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## New mapping study shows rising groundwater a major climate risk for the S.F. Bay Area

***Data show shallow groundwater is already widespread, with sea-level rise to push groundwater levels higher***

**January 17, 2022** - Recent storms have highlighted the Bay Area's vulnerability to lowland flooding. A report with maps released today by Pathways Climate Institute (Pathways) and San Francisco Estuary Institute (SFEI), identifies rising groundwater as a key contributor to the flooding challenge in the region's shoreline communities. The companion [StoryMaps](#) provide a high-level overview of this challenge.

The groundwater table varies seasonally in response to dry summers and winter seasons with significant precipitation. This study mapped groundwater elevations representative of wet winter conditions, which typically occur in response to large precipitation events. The maps are representative of where the groundwater table is right now in response to the recent series of atmospheric rivers impacting the region. As sea levels rise, the level of overlying and adjacent groundwater rises too, further increasing the elevation of the groundwater table. Shoreline flood projections not accounting for groundwater rise in response to rising seas are missing a key component of flood risk.

With a grant from the [California Resilience Challenge](#), Pathways and SFEI collaborated on new research to define and map this emerging climate risk. The researchers compiled groundwater measurements from contamination monitoring wells, data from boreholes drilled prior to construction projects, and tidal and creek water surface elevations. These data were used to create a depth to groundwater map for four Bay Area counties: Alameda, Marin, San Francisco, and San Mateo. The mapping covers both [current conditions](#) and [projected future conditions with sea-level rise](#). Representatives from the four counties, and cities within those counties, helped with data collection and reviewed the maps for accuracy.

While a few previous studies have looked at groundwater rise in the Bay Area, this new report and associated data fill a key gap for adaptation planners in the region by providing a more comprehensive, accurate, and thoroughly vetted dataset for use by decision makers. Many of the climate change vulnerability assessments and adaptation plans being developed in the Bay Area do not yet account for the risk of flooding from below.

“We are currently updating our Local Hazard Mitigation Plan and Safety Element of the General Plan, and plan to include the findings of this report in the update,” said Elizabeth Carrade, Sustainability Coordinator for the City of Albany.

San Francisco is already using the study’s findings to inform adaptation strategies through the Climate SF program and as a factor in decision making for capital improvement projects. “This has been a missing piece of the puzzle, and having an accurate data set to work from will help ensure that new projects are designed for a rising groundwater table,” said Brian Strong, San Francisco’s Chief Resilience Officer.

Some of the risks associated with rising groundwater occur before water emerges above the ground surface and causes flooding. In many places, underground infrastructure was not designed for a high groundwater table and can be damaged as groundwater rises. For example, rising groundwater can destabilize foundations and pipes, flood basements and other underground structures, and increase infiltration into sewers. Other concerns include increased risk of liquefaction (when the ground behaves as a liquid during an earthquake) and mobilization of contaminants in low-lying communities.

“This study helps identify places where groundwater is shallow and rising. However, more research is needed to better understand how changes in groundwater flow may impact contaminated sites,” said Dr. Kristina Hill, a professor at UC Berkeley and a co-author of the report. “Even a few inches of groundwater rise may mobilize contaminants or change flow directions, causing contaminants in soil to spread. Existing remediation plans don’t account for this.” As with many climate impacts, risks of contaminant remobilization are disproportionately faced by low-income communities and communities of color, as historical injustices mean that they are more likely to live near contaminated sites.

“We see in the mapping that many of the places most exposed to flooding from emergent groundwater are in areas constructed on historical wetlands,” said Ellen Plane, an environmental scientist at SFEI and a co-author of the study. Like in many other coastal cities, much of the development surrounding San Francisco Bay was built on newly created land — in some places the wetlands were filled to a few feet above the high tide line, and in others they were drained and surrounded by levees. “Rising groundwater is a particular concern in areas built on artificial fill because the unconsolidated material used to ‘reclaim’ the wetlands is more susceptible to liquefaction, and often, the fill that was used is contaminated,” said Plane.

Regulatory agencies are starting to take note of the rising groundwater issue. The San Francisco Bay Regional Water Quality Control Board recently made one key move in revising regulations by requiring that bayfront landfills identify strategies for protecting landfills from groundwater rise in their long-term flood protection plans. Many of the Bay Area’s landfills, including closed and active landfills, are located at the Bay margin.

When it comes to sea-level rise adaptation, planners need to account not only for coastal flooding but also flooding from below. “This study shows that groundwater emergence will occur in low-lying inland areas that may previously have considered themselves “safe” from sea-level rise,” said Dr. Kris May, CEO of Pathways Climate Institute and a co-author of the study.

And in areas that are already planning for sea-level rise, adaptation plans may need to be adjusted to ensure precious dollars are spent wisely. “Levees and seawalls may help with coastal flooding, but they won’t be a silver bullet — we will still need to deal with rising groundwater inland of these structures. We need integrated adaptation solutions that account for multiple sources of flooding – the full hydrologic cycle, a rising Bay, rising groundwater, and increasing extreme precipitation like the storm that impacted the Bay Area on Dec 31, 2022,” said May. “Rising groundwater saturates the soil as it rises, so there’s less room for infiltration. That can exacerbate flooding issues, especially during wet winters with lots of big storms, like the one we’re experiencing now.” ”

**Website link:** <https://www.sfei.org/projects/shallow-groundwater-response-sea-level-rise>

**Pathways Climate Institute:** We Help Communities Create Pathways to Climate Resilience. We integrate science, engineering, policy, and community engagement into adaptation pathways that address today’s climate hazards and tomorrow’s uncertainties.

**San Francisco Estuary Institute (SFEI)** is one of California’s premier aquatic and ecosystem science institutes, committed to providing scientific support and tools for decision-making and communication through collaborative efforts. Learn more at [www.sfei.org](http://www.sfei.org).