2. Natural Hazards

Like many California communities, Oakland faces numerous natural hazards, including geologic and seismic hazards, fire, flooding, and sea level rise. This section defines and describes each of these natural hazards in Oakland and highlights where communities are disproportionately vulnerable to their impacts.

2.1 GEOLOGIC AND SEISMIC HAZARDS

TOPOGRAPHY AND SOILS

Oakland sits at the intersection of two plates of the earth's crust. Within the last five million years, the faulting and folding of earthquake plates uplifted the present Oakland Hills and created what is now the San Francisco Bay, while erosion and sedimentation from the San Joaquin/Sacramento Delta have created the broad alluvial plain on which most of Oakland lies.

Oakland's topography falls into two broad categories: The lowlands (or flatlands), which include the flat coastal land surrounding the bay, tidal flats, and the more gently sloped inland land, and the uplands (or the hills). The city's topography rises from an elevation of sea level at its western edge to approximately 1,760 feet in the northeast Oakland Hills. Slopes are generally steeper in the hills, with areas in the Oakland Hills, especially areas east of Highway 13/I-580, exceeding slopes of 30 percent. Significant portions of neighborhoods northeast of Lake Merritt, such as Grand Lake, as well as Hills-adjacent parts of East Oakland have slopes exceeding 15 percent. The terrain flattens out toward the western and southwestern parts of the city as well as north of I-980; these relatively flat areas include Downtown, West Oakland, most of North Oakland, the Port and Airport, and most of East Oakland.

Several soil types occur within Oakland with varied qualities that affect how fast it erodes, its absorbency, how it behaves in an earthquake, how it reacts to metals (known as corrosivity), and other factors. The three primary soil types in Oakland are the bay muds located along the shoreline and in the landfilled areas; the alluvium and dune-sand deposits in the flatland and lower hill areas; and the sandstones and shale fragments of the upper hill areas. Bay mud consists of fine-grained, unconsolidated sand, silt, and clay with abundant organic material; over time, bay muds near the original shoreline have been overlain with artificial fill, typically consisting of mixed material such as rock and other debris. Soils in the flatlands have been formed by thousands of years of hillside erosion and are characterized by high corrosivity and low erosion potential. Finally, soils in the upper hills are composed of sandstone and shale materials, while soils in the lower hills consist of variable soils deposited through erosion, landsliding and artificial cutting and filling.[1]

1 City of Oakland, 2004. City of Oakland General Plan, Safety Element. Available online: https://www.oaklandca.gov/resources/safety-element

TYPES OF SEISMIC HAZARDS

There are various hazards associated with an earthquake. **Surface rupture** occurs when the ground surface is broken due to fault movement during an earthquake, and usually occurs along an active or potentially active fault trace.

- **Fault creep** is the slow, constant slippage that can occur on active faults absent an earthquake. Surface rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Examples of fault creep are well known along the Hayward Fault where it crosses highly developed areas in Alameda County.[2] This slow surface creep offsets and deforms curbs, streets, buildings, and other structures that lie near the fault.

Ground shaking generally refers to all aspects of motion of the earth's surface resulting from an earthquake and is often the primary cause of damage from seismic events. The extent of ground shaking depends on the magnitude and intensity of the earthquake, distance from the rupture (e.g., epicenter), and local geologic conditions.

- *Intensity* is a subjective measure of the perceptible effects of seismic energy at a given point, commonly measured by the Modified Mercalli Intensity Scale (MMI). This scale reports the

2 Alquist-Priolo Earthquake Fault Zones, 2019, California Department of Conservation (https://www.conservation. ca.gov/cgs/alquist-priolo)

intensity of shaking on a 10-tiered scale from "not felt except by a few under especially favorable circumstances" (I, or low), to "some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent"

- *Magnitude* is an objective measure of an earthquake's size at its release, typically reported by the moment magnitude (MW) scale, which looks at the distance a fault moves and the force required to move it.

Liquefaction occurs when loose, saturated, granular soil, usually found near the ground surface, is temporarily transformed from a solid to a liquefied state as a result of seismic ground shaking, or other rapid loading, causing the soil to lose strength and lose its ability to support structures. Additionally, liquefied soil exerts higher pressure on retaining walls causing them to tilt or slide and can trigger landslides.

- According to the 2021 – 2026 Local Hazard Mitigation Plan, sections of Oakland's shoreline, such as the Port of Oakland and the Oakland International Airport, are increasingly vulnerable to liquefaction during seismic events due to the abundance of loose, saturated, and granular soil types.

Land subsidence is a gradual settling or sudden sinking of the Earth's surface due to removal or displacement of subsurface earth materials. The principal causes include aquifer-system compaction associated with groundwater withdrawals, drainage of organic soils, underground mining, natural compaction, or collapse, such as with sinkholes or thawing permafrost. Subsidence can also be caused by natural events such as earthquakes.

- Subsidence occurs around the banks of the San Francisco Bay, impacting Oakland's coastline. This subsidence is largely influenced by the tectonics of the region as well as by sediment compaction of the landfill and Bay Mud deposits that comprise much of the soil in the area. Subsidence occurs with rates exceeding five millimeters per year in the San Francisco Bay Area.[3]

3 Blackwell, Em, Manoochehr Shirzaei, Chandrakanta Ojha, and Susanna Werth. 2020. "Tracking California's Sinking Coast From Space: Implications For Relative Sea-Level Rise." Science Advances 6(31):eaba4551. Retrieved from https://advances.sciencemag.org

Landslides and mudslides generally have the potential to occur on most sloped land. The risks tend to be greatest where a number of contributing factors are present, including slopes over 15 percent; weak, unconsolidated, or shallow soils; water saturation; a history of landslides; active earthquake faults; and extensive grading or vegetation removal (from fires or development activity). The slide itself is usually triggered by an earthquake, heavy rain, or misdirected runoff.

- Slopes at the greatest risk for landslides in the city are concentrated throughout the Oakland Hills (especially in the northern hills) and within two miles south of Highway 13.
- The landslide hazard in the Oakland Hills is exacerbated by the fact that the area is situated near the Hayward fault. During a major earthquake on that fault, landslides may occur in the hills in response to strong ground movements anticipated to occur in the area. Landslides could block roads, which would hamper evacuation, firefighting, and relief operations within the area. While efforts have been taken by the City through the development process to minimize landslide potential, most hillside development predates the imposition of grading and related requirements. For this reason, older hillside homes and subdivisions are the most susceptible to damage from landslides.

GEOLOGIC AND SEISMIC HAZARDS

Oakland is located between two known active fault zones – Hayward and San Andreas. The Hayward Fault Zone extends north-northwest to south-southeast approximately 55 miles from San Jose to Point Pinole along the eastern side of Oakland, as shown on **Figure SAF-1**. The fault is active, producing large earthquakes historically, and is designated as an Alquist-Priolo Earthquake Fault Zone (EFZ).[4,5] The San Andreas Fault Zone is a system of faults trending northwest for approximately 600 miles, from the Gulf of California to Cape Mendocino. It also has been designated an EFZ. There have been numerous large and destructive earthquakes generated from the San Andreas Fault Zone, including the 1906 San Francisco earthquake and the 1989 Loma Prieta earthquake. The Working Group on California Earthquake Probabilities has estimated that the entire San Francisco Bay Area has a 72 percent chance of experiencing an earthquake of magnitude 6.7 or higher over the next 30 years, with the Hayward and San Andreas faults being the most likely to cause such an event.

Strong seismic ground shaking and earthquake induced liquefaction and/or landslides are the primary geologic hazards of concern in Oakland in the event of an earthquake. The Probabilistic Seismic Hazard Assessment reveals that most of Oakland is at risk for violent shaking, while part of the Port, including Oakland International Airport, is at risk for severe shaking.[6] Other earthquake ground shaking scenarios are modeled in the City's Hazard Mapper, which shows groundshaking risk for earthquakes that may occur at the Calaveras, Hayward, and San Andreas fault zones.[7] Liquefaction is the rapid loss of shear strength experi-

4 In accordance with the Alquist-Priolo Earthquake Fault Zoning Act (Alquist-Priolo Act) of 1972, the State Geologist established regulatory zones, called "Earthquake Fault Zones," around the surface traces of active faults and published maps showing the earthquake fault zones. Within the fault zones, buildings for human occupancy cannot be constructed across the surface trace of active faults.

5 Working Group on California Earthquake Probabilities, 2015a. Long-Term Time-Dependent Probabilities for the Third Uniform California Earthquake Rupture Forecast (UCERF3). Bulletin of the Seismological Society of America, Vol. 105, No. 2A. pp. 511-543. April 2015. doi: 10.1785/0120140093

6 Ibid.

7 The City of Oakland Hazard Mapper. Available at https://oakgis.maps.arcgis.com/apps/MapSeries/index.html?appid=f84855cfff9b464c94aa6fc44bd660c3. Accessed Feb 2023.

enced in saturated soils below groundwater level during strong earthquake shaking. Liquefaction can move blocks of soil, placing strain on buried pipelines that can lead to leaks or pipe failure. Liquefaction susceptibility is generally highest in the low-lying coastal areas of Oakland, and around Lake Merritt and the Channel that connects it to the Estuary (**Figure SAF-1**). Earthquake-induced landslides are a particular type of landslide in which rocks and soil are displaced due to strong ground shaking. **Figure SAF-2** also shows that landslides are most likely in the hillier parts of Oakland.

The degree of damage caused by an earthquake depends on an area's geologic composition, the number of people and the designated land uses, the prevailing construction standards, the prevalence and condition of gas lines, the condition of water and sewer main lines, the efficiency of the emergency-response system, and even the time of day and day of the week. Most of Oakland's geologic and seismic threat comes from impacts to City utility lifelines, quake-related fire, landslide, or flood, and impacts to structures or buildings, which can include partial or total collapse. The potential for structural hazards largely depends on the structure's design and construction type. While modern building codes require seismic study, safety measures, and earthquake-resistant design to help protect communities against structural hazards, many buildings in Oakland were built before these codes were in place.

While it is impossible to prevent earthquakes, the loss and damage resulting from their impacts can be minimized through proper design and construction of structures, public infrastructure, and land use development. Geological investigations and greater oversight of engineering practices and construction techniques will continue to remain essential elements of the development process, and the safety of existing buildings must be upgraded whenever possible. The City's building electrification plan, as outlined in the 2030 ECAP, will not only drive long-term building energy efficiency improvements but also enhance infrastructure safety during earthquakes. The ECAP proposes a two stage process: in stage 1, new developments will no longer incorporate gas connections, and in stage 2, existing buildings will stop using gas. This will allow the City to gradually decommission parts of the gas pipeline system, reducing the risk of gas main ruptures during earthquakes.

SOCIAL VULNERABILITY

Based on the location of hazards and vulnerable communities illustrated in the figures, higher-income residents and white residents who make up the majority of the population in census tracts along the city's northern edge in the hills are more likely to be at risk of landslides and ground shaking, while lower-income areas and communities of color are more likely to be affected by moderate susceptibility to liquefaction (the highest liquefaction risks are along the shoreline in industrial areas and in the Jack London and Brooklyn Basin areas). From Mid-60th Avenue along the Hegenberger corridor past 98th Avenue and West Oakland along West Grand Avenue, East Oakland is also vulnerable and contains a large percentage of households of color, who are often already more burdened by housing costs than white households. Due to the large-scale nature of seismic events, however, the entirety of Oakland is generally at risk of geologic hazards. Goals and policies developed by the City will work to mitigate these geologic and seismic hazards while prioritizing adaptation for socially vulnerable groups through compliance with state laws, geotechnical regulations, and local policies and programs.

INSTITUTIONAL AND REGULATORY FRAMEWORK

Following the devastation of the San Fernando earthquake in 1971 (magnitude 6.6), California created the Alquist-Priolo Act to reduce damage and losses from surface fault rupture. This act established regulatory zones surrounding the surface traces of active faults in California so that a structure for human occupancy cannot be placed or built on active faults with potential for surface rupture and must be sited at a minimum distance from the fault.[8]

Established in 1990, Seismic Hazards Mapping Act (SHMA) directs the Department of Conservation, California Geological Survey to identify and map areas prone to earthquake hazards of liquefaction, earthquake-induced landslides, and amplified ground shaking. The purpose of the SHMA is to reduce the threat to public safety and to minimize the loss of life and property by identifying and mitigating these seismic hazards. The SHMA requires the State Geologist to establish regulatory zones and to issue appropriate seismic hazard zone maps to all affected cities, counties, and state agencies for their use in planning and controlling construction and development.[9]

While an earthquake fault zone generally prohibits location of structures for human occupancy within 50 feet of a trace of an active fault line, the State may grant exceptions for development within an earthquake fault zone if a geologic investigation approved by the State Geologist shows that the structure is not situated upon a trace of an active fault line.[10]

To further address earthquake hazards, and pursuant to Oakland Municipal Code Chapter 15.20, the City of Oakland applies Standard Conditions of Approval to all projects that involve new structures, major additions, and subdivisions located in an Earthquake Fault Zone per the State Alquist-Priolo Fault Zoning Act and in a seismic hazard zone per the State Seismic Hazards Mapping Act.

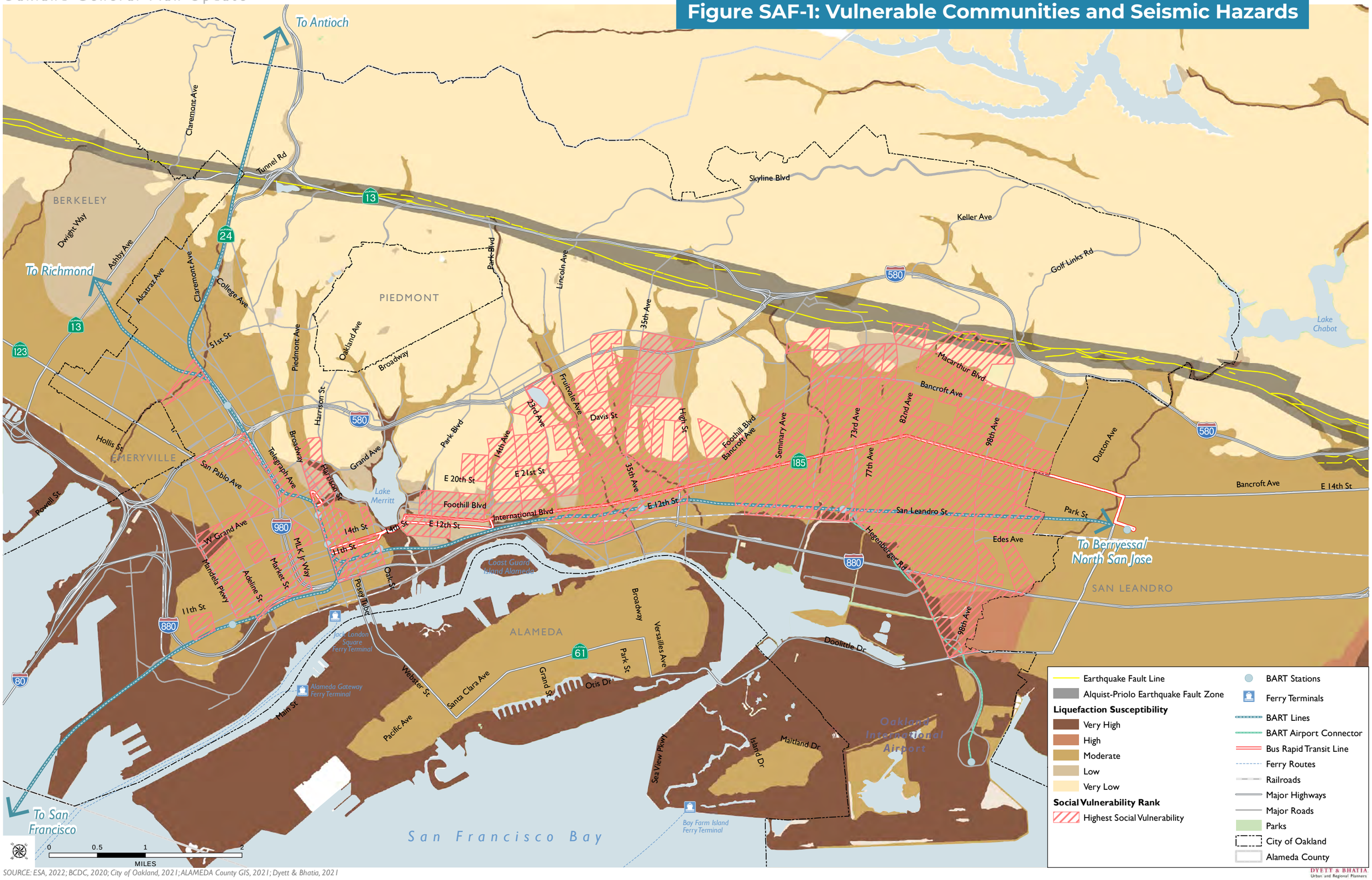
The City of Oakland's Soft Story Retrofit Program also works to save lives by strengthening buildings with large ground-floor openings or weak stories that are particularly prone to collapse during an earthquake. Effective January 22, 2019, Municipal Ordinance No. 13516 requires residential property owners of subject buildings to strengthen these vulnerable buildings with seismic retrofits. Actions in the Safety Element (found in Chapter 5) direct study and evaluation of other types of buildings that may be at risk, including those made of non-ductile (or inflexible) concrete. Use of this material was one of the factors associated with rampant building collapse caused by the February 2023 earthquakes in Turkey.

8 Alquist-Priolo Earthquake Fault Zones, 2019, California Department of Conservation (https://www.conservation. ca.gov/cgs/alquist-priolo)

9 Public Resources Code, Chapter 7.8, Section 2690-2699.6

10 Public Resources Code, section 2621.7

Figure SAF-1: Vulnerable Communities and Seismic Hazards



SOURCE: ESA, 2022; BCDC, 2020; City of Oakland, 2021; ALAMEDA County GIS, 2021; Dyett & Bhatia, 2021

Figure SAF-2: Vulnerable Communities and Landslide Hazards

BERKELEY
PIEDMONT
EMERYVILLE
ALAMEDA
SAN LEANDRO
Oakland International Airport
Lake Merritt
Lake Chabot
San Francisco Bay
Coast Guard Island Alameda
To Antioch
To Richmond
To San Francisco
To Berryessa/ North San Jose
Claremont Ave
Tunnel Rd
Dwight Way
Ashby Ave
Alcatraz Ave
College Ave
51st St
Piedmont Ave
Oakland Ave
Broadway
Park Blvd
Lincoln Ave
35th Ave
Skyline Blvd
Keller Ave
Golf Links Rd
Macarthur Blvd
Bancroft Ave
Fruitvale Ave
Davis St
23rd Ave
14th Ave
E 20th St
E 21st St
High St
Foothill Blvd
Bancroft Ave
Seminary Ave
73rd Ave
77th Ave
82nd Ave
98th Ave
Dutton Ave
E 14th St
Harrison St
Grand Ave
Telegraph Ave
San Pablo Ave
Powell St
W Grand Ave
Mandela Pkwy
Adeline St
Market St
MLK Jr Way
11th St
14th St
E 12th St
International Blvd
San Leandro St
Park St
Edes Ave
Hegenberger Rd
Oak St
Posey Tube
Webster St
Broadway
Versailles Ave
Park St
Grand St
Otis Dr
Santa Clara Ave
Doolittle Dr
Main St
Pacific Ave
Sea View Pkwy
Island Dr
Maitland Dr
Jack London Square Ferry Terminal
Alameda Gateway Ferry Terminal
Bay Farm Island Ferry Terminal
13
24
580
980
880
80
123
61
185

Existing Landslide Areas
Landslide Hazard (USGS)
- Mostly Landslides
- Few Landslides
- Surficial Deposits

Landslide Zones (CGS)
- Landslide Seismic Hazard - Zone of Required Investigation

Social Vulnerability Rank
- Highest Social Vulnerability

- BART Stations
- Ferry Terminals
- BART Lines
- BART Airport Connector
- Bus Rapid Transit Line
- Ferry Routes
- Railroads
- Major Highways
- Major Roads
- Parks
- City of Oakland
- Alameda County

0 0.5 1 2
MILES

SOURCE: BCDC, 2020; CGS Information Warehouse, Department of Conservation, data accessed 2022; MTC/ABAG Hazard Viewer, data accessed 2021; City of Oakland, 2021; ALAMEDA County GIS, 2021; Dyett & Bhatia, 2022

GOALS AND POLICIES

GOAL SAF-1: MINIMIZE THE RISK TO LIFE AND PROPERTY CAUSED BY SEISMIC AND GEOLOGIC HAZARDS.

SAF-1.1 **Seismic Hazards.** Develop and continue to enforce and carry out regulations and programs to reduce seismic hazards and hazards from seismically triggered phenomena. Prioritize programs in areas of highest seismic risk and seismic vulnerability.

SAF-1.2 **Structural Hazards.** Continue, enhance, or develop regulations and programs designed to minimize seismically related structural hazards from new and existing buildings.

SAF-1.3 **Limit Development in Hazardous Areas and Minimize Erosion.** Minimize threat to structures and humans by limiting development in areas subject to landslides or other geologic threat and undertake efforts to limit erosion from new development.

SAF-1.4 **Seismic Hazard Coordination.** Work with other public agencies to reduce potential damage from earthquakes to "lifeline" utility, economic, and transportation systems, including Caltrans; BART; PG&E, EBMUD, and other utilities providers; the Port of Oakland; and others.

2.2 FIRE

WILDFIRE/WILDFIRE URBAN INTERFACE

As climate change exacerbates drought conditions in California, wildfire threats have become increasingly common. A wildfire is any uncontrolled fire on undeveloped land that requires fire suppression. According to the City of Oakland 2021 – 2026 Local Hazard Mitigation Plan, wildfires are common in the Bay Area, with large historic wildfires recorded in 1961, 1962, 1964, 1965, 1970, 1981, 1985, 1988, and 1991. Between 1954 and 2020, FEMA issued major disaster (DR), emergency (EM) and fire management assistance declarations for two fire hazard-related events in Alameda County. The 1991 Oakland Hills Fire (Tunnel Fire) killed 25 people, injured 150 others, burned 1,520 acres, destroyed thousands of homes, and caused $1.7 billion in losses. The high winds, steep terrain, and heavy fuel load made fighting this historic wildfire a major challenge. Major wildfires that occur outside the city still have profound impacts on economies, health, and ecosystem function throughout the region.

State law requires the California Department of Forestry and Fire Protection (CAL FIRE), to identify areas, or zones, of very high fire hazard severity potential under the Fire and Resources Assessment Program (FRAP). These Fire Hazard Severity Zones (FHSZ) are mapped and identified based on expected burn probabilities, potential fuels over a 30- to 50-year time period, and their correlated expected fire behavior, in order to better predict possible vegetation fire exposure to buildings and developments. As shown in **Figure SAF-3**, the eastern portion of the city in the Oakland Hills is designated as a Very High Fire Hazard Severity Zone (VHFHSZ) and a Local Responsibility Area (LRA), where local governments have fiscal responsibility for wildfire protection. This portion of the city is adjacent to State Responsibility Areas (SRAs), where the State has responsibility for wildfire protection, also designated as VHFHSZ. Approximately 10,800 acres of land in Oakland are designated as VHFHSZ, representing approximately 22 percent of land area in City limits. This is the largest VHFHSZ by acreage within a Bay Area city boundary. CAL FIRE is currently updating these maps to reflect climate change and wind activity patterns, with likely expanded areas designated at higher tiers of wildfire threat.

Additionally, the Oakland Hills area is largely defined as part of the wildland-urban interface (WUI). The WUI is an area where structures and other human development meets or intermingles with undeveloped wildlands. This designation is based on the fuel load, weather and terrain factors that influence fire likelihood and fire behavior. The mapped WUI includes these areas mapped as VHFHSZ and includes additional land area further west in the more developed areas of the city. While many of the fires in the WUI are small and can be controlled, the proximity of dense residential communities to areas that are fire-prone increases the hazard of wildfire in Oakland. Larger fires in this ecosystem should be anticipated every 10-20 years.[11] Wildfire in the urban interface is a growing concern in the Bay Area. In the past 60 years, the region has experienced over 500 wildfires which have threatened public safety, property, infrastructure, air quality, water quality, and natural environments. [12]

A significant number of structures are vulnerable to wildfire in the City. As of 2008, California State Building code requires minimum standards be met for new buildings in fire hazard severity zones. Most housing in the city—84 percent—was built prior to this code requirement (U.S. Census, 2020). It is unknown how many of these structures are in fire hazard zones, though the 2021-2026 LHMP estimates that 13 percent of Oaklanders (over 15,000 homes) reside in either a high or very-high wildfire severity zone. Any proposed development in the VHFHSZ must comply with state and city requirements for building standards, vegetation management, points of egress, and other measures, as well as other policies included in this Element. As described in the LHMP, an estimated 35 percent of the critical facilities in the city are located in wildfire risk areas, with many of these facilities believed to be wood-frame. Because these facilities could have a significant amount of functional downtime after a wildfire, both mitigation and operations planning continuity will be necessary to develop procedures for providing services under circumstances where access to critical facilities is limited.

11 City of Oakland, 2017. City of Oakland General Plan Update, Safety Element. Available online: https://www.oaklandca.gov/resources/safety-element

12 Association of Bay Area Governments (ABAG), 2021. Wildfires. Available online: https://abag.ca.gov/our-work/resilience/data-research/wildfire#:~:text=Wildfire%20Risk%20and%20Resources,destroyed%20 more%20than%208%2C000%20structures.

Further, tree mortality in the WUI increases the level of dead wood that can act as fuel. Increased fuel loading due to tree mortality increases the level of fire hazard for adjacent communities.[13] Climate change also compounds threat, as increased temperature and more frequent drought stress trees and speed up tree deaths, but also can result in less water storage in soils, reduced biomass in soils, and extended periods of dry grasses. All of these expand the risk of both fire ignition and severity. The California Public Utilities Commission (CPUC) maps these high fire-threat areas where there is a higher risk for power line fires igniting and spreading rapidly. As shown on **Figure SAF-4**, tree die-back in East Bay Regional Parks (e.g., Reinhardt, Anthony Chabot) puts adjacent areas of Oakland at risk for wildfire impacts, including secondary impacts of air and water pollution, erosion, and landslides.

URBAN FIRE

An urban fire is a fire that can rapidly spread to adjoining structures and damage or destroy large commercial buildings, apartment complexes, and other residential or commercial facilities. As described previously, much of the fire hazard that Oakland faces is due to the proximity of dense, residential communities and urban areas to areas with high fire risk due to steep slopes, vegetation that can act as fuel for fires, and seasonal winds which can spread fire. The primary factors affecting the risk of structural fire are the age and condition of the building or structure, its proximity to other structures, and the methods and materials used in its construction. As the City grows and development becomes denser, the possibility of urban fires increases.

Urban fires usually result from sources within buildings themselves, though recently the region has also observed an uptick in fires originating in homeless encampments. Smoking in bed, faulty wiring, children playing with matches, and appliance malfunctions are often causes of structural fires. Additionally, cinders from wood-burning fireplaces that remain alive and travel considerable distances have also been blamed for starting fires near residential locations. Therefore, urban fires can generally be mitigated through implementing and enforcing proper building code requirements, reducing the prevalence of gas lines and appliances, adherence to fire flow requirement minimums, and instituting zoning or subdivision ordinance requirements as described in the Institutional and Regulatory Framework section.

SOCIAL VULNERABILITY

Global climate change has contributed to greater frequency and severity of extreme climate and weather, with increased chance of compound extreme events such as concurrent heat waves and droughts as well as fire weather.[14] While Oakland enjoys a relatively temperate climate due to its bayfront location, changes in climate conditions are already affecting the city, and felt most acutely by frontline communities.

Based on the location of the WUI area and vulnerable communities, higher-income and white residents who make up the majority of the population in the Oakland Hills are more likely to be at significant risk to wildfires. Uncontrolled wildland fires do have the risk of spreading beyond the very high and high vulnerability areas into urban areas, which could impact socially-vulnerable populations. Additionally, the entire city will be impacted by wildfires occurring throughout the metropolitan region via impacts on air/wildfire smoke, water, and soil quality; damage to energy infrastructure and roads; and strain on local firefighting resources as the fire department is called to respond to fires across the region and state. Unhoused populations, outdoor workers, residents who live in poorly insulated or ventilated homes, and people who are already burdened by elevated local (indoor/outdoor) pollution are increasingly at risk due to the consequences of climate change that have exacerbated the now-annual "smoke season." Goals and policies developed by the City will work to mitigate fire hazards while prioritizing adaptation for socially vulnerable groups through compliance with state laws, fire safe development regulations, and local policies and programs.

VHFHSZ and Housing Development

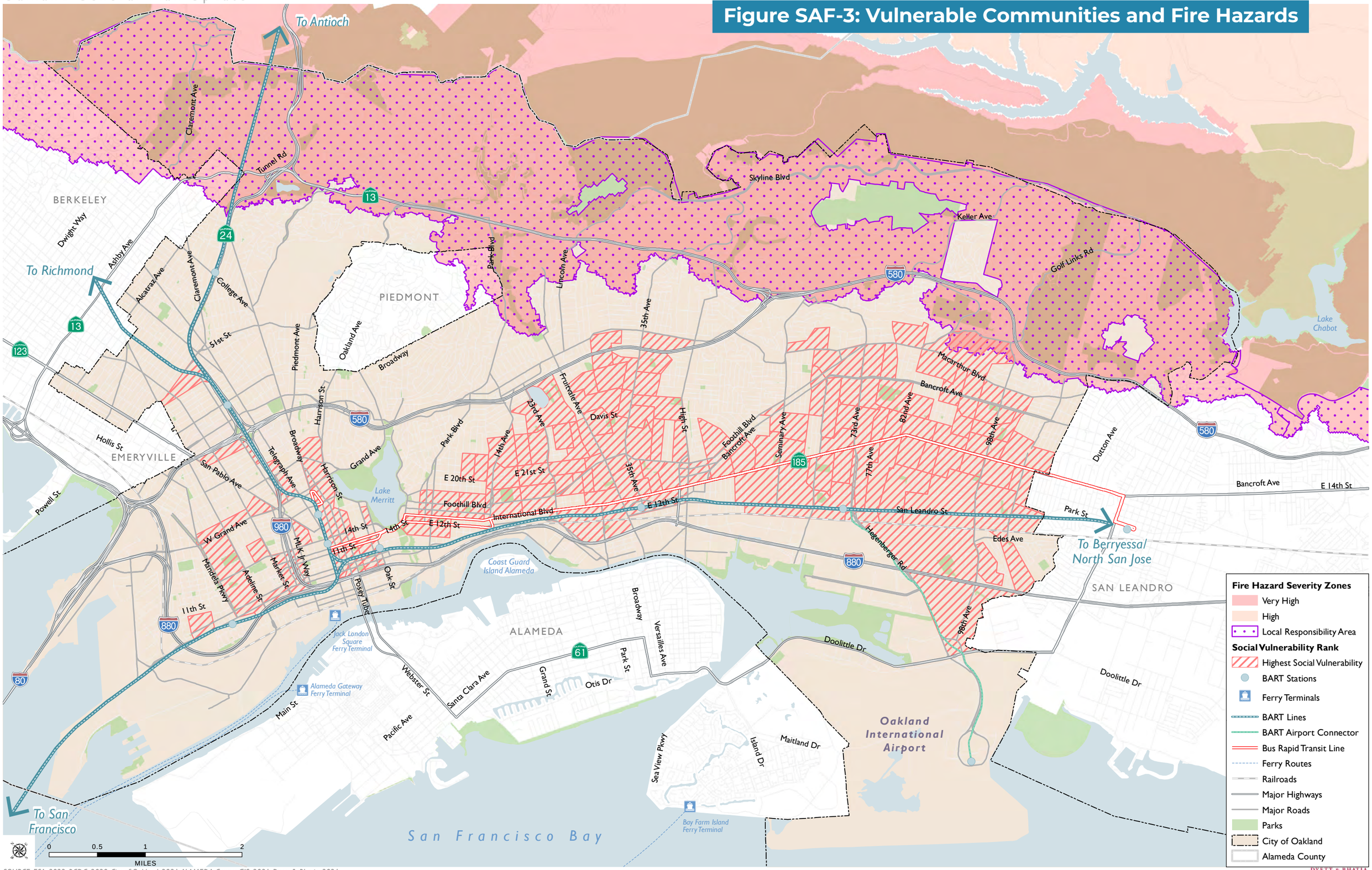
As described previously, the Oakland Hills are largely within a very high fire hazard severity zone/wildland urban interface. Much of the land in the hills is currently zoned for either open space (OS), or Hillside Residential (RH), which is intended to maintain, and enhance residential areas that are primarily characterized by detached, single unit structures on hillside lots. One of the purposes of zoning is to protect public health; for example, preventing a large amount of development in the fire-prone hills is one way to avoid strain on evacuation routes. However, as described in the EJ and Safety Elements, single-family zoning has also explicitly been used as a tool to racially segregate neighborhoods. While civil rights legislation outlawed overt housing discrimination in the 20th century, exclusionary zoning policies that restrict higher density-housing continue to have the effect of limiting racial and economic diversity in these areas.

As part of efforts to advance racial equity, policies in the General Plan attempt to balance fire safety considerations with actions that further opportunity in exclusionary single-family areas. For example, the City is proposing an Affordable Housing Overlay, which allows 100 percent affordable developments by-right in select areas located in the VHFHSZ that have adequate emergency access and evaluated for congestion issues in emergency wildfire scenarios (see "Emergency Evacuation" in Chapter 4). Coupled with any zoning changes, the City will continue to require that new development prepare a Fire Protection Plan (Policy SAF-2.3) and will implement specific policies to aid evacuation in these constrained areas.

13 CAL FIRE, 2022. Tree Mortality. Available online at https://frap.fire.ca.gov/frap-projects/tree-mortality/. Accessed January 10, 2022.

14 Intergovernmental Panel on Climate Change (IPCC), Climate Change 2021: The Physical Science Basis (Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change), Cambridge University Press, 2021,

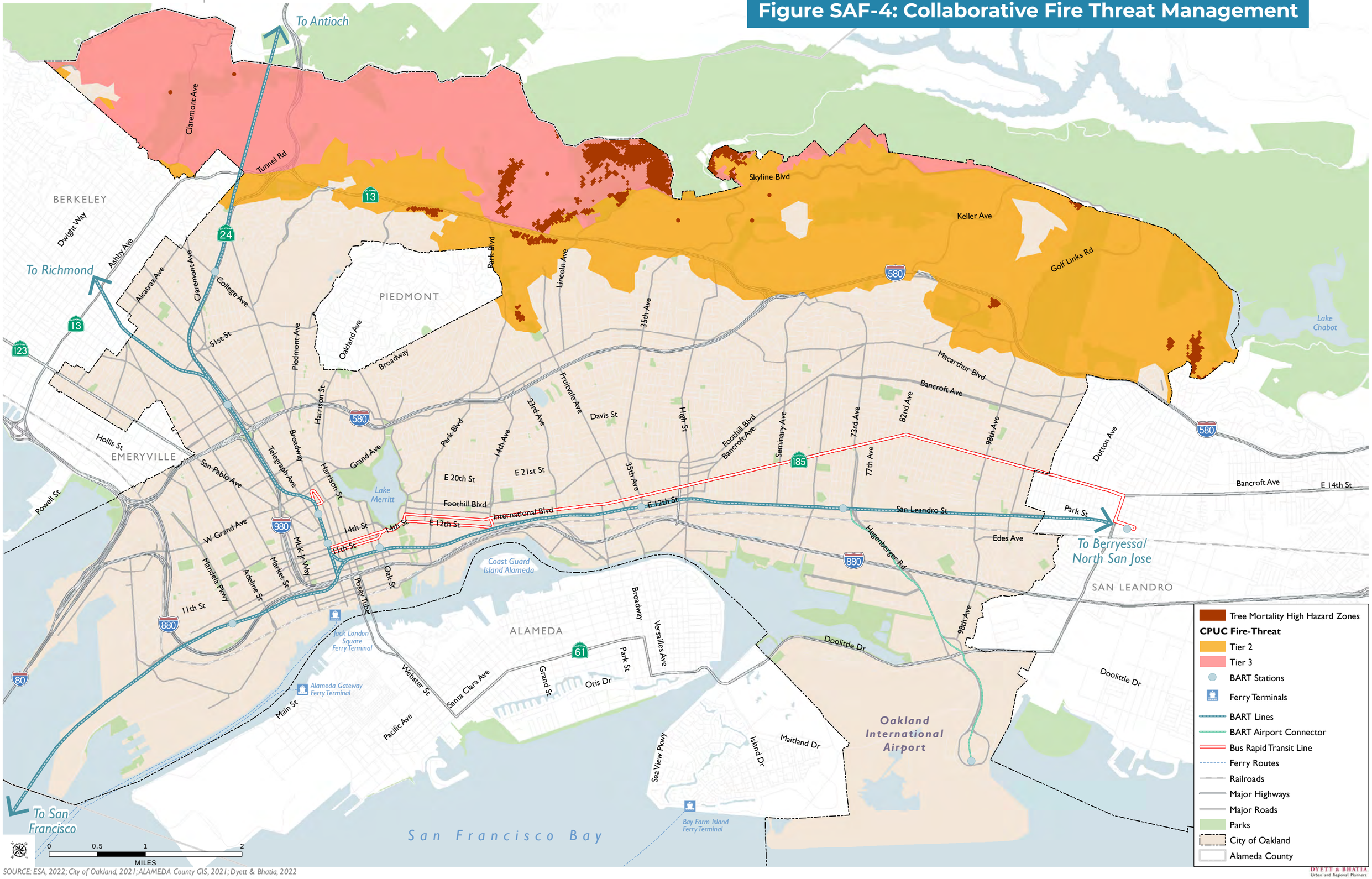
Figure SAF-3: Vulnerable Communities and Fire Hazards



SOURCE: ESA, 2022; BCDC, 2020; City of Oakland, 2021; ALAMEDA County GIS, 2021; Dyett & Bhatia, 2021

DYETT & BHATIA
Urban and Regional Planners

Figure SAF-4: Collaborative Fire Threat Management



SOURCE: ESA, 2022; City of Oakland, 2021; ALAMEDA County GIS, 2021; Dyett & Bhatia, 2022

DYETT & BHATIA
Urban and Regional Planners

INSTITUTIONAL AND REGULATORY FRAMEWORK

Fire Safe Development Codes

The California Fire Code (Title 24, Part 9 of the California Code) establishes regulations to protect life and property from the hazards of fires in new and existing buildings and structures. The provisions of the Fire Code apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal, and demolition of buildings or structures throughout California. Public Resources Code 4291 includes regulations and defensible space requirements for areas located in SRAs. The City adopted and amended the 2019 California Fire Code and regulates fire safety in Chapter 15 of the Oakland Municipal Code (OMC). Additionally, the OMC includes a vegetation management inspection program to inspect properties in VHFHSZs for proper vegetation management and includes a chapter of special construction requirements in fire hazard areas in the areas damaged by the 1991 Tunnel Fire.

Peakload Water Supply Requirement

The Fire Code stipulates fire-flow requirements for buildings.[15] Fire-flow is the rate of a water supply, measured at 20 pounds per square inch (psi) (138 kPa) residual pressure, that is available for firefighting. Fire-flow minimums vary depending on building use, building size, and if a sprinkler system is provided. Water mains serving one- and two-family dwellings, townhouses, and group homes must provide a fire-flow of 1,000 gallons per minute (gpm) for buildings without an automatic sprinkler system, or 500 gpm for buildings with fire protection devices such as automatic sprinkler systems. The required fire-flow standard for commercial, industrial, manufacturing, and large apartment buildings varies from 1,500 to 8,000 gpm based on the type of construction, type of use, and any built-in fire protection devices. School buildings are within Appendix BB of the Fire Code and range between 1,500 to 8,000 gpm depending on type and square footage.

15 California Fire Code 2019, Appendix B Fire-Flow Requirements for Buildings. Table B105.1(1) and Table B105.1(2).

According to the East Bay Municipal Utility District's (EBMUD) Water Shortage Contingency Plan, Oakland obtains most of its water supply from the Mokelumne River, EBMUD's primary water source. Water flows into Oakland primarily through the Claremont tunnel from the Orinda water treatment plant, then through several aqueducts and large transmission mains into smaller distribution mains supplying the entire city; at the same time, water is stored at various reservoirs located throughout the city. EBMUD is actively planning and implementing additional sources of water supplies from multiple sources, including development of the Bayside Groundwater Project to bank excess water in wet years and withdraw water in drought years, increasing the production and delivery of recycled water in its service area, use of the Freeport Regional Water Facility Long Term Renewal Contract with the U.S. Bureau of Reclamation, and developing water transfers and contracts with other water agencies. The Oakland Fire Department participates in annual meetings with EBMUD and other local jurisdictions to plan for adequate water capacity.

Minimum Road Widths and Clearances Around Structures

Clear emergency vehicle access to buildings is very important in the event of a fire or seismic event. Such access is regulated by the adopted and amended Fire Code. Under the current Fire Code, all portions of a building shall be within 150 feet of a serviceable fire access road. Fire apparatus access roads shall be all weather roads with a minimum width of 20 feet. However, many streets in the Oakland Hills do not meet current Municipal Code Standards for minimum width and are in steep areas without off-street parking; therefore, residents park on the narrow streets making the streets even narrower and less accessible for emergency responders.[16] Additionally, city infrastructure surveys have shown that the VHFHSZ has many narrow streets with dead ends. Considering these factors, conditions related to emergency response are currently not adequate to serve the population living in the VHFHSZ.

Prompted by community members' concerns and the leadership of City councilmembers in Council Districts 1 and 4, the City of Oakland continues to develop solutions to address a serious public safety issue regarding emergency vehicle access through narrow streets. This is especially an issue in Oakland's hills where residents have reported delays in emergency response due to parked cars blocking the roadway, leaving too narrow a space for typically-larger emergency vehicles to safely pass. New signs and enforcement efforts were launched in 2017, with input from the Oakland Fire Department, Oakland Public Works, the Oakland Department of Transportation and the City Administrator's Office. The Fire Department has also explored legislation that would formally prohibit all street parking in the hills on Red Flag Days which are issued by the National Weather Service for weather events which may result in extreme fire behavior that will occur within 24 hours.

Creating defensible space, or the clearance around structures, is another mechanism for improving a building's chance of surviving a wildfire by limiting combustible materials and vegetation up to a 100 feet radius around the structure. The Fire Code requires buildings and structures within areas designated as a VHFHSZ to maintain defensible space. In the adopted and amended Fire Code, the City of Oakland is required to maintain an effective 30-foot defensible space by removing and clearing away flammable vegetation and combustible growth from structures. The OMC and vegetation inspection program requires that owners of both vacant and developed lots in the area comply with fire-hazard-abatement requirements, which include removal of overgrown grass, brush and weeds; the removal of low-hanging tree branches, street-address numbers visible from the road;

16 City of Oakland Planning Commission, 2021. Case File Number ZA21006 Staff Report. June 2, 2021. Available online: https://oaklandside.org/ wp-content/uploads/2021/06/02-Staff-Report-020621_CPC_Staff_ReportUpdated-signed.pdf

and maintenance of firebreaks, which area natural or constructed barrier used to stop or check fires that may occur or to provide a control line from which to work. To align with the City's objective of preserving and enhancing green infrastructure networks, it is important that the provision of defensible space does not result in the expansion of impervious surface area. Property owners should integrate defensible space strategies with green infrastructure as much as possible.

In 2021, planning efforts were initiated to develop a Vegetation Management Plan, which includes various activities, such as goat grazing, vegetation clearing and monitoring, and brush clearance for more than 1,400 acres of City property plus 300 acres of roadside treatment areas within the designated VHFHSZ in the Oakland Hills. Policies and actions in the General Plan support development and implementation of the Vegetation Management Plan and consideration of other methods to provide ongoing revenue for additional efforts for vegetation management. The Vegetation Management Plan is expected to be adopted in winter 2023/2024.

Responsible Agencies

There are several agencies responsible for fire prevention and emergency response in the Bay Area. This Element emphasizes interagency coordination and planning efforts between the City of Oakland and the following agencies to best mitigate and adapt to urban fire and wildfire. In addition, the City aims to closely consult and coordinate with community-based organizations in order to best engage residents about fire hazards. Such community groups may include the Greenlining Institute, Oakland Climate Action Coalition, and Communities for a Better Environment.

The California Department of Forestry and Fire Protection (CAL FIRE) manages fire prevention and response for the State of California. CAL FIRE oversees enforcement of California's forest protection regulations, implements fuel management projects, participates in forest conservation and management, and provides training and educational programs. CAL FIRE also engages in general emergency response activities.

Fuel Reduction and Management

In December 2021, the City was awarded over $820,0000 in new grant funding from CAL FIRE to selectively remove approximately 250 dead, dying, or otherwise hazardous trees, and selectively prune hazardous branches on trees lining or overhanging the Skyline Boulevard Evacuation Corridor, beginning at Shepherd Canyon Road and ending at Keller Avenue, and plant 150 Oak trees to serve as shaded fuel breaks. Starting in 2022, tree crews have been working closely with the Oakland Fire Department (OFD) and the Public Works Department to advance the project. These funds come from CAL FIRE's budget available for distribution for fire fuels reduction projects.

The Oakland Fire Department is the primary emergency response service provider for the City of Oakland, and provides comprehensive strategies and training in fire prevention, fire suppression, emergency medical services, all risk mitigation, emergency preparedness, 911 services and community-based fire services.

The Vegetation Management Unit (VMU) serves to inspect properties in the Oakland Hills, much of which is designated as a VHFHSZ. The VMU works under the Oakland Fire Department's Fire Prevention Bureau. The VMU is responsible for the inspections of over 20,000 homes and vacant parcels in the VHFHSZ. The purpose of these inspections is to identify and mitigate hazards that could contribute to the spread, growth, and intensity of wildfire. The VMU conducts inspections annually, and property owners are required to actively maintain their parcels in a fire-safe condition year-round.

The Emergency Management Services Division (EMSD) exists within the Oakland Fire Department and is the primary agency responsible for responding to, recovering from, and mitigating against any hazard that affects the City of Oakland.

GOALS AND POLICIES

GOAL SAF-2: PROACTIVELY PREVENT URBAN FIRES AND EXPOSURE TO WILDFIRE AND PROTECT COMMUNITY MEMBERS AND PROPERTY FROM FIRE DANGER.

SAF-2.1 Structural Fires. Continue, enhance, or implement programs that seek to reduce the risk of structural fires. Prioritize programs in areas with greatest risk and greatest social vulnerability.

SAF-2.2 Vegetation and Urban Forest Management. Manage vegetation and the urban forest to reduce combustible load, erosion, and other risks exacerbated by climate change.

- Adopt and fully implement a Vegetation Management Plan for high-fire risk areas. Continue to update and enforce the Oakland Fire Code to require building owners in high-risk areas to maintain defensible space and implement fire prevention measures. As part of the Vegetation Management Plan, build partnerships with and consult indigenous groups on sacred burning and other traditional fire suppression techniques.
- Implement the Urban Forest Master Plan, a comprehensive, area-wide urban canopy and vegetation plan that identifies locations where trees can be added and maintained, such as parks, streets, and rights-of-way. As a follow-up action, proactively address soil sequestration of carbon and water in frontline communities most affected by wildfire and other climate risks. *See Environmental Justice Element policy EJ-6.16 for other urban forest objectives.*

SAF-2.3 Development in the Very High Fire Hazard Severity Zone (VHFHSZ). Prioritize development in areas with existing adequate road networks, evacuation routes, and water infrastructure. Require any new development in the Very High Fire Hazard Severity Zone to prepare a Fire Protection Plan that minimizes risks by:

- Assessing site-specific characteristics such as topography, slope, vegetation type, wind patterns etc.
- Siting and designing development to avoid hazardous locations (e.g. through fire breaks) to the extent feasible.
- Incorporating fuel modification and brush clearance techniques in accordance with applicable fire safety requirements and carried out in a manner which reduces impacts to environmentally sensitive habitat to the maximum feasible extent.
- Using fire-resistant building materials and design features, such as visible signage, consistent with the adopted Oakland Municipal Code and Fire and Building Code standards.
- Using fire-retardant, native plant species in landscaping.
- Complying with established standards and specifications for fuel modification, defensible space, access, and water facilities.
- Banning fuel storage (e.g., fuel storage for power generators) in VHFHSZ.
- Requiring street improvements to comply with minimum fire road access standards.
- Disallowing new subdivisions in areas with less than two evacuation routes (as shown in **Figure SAF-11d**), unless a development were to be able to provide additional connections to ameliorate this condition.

SAF-2.4 Slope-Density Regulations. Reduce permitted development densities and intensities by slope tiers—such as between 15 and 30 percent slope, and greater than 30 percent slope—in hills/hillside areas. *This consideration would be considered and reflected as part of the LUTE update.*

SAF-2.5 Financial Assistance. Identify or develop programs to provide financial incentives or assistance to low-income households for defensible space maintenance, home hardening, and other measures to reduce risk.

SAF-2.6 Agency Coordination. Continue to participate not only in general mutual-aid agreements but also in agreements with adjoining jurisdictions and other public agencies for cooperative response to fires, including multi-jurisdictional programs and task forces.

SAF-2.7 Protect Against Smoke and Wildfire. Improve access to better indoor air quality to protect against smoke and wildfire through methods such as requiring installation of MERV filters in new developments and identifying additional clean air centers and resilience spaces within residential areas.

SAF-2.8 Water Infrastructure. In partnership with EBMUD, plan for the ongoing maintenance and long-term integrity of planned and existing water supply infrastructure, including peak load water supply.

2.3 CLIMATE CHANGE

The consequences of climate change are intensifying worldwide, underscoring the urgent need for action. California is one of the most "climate-challenged" regions of North America; its historical climate is highly variable, and climate change is making extreme conditions more frequent and severe.[17] Given the complexity of the global climate system and the significant uncertainty regarding long-term greenhouse gas emissions, the results of different climate change projections can look quite different. See the City of Oakland's Climate Change Vulnerability Assessment for more information regarding climate projections that inform this Safety Element. Because climate change is cross-cutting, goals, actions, and policies related to climate change are incorporated into each associated hazard, as well as in the Environmental Justice Element.

In the San Francisco Bay Area, annual maximum temperatures have already increased by 1.7°F from 1950-2005, sea levels have risen over eight inches in the last 100 years, and several studies suggest that the coastal fog critical to the Bay Area climate is less frequent than before. Such changes will also affect the natural ecosystems that characterize the Bay Area, such as becoming less suitable for the iconic redwood forests that once dominated the region.[18] Despite global efforts to reduce greenhouse gas emissions, changes in temperature, precipitation, and sea level rise are projected to increase significantly in the coming decades and will produce substantial impacts on Bay Area social systems and the built environment as well as natural and managed resource systems. Oakland is among a growing number of Bay Area local governments, agencies, nonprofits, and private sector stakeholders that are taking actions that advance climate adaptation and resilience, including through its 2030 ECAP.

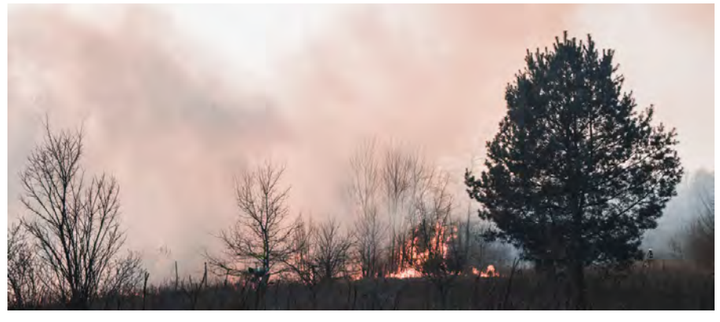
17 Louise Bedsworth, et. al., "California's Fourth Climate Change Assessment Statewide Summary Report," California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, California Public Utilities Commission, 2018, https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf. Accessed February 10, 2022.

18 David Ackerly, et. al., "California's Fourth Climate Change Assessment San Francisco Bay Area Summary Report," University of California, Berkeley, 2018, https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUMCCCA4-2018-005_SanFranciscoBayArea_ADA.pdf. Accessed February 10, 2022.

The continual emission of greenhouse gases (GHGs) and resulting effects on the climate crisis are an issue of equity. Frontline communities, those who have been and will continue to be hit first and worst by the impacts of environmental injustice and the climate crisis, are often the least able to adapt, resist, or recover from climate impacts.[19] For example, increasingly extreme climate conditions will have cost implications, such as energy costs needed to heat or cool a home. These additional costs will be felt more acutely by populations that are already impacted by severe housing, transportation, and/or healthcare cost burdens. Furthermore, neighborhood characteristics affected by historical disinvestment and other racial disparities create even more of a burden. For example, neighborhoods with fewer trees and green spaces or inadequate funding to maintain these resources would lack the benefits experienced by a neighborhood with ample shade and cooling from a healthy urban forest (discussed in the 'Urban heat and drought' section). Additionally, people who do not own a car and rely on public transportation may be exposed to extreme climate conditions, especially where public transportation infrastructure is not designed for these conditions.

Alameda County faces climate change exposures that pose considerable health risks to the population, especially to frontline communities. For further information on impacts to vulnerable groups, see the City of Oakland's Climate Change Vulnerability Assessment and the 2030 ECAP (see callout box on p. 4-3). Climate change will result in increased impacts on natural hazards, including wildfire, flooding, sea level rise, drought, and urban heat. Thus, the Safety Element incorporates a range of topics as well as climate change adaptation and resiliency strategies into its goals and policies.

19 City of Oakland, Oakland 2030 Equitable Climate Action Plan, 2020.



INCREASED IMPACTS ON WILDFIRE, PRECIPITATION CHANGES, SEA LEVEL RISE

As global climate change intensifies the frequency and severity of extreme climate and weather, it has led to an increased likelihood in compound extreme events, such as concurrent heat waves, droughts, and fire weather.[20] Historically, wildfire has exhibited a cyclical pattern within California—some years may see intense wildfire while others may not. As wildfire emerges from a variety of climate conditions including type of vegetative cover, precipitation, and temperature, wildfire severity will continue to fluctuate over time. However, climate change will favor many of the climatic conditions that make wildfire more likely, meaning that average wildfire intensity will gradually increase. Wildfire is associated with a host of secondary impacts such as smoke production and air quality issues, reductions in soil and water quality, landslides, erosion, and impacts to health, energy, and transit systems.

Climate change models predict changes in the seasonal distribution of precipitation, with rainfall becoming more concentrated in the winter months and falling in fewer, higher-intensity events. These changes may result in a number of secondary impacts, such as flooding, reduction in winter snowpack, drought, groundwater depletion, increased wildfire risk, changes in streamflow, and strain to health, energy, and infrastructure systems. Flooding effects will be felt most strongly in coastal and low-lying areas, and areas with inadequate stormwater infrastructure.

Projections for global sea level rise vary between one foot in the next few decades up to seven feet anticipated by 2100. According to sea level rise scenarios outlined in the City of Oakland 2021 – 2026 LHMP, the San Francisco Bay is projected to experience a 48-inch rise in sea level by 2050, and a 108 inch rise in sea level by 2100.[21] Potential for new or prolonged flooding as the sea level rises will increasingly reach beyond the city's shoreline; areas once considered to be outside of the floodplain will begin to experience periodic coastal and/

20 Intergovernmental Panel on Climate Change (IPCC), Climate Change 2021: The Physical Science Basis (Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2021,

21 California Ocean Protection Council, Sea-Level Rise Guidance, 2018.

or urban flooding, especially places like the Port of Oakland and the Oakland International Airport, which are chronically subsiding (i.e., sinking because they are built on bay fill) and are at higher risk of liquefaction during seismic events.[22] Neighborhoods/tracts that will be most affected by sea level rise are shown in **Table SAF-1**.

URBAN HEAT AND DROUGHT

Alongside the rise in global temperatures, precipitation patterns in California are also changing. Less precipitation is falling as snow, and more is falling as rain. Reduced winter snowpack will negatively impact local water availability, particularly during drought periods. Drought frequency may also increase as rainstorms become less likely during the summer months.

As of 2022, the entire state of California remains in extreme drought conditions due to a lack of rainfall and higher average temperatures as a result of climate change. Effects from drought may be felt most acutely in winter months, with drought periods also becoming more likely in the future. The driest winter months in 100 years mark the third year of drought for the state. January, February, and March of 2022 had the least rain and snow on record for any of these months in California. This is the state's second extreme drought in 10 years, indicating the impacts of a changing climate[23].

Climate change also affects public health: global temperature increases and exacerbated climate severity can lead to respiratory issues from wildfire smoke , an extended allergy season, and heat-related illness. Drought also has public health implications for food systems. As the ECAP notes, worsening climate change impacts, including prolonged drought, unpredictable weather patterns, fires, and flooding, are already straining and disrupting agricultural resources and food supply chains, which also exacerbate local food insecurity. Policies related to food security and accessibility are found in the Environmental Justice Element.

22 City of Oakland, 2021-2026 Hazard Mitigation Plan, July 2021, https://cao-94612.s3.amazonaws.com/documents/2021-07-01_OaklandHMP_AdoptedFinal-1.pdf.

23 California, State of. "Current Drought Conditions." California Drought Action, drought.ca.gov/current-drought-conditions/.

Table SAF-1: Top 10th Percentile Tracts by Indicator — Climate Change Topic

HEAT HEALTH EVENTS MAX TEMP		ENERGY COST BURDEN		SEA LEVEL RISE	
Tract Name[1]	**Score**	**Tract Name**	**Score**	**Tract Name**	**Score**
Panoramic Hill	1.00	**Lockwood/Coliseum/Rudsdale**	1.00	Port Lower*	1.00
		Lower San Antonio East	0.99	**Port Upper**	0.99
		Fitchburg	0.98	Acorn Industrial*	0.98
		Castlemont	0.97	**Brookfield Village/Hegenberger**	0.97
		New Highland	0.96	**Lockwood/Coliseum/Rudsdale**	0.96
		Brookfield Village	0.96	**Prescott/Mandela Peralta**	0.96
		Bancroft/Havenscourt East	0.95	**Chinatown/Laney**	0.95
		Seminary	0.94	**Jack London Square**	0.94
		Stonehurst	0.93	**McClymonds**	0.93
		Webster	0.92	**Melrose**	0.92
		Arroyo Viejo	0.91	Eastlake	0.91
		Sobrante Park	0.90	**Oakland Estuary**	0.90

Note: Bolded and green census tracts are EJ Communities.

1. Only includes one tract in top decile due to ties. Next highest score is 0.89.

**Indicates census tract with low population.*

While the combined effects of regional topography, oceanic currents, fog exposure, and onshore winds function like a natural air conditioner for the Bay Area, studies suggest that summertime fog off California has declined substantially, making warming near the coast as much of a concern as in inland areas. Increases in urban temperature may be felt most acutely by those living in urban heat islands – pockets of the urban environment where temperatures can dramatically exceed those in neighboring non-urban areas. The proliferation of paved surfaces in built environments can lead to these urban heat islands, especially in places where urban forestry and water bodies are not commonly found. This can further increase summertime cooling costs. For Oakland residents, this means that both the city's hills and flatlands will feel the heat, and the built environment will be a key driver for maintaining the comfort and health of Oaklanders.

Local hotspots in the city that will have increased heat exposure—including parts of Fruitvale/South Kennedy, the Coliseum Industrial Complex, Frick/Bancroft Business area, Castlemont, Oak Knolls-Golf Links/Chabot Park, Webster, and the Oakland International Airport area—are hotter than their surroundings. Urban heat island effects can be moderated by the cooling effects of trees and irrigation in urban landscapes, which have been estimated to reduce daytime summer temperatures across urbanized portions of the Bay Area by an average of 1.8°F. See the Environmental Justice Element for more information on efforts to increase tree canopy in underserved areas. Areas of greatest urban heat exposure, greatest energy cost burden, and greatest risk for sea level rise as identified as part of the EJ Communities screening analysis are shown in **Table SAF-1**.

2.4 HYDROLOGY AND FLOODING

HYDROLOGY

Flooding is the inundation of normally dry land as a result of a rise in the level of surface waters or the rapid accumulation of storm-water runoff. It becomes a hazard when the flow of water has the potential to damage property and threaten human life or health. Oakland is subject to riverine flooding, flash flooding, and stormwater flooding. Riverine flooding occurs when streams and rivers exceed the capacity of their channels to accommodate water flow and water overflows the banks, spilling out into adjacent land. The National Weather Service defines a flash flood as a "rapid and extreme flow of high water into a normally dry area, or a rapid rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event." Stormwater flooding occurs from a precipitation event that can overwhelm a stormwater management system, causing water to inundate roads and property.

The City of Oakland's watershed consists of 15 main creeks, over 30 tributaries, Lake Merritt, Lake Temescal, and the Oakland Estuary. According to FEMA's December 21, 2018, Flood Insurance Study (FIS), the City of Oakland drainage systems are adequate to carry low frequency storm runoff. However, larger storms can cause stormwater flooding.

FLOODING

Storm-Induced Flooding and Flood Hazard Zones

Flood hazards are mapped by the Federal Emergency Management Agency (FEMA) as part of the National Flood Insurance Program. The 100-year Flood Zone, which has a 1 percent annual chance flood risk, and 500-year Flood Zone, which has a 0.2 percent annual chance flood risk, are depicted in **Figure SAF-5**. Flood hazards are dynamic and can change frequently due to a variety of factors, including weather patterns, erosion, and new development. FEMA, through the Risk MAP program, works with communities to collect new or updated flood hazard data and periodically updates flood maps to reflect these changes. The primary areas of flooding in Oakland are along the shoreline of the San Francisco Bay, Oakland Estuary, and San Leandro Bay. Flooding is also associated with Lake Merritt and Glen Echo Creek, as well as Arroyo Viejo, Lion, Sausal, and Peralta creeks, and the areas near these bodies of water are at the most risk of being impacted during flood events. Most of the City's developed shoreline is not within the current 100-year Flood Zone, except the north part of the Oakland International Airport.[24] The LHMP estimates that there are approximately 14,600 structures in the 100-year Flood Zone, and major new development is also occurring in several areas along the shoreline, including the Brooklyn Basin area. While recent projects take sea level rise projections into account, areas that pre-date updated flood maps and the latest best available sea level rise science may be at risk of flooding in the future.

Historically, flooding has been the most frequent natural hazard occurring in Oakland, with most hazard associated with excess stormwater runoff from heavy rain. Since 1950, the National Climatic Data Center (NCDC) reported flood events, 26 of which were flash floods, within Alameda County, amounting to a total of $18,349,000 in lost property damages. As described in the City of Oakland 2021 – 2026 LHMP, Alameda County and the communities within it have experienced 12 flooding events since 1969 for which federal disaster declarations were issued. Many flood events do not trigger federal disaster declaration protocol but have significant impacts on their communities. Large floods can result in multiple severe and widespread impacts including damage to electric and transportation infrastructure, destruction of homes and businesses, increased rates of flood-borne disease, and loss of life.

Severe flooding in the region is often the result of a combination of topographic features; severe weather or excessive rainfall; and infrastructure characteristics such as inadequate stormwater drainage and elevated levels of impervious surface. Stormwater flooding is most likely to occur in areas with elevated levels of impervious surface and in places where stormwater infrastructure is impaired or inadequate.[25]

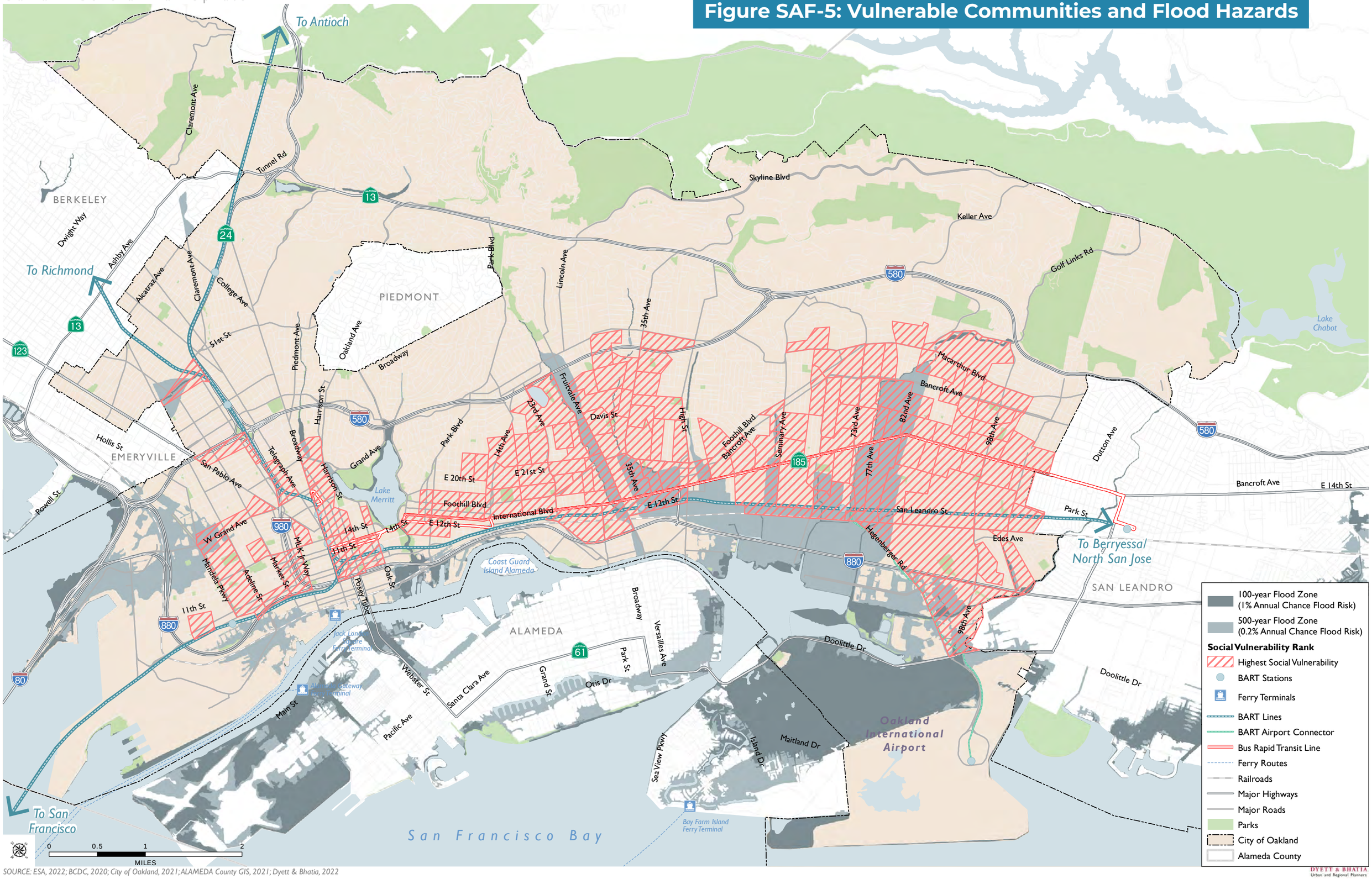
To help address storm-induced flooding in areas with inadequate stormwater drainage, the City of Oakland is developing a new Storm Drainage Master Plan that will include a detailed and comprehensive examination of, including condition and sizing, its storm drainage system, and will model flooding conditions and create a list of high priority capital projects for future work. This project is also identifying and developing conceptual plans for large green stormwater infrastructure (GSI) projects designed to capture stormwater from a large watershed area (from 1 to over 100 acres). If feasible to build, the large GSI projects would help alleviate flooding in specific areas with inadequate storm drainage. The project is also evaluating opportunities to daylight creeks where multiple benefits could be achieved such as urban greening, flood protection, and habitat enhancement. The Storm Drainage Master Plan will be completed in 2024.

In 2019, the City of Oakland developed a Green Stormwater Infrastructure Plan to comply with the California Regional Water Quality Control Board's Municipal Regional Stormwater Permit (MRP), work within the Alameda Countywide Clean Water Program, and to protect and restore watersheds within the City. "Green Stormwater Infrastructure" refers to a variety of practices and engineered facilities designed to detain and clean, capture and reuse, or infiltrate stormwater runoff to reduce the volume of runoff and improve water quality. In accordance with the City's Resilient Oakland Playbook, Oakland will use green stormwater

24 The portion of the airport designated by FEMA as Zone X indicates an area that is determined to be outside the 500-year flood and is protected by levee from 100-year flood.

25 2021 Local Hazard Mitigation Plan [LHMP]." City of Oakland, https://www.oaklandca.gov/topics/2021-local-hazard-mitigation-plan. Accessed 9 Sept. 2022.

Figure SAF-5: Vulnerable Communities and Flood Hazards



SOURCE: ESA, 2022; BCDC, 2020; City of Oakland, 2021; ALAMEDA County GIS, 2021; Dyett & Bhatia, 2022

infrastructure to manage stormwater and help reduce the risk of nuisance flooding, where feasible, from smaller storms.

See the Environmental Justice Element for more information on how the City plans to use green stormwater infrastructure and urban greening to address water quality issues and inequities in environmental justice communities.

Tsunami and Seiche

A tsunami is a series of high-energy waves that radiate outward like pond ripples from an area where a generating event occurs, arriving at shorelines over an extended period. Tsunamis can be induced by earthquakes, landslides, and submarine volcanic explosions. According to the 2016 Alameda County Local Hazard Mitigation Plan, tsunamis have not been a major problem in Alameda County or most of the Bay Area and have resulted in insignificant damage. Further, the hazard in the bay is much smaller than along the Pacific Coast, as the bay is an enclosed body of water. From 1812 to 2000, NOAA recorded 22 tsunamis in the Bay Area.

Flooding from tsunamis would affect low-lying areas along San Francisco Bay and the Oakland Estuary, especially filled areas that are only a few feet above sea level. Areas that could be flooded with several feet of water include the Bay Bridge landing, the outer and middle harbor of the Port of Oakland's seaport, the San Leandro Bay shoreline (including Martin Luther King, Jr. Regional Shoreline) and the Oakland International Airport's shoreline. Areas along the inner harbor, Brooklyn Basin and the tidal channel would be sheltered by the island of Alameda. The likelihood of large-scale devastation in Oakland resulting from tsunamis appears to be small, especially as there would usually be several hours to evacuate residents and undertake other emergency preparations for most tsunamis approaching the coast.[26]

A seiche is a resonant, side-to-side movement of water in a closed or mostly closed body of water such as the San Francisco Bay. The USGS defines a seiche as the sloshing of a closed body of water which can be caused from earthquake shaking. Unlike tsunamis, which are created by the sudden uplift of the sea floor, seismic seiches are standing waves that occur when an earthquake passes through the area. In Oakland, the only threat of large-scale damage from seiches appears to come from downstream flooding that would be caused by large volumes of water overtopping a dam or reservoir. Thus, the likelihood of large-scale devastation in Oakland resulting from seiches is minimal.[27]

Dam Failure and Inundation

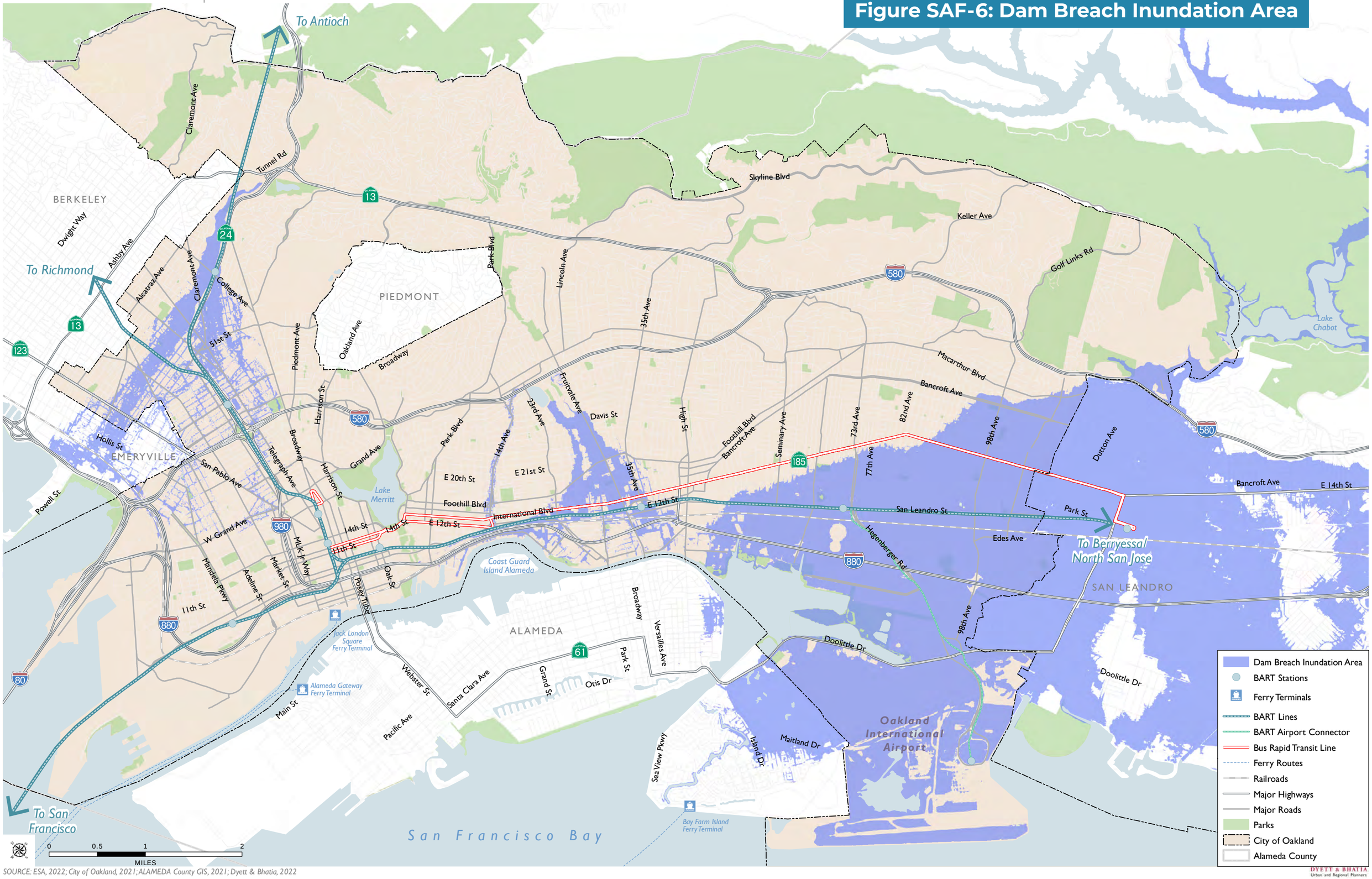
The California Department of Water Resources' Division of Safety of Dams reviews and approves inundation maps for extremely high, high, and significant hazard dams. There are four dams in Oakland that are considered extremely high hazard dams: Lake Temescal, Central, Dunsmuir Reservoir, and Chabot. Piedmont and Seneca dams are also in the vicinity, but they are considered a low hazard and do not have associated inundation maps. **Figure SAF-6** depicts the inundation areas for Lake Temescal, Central, Dunsmuir Reservoir, and Chabot dams.

According to the 2021 – 2026 LHMP, many dam failures in the United States have been secondary results of other disasters. The most common causes are earthquakes, landslides, extreme storms, equipment malfunction, structural damage, foundation failures, and sabotage. Poor construction, lack of maintenance and repair, and deficient operational procedures are preventable or correctable by a program of regular inspections. Terrorism and vandalism are serious concerns that all operators of public facilities must plan for; these threats are under continuous review by public safety agencies. Flooding from dam failure, while unlikely, could have catastrophic impacts on portions of North and East Oakland. However, the risk posed by dam failures is mitigated by the regulatory safeguards in place.

26 City of Oakland, 2004. City of Oakland General Plan, Safety Element. Available online: https://www.oaklandca.gov/resources/safety-element

27 City of Oakland, 2004. City of Oakland General Plan, Safety Element. Available online: https://www.oaklandca.gov/resources/safety-element

Figure SAF-6: Dam Breach Inundation Area



SOURCE: ESA, 2022; City of Oakland, 2021; ALAMEDA County GIS, 2021; Dyett & Bhatia, 2022

DYETT & BHATIA
Urban and Regional Planners

SEA LEVEL RISE

Oakland is bordered to the west by more than 20 miles of San Francisco Bay coastline. While the bay is an important biological, cultural, recreational, and economic resource, it also poses an environmental risk to residents and properties located near the waterfront. Sea level rise, the rise in global sea level accompanying other effects of global climate change, has already increased San Francisco Bay water levels by nearly eight inches in the last century.[28] As sea level rise increases further, it will increase the flooding hazard from the bay, especially during storm events.

Additionally, relatively new research by the SF Estuary Institute, (SFEI) UC Berkeley, and Pathways Climate Institute discussed in the Climate Vulnerability Assessment suggests that rising water tables caused by sea-level rise could result in previously unexamined hazards for residents and infrastructure in those areas. According to a report prepared by the Pathways Climate Institute and SFEI, "low-lying inland areas could flood from below by emergent groundwater long before coastal floodwaters overtop the shoreline."[29] Compounding the hazards associated with sea level rise related flooding alone, emergent groundwater can cause legacy soil contamination to migrate to the surface, mobilizing toxic liquids and waste from contaminated pits or piles. As discussed in the Environmental Justice Element, groundwater contamination hazards are more likely to affect low-lying census tracts closer to the waterfront than census tracts located in the Oakland Hills.

Following from the sea-level rise (SLR) projections used in the City's 2021-2026 LHMP, the 100-year coastal flood with 0.5 foot of SLR and 5.5 feet of SLR, respectively, provide a near-term and long-term indication of future flood hazards. For 0.5 foot of SLR (**Figure SAF-7**), the City's exposure to 100-year coastal flooding remains similar to present day, with Oakland International Airport being most at risk. A few other small sections of the City shoreline are also exposed to 100-year flood hazards. Potential for new or prolonged flooding as the sea level rises will increasingly reach beyond the city's shoreline; areas once considered to be outside of the floodplain will begin to experience periodic coastal and/or urban flooding, especially places like the Port of Oakland and the Oakland International Airport, which are chronically subsiding (i.e., sinking because they are built on bay fill) and are at higher risk of liquefaction during seismic events.[30]

SOCIAL VULNERABILITY

Lower-income areas and communities of color, particularly in Oakland's flatlands, are most affected by sea level rise hazards. Neighborhoods at risk of flood hazards primarily include Central/East Oakland, Coliseum/Airport, and census tracts in Eastlake/Fruitvale, and West Oakland. The dam breach inundation area affects the majority of Central/East Oakland as well as parts of Eastlake/Fruitvale and North Oakland. Sea level rise and tsunamis will primarily impact populations located along the coastline in West Oakland and Central/East Oakland, as well as the Port of Oakland and the Oakland International Airport.

Unhoused individuals are especially vulnerable to climate change impacts. Unhoused individuals experience elevated levels of exposure to environmental stressors such as high heat, poor air quality, and flooding. In the event of a climate emergency, unhoused populations may lack a secure place to shelter and they are often more difficult to reach via emergency alert systems.[31] Additionally, unhoused individuals may be overlooked during disaster planning initiatives, and often lack legal standing that may be required to access support services and resources during and after climate disasters. Vulnerable populations such as individuals with disabilities, children, and elderly populations also face unique challenges related to the impacts of climate change. For an in depth discussion of the relationship between social vulnerability and climate change in Oakland, please refer to the Climate Hazards and Vulnerability Assessment.

Goals and policies developed by the City will work to mitigate these flood and sea level rise hazards while prioritizing adaptation for socially vulnerable groups through the development of local policies and resilience programs in association with state guidance. Such policies will foster community and regional engagement for sea level rise planning. Coupled with policies on future sea level rise monitoring, findings from these engagement efforts will help the City establish planning thresholds for new development, sea level rise adaptation strategies, and other shoreline protection measures. Climate adaptation strategies called out in the 2030 ECAP include the development of at least three Resilience Hubs by 2030, two of which (those serving West Oakland and East Oakland) will be located in areas at risk of flood hazards.

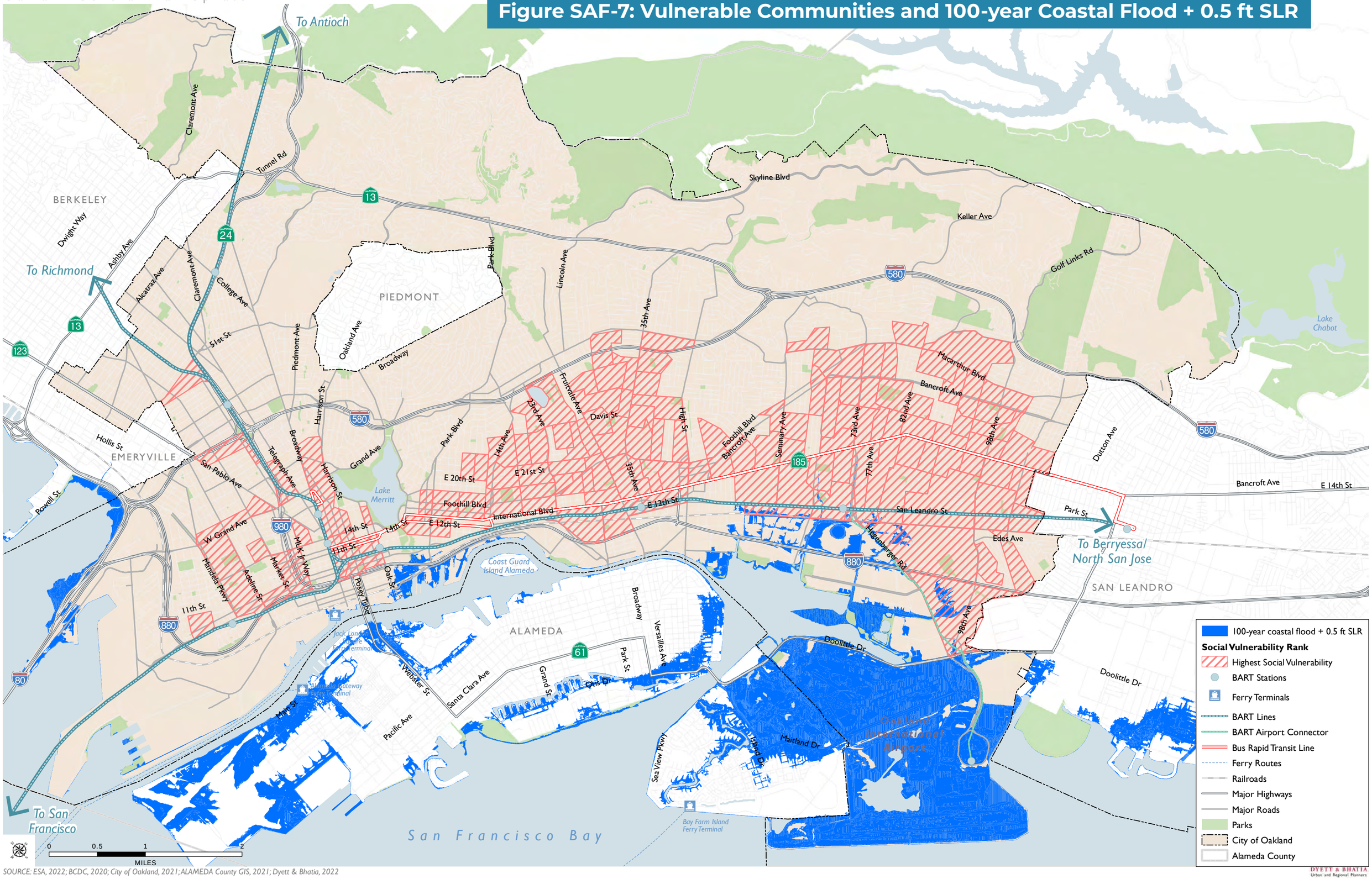
28 National Oceanic and Atmospheric Administration (NOAA), 2018. Center for Operational Oceanographic Products and Services (CO-OPS), NOAA Sea-Level Trends 1987-2018, 2018. tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9414290.

29 May, C. L.; Mohan, A.; Plane, E.; Ramirez-Lopez, D.; Mak, M.; Luchinsky, L.; Hale, T.; Hill, K. 2022. Shallow Groundwater Response to Sea-Level Rise: Alameda, Marin, San Francisco, and San Mateo Counties. Pathways Climate Institute and San Francisco Estuary Institute.

30 City of Oakland, 2021-2026 Hazard Mitigation Plan, July 2021, https://cao-94612.s3.amazonaws.com/documents/2021-07-01_OaklandHMP_AdoptedFinal-1.pdf.

31 Thomas, K., Hardy RD., Lazrus H., Mendez M., Orlove B., Rivera-Collazo, I., Roberts JT., Rockman M., Warner BP., Winthrop R., Explaining differential vulnerability to climate change: A social science review (December 2018). Oct 29 2019: https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.565.

Figure SAF-7: Vulnerable Communities and 100-year Coastal Flood + 0.5 ft SLR



SOURCE: ESA, 2022; BCDC, 2020; City of Oakland, 2021; ALAMEDA County GIS, 2021; Dyett & Bhatia, 2022

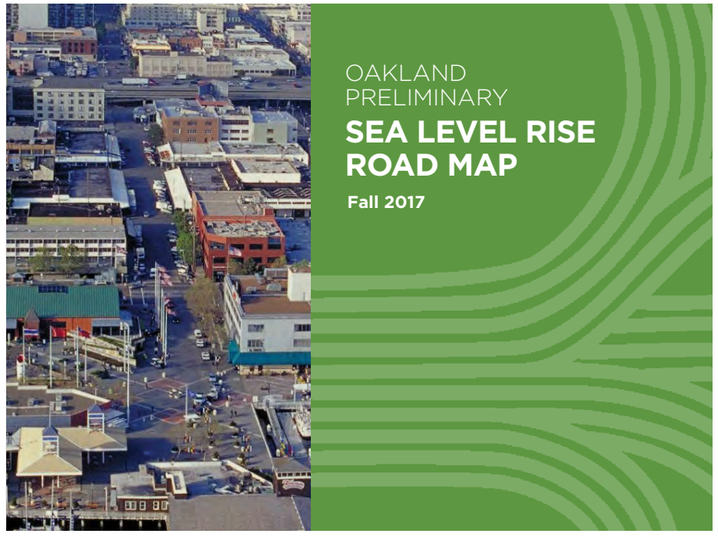
INSTITUTIONAL AND REGULATORY FRAMEWORK

FEMA is responsible for managing the 100-year floodplain, areas with a 1 percent or greater chance of flooding in any given year. A Flood Insurance Rate Map, an official FEMA-prepared map, is used to delineate both the Special Flood Hazard Areas (the 100-year floodplain) and the flood-risk premium zones in a community (as shown in **Figure SAF-5**). Under Executive Order 11988, FEMA requires local governments that are covered by the National Flood Insurance Program to pass and enforce a floodplain management ordinance that specifies minimum requirements for any construction within the 100-year floodplain. FEMA administers the National Flood Insurance Program, which includes floodplain management and flood hazard mapping and provides subsidized flood insurance to communities that comply with FEMA regulations to limit development in floodplains.

Current state guidance calls for preparing for at least 3.5 feet of sea-level rise by 2050.[32] These adaptation strategies will be incorporated into the goals and policies of the Safety Element. Should in the long-term future a regional sea level rise adaptation solution, such as water lock near the Golden Gate Bridge, be pursued, this would affect Oakland as well.

The City's ongoing efforts have begun to address how shorelines could be protected from sea level rise in the future. The 2017 Preliminary Sea Level Rise Road Map was developed as part of Resilient Oakland, a coordinated effort to align resources, plans, and actions in support of a thriving and resilient community. Oakland was competitively selected in December 2013 to join 100 Resilient Cities, an initiative pioneered by the Rockefeller Foundation that aims to help cities around the world build resilience to the social, economic, and physical challenges of the 21st century. Several groundbreaking sea level rise studies have already been conducted for parts of the Oakland shoreline. Based on these studies, critical assets such as highways, transit stations, schools, wastewater infrastructure, and landfills are anticipated to be impacted by sea level rise. The Road Map builds on the findings from those studies, as well as other work carried out by the City and community organizations, to document existing conditions, set forth potential actions to address these conditions, and continue focus on this critical area of the City's resilience. To address changes since the 2017 Sea Level Rise Road Map and incorporate the most recent climate data, the City Administrator's Office plans to update the Sea Level Rise Road Map in 2023.

Priority actions for the City of Oakland identified by the Sea Level Rise Road Map include identifying and pursuing engagement and collaboration opportunities, participating in regional coordination, better understanding neighborhood vulnerabilities, enabling climate-smart development, and identifying funding to develop a citywide comprehensive adaptation strategy. The Safety Element incorporates these priority actions in its goals and policies to ensure implementation is occurring in an efficient and appropriate manner. The Vulnerability Assessment also provides a starting place for community engagement around potential climate change impacts and resilience strategies. Under uncertain future climate change scenarios, protecting shorelines and adapting to sea level rise will need to continue to be an iterative process that requires community coordination and guidance. See the previous Climate Change section in this Element for more information regarding future climate change projections.



Responsible Agencies

There are several agencies responsible for flood management and emergency response in the Bay Area. This Element emphasizes interagency coordination and planning efforts between the City of Oakland and the following agencies to best mitigate and adapt to flooding and sea level rise. In addition, the City aims to closely consult and coordinate with community-based organizations in order to best engage residents about flooding hazards and sea level rise. Such community groups may include Save The Bay, SF Estuary Institute, and the East Oakland Collective.

The California Department of Water Resources engages in flood management and flood emergency response programs. It developed the Flood Emergency Response Information Exchange to improve flood emergency preparedness, response, and recovery. The Department also implements the Sustainable Groundwater Management Act and administers the California Statewide Groundwater Elevation Monitoring Program.

San Francisco Bay Regional Water Quality Control Board enforces waterway protection and pollution control regulations in Oakland. In 2009 it adopted the NPDES Municipal Regional Stormwater Permit (MRP), which requires the City to use GSI (aka Low Impact Development) to treat and control stormwater on-site for development projects that add/replace impervious surfaces. The permit also requires the City to retrofit five additional acres of existing impervious surface so that it is treated and managed by GSI between 2022 and 6/30/2027).

Bay Conservation and Development Commission (BCDC) has regulatory jurisdiction over existing and proposed land use changes and structures within 100 feet (inland) from the Bayshore's mean high water elevation. Sea Level Rise vulnerability and risk assessments are required when planning shoreline areas or designing larger shoreline projects in BCDC's jurisdiction. Risk assessments must be based on the best available estimates of future SLR. New projects on Bay fill, likely to be affected by future SLR and storm surge activity during the life of the project, must meet additional requirements, and when feasible, integrate hard shoreline protection structures with natural features that enhance the Bay ecosystem (e.g., including marsh and/or upland vegetation).

32 California Ocean Protection Council, 2020. Strategic Plan to Protect California's Coast and Ocean 2020-2025

Alameda County Flood Control & Water Conservation District plans, constructs, and maintains Western Alameda County's flood control systems such as creeks, channels, levees pump stations, reservoirs, and dams. It also performs hydrologic, geotechnical, and environmental studies, and enforces waterway pollution control regulations in waterways under Alameda County jurisdiction.

The Port of Oakland, under the direction of the Port Commission, has broad regulatory authority over trust lands granted pursuant to the Burton Act. The Port has its own land use and development code, and oversees the permitting of new construction and rehabilitation projects in its jurisdiction, though the Port must obtain building permits through the City's Planning and Building Department. Jurisdictional authority of the Port includes 20 miles of waterfront, and includes ground, commercial, retail, office, industrial, and maritime industrial leases, and landmarks such as Jack London Square.

The Emergency Management Services Division (EMSD) exists within the Oakland Fire Department and is the primary agency responsible for responding to, recovering from, and mitigating against any hazard that affects the City of Oakland.

GOALS AND POLICIES

GOAL SAF-3: PROTECT PEOPLE AND PROPERTY FROM FLOODING.

SAF-3.1 Minimize Storm Induced Flooding. Continue or strengthen city programs that seek to minimize the storm-induced flooding hazard.

SAF-3.2 Storm-Induced Flooding Structural Risk. Enforce and update local ordinances, and comply with regional orders, that would reduce the risk of storm-induced flooding.

SAF-3.3 Reestablish Full Compliance and Good Standing Under the National Flood Insurance Program (NFIP). The City will coordinate with FEMA Region IX and DWR to address all identified issues from the open September 2017 Community Assistance Visit (CAV) to reestablish the City's full compliance and good standing under the NFIP.

SAF-3.4 Flood Control Coordination. Continue to coordinate with FEMA, the Alameda County Flood Control and Water Conservation District (ACFCWCD), and the State Division of Safety of Dams on flood-control-related projects.

SAF-3.5 Green Stormwater Infrastructure. Fund and implement a green infrastructure program for the installation and maintenance of projects and existing civic resources such as the parks system and public spaces, to improve stormwater management, support biodiversity, reduce air pollution exposure, improve water quality, and increase access to natural spaces, including trees. Prioritize green stormwater infrastructure investment in frontline communities, particularly in residential neighborhoods dominated by concrete and asphalt with limited green space and elevated air pollution; in Priority Conservation Areas; and in areas where green infrastructure, including trees and other types of vegetated buffers, can effectively address stormwater management issues and reduce air pollution exposure among sensitive populations. *This policy is cross-listed as Action EJ-A.13 in the Environmental Justice Element.*

GOAL SAF-4: PROACTIVELY PLAN FOR IMPACTS OF SEA LEVEL RISE ON PEOPLE, PROPERTY, AND ESSENTIAL INFRASTRUCTURE.

SAF-4.1 Sea Level Rise and Community Engagement. As recommended in the Sea Level Rise Roadmap and ECAP, develop a plan for continuing collaboration with community groups and local organizations working to address sea level rise adaptation and building resilience of vulnerable communities. Work with communities to use community-generated data critical to future SLR mapping efforts.

SAF-4.2 Current Development and Sea Level Rise. Use in planning and development reviews, as applicable, the best available science about projected sea level rise and other climate change-related environmental changes when addressing flooding, potential for groundwater contamination, and other hazards associated with sea level rise.

SAF-4.3 New Development and Sea Level Rise. Develop sea-level rise standards/horizon that will guide adaption and resiliency planning as part of the updated Sea Level Rise Roadmap, including recommendations and regulations for a suite of shoreline protection measures (including ecologically-friendly adaptation options), protective setbacks, and other adaptation strategies, to be incorporated into future development projects.

SAF-4.4 Sea Level Rise Vulnerability Assessment. Require applicants proposing to develop in a future inundation area (as depicted in a SLR scenario to be determined in subsequent administrative regulations or documents) to conduct a Sea Level Rise vulnerability assessment for the project, prepare a Sea Level Rise Adaptation Plan for implementation as part of the project designs, and submit the assessment, adaptation plan, and conceptual design to the City for review and approval.

SAF-4.5 Evaluating Bay/Watershed Flooding Potential. In partnership with other agencies, including the Port of Oakland, the Bay Area Bay Conservation and Development Commission, and the ACFCWCD, re-evaluate both Bay flooding and watershed flooding potential at key milestones in the Safety Element's implementation horizon, to manage for changing sea level rise projections.

SAF-4.6 Sea Level Rise Regional Strategy. As part of the Sea Level Rise Roadmap update, continue to work with regional entities to address rising water levels in the San Francisco Bay and coordinate with the City's other climate adaptation efforts.

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