LBA: Sea-Level Rise

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NS50: Empirical Analyses

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Understanding Sea-Level Rise: What Do We Need To Know?

An increasing, general trend of sea-level rise has been observed in the past century and a half (Figure 1). National Oceanic and Atmospheric Administration (NOAA) illustrated the extent to which sea-level rise contributes to flooding in coastal communities in its flooding report of 2020, noting a significant increase in flooding incidents along the U.S. coast in the past two decades. Considering unchecked greenhouse gas emissions, subsequent global warming, and the resulting rise in sea levels, flooding events are expected to occur more frequently and with greater force in the coming years (National Oceanic and Atmospheric Administration, 2020). Since the 1970s, thermal expansion of the oceans, caused by global warming, has assumed a greater role in rising sea levels (Thomas et al, 2020).

If the trajectory of sea-level rise continues as currently observed, 300 million people are expected to be vulnerable to heavy floods by 2050 while 200 million people are estimated to be living below high tide line by 2100 (Climate Central, 2019). Even if intense greenhouse gas emission cuts are implemented immediately, there is a strong scientific consensus that global sea levels will rise by at least 1 ft by the end of the century (Kopp et al, 2017).[1]

Effective predictive models can be used to understand regional implications of sea-level rise and the extent of flooding impacts on coastal communities.[2]

[1] #evidencebased: All the claims presented to identify #rightproblem are established as supported by numerous authoritative and relevant sources.

[2] #rightproblem: The nature of sea-level rise is identified and contextualized with a focus on its causes and future consequences. This sets the ground for further exploration of the problem using #dataviz and #modeling.

Sea-Level Rise Implications: San Francisco

Observations

According to California Coastal Commission, San Francisco tide gauge has experienced an 8 in increase in the past century. The city is further estimated to experience a 2.4 to 6.9 ft rise in sea level by the year 2100 (California Ocean Protection Council, 2018), posing significant social and economic threats to the city, particularly downtown.

Built nearly a century ago and supporting over $100 billion of the city's infrastructure and economic activities, the Embarcadero Sea Wall (Figure 2) presents a picture of weakened waterfront protection and cannot be relied on protecting the city from expected high tides (SF Port Resilience, 2020). Since it borders areas with unimpeded access to the ocean, San Francisco's eastern waterfront is deeply vulnerable to high tides and flooding (Figures 3, 4, 5, 6).

Projections from three different models show the Ferry Building (a landmark site along the Embarcadero Sea Wall) and its associated ferry terminals to be below annual flood line and directly vulnerable to high tides (Figures 3, 4, 5, 6). Assuming a 6 ft rise in sea level by 2100 (Figure 4, 5), extensive parts of the Ferry Building, compared to the projections for 2070 (Figure 3), are projected to be inundated with 80% degree of confidence (Figure 6).

The projections can be made to differ by modeling different scenarios of carbon footprint and greenhouse gas emissions. Generally, these projections do not consider seasonal fluctuations in sea-level and natural landform changes. They are also not accurate in terms of mapping the exact location of damage, but a high confidence in the extent of damage is useful for disaster mitigation.[3]

[3] #modeling: Three different models are correctly identified and evaluated based on their merits.

Hypothesis and Predictions

Based on the models and observations, it is hypothesized that increase in annual flood line poses a risk to passenger transportation to and from the Ferry Building in San Francisco. It is predicted that increase in tide height will cause delays in and cancellations of ferry trips, impede ferry routes, and reduce clearance for large vessels passing under bridges. It will also demand frequent rebuilding of transportation facilities like docks, terminals, piers, and jetties.

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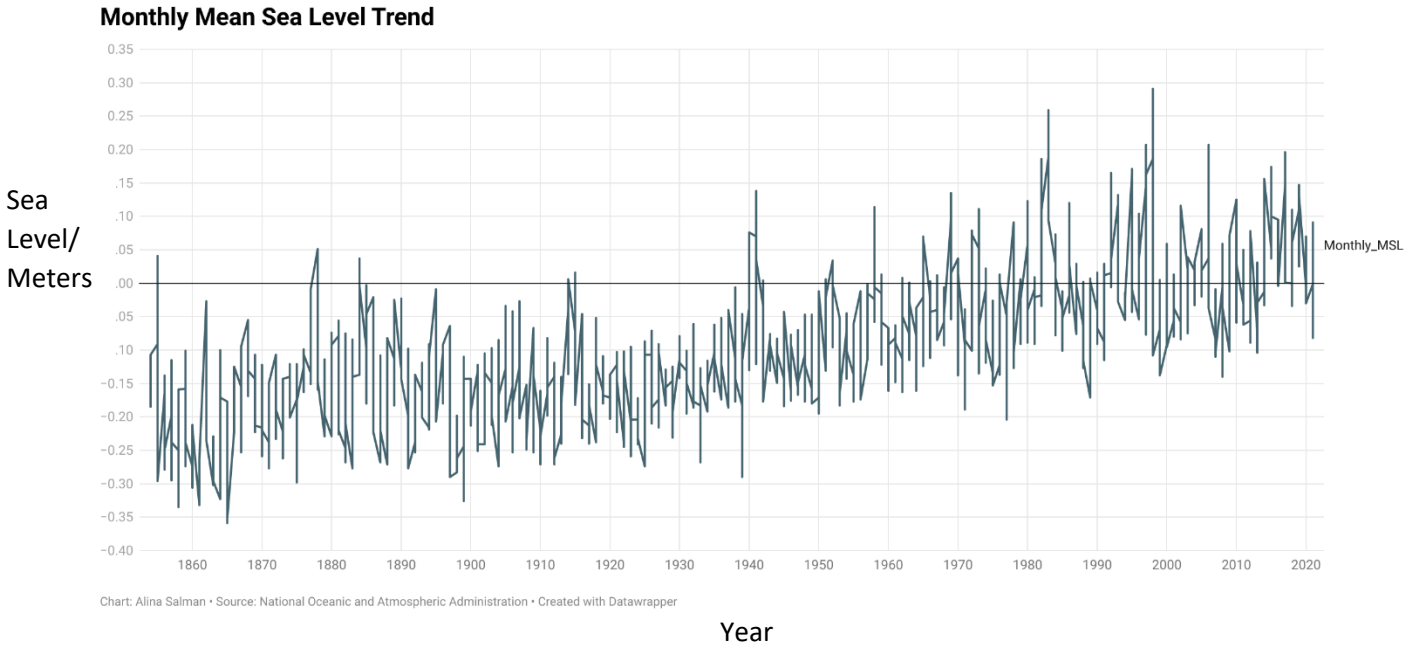


Figure 1. Monthly Mean Sea Level Trends for San Francisco, California from 1860 to 2020. A general trend of increasing monthly mean sea levels can be observed.

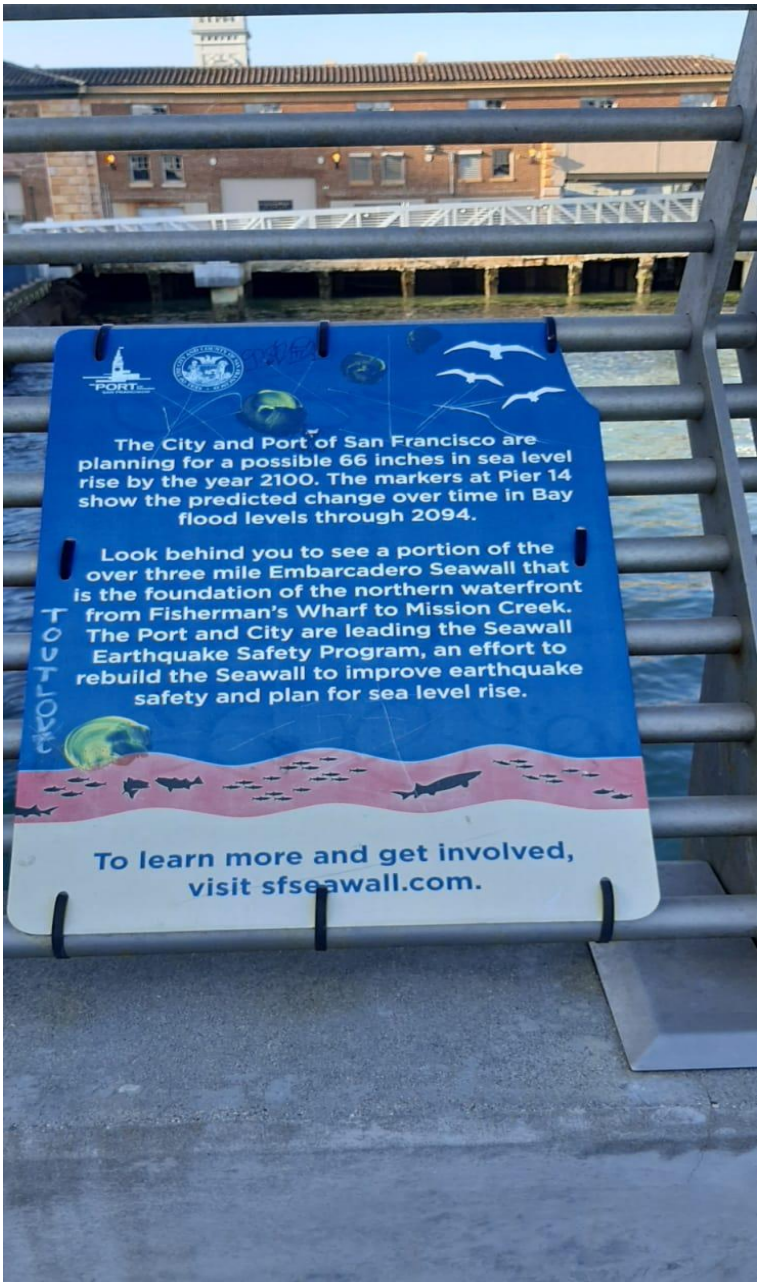
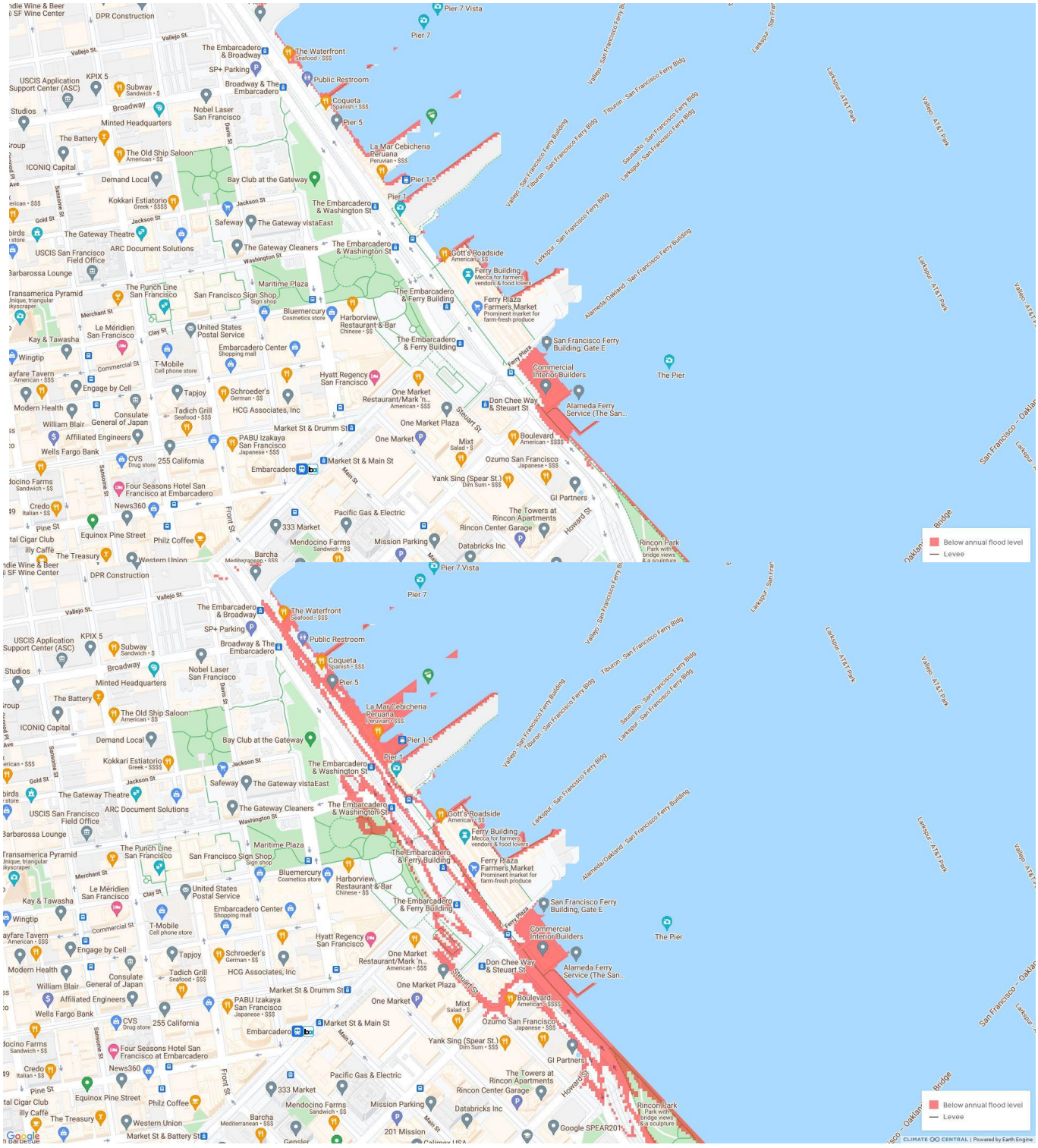
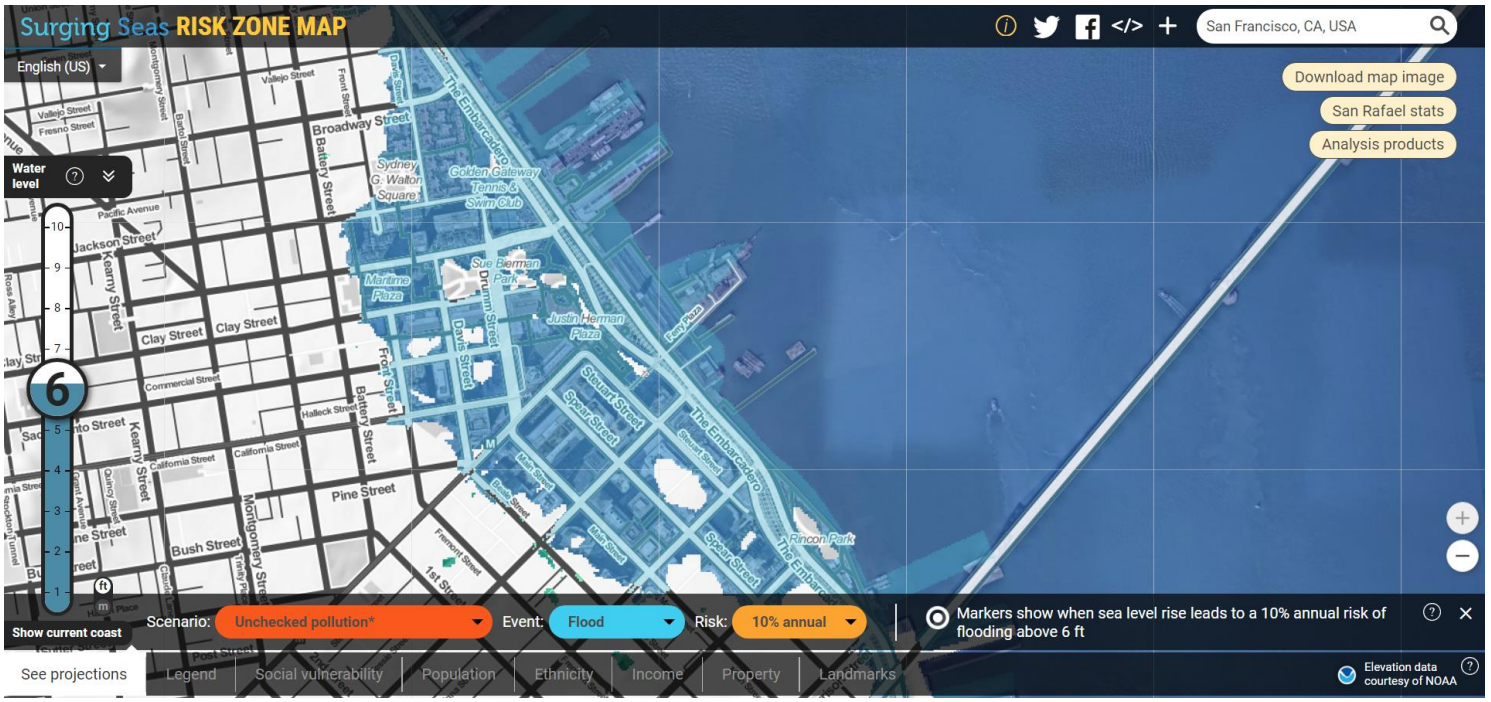


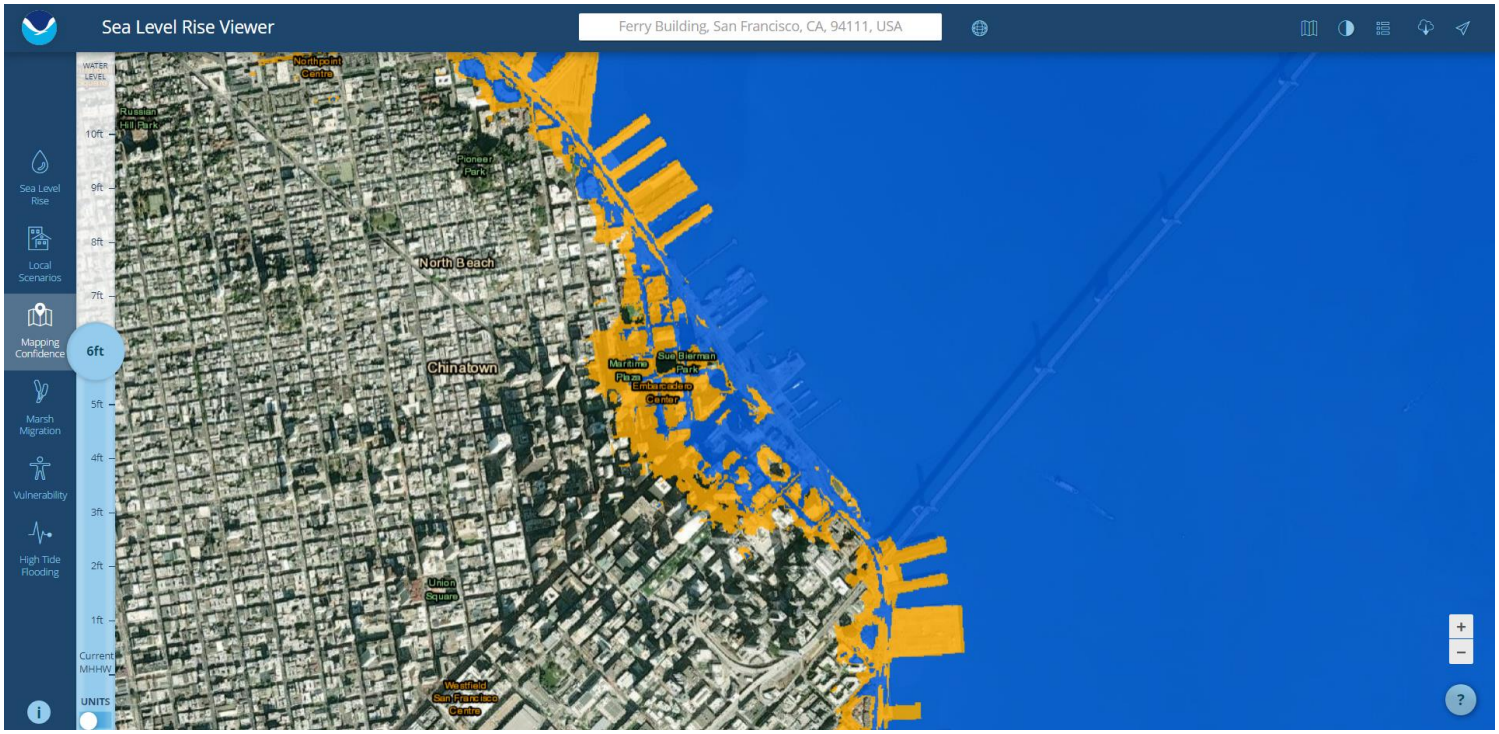
Figure 2: Sea Wall Awareness at Pier 14, by the Ferry Building.



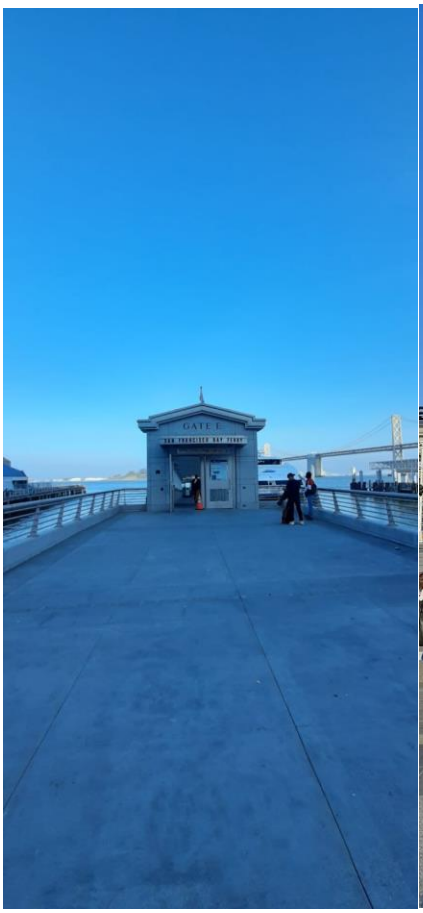
Figures 3 and 4: Climate Central's model for land projected to be below annual flood line by year 2070 (above) and 2100 (below). Shows inundation along Ferry Plaza and the Embarcadero Sea Wall.



Figures 5: Surging Seas Risk Zone Map shows Ferry Plaza as the most vulnerable when 6 ft is expected in sea level rise. This projection includes modelling of different pollution scenarios and different levels of flood risks.



Figures 6: Sea Level Rise Viewer's model for San Francisco shows mapping confidence in inundation of areas. Ferry Plaza is a location with 80% confidence in floods overtaking the location.




Figures 7, 8, and 9: Photographs taken at the Ferry Plaza and Gate E Terminal showing real-life images of locations marked on the maps.

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