

Effects of Sea Level Rise and Extreme Precipitation on Groundwater Emergence and Contaminant Migration for Smart City Planning

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Sea level rise and increasingly frequent extreme precipitation events are reshaping the hydrology of coastal cities. Rising shallow groundwater, especially along preferential flow pathways such as sewer trenches and buried infrastructure, is amplified during atmospheric river events and, near the shoreline, by highest astronomical tides. In large areas of the San Francisco Bay shoreline, which is built on artificial fill over former wetlands, groundwater emergence is a driver of urban flooding and potential contaminant mobilization. Field-based hydrogeologic monitoring, geochemical and isotopic tracers, and groundwater vulnerability indexing were used to identify locations of rising and emerging groundwater and to prioritize sites at risk of contaminant mobilization.

These findings have direct implications for Smart City planning. Traditional resilience frameworks focus on visible surface inundation but often neglect subsurface processes that impact utility trenches, foundations, transportation networks, and stormwater systems. By integrating groundwater level data, real-time tide and rainfall data, and predictive modeling into urban infrastructure planning, cities can anticipate and respond dynamically to compound flood risks.

Incorporating subsurface hydrology into Smart City initiatives broadens climate resilience planning, enhancing flood forecasting, strengthening infrastructure design, and protecting public health by identifying hotspots where groundwater rise mobilizes buried contaminants. The increasing frequency and intensity of groundwater emergence episodes highlight escalating flood risk and the urgent need for proactive monitoring and adaptation. Effective resilience requires coupling technological innovation with hydrogeologic science, enabling coastal cities to become truly “smart” systems: tracking the variability and drivers of groundwater emergence, anticipating contaminant mobilization, protecting vulnerable communities, and sustainably managing land and water resources in an era of accelerating sea level rise and extreme events.

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