HAZARDS AND VULNERABILITIES

SEA LEVEL RISE

CLIMATE CHANGE AND COASTAL FLOODING

Our changing climate is changing the entire water cycle. Sea levels are rising, groundwater tables are rising, and precipitation intensity is increasing. In the Bay Area, we are already experiencing the impacts of climate change. The photos to the right show instances of wave overtopping and coastal flooding in Alameda during storms in January of 2024 (*photo credits: Maurice Ramirez*).

As these risks increase overtime, the potential impacts to our communities will also grow. In the absence of adaptation, rising seas and coastal flooding can overtop shorelines, causing damage from flooding on our shorelines and spreading to low-lying inland neighborhoods. Rising groundwater, pushed to the surface by rising sea levels, can also impact communities from below.

The vulnerability of our shoreline is varied, dependent on elevation and exposure to waves from the bay. Much of our region's shoreline is constructed from bayfill on areas that were formerly tidal marsh or mudflat. These areas are especially vulnerable to coastal flooding.

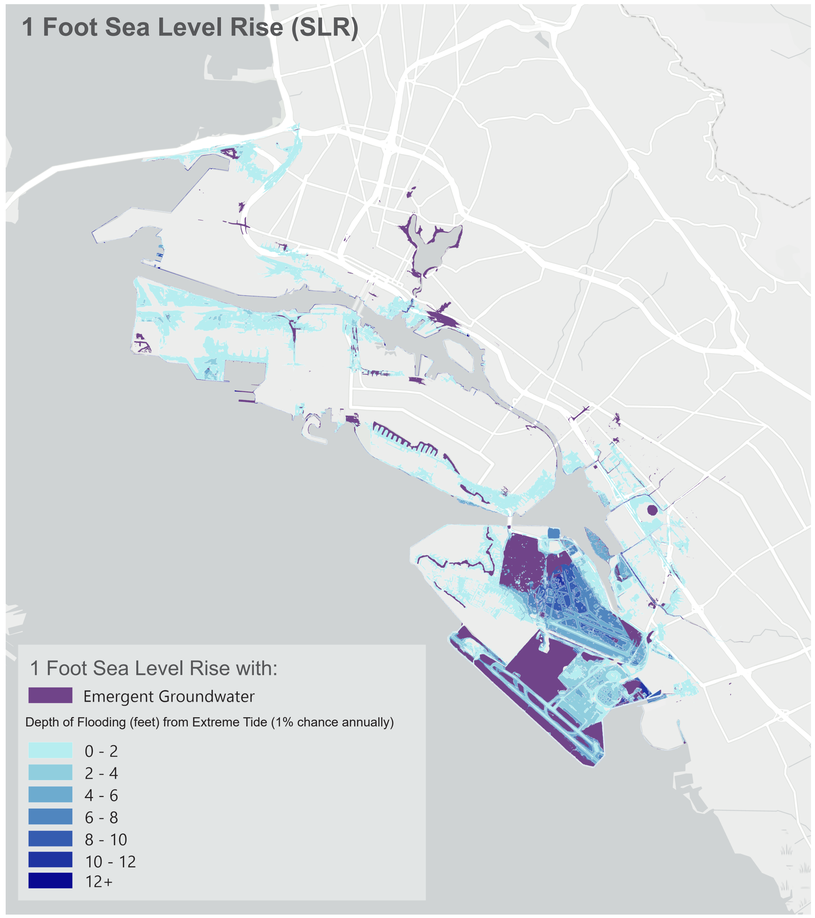
The maps below show how surface flooding will affect our communities over time, depending on the rate of sea level rise. Blue shaded areas represent coastal flooding with sea level rise plus an extreme tide. Darker blue indicates deeper floodwater, lighter blue indicates shallower floodwater. Purple-shaded areas represent areas where groundwater emerges above the ground surface.

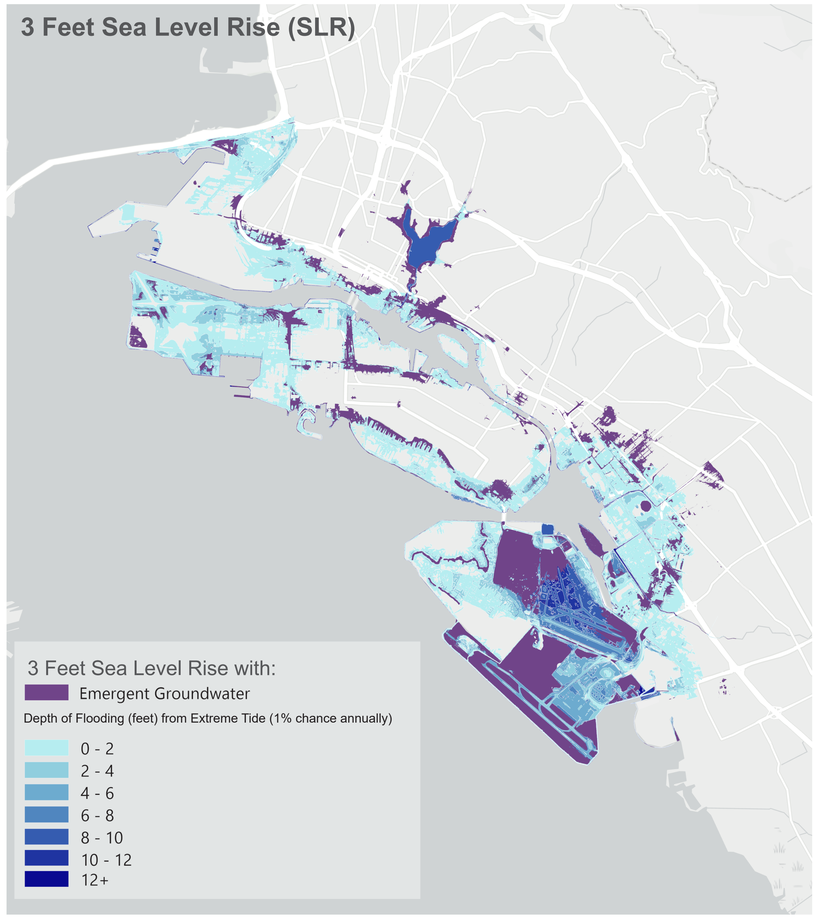
Wave overtopping at Veteran's Court

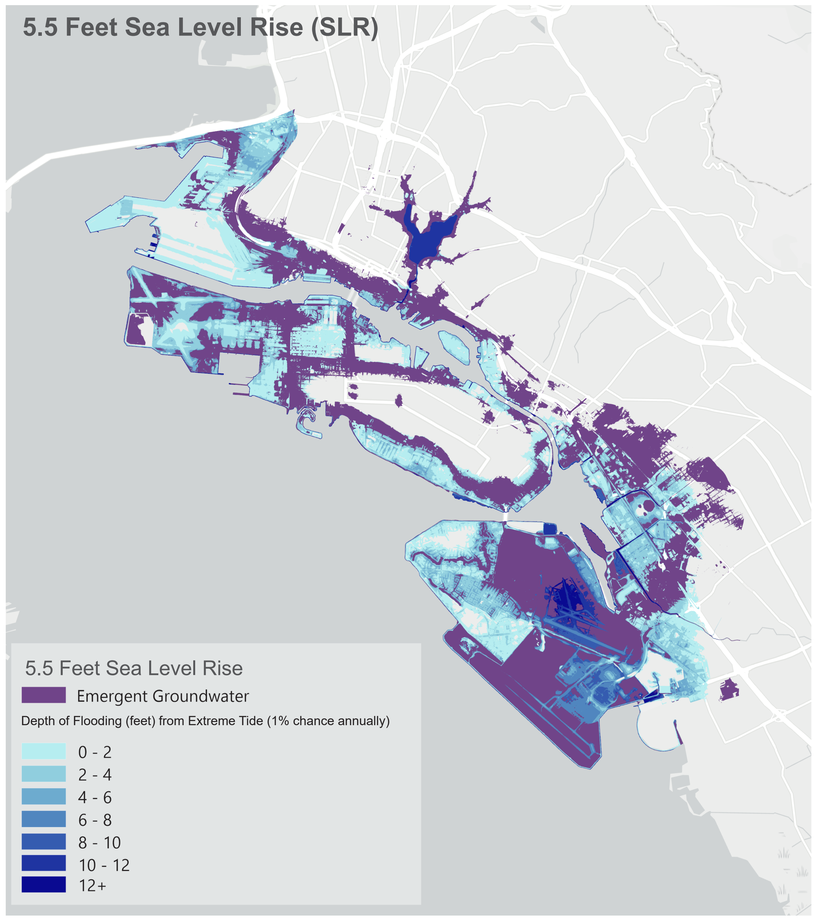
Coastal flooding along the Alameda Beach Bay Trail

Wave overtopping at Elsie Roemer shoreline

COASTAL FLOODING AND EMERGENT GROUNDWATER







ALAMEDA

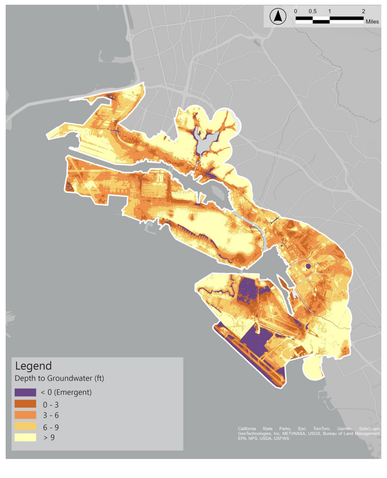
HAZARDS AND VULNERABILITIES

MULTIPLE HAZARDS

WHAT ELSE DO WE NEED TO CONSIDER?

As we plan to adapt our shorelines to address vulnerabilities associated with sea level rise and coastal flooding, we must also consider related hazards. Adaptation planning must take into account risks associated with groundwater rise, contamination, seismic hazards (for example, liquefaction) and stormwater flooding. We must also analyze the interactions between these risks. For example, coastal flood protection infrastructure must be designed to withstand seismic events. Stormwater management infrastructure may need to be adapted to coordinate with shoreline flood defense and remain functional with rising tide levels.

Groundwater

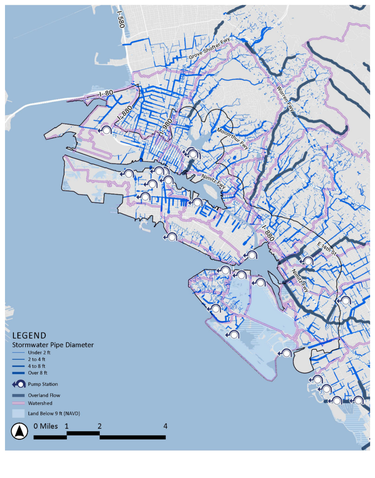


As sea levels rise, salty groundwater connected to the bay migrates inland, pushing fresher shallow inland groundwater upward, causing the groundwater table to rise (the groundwater table sits between the unsaturated soil zone above, and the saturated groundwater zone below).

The unsaturated zone acts like a sponge, absorbing rainfall and reducing rainfall runoff and stormwater flooding. As the groundwater table rises toward the ground surface, the unsaturated zone will shrink, reducing the capacity of the soil to absorb rainfall. This can increase the likelihood of stormwater flooding during rainfall events.

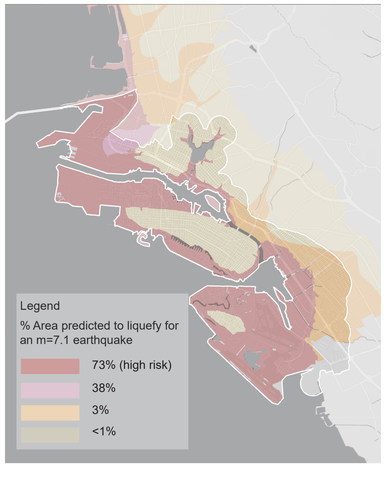
Groundwater rise can also contribute to inland flooding in low-lying coastal areas. When the groundwater table rises above the ground surface, emergent groundwater can occur (see purple areas on the map). In some areas, heavy rainfall can cause the groundwater table to remain above the ground surface for weeks at a time, even on sunny days long after the storms have passed.

Stormwater Drainage



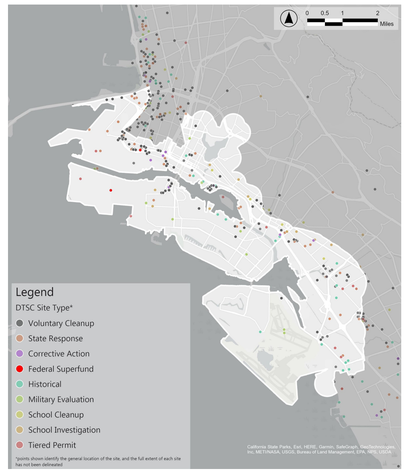
Stormwater flooding is caused by extreme precipitation, tidal influences, undersized and aging infrastructure, and increased urbanization. As extreme storms increase in frequency and intensity, and sea levels rise in the Bay, stormwater flood hazards will increase.

Liquefaction



Liquefaction is a process where water-saturated soil temporarily loses its strength and acts like a fluid, often during an earthquake Starting in the mid-19th century, artificial fill was added to the bay shoreline to create new developable land. Artificial fills placed before 1965 are generally not compacted and have high liquefaction potential.

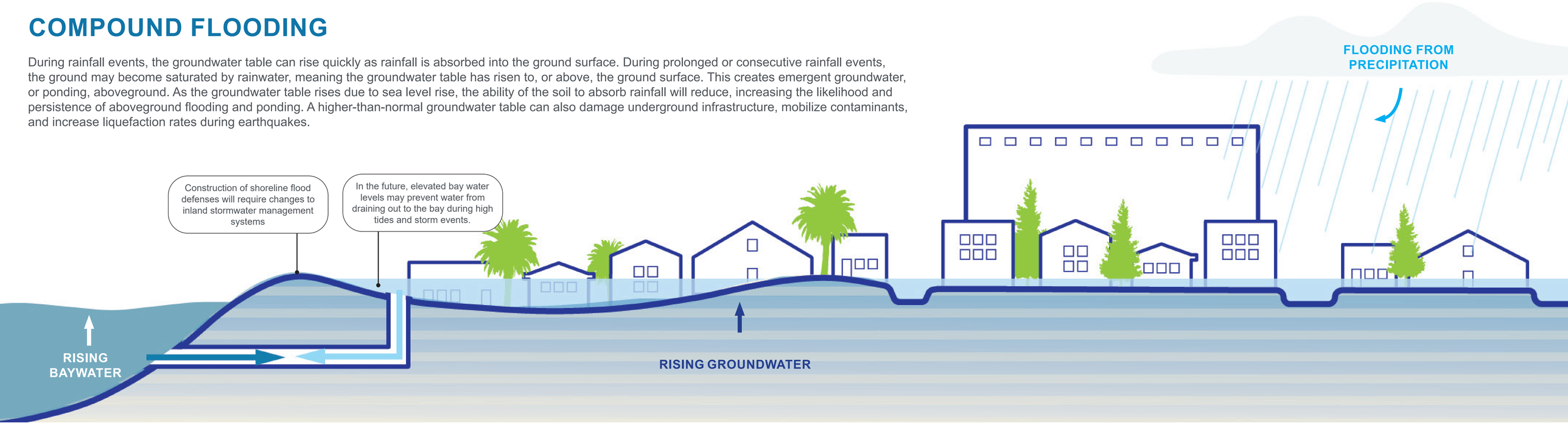
Contaminated Sites



Contaminants that migrate from upland areas to the Bay have the potential to cause harm to communities and the environment. The Department of Toxic Substances Control (DTSC) EnviroStor database includes an inventory of potentially contaminated sites, sites under investigation, sites undergoing cleanup, sites in the monitoring phase, and closed sites.

COMPOUND FLOODING

During rainfall events, the groundwater table can rise quickly as rainfall is absorbed into the ground surface. During prolonged or consecutive rainfall events, the ground may become saturated by rainwater, meaning the groundwater table has risen to, or above, the ground surface. This creates emergent groundwater, or ponding, aboveground. As the groundwater table rises due to sea level rise, the ability of the soil to absorb rainfall will reduce, increasing the likelihood and persistence of aboveground flooding and ponding. A higher-than-normal groundwater table can also damage underground infrastructure, mobilize contaminants, and increase liquefaction rates during earthquakes.



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