable transportation system regardless of the future we face
  - Test FHWA methodology
- Boundaries:
  - State-owned infrastructure
  - Report due to FHWA November 30, 2011

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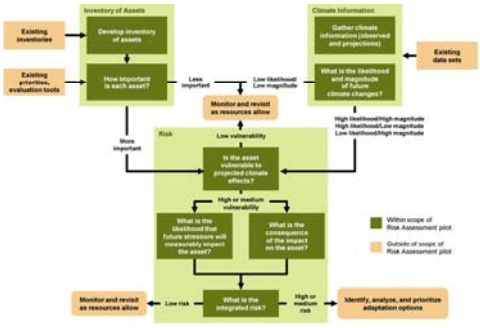
FHWA Risk Assessment Model



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Our approach uses internal experts

- Local maintenance, bridge preservation, hydraulics, geotechnical, materials, project development, planners, environmental staff
- Workshop format (similar to cost/risk assessments)
- Share climate change information and why this was important – stressed what is happening now (observed)
- Question: "How resilient is our existing system?

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We use our experience to gauge future impacts

Scour and damage to structures - Just off US 12 Davis Creek

Responsible Asset Management
Reliable Transportation System

- Vulnerability - Risk Assessment (near complete!)
- Sea-level rise mapping
- Scour & hazard monitoring
- Strategic plan element
- Planning guidance
- Project-level analysis

See WSDOT's project-level guidance on WSDOT's Energy webpage:
http://www.wsdot.wa.gov/Environment/Air/Energy.htm

Climate and weather-related impacts

Being prepared means:

- Understand the forecast
- Assess our risks
- Integrate into planning and design
- Partner with others
- Build to last