ALAMEDA

Climate Action and Resiliency Plan (CARP)

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Executive Summary

Introduction

Climate change is a threat to all of us, worldwide and here at home in Alameda. Every day, human behavior accelerates climate change by releasing harmful greenhouse gas (GHG) emissions that warm the Earth's atmosphere and cause severe impacts. Rising sea and groundwater levels, unhealthy air quality from wildfires, more intense rainstorms, warmer weather, and longer droughts are just some of the impacts our city is experiencing—and will continue to experience—if we don't act now to mitigate our contributions to climate change. As an island city in San Francisco Bay, Alameda is especially vulnerable to flooding. Alameda City Council's March 2019 declaration of a climate emergency is a call to action at all levels of government to restore a safe climate.

Thankfully, Alameda has a rich history of community support for environmental stewardship, and the City is responding by taking bold action. That is why the City of Alameda has developed this *Climate Action and Resiliency Plan* (CARP).

Our Vision

The City will use the CARP to position Alameda as an innovative climate leader, paving the way for cities around the region, state, and country to follow our example. The plan adopts an integrated approach known as the "Climate Safe Path," which emphasizes *reducing* GHGs to achieve net zero carbon emissions as soon as possible, as well as *adapting* our city to handle the climate change impacts we already experience today. The end result will be a resilient, sustainable, and vibrant city that has low vehicle traffic, well-functioning infrastructure, and beautiful natural amenities—a place where Alamedans can thrive for generations.

Importantly, the CARP aims to be equitable, inclusive, and community-driven. Throughout its development, the City partnered with key groups, such as the Community Action for a Sustainable Alameda (CASA) coalition and other community groups, to obtain public feedback and gauge community concerns. The City also made sure to continually address the disproportionate impacts that climate change may have on Alameda's vulnerable, socioeconomically disadvantaged populations.

By committing to resilience, sustainability, and social equity in our efforts to combat climate change, we are creating a historic moment here in Alameda. Although we must adapt and make some difficult, costly decisions to protect our city, the Climate Safe Path represents a vital down payment on our future.

Reducing GHG Emissions

If global GHG emissions do not decrease, and if we do not prepare for sea level rise and more intense storms, many parts of Alameda will see frequent flooding in the near future, and some parts could be permanently underwater by mid-century. The most effective long-term strategy for keeping our city above water is to achieve zero GHG emissions worldwide. Alameda's role in that effort is to aggressively reduce its own emissions by adopting innovative programs and paving the way for others to follow.

Current Status and Projections

Alameda has been working to reduce its GHG emissions since 2008. We estimate that by 2020, our emissions will have decreased by 23 percent below the baseline year of 2005. This is largely because our energy is getting cleaner as Alameda Municipal Power (AMP) shifts to providing 100 percent clean electricity to all Alamedans. If that continues, our remaining production-based emissions—i.e., emissions

produced within city limits—will come mostly from transportation (about 70 percent) and natural gas use in buildings (about 27 percent). Since 2005, emissions reductions from transportation and natural gas have only been 1 percent and 17 percent, respectively. Unprecedented levels of behavior change will be needed from Alamedans to reach the deep emissions cuts called for in this plan.

However, because Alameda has no factories and instead imports almost everything from off the island, our consumption-based emissions (i.e., the emissions associated with the goods and services we buy) are much higher per person than our production-based emissions. That means consumption-based emissions create one of the best opportunities for Alamedans to make a difference in their carbon footprints. For example, Alamedans can buy fewer products. When we do buy products, then we can buy durable, secondhand, and locally and sustainably produced products.

To tackle this challenge, the City has set a goal that is even more ambitious than the State of California's: reduce emissions by **50 percent below 2005 levels by 2030.** Achieving this goal means the City must carry out already committed to actions (e.g., Transportation Choices Plan [TCP] and the Zero Waste Implementation Plan [ZWIP] Update) and new actions proposed in the CARP.

At the same time, our community must look for opportunities to achieve net zero GHG emissions as quickly as possible. The specific path toward net zero GHG emissions is uncertain, but with the next CARP update expected in 2025, and through close collaboration with policymakers and community members, we will have a better understanding of how to accomplish this goal.

Actions

In addition to continuing already committed to GHG reduction actions, the CARP proposes the following new actions:

- **Transportation:** Reduce the impacts of solo driving by encouraging mode shift (e.g., taking the bus, bicycling, walking, and telecommuting) and electric vehicle (EV) use. One approach to these actions is to pursue innovative programs such as peak-hour congestion pricing.
- **Buildings:** Now that we have shifted to 100 percent clean electricity, eliminate as much natural gas use as possible by fuel shifting—that is, converting natural gas use to electricity use. This can be accomplished by requiring new residential developments to be all-electric and replacing gas-powered appliances in existing buildings.
- **Sequestration:** Draw down carbon already in the atmosphere by applying compost (created from diverted organic waste) in parks and open areas and planting more trees. The City will begin its sequestration efforts with pilot projects and eventually expand them to larger areas.
- **Waste:** Reduce the amount of material we send to landfill by increasing composting and recycling, as laid out in the ZWIP Update. This will pave the way for reaching true sustainability by transitioning to a circular economy that keeps raw materials in a constant flow, rather than a linear economy that extracts raw materials and then disposes of them.

Building Resilience

Building resilience to climate change in Alameda is crucial for ensuring the long-term viability of our city and the health of our residents. We're already experiencing climate impacts, and they're only expected to get worse. Therefore, the CARP proposes a science-driven, flexible, and practical adaptive management approach to strengthening resilience over time.

Current Vulnerabilities

The City's adaptation strategies prioritize planning for impacts that will occur soonest and with greatest consequence. In the case of Alameda, the impact of most immediate concern is flooding. The city already struggles with street flooding from storm drains during storm events. These events are likely to become more frequent and severe in the future. Additional stressors on the stormwater system will also come from rising sea and groundwater levels.

When assessing Alameda's vulnerability to flooding, the CARP mostly focuses on a scenario of a total water level of 36 inches above today's high tide. The City chose this scenario because significant overtopping (when Bay water spills over shoreline protection structures) begins to occur at 36 inches above today's high tide line, and because it is roughly equivalent to the surge of water caused by a 50-year storm today.

Other impacts of concern to Alameda include extreme heat, wildfire smoke, and droughts. These events are becoming more severe and longer-lasting due to climate change, and they present significant risks to Alameda's public health, air quality, water supply, and water quality.

Of particular concern, vulnerable populations (e.g., transit-dependent, children and elderly, disabled, very low-income) are often more likely to experience these climate change impacts and are least able to protect themselves against them. For this reason, the City conducted a social vulnerability assessment (SVA) during the CARP development that identifies which neighborhoods in Alameda have the highest concentrations of households with socioeconomic characteristics that make them more vulnerable to the impacts of climate hazards. The City used the results of the assessment to propose the equitable, inclusive resiliency actions found in the CARP. For example, the assessment led to prioritizing adaptation strategies to protect bus lines serving transit-dependent neighborhoods from overland flood risk.

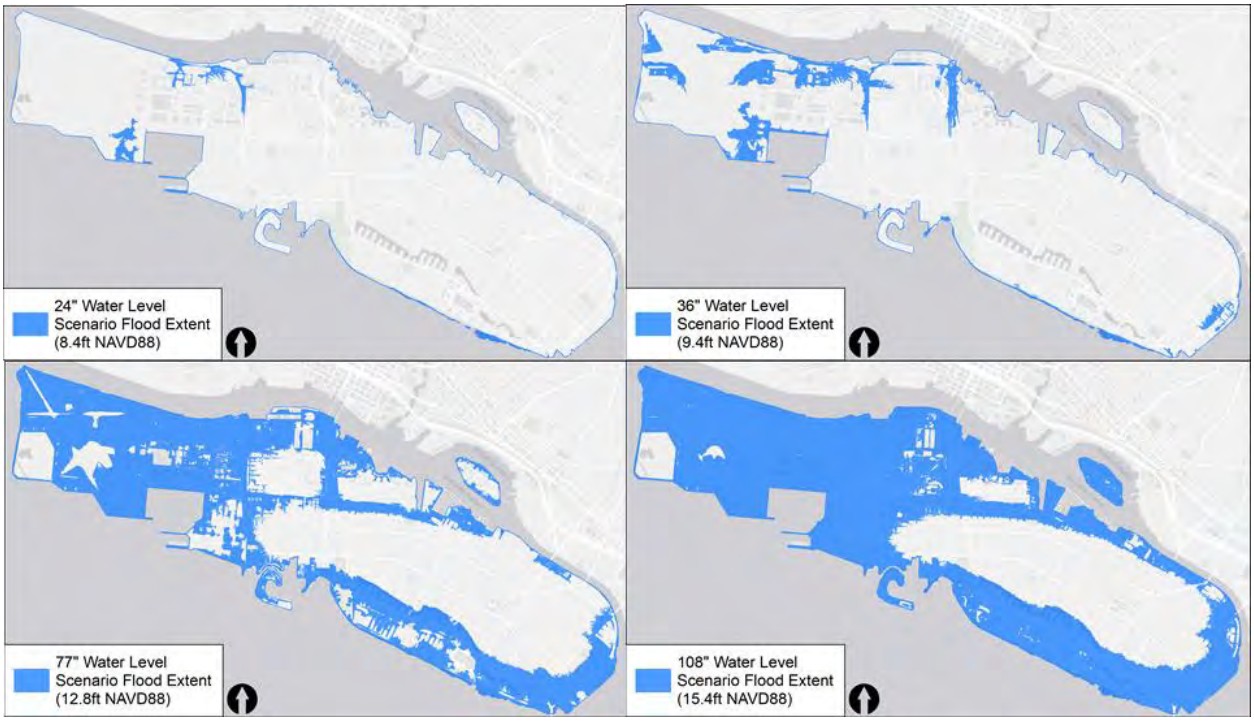


Figure ES-1. Maps showing inundation for 24-, 36-, 77-, and 108-inch total water level scenarios (above mean higher high water).

Actions

The CARP identifies 11 location-based assets or areas that are especially vulnerable to—and must be protected from—flooding impacts in the near future. The stormwater pipe and pump station capacity upgrades, identified in a previous master planning effort, are so critical to adapting to a changing climate that this work is included as one of the 11 especially vulnerable assets. To date, adequate funding has prevented these projects from moving forward. For the storm system to remain effective in conveying urban runoff to the Bay, these projects must be funded and constructed.

Specific and defined solutions for the shoreline overtopping and associated flooding vulnerabilities identified in the CARP are beyond the realm of this report. Instead, the CARP presents a menu of options for building resiliency in these areas, such as investing in living shorelines and wetlands restoration and managed retreat, as opposed to only relying on engineered levees and seawalls. These natural features attenuate waves, store carbon, mitigate the impacts of sea level rise and storms, and provide valuable ecosystem service benefits.

The CARP also recommends strategies and actions to address climate risks in other vulnerable sectors throughout Alameda. These sectors include buildings, critical services, land use, shoreline and natural areas, transportation, contaminated lands and waste, utilities, and public health. Actions for both location- and sector-based vulnerabilities will move forward after public discussion has advanced, funding is available, and design and permitting activities are completed.

Implementing the CARP

Our success in implementing mitigation and adaptation measures in Alameda will depend on a variety of factors. City staff will not only have to organize and assess their current organizational structure before implementation, but they must also find or raise new revenue to fund the CARP's proposed actions, then continuously monitor progress to ensure the plan stays on track. Because CARP implementation will be challenging, Alameda must act now to begin this essential process.

Funding

The cost of climate action will be high, but the cost of inaction is even higher. For example, Alameda's **building damage and land loss from sea level rise in 2100 could be around $6.8 billion, and adaptations to address that water level could cost less than $1 billion**. A limited analysis comparing only the costs of raising existing shoreline structures (90 percent of the coastline) to the benefit of avoiding flood damage for only land and buildings yields a benefit to cost ratio of about 3.5 to 1 to 8 to 1 in all three sea level rise plus 100-year storm scenarios assessed in this study. This excludes non-market values, stormwater system costs and benefits, and a number of other factors, but these ratios are in line with research the Federal Emergency Management Agency (FEMA) has conducted related to the benefit-cost ratio of $6 dollars saved per $1 invested (NIBS, 2017).

To implement GHG reduction and resilience strategies, Alameda will need to use a mix of federal, regional, state, and local dollars and grants. Alameda City Council's approval of the 11 areas and assets of location-based priority flooding for adaptation action is an important first step in supporting development of competitive grant applications for the planning, design, and construction of this work. In addition, some portion of the overall costs will need to be covered by locally raised revenues from congestion pricing, stormwater fees, special districts, and/or an infrastructure bond.

The City should also commit to creating a new, long-term Climate Fund. Such a fund could be used to match grants obtained for implementation, offset permit fees associated with building improvements, retrofit buildings from gas to electric power, implement carbon sequestration projects, purchase carbon offsets, or initiate other CARP measures.

Responsibilities, Structure, and Staffing

Successful implementation will also largely depend on a concerted team effort by City staff. While the City Council is responsible for adopting this plan and the City Manager will ensure we achieve its goals, the Assistant City Manager will ultimately be responsible for ensuring implementation stays on track among the various City departments involved in the process. A new, full-time Sustainability Coordinator will report to the Assistant City Manager and liaise with various climate change and resiliency groups, as well as City staff and community members.

Additionally, a Green Working Team (GWT) composed of department directors and City staff will meet quarterly to discuss implementation progress and roadblocks. A Task Force (TF) composed of community representatives will also meet annually to advise implementation of the plan on an ongoing basis. To fully implement all of the measures in this plan, the City would need to build its capacity and hire 11 or more additional full-time employees.

Monitoring, Reporting, and Metrics

The City will establish a tracking and reporting system to evaluate the efficacy of GHG reduction and adaptation actions. This transparent system will help maintain the public's trust and ensure the equitable distribution of climate-related projects among our communities. As part of the monitoring process, the Sustainability Coordinator will annually report to the City Council on progress made based on key metrics for GHG reduction and resiliency. The 2024 annual report will include updated GHG inventories, which are critical to determining whether City actions are yielding the desired results. And in 2025, the Coordinator will share an in-depth update to the CARP with new recommendations for 2025–2030 and achieving net zero GHG emissions.

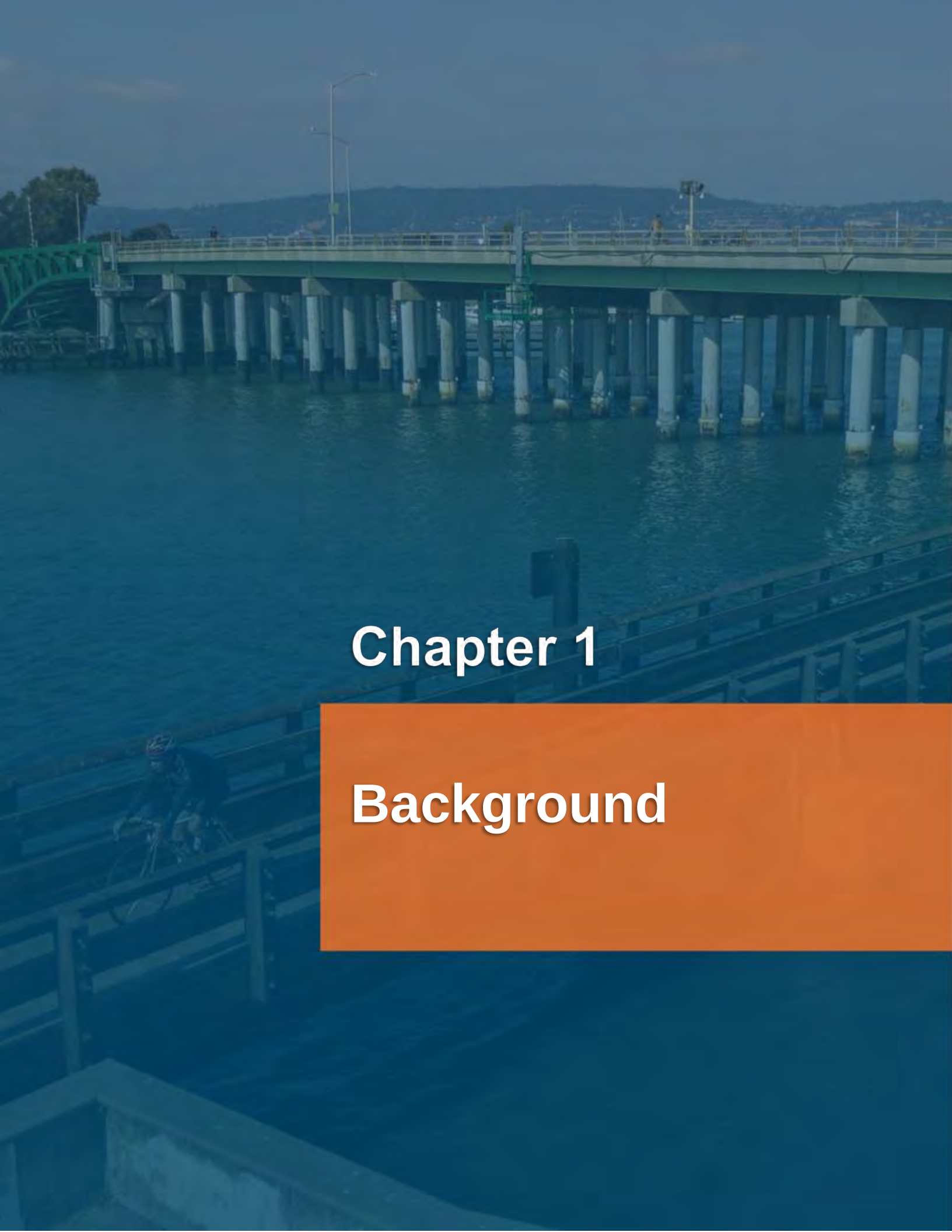
Partners, Stakeholders, and Communities

One of the driving elements of the CARP's development was close collaboration with Alameda partners, stakeholders, and community members, and their continued involvement will be essential to the plan's long-term success. Because many adaptation challenges can only be addressed through inter-jurisdictional coordination, the City will partner with agencies such as the California Department of Transportation (Caltrans) and the East Bay Regional Park District (EBRPD); the Port of Oakland; the East Bay Municipal Utility District (EBMUD); and Pacific Gas and Electric (PG&E), AT&T, and other telecommunications companies. These partnerships will help us raise the climate change alarm beyond Alameda's borders and make adaptation and mitigation priorities in our surrounding communities.

Ongoing collaboration with the Alameda community is also necessary. After plan adoption, the City will reconvene the climate action TF and expand its membership to be more representative of Alameda's diverse community. The City will also continue to engage with youth in particular and help interested community members find ways to get involved in climate action and make a difference.

Call to Action

The City of Alameda will take the lead in implementing the CARP and getting us on a Climate Safe Path, all the while serving as an example to other cities that are also striving to achieve net zero GHG emissions and resilience in the face of ongoing climate change. But the success of this bold action plan will also depend on the involvement of everyone here in Alameda. From young students to retirees, renters to homeowners' associations (HOAs), businesses and agency stakeholders to environmental and community groups, we all have a stake in ensuring that Alameda remains sustainable, resilient, equitable, and vibrant for generations to come.



Chapter 1

Background

Introduction

Climate change is a worldwide threat, and the City of Alameda is experiencing impacts in its own backyard. The Intergovernmental Panel on Climate Change (IPCC) reports that human behavior—particularly burning fossil fuels—accelerates climate change by releasing harmful GHG emissions. The GHGs of most concern are carbon dioxide (CO2), methane, nitrous oxide, ozone, and halocarbons (non-metallic carbon compounds in the air). Once these emissions overpower the earth's climate systems, they will accelerate global warming beyond the rate at which it is occurring today.

Because of its location in the densely populated, San Francisco Bay Area, the City of Alameda is especially vulnerable to climate change impacts. For example, the San Francisco Bay has risen 8 inches in the last century, and could rise 2 feet by 2050, and 6 feet or more by 2100. In addition to rising sea levels, other major threats include unhealthy air quality from episodic wildfires, more intense rainstorms, warmer weather, a rise in groundwater levels, and longer, deeper droughts.

These changes can impact transportation, drinking water, sanitary sewerage, power, communications, stormwater drainage, water quality, air quality, public and ecosystem health, food supply, personal property, housing supply, and the economy. Alameda's businesses and residents can contribute to or mitigate the problem. The cars we drive, the goods we buy, the way we heat our homes, whether we compost, and even the way we eat all affect our GHG emissions. The choices we make as a community matter.

Given our unique vulnerability, Alameda has already taken a proactive stance to mitigate its contributions to climate change. For example, in 2008, Alameda released the *Local Action Plan for Climate Protection,* which set a goal of reducing Alameda's GHG emissions to 25 percent below 2005 levels[1] by 2020 (COA, 2008). Since then, Alameda estimates it has reduced its GHG emissions by 23 percent and was one of the first cities in California to pass a stringent ordinance focused on reducing the generation of single-use plastic food ware. Alameda also improved its public outreach during poor air quality events and initiated a dune restoration and shoreline protection project at Encinal Beach, to name just a few steps taken (see text box at right for other activities).

Much work remains to be done. That's why the City of Alameda has developed the CARP.

Accomplishments Since Alameda's Local Action Plan for Climate Protection 2008

- CASA is formed to help achieve the goals of the 2008 Local Action Plan.
- Update to the Storm Drain Master Plan with a number of improvement projects implemented.
- Adoption of the 2016 Local Hazard Mitigation Plan, which outlines plans to increase resilience of buildings, utilities, transportation assets, and open space to hazards.
- Development and implementation of the TCP, the ZWIP (2010), and the ZWIP Update (2018), which are decreasing GHG emissions in the city.
- City joins Global Covenant of Mayors on Climate and Energy in 2017.
- City Council declares a climate emergency in 2019.
- Public engagement efforts to form the best past path toward climate resiliency.

[1] The City of Alameda generated approximately 367,648 carbon dioxide equivalent units of GHG emissions in 2005.

Climate Safe Path: Adaptation and GHG Reduction

The CARP expands the scope of the City's 2008 plan by adopting an integrated approach consisting of both **adaptation** and **GHG reduction.**

Alameda is *reducing GHG emissions* by making sustainability improvements to the city's buildings, transportation, waste management, and trees and parks. These improvements put Alameda on a path to net zero carbon emissions, which is necessary for a sustainable future. The actions the City takes to reduce GHGs also have significant benefits for the present: they will bring about cleaner air, better public health, reduced traffic congestion, and a higher quality of life for all Alamedans.

However, even if GHG emissions were to end today, Alameda would still have to contend with a variety of climate change impacts over the next several decades. The city has already suffered some of these impacts, such as last year's wildfire smoke. To prepare for increased flooding, drought, heat waves, and unhealthy air quality, Alameda must pursue *climate adaptation strategies*. These strategies focus on addressing short- and medium-term risks while also keeping an eye on long-term risks so that we are prepared for more dramatic shifts that could take place.

As a social issue, climate change is full of contrasts. The scale of global GHG emissions is massive, and Alameda is just a small, suburban city. We don't know how fast climate impacts will escalate, but we do know that traffic is congested and potholes must be repaired. These contrasts of scale can make climate action seem abstract or intractable.

While Alameda cannot stop climate change on its own, our success in bold climate action will pave the way for cities around California—the fifth largest economy in the world—to do the same. In fact, Alameda is part of the Global Covenant of Mayors, a coalition of cities and local governments worldwide that comprise 1 billion people and are collectively committed to drastically cutting GHG emissions. What we do in Alameda can make a global difference. At the same time, preparing for the impacts of climate change is imperative for protecting the health of current and future generations. As a low-lying island city, Alameda could face significant consequences from increased flooding. Without thorough preparation, climate impacts in Alameda could be severe.

By combining the goals of GHG reduction and climate adaptation, Alameda is taking what is called the "Climate Safe Path." Our actions contribute to lower GHG emissions, which if successful would greatly reduce the climate risks our city would face. At the same time, Alameda is planning to protect itself in case the worst impacts of climate change come to pass despite our best efforts. The Climate Safe Path is illustrated in Figure 1-1.

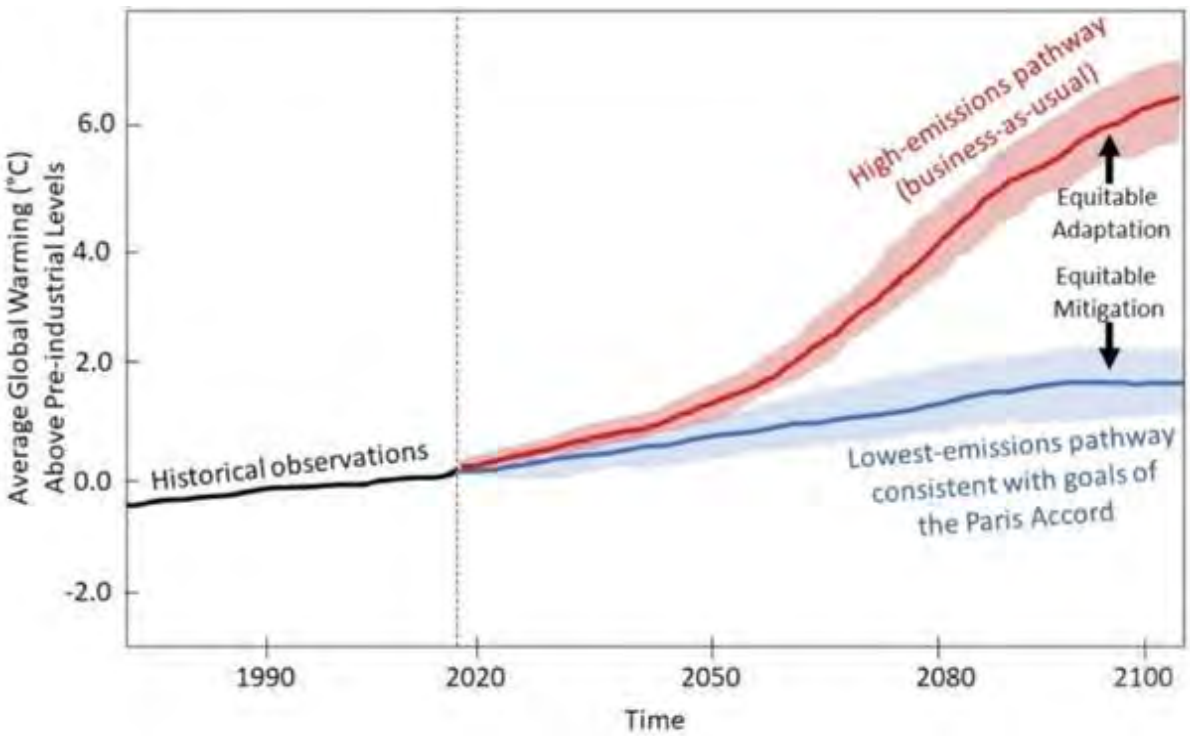


Figure 1-1. The City of Alameda will position itself as a leader in adopting the Climate Safe Path of GHG reduction (i.e., "mitigation") and adaptation planning shown above to meet both global and local goals. Following this path means working to limit global climate impacts while addressing those impacts that are experienced locally. Credit: CSIWG (2018).

The combination of mitigation and adaptation into a single, actionable plan also identifies significant **co-benefits:** benefits other than improving the climate that result from preparing for climate hazards and cutting GHG emissions. Co-benefits include improved health, better stormwater runoff management, and a more livable and vibrant community. Figure 1-2 shows examples of adaptation and GHG reduction strategies and actions that can accomplish goals in both areas. Identifying these co-benefits is critical to maximizing efficiency in implementation and reducing overall costs. For example:

- Trees not only help settle airborne particles during wildfire smoke events, but also remove carbon from the atmosphere and reduce heat impacts.
- Creating transit alternatives like bike routes and ferries that allow Alamedans to avoid the Webster and Posey Tubes not only reduce GHG emissions from cars, but also make Alamedans less reliant on those flood-prone transportation routes.
- Creating "living shorelines" not only protects against flooding, but also can sequester carbon, create valuable wildlife habitat, and clean the water in the Bay.

The CARP emphasizes co-benefits at every opportunity. Identifying co-benefits ensures that we are getting the most value out of every investment made. Maximizing co-benefits also recognizes that Alameda's vision is not simply to reduce emissions or better protect against climate hazards, but also to become a more sustainable, livable, and vibrant community overall.

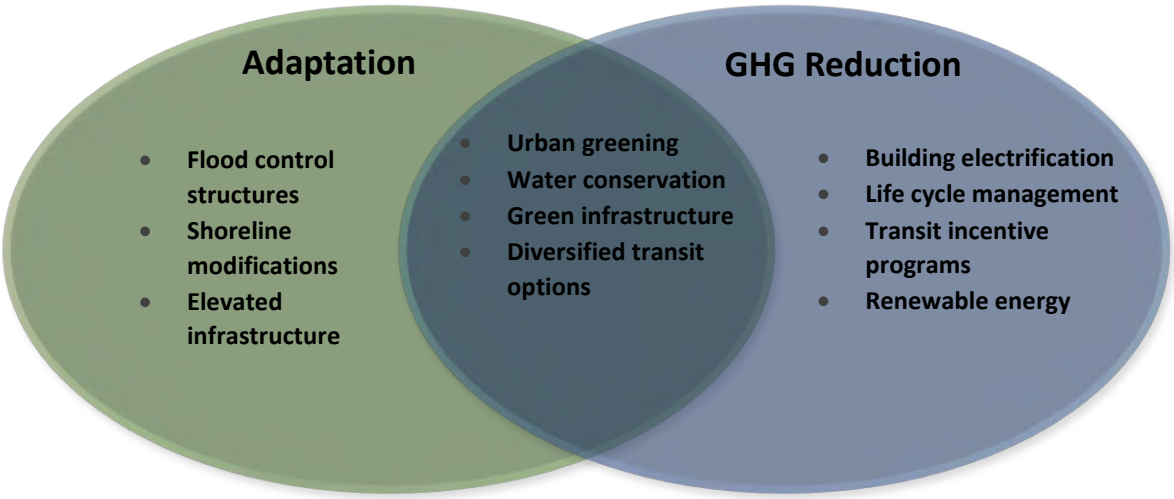


Figure 1-2. GHG reduction and adaptation strategies and actions that have co-benefits.

CARP Vision and Goals

By promoting both mitigation and adaptation measures, the CARP will help the City of Alameda achieve an overarching goal to increase Alameda's resilience to climate change and ensure a sustainable and healthy environment, society, and economy.

The CARP outlines a path to achieve eight targeted goals, leading to the overarching goal and ultimately the City's vision. These include an ambitious goal for GHG reductions, a set of specific goals for increasing resilience to climate hazards, and a final goal for the City to effectively implement the plan and build capacity.

1. **GHG reduction:** Reduce GHG emissions to 50 percent below 2005 levels by 2030 and achieve net zero GHG emissions as soon as possible. Alameda will achieve these targets by completing current actions and implementing new actions focused on transportation, building management, waste management, and carbon sequestration. Co-benefits of GHG reduction include the reduction of fossil fuel pollutants and a reduction in asthma, cardiovascular disease, and other health issues.
2. **Sea level rise and storm surges:** Protect assets from sea level rise and storm surges, plan future land use to avoid impacts, and enhance natural shoreline habitat to mitigate impacts.
3. **Inland flooding:** Increase the resiliency and capacity of the stormwater system to prevent flooding of assets during extreme precipitation events.

Our Vision for the *Climate Action and Resiliency Plan*

Alameda will be an innovative leader in achieving net zero carbon emissions and community resilience as soon as possible, and serve as an example that inspires similarly impacted cities to do the same. Our community members will be a vital part of this ongoing process.

(*Note: Alameda revised the CARP vision based on the City Council's March 2019 declaration of a climate emergency.*)

GHG Reduction Goals

Reduce GHG emissions to 50 percent below 2005 levels by 2030 and achieve net zero emissions as soon as possible.

4. **Drought:** Reduce water consumption and increase drought-resistant landscaping. EBMUD is bringing recycled water to the main island by 2023.
5. **Extreme heat:** Reduce the heat island effect and protect vulnerable populations from heat impacts during heat waves.
6. **Wildfires:** Protect public health from smoke impacts during wildfire events, especially among vulnerable populations.
7. **Earthquakes/liquefaction:** Ensure that building and infrastructure retrofits and new design standards in areas at high risk of liquefaction consider both seismic risk and sea level rise impacts.
8. **Effective implementation and capacity building:** Develop financial and human resources and increase transparency, community engagement, social resilience, and support for effective CARP implementation.

The CARP is a living document, and the starting point for the City's climate action efforts over the next decade and beyond. The goals and commitments of this document will be regularly revisited throughout implementation.

CARP Scope and Content

The CARP presents recommendations and strategies for implementing climate change adaptation and mitigation actions in Alameda. Chapter 2 describes the guiding principles and process the City used to develop the plan. Chapter 3 lays out a plan to mitigate climate change impacts by reducing GHG emissions. Chapter 4 describes how the City will adapt to existing and likely future climate change impacts. Chapter 5 highlights how the City will make economically informed climate change decisions when operationalizing the CARP. Finally, Chapter 6 describes how the City will implement the CARP in their operations, as well as work with partners and stakeholders to promote widespread adoption among Alameda community members.

Fruitvale Avenue Bridge. Photo credit: Tobin

Chapter 2

How We Developed the Plan

Guiding Principles

The City of Alameda adhered to a set of guiding principles in developing the CARP. These principles include aligning with state goals to address climate change impacts and reduce GHG emissions, building on broader adaptation planning efforts in the region, and supporting county mitigation and adaptation targets. Furthermore, the development process included an overarching commitment to social equity that considered the impacts climate change and the proposed CARP actions will have on Alameda communities, particularly among socially vulnerable populations.

Aligning with State Goals

The City of Alameda's joint efforts to address climate change impacts and reduce GHG emissions align closely with various state policies. For example, the CARP's recommendations to prevent further sea level rise in Alameda align with the mandates of Assembly Bill (AB) 691. AB 691 was enacted on October 5, 2013, and requires trustees of public trust lands (receiving more than $250,000 in annual gross revenue from those lands) to prepare and submit assessments of how they propose to address sea level rise impacts that could result from their activities.

The CARP also sets the stage for the City to address Senate Bill (SB) 1383 regulations, which target short-lived climate pollutants. SB 1383 requires the state to decrease methane emissions by reducing the landfill disposal of organic waste by 50 percent from 2014 levels by 2020, and by 75 percent by 2025. Under these regulations, Alameda must institute programs and jurisdictional mandates that support comprehensive organics management.

Furthermore, the CARP's goals align with AB 32, the supporting Scoping Plan, and Executive Orders (EOs) B-30-15 and B-55-18. These suggest local governments develop climate plans that address both GHG emissions and climate change adaptation, as well as mandate that California achieve a 40 percent GHG emissions reduction by 2030 and an 80 percent reduction by 2050 (below 1990 levels). EO B-30-15 also directs state planning and investment to carry out both GHG emissions reduction and climate change adaptation measures. In addition, EO B-55-18 establishes a new statewide goal to achieve as soon as possible, and no later than 2045, as well as to achieve and maintain net negative emissions thereafter.

Finally, in keeping with California's 2019 Building Energy Efficiency Standards, the CARP recommends ways that Alameda businesses and residents can reduce their reliance on fossil fuels. The California Energy Commission (CEC) adopted these building standards[2] on May 9, 2018 (effective January 1, 2020), to reduce wasteful and inefficient energy consumption, as well as enhance the state's overall environmental quality.

Building on Regional Planning

The CARP also builds on a history of broader adaptation planning in the region. It expands the work of the Bay Conservation and Development Commission's (BCDC's) Adapting to Rising Tides (ART) Program, which helps build local and regional resilience to sea level rise and storms. The City of Alameda actively participated in one of the ART Program's first sea level rise vulnerability assessment and adaptation planning processes. The CARP draws in the latest climate projections from that work and builds on it by considering a range of climate impacts. The CARP also identifies opportunities for ongoing

[2] Adopted as Title 24, Part 6, of the California Code of Regulations.

and expanded collaboration among the City of Alameda and neighboring jurisdictions and asset managers (e.g., City of Oakland, EBRPD).

Other regional efforts that have informed the CARP's development include recommendations from the Association of Bay Area Governments' (ABAG's) Stronger Housing, Safer Communities Project to address housing and community vulnerability to hazards, as well as transportation-related projects, such as the Metropolitan Transportation Commission's (MTC's) *Plan Bay Area 2040* regional transportation plan. As part of its planning process, MTC is currently exploring sea level rise impacts on the region for the first time. The CARP supports *Plan Bay Area 2040's* targets to reduce per capita CO2 emissions from cars and light trucks by 15 percent by 2040.

Supporting County Targets

Climate change adaptation and mitigation are also priorities at the county level. For example, Alameda County recently showed its commitment to climate change adaptation by developing the resource, *Climate Change Adaptation Workshops: A Planning Guide for Local Government Staff*. Public agencies can use the guide to identify and implement tangible adaptation initiatives related to specific, local impacts like wildfire smoke.

Alameda County is also one of the founding members of the Cool Counties Initiative—a coalition of 39 counties in 20 states that work toward achieving bold adaptation and mitigation goals. The CARP supports and goes beyond Alameda County's pledge under the initiative to partner with community leaders to reduce GHG emissions to 80 percent below 2007 levels by 2050.

Committing to Equity

The City of Alameda considered all aspects of sustainability in the planning process: society and equity, economy, environment, and governance. The City examined society and equity in terms of the impacts that both climate change and the proposed CARP actions will have on communities and the communities on which they rely. Equitable mitigation and adaptation strategies are essential to the plan's long-term success.

The CARP planning process included conducting an SVA (see Appendix G) to better understand and address climate impacts that are disproportionately distributed across the Alameda community. Even in cases where the physical impacts have a similar distribution, not all households have the same ability and resources to respond to and recover from extreme weather events and hazards. For example, a household without access to a car or savings will have a harder time evacuating during extreme weather. An important first step in building equity into planning is to understand these disproportionate impacts.[3]

The disaster cycle of preparation, response, and recovery will be more difficult for more vulnerable populations. This is true for both acute events (such as wind storms and extreme high tides) and the gradual effects of poor air quality, frequent minor flooding, eventual loss of public and private buildings, and the overall effect on the economy. Vulnerable and less resilient populations may include people with mobility, visual, auditory, cognitive, or mental health disabilities; limited English; substandard or illegal housing; food insecurity; lack of access to the internet, phone service, social media, and other media; limited transportation options; lack of savings; and/or lack of social and familial support. These

[3] Throughout the CARP, there are references to "socially vulnerable populations." These are populations that are expected to be more vulnerable to climate impacts due to social and demographic factors as indicated by the SVA. This language is not meant to indicate equivalency with California Environmental Protection Agency's definition of "disadvantaged communities."

populations may be more difficult to warn or inform. They may also have a harder time preparing to shelter in place, evacuating, or surviving afterwards without supplies, savings, a place to stay, or a steady job.

During the SVA, City staff examined social factors affecting Alamedans' ability to respond to climate threats like flooding, heat, and wildfire smoke and identified neighborhoods that may be most impacted. As shown throughout the CARP, the SVA informed both the climate change vulnerability assessment and the recommended strategies to address those vulnerabilities. The SVA findings should continue to be used in further public engagement and outreach during CARP implementation.

CARP Development Process

The City of Alameda Public Works Department contracted with Eastern Research Group, Inc. (ERG) to develop the CARP. The development process took approximately one year and included significant collaboration among Alameda staff, community members, and outside subject matter experts.

Key steps in the CARP development process included the following:

- **Step 1: Synthesize existing information and develop vision, goals, and objectives.** After synthesizing existing data and reports on climate vulnerabilities and GHG mitigation strategies, the City developed GHG reduction targets and resilience goals.
- **Step 2: Scope and organize teams.** The City defined an organizational structure for working with key partners and community members, resulting in a TF and GWT. These teams shared ideas for stakeholder outreach and engagement strategies and provided input on all interim project deliverables.
- **Step 3: Conduct stakeholder engagement and community outreach.** The City developed and distributed a survey to obtain the community's feedback and views on climate action planning. The City also planned and conducted three community workshops. Community outreach and stakeholder engagement were conducted throughout the planning process.
- **Step 4: Assess risk for adaptation planning.** The City conducted a vulnerability assessment to understand Alameda's risk of climate impacts and identified key vulnerabilities across asset categories and for the city as a whole.
- **Step 5: Develop and advance existing adaption solutions.** The City developed sea level rise adaptation recommendations for 11 priority assets and developed adaptation actions to address all climate hazards across all asset categories for citywide implementation.
- **Step 6: Develop GHG emissions reduction actions.** The City reviewed the 2015 GHG emissions inventory and projections to develop detailed GHG emissions reduction actions, then worked with AMP and stakeholders to select the final actions needed to achieve its GHG emissions reduction goal for 2030 and net zero GHG emissions as soon as possible.
- **Step 7: Draft and finalize the plan.** The City developed a draft CARP, which was revised to incorporate feedback during the review process, and then produced a final CARP.

Figure 2-1. CARP development process

Stakeholder Engagement

Stakeholder engagement was a key component of developing the CARP (and will continue to play a vital role in its future success). The City, in collaboration with ERG, engaged Alameda residents, other City staff, subject matter experts, and community leaders to obtain their input and feedback. The stakeholder engagement process included GWT meetings, TF meetings, community input sessions, online input, and other City-led engagement activities.

Green Working Team

The GWT consisted of representatives from core City departments and key partners, including AMP, CASA, and other invited representatives depending on each meeting's topic. The City hosted five GWT meetings to gather input on draft CARP outputs and products. During the meetings, team members:

- Synthesized existing data and reports on climate vulnerabilities;
- Discussed GHG mitigation strategies;
- Reviewed and provided input on the adaptation vulnerability assessment and strategies/actions; and
- Reviewed the GHG emissions inventory, projections, and strategies to achieve reduction targets.

Task Force

The TF included a diverse group of key partners representing Alameda business and community interests. The TF's contributions included:

- Acting as an outreach committee that provided strategic advice to the City and consulting team, represented Alameda's broader community interests, and disseminated information to the community;
- Providing input on key partner engagement activities, including community workshop structure and content; and
- Advising the City and ERG, and helping to identify needs, areas of alignment, challenges, and opportunities to contribute to the successful adoption of the CARP.

Community Input Sessions

The City coordinated three community input sessions for the public to provide input on the CARP development. The dates and objectives of each session were as follows:

Community Input Session #1

Community Input Session #2

- **Session #1 (September 24–26, 2018; 122 attendees):** The meeting focused on increasing mutual understanding between the City and community members about the vision and goals for the CARP, as well as learning about community priorities. It also solicited ideas for actions that the City and community can take to achieve their goals of increasing resilience and mitigation (see Appendix A).
- **Session #2 (January 26, 2019; 70 attendees):** The City and ERG presented the vulnerability assessment results and proposed GHG emissions reduction actions. The meeting focused on sharing the CARP vision and recapping outcomes from the first session, ensuring that residents understand climate risks and hazards (and options to address them), and soliciting feedback on priority adaptation strategies and GHG reduction actions that both the City and community can adopt. The community also reviewed draft adaptation strategies and project priorities (for mitigation) and alternatives (for adaptation) (see Appendix B).
- **Session #3 (May 20, 2019; 44 attendees):** The City and ERG presented the draft CARP and solicited oral feedback from 33 members of the public to shape the final plan (see Appendix C). The draft CARP was open for public comment on an online platform starting May 14, 2019, and closed on May 31, 2019.

Online Input

The City used the online platform OpenGov to share the details presented at the input sessions and collect any additional feedback from those who could not attend any of the three sessions or had more feedback to contribute following the in-person input sessions. Community members also directly submitted inquiries and suggestions via e-mail or phone calls to City staff.

City-Led Stakeholder Engagement

City staff also engaged with residents in the following ways during the CARP planning process:

- Distributed informational materials at the Tuesday and Saturday farmers markets leading up to the input sessions and talked to farmers market visitors about climate action.
- Met with various community organizations, including those focused on housing, gardening, politics, and homelessness, to discuss the CARP and its relevance to their mission and goals.

- Joined former Miss Alameda Jessica Jane Robinson's *Resilience Birthright* book signing event at a local tea house.
- Gave in-class presentations on local climate action and resiliency in spring 2018 at four Alameda high schools and one Alameda middle school, reaching approximately 200 students.
- Conducted engagement activities for high school environmental clubs from Alameda High, Encinal High, Alameda Community Learning Center, and St. Joseph's Notre Dame High School. This included reproducing a Ketso activity that community members engaged in during the first input session.

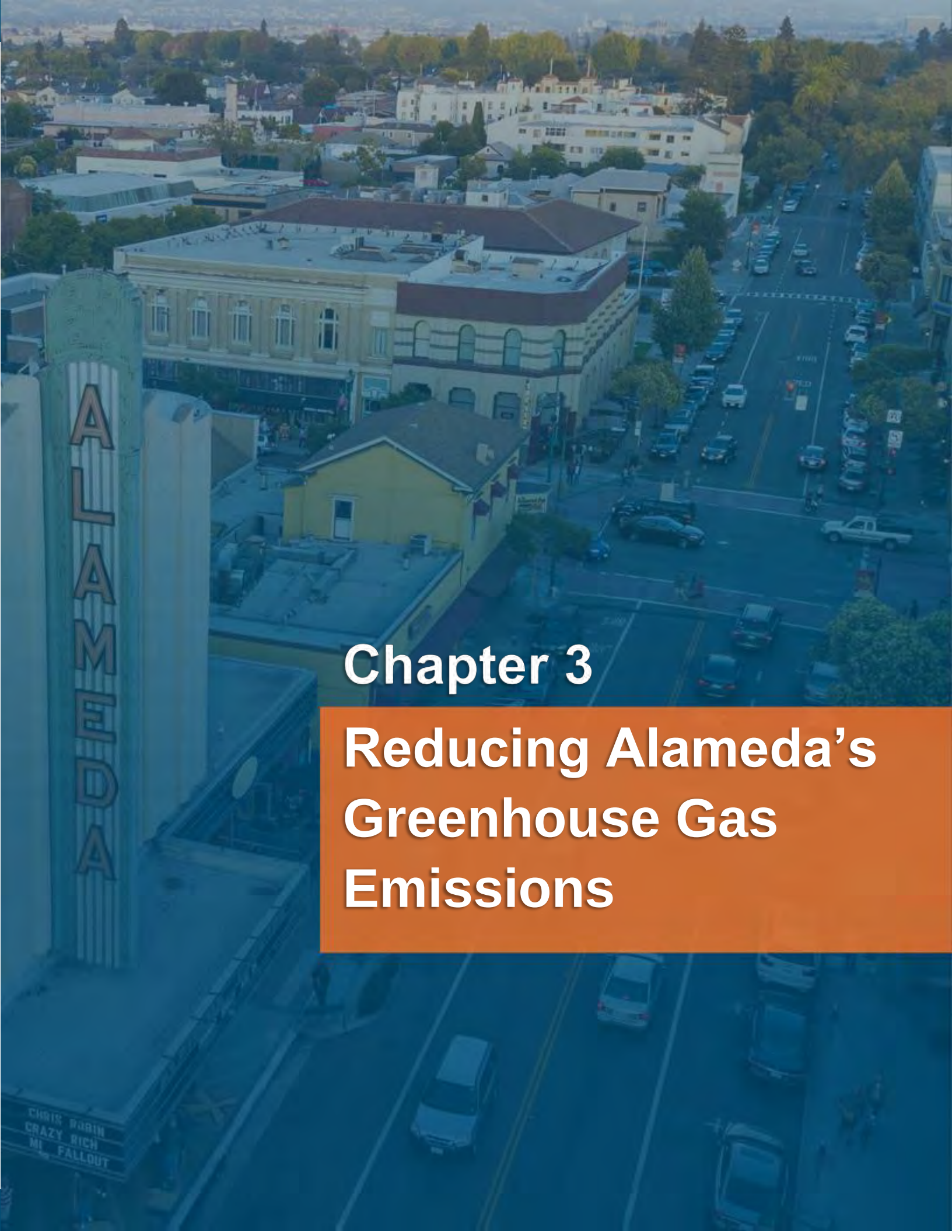
Miss Alameda Jessica Jane Robinson's Book Signing

- Supported a team of high schoolers from Alameda Community Learning Center and Encinal High who produced two short videos about the CARP from a youth perspective (available online at tinyurl.com/YouthCARPVideo1).
- Supported a group of Alameda high school sustainability leaders who created and hosted a youth climate festival in Lincoln Park in April 2019.
- Presented a draft CARP to the following boards and commissions for comment: Planning Board, Recreation and Parks Commission, Commission on Disability, Social Services and Human Relations Board, Transportation Commission, and Public Utilities Board (PUB).

Alameda Youth Sustainability Festival

There are many approaches to engagement, as residents resonate with different parts of the CARP depending on their own life experiences, needs, and interests. Therefore, effective outreach requires special attention, care, sensitivity, and expertise. It is especially important to frame the CARP with relevancy, in part by emphasizing elements that are practical and tangible, such as health, food production, and transportation. Please see Chapter 6 for key stakeholder engagement approaches as we move forward in implementing the CARP.

The work of numerous public agencies and climate change nonprofits locally and in our region contributed to this CARP. These include the Bay Area Regional Collaborative, BCDC and its ART Program, Bay Area Climate Adaptation Network (BayCAN), Caltrans (District 4), City of Oakland, EBRPD, Greenbelt Alliance, Port of Oakland, Resilient by Design, San Francisco Estuary Institute (SFEI), Sierra Club (Alameda County and national), StopWaste, and many others.



Chapter 3

Reducing Alameda's Greenhouse Gas Emissions

GHG Emissions Reductions

The City of Alameda has worked to reduce GHG emissions since 2008. Alameda estimates a 23 percent reduction in emissions since 2005, just short of the 25 percent reduction goal for 2020 that the City set in 2008. This compares with a reduction of about 12 percent for the nation as a whole (U.S. EPA, 2019) and a rise of 23 percent for the world (Olivier, 2018).

Alameda's success as a Bay Area climate leader is also demonstrated in the city's low per capita GHG emissions. Table 3-1 shows that in 2015, per capita emissions were lower for Alameda than the California average and comparable Bay Area cities.

Table 3-1. Per Capita GHG Emissions Rates (Sources: COA, 2018a; ABAG, 2019)

Location	MTCO2e/Person[a]
California (average 2015)	11.2
Emeryville (2014)	15.4
San Leandro (2010)	7.4
Oakland (2013)	6.8
San Francisco (2012)	5.7
Alameda (2015)	5.3
Berkeley (2012)	4.9
Antioch (2015)	4.0

[a] Emissions are shown in units of metric tons of carbon dioxide equivalent (MTCO2e), a method for converting the global warming impact of different GHGs into one standardized unit.

Alameda's lower emissions compared to the statewide and national averages are due to a number of reasons. One is our moderate climate and relatively small average lot and building size, which keep heating and cooling needs low. Another is our relatively high level of transit use for a U.S. city, as well as our proximity to major employment centers in San Francisco and Oakland. Lastly, Alamedans have successfully increased composting and recycling rates, which decrease methane emissions from decomposing organic matter and landfills as well as upstream emissions from the recycling of materials.

The estimated 23 percent decrease in our GHG emissions from 2005 to 2020 is mostly the result of AMP's shift to 100 percent clean electricity, which effectively eliminates Alameda's GHG emissions from electricity consumption. In addition, Alameda's GHG emissions from waste were cut almost in half due to the success of the ZWIP and its Update, and there was a steady downtick in vehicle miles traveled (VMT) from passenger cars. Alamedans' investment—with AMP's help—in the energy efficiency of their homes and businesses also plays an important role.

The road to deeper GHG emissions cuts is more difficult. As long as AMP continues to provide 100 percent clean electricity—a policy that is subject to ongoing approval by the PUB—almost all of

Alameda's emissions will come from the transportation sector (about 70 percent) and natural gas consumption (about 27 percent).

The large majority of natural gas is used in heating our homes and water. A much smaller, but still important, percentage is used for stoves, dryers, and industrial uses. Simply put, reducing natural gas consumption requires replacing gas-powered furnaces, water heaters, and other appliances with their electric equivalents. With approximately 30,000 homes in Alameda, this is a daunting task, yet a necessary one if we are to do our part in reducing GHG emissions and avoiding the worst impacts of climate change. Given that Alameda is largely already built out, our state-mandated housing targets only amount to 2,000 new units built by 2030. As a result, our most important policies from a GHG perspective focus on retrofitting existing buildings.

Reducing GHG emissions from the transportation sector is perhaps even more difficult. The first priority is to create transportation options that make it sensible for Alamedans to choose walking, biking, or transit over driving alone. This is because even if cars are electric, they still create traffic congestion and its associated problems. In addition to providing more transit options, transit vehicles such as ferries and buses must be upgraded so that they are all powered by electricity or hydrogen fuel cells that have no carbon footprint. For all trips that are still made by personal automobile, eliminating emissions requires replacing all cars powered by fossil fuels with electric equivalents, which would run on 100 percent clean electricity powered by AMP. Alameda, like almost all cities in the United States, was built to favor the automobile, so precipitating a widespread shift from car use to other options may require innovative policies like congestion pricing, which was recently approved in New York City and has been put in place in cities such as Vancouver (Canada) and London.

Congestion pricing is a fee charged to vehicles traveling into or within a predetermined area to reduce traffic congestion. In Alameda, congestion pricing could establish tolls that would charge a fee during peak traffic hours at the Webster and Posey Tubes and the two bridges connecting Alameda with Oakland. Congestion pricing could address many of Alameda's local priorities, including relieving traffic congestion, reducing GHG emissions, improving local air quality, and raising revenues for improvements to the transportation system. Studies indicate that a $5 toll can reduce daily commuter VMT by as much as 20 percent (CAPCOA, 2010). Alameda congestion pricing would only occur during peak commute hours, and could include exemptions for carpools, EVs, and buses. Although congestion pricing could be a powerful tool for achieving many benefits at once, there are also important drawbacks to assess, such as the burden on local businesses and low-income drivers, as well as lack of transit alternatives from some parts of the island. Before moving this policy toward implementation, the City would conduct robust feasibility studies and community engagement. State law would need to be changed, since city governments are not currently authorized to establish tolls, and in-depth collaboration would be required with Alameda County, Caltrans, and other relevant agencies. Also, due to ever-increasing population and commute demands, Bay Area regional transportation planners have identified the need for a second transbay Bay Area Rapid Transit (BART) tube connecting San Francisco to Oakland (Hoge, 2018). Discussions surrounding a second BART tube have intensified recently, but many unknowns still exist. A specific timeline has not been developed and the construction price would run into the tens of billions of dollars (Hoge, 2018). Routing the BART tube through Alameda would potentially provide the opportunity of obtaining a BART station in the city. A BART station in Alameda would significantly alleviate congestion on the existing transportation links to and from the island (Hoge, 2018). The construction of an Alameda BART station, however, is likely contingent upon the designation of land for a station and, more importantly, the cultivation of sufficient future ridership.

Deep emissions cuts in the transportation and building sectors will require behavior change from tens of thousands of Alamedans who must upgrade their homes to run on electricity instead of natural gas. Tens of thousands will also need to choose transit and biking over driving, or an EV over a fossil fuel car. To bring about such behavior change, there are two categories of policy tools: “carrots,” which provide incentives for sustainable actions, and “sticks,” which provide disincentives for unsustainable actions. With the exception of a requirement for new residential developments to be all-electric and the possibility of congestion pricing, the CARP opts for incentives rather than disincentives.

This is largely out of consideration for social equity. Disincentives often come in the form of fees, which could add to the cost of living for households that are economically vulnerable. Given that low-income households typically have the lowest carbon emissions, adding to the economic burden on such households is not a socially equitable outcome. Disincentives and requirements may be considered in future iterations of the CARP; if so, they will be vetted to ensure they do not burden low-income Alamedans.

The City’s new goal is more ambitious than that set by the State of California: reducing emissions by 50 percent below 2005 levels by 2030. We expect to reach that goal by fully implementing City actions already committed to in plans such as the TCP and ZWIP Update, and by implementing new actions defined in this CARP. With the recent declaration of a climate emergency in Alameda in March 2019, the City continues to strive to reach net zero emissions[4] as quickly as feasible.

GHG Emissions Inventory and Projections

In 2017, the City developed an inventory for a new 2015 baseline with updated emissions projections for 2020 and 2030. The City also evaluated progress toward meeting their 2020 goal. As part of the CARP, the City reviewed and revised the 2015 inventory to incorporate the latest population and job projections from ABAG, as well as changes in the impacts of forecasted reductions previously estimated in the 2017 inventory document.

Figure 3-1 shows the breakdown of emissions by sector (i.e., transportation; building energy; and waste, water, and wastewater) from the 2015 inventory and the projected emissions in 2020 based on the business as usual (BAU) scenario. As shown, there is a projected decrease in transportation emissions in 2020 primarily due to increased (Pavley) fuel efficiency standards and California Air Resources Board (CARB) estimates for increased EV adoption. The projected increase in building energy use emissions is primarily due to growth in population and jobs. For a more detailed breakdown of Alameda's emissions, refer to Appendix D and the 2015 community-wide GHG inventory and projection to 2020 goal (COA, 2018a).

[4] Net zero CO2 emissions refers to balancing the amount of carbon released with an equivalent amount of carbon sequestered.

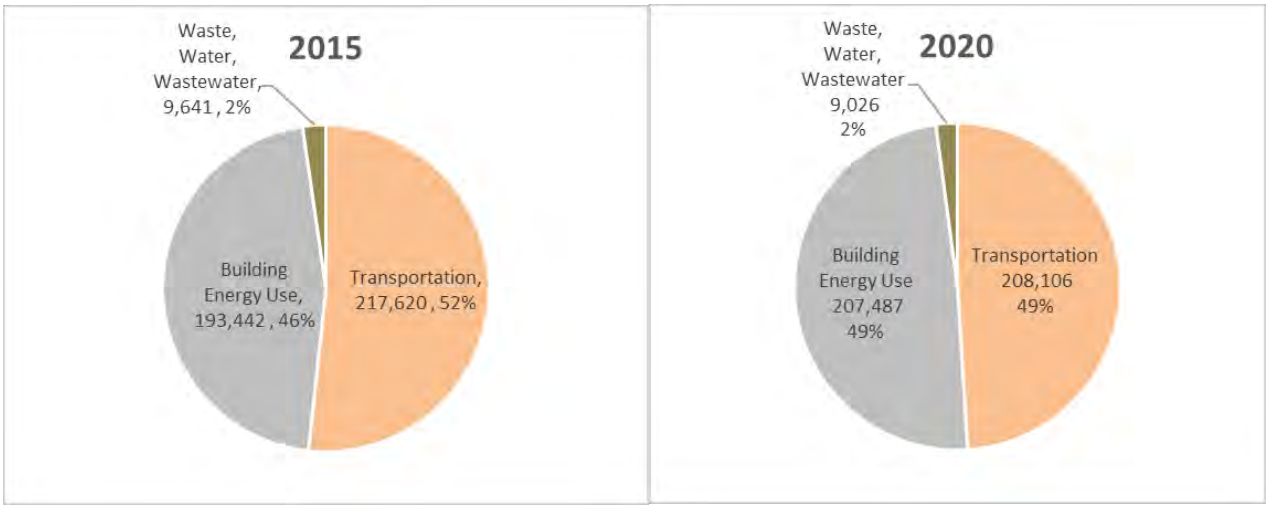


Figure 3-1. Alameda's 2015 and 2020 BAU emissions by sector (MTCO2e).

GHG Emissions Reduction Goals

California's statewide GHG emissions reduction goal is 40 percent below 1990 levels by 2030[5] and 80 percent below 1990 levels by 2050.[6] Within the *2008 Local Action Plan for Climate Protection*, Alameda adopted a reduction goal of **25 percent below 2005 levels by 2020**. The GHG reduction goals for comparable Bay Area and other cities are shown in Table 3-2.

Alameda Commits to an Ambitious GHG Emissions Reduction Goal in 2030

With significant support from City staff and stakeholders, Alameda commits to an ambitious reduction goal of **50 percent below 2005 levels by 2030**. This is more aggressive than the state goal and aligns with the goals established by many other Bay Area jurisdictions. Also, this supports reaching net zero GHG emissions as soon as possible.

Table 3-2. Summary of Selected GHG Reduction Goals

Target Year	Goal	City
2025	40% below 1990 levels	San Francisco
2030	50% below 2008 levels	Seattle
	80% below 1990 levels	Palo Alto
2040	Net zero GHG emissions	Seattle
2050	80% below 1990 levels	Santa Cruz
	80% below 2000 levels	Berkeley
	83% below 2005 levels	Oakland

[5] Per EO B-30-15
[6] Per EO S-03-05

Based on the results of the CARP analysis, Alameda is projected to reduce GHG emissions by 23 percent from 2005 levels in 2020 (i.e., about 95 percent of the reduction goal). Alameda's ability to achieve the ambitious 2030 goal of 50 percent below 2005 levels is based on achieving full implementation of the City's already committed to GHG initiatives and programs. However, these actions alone are not enough to attain the 50 percent reduction goal for 2030. Therefore, the City commits to implementing additional actions—beyond their existing commitments—to achieve Alameda's ambitious climate action goals.

Figure 3-2 illustrates the impact of full implementation of the already committed to and new GHG emissions reduction programs and actions. This figure shows the historical GHG emissions inventory and future BAU emissions projections (top blue line). The BAU projections include reductions attributable to the following state initiatives: Pavley fuel efficiency standards, energy efficiency improvements from Title 24 standards, and CARB estimates on increased EV adoption. The emissions reductions from the City's already committed to actions are shown in green. Sector-specific emissions reductions from new transportation, building energy, and sequestration actions are also shown in sector-specific colors. These reductions reflect the significant impact of already committed to City actions, the majority of which come from the 100 percent clean power AMP will deliver starting in 2020. The addition of new actions to be implemented will enable the City to meet its ambitious goal of a 50 percent emissions reduction (from 2005 levels) by 2030.

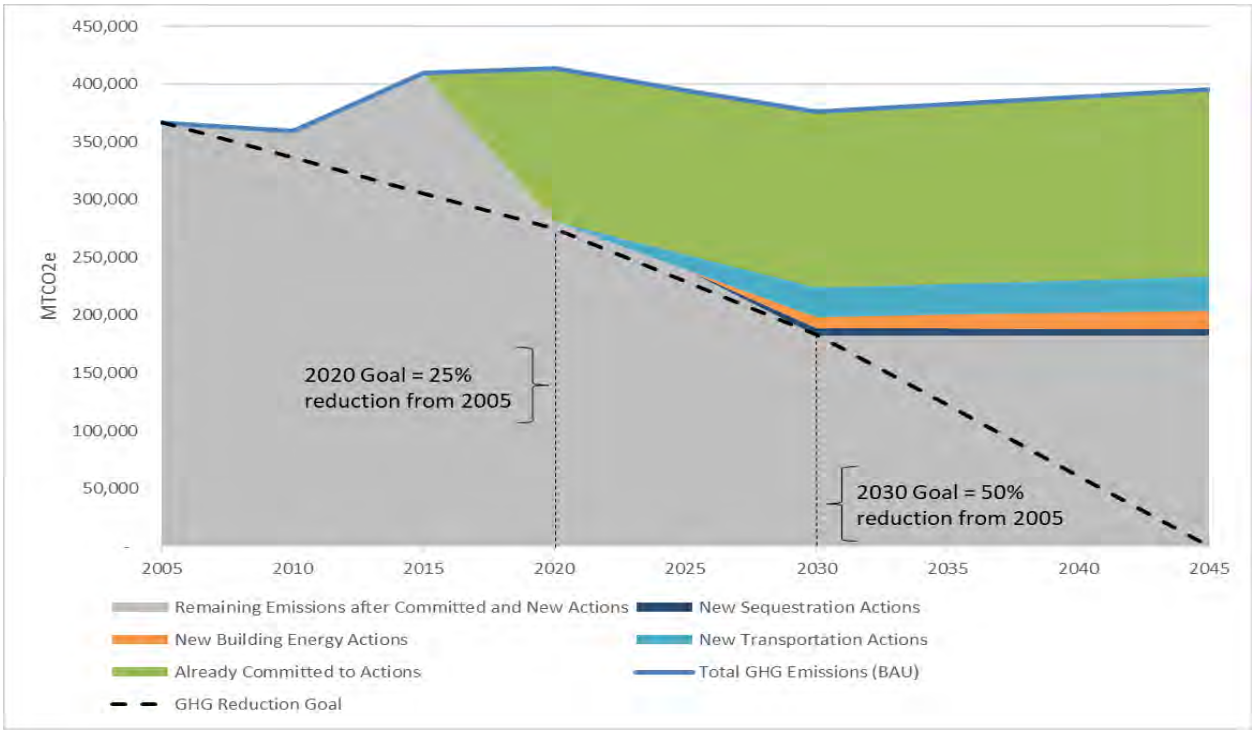


Figure 3-2. GHG emissions, goals, and reductions by sector: 2005–2030.

The City will update its GHG emissions inventory and future emissions projections periodically to evaluate the effectiveness of actions already implemented, adjust assumptions and implementation strategies, and explore new strategies and technologies that may emerge over time. The next inventory update will be completed no later than 2024 to guide an overall update to the CARP, which will be completed no later than 2025.

GHG Emissions Reduction Actions

Alameda is actively developing and implementing GHG emissions reduction programs in the key emissions sectors: transportation, building energy use, and waste. The many programs and projects the City will implement are referred to as "already committed to actions"—actions that the City has already committed to outside of this planning process but has not yet implemented. The already committed to actions, in combination with new actions presented in the CARP, provide the roadmap for achieving the 2030 emissions reduction goal and net zero GHG emissions as soon as possible.

City Actions Already Committed To

Three programs currently underway in Alameda reduce GHG emissions: AMP's delivery of 100 percent clean power by 2020, the TCP, and the ZWIP Update. Table 3-3 shows the specific actions implemented under these programs and the annual reductions they are predicted to achieve in 2030.

Table 3-3. Alameda's Already Committed to GHG Emissions Reduction Actions, Co-Benefits, and Reductions

Projected GHG Emissions Reduction Actions and Co-Benefits from Already Committed to Actions	2030 Annual Emissions Reductions (MTCO2e)
Provide electricity to all residential and commercial users in Alameda from 100% clean energy sources by 2020. *Co-benefits: Reduces reliance on fossil fuels.*	134,189[a]
Implement the TCP, which includes the following (COA, 2018b): ■ Citywide transportation management association; ■ Additional carpool lanes; ■ Additional facilities for biking and walking; ■ New shared mobility services like bike share and car share; ■ Bus service improvements (Alameda Point, crosstown express, and transbay service; regional transit hub); *EasyPass* expansion; ■ Parking management; ■ Increased ferry access and service; and ■ Traffic calming. Co-benefits: ■ *Reduces traffic congestion;* ■ *Increases safety;* ■ *Expands mobility for underserved populations; and* ■ *Increases resiliency of local transportation network.*	14,000[b]

Projected GHG Emissions Reduction Actions and Co-Benefits from Already Committed to Actions	2030 Annual Emissions Reductions (MTCO2e)
Implement the ZWIP Update to achieve 89% diversion, or 1.2 pounds per person per day of waste disposed of in landfills by 2020: ■ Support zero waste culture in Alameda; ■ Provide targeted technical assistance in commercial and multifamily sectors; ■ Create a food recovery program and enhance organics management; ■ Update the construction and demolition (C&D) ordinance and conduct outreach; and ■ Expand the high diversion franchise agreement. *Co-benefits:* ■ *Increases available compost, which has numerous benefits when applied to soil; and* ■ *Reduces waste generation, saving resources and avoiding "upstream" emissions.*	3,416[b]
Plant 2,000 new trees. *Co-benefits:* ■ *Decreases water use from drought-tolerant plants;* ■ *Provides shade;* ■ *Slows soil erosion;* ■ *Blocks sound;* ■ *Helps settle particles in the air;* ■ *Reduces heat island effect;* ■ *Provides bird habitat; and* ■ *Enhances beauty of the city and desirability of the community.*	290[a]
Total emissions reduction from current City actions	***151,895***

[a] Source: Appendix F.

[b] Source: Appendix D and the 2015 community-wide GHG inventory and projection to 2020 goal (COA, 2018a). ZWIP 2030 impact lowered to 89 percent diversion from 95 percent diversion in the inventory document.

[c] AC Transit's *EasyPass* program provides Alameda residents with a bus pass that is valid at any time on all AC Transit lines, both local and transbay. The *EasyPass* is "loaded" on a fare card with a photo and name on the back. See http://www.actransit.org/wp-content/uploads/3.14.000613_Park_Alameda_EasyPass_FAQ_WEB.pdf for more information.

Impacts from Already Committed to Actions

Figure 3-3 shows that beginning in 2020 with AMP's delivery of 100 percent clean electricity, the majority of Alameda's emissions will come from the transportation sector (i.e., about 70 percent of Alameda's annual GHG emissions). To reach our sustainability goals, Alameda must achieve deep cuts in transportation emissions.

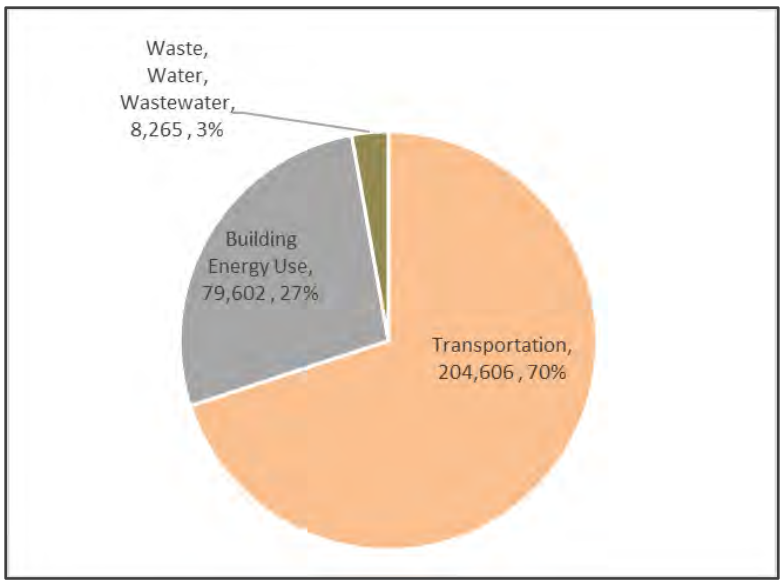


Figure 3-3. Alameda's 2020 GHG emissions projections, including impacts from already committed to actions.

Figure 3-4 illustrates the total BAU emissions forecast for 2030 along with the impacts of the City's already committed to and new actions in each year. The green bar shows the GHG emissions goal for each year.

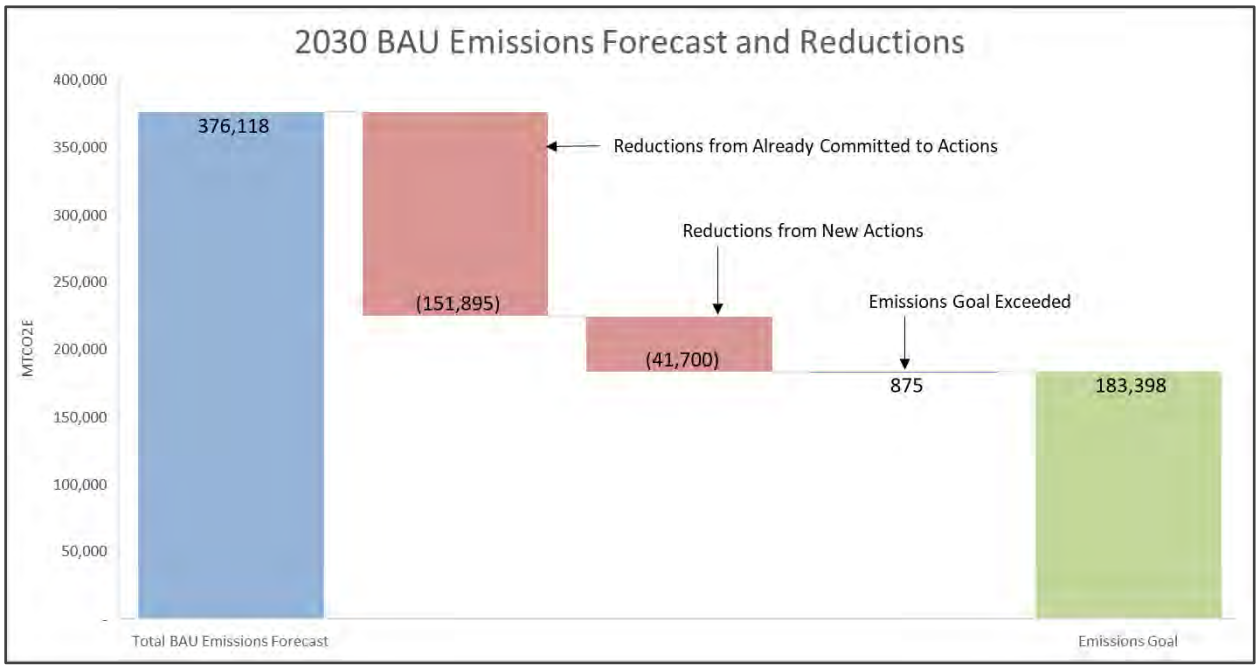


Figure 3-4. Alameda's 2030 BAU GHG emissions projection, already committed to actions, new actions, and goal.

Unofficial rendering of a concept for potential West End bike/pedestrian bridge as envisioned for TCP Project 39.

Additional GHG Emissions Reduction Actions

Through extensive stakeholder engagement, the City identified which GHG emissions reduction actions are most feasible, will have the highest impact, and have substantial public support. The City compiled an initial list of about 450 GHG emissions reduction ideas based on responses to a City survey distributed via Facebook in summer 2018, input received during community workshops, and best practices identified in other cities' climate action plans. Appendix E contains the initial list of ideas, including those that are not recommended in the CARP, along with the origin of each idea.

The City held a series of meetings and vetting sessions before selecting the final, new GHG emissions reduction actions for the CARP. Some ideas were removed from further consideration due to factors such as high costs, lack of enforcement ability, and technical infeasibility. For example, the City did not consider a total ban on natural gas and a ban on purchases of new natural gas appliances because of their inability to implement and enforce these ideas. Also, EV-only lanes were dropped from consideration because most city roads are two-lane and cannot be set aside for EVs only, and because EV access to high occupancy vehicle lanes is being phased out in California.

The City conducted a detailed analysis of the final actions to determine their GHG emissions reduction amounts (MTCO2e), other benefits (co-benefits with adaptation and others), and the lead agency responsible for implementation. These are listed in Table 3-4–Table 3-7 by sector. Actions that are slated for implementation after 2030 have "N/A" listed for their expected emissions reductions in 2030. Appendix F summarizes each action and provides other relevant information, including key assumptions and data

used in the analysis, abatement costs (i.e., capital and annual operations and maintenance costs), and references.

Transportation

There are three ways to reduce emissions from the transportation sector: mode shift, alternative fuel use, and less frequent travel. Mode shift is increasing the number of Alamedans who choose low-carbon forms of transportation, such as taking the bus, bicycling, or walking, over driving solo in conventional vehicles. The key statistic for mode shift is VMT. Reducing VMT reduces GHG emissions. The citywide TCP, which the City Council approved in 2018, focuses on mode shift to reduce drive-alone trips, congestion, VMT, and the resulting emissions. In addition to mode shift, one can completely cut VMT by avoiding trips, either by telecommuting (for those who have that option) or by combining multiple trips into one.

The second way to reduce transportation emissions is to reduce the carbon emissions from the vehicles we already use. This means driving alternative fuel vehicles such as all-electric, electric-gas hybrid, or hydrogen fuel cell vehicles. The shift to electricity-powered vehicles includes normal passenger cars, buses, ferries, and—once technology improves—heavy-duty vehicles and trucks. For example, AC Transit is a national leader in using fuel cell electric buses and plans to operate at zero GHG emissions by 2040.

Of the two approaches, mode shift is our first priority. Lowering VMT reduces traffic congestion, air pollution, and noise pollution, and it often results in increased community health and safety, more vibrant communities, and improved transportation options that benefit those without access to a vehicle. However, mode shift alone will not enable Alameda to reach its GHG reduction goals. We also need to support a widespread transition to EVs of all categories. With AMP's 100 percent clean electricity, EV emissions will come only from the materials used to manufacture and ship the car, with no emissions coming from the electricity that powers it.

Part 1: Encouraging Mode Shift by Building on the TCP

The TCP lays out 39 programs and projects designed to reduce VMT and the number of drive-alone trips during peak commute times. The CARP determined that to reach our GHG reduction goals, we need to amplify actions already in the TCP to achieve even greater mode shift, thereby reducing VMT and the emissions they produce. The CARP will also support the actions and strategies of the Active Transportation Plan, once it is adopted, to support further mode shift from solo driving to biking and walking. Of the actions below (Table 3-4), three (i.e., telecommuting, traffic signal synchronization, ban gas-powered leaf blowers) are new to this plan. (Note that the leaf-blower ban is included in this group because it reduces GHG emissions from the "off-road lawn and garden equipment" source category.) The remaining actions build on existing actions in the TCP.

Table 3-4. New GHG Emissions Reduction Actions for the Transportation Sector: Mode Shift

New Actions — Transportation (Mode Shift)	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
Transportation mode shift actions: T1–T5	2030: 5,124	■ 2030 VMT reduced (T1, T2, T4): 12,178,456	See below.	See below.
T1. Telecommuting. Encourage employees and employers to reduce commute trips by telecommuting. Develop outreach program and take steps to overcome barriers to implementation, such as eliminating double taxing and providing employer tax incentives. Because telecommuting will reduce VMT from commuters that work in Alameda as well as those that leave the island to work elsewhere, to be successful, this action must include outreach to employers beyond Alameda's borders. Also, implementation will include a combination of programs that encourage telecommuting and land use decisions that increase work-live and mixed zoning. As a regional issue, implementation of a telecommuting action will benefit from regional partners such as the Bay Area Commuter Benefits Program (CBP) (see https://511.org/employers/commuter/news). Because the CBP has access to all Bay Area employers with 50 or more employees, coordination with the program may help overcome some of the barriers to outreach.	2030: 2,968	■ T1 assumes 25% of Alamedans would telecommute an average of 1.5 days per week, which would result in a 5.5% reduction in commuter VMT. ■ Annual reduction in VMT would be 8,467,760 in 2030.	■ Reduces criteria pollutant and toxic emissions; and ■ Reduces traffic congestion and travel times.	■ Planning, Building and Transportation ■ Public Works ■ Economic Development ■ Information Technology ■ AMP

New Actions — Transportation (Mode Shift)	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
T2. Build additional bike lanes. Expand TCP project/programs by adding more dedicated and protected bike lanes and making pedestrian/bicycle improvements that increase safety, make it easier for people to use these modes, and connect residential neighborhoods with commercial centers and workplaces.	2030: 962	■ T2 assumes that every 1 mile of bike lane per 1 sq. mile of land area results in a 1% decrease in VMT for a total annual VMT reduction of 2,744,412 in 2030. ■ Reductions based on assumption of 10.44 additional miles of bike lanes constructed. (Alameda has 10.44 sq. miles of land area.) ■ The TCP commits to building 6.1 miles of bike lanes.	■ Reduces criteria pollutant and toxic emissions; ■ Reduces traffic congestion and travel times; ■ Improves health of Alameda residents; ■ Increases redundancy and resilience of transportation system; and ■ Improves emergency response.	■ Planning, Building and Transportation ■ Public Works
T3. Traffic signal synchronization. By 2030, improve synchronized timing of 25 traffic lights to improve traffic flow by slowing vehicle speeds and reducing idling.	2030: 779	■ T3 assumes synchronization of 25 (out of 86 existing) traffic signals. ■ T3 assumes annual gas savings per signal synchronized is 3,551 gallons, which corresponds to 31.18 MTCO2e. ■ T3 and TCP Project 10 both require upgrades to traffic signal control boxes and should be completed together.	■ Reduces criteria pollutant and toxic emissions; and ■ Reduces traffic congestion and travel times.	■ Public Works ■ Planning, Building and Transportation

New Actions — Transportation (Mode Shift)	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
T4. Expand *EasyPass* program. Provide 5,000 additional passes by 2030.	2030: 339	■ T4 adds another 5,000 passes to the 5,000 already committed to in the TCP, for a total of 10,000 passes to be distributed by 2030. ■ T4 assumes *EasyPass* users would reduce their VMT by 20%, or a total annual VMT reduction of 966,284 in 2030.	■ Reduces criteria pollutant and toxic emissions; and ■ Reduces traffic congestion and travel times.	■ City Council ■ AC Transit ■ Planning, Building and Transportation ■ Public Works
T5. Ban gas-powered leaf blowers. Ban gas-powered leaf blowers in the City of Alameda.	2030: 76	■ T5 assumes 50% of gas-powered leaf blowers are converted to electric and 50% cease operation.	■ Reduces criteria pollutant and toxic emissions; and ■ Reduces noise.	■ Planning, Building and Transportation
Supplemental actions: ■ Continue to support regional GHG emissions reduction goals and the *Regional Sustainable Communities Strategy: Plan Bay Area* by planning for and approving higher-density residential and mixed use residential projects on sites in Alameda identified in the Regional Plan, General Plan and Housing Element, and Municipal Code for higher-density, transit-oriented development. ■ City Public Works is investigating the use of goats to maintain landscapes (instead of lawn and garden equipment) as part of efforts to green its operations.				

Part 2: Transition to Electric, Zero Emission Vehicles

Because the TCP focuses on reducing drive-alone trips, it does not contain projects related to EVs. Though adoption of EVs should be secondary to mode shift due to the health, safety, and congestion benefits of mode shift strategies, adoption of EVs remains an integral strategy for reducing GHG emissions from the transportation sector. The actions below are steps that the City of Alameda can take to encourage residents to replace vehicles powered by fossil fuels with those powered by clean electricity.

It is important to note these aspects of the actions and their GHG reductions, as shown in Table 3-5:

- AMP programs: Some of the assumptions in the actions are based on AMP programs and electricity rates, which are subject to change according to the direction of the PUB.
- Battery recycling: The carbon dioxide equivalent (CO2e) reductions from the EV actions have been adjusted to reflect the offsetting emissions from battery recycling based on typical EV battery weights and 1.0 kg CO2/kg battery recycled data from Sullivan and Gaines (2010).

A variety of terms are used to evaluate EV-related GHG emissions reductions, including the following:

- EVs: vehicles that run wholly or partially on electric power and that can be recharged via the electrical grid. EVs include:
  - Battery electric vehicles (BEVs): vehicles that operate solely on electric propulsion, store electric power in onboard battery systems, and can be recharged via the electric grid.
  - Plug-in hybrid electric vehicles (PHEVs): vehicles that can operate on electric or gasoline propulsion, and that can be recharged via the electric grid.
- Super ultra-low emission vehicles (SULEVs): vehicles certified as meeting specified SULEV tailpipe emissions standards under the California Low Emission Vehicle (LEV) III regulations.
- Zero emission vehicles (ZEVs): vehicles certified as producing zero tailpipe emissions under the California LEV III regulations.
- Electric vehicle supply equipment (EVSE): the conductors, including the ungrounded, grounded, and equipment grounding conductors, as well as the EV connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatuses installed specifically to transfer energy between the premises wiring and the EV as defined in the 2016 California Green Building Standards Code.

Table 3-5. New GHG Emissions Reduction Actions for the Transportation Sector: Vehicle Electrification

New Actions — Transportation (Vehicle Electrification)	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
Transportation vehicle electrification actions: T6–T10	2030: 20,484	■ Strategies T6–T10 do not assume any changes in VMT. ■ Strategies T6–T10 assume 7,378 new EVs will be in use in Alameda by 2030, such that EVs will comprise 12% of all vehicles in Alameda by 2030.	■ T6–T10 decrease other non-GHG air pollutants by reducing driving in conventional vehicles, in addition to the other benefits shown below. ■ While an EV operator's electric bill will increase, this cost increase is likely less than what would have been spent monthly for gasoline if driving habits otherwise remain the same.	See below.
T6. Increase availability of EV charging stations citywide. Ensure that all new developments with new parking lots install charging stations for residents and/or customers. Streamline permitting processes for existing homeowners and business owners who wish to install charging stations. Add public charging stations in all City-owned parking lots. Allow residents to rent their driveways and private EV chargers to renters who do not have access to convenient charging.	2030: 8,209	■ T6 assumes meeting the EV charging space requirements of the California Green Building Standards Code: mandatory EV space requirements of 1 space per single family and 10% of total parking spaces for multifamily with more than 17 units and for non-residential.	■ Supports local access to EV charging for residential and public locations; ■ Helps remove range anxiety for EV owners; and ■ Likely increases purchases of EVs, which would also increase AMP revenue.	■ Planning, Building and Transportation ■ Public Works

New Actions — Transportation (Vehicle Electrification)	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
T7. Promote purchase of LEVs and ZEVs. Implement communications and outreach activities to promote the acquisition of light-duty EVs. The program could be modeled after California-based or federal Clean Cities programs in terms of promotional activities and structure. A five-year program is adequate for supporting early EV market liftoff locally. AMP participation in such a program is subject to PUB approval.	2030: 6,125	■ T7 assumes implementation of a five-year program that would result in 390 new EVs per year. ■ T9 is modeled after the national Clean Cities program.	■ Could increase local charging infrastructure development and ultimately drive down EV purchase costs; and ■ Could increase AMP revenue.	■ AMP ■ City Manager Office
T8. Continue programs to encourage new EV purchases. Encourage EV ownership by promoting a manufacturer's suggested retail price rebate ($2,000 for each new EV purchase). Also, emphasize continuation of programs from AMP, subject to PUB approval, to provide electricity rate discounts ($0.06/kilowatt-hour [kWh] per EV owner) and rebates to residential and non-residential customers who purchase a Level 2 EV charging station. AMP staff are currently developing more EV initiatives and will be taking the various programs to the PUB for approval in the coming year. Allow curbside charger installations for EV owners without assigned off-street parking.	2030: 5,314	■ T8 assumes a discount of $2,000 per new EV registration, and a continued AMP discount rate for light-duty EVs of $0.06/kWh. ■ The $2,000 rebate is assumed to increase EV purchases in Alameda by 20.6%. ■ The continued availability of these programs is subject to PUB approval.	■ Increases purchases of EVs, which would increase AMP revenue.	■ AMP ■ City Manager Office

New Actions — Transportation (Vehicle Electrification)	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
T9. Continue to encourage businesses to install EV charging stations. Implement communications and outreach activities to encourage workplaces and businesses to install EV charging systems. This will provide more destination charging options for EV owners, thereby addressing range anxiety fears for current and prospective EV owners. Businesses can take advantage of AMP's current charger rebates.	2030: 691	■ T11 assumes 52 new workplace/retail public chargers installed per year over the five-year program. ■ Modeled after U.S. Department of Energy's national workplace charging program.	■ Supports local access to EV charging for workplaces; ■ Helps remove range anxiety for EV owners; and ■ Could increase purchases of BEVs vs. PHEVs, which would increase AMP revenue.	■ AMP ■ Planning, Building and Transportation
T10. Electrify City's fleet. Convert the light-duty portion of the City's vehicle fleet to EVs.	2030: 145	■ T10 assumes that 208 light-duty, non-police-patrol, and police-patrol vehicles are replaced with EVs by 2030. ■ T10 does not assume that the heavy-duty vehicles in the City's fleet will be converted.	■ Provides quieter and cleaner City fleet; and ■ Lowers maintenance requirements and operating costs.	■ Public Works

Land Use and Housing

Researchers, policymakers, and planners widely accept that high-density developments located near transit corridors result in lower GHG emissions on a per-unit basis as compared to low-density developments. The Urban Land Institute's *Growing Cooler* report (Ewing et al., 2008) states that compact development alone has the potential to reduce national transportation CO2 emissions by 7 to 10 percent when compared to continuing urban sprawl. Additional CO2 reductions occur from decreases in energy use (for heating and cooling) and consumption-based emissions in high- as compared to low-density developments. Researchers at the University of California (UC) Berkeley state that California's residential housing sector will be key to achieving the state's economic and environmental goals through 2030 and beyond (Decker et al., 2017). A study at Oak Ridge National Laboratory (Brown and Southworth, 2008) states that a suburban density of four homes/acre produces 25 percent more CO2 emissions than an urban development of 20 homes/acre.

GHG emissions reductions expected under various densities can be estimated based on VMT, where the percent change in VMT is roughly the same as the percent change in CO2e emissions (CAPCOA, 2010). For example, the Marina Cove development on Buena Vista Avenue is an 89-unit mix of townhomes and single-family homes on a 7.14-acre property (i.e., 12.5 units/acre). The site is located directly on AC Transit Line 19 with direct service to downtown Oakland and BART. In comparison, the VMT and GHG emissions from a proposed development planned as a 330-unit, high-density project on an approximately 8-acre site directly on an AC Transit line (i.e., 40 units/acre) are estimated to be approximately 25 percent less than the VMT and GHG emissions attributable to Marina Cove. Other ways that high-density housing can result in carbon emissions savings include decreased heating and cooling costs, because units tend to be smaller and easier to heat/cool, as well as decreased total construction materials, resulting in decreased carbon emissions from the production of cement, steel, timber, and other products.

In addition to the connection between density and GHG emissions, there is also a connection between affordability and GHG emissions. Alameda requires that a minimum of 15 percent of all units in a project be deed-restricted for affordable housing. This aligns with Alameda's 2018 Economic Development Strategic Plan vision of providing a wide range of housing consistent with the Housing Element and maintaining a commitment to social equity (COA, 2018c).

There are many reasons to support a range of housing affordability options in a community, and one of them is that greater availability of affordable housing decreases GHG emissions. Low-income residents are more likely than high-income residents to use transit, which has lower GHG emissions than driving a car powered by fossil fuels. Affordable housing options also allow lower-income workers in Alameda to live near their place of work, as opposed to commuting from faraway yet affordable cities on the periphery of the Bay Area. Living close to work reduces VMT and associated GHG emissions. Additionally, income is highly correlated with consumption. Lower-income households tend to consume less and, as a result, have lower carbon footprints. (For more information, see "Consumption-Based Emissions" on page 40.) As the City of Alameda considers zoning changes and actions to accommodate regional housing needs, those changes and actions—if done well—can significantly impact the City's goals of reducing GHG emissions.

In summary, the City should consider the following climate change principles in all future land use and housing policy decisions:

- Change zoning to allow more multifamily use, reduced parking requirements, and increased allowable density while shortening overly lengthy permitting timelines.
- Implement anti-displacement policies, such as preservation of affordable housing, tenant protection, and guarantee of lease renewal to build on the City's Rent Stabilization Ordinance.

- Direct more funds to rail and bus rapid transit investments. Additionally, improve bus and other connections to rail and bus rapid transit, including increasing walking/bike infrastructure.
- To address future regional housing needs, providing housing on fewer sites that support higher-density development has lower GHG emissions than providing housing at more sites with lower densities.
- Multifamily housing configurations are better than single-family configurations.
- Eliminate minimum parking requirements and establish maximum parking requirements, similar to the standards adopted for Alameda Point in 2014.

In addition, the City will continue to support regional GHG emissions goals and the *Regional Sustainable Communities Strategy: Plan Bay Area* by planning for and approving higher-density residential and mixed use residential projects on sites in Alameda identified in the Regional Plan, General Plan and Housing Element, and Municipal Code for higher-density, transit-oriented development.

Energy Use in Buildings

With AMP providing 100 percent clean electricity beginning in 2020, Alameda's GHG emissions from the building sector will come primarily from natural gas consumption. Accordingly, the CARP's recommended new actions for the building sector focus on reducing GHG emissions related to natural gas use in buildings (Table 3-6).

The first step toward this goal requires fuel switching from natural gas to electricity in existing buildings. The second step requires new residential developments to be all-electric. This means replacing gas-powered appliances like furnaces, water heaters, clothes dryers, and stoves with their electric equivalents while improving insulation and efficiency so that less energy is needed.

PG&E Applies Best Practices to Reduce GHG Emissions

According to PG&E's 2018 Gas Safety Plan, the natural gas provider will:

- Ensure compliance with SB 1371, which requires the adoption of rules and procedures to minimize natural gas leakage from California Public Utilities Commission-regulated natural gas pipeline facilities.
- Implement a gas leak abatement program that includes annual methane emissions tracking reporting and a biennial best practices compliance plan submission.

Note that methane is a powerful GHG that is approximately 86 times more harmful than CO_2 over a 20-year period.

Housing Authority's Rehabilitation Programs Assist New Homeowners

The City of Alameda's Housing Authority offers several Housing Rehabilitation Programs, which provide low-interest loans and grants to eligible homeowners in Alameda. Rental property owners, whose units are occupied by 51 percent or more low-income renters, are also eligible for low-interest loans to make repairs and qualified property improvements. Senior and disabled households may be eligible for additional assistance. Support is given during the bid process and continues during the construction phases of the project. This assistance is provided as a no-cost program benefit. Rehabilitation staff have technical skills and experience to help your project progress from need to completion. Visit www.alamedahsg.org to find more information about Residential Rehabilitation Programs under Community Housing Resources.

While there is still much to learn in the push toward buildings powered by 100 percent clean energy provided by AMP, early studies suggest that all-electric homes and businesses can have lower energy bills) than current homes and businesses (Petersen et al., 2019). Under SB 1037, AMP reports annually to its customers and to the CEC on its investment in energy efficiency and demand-reduction programs. The report describes AMP's programs, expenditures, and expected and actual energy savings, and it demonstrates cost-effectiveness (among other metrics) in procuring energy. Because this reporting is in terms of kWh savings, another method is needed to account for carbon savings under AMP's programs. As the focus on fuel switching from natural gas to electricity gains traction, AMP and its fellow publicly owned utilities may need to work together to develop a tool that reports on carbon savings for each measure. Subject to PUB approval, AMP may develop additional programs that support fuel switching in buildings from natural gas to electricity.

Table 3-6. New GHG Emissions Reduction Actions for the Energy Use in Buildings Sector

New Actions — Energy Use in Buildings	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
E1. "Fuel switch" in existing buildings. Convert natural gas consumption to electricity use in residential and commercial buildings. Require fuel switching from natural gas-powered appliances and heating to electric-powered appliances and heating when existing residential buildings are being substantially expanded. Draft ordinances to establish fuel switching requirements. If all-electric construction is more expensive than units with gas utilities, consider exemptions for 100% affordable housing projects. The City of Alameda will support programs that encourage homeowners/commercial building owners to implement electrification retrofits.	2030: 7,836	■ E1 assumes that 12% of residential and commercial natural gas is replaced with electricity by 2030. ■ Emissions reductions resulting from E1 are discrete and above and beyond emissions reductions associated with E3.	■ Increases AMP revenue; ■ Improves safety (mitigates hazards associated with natural gas explosions); and ■ Can encourage flood-proofing retrofits by ensuring electrical panels are not located in areas of the house prone to flooding.	■ Planning, Building and Transportation
E2. Electrification of new residential construction. Prepare ordinances requiring all new residential construction to be 100% electric-powered with no gas hookups.	2030: 1,887	■ E2 assumes that all new residential construction will be all-electric, with no gas hookups. This equates to 2,727 residences constructed as all-electric by 2030.	■ Increases AMP revenue; and ■ Can encourage flood-proofing retrofits by ensuring electrical panels are not located in areas of the house prone to flooding.	■ City Council ■ Planning Board ■ Planning, Building and Transportation

New Actions — Energy Use in Buildings	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
E3. Programs to encourage fuel switching in certain appliances. Encourage the PUB to continue implementing AMP rebate programs encouraging residential customers to install ENERGY STAR-labeled electric clothes dryers and electric heat pump water heaters.	2030: 447	■ E3 assumes that 10% of AMP's residential customers will replace natural gas clothes dryers with electric dryers by 2030 (3,819 customers). ■ E3 assumes that 1% of AMP's residential customers will replace natural gas water heaters with electric heat pump water heaters by 2030 (382 customers).	■ Increases AMP revenue; and ■ Improves safety (mitigates hazards associated with natural gas explosions).	■ Public Works ■ AMP ■ Recreation and Parks
E4. Green roof installations on new developments at Alameda Point. Require at least 10% of roof areas on new development in Alameda Point to be installed as green roofs. This action aligns with the Alameda Point Stormwater Management Plan requirements.	2030: 6	■ E4 assumes green roofs will be implemented on 10% of the roof areas (on average) of 1,909 residential units and 25 commercial units by 2030.	■ Increases adoption of green infrastructure; ■ Reduces building operating cost; ■ Promotes cooling effect; ■ Controls stormwater runoff; ■ Increases sequestration; and ■ Improves workplace environment and employee health with accessible green roofs.	■ Base Reuse ■ Planning, Building and Transportation

Supplemental actions:

- Promote distributed generation (rooftop solar). The 2019 Building Energy Efficiency Standards that will become effective January 1, 2020, require that all new residential buildings incorporate rooftop solar. In addition, AMP currently has two solar rate plans that help motivate customers to install solar. The continuation of these plans is subject to PUB approval. Net energy metering is a special rate plan for solar and renewable generation customers who were interconnected before July 31, 2017. Eligible renewable generation is a special rate plan for new renewable generation customers that went into effect on December 31, 2016. These programs—taken together with appropriate battery storage—help Alamedans become more climate-resilient and will help decrease reliance on the electric grid during any energy emergency.
- Draft zoning code amendment to facilitate reduction in energy use by exempting energy-efficient windows and doors from the design review process.

Sequestration

In addition to halting the release of new emissions into the atmosphere, an essential part of the global strategy for addressing climate change is drawing down carbon from the atmosphere. While constraints of space and Alameda's urban character mean that more of our impact comes from curbing our emissions, carbon sequestration is nonetheless an important component of Alameda's climate action strategy.

This plan focuses on two ways to draw down carbon (Table 3-7). First is applying compost to vegetated areas in Alameda. The compost spurs a process that draws down carbon from the atmosphere and stores it in the soil. The second method is planting trees, which also provide numerous hazard reduction and quality-of-life benefits. Trees sequester carbon by breathing in CO2 and store the carbon as plant material.

Alameda's Tree Canopy Assessment indicates that the City's current inventory of planted trees sequesters over 11,000 MTCO2e each year (COA, 2017). An already committed to action adds 2,000 trees to that inventory, and the new action increases that by 1,500 more trees by 2030. This will bring Alameda's inventory of planted trees to "full stock" according to the 2010 Master Tree Street Plan (COA, 2010). City Public Works and the Recreation and Parks Department will focus planting on the types of trees that have the best sequestration potential to help ensure the predicted sequestration is achieved. This action will also engage the public by providing volume discount pricing at local nurseries for residents who want to plant their own trees.

Table 3-7. New GHG Emissions Reduction Actions for Sequestration

New Actions — Sequestration	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
S1. Apply compost to Alameda parks and open spaces. Diverted organic waste will be processed into compost that will be used in Alameda parks and other open spaces, such as preserved areas in Alameda Point.	2030: 5,560 2050: 5,796	■ S2 assumes that by 2030, the City applies compost from 13,238 tons of diverted organic waste to vegetated areas each year. By 2050, it is estimated that the amount of diverted organics grows to 13,800 tons per year.	■ Promotes stormwater recharge, flood reduction, and heat/drought resilience; ■ Promotes organic enrichment of soils (carbon farming) for moisture retention, healthy trees, and carbon sequestration; and ■ Decreases soil erosion, water usage, and use of fertilizers and herbicides.	■ Recreation and Parks ■ Public Works
S2. Further develop urban forest. Plant more trees in Alameda, increase landscaped islands, replace damaged trees, and make carbon sequestration a higher priority for the landscape maintenance contract. This action estimates the sequestration potential of planting 1,500 new trees in Alameda, in addition to the 2,000 new trees by 2030 that are already part of already committed to actions. The 1,500 new trees will comprise planting by the City and the public. The public will be incentivized by a volume discount to be negotiated by the City with local nurseries. Vouchers for the trees may also be available.	2030: 356 2050: 356	■ S1 assumes that 350 trees per year (i.e., 200 under an already committed to action, and 150 under the new action) will be planted from 2020 to 2030, resulting in 3,500 new trees planted by 2030.	■ Decreases water use from drought-tolerant plants; ■ Provides shade (reduces heat-related risk); ■ Slows soil erosion; ■ Blocks sound; ■ Helps settle particles in the air (reduces wildfire-smoke impacts); ■ Provides bird habitat; and ■ Enhances beauty of the city and desirability of the community.	■ Public Works ■ Recreation and Parks

New Actions — Sequestration	GHG Emissions Reduction (MTCO2e)	Key Factors for Implementation	Other Benefits	Responsible Entities
Supplemental actions: ■ Encourage urban farming and Climate Victory Gardens as a means of sequestration and resiliency (e.g., create rooftop and vertical gardens, convert vacant lots to community gardens). Consider partnerships with Alameda Backyard Growers and other community-based gardening organizations. Co-benefits include distributing surplus organic food to low-income residents via food banks. ■ Support and fund the vision of coastal dune, grassland, and wetland/marsh habitat enhancement and creation at Alameda Point to support sea level rise adaptation and carbon sequestration, among other benefits such as wildlife habitat and creation.				

Consumption-Based Emissions

The emissions inventories described thus far for the Alameda community are for "production-based" activities, meaning they are directly produced in or attributable to Alameda (e.g., emissions from the gas burned in cars and fossil fuels burned to provide natural gas and electricity). Calculating production-based emissions is the standard method that cities use to estimate emissions; however, this does not provide the full emissions picture. Because Alameda imports far more goods than it exports (i.e., most of the goods consumed in Alameda are produced outside of the city), the emissions Alameda is responsible for as a consumer of goods and services are much higher than the emissions directly produced within city limits.

Emissions are generated during the manufacture and transport of all physical things we buy. A hamburger, a plastic toy, the concrete in a building—all of these things have carbon footprints, and they can be surprisingly significant. A cheeseburger, for example, is estimated to have a carbon footprint of about 9 pounds of carbon released into the atmosphere per burger, the equivalent of burning about half a gallon of gasoline. The emissions associated with the goods and services we buy are called "consumption-based emissions."

Although there is no standard method that municipalities can use to estimate their consumption-based emissions, a UC Berkeley model estimates emissions based on a number of factors, including household size, a cost of living index, and a consumer expenditures survey (Jones and Kammen, 2015). Research shows that the model's biggest predictor of consumption-based emissions is average household income. Figure 3-5 shows that study's estimates of emissions in Alameda.

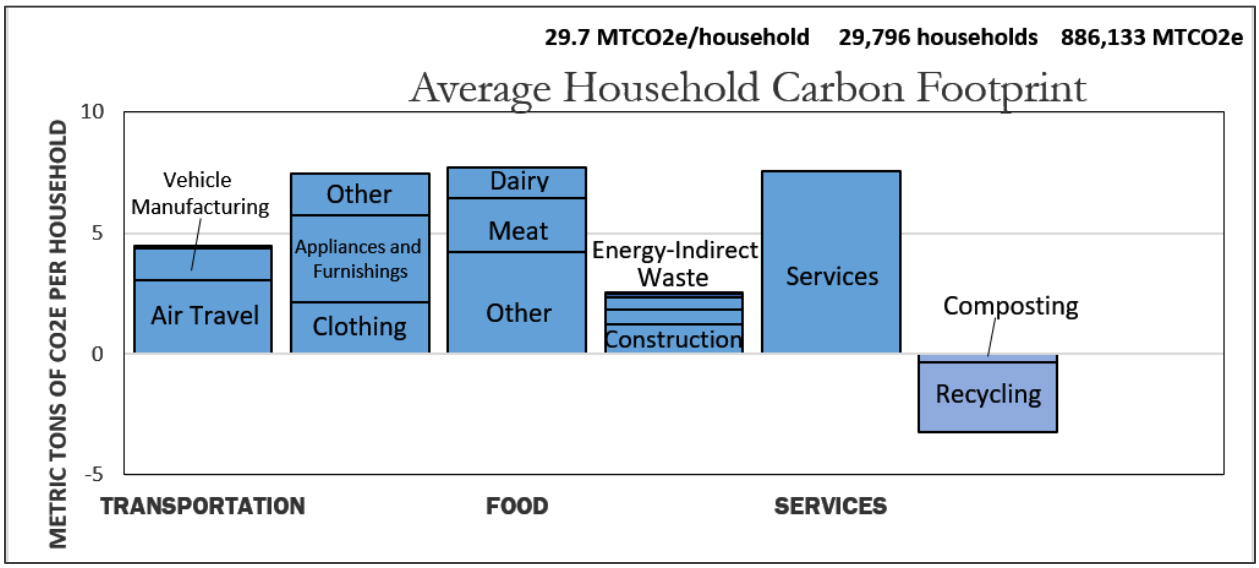


Figure 3-5. Alameda's consumption-based GHG inventory (Jones and Kammen, 2015).

What Can You Do?

Consumption-based emissions create one of the best opportunities for individuals who want to make a difference in their carbon footprint:

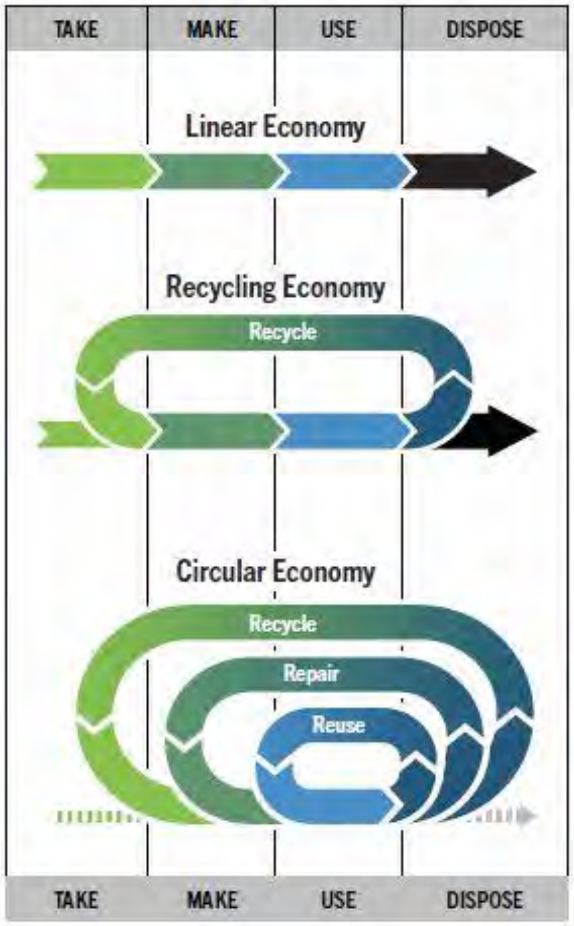
- Buy less. Almost everything we buy has a carbon footprint.
- Buy things that are durable, secondhand, and locally and sustainably produced.
- Eat fewer animal products and minimize wasted food. If the food system was a country, it would be the third largest emitter of GHGs in the world.
- Grow a garden and produce some of your own food.
- Seismically retrofit your home. Minimizing building materials needed to rebuild after an earthquake saves large amounts of GHG emissions.
- Fly less to make one of the single biggest GHG reductions on an individual level.

More ideas and details on how to reduce your personal carbon footprint are available at www.tinyurl.com/AlamedaCARP.

In Alameda, the average household carbon footprint is about 40.5 MTCO2e/year. This is lower than the Bay Area average of about 44.3 MTCO2e/year per household, and the U.S. average of about 49.8 MTCO2e/year per household. Excluding emissions from direct and indirect vehicle fuels, natural gas, electricity, and waste, which are also counted in the production-based inventory, Alameda's consumption-based emissions are estimated as 29.7 MTCO2e/year per household. This is almost three times higher than Alameda's production-based emissions, which in 2019 are estimated to be about 10.1 MTCO2e/year per household. Consumption-based emissions are higher because most of the goods Alameda consumes are produced outside of the city.

This means that reducing consumption-based emissions provides a significant opportunity for reducing emissions overall. For example, if every household in Alameda reduced meat consumption and air travel by only 10 percent, approximately 16,000 MTCO2e would be saved per year. This is a higher level of savings than would be produced by any of the GHG reduction actions listed in the previous section.

In recognition of the importance of consumption-based emissions for Alameda, the City will use the best available data to estimate a consumption-based emissions inventory while also completing a production-based inventory.



Beyond just addressing "end of life" issues with waste materials, circular economy principles address many aspects of eliminating waste, across many lifecycles.

Source: StopWaste.org, June 2018

What Is the City Doing?

The City of Alameda is taking on this challenge primarily through the ZWIP Update, which includes programs and policies designed to reduce the amount of material we send to landfills (see Table 2-1 in the ZWIP Update for more information). Alamedans can achieve this by buying fewer single-use materials and increasing recycling and composting. Recycling materials, including construction materials like concrete, wood, and metal, reduces our need to extract and manufacture new material and avoids the carbon footprint associated with those processes. The California Green Building Standards Code requires at least 65 percent (by weight) of waste hauled from all C&D projects to be recycled.

Sending organics (e.g., food scraps) to landfills produces methane, a GHG approximately 86 times more harmful than CO2 over a 20-year period. Composting these organics and then applying the compost amendment to soils and vegetated areas results in the removal (or sequestration) of carbon from the atmosphere.

An important strategy in the ZWIP Update is the City's support of a "zero waste culture" in Alameda. A zero waste culture not only promotes waste reduction through reuse, recycling, and composting programs, but also emphasizes a circular economy model, which considers the entire life cycle of products and services and maximizes the reuse of materials at the end of their useful life.

Toward Net Zero GHG Emissions

The City of Alameda has joined a small number of cities such as Berkeley, Hayward, and Oakland to declare a climate emergency and support a global push to net zero GHG emissions.[7] Below we describe steps that will likely be required for Alameda to reach net zero emissions.

First, the City will have to adopt or accelerate large-scale transportation projects that reduce solo driving, such as congestion pricing, a new Alameda BART station, free AC Transit bus passes to all Alamedans, and a new estuary crossing for bicyclists and pedestrians. The hurdles to advancing these projects are significant, yet if implemented, Alameda's carbon footprint from transportation would shrink dramatically. Traffic congestion would also decrease significantly.

Second, all existing buildings and vehicles will have to shift from being powered by fossil fuels to being powered by 100 percent clean electricity or other energy sources. Achieving this level of fuel switching in buildings might be accomplished through step-by-step replacement of fossil fuel-powered appliances, or it might involve a natural gas ban—a move that no U.S. city has yet taken, but that cities such as Amsterdam and Vancouver, Canada, are moving toward. Successful implementation of other transportation projects would reduce the number of Alamedans who drive, but those who do would need to replace fossil fuel-powered cars with vehicles powered by clean energy.

Third, the City would likely need to shift its efforts from incentives, upon which this plan heavily relies, to mandates. Existing incentives would also need to be increased. To eliminate fossil fuel emissions from Alameda's residential buildings, every building would have to be retrofitted with electricity-powered furnaces, water heaters, dryers, and stoves. These retrofits would also typically require electrical panel upgrades. A complete retrofit could cost property owners nearly $30,000 per single family home (or $900 million citywide). Though some property owners might elect to undertake these conversions with incentives, it is likely that the City would have to mandate the majority of retrofits to reach net zero GHG

[7] Net zero CO2 emissions refers to balancing the amount of carbon released with an equivalent amount of carbon sequestered.

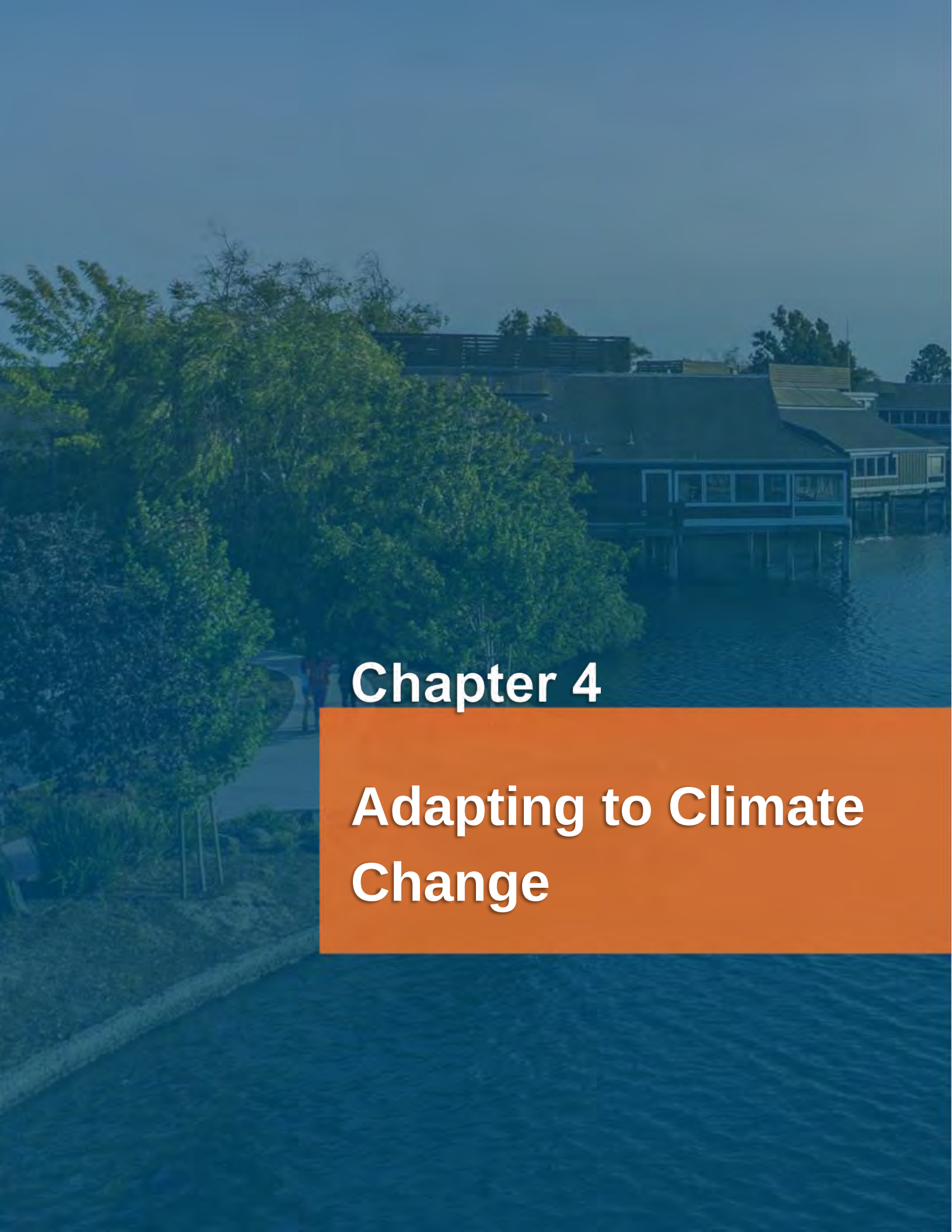
emissions. A similar mandate might be possible for the necessary conversion to EVs, though the legal and policy impacts of such a change warrant further analysis.

Fourth, AC Transit and AMP's capacity to deliver carbon-free services would have to go through a substantial expansion. If enough Alamedans used AC Transit bus passes to achieve net zero emissions, AC Transit would have to run additional buses to provide sufficient service, and each bus would have to be carbon neutral. Similarly, AMP would have to significantly expand its infrastructure and power purchasing to handle all the additional load caused by all-electric buildings and cars.

Fifth, while successful implementation of the above would bring Alameda's GHG emissions close to zero, it is likely that some emissions would remain. To reach zero, the City will likely have to significantly expand carbon sequestration efforts. In addition to planting more trees and applying more compost, achieving net zero GHG emissions could require technologies and applications not yet implemented in a municipal context. The City may also need to purchase carbon offsets in the future to help achieve net zero GHG emissions, and the proposed Climate Fund could be a source of funds for those offsets.

Finally, a true accounting of net zero emissions must also consider consumption-based emissions, as discussed on page 40. Since Alameda imports most of its goods and materials from off the island, the city's carbon footprint from "upstream" sources related to food, building materials, and consumer products, is much larger than the footprint of "downstream" sources such as vehicle tailpipe emissions and natural gas use in buildings. While upstream emissions are exceedingly difficult to quantify at the city scale, a good-faith effort toward citywide net zero GHG gas emissions would also include a substantial effort to reduce upstream emissions.

Although it is challenging, by achieving net zero emissions, Alameda would become a model for the rest of the state, country, and world in charting a path toward a climate safe future—one that preserves Alameda's communities for decades to come.



Chapter 4

Adapting to Climate Change

Climate Change Adaptation

Building resilience to climate change in Alameda is crucial for ensuring the long-term viability of our city and the health of our residents. We're already experiencing climate impacts, and they're expected to get worse. This plan lays out short- and long-term strategies for building climate resilience and supporting the health and safety of our community.

The CARP pulled together the substantial analysis and climate change preparation the City has already completed, and it builds on that foundation by identifying gaps in the prior analysis and suggesting actions to address our remaining short-term vulnerabilities. The plan also presents a framework that allows Alameda to prepare for an uncertain, longer-term future while making wise use of current resources.

To systematically tackle an issue as complex as climate change, each major climate impact (e.g., flooding, extreme heat) is considered in turn, as is each major sector of the built environment. The social and economic aspects of vulnerability are considered throughout the CARP. Given Alameda's setting as a low-lying island city, particular attention is given to the issues of sea level rise and flooding.

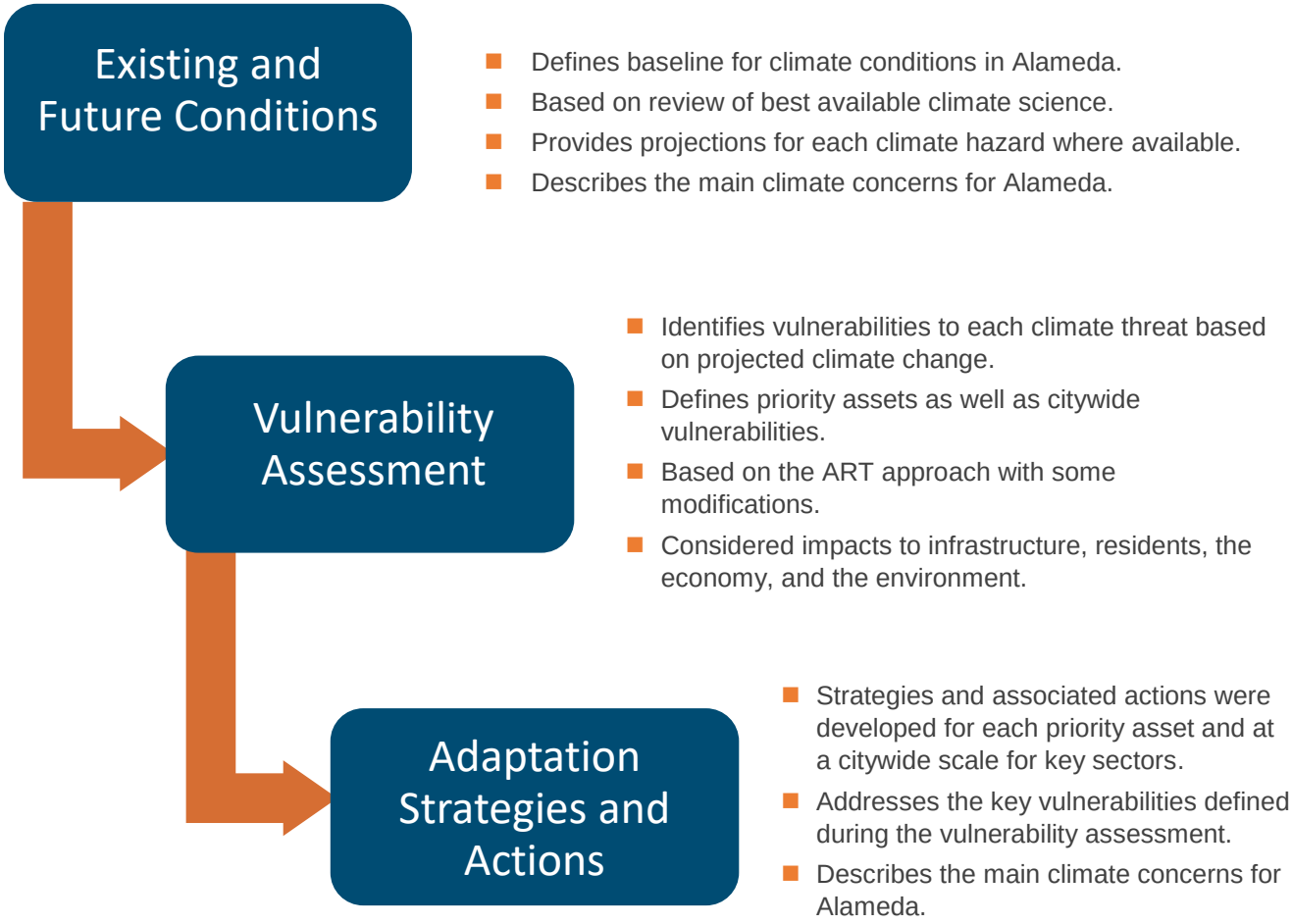
This analysis indicates that Alameda's climate vulnerabilities are cause for neither panic nor complacency. Significant challenges remain, but with persistence and commitment, the City and community have enough time to proactively address climate impacts and work toward a climate safe, healthy, sustainable Alameda.

We are committed to identifying and implementing adaptation actions that address the climate hazard-specific goals found in Table 4-1.

Table 4-1. Climate Hazard-Specific Goals That Drive the CARP

Hazard	Goal
Sea level rise and storm surge	Protect assets from sea level rise and storm surge, plan future land use to avoid impacts, and enhance natural shoreline habitat to mitigate impacts.
Inland flooding	Increase resiliency and capacity of the stormwater system to prevent flooding of assets during extreme precipitation events.
Drought	Reduce water consumption and increase drought-resistant landscaping.
Extreme heat	Reduce heat island effect and protect vulnerable populations from heat impacts during heat waves.
Wildfires	Protect public health from smoke impacts during wildfire events, especially among vulnerable populations.
Liquefaction/ earthquakes	Ensure building and infrastructure retrofit and new design standards in areas at high risk of liquefaction consider both seismic risk and sea level rise impacts.

To accomplish these goals, the CARP includes the adaptation-focused components shown in the following graphic. As conditions change, each component should be revisited as described in Chapter 6, "From Plan to Action," to update Alameda's vulnerabilities and ensure that the most effective strategies are prioritized and funded going forward.



Existing and Future Conditions Summary

Research on the impacts of climate change is an evolving science. This vulnerability assessment considered several current sources of information to characterize both existing climate change impacts

Investigating Regional Climate and Socioeconomic Risks

Alameda is part of a regional community in the Bay Area that is at high risk from the impacts of climate change. While the maps depicting climate hazards shown throughout the CARP present impacts to Alameda only, the regional context should be kept in mind, as some solutions will require regional approaches.

Organizations and agencies in the Bay Area and around the state have developed interactive, web-based maps to view climate impacts. Those interested in better understanding regional hazards are encouraged to explore the following products by clicking on these links:

- ART Bay Shoreline Flood Explorer
- Cal-Adapt
- CalEnviroScreen
- ABAG Resilience Program: Earthquake Risk Resources
- Climate Central States at Risk Platform

and projections of future climate change impacts. Table 4-2 summarizes existing and projected climate impacts in Alameda from our review of the literature at the time of the assessment.

The California Ocean Protection Council (OPC) guidance describes probabilistic sea level rise projections for each decade up to 2100 as well as longer-term projections with much higher levels of uncertainty. The guidance presents projections under lower and higher GHG emissions scenarios, and for several probabilities (67 percent chance, 1-in-20 chance, and 1-in-200 chance), to allow decision-makers to determine their level of risk aversion for climate planning.

Ranges in Table 4-2 represent the “Low Risk Aversion” (67 percent probability range) to “High Risk Aversion” (1-in-200 chance) projections with the “Extreme Risk Aversion” or H++ projection in parentheses. A high emissions scenario is presented in the table for the year 2100. A table of a range of sea level rise projections from the most recent *State of California Sea-Level Rise Guidance* is included in Chapter 5, “Making Economically Informed Climate Change Decisions” (Table 5-1).

Table 4-2. Observed and Projected Climate Impacts

Hazard	Impacts to Date	Year	Projection	Source (for projection)
Sea level rise	Sea level in the San Francisco Bay has risen over 20 cm (8 inches) in the last 100 years.[8]	2030	6–10 inches (H++ = 12 inches).	Griggs et al., 2017
		2050	10–23 inches (H++ = 32 inches).	Griggs et al., 2017
		2100[9]	29–83 inches (H++ = 122 inches).	Griggs et al., 2017
			More frequent, extensive/longer-duration flooding. Shoreline erosion and overtopping. Elevated groundwater. Permanent inundation and associated impacts.	California's Fourth Climate Change Assessment (2018)[1]
Precipitation (overland flooding)	Decline in Sierra Nevada snowpack has occurred over the last half-century.[1]	2035	4.8–14.5 percent more intense precipitation (defined as inches/hour).	U.S. EPA, 2016
		2060	9.3–28.3 percent more intense precipitation.	U.S. EPA, 2016
	The 2012–2016 California drought led to the most severe moisture deficits in the last 1,200 years and a 1-in-500 year low in Sierra snowpack.		Precipitation in the Bay Area will continue to exhibit high year-to-year variability "booms and busts" with very wet and very dry years. The frequency and severity of extreme storms is predicted to increase.	California's Fourth Climate Change Assessment (2018)
Heat events	Average annual max temperature increased by 1.7°F (1950–2005).[1]	2050	+4 extreme heat days (>90.4°F). +21 warm nights (>62.6°F).	Cal-Adapt
		2099	+8 extreme heat days. +55 warm nights.	Cal-Adapt
			Increases in temperature will likely cause longer and deeper California droughts.	Cal-Adapt
			Increase in heat wave length and frequency. 4.1–6.2°F increase by 2100; extreme heat days (over 85°F) increase to 15–40 and potentially 90 days by 2100.	California's Fourth Climate Change Assessment (2018)

[8] Thorne et al., 2018.
[9] Range represents the "Low Risk Aversion" to "High Risk Aversion" projections with the "Extreme Risk Aversion" or H++ projection in parentheses. A high emissions scenario is presented on the table for the year 2100.

Hazard	Impacts to Date	Year	Projection	Source (for projection)
Earthquakes (liquefaction)	Highest hazard liquefaction areas mapped in Bay Area include Alameda Island.[10]	Next 30 years	72 percent chance of M6.7 or greater in Bay Area. 28 percent chance of M6.7 or greater on Hayward Fault.[11]	ABAG
		Next 50 years	10 percent chance of MMI 8 to 9 shaking in Alameda.	ABAG
Wildfire smoke	Air Quality Index of 271, worst San Francisco air quality on record, occurred Nov. 16, 2018. Record number of consecutive hazardous air days during Camp Fire 2018.	Next 50 years	Increased wildfire frequency and number of hectares burned; increased air pollution from wildfires. Estimates for assessing wildfire regimes vary due to land use patterns, climate change (primarily drought), wind direction, and other factors.	California's Fourth Climate Change Assessment (2018)

[10] USGS, 2006; n.d.-a
[11] M = magnitude; MMI = modified Mercalli intensity

Sea Level Rise

King tides in Alameda already result in flooding along low-lying stretches of shoreline and are responsible for elevated groundwater that can lead to basement flooding. The CARP considers how these conditions will change with sea level rise into the future.

The CARP evaluates tidal flooding—storm surge and sea level rise—in terms of total water level above today's mean higher high water (MHHW) level. Using total water level recognizes the contribution of both sea level rise and storm surge to flooding and reflects a range of scenarios. For example, a total water level of 36 inches above today's high tide can result from the following:

- Five-year storm event today;
- 6 inches of sea level rise plus a two-year storm in the short term (6 inches sea level rise likely by 2030); and
- 24 inches of sea level rise (around 2050).

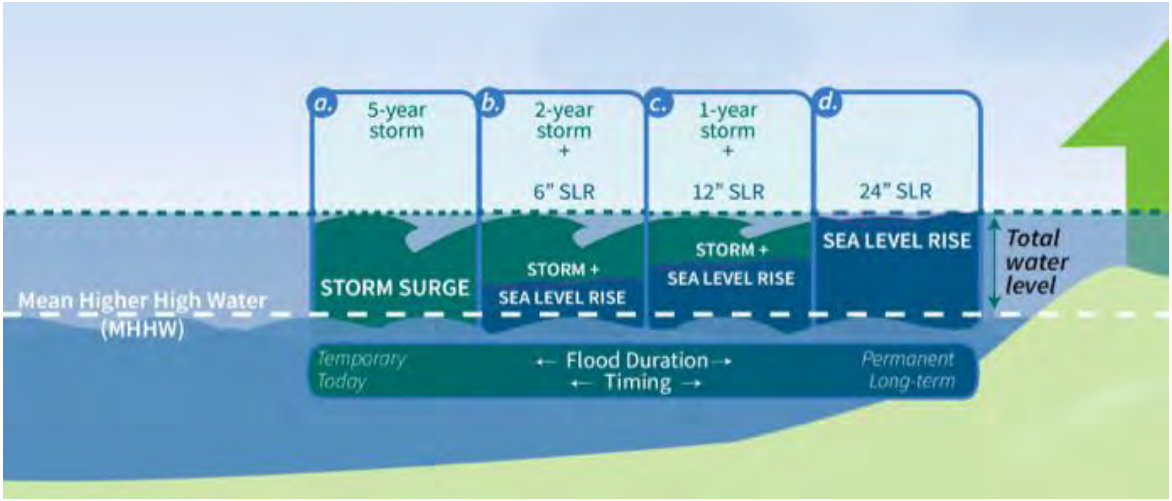


Figure 4-1. Image depicting total water level as a combination of sea level rise and storm surge (Credit: ART, San Francisco BCDC).

Applying a total water level approach enables us to plan actions that address temporary impacts of today's winter storms while simultaneously planning to address more permanent inundation from sea level rise. Figure 4-2 shows maps depicting inundation for 24-, 36-, 77-, and 108-inch total water level scenarios.

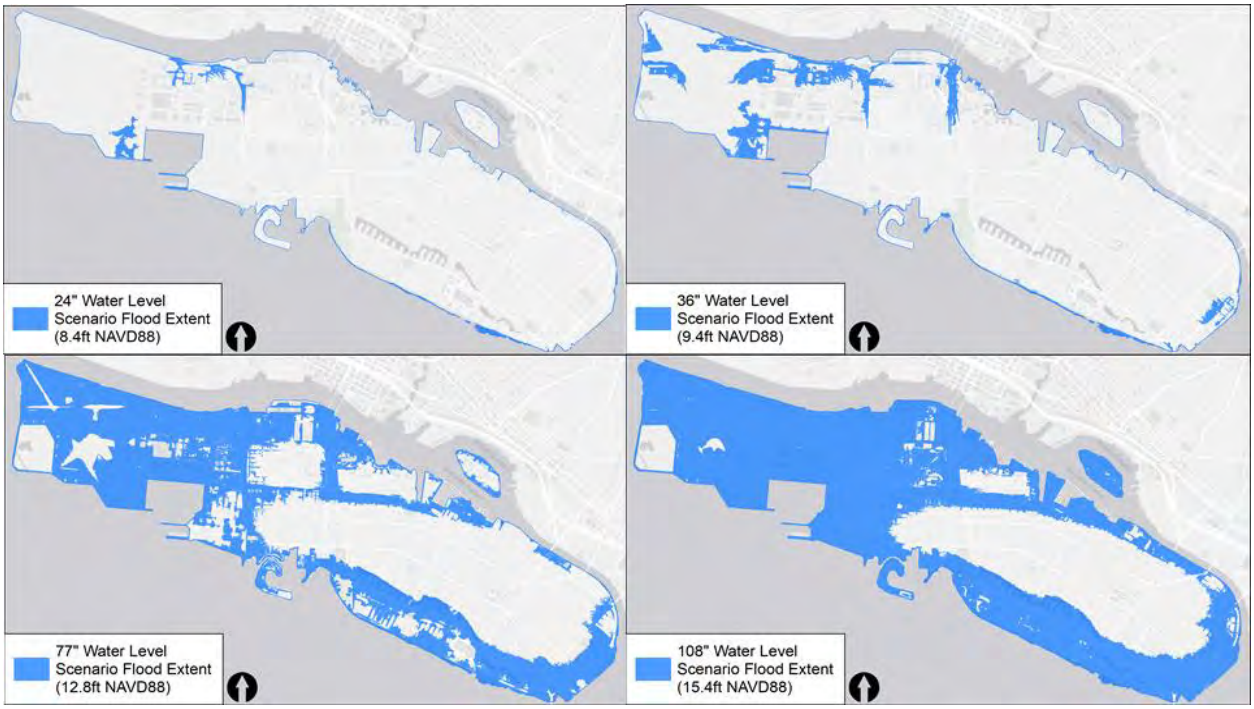
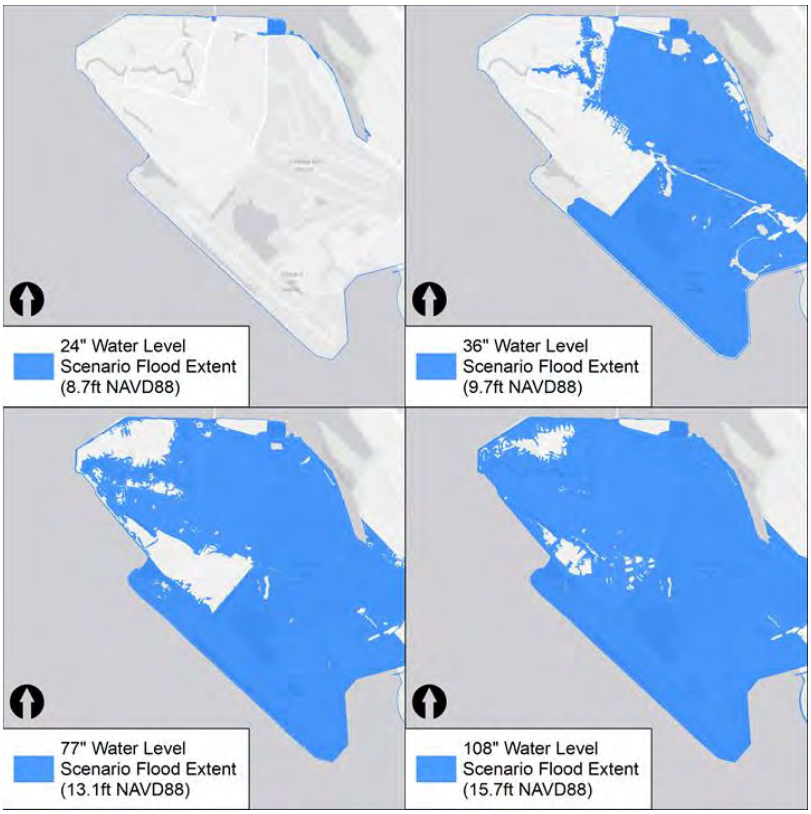


Figure 4-2. Maps depicting inundation for MHHW + 24-, 36-, 77-, and 108-inch total water level scenarios. Bay Farm Island is shown below.

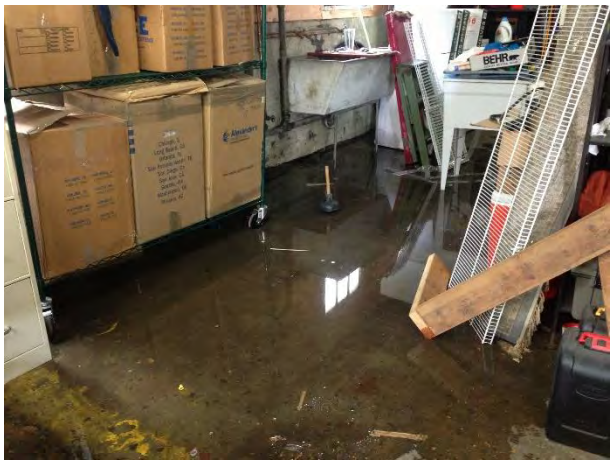


Impacts of Sea Level Rise on Groundwater Levels

Sea level rise can have a major impact on local and regional groundwater levels. Rising groundwater can damage underground assets like cables and pipes and increase the basement flooding that many Alamedans already experience. Depending on the thickness of the freshwater lens and the rate of groundwater level rise, saltwater intrusion can corrode some metallic-based infrastructure materials. High groundwater levels can also reduce the efficacy and capacity of the stormwater system, potentially resulting in surface flooding. The magnitude of groundwater rise due to sea level rise varies based on local geology and hydrology. Figure 4-3 shows the relationship between sea level rise and groundwater in areas such as Alameda with shallow coastal aquifers.

Researchers with Silvestrum Climate Associates and UC Berkeley collaborated on the development of a high-level, regional shallow groundwater layer for the San Francisco Bay Area using groundwater monitoring well data collected for the Regional Water Quality Control Board (RWQCB) (Plane et al., 2017). The regional data set highlights areas around the Bay where the existing groundwater surface is within 6.5 feet of the ground surface. As sea levels rise, the groundwater surface will also rise, and these areas are at the greatest risk of flooding due to emergent groundwater. However, given the sparse well data available within city limits, as well as a strong tidal and precipitation influence within Alameda soils, improvements to the data set are required to better inform climate adaptation efforts (Mohan et al., 2019).

The City recently engaged with Silvestrum to develop three data sets: an estimate of the wet-season groundwater surface (i.e., the highest groundwater surface observed during very wet winters), an estimate of the dry-season groundwater surface (i.e., the lowest groundwater surface observed during dry summers and periods of drought), and contaminant mapping of water quality constituents with human-health benchmarks. Areas with sparse data will be supplemented with geotechnical soil boring data collected throughout the city and the Oakland International Airport. These data will help Alameda develop specific strategies to address the dual threat of groundwater and sea level rise in the future.



Basement flooding. Photo credit: Arthaey Angosii

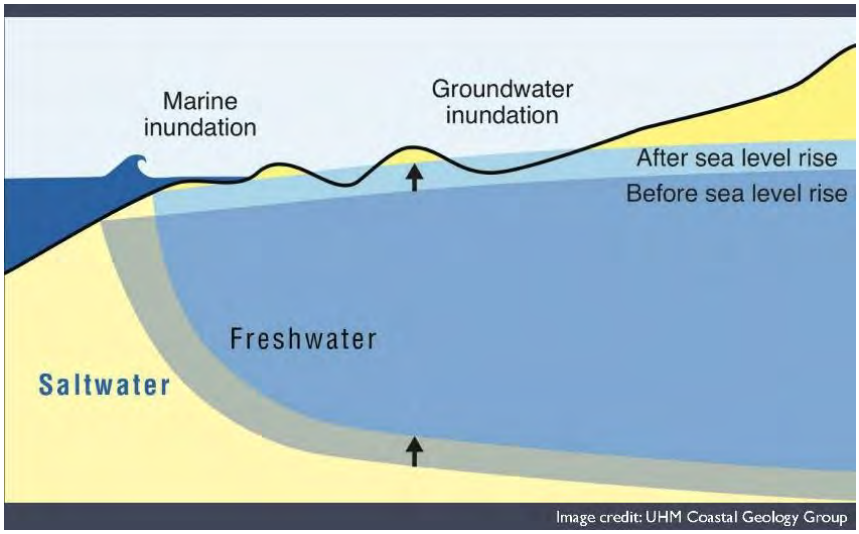


Figure 4-3. Conceptual diagram of the relationship between sea level rise and groundwater, highlighting the potential for flooding and inundation to occur in shallow areas that are not hydrologically connected to the ocean (Habel et al., 2017).

Flooding from Bigger Storms

Alameda is vulnerable to overland flooding during heavy precipitation events. The city currently struggles with street flooding from storm drains during storm events and is planning to upgrade the stormwater system's capacity to help address some of these issues. As shown in Table 4-2, precipitation events are highly likely to become more severe in the future, placing increased stress on a stormwater system that will also feel the impact of rising ocean and groundwater levels. Figure 4-4 depicts modeled surface flooding in Alameda based on a historic 25-year rainstorm event. The model shows where water may overwhelm the stormwater system. These modeled flood nodes were used during the vulnerability assessment to specifically consider the risk of overland flooding separately from flooding due to sea level rise and storm surge.

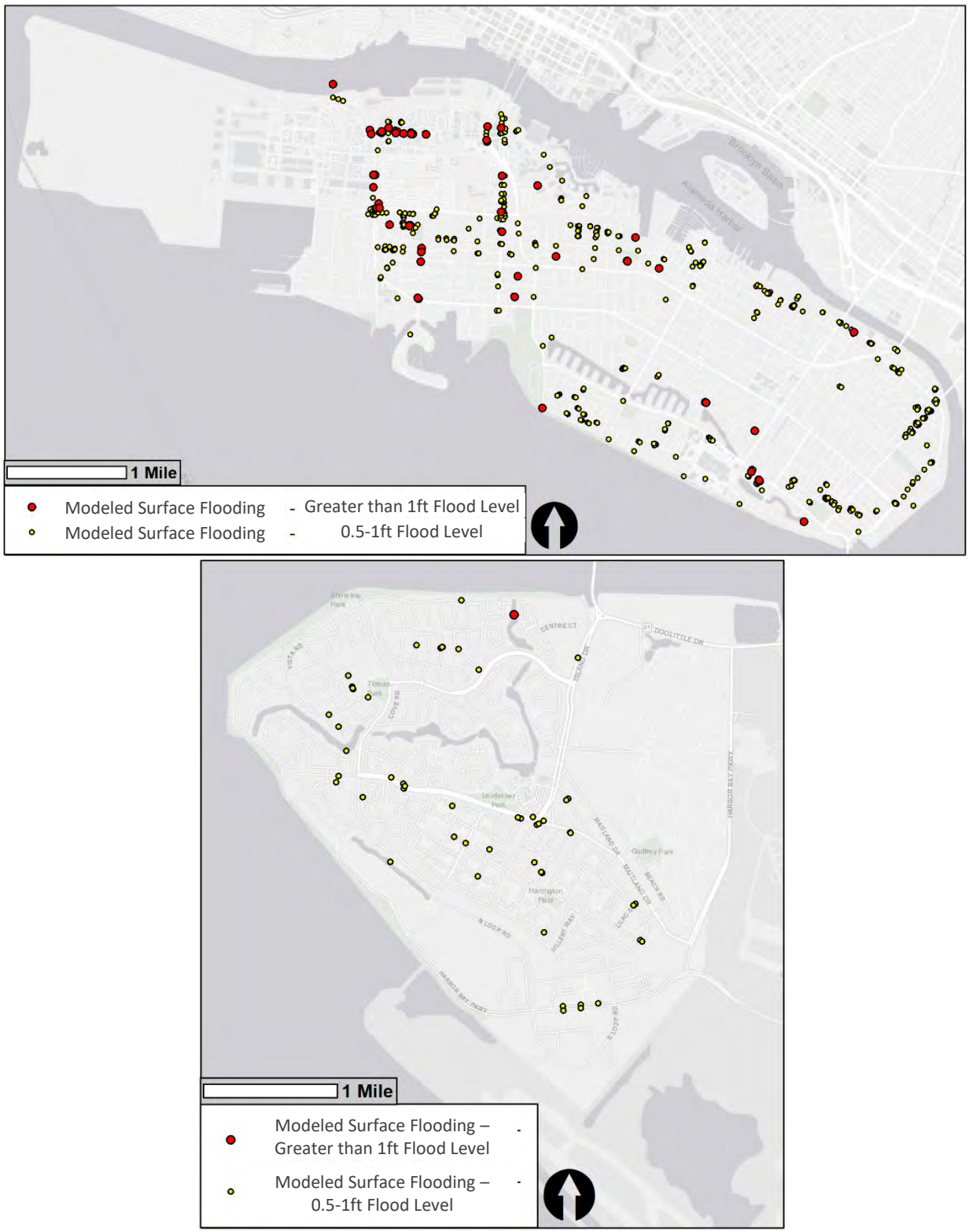


Figure 4-4. Modeled surface flooding in Alameda for a 25-year storm event. Results were filtered to show only locations with modeled flood depths of greater than 0.5 feet above street level. The points shown on this map reflect model node locations and do not represent actual locations of flooding. These nodes were used to roughly identify areas of elevated surface flood risk.

Heat

Extreme heat events are expected to increase in both severity and duration in Alameda due to climate change. Heat impacts can be exacerbated by Alameda's relatively high average maximum relative humidity (California Energy Commission, 2018). Annual mean maximum temperature could increase by 9°F by 2100. The annual number of extreme heat days (over 85°F) could increase up to 90 days by 2100 according to California's Fourth Climate Change Assessment (2018). Extreme heat events can result in serious impacts to public health and even cause death. Most vulnerable populations have pre-existing health issues, live in areas prone to the heat island effect, and/or have limited access to cooling. These negative impacts are particularly acute for the economically disadvantaged, the transit-dependent, the very young, the elderly, those in poor health, the homeless, and those who work or spend significant time outdoors. Increasing extreme heat events also increase the risk of drought and wildfire, and increased use of air conditioning during heat waves will increase energy use and GHG emissions associated with energy use.

The impacts of extreme heat events will be most severely felt in highly developed areas of Alameda that are mostly paved and surrounded by buildings constructed of dark (heat absorbing) materials without the cooling benefits of tree shade. This creates what is known as the heat island effect, which can increase the temperature locally during extreme heat events. Extreme heat may also cause pavement heave and damage to transportation infrastructure and functioning (Caltrans, 2018).

Drought

Increasing average daily temperatures, decreasing snowpack, and "boom or bust" precipitation patterns are increasing California's risk of more frequent and severe droughts. The 2012–2016 drought resulted in the most severe moisture deficit in 1,200 years.

Ninety percent of Alameda's water supply—provided by EBMUD—comes from the Mokelumne River watershed in the Sierra Nevada; the remaining 10 percent is runoff from watershed lands in the East Bay (EBMUD, n.d.-b). Thus, Alameda's drought vulnerability is tied to the vulnerability of EBMUD's water supply system. Rising temperatures that reduce snowpack also pose a major risk to EBMUD's water supply (EBMUD, n.d.-a). Additionally, EBMUD relies on over 15 miles of aqueducts and pipes that transport water across the Sacramento-San Joaquin River Delta ecosystem, which has become increasingly vulnerable to flooding, landslides, and earthquakes. Both the quality and quantity of potable water can be impacted when the water supply distribution system is compromised. For example, in September 2017, an unprotected cross connection from an irrigation line impacted the quality of water supplied to hundreds of Alameda homes and businesses.

According to EBMUD's (2014) Climate Change Monitoring and Response Plan, potential risks to water supply include:

- Increased demands for outdoor water use;
- Increased drought frequency, intensity, and duration;
- Decreased snowpack; and
- Changes in the timing of the Mokelumne River spring runoff.

Alameda can reduce its per capita water use to increase resiliency to drought. EBMUD's (2015) Urban Water Management Plan calls for a combination of rationing, conservation, and use of recycled water to satisfy demand through 2040 and offers methods to conserve water.

Liquefaction from Earthquakes

Although earthquakes are not explicitly a climate hazard, climate change could potentially cause them to become more destructive because of an increased risk of liquefaction—the process by which semi-saturated or saturated sediment loses structural competency under intense shaking (USGS, n.d.-b). Lack of earthquake preparation can also contribute to climate change—buildings that are not retrofitted to seismic standards require greater materials to rebuild, which produces significant GHG emissions. Rising groundwater associated with sea level rise can increase the amount of saturated sediment and the risk of liquefaction. This is especially concerning in Alameda where substantial portions of the city are built on relatively loose fill material that is highly susceptible to liquefaction. Figure 4-5 shows the liquefaction hazard in the Alameda area as defined by the U.S. Geological Survey (USGS, n.d.-b).

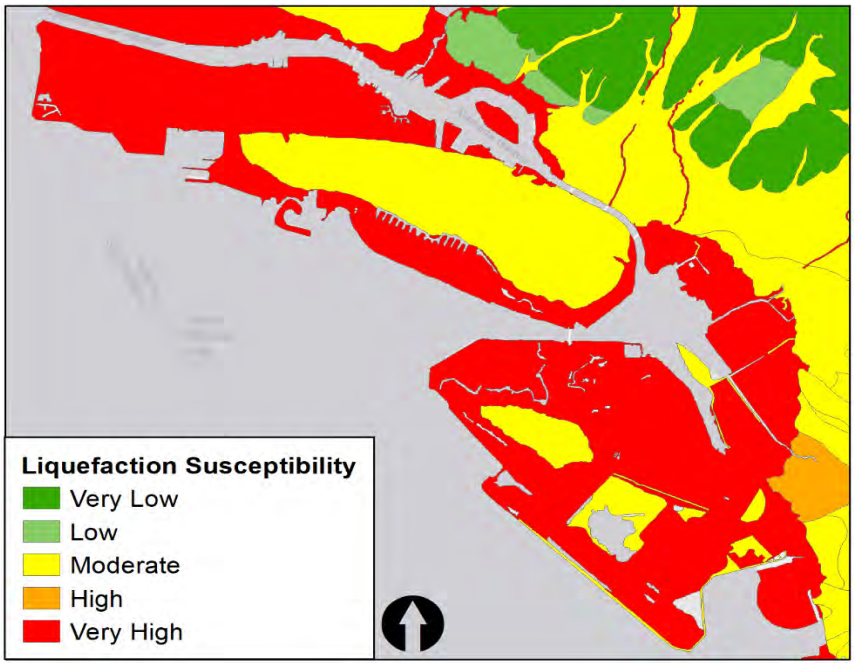


Figure 4-5. Liquefaction susceptibility in Alameda. Data from USGS (2006).

Wildfire Smoke

Wildfires occurring outside the region can impact public health in Alameda. Wildfire smoke can reach hazardous levels—as measured by the U.S. Environmental Protection Agency's (EPA's) Air Quality Index—while active fires and winds carry smoke into the region. Air quality impacts from wildfires recently raised public awareness and concern during the Camp Fire that occurred in fall 2018. During that event, air quality, measured by $PM_{2.5}$ (particulate matter with a diameter of 2.5 micrometers or less), was rated "hazardous for all groups" for 12 consecutive days, with the peak occurring on November 16, 2018, when "very unhealthy" levels were recorded at a monitoring station near Alameda (Bay Area Air Quality Monitoring District).

There are no established climate projections for increased risk of wildfire smoke; the existing projections focus on determining areas susceptible to wildfires themselves and not specifically the downwind impacts. Nonetheless, increases in air temperature and the frequency and severity of droughts are likely to result in an elevated risk of more intense, prolonged, and/or large-scale fires throughout California,

which could create conditions like those experienced in November 2018. During a poor air quality event, the Bay Area Air Quality Management District provides air monitoring data for several constituents—including ozone and $PM_{2.5}$—that track smoke impacts.

The high unpredictability of wildfires and their impact on downwind areas heightens the vulnerability of Alamedans to wildfire risk. Furthermore, because wildfires spread so quickly and wind direction may suddenly change, there is little lead time to warn and prepare residents for wildfire smoke impacts. It is also difficult to predict the severity of wildfire smoke impacts or how long they are likely to last. Community members are generally taken by surprise and don't realize how hazardous air quality may be to their health. The most vulnerable populations are the very young, the elderly, those with existing cardiovascular and respiratory ailments such as asthma, and those who work outdoors or who live and/or work in places that are not air-conditioned.

Vulnerability Assessment

Introduction

The vulnerability assessment methodology used for the CARP is based on BCDC's ART approach. The methodology prioritizes high-consequence, high-sensitivity assets first, while recognizing that solutions need to be designed to account for longer-term impacts. The vulnerability assessment will be revisited periodically as conditions, scientific understanding, and/or priorities change.

Key Components of Vulnerability

- **Exposure**: extent to which an asset experiences an impact.
- **Sensitivity**: degree to which assets are affected by the impact.
- **Adaptive capacity**: ability to adjust to an adverse impact.
- **Consequence**: severity or seriousness of the impact to the city.

The relationship among the different vulnerability assessment components and overall vulnerability are shown in Figure 4-6 below.

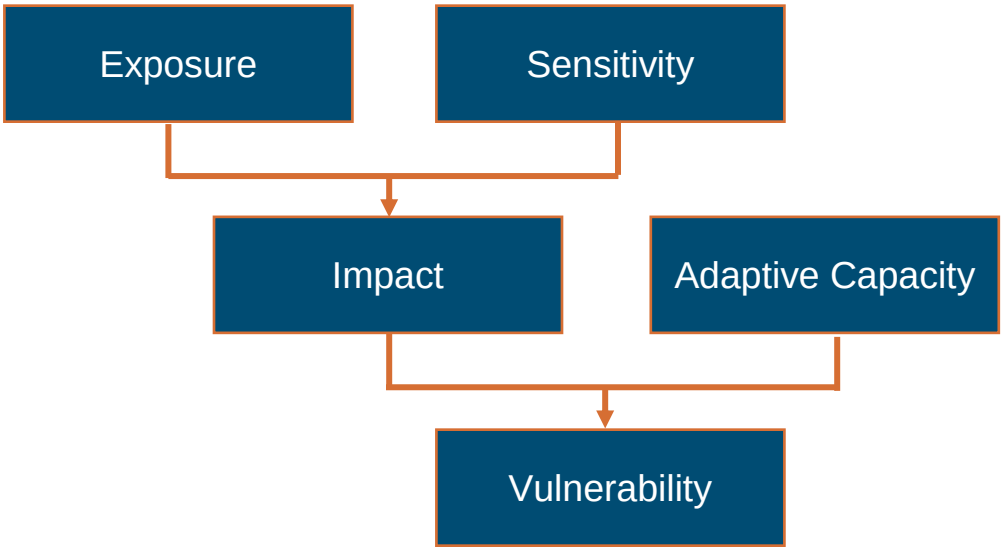


Figure 4-6. Graphic depicting the relationship among vulnerability assessment components and overall vulnerability.

The main steps of the vulnerability assessment process are described below:

1. Scan major climate hazards and a range of city assets to better understand how climate change may impact Alameda.
2. Consider social vulnerability and a community's ability to respond to climate threats.
3. Identify areas with location-based priority flooding that have high exposure to projected sea level rise and experience substantial consequences from impacts.
4. Conduct a more detailed vulnerability assessment for location-based priority flooding, considering site-specific characteristics.
5. Identify climate vulnerabilities across all of Alameda.

The vulnerability assessment consists of three sections. First is the SVA, which looks at socioeconomic factors that can exacerbate the impacts of climate hazards on Alameda communities. The second section describes the locations in Alameda that are most vulnerable to sea level rise and shoreline flooding. The final section examines climate risks across all of Alameda, including risks due to increased flooding and other climate impacts.

Three appendices correspond to each of these three key segments of the vulnerability assessment, providing additional details on the analysis:

- Appendix G: "Social Vulnerability Assessment";
- Appendix H: "Location-Based Priority Flooding (Detailed Vulnerability Assessment)"; and
- Appendix I: "Climate Risk Across Alameda (Detailed Vulnerability Assessment)."

Location-Based Priority Flooding

The vulnerability assessment defined location-based priority flooding as those assets or areas exposed to flooding risk soonest and with greatest consequence. Locations with significant flooding at a total water level of 24 or 36 inches (above today's high tide) were identified as at risk of sea level rise flooding "soon." Following climate change projections from the State of California, which the OPC published in 2017 (Griggs et al., 2017), 36 inches of sea level rise can be expected in 2050–2070 when considering a high emissions scenario with medium to high risk aversion. A total water level of 36 inches is also equivalent to 50-year storm surge today. Alameda is implementing climate-smart planning, as outlined in AB 2800, the "Climate-Safe Path for All." Therefore, as Alameda demonstrates leadership in GHG emissions reduction, the City should monitor global GHG emissions reduction trajectories and incorporate them into the planning process.

The following criteria[12] were used to identify location-based priority flooding assets:

- Exposure assessment: Define the extent to which an asset experiences an impact. This includes considering the percent of an asset impacted as well as the probability of occurrence. The CARP vulnerability assessment was primarily concerned with exposure to flooding due to sea level rise and precipitation. Exposure in this assessment included both magnitude and timing (i.e., how much an asset is exposed to an impact and when exposure begins).
- Sensitivity assessment: Determine the degree to which assets are affected by climate change impacts, including non-physical influences like governance. Sensitivity refers specifically to the asset itself, whereas consequence considers impacts to surrounding communities and assets.
- Consequence assessment: Determine how impacts to the asset affect the surrounding community and assets, as well as Alameda more generally. Consider impacts to vulnerable communities as defined by a range of social vulnerability indicators.
- Adaptive capacity assessment: Define the ability of assets, systems, or people to adjust to an adverse impact. Consider how changes in operations and/or minor physical improvements could increase the resilience of an asset to climate change.
- Gap analysis: Consider assets and neighborhoods already addressed in existing City plans and commitments. Identify gaps to determine which assets are most critical to address. Determine the extent to which existing plans and commitments incorporate climate change.

The City has already evaluated sea level rise for select assets and projects. The CARP's vulnerability assessment did not re-examine existing commitments to adaptation, but rather builds on and aligns with those actions underway. Table 4-3 summarizes the key vulnerable assets addressed in existing City plans and/or commitments.

Table 4-3. Key Vulnerable Assets in Existing City Plans and Commitments

Asset	Plan
Alameda Point Shoreline	Alameda Point Master Infrastructure Plan (MIP)
City Hall West	Alameda Point MIP
Main Street Ferry Terminal	Alameda Point MIP

[12] These components are adapted from the ART process, which considers exposure, sensitivity, and adaptive capacity as components of vulnerability. The ART process also defines risk as the combination of likelihood and consequence, with consequence contributing more to overall risk.

Asset	Plan
Shoreline along Main Street Ferry Terminal	Alameda Point MIP
Northern Waterfront	Northern Waterfront Development Plans
Shoreline Drive	City's 2017–2019 Capital Budget
Veteran's Court Seawall	Storm Drain Master Plan 2008 (focus on capacity upgrades)
Storm Drain Pump Stations	Storm Drain Master Plan 2008
Sewer Pump Stations	Sewer System Management Plan 2017
State Route (SR) 260	Caltrans State Route 260 Transportation Concept Report (signed 2011, reaffirmed 2017)

The sections below summarize the vulnerability assessment results for the location-based priority flooding and climate change vulnerabilities broadly applied by sector in Alameda. Appendices G and H contain detailed vulnerability profiles that align with the planning framework developed by the ART Program. The profiles include vulnerability statements that consider the physical, functional, governance, and informational components of an asset that contribute to sensitivities to climate impacts. Key issues and vulnerabilities for each shoreline segment as well as adaptive capacity and potential consequences are identified.

Social Vulnerability Assessment

As Alameda prioritizes and implements adaptation actions, the City must continue to consider how vulnerable populations may be disproportionately impacted and ensure that those residents least able to protect themselves are given the support they need.

To guide strategy development, City staff examined social factors affecting Alamedans' ability to respond to climate threats like extreme heat and wildfire smoke. The results are documented in an SVA included in its entirety in Appendix G. Building on previous work by the ART Program and ABAG, the SVA used 10 indicators of social vulnerability based on census household data:

- Transit-dependent (no personal vehicle);
- Renters;
- Severe housing cost burden;
- Residents under 5;
- Residents over 65 living alone;
- Disabled;

- Single-parent households;
- No high school degree;
- Very low-income;
- Communities of color;
- Limited English proficiency; and
- Not U.S. citizens.

Social Vulnerability Level	Number of Indicators
Highest	8 or more in the 70th percentile 6 or more in the 90th percentile
High	6-7 in the 70th percentile 4-5 in the 90th percentile
Moderate	4-5 in the 70th percentile 3 in the 90th percentile
Low	Does not meet any of the above criteria

Figure 4-7. Social vulnerability index for City of Alameda.

Figure 4-7 presents the number of social vulnerability indicators that are within the 70th or 90th percentile when compared against the rest of the Bay Area for each of the 57 census block groups in Alameda (with high and highest vulnerability block groups outlined in blue and labeled by block group number). See Table G-3 in Appendix G for a description of each individual block group and its bordering streets. Key takeaways from the SVA include the following:

- Households with multiple indicators face unique challenges and exacerbated vulnerabilities. For example, an individual who is low-income and a renter may have fewer options to invest in flood-proofing their home and may struggle to replace possessions damaged in a flood. Considering the causes and effects of compounded vulnerability is crucial for developing effective resilience strategies.
- Most of the neighborhoods prone to flooding in the near term are among the 14 most socially vulnerable block groups identified.
- All 14 of the most vulnerable block groups have a high rate of transit dependence, and 12 of those 14 have a large proportion of low-income households. Building resilience can result in increased tax burden, which could be particularly harmful for low-income residents.
- A significant population of households speak English “less than very well”; almost half of these households primarily speak Chinese.
- It is important to not only create programs and services for climate resilience, but also to ensure that residents know about them, trust them, and know how to use them. For example, for a wildfire smoke communications service to be effective, it must be available in multiple languages, provided through a variety of relevant media, and delivered in a user-friendly format.
- The SVA informed both the vulnerability assessment and the recommended strategies to address those vulnerabilities. The SVA also provided valuable information for community outreach and education during the CARP development process and will continue to be used in further public engagement during CARP implementation.

Location-Based Priority Flooding

The 11 priority flooding locations fall within three categories: shoreline, natural and recreation areas; utilities; and transportation. A detailed map for each location showing 36, 48, and 52 inches of sea level rise, as well as a one-page description of exposure, sensitivity, consequence, and adaptive capacity, are included in Appendix H.

Shoreline, Natural, and Recreation Areas

The vulnerability assessment identified critical points of overtopping along the shoreline of Alameda that, if addressed, could substantially reduce flooding and inundation threatening residents, businesses, parks, and key assets in Alameda. These segments are discrete locations along the shoreline that overtop at lower sea level rise scenarios (24 or 36 inches) and therefore should be addressed first to help protect other assets and increase the resilience of the shoreline to greater amounts of sea level rise.

Several other segments of the Alameda Point shoreline that are likely to be overtopped at 24 or 36 inches of sea level rise were not defined as high priority because they are already addressed through the approved Alameda Point MIP. The MIP established a framework for sea level rise protection and adaptation at Alameda Point based on the best available science. It also set forth a monitoring and financing program to periodically review the latest science, sea level rise estimates, and guidance from local, state, and federal regulatory agencies. Amendments to the MIP will be adopted as needed to reflect any notable conclusions from the ongoing monitoring. In fact, an MIP amendment will be adopted to consistently reflect the conclusions of the CARP along with the latest OPC sea level rise projections and guidance from 2018.

Transportation

Alameda relies heavily on functional bridges and tunnels to connect to the mainland, and a large population relies on transit systems to commute. The vulnerability assessment focused on those assets that transit-dependent populations most heavily use, such as roadways used by multiple AC Transit bus routes, as well as transportation assets that are essential corridors on and off the island. To help organize and simplify the results of the assessment, several transportation assets were bundled in the summaries presented below.

Note: Transportation assets are also sensitive to the effects of other climate hazards, particularly extreme heat, which can damage road surfaces and pose a hazard to workers. The summaries included here do not discuss heat specifically because Alameda is not expected to experience temperatures that can heavily impact transportation assets. While ferry access is essential on Alameda, the Main Street Ferry Terminal was not identified as a high vulnerability because the City already has plans to adapt the area to address flood risk at ferry access points.

Storm Utilities

Ensuring the long-term viability of utility systems in Alameda is important to maintaining a healthy and vibrant city. In particular, the stormwater system is critical for ensuring proper drainage to prevent roads and neighborhoods from flooding during storm events. The City has identified deficiencies in the stormwater system that need to be funded and addressed to prepare Alameda for the impacts of sea level rise and increased storm intensity and/or frequency. The vulnerability assessment identified additional threats facing the stormwater system that would not be resolved by capacity upgrades to the system.

Threats to the stormwater system include rising ocean levels, rising groundwater levels, and increased storm intensity and/or frequency. Gravity-fed components of the stormwater system are particularly vulnerable to rising ocean levels because outfalls can be blocked. Future pumps may be required in locations currently served by gravity-fed outfalls. Rising groundwater levels associated with sea level rise add more stress to the system overall and could potentially damage or reduce the functionality of subsurface infrastructure. Additional assessment of the risk posed by rising groundwater levels is needed as new information on groundwater, including modeling results, becomes available.

Table 4-4 shows the 11 location-based priority flooding assets identified during the vulnerability assessment, two of which include various locations. Figure 4-8 shows their locations spatially on Alameda Island, while Figure 4-9 shows the flooding areas on Bay Farm Island.

Table 4-4. Location-Based Priority Flooding Assets

Asset Category	Asset Name	ID for Figures 4-8 and 4-9	Exposure (Sea Level Rise)[a]	Exposure (25-Year Flood)[b]	Sensitivity[c]	Consequence[d]	Adaptive Capacity[e]
Shoreline, Natural, and Recreation Areas	Shoreline Adjacent to Webster and Posey Tubes	1	Moderate (36")	None	Low	High	Moderate
	Veteran's Court Seawall	10	Moderate (36")	None	High	Moderate	Moderate
	Crown Beach and Bird Sanctuary	3	High (12")	None	High	Moderate	Moderate
	Bay Farm Island Bridge Touch Down Area (Alameda Island side)	4	Low (>48")	None	Moderate	Moderate	Moderate
	Eastshore Drive	5	Moderate (36")	None	Moderate	High	High
	Bay Farm Island Lagoon System 1 Outlet Gate and Seawall	9	Moderate (36")	None	Moderate	Moderate	Moderate
Utilities	Storm Drain Pipes and Pump Stations	Citywide	Moderate (36")	Varies	High	Moderate	Moderate
	Bayview Weir and Outfall	7	High (24")	None	High	High	High
Transportation	SR260 and Posey/Webster Tubes	2	Moderate (36")	High (1 ft+ flood)	High	High	Low
	Critical and High-Use Roadways (used by AC Transit)	6	Low (>48")	High (1 ft+ flood)	Moderate	High	Moderate
	SR61/Doolittle Drive	8	Moderate (36")	High (1 ft+ flood)	Low	High	Moderate

[a] Exposure (sea level rise): Low= > MHHW+48"; Moderate=MHHW+36"; High=MHHW+12–24"

[b] Exposure (25-year precipitation event): Low= <0.5 flood levels (above surface flooding); Moderate= 0.5–1ft flood levels; 1+ft flood levels

c Sensitivity: Low= flood water recedes without major damage; Moderate= asset will be damaged by flooding (e.g., office), but equipment is not highly sensitive; High= asset is highly sensitive or already failing, and it provides sensitive habitat to protected species

[d] Consequence: Low= minor/temporary precipitation-based flooding of residential neighborhood; Moderate= limited access to public services; High= restricted movement of emergency responders

e Adaptive Capacity: Low= cannot adjust in place, and asset must be relocated or elevated; Moderate= major changes or replacement of existing asset are required; High: asset can adapt to new impacts given changes in operations and/or minor physical improvements

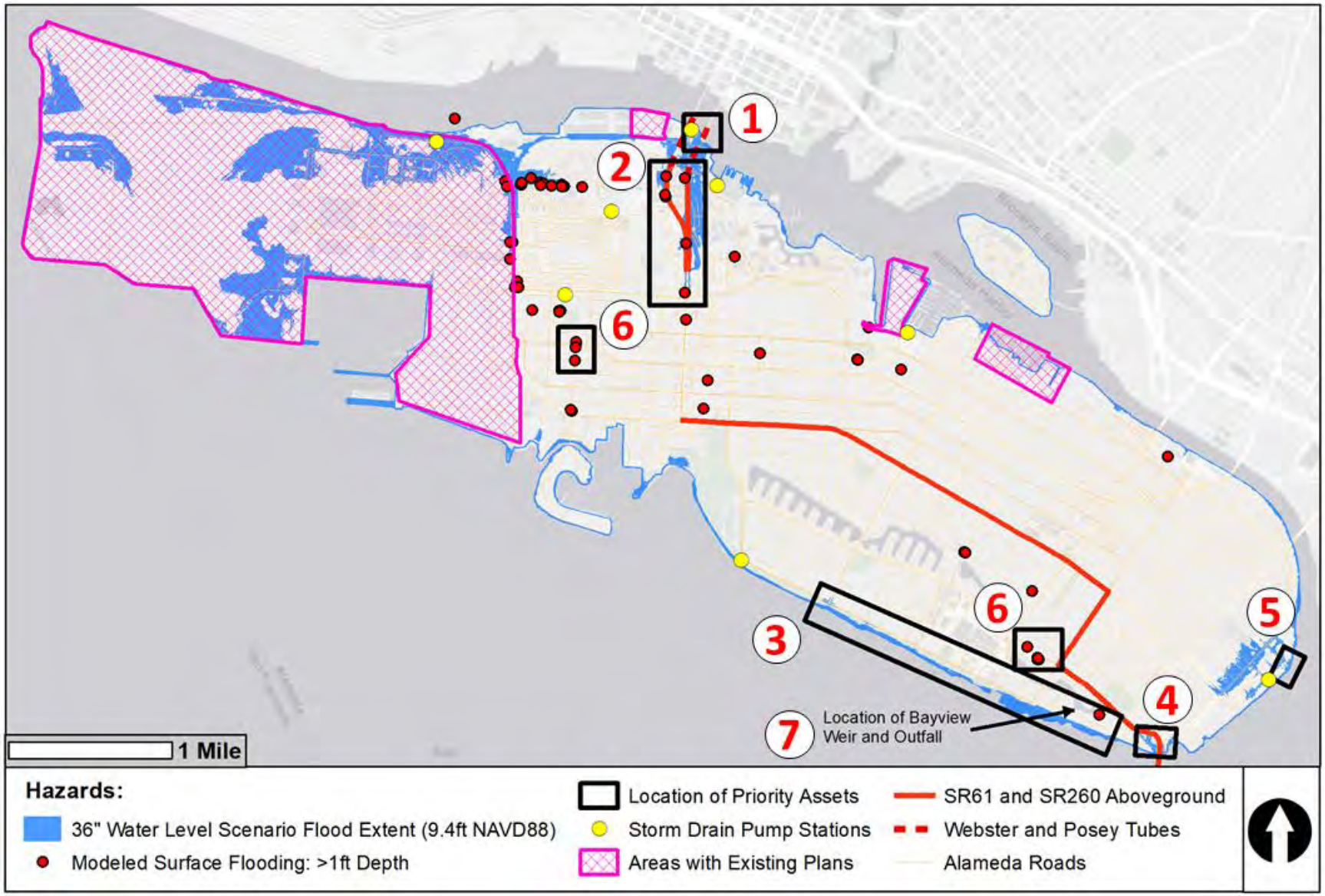


Figure 4-8. Map showing the areas of location-based priority flooding on Alameda Island.

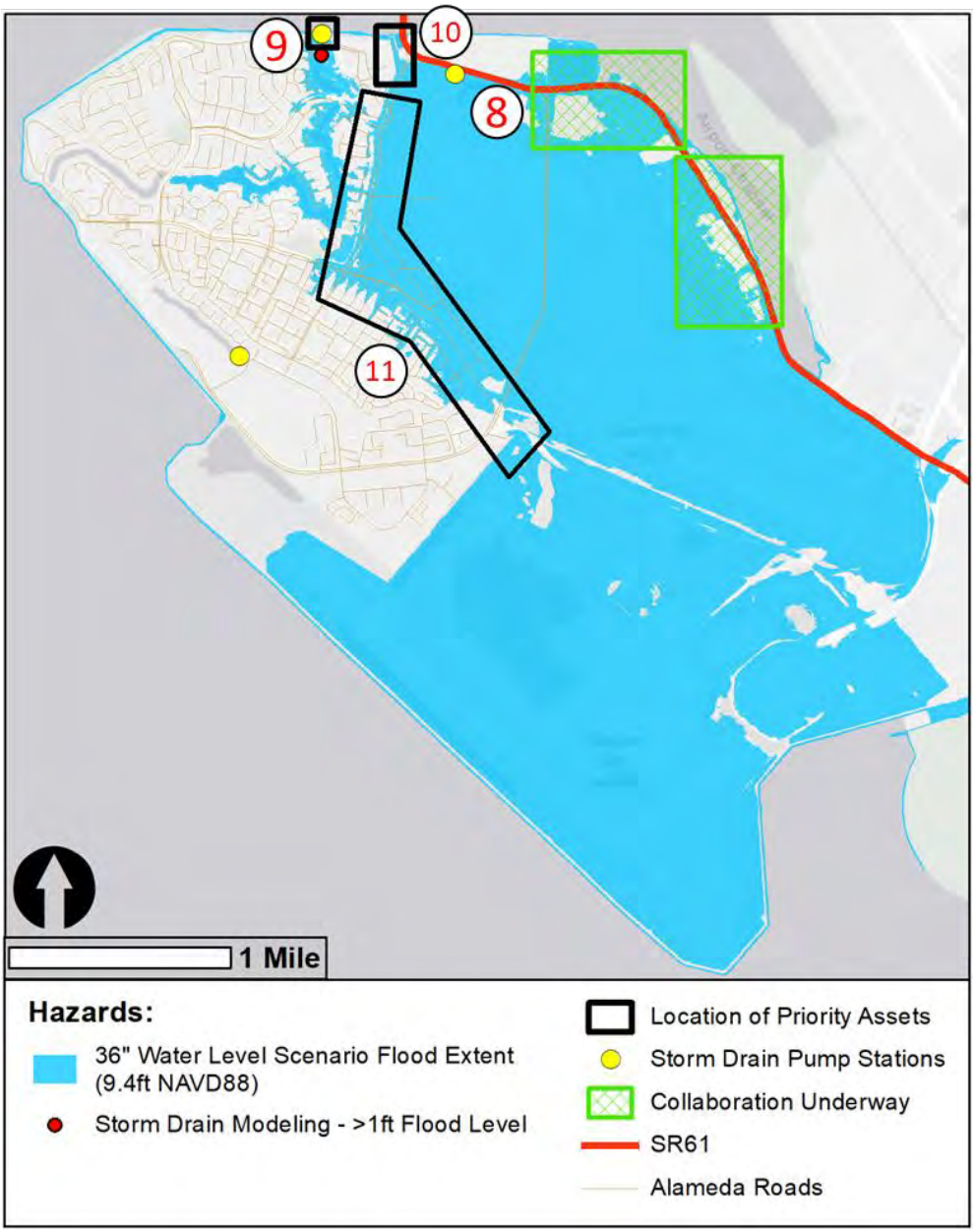


Figure 4-9. Map showing the areas of location-based priority flooding on Bay Farm Island.

Climate Risk Vulnerabilities Across Alameda

The vulnerability assessment considered vulnerabilities that are broadly relevant throughout the city to identify adaptation strategies that can be broadly applied within each sector. The following sectors were evaluated:[13]

- Buildings;
- Critical services;
- Land use;
- Shoreline, natural, and recreation areas;
- Transportation;
- Contaminated lands and waste;
- Utilities; and
- Public health and welfare.

These sectors were selected in part because they help capture vulnerabilities that affect all of Alameda but also cover specific vulnerabilities associated with disadvantaged communities. For example, the buildings and critical services categories include facilities that provide care and support to disabled, elderly, infirm, and low-income residents, among others. Transit-dependent populations heavily rely on a functioning transportation system, making it critical to include the transportation sector. The land use and shoreline vulnerability assessments identify how land use policies and shoreline issues may disproportionately impact disadvantaged communities because of their location or socioeconomic characteristics. Lastly, the pollution burden representing contaminated lands considers sensitive populations and socioeconomic factors.

Below is a brief summary of the climate risk vulnerabilities in Alameda. Appendix I contains additional details on the buildings; critical services; land use; shoreline, natural, and recreation areas; and transportation sectors. Specifically, the appendix provides information about exposure, sensitivity, adaptive capacity, and consequences.

Buildings

Alameda has an extensive inventory of buildings that are vulnerable to flooding from sea level rise, storm surge, and major rainfall events. Damage to homes, businesses, community facilities, and their associated infrastructure represents a serious socioeconomic threat to the city. Buildings constructed in Alameda are not generally designed to withstand projected levels of flooding or saltwater exposure. Furthermore, liquefaction risk is high. Damage to community services like shelters, hospitals, and elderly care facilities can disproportionately impact vulnerable populations, including those who are ill, immobile, elderly, or economically disadvantaged. City buildings do not currently have design requirements that require cool building methods to mitigate heat impacts—buildings and surrounding paved areas may encourage the heat island effect during heat waves.

Critical Services

Alameda's critical services—fire, police, emergency medical services (EMS), schools, hospitals—are vulnerable to flooding from sea level rise, storm surge, and major rainfall events, primarily due to access issues created by flood events and the resulting inability to provide services. Disruption directly to

[13] Note: This list is not comprehensive of all asset categories or sectors in Alameda but does capture the most critical components, as well as those sectors that are most vulnerable to climate change.

Alameda's critical facilities or the transportation system on which they rely can exacerbate climate impacts because the public depends on these services most during emergencies. Schools are especially important to disadvantaged and vulnerable communities because they rely on these services for child care and meals. Critical services are important not only during a rapidly developing hazard event, but also during slower moving hazards like a heat wave or poor air quality event. Critical services must have systems in place to communicate with the public, avoid becoming overtaxed, and keep their staff safe as they care for the public.

Land Use

Given Alameda's exposure to a wide range of climate hazards, most notably sea level rise and storm surge flooding, existing and future land use planning needs to incorporate adaptation strategies to keep residents and businesses out of harm's way. This involves important decisions about how to modify existing land use, where development opportunities still exist, and how to design new development and redevelopment that can adapt to future climate conditions—particularly flood and liquefaction risk. Land use policies are an important avenue to creating a resilient Alameda.

Shoreline, Natural, and Recreation Areas

Alameda has both engineered shorelines (primarily seawalls or levees and associated riprap and other armoring) and a variety of natural shoreline habitats. These natural shorelines attenuate waves and mitigate the impacts of sea level rise and storms. They also provide ecosystem service benefits, including open space, water quality, air quality, carbon sequestration, and habitats. Shoreline areas include wetlands, tidal flats, and marshes. Both engineered and natural shorelines provide recreational benefits, as the San Francisco Bay Trail and other public shoreline access points run along them. Both engineered and natural shorelines face risks of overtopping, erosion, and potential failure as San Francisco Bay water levels rise, and they will need to be adapted over time. Deferred maintenance of some flood protection structures makes them more vulnerable.

Transportation

The transportation sector contains a vast network of assets that are critical to social, economic, and physical well-being, as well as emergency response. These transportation assets connect Alameda to other services regionally and beyond, and they support vehicular movement (roads, bridges, tunnels), public transit (bus and passenger ferries), boats, and bicycle/pedestrian paths. The transportation sector's vulnerability to sea level rise and flooding from intensifying storm events not only puts these assets at risk, but also affects other sectors, amplifying socioeconomic and public health risks. Some of the transportation system's vulnerability stems from its lack of redundancy. With limited connections on and off the island of Alameda, the community will strongly feel any disruptions to tunnels, bridges, or ferry service. Some isolated areas, like Ballena Island, rely on single methods of access and are at elevated risk if inundation undermines or blocks transportation assets.

Contaminated Lands and Waste

Properties with land use histories that include heavy industrial and manufacturing operations could potentially have contaminants in their soil and groundwater. Contaminants at these properties are addressed through remedial action plans that are implemented under the oversight of the California Environmental Protection Agency (CalEPA) or, in the case of federal properties and Superfund properties, the U.S. EPA. These types of properties can be vulnerable to sea level rise impacts such as flooding and rising groundwater if those changes result in a release of hazardous substances. CalEnviroScreen (June 2018) identifies several contaminated and cleanup sites within Alameda. Additional information regarding contaminated sites within Alameda can be found at the CalEPA

Department of Toxic Substances Control (DTSC) EnviroStor website and the CalEPA RWQCB GeoTracker website.

The impact that sea level rise will have on contaminated sites is specific to the environmental conditions at each property. The types of contaminants and how they respond to changes in groundwater elevation, groundwater flow gradients, changes in geochemistry, and current site uses are just some of the parameters that would factor into how rising sea levels might impact these properties. Remedial action plans include pre-cleanup monitoring of environmental conditions to identify the contaminants that need to be addressed. Some remedial actions are short-term activities that include removing material from the property, while other remedial actions are more complex and can take decades to complete, such as pumping and treating contaminated groundwater. Remedial action plans also include implementing monitoring programs during and after remediation to verify the effectiveness of the remedial activity. These monitoring programs can assess the effect of changing environmental conditions on contaminants within a particular site. If, after the remedial action is complete, the property use is changed, or if the environmental conditions significantly change, the oversight agency can require additional environmental characterization of the property to verify that previous remedial activities are still effectively protecting human health and the environment.

Case Study: Alameda Point

Alameda Point can be used as a case study for how contaminated sites can be managed to account for the effects of sea level rise. Alameda Point is the former naval air station previously located on the western portion of Alameda. The naval base operated from 1940 until it was officially closed in 1997. During its operation, a number of industrial activities across the base resulted in residual contamination in soil and groundwater that continue to be addressed today. Contaminants in soil and groundwater include petroleum hydrocarbons, metals, chlorinated solvents, semi-volatile organic compounds, and radiological isotopes. The U.S. Navy is required to complete remedial activities under the oversight of the U.S. EPA as well as the DTSC and the RWQCB. Remedial technologies implemented at Alameda Point generally include the following:

This former naval base in being remediated and provides opportunity to expand the existing wetlands. Photo credit: Richard Bangert.

- **Excavation and removal:** Soil contamination is excavated from the property and disposed of at a facility outside of Alameda. Under this scenario, it is not expected that sea level rise will adversely affect the site because the source material has been removed.
- **In situ groundwater treatment:** These technologies typically use substrates that can be injected into the groundwater to degrade the specific contaminant. They are generally used for sites that have chlorinated solvents or petroleum hydrocarbons in groundwater. The Alameda Point remedial plan requires extensive monitoring during remediation and post-remediation to verify that the remedial action can achieve its goals. The monitoring programs can assess what a change in condition (e.g., rising groundwater levels) has on the contaminant in question. These remedial activities typically degrade the contaminant to concentrations that are protective of human health and the environment; therefore, it is not expected that sea level rise will adversely affect the site.
- **Capping and institutional/engineering controls:** In some instances, soil contamination or contamination within subsurface utilities is addressed through capping or institutional controls. Typically, a cap will require the installation of a layer of soil that eliminates direct contact with the contaminated soil and can prevent surface water from infiltrating into the contaminated soil and into the groundwater. Institutional controls are measures recorded in a property deed that restrict how a property is used and/or what activities are permissible. A remedy that includes these types of measures requires long-term monitoring to verify that the remedy remains protective of human health and the environment. Inspections are typically required annually, and the remedy must be evaluated in detail at five-year intervals. The additional monitoring will identify if changing conditions resulting from sea level rise are adversely affecting the environmental conditions at the site.

Utilities

The following entities manage and maintain utility systems in Alameda:

- Stormwater system = City of Alameda;
- Wastewater system = EBMUD (treatment and transmission) and City of Alameda (sewer collection system within city limits);
- Drinking water system = EBMUD;
- Energy (electricity) = AMP;
- Energy (natural gas) = PG&E; and
- Communications = varied (private).

These agencies have completed assessments on some utility sectors in Alameda, including the PG&E vulnerability assessment, City of Alameda storm drain modeling, and EBMUD water supply assessments. Plans are in place for specific utility sectors, including the City of Alameda Storm Drain Master Plan, City of Alameda Sewer Master Plan, EBMUD 2015 Urban Water Management Plan, and EBMUD Sewer System Management Plan. Collectively, these plans address key vulnerabilities to the city's utility systems to ensure climate change impacts are integrated into short- and long-term planning.

Stormwater system vulnerabilities: The City must address stormwater system vulnerabilities and deficiencies identified during previous storm drain and sea level rise modeling. Given the criticality of addressing the stormwater system, it is highlighted as a priority asset.

Sewer system vulnerabilities: The City's Sewer Master Plan includes a hydraulic capacity assessment and recommendations for upgrades and replacements. As the state and others release new guidance, the City of Alameda can determine the best way to incorporate climate change in sewer system modeling and planning. Potential impacts from climate change include infrastructure damage associated with flooding (e.g., to sewer pumps), rising groundwater levels (e.g., to pipes and other subsurface assets), and low flow during periods of drought and increased water conservation efforts.

Energy system vulnerabilities: This vulnerability assessment reviewed AMP electrical facilities and found none to be at high risk of exposure to sea level rise or storm-event flooding. The assessment did not include utility poles, but they are likely vulnerable to flooding in multiple locations. The greatest risks to the energy system are liquefaction and other impacts to buried infrastructure, including corrosion of pipes. PG&E completed a vulnerability assessment that included the natural gas system but was not specific to Alameda. This assessment lays the foundation for PG&E to identify strategies to address key threats, but the City has limited control over the natural gas infrastructure within Alameda. Addressing flooding due to overtopping of the shoreline will go a long way toward protecting critical energy system infrastructure over the longer term but will not increase the resilience of buried infrastructure to seismic hazards such as liquefaction.

Communications system vulnerabilities: Understanding vulnerabilities and identifying adaptations for the telecommunications system is very complicated due to its varied oversight and ownership, as well as relatively limited regulation of the system. There are few examples of comprehensive assessments of how climate hazards impact telecommunications assets due to the complexity of the system. Several City-owned buildings are related to communications infrastructure in Alameda, including Building 2 on Alameda Point (telecom switch station). This building is a critical facility for AT&T telecommunications infrastructure on Alameda Point. The vulnerability assessment concluded that this facility is not directly exposed to sea level rise and flooding but may be vulnerable to rising temperatures because it lacks an

internal climate control system. The Alameda Point MIP includes flood protection systems that could protect Building 2 and other telecom assets on Alameda Point, but it does not cover internal adaptations for specific buildings. More broadly, the communications system is critical to emergency services, and protections to ensure uninterrupted connectivity are very important. However, the varied ownership and oversight of the telecommunications system makes it difficult to implement adaptations because the City of Alameda does not directly control assets.

Public Health and Welfare

Climate change can have major and insidious impacts on public health, the extent of which varies depending on geography, the number and severity of climate change impacts affecting a particular population, socioeconomic status, and other factors. Socially vulnerable populations are particularly at risk. Climate-related public health impacts affecting Alameda consist primarily of higher temperatures, increased air pollution from wildfires, increased flooding from sea level rise and rainstorm events, and—to a certain extent—severe drought.

Flooding in particular can cause multiple public health impacts, such as mobilizing contaminants in soil (from hazardous waste sites), preventing access to safety, or preventing access to health care facilities due to flooded roads or public transit routes. More extreme heat events represent another major public health risk, as vulnerable populations (elderly, infants, those with existing health conditions, those living and working in areas without adequate shade, and those with limited access to air conditioning) can suffer heat exhaustion, stroke, difficulty breathing, and even death. When heat is combined with air pollution impacts, such as elevated ozone levels and wildfire smoke, the impacts are exacerbated. In addition, Alamedans are inexperienced in dealing with extreme heat and wildfires and therefore lack adequate preparation. Others lack resources to purchase air conditioning. More energy use for air conditioning results in increased costs, further affecting those with limited resources. It also increases GHG emissions, which further affects climate change and its associated impacts.

California's Fourth Climate Change Assessment highlights the indirect effects of climate change in the Bay Area, such as the combined impacts of increased allergens, air pollution, harmful algal blooms, heat, and disease vectors (e.g., insect and rodent populations). While each of these stressors can seem minor in isolation, their combined effects represent significant public health impacts to socially vulnerable populations who lack the financial capacity to respond.

Adaptation Strategies and Actions

A range of climate hazards already impact the City of Alameda, including flooding from storm events, wildfire smoke, drought, and extreme heat events. Over the coming decades, the city will experience increasing sea level rise and frequency of flood events. We can begin acting now to reduce the immediate impacts of climate change while building toward longer-term solutions to protect communities, critical assets, the environment, and businesses from flooding and other climate impacts.

This section begins with an overview of adaptive management: the approach of adapting to changing hazards over time. It then provides an overview of key terminology, followed by specifics on recommended adaptation strategies.

Consistent with and in response to the CARP's vulnerability assessment, adaptation strategies are grouped into the following categories:

- Strategies to address the 11 location-based priority flooding assets identified during the vulnerability assessment; and
- Strategies to build resiliency against climate risk by sector.

The recommended strategies and actions within the CARP build upon many other adaptation actions already underway or planned in Alameda. The CARP does not reanalyze actions within existing City plans and reflected in existing City commitments, but rather highlights opportunities to integrate and build upon them to achieve the CARP's overall resiliency goals.

Existing City Plans and Commitments Addressing Adaptation

- Alameda Point MIP
- Northern Waterfront Development Plans
- City's 2017–2019 Capital Budget
- Storm Drain Master Plan 2008
- Storm Drain Pump Station Upgrades 2012
- Storm Drain Master Plan Capital Improvement Program Update 2017
- Sewer System Management Plan 2017
- Caltrans State Route 260 Transportation Concept Report (signed 2011, reaffirmed 2017)
- Alameda Point Town Center and Waterfront Precise Plan
- Upcoming Green Infrastructure Plan

Suggested adaptation strategies for location-based priority flooding sites incorporate previous studies and are illustrated with high-level conceptual designs. Further study, engineering design, and community engagement are needed to develop site-specific plan and design requirements for the priority assets and to fully understand environmental, fiscal, and community aspects of the projects.

Strategies to build resiliency by sector are meant to be broadly applicable within Alameda. Collectively, these strategies help us address the CARP's climate hazard-specific goals and build a climate-resilient community. Additional details on each set of strategies are provided in Appendix J.

The City can undertake some strategies over the next several years and should approach others in phases. As conditions change and climate projections evolve, the City can evaluate current management practices and implement additional adaptation strategies. This approach is known as "adaptive management" and is defined by the IPCC as:

> *A process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables (IPCC, 2014).*

The CARP focuses first on protecting assets that are likely to be compromised soonest and with greatest consequence while accommodating longer-term solutions. This approach recognizes a greater understanding of nearer-term risks and allows time to take advantage of technologies and science that will evolve to better address long-term impacts, which are less certain today.

Under this approach, shoreline strategies do not necessarily need to be built to end-of-century water levels today. Rather, the CARP recommends developing adaptation pathways that specify how existing adaptation strategies can be supplemented, adjusted, or replaced under changing future conditions. Triggers must be designated to initiate the adjusted adaptation action. For example, shoreline protection

can be built higher when a future sea level rise trigger is reached. Adaptive management, adaptation pathways, and use of triggers are discussed further in Chapter 6, “From Plan to Action.”

Sea Level Rise Terminology and Projections

In discussing strategies to address sea level rise and storm surge risks, we refer to future San Francisco Bay water levels in terms of total water level above today’s high tide (MHHW). Total water level allows us to express that higher water levels can occur due to a combination of temporary storm surge and permanent sea level rise, helping us to simultaneously plan to address temporary and long-term flooding impacts. This concept is visualized in Figure 4-1. Table 4-5 presents the main total water level projections referenced in the CARP, the flood scenarios represented, and their respective elevations in NAVD88 (North American Vertical Datum of 1988)—the same datum applied in FEMA flood maps.

Table 4-5. Flood Scenarios and Sea Level Rise Projections Applied in CARP Sea Level Rise Planning

TWL	Elevation (NAVD88)	Flooding Scenarios: SLR + Storm Surge	Timing for SLR Projections
MHHW + 36”	~9.5 feet	50-year storm 6” SLR + 25-year storm 12” SLR + 5-year storm 18” SLR + 2-year storm 24” SLR + king tide 36” SLR	Immediate (storm risk) Before 2030 2030–2040 2040–2050 2050 2060–2070
MHHW + 42”	~10 feet (base flood elevation)	100-year storm 42” SLR	Immediate (storm risk) 2070
MHHW + 66”	~12 feet	24” SLR + 100-year storm 30” SLR + 50-year storm 36” SLR + 25-year storm 42” SLR + 5-year storm 48” SLR + 2-year storm 52” SLR + king tide 66” SLR	2050 2060 2060–2070 2070 2070+ 2070+ 2070+
MHHW + 108”	~15.5 feet	66” SLR + 100-year storm 84” SLR + 5-year storm 108” SLR	2070+ 2070+ 2070+
MHHW + 124”	~16.75 feet	84” SLR + 100-year storm	2100

Note: Sea level rise (SLR) projections correspond to medium-high risk aversion decision, high emissions scenarios from *Rising Seas in California: An Update on Sea-Level Rise Science* (Griggs et al., 2017).

When selecting sea level rise projections to plan for the shoreline's future, the CARP aligns with the California OPC's sea level rise guidance, giving more weight to the "medium-high risk aversion" scenario and higher GHG emissions scenarios (OPC, 2018):

- MHHW + approximately 24 inches of sea level rise by 2050; and
- MHHW + 71 inches to 83 inches of sea level rise by 2100 (OPC guidance also recommends considering storm surge in planning).

To help frame recommendations for adaptations in Alameda, the CARP describes **strategies** for increasing resilience and specific **actions** the City can take to collectively implement those strategies to address climate vulnerabilities. Distinguishing between actions and strategies helps illustrate how the City can make concrete progress toward climate goals by implementing individual actions or projects within a broader strategic approach.

Methods

After completing the vulnerability assessment, the City analyzed climate vulnerabilities in Alameda that existing City plans already address. Next, the team designed strategies to address Alameda's remaining vulnerabilities by drawing on a wide range of resources, including academic research, lessons from neighboring jurisdictions, knowledge of City staff, local community expertise, and regional and state government guidance (e.g., ART Program and ABAG). In developing strategies to adapt the shoreline and utilities to flood risk, concept plans from Alameda Public Works as well as existing research on natural shoreline protection potential in California and the Bay Area, specifically, proved especially important. For example, research by SFEI and SPUR on the *San Francisco Bay Adaptation Atlas* was a key resource.

The Alameda community provided valuable assistance in developing and refining adaptation strategies through participation in community input sessions and other forms of engagement within the city. The City considered potential strategies through the frames of society and equity, economy, environment, and governance. The City also considered co-benefits between climate mitigation and climate adaptation. Ultimately, the City drew on these diverse resources to develop adaptation strategies that address vulnerabilities and help meet Alameda's climate resilience vision and goal.

The recommendations provided here are not exhaustive—Alameda could consider dozens of other relevant strategies moving forward. As the City and community decide how best to prioritize and implement these actions, we recommend using the evaluation criteria below, which were presented and discussed at the January 2019 community input session and can be modified as needed:

- How much will the strategy cost? What will be the cost of inaction and who will bear it?
- How significant will the benefits be?
  - Social (e.g., public access, vulnerable populations served);
  - Economic (e.g., business, residential, city assets protected); and
  - Environmental (e.g., GHG co-benefits and promotion of "green" practices).
- How effective will the strategy be in addressing the issue?
- How feasible is the strategy to implement (responsible entity, timing, community support, ownership, technology/data limitations, regulatory approvals, and cooperation with other entities)?

As the City continues to monitor the impacts of climate change and better understand the threats Alameda faces, other actions may be identified. More details on specific metrics for monitoring climate change impacts and the effectiveness of adaptation strategies can be found in Chapter 6, “From Plan to Action.” It is important to periodically revisit these recommendations to ensure that resources are spent effectively. Priorities and recommended actions may shift as climate science and the City’s governance evolve.

Strategies for Location-Based Priority Flooding

Flooding is the greatest climate threat that Alameda faces. The vulnerability assessment identified priority assets based on the risk posed by both temporary flooding due to storm surge/overland flooding and permanent inundation from sea level rise. Strategies and associated actions to adapt to this threat are presented for short- (< five years), mid- (five to 10 years), and long-term (> 10 years) time horizons.

Specific information for each priority asset includes:

- Recommendations for short-, mid-, and long-term actions;
- Barriers and limitations to implementation;
- Site-specific considerations; and
- Case studies and examples if available.

Recommendations are built on analyses of previous City studies, review of activities implemented in other municipalities, and guidance from state and federal entities on designing adaptation strategies for coastal flooding. The order of actions presented for each asset does not indicate higher or lower ranking. The City should identify the preferred approach(es) for each priority asset and proceed with feasibility and engineering studies to develop more detailed project designs. Strategies for location-based priority flooding are outlined in the tables that follow. Additional site-specific considerations, case studies, limitations to implementation, and costs and benefits of adaptation are detailed in Appendix J.

Table 4-6. Adaptation Planning: Crown Beach

Short-Term (<5 years)	ALL ALL 1 2 ALL	• **Coordinate with EBRPD on master planning for the site**, including the public process. • **Study the geomorphology** of the beach. Study sand movement to predict where/how beach elevation will change over time and refine future strategies. • **Study opportunities for Elsie Roemer salt marsh to migrate with sea level rise.** Consider purchase of property as they become available. Fund native plant restoration to support long-term marsh health. • **Increase current dune management.** Dunes stabilize the beach and provide additional protection to the road. Strengthen and build existing dunes by further establishing native plants. Limit vehicular access to promote plant growth on the beach. • **Continue current practice of annually redistributing sand down the beach** (as needed).
Mid-Term (5–10 years)	3 ALL	• **Widen shoreline into the Bay.** Consider opportunities to move the shoreline into the Bay at a more gradual slope to protect against erosion. • **Develop long-term monitoring and trigger thresholds plan.** After 2 to 3 feet of sea level rise, additional strategies may need to be considered and 10 years of lead time will be needed (for feasibility studies, funding, etc.). Thresholds can be developed to trigger exploration of additional strategies, such as adding jetties/groins, oyster reefs (integrated into existing eel grass), or cobble berms to further control erosion.
Long-Term (>10 years)	4	• **Allow the beach to move inland.** If the beach erodes, there may be opportunities to simply allow it to move inland given the amount of open space available in the park.

CROWN BEACH

Crown Memorial State Beach is a 2.5-mile sandy beach, owned by California State Parks and the City of Alameda. Operated and managed by EBRPD, the beach is a popular spot for recreation and provides wildlife habitat. It also serves as shoreline protection for Shoreline Drive, the adjacent community, and important infrastructure such as stormwater outfalls. Sand is not naturally transported to the beach, so it must be periodically redistributed and replenished as it erodes slowly over time or suddenly in a large storm.

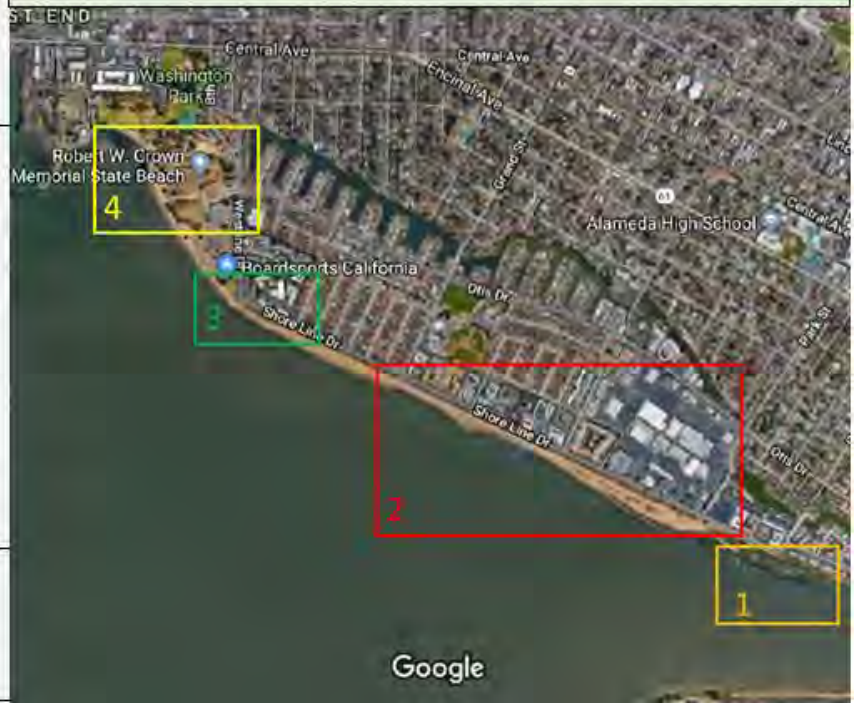


Table 4-7. Adaptation Planning: Eastshore Drive

Short-Term (<5 years)	1 2 2	• **Hydrodynamically model the mudflats and future impacts of sea level rise.** Assessing the full benefits that mudflats provide and their ability to adapt as water levels rise is needed to fill current information gaps. • **Integrate adaptation between public pathway improvement projects and private parcels.** Several public pathways are under consideration for improvement in this area. Selection criteria for park improvement projects could include potential for project to be integrated into broader flood protection improvements. • **Build higher barriers that can be further built up over time.** The City and homeowners should collaborate to clarify responsibility for maintenance of flood protection given parcel and jurisdictional boundaries, then begin developing barriers that protect against mid-century sea level rise and a 100-year flood.
Mid-Term (5–10 years)	1 ALL	• **Mudflat augmentation.** Add additional dredged sediment to the existing mudflats to help them maintain necessary elevation and structure as waters rise, ensuring they continue providing benefits. Support submerged aquatic vegetation in San Leandro Bay. • **Develop long-term monitoring and trigger thresholds plan.** Develop thresholds that trigger construction of higher levels of flood control.
Long-Term (>10 years)	ALL 2	• **Tidal neighborhoods.** If property ownership changes in the coming decades in this area (transfer to developer or City), evaluate potential for floating neighborhoods proposed by the Resilient By Design "Estuary Commons" project. • **Consider property purchase for migration/enhancement of mudflats for flood protection,** pending findings of hydrodynamic model of mudflats with sea level rise.

EASTSHORE DRIVE

Eastshore Drive is the easternmost road on Alameda Island. It runs north-south, providing access to the Eastshore and Fernside residential neighborhoods. Though there are several public pathways leading to the water along Eastshore Drive, the eastern waterfront as a whole primarily consists of private homes. The shoreline is currently protected by a combination of sloped riprap (pilled rock) and vertical bulkheads (walls) running along backyards. There are existing mudflats along the east side of Alameda Island. Mudflats provide many benefits, including wave attenuation and reduced erosion, and they serve as vital habitat for shore and water birds. FEMA recently determined that sections of the Eastshore neighborhood are within the 100-year flood zone. Inundation maps representing sea level rise and storm surge also indicate flood risk within this area.

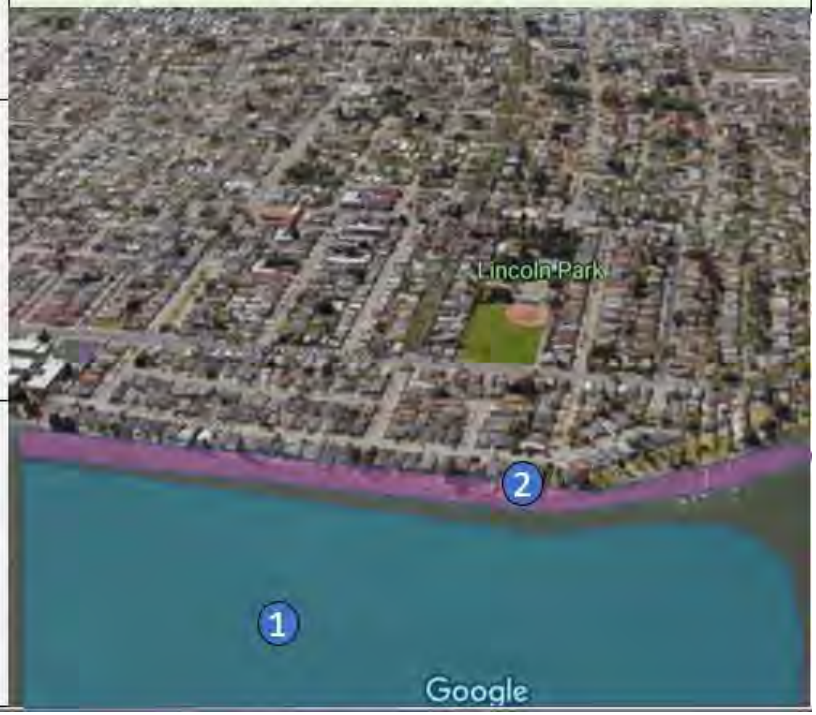


Table 4-8. Adaptation Planning: Shoreline Near Webster and Posey Tubes

Short-Term (<5 years)	1 2 ALL ALL	• **Design and implement levee and seawall expansions to protect from a 100-year storm event** using existing levees and seawalls. The City's initial conceptual drawings for this location identify areas that need to be raised/reconstructed. • **Compile a comprehensive geospatial record of land ownership shoreline.** • **Establish memoranda of understanding as needed with private landowners.** Ensure shoreline actions consider their needs and that they actively implement flood protection actions moving forward. • **Develop evacuation plan for senior centers and other care facilities in affected area.**
Mid-Term (5-10 years)	3 ALL 4	• **Require flood-proofing for critical inland facilities** like the Hazardous Materials Transfer Station. • **Investigate options to modify existing public trail and open space to accommodate temporary flooding.** Consider appropriate vegetation, stormwater management structures, and other natural water-tolerant features. • **Expand existing levees and seawalls to address longer-term water levels.** To address higher water levels beyond the FEMA 1% annual chance floodplain, the City should consider further elevating existing levees and seawalls to 13' NAVD88 and extending seawalls to the northwest. Public access for bicycles and pedestrians along the levee must be maintained or added.
Long-Term (>10 years)	ALL	• **Develop long-term northern waterfront shoreline strategy.** Investigate land use policy changes (zoning, building regulations, etc.), including "zoning overlays" in high-risk areas. Create regulations for new and redevelopment projects. Limit development within a certain distance from the shoreline.

SHORELINE NEAR WEBSTER & POSEY TUBES

A small segment of shoreline above the Webster and Posey Tubes at the north end of Mariner Square Drive is likely to overtop due to sea level rise at and beyond 36 inches. Overtopping at this location is linked to projected inundation that extends along Webster Street and nearby roads and into the Webster and Posey Tubes. The shoreline in this area is dominated by engineered levees and seawalls, as well as commercial buildings and residential facilities (e.g., the Oakmont Senior Center at Mariner Point), that occupy parcels very close to the current shoreline. Addressing shoreline overtopping in this location is likely to prevent flooding and inundation of critical roadways that provide access to/from Alameda Island.

Table 4-9. Adaptation Planning: Bay Farm Island Lagoon System 1 Outlet Gate and Seawall

Short-Term (<5 years)	1 1 1	• **Conduct a geotechnical study.** Determine the structural condition of the existing shoreline to better understand long-term modifications that may be necessary. • **Elevate existing seawall to provide immediate protection from storms and king tides.** Implement recommendations from previous stormwater system assessments. A new 2' retaining wall built behind the existing seawall will make shoreline protections level with tide gate structure platform and adjacent shoreline. • **Implement upgrades to HBI System 1 Pump Station** identified in previous storm drain master planning efforts and lagoon studies.
Mid-Term (5–10 years)	2 3	• **Investigate options for submerged aquatic vegetation (SAV) at this location.** Bay Area assessments for natural shoreline feasibility identified San Leandro Bay and the canal as potential locations for SAV. • **Begin design of large-scale shoreline modifications along the Bay Farm Island north shore.** After 2 to 3 feet of sea level rise, additional strategies may need to be considered and 10 years of lead time will be needed (for feasibility studies, funding, etc.). Thresholds can be developed to trigger exploration of additional strategies such as elevating the existing shoreline or expanding it outwards into the Bay, as well as converting it into a living or horizontal levee.
Long-Term (>10 years)	ALL	• **Coordinate the approach to flooding across Bay Farm Island.** Flooding on Bay Farm Island is connected to several locations of shoreline overtopping in both Alameda and Oakland. A coordinated approach to shoreline modifications is necessary to reduce the risk of flooding.

BAY FARM ISLAND LAGOON SYSTEM 1 OUTLET GATE & SEAWALL

At the north end of Bay Farm Island Harbor Bay Lagoon System 1 is a narrow, 100-foot long isthmus of land separating the lagoon from San Leandro Bay that can be considered a seawall. It is not a FEMA-certified seawall, and the underlying shoreline's structural competency is unknown. The seawall is not level with the adjacent shoreline, providing a conduit for floodwaters due to sea level rise and storm surge. Overtopping at this location has the potential to compromise the lagoon system, leading to flooding of neighborhoods throughout Bay Farm Island. The tide gate structure at this location is used to drain the lagoon system during low tide. A supplemental pump can also lower lagoon water levels if the tide gate is submerged.

Table 4-10. Adaptation Planning: Veteran's Court Seawall

Short-Term (<5 years)	1 2 3	• **Regrade and elevate road to convert Veteran's Court into a flood protection structure.** Initial City conceptual designs call for elevating the roadway and retreating the cul-de-sac to Veteran's Memorial Park. A small 3' to 4' earthen berm would tie into existing ground near Island Drive, preventing water from flowing along the roadway and impacting other areas. • **Repair/replace and elevate existing seawall.** Implement recommendations from Bay Farm Island Technical Study, including raising existing shoreline structure to provide greater flood protection. • **Enhance wave attenuation and erosion control features like submerged aquatic vegetation.** This may provide some additional protection to the existing seawall.
Mid-Term (5–10 years)	ALL 4	• **Integrate activities at Veteran's Court seawall into broader Bay Farm Island flood control strategies.** Flooding on Bay Farm Island originates from multiple locations, so any adaptations at an individual site should be part of a larger coherent approach for shoreline modifications across the island. • **Investigate options to convert Veteran's Court area into a living levee.** This would require either retreat away from Veteran's Court or encroachment into the canal, as well as a long-term management plan to maintain adequate levee elevation.
Long-Term (>10 years)	5	• **Consider further removal of impervious surfaces.** Short-term plans call for converting existing impervious surface into natural area to aid drainage. Long-term options could include converting Veteran's Court roadway into a shoreline park with pedestrian/bike access. Consider features like De-Pave Park as models for transitioning developed land to natural.

VETERAN'S COURT SEAWALL

A major source of potential flooding on Bay Farm Island is the Veteran's Court area. The shoreline along Veteran's Court is primarily a constructed seawall that is not engineered to meet FEMA requirements. Overtopping in this location may lead to inundation of adjacent neighborhoods at mid-century water levels—or inundation during very intense, current storm events—and will likely contribute to larger-scale flooding across Bay Farm Island at higher water levels. Addressing shoreline deficiencies at Veteran's Court is only part of a larger effort needed across Bay Farm Island, in both Alameda and Oakland.

Table 4-11. Adaptation Planning: Bay Farm Island Touchdown and Towata Park

Short-Term (<5 years)	ALL ALL 1 2 ALL	• **Conduct inventory of existing shoreline protection structures.** Determine ownership; where seawalls, riprap, and other protection structures are most deficient in elevation; and where repairs are most needed to guide immediate actions. • **Carry out engineering study to determine alternative conceptual designs for improved shoreline protection.** Study should include potential for beach creation along the fortified shoreline and expanded submerged vegetation restoration to reduce stress and wave runup on fortified shoreline. • **Conduct focused study on adaptation measures available at Towata Park.** Given that there is more space available at the park than along the homes, a design alternatives study may identify options besides a hardened shoreline in this area, such as a beach that integrates park improvements (e.g., kayak launch). • **Assess bridge vulnerability.** Include assessment of pilings, machinery rooms, motors, and vertical clearance. • **Repair/replace and elevate existing shoreline protection** (based on study outcomes). Provide 100-year flood protection plus protection to mid-century sea level rise projections.
Mid-Term (5-10 years)	ALL	• **Develop long-term monitoring and trigger thresholds plan.** Develop thresholds that trigger construction of higher levels of flood control.
Long-Term (>10 years)	ALL	• **Consider local ordinance requiring or encouraging flood retrofits in this neighborhood.**

BAY FARM ISLAND TOUCHDOWN AND TOWATA PARK

This stretch of shoreline provides flood protection to the adjacent residential area, Bridgeview Isle, and Krusi Park. The area of earliest concern is directly to the west of the bridge (on the Alameda Island side) by Towata Park, where overtopping begins at a total water level of 24 inches. At a total water level of 36 inches, homes in the Ravens Cove HOA and some nearby houses are impacted. At 48 inches, the flood area expands significantly. Today's shoreline is made up of seawalls and riprap. Towata Park is owned and managed by the City of Alameda Recreation and Parks Department. EBMUD has an easement in the area. The HOA appears to own part of the shoreline as well, though clarification is needed.

Table 4-12. Adaptation Planning: SR260, Including Posey and Webster Tubes

Short-Term (<5 years)	1 2 2	• **Address flooding at the Webster Tube exit and Posey Tube entrance.** Road grading and floodwalls along the ramps to the tunnels can block overland flooding and reduce disruptions to tunnels. • **Install saltwater-resistant pumps in the tubes.** Current pumps are designed for stormwater only and are likely to be compromised if sea level rise or storm surge results in saltwater in the tunnels. • **Implement flood-proofing for ventilation, electrical, and pumping infrastructure.** Ensure long-term sustainability of tubes by protecting critical infrastructure from flooding.
Mid-Term (5–10 years)	3 3	• **Implement results of West End Bicycle and Pedestrian Crossing Feasibility and Design Study** (Project 39 in TCP). The Caltrans District 4 Bike Plan (2018) lists a "new separated crossing" as a top tier project. • **Increase Transportation Redundancy.** The Alameda TCP outlines several projects, including water taxis, bike/pedestrian alternatives (Projects 37, 39), and other projects to increase transportation redundancy—e.g., a new BART connection (Project 35).

SR260 INCLUDING POSEY & WEBSTER TUBES

SR260, including the Webster and Posey Tubes, is a critical transportation corridor connecting Alameda and Oakland. It is owned and maintained by Caltrans. The City of Alameda has limited jurisdictional oversight of the roadway and tunnels but coordinates closely with Caltrans on tunnel projects. The route is used heavily by commuters and businesses, and it serves as a major commercial route connecting the Port of Oakland with storage facilities in Alameda. Despite the age of the Posey Tube (built in 1928; oldest underwater tunnel in the United States), seismic retrofits completed in 2004 helped rehabilitate the tunnel and increase its functional lifespan. Modifications to the tubes are likely necessary to protect them from floodwaters. Shoreline modifications in this area will be critical to preventing flooding in the tubes, but actions should still be implemented to prevent disruptions if shoreline flood protection structures fail.

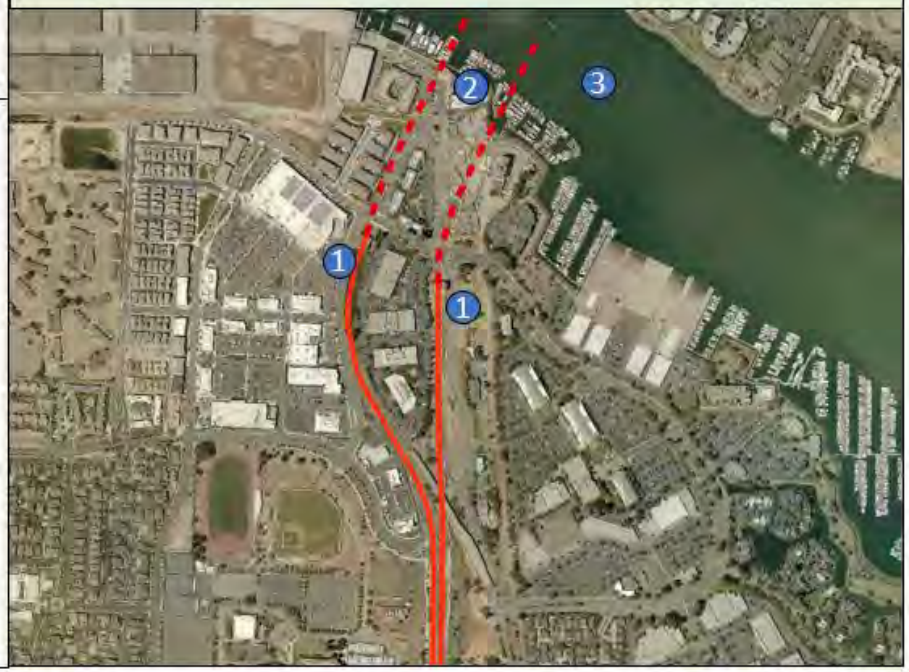


Table 4-13. Adaptation Planning: SR61/Doolittle Drive

Short-Term (<5 years)	1 2 3 4	• **Work with model airplane field to adapt/regrade the field.** Some of the earliest flood risk to SR61 is at the intersection with Harbor Bay Parkway. The water would flow over the field before affecting the road. This could be prevented by regrading the field to prevent overtopping from Doolittle Pond. • **Support neighboring adaptation efforts.** Past adaptation design efforts have proposed extending Arrowhead Marsh southward into the seaplane canal, as well as relocating Doolittle Drive westward (toward Earhart Drive) and raising it onto a horizontal levee. While such strategies represent a long-term effort taking place in Oakland, they could significantly reduce Bay Farm's flood risk. The funding, multijurisdictional political will, and research to support this work need to start now. • **Study potential for mudflat augmentation or beach erosion** to reduce overtopping of Doolittle Pond.
Mid-Term (5–10 years)	5	• **Collaborate with Regional Water Quality Control Board on updates to the long-term flood protection plan contained within the Doolittle Landfill's Waste Discharge Requirements (WDRs).** WDRs are updates to ensure monitoring and management requirements remain appropriate to site conditions. A WDR update could provide an opportunity to discuss integration of site flood protection into broader shoreline adaptation efforts.
Long-Term (>10 years)	6 7	• **Explore opportunities to collaborate with the golf course on flood control.** • **Explore converting roadways on the east side of the Bay Farm community into levees.**

SR61/DOOLITTLE DRIVE

SR61 is a state highway owned and maintained by Caltrans. The route runs from the intersection with SR112 near the Oakland Airport across Alameda and terminates at the intersection of Webster Street in Alameda, operating as an important corridor from the island of Alameda to Bay Farm Island, and to the airport and the City of Oakland. The route includes the Bay Farm Island Bridge (connecting Alameda Island and Bay Farm Island). Multiple AC Transit bus routes, including several serving transit-dependent communities, use SR61. The City of Alameda has designated SR61 south of Otis Drive as a primary evacuation route. While isolated segments of SR61 within the City of Alameda are at risk of flooding (near Veteran's Court and the intersection of SR61 and Harbor Bay Parkway), major flood risk originates with overtopping of Doolittle Drive within the City of Oakland. There is a risk that water could overtop Doolittle Drive and then flood the airport, golf course, and finally nearby residential neighborhoods.

Table 4-14. Adaptation Planning: Critical and High-Use Roadways

Short-Term (<5 years)	ALL ALL ALL ALL	• **Address culvert and road drainage issues in areas identified as vulnerable to sea level rise and storm drain flooding** (see maps to right). Expand consideration of transit-dependent communities in road project prioritization. • **Investigate options for green infrastructure in road design**, including permeable pavement, bioswales, and distributed small-scale stormwater best management practices where appropriate. Implement recommendations guidance and strategies in the City's Green Infrastructure Plan. • **Support expanded WETA service** at the Main Street Ferry Terminal and a new terminal in the Seaplane Lagoon. • **Work with AC Transit to install bus shelters** so riders are protected from the elements on rainy days or during heat waves.
Mid-Term (5–10 years)	ALL ALL	• **Work with high-risk neighborhoods and AC Transit** to develop a dynamic routing and notification system for buses during storm events. • **Expand flood-proofing for bus stops,** including elevating high-use stops in areas where floodwaters are likely and work with AC Transit to develop a community messaging system for rerouting of buses during flood events.
Long-Term (>20 years)	ALL	• **Continue to implement shoreline modifications to prevent the flooding and disruption of key roadways and transit**. The City can work with key partners like AC Transit, leaders in socioeconomically disadvantaged communities, and neighboring jurisdictions to study and implement transit system alternatives such as a greatly expanded ferry service that could reduce reliance on surface streets.

CRITICAL & HIGH-USE ROADWAYS

These are bundles of important roads in Alameda that private vehicles and public transit use. They are also important routes for emergency services. These roadways are defined in part based on the location of AC Transit bus routes that serve transit-dependent populations in Alameda, including Line 96, which serves Alameda Point (and the planned location of a Bus Rapid Transit stop). Although many roads in Alameda may be exposed to sea level rise and/or storm drain flooding, transit routes enable the City to ensure social equity when building resilience in Alameda. Maintaining a functioning and accessible transit system across the island also serves all residents that use transit for commuting and errands. Strategies suggested here often apply to many roads across the city. However, the CARP process indicates the importance of addressing issues along these key roads, which provide important services for transit-dependent communities in Alameda.

Table 4-15. Adaptation Planning: Storm Drain Pipes and Pump Stations

Short-Term (<5 years)	ALL ALL ALL	• **Implement recommendations in City's existing master planning efforts.** Projects include major efforts like lagoon dredging and capacity upgrades at priority pump stations, including Arbor Street, Webster Street, and Central/Eastshore. • **Consider projected future water levels when designing stormwater upgrades.** Storm pipe and pump station design should consider projected water levels at the end of the design lifespan for an upgrade. Additional elements like flood-proofing should be considered for infrastructure with long useful lifespans. • **Study groundwater and consider impacts on stormwater management.** Consider the impact of stormwater alternatives such as under-drained treatment on capacity requirements for pump stations and pumps. Study potential increases in flow if stormwater is managed through alternatives to infiltration and incorporate findings in stormwater improvements.
Mid-Term (5–10 years)	ALL ALL	• **Continue to implement recommendations in City's existing master planning efforts.** Stormwater improvements beyond 5 years are tightly linked to shoreline improvements and other adaptation actions described throughout the CARP. • **Periodically update storm drain models.** At this time, it is unclear what capacity improvements or other upgrades might be needed beyond a 10-year planning horizon. Storm drain modeling will be revisited periodically and should begin to incorporate projected changes in storm intensity.
Long-Term (>10 years)	ALL	• **Comprehensive approach to shoreline and stormwater management.**

STORM DRAIN PIPES & PUMP STATIONS

Existing stormwater system planning has identified several important upgrades to the storm drain pipes and pump stations necessary to address current storms, which are likely to become more frequent with climate change. Without upgrading the system, runoff water may more frequently overtop the curb and threaten property and safety. It is crucial for the City to fund and implement stormwater pipe and pump stations projects already identified in master planning work. Sea level rise is likely to cause groundwater in Alameda to rise, exacerbating existing deficiencies in the stormwater system. At the same time, storm events and associated flooding can overwhelm stormwater infrastructure and lead to flooding throughout the system. A comprehensive approach to shoreline and stormwater system adaptation will ensure that Alameda is prepared for a future of increased flooding. Over the mid- and long-term, we will monitor groundwater levels and determine what impacts higher water levels have on stormwater management. We may need to consider large-scale efforts to manage groundwater levels.

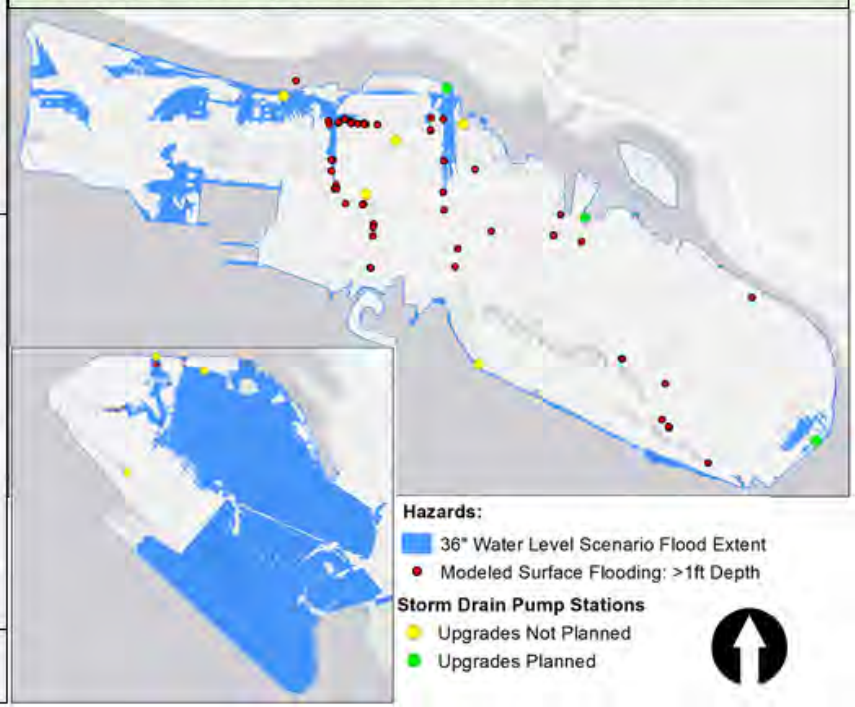


Table 4-16. Adaptation Planning: Bayview Weir and Outfall

Short-Term (<5 years)	ALL 1 2	• **Implement identified improvements from stormwater system master planning.** Master planning efforts have identified the need for upgrades, including dredging and new flap gates. • **Analyze the structure of the weir.** Determine the structural characteristics of the weir to better understand geotechnical conditions and gather information necessary to design a pump station. • **Monitor water levels at the outfall.** Establish a system to monitor water levels at the outfall to track the length of time the outfall is exposed. This information can help determine how soon a new pump station is needed.
Mid-Term (5–10 years)	1 ALL	• **Install a new pump station.** Begin planning, design, and permitting processes for a new pump station at the Bayview weir location. A pump station is needed at this site to ensure lagoon water levels can be maintained during storm events. Once the existing outfall is underwater for the majority of the day, it is no longer effective to control water levels through a gravity system. • **Integrate weir and outfall upgrades with other modifications along Shoreline Drive.** Implement recommendations from stormwater master planning efforts along Shoreline Drive to help better manage stormwater on the southern shore.
Long-Term (>10 years)	ALL	• **Address shoreline issues in nearby areas.** In the longer term, substantial inundation across Alameda Island could directly connect the Bay and the South Shore lagoon system. Shoreline modifications are necessary to prevent this inundation and maintain the long-term viability of the lagoon system.

BAYVIEW WEIR & OUTFALL

The Bayview weir and outfall are in need of repairs and/or replacement. The greatest vulnerability to the system is from sea level rise, which will eventually prevent the gravity-fed system from operating, necessitating the installation of an active pump station. Several information gaps need to be filled to determine the best approach to address deficiencies in the existing system. We can take a number of interim steps to address the vulnerability of the weir and outfall while securing funds for a new pump station. Over the longer term, it is necessary to fund and implement recommendations in existing master planning efforts for the stormwater system. Addressing vulnerabilities at this location is crucial to ensuring ongoing functionality of the lagoon system and to maintaining flood protection for homes adjacent to the lagoons.

Increasing Resiliency by Sector

The CARP vulnerability assessment evaluated hazard-specific vulnerabilities citywide across all asset categories, considering the impacts of heat, drought, wildfire smoke, flooding, and sea level rise. The City team analyzed potential impacts of sea level rise and storm events in depth due to their particularly serious long-term consequences for Alameda.

This section presents sea level rise and flooding adaptation actions for each citywide asset category, as well as adaptation actions for other hazards (drought, heat, wildfire smoke, and contaminated lands). Many of these actions require additional analysis to determine project-specific details, such as where implementation would be most effective, where operational changes are needed, or where specific policies should be drafted. Where possible, details on responsible entities, key stakeholders, and additional studies are provided.

Strategies and associated actions are provided for the following asset categories:

- Buildings;
- Critical services;
- Land use;
- Shoreline, natural, and recreation areas;
- Transportation;
- Contaminated lands and waste;
- Utilities; and
- Public health and welfare.

Within each of these categories, the CARP highlights where and how social vulnerability (individuals, households, and neighborhoods that may be disproportionately harmed by a hazard) must be integrated into the siting, design, and implementation of strategies. Social vulnerability to climate hazards is further described in Appendix G. Recommendations for applying these social vulnerability findings as the City works on equitable plan implementation are further described in Chapter 6 ("From Plan to Action").

Throughout this section, adaptation strategies and associated actions are presented in tables for each asset category listed above. Table 4-17 explains the key information contained in these tables.

Table 4-17. Key Categories of Information Contained Within Citywide Strategy Tables

Relative Cost	Responsible Entity	General Timeline
An *approximation* of the relative cost of implementation for the lead entity; given the wide range of strategies and potential costs, this is meant as guidance to compare relative costs within each asset category. - $ **= low cost** - $$ **= medium cost** - $$$ **= high cost**	Primary entity or entities responsible for implementation.	An *approximate* timeline for implementation to be underway. The following bins are used: - **Short** = < Five years - **Medium** = Five to 10 years - **Long** = > 10 years

Buildings

Alameda has an extensive inventory of buildings that are vulnerable to flooding from sea level rise, storm surge, and major rainfall events. Many buildings in the city are sensitive to flooding and exposure to saltwater. Sea level rise exacerbates the risk posed by liquefaction from earthquakes. It also increases the frequency at which temporary storm surge will cause flooding. Damage to buildings can disrupt key community services and disproportionately impact vulnerable populations that rely on those services, such as the young, elderly, ill, immobile, and economically disadvantaged. Addressing the risks posed to buildings in Alameda is possible through a combination of policy or code changes and implementation of flood protection and other hazard reduction actions. In terms of flood protection, the strategies in Table 4-18 are intended to help buildings and communities withstand and/or avoid temporary flood events. They will not enable buildings to persist in the face of permanent inundation from sea level rise (which must be addressed with shoreline strategies).

Green Roofs, Cool Roofs, and Rooftop Solar

Installation of green roofs, cool roofs, and rooftop solar all provide GHG emissions reduction benefits (see Chapter 3). These actions increase the community's resilience to climate impacts. Green roofs can reduce the influx of stormwater during a major rainstorm. Green and cool roofs can help households and businesses tolerate heat waves. Rooftop solar increases community resiliency through energy security. Should the electric grid be interrupted during a hazard event, solar provides an important backup when combined with energy storage.

In implementing strategies, the City must consider opportunities to increase home resilience for renters. Some of the strategies described in Table 4-18 (e.g., composting, solar panels, green/cool roofs) have co-benefits in terms of GHG mitigation.

Alameda's building stock is also highly vulnerable to earthquakes and associated liquefaction. The CARP does not go into detail on seismic retrofits, but details on the City's approach to addressing earthquake risk can be found in the 2016 Local Hazard Mitigation Plan.

Table 4-18. Increasing Resiliency for Buildings

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Encourage implementation of flood-proofing	The Alameda Building Code currently requires that any new building construction or substantial improvements within the special flood hazard area (100-year floodplain) be elevated and flood-proofed in accordance with FEMA requirements. Alameda should consider re-defining “substantial improvement” to capture more redevelopment projects that currently do not meet the threshold for this requirement.	$	City of Alameda	Short
Encourage implementation of flood-proofing	Implement programs to encourage flood-proofing retrofits to existing buildings and redevelopment in flood-prone areas. Amend local codes and by-laws to mandate flood-proofing techniques in defined flood hazard zones and adjacent areas to protect them from future sea level rise while considering the impact on disadvantaged communities. Inventory and prioritize highest at-risk buildings, including those serving vulnerable populations, for resiliency upgrades. Alameda should identify options to help low-income households and other vulnerable residents pay for flood retrofits.	$	City of Alameda	Medium
Encourage implementation of flood-proofing	Consider incorporating sea level rise into the flood management section of the Building Code (Appendix H) to encourage, incentivize, or require compliance with base floor elevation and flood-proofing requirements to mid-century sea levels.	$	City of Alameda	Medium
Engage the community in climate adaptation efforts and build grassroots support	Launch a consumer education campaign on flood insurance and flood preparedness. Develop materials to help residents and businesses identify financial support for flood insurance and flood retrofits. Engage community leaders in reaching out to underserved and vulnerable communities to give them the support they need.	$	City of Alameda and FEMA	Short
Manage costs associated with growing flood risk	Work with FEMA to identify ways to increase Alameda’s Community Rating to reduce flood insurance costs.	$	City of Alameda and FEMA	Short

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Investigate and adopt requirements for managing runoff from impervious surfaces using green infrastructure	Building Code chapter 15.08, section 458.10 (site design), requires construction projects creating over 2500 ft² of impervious surface to incorporate at least one of six stormwater infiltration measures. This provision should be reviewed for effectiveness and strengthened as necessary to add other options (e.g., de-paving, under-drains in high groundwater areas) and include runoff reduction targets. Should site constraints limit meeting targets, the City should consider an in-lieu fee program. Under this program, in lieu of fully meeting targets, funds are deposited into a dedicated account to be used for strategically designing and constructing stormwater management projects citywide to optimize flood mitigation and co-benefits. By systematically targeting optimal stormwater recharge, the City can align this requirement with green street priority projects and provide irrigation for tree planting in heat island areas. Compost can be used as part of this effort to provide healthy soils for healthy tree growth and carbon sequestration. Consider expanding an in-lieu fee program for meeting other resilience measures to support projects that address multiple vulnerabilities.	$	City of Alameda	Short
Implement requirements for managing runoff from impervious surfaces using green infrastructure	Consider design modifications for infiltration-based green infrastructure in areas with shallow groundwater. Incorporate requirements for stormwater management in new development and redevelopment permits. For example, see concept drawings for "under-drained stormwater treatment" in the Draft Alameda Point Storm Water Plan. Ensure that capacity upgrades to the stormwater system (e.g., pipe and pump upgrades) can accommodate increased flow from non-infiltration stormwater management approaches.	$$	City of Alameda	Short
Study groundwater to better understand current groundwater conditions and the impact of sea level rise	Develop a model of groundwater levels across Alameda, either by expanding and adopting regional groundwater models or creating a new model with more locally specific data. Model the impact of sea level rise on groundwater and project groundwater elevations and salinity at mid- and end-of-century levels. Assess building vulnerability (e.g., systems in basements) to future groundwater levels/salinity and integrate building adaptation strategies for future groundwater conditions into the CARP. Install groundwater monitoring wells as needed to collect long-term data on groundwater levels.	$$	City of Alameda, USGS, and Alameda County	Medium

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Promote retrofit efforts to reduce the impact of earthquakes and liquefaction	Explore incorporation of new requirements for new development and redevelopment permits to increase building resilience to liquefaction. Continue and expand existing efforts like the Soft Stories Building Program to retrofit homes and businesses for earthquakes. In areas with existing buildings that are built on fill and more susceptible to liquefaction (e.g., reuse areas on Alameda Point), liquefaction mitigation measures are restricted to existing structures and utilities (ground improvement techniques are not possible). In areas with no current development, ground improvement techniques are possible to increase the density of the substrate. See Alameda Point MIP for more detailed examples of the engineering techniques available to address liquefaction. These and other relevant techniques should be incorporated as possible into future new development and redevelopment plans across Alameda, especially in areas along the shoreline that are built on fill and more susceptible to liquefaction.	$$$	City of Alameda	Medium
Encourage installation of solar panels and storage	Incentivize installation of solar panels on existing rooftops and solar canopies over parking lots (in conjunction with changing parking surfaces to water-permeable materials to lessen stormwater runoff).	$$	City of Alameda	Medium
Modify building codes to encourage implementation of heat reduction techniques	Review building codes and identify provisions for encouraging/requiring the installation of cool roofs, green roofs, and/or other energy-efficient cool building methods. These methods mitigate heat impacts and reduce runoff (green roofs) for new development and substantial redevelopment that involve roof repair/replacement. Consider prioritizing and incentivizing cool/green roofs in heat island areas.	$$	City of Alameda	Short

Critical Services

The main threat to Alameda's critical services—fire, police, EMS, schools, and hospitals—is impeded access due to flooding. Disruption of Alameda's critical facilities can significantly exacerbate flood impacts because residents depend on these services the most during such events. Although some critical facilities are located within the flood zone and are directly exposed to flooding, much of the disruption to critical services occurs because emergency vehicles are not able to travel on flooded roadways. Addressing infrastructure vulnerabilities in the transportation sector, as well as shoreline vulnerabilities that increase flood risk, will go a long way toward maintaining functioning critical services in Alameda. There are also opportunities to adjust protocols and implement operational changes that can help fire, police, EMS, and other critical services adapt to climate change and institutionalize flexibility into operations.

The importance of critical services during emergencies is heightened in communities where residents may not have the ability or means to prepare for, respond to, or recover from an incident. Regular engagement and open lines of communication are key to ensuring vulnerable residents, especially those with language barriers or other factors that limit their access to information, are adequately served in the event of an emergency.

Additional information on the City's approach to hazard mitigation planning, particularly as it relates to critical services and non-climate hazards like earthquakes, is available in the 2016 Local Hazard Mitigation Plan.

What Can You Do to Support Resilience Planning and Ensure Effective Hazard Response?

- Get tips on disaster preparedness for you and your family at alamedaca.gov/Departments/Fire-Department/Disaster-Preparedness.
- Support your neighbors in disaster situations by completing the Community Emergency Response Team training at alamedaca.gov/emergency-info/cert.
- Build community and make your home more resilient through free classes at alamedabackyardgrowers.org.
- Consider these tips to detain rain runoff from your home during a storm: www.cleanwaterprogram.org.
- Understand sea level rise and storm surge risks to your neighborhood by checking out the Bay Shoreline Flood Explorer: explorer.adaptingtorisingtides.org.

Table 4-19. Increasing Resiliency for Critical Services

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Establish protocols to facilitate effective emergency response	Develop and update protocols for routing emergency services (fire, ambulance, police) to ensure all homes and businesses can be accessed in the event of an emergency. Establish plans to stage equipment (e.g., portable pumps) in strategic areas before a storm event. Consider long-term plans for maintaining access to all areas in Alameda as water levels rise.	$	City of Alameda and Water Emergency Transit Authority (WETA)	Medium
Establish protocols to facilitate effective emergency response	Develop plans to address how other critical facilities can fill the gap if the Bay Farm Island fire station is cut off from parts of the community (due to road flooding).	$	City of Alameda	Medium
Establish protocols to facilitate effective emergency response	Keep current the City's Emergency Response Plan, including a disaster debris plan. Obtain review from California Office of Emergency Services (CalOES) and develop agreements with contractors and haulers to provide quick turnaround debris handling bids. Update list and agreements annually. Reassess after events.	$	City of Alameda, CalOES, and County Emergency Operations Center	Medium
Establish protocols to facilitate effective emergency response	Amend emergency response policies, procedures, and trainings to be responsive to the specific needs and characteristics of individuals and households being served, such as having the specialized equipment or evacuation procedures necessary for medically or mobility challenged people.	$	City of Alameda and Community Emergency Response Team (CERT)	Short
Develop effective emergency alert communication system	Develop a citywide communication plan that addresses general and emergency communication with the public. Continue to use Next Door and other social media platforms to disseminate important information. Continue the use of AC Alert, Alameda County's mass notification system, which the City also uses to notify community members of important safety information.	$ AC Alert is funded by Urban Areas Security Initiative grant funds—no cost to the City at this time.	City of Alameda	Short

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Develop effective emergency alert communication system	Encourage participation and provide public education about AC Alert and 211—Eden Information and Referral (Eden I&R), a program that has translation services and provides a hub of critical information during emergencies or disasters. Ensure underserved communities are given the support needed to participate (translations, technical assistance, etc.).	$ 211 is a free service.	City of Alameda	Short
Develop effective emergency alert communication system	Investigate options for disseminating emergency alerts through key community leaders to increase their reach in disadvantaged communities. Work with community groups to develop an effective disaster communication system so that all community members, including those who are non-English speaking, receive key communications from city/local officials before, during, and after a disaster event.	$	City of Alameda and CERT	Short
Strengthen community resilience	Create a community capacity inventory by bringing together community organizations and local jurisdictions to determine components of the inventory and how to update them.	$	City of Alameda and CERT	Short
Strengthen community resilience	Coordinate with nonprofit, community, and faith-based organizations to build strong social networks in neighborhoods, especially those exhibiting characteristics that make them more vulnerable, such as Alameda Point and Alameda Landing. Develop community-led education and outreach campaigns designed for specific local populations on the risks of sea level rise and storm events.	$	City of Alameda and CERT	Short
Strengthen community resilience	Provide technical assistance to neighborhoods to support the development and maintenance of disaster plans, including storm evacuation procedures and shelter-in-place guidelines. Include and support the role of community organizations in these plans to acknowledge and grow neighborhood resilience.	$	City of Alameda and CERT	Short

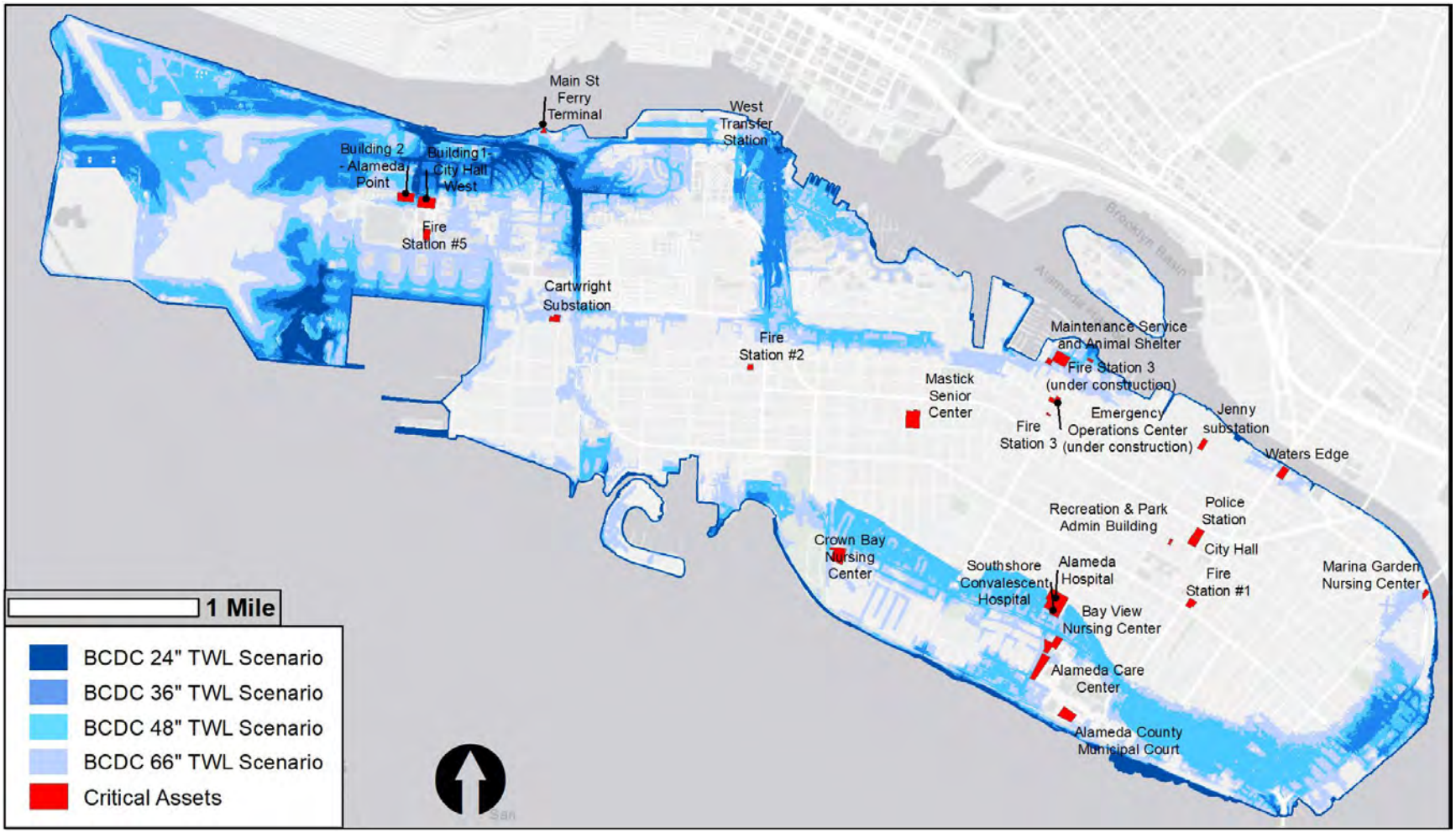


Figure 4-10. Map showing the location of important assets in Alameda defined as having critical recovery priority in the 2016 Local Hazard Mitigation Plan. These assets are shown relative to several total water level scenarios to show the range of exposure.

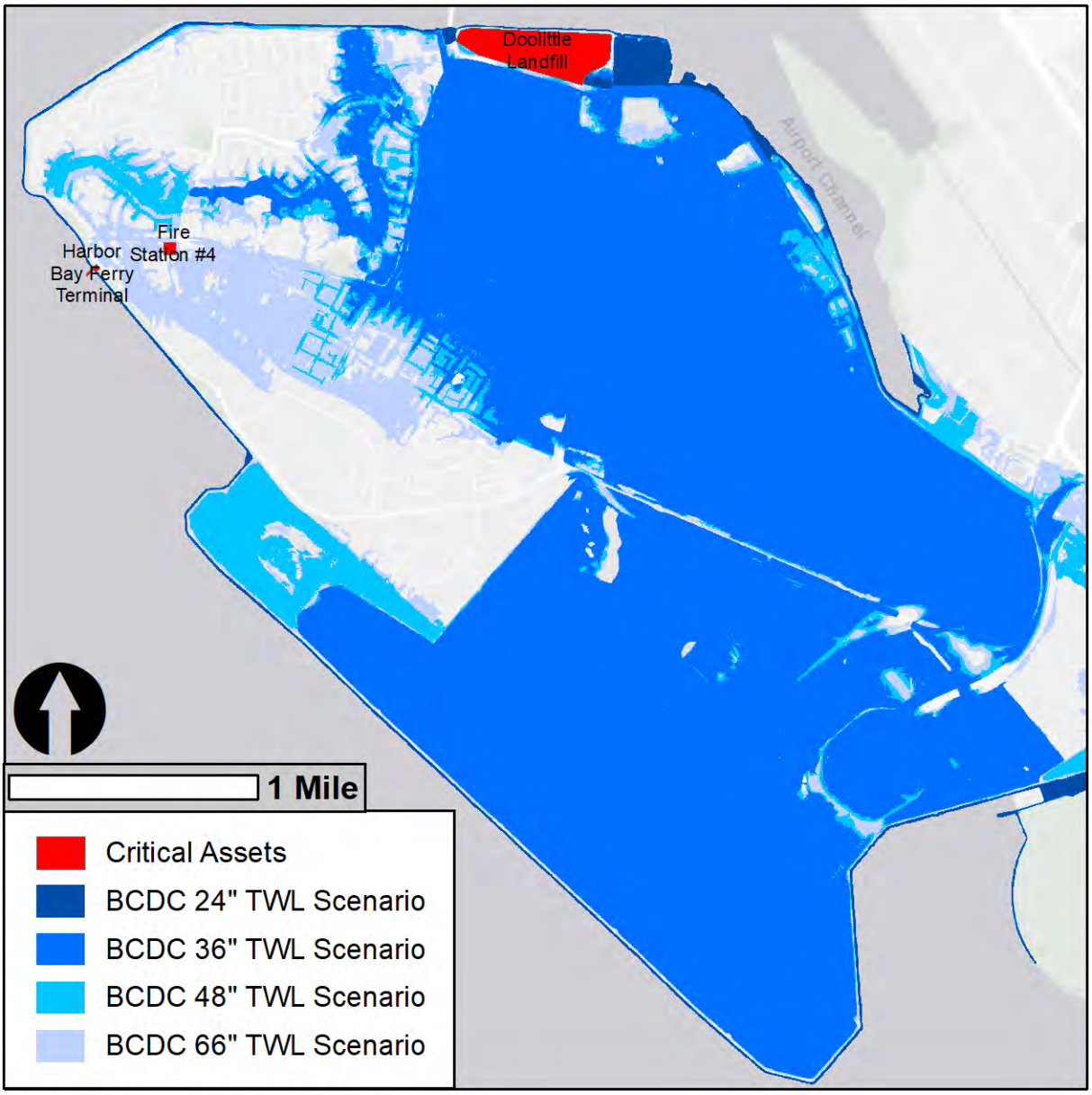


Figure 4-11. Map showing the location of important assets on Bay Farm Island defined as having critical recovery priority in the 2016 Local Hazard Mitigation Plan. These assets are shown relative to several total water level scenarios to show the range of exposure.

Land Use

The City of Alameda has limited open space, as it is dominated by suburban development. The undeveloped areas are concentrated at Alameda Point and the northern waterfront, remnants of the island's naval and industrial waterfront past. Sections of the northern waterfront and part of Alameda Point are slated for redevelopment with 500 acres of northwest territories designated as a nature reserve. In some ways, redevelopment allows for easier adaptation planning. Redeveloped areas at Alameda Point can be regraded with new streets, levees, and storm drain systems from the start. This infrastructure is specifically designed to reduce flood risk. These changes to our utilities and basic infrastructure can be more challenging to put into place in and around our existing neighborhoods (though still possible).

Green Infrastructure to Manage and Treat Stormwater Case Study: Alameda Point

Stormwater management plans for the City's future development at Alameda Point call for 100 percent treated stormwater. This will be accomplished through 100 percent green streets, basins connected to outfalls that will be adaptable to sea level rise, drastic decreases in impervious surfaces, and rainwater harvesting, among other approaches. The result will be reduced stormwater flood risk and reduced water pollution in the San Francisco Bay.

The CARP contains several strategies to integrate with these new plans and protect existing Alameda neighborhoods from sea level rise. Some of these strategies are specifically focused on shorelines and protecting the many homes, businesses, infrastructure public services, and natural resources close to the shoreline. As sea level rises over the decades, it will take more resources to continue keeping all shoreline neighborhoods dry. As such, a series of strategies are proposed in Table 4-20 to encourage the City to limit development of critical facilities and infrastructure near the shoreline and encourage new development in low flood risk areas. The City may also wish to take advantage of opportunities that arise to convert shoreline parcels into open space. The City is also working to regrade streets and create stormwater detention/bioswales through street, bike, and pedestrian transportation projects (e.g., Central Avenue Complete Street Project).

Future land use decisions in the city, specifically Bay Farm Island, may be significantly influenced by land use and management decisions made by neighboring land and asset managers to the east in the City of Oakland and at the Oakland Airport, EBRPD, and Caltrans. Some of the flood risk to the Bay Farm community originates along the MLK Jr. Regional Shoreline, Doolittle Drive, and the airport before overtopping the City of Alameda's golf course and then impacting Bay Farm neighborhoods. The City of Alameda has opportunities to collaborate with these neighboring jurisdictions to address this flood risk. Should it persist into the future, the City could consider collaborating with the golf course on flood control or explore turning Harbor Bay Parkway into a levee.

Strategies in Table 4-20 that encourage wetlands restoration will have carbon sequestration co-benefits. Strategies encouraging clustered development may have the co-benefit of reduced GHG emissions from transportation. Strategies that place a financial burden on residents should be carefully considered in terms of disproportionate impacts on community members.

Table 4-20. Increasing Land Use Resiliency

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Limit building and encourage open space in risk zones	Update all master plans and City ordinances governing land use to incorporate adaptation strategies outlined in the CARP.	$$	City of Alameda	Medium
Limit building and encourage open space in risk zones	Develop and implement policies to prioritize open-space protection and restoration to account for sea level rise; leverage opportunities to evaluate strategic open-space planning for inundation and containment areas in near-shore green spaces.	$	City of Alameda and EBRPD	Short
Encourage development in lower-risk areas	Develop incentives for cluster development in low-risk areas using density bonuses, reduced impact fees, tax incentives, and streamlined permitting.	$$	City of Alameda	Medium
Disclose shoreline risks	Develop and implement disclosure requirements for real estate agents and lessors for residential and commercial properties with regards to future flood and groundwater exposure due to sea level rise and the particularly high vulnerability of habitable below-grade space.	$	City of Alameda	Short
Limit building and encourage open space in risk zones	Create a voluntary transfer of development rights program to allow property owners to sell development rights in high-risk areas in exchange for rights in low-risk areas.	$	City of Alameda	Medium
Limit building and encourage open space in risk zones	Define and establish “zoning overlays” that identify areas at high risk for various hazards (e.g., 100-year floodplain, sea level rise inundation zones). These overlays can be used to define location-specific policies imposed on existing zoned areas to create new requirements specific to the hazards. Additional conditions can be defined based on triggers or thresholds (e.g., a certain amount of sea level rise) to expand the land use restrictions or require additional adaptation actions for redevelopment.	$	City of Alameda	Short–Medium
Use open space for flood control	Explore opportunities to collaborate with the golf course on flood control measures.	$$	City of Alameda	Long

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Use open space for flood control	Support and fund development of a nature reserve at Alameda Point.	$$	City of Alameda, U.S. Fish and Wildlife Service, and U.S. Department of Veterans Affairs (VA)	Short–Long
Mandate flood-resilient multi-unit and commercial development for high-risk areas	In addition to implementing FEMA special flood zone requirements, condition new multi-unit and commercial development within the flood extent of a projected 36” of SLR plus 100-year storm to provide protection against that level of flooding.	$$$	City of Alameda	Medium
Engage the community in climate adaptation efforts and build grassroots support	Encourage urban farming and Climate Victory Gardens as a means of sequestration and resiliency (e.g., create rooftop and vertical gardens, convert vacant lots to community gardens). Consider partnerships with Alameda Backyard Growers and other community-based gardening organizations.	$	City of Alameda	Short
Engage the community in climate adaptation efforts and build grassroots support	Launch neighborhood-based pilot projects to test new ideas, foster creativity and ownership (e.g., adopt-a-swale, de-paving and community garden/open space, tree-shaded areas), and combine multiple strategies across vulnerabilities (heat/drought/flooding). Engage citizens in hands-on, visible improvements and host annual workshops to showcase success. Evaluate successes and failures and incorporate feedback to scale up successful actions and develop new ideas to test in the future. Prioritize vulnerable neighborhoods and underserved populations (e.g., transit-dependent, non-English speaking).	$	City of Alameda	Short

Shoreline, Natural, and Recreation Areas

Today's Alameda shoreline consists largely of man-made structures: revetments, bulkheads, seawalls, dikes, berms, and levees. Key exceptions include Crown Beach and the salt marsh at Elsie Roemer Bird Sanctuary, where natural features provide shoreline protection. As Alameda prepares for sea level rise, shoreline protection must be designed to address higher storm surge and higher overall Bay water levels. Early impacts (at a total water level of MHHW + 36 inches) are predicted to affect Alameda Point, the Eastshore, the Harbor Bay Community, and the area around the tubes. Over the coming decades, additional stretches of shoreline must also be designed to address higher water levels.

Incorporating Ecologically Friendly Features Along Seawalls and Urban Shorelines: Seattle Case Study

The City of Seattle's downtown seawall is full of habitat features that encourage young salmon to migrate along the shore and recruit algae and small invertebrates. Other major cities are watching their results closely to see what can be applied elsewhere. The City of Alameda may also be able to apply lessons learned along its active northern waterfront and other shoreline protection structures. The U.S. Army Corps of Engineers Institute of Water Resources refers to these kinds of gray-green infrastructure approaches as SAGE (Systems Approach to Geomorphic Engineering).

Along the Oakland-Alameda channel, which is already lined with seawalls and bulkheads, the City will likely need to continue use of more traditional structural solutions, known as "gray" infrastructure, such as levees and seawalls. This is because the deep channel and space constraints limit the potential to implement more nature-based adaptation options. That said, there may be opportunities to build cavities, pools, irregular shapes, exposed aggregate, and other components into these walls that help maximize invertebrate habitat diversity. Any shoreline protection built along the channel will need to maintain public access for walking and bicycling. Maintaining and expanding public waterfront access into the future is a priority along much of the shoreline (in accordance with BCDC policy).

Along San Leandro Bay (the Eastshore and Bay Farm Island), there may be opportunities to reduce wave and erosion pressures on current (and future expanded) fortified structures by augmenting mudflats, expanding restoration of submerged aquatic vegetation, and/or building beaches along the fortified structures (SFEI and SPUR, 2019). By attenuating waves, these natural features can reduce height requirements for fortified structures.

Alameda's Eastshore Drive neighborhood. Credit: Maurice Ramirez

While a site-specific study of Crown Beach geomorphology is still needed, the site appears to have significant adaptive capacity, meaning it can adjust to moderate potential damages and the consequences of climate change. The dunes on the east end have space to be expanded to provide additional protection. By Crab Cove and the Sand Castle Picnic Area, there is open park space that could allow the beach to migrate inland. This would require realignment or adaptation of the San Francisco Bay Trail, which runs along the beach. Crown Beach State

Marine Reserve (a mudflat) and Elsie Roemer Bird Sanctuary (a salt marsh) will require studies to determine strategies to help these critical habitats keep pace with sea level rise. Erosion control projects such as oyster balls or jetties can also be explored in the future for Crown Beach.

Recent work under SFEI and SPUR's *San Francisco Bay Adaptation Atlas* project indicates that it may be worthwhile for the City to investigate the potential benefits of creating beaches along the fortified shorelines on the west side of Bay Farm Island and surrounding Alameda Point (SFEI and SPUR, 2019). SFEI and SPUR's *Adaptation Atlas* applies an "operational landscape units" approach to divide the Bay into geographic areas that share common physical characteristics, thereby identifying where natural and nature-based adaptation approaches can help create a resilient shoreline. This report describes how beaches can reduce height requirements for fortified structures.

Encinal Dune Restoration and Shoreline Stabilization Project

Thanks to the San Francisco Bay Restoration Authority (distributing the Measure AA parcel tax funds passed in 2016), a project is moving forward to restore sand dunes near Encinal High School. The effort is expected to create prime habitat for threatened bird species like the snowy plover and to provide the community with an improved recreational experience (e.g., upgraded boat launch).

Table 4-21. Increasing Resiliency for Shoreline, atural, and Recreation Areas

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Maintain, repair, and raise shoreline structures	Conduct a comprehensive assessment of shoreline structure condition citywide to prioritize areas with deferred maintenance and other structural issues and identify ownership of each shoreline protection structure.	$	City of Alameda	Short
Maintain, repair, and raise shoreline structures	Establish and implement a new maintenance and repair plan for shoreline structures to reduce amount of deferred maintenance. Focus maintenance and repair efforts on segments of the shoreline that could substantially deteriorate over time, exposing that area to overtopping and inundation if the structure fails.	$$–$$$ (long-term management plan; cost to vary over time)	City of Alameda	Short-term initiation (implemented to term)
Maintain, repair, and raise shoreline structures	Establish a strategy for addressing shoreline structures that are not owned by the City and consider adopting a policy that calls for the City to purchase the parcels when they become available.	$	City of Alameda	Short
Develop processes for collaborative shoreline decision-making	Get involved in BCDC's Bay Fill Policy Working Group to advocate for amendments to the San Francisco Bay Plan to allow for easier permitting of habitat and resilience projects that involve fill in the Bay (beach creation, mudflat augmentation, etc.).	$	City of Alameda	Short
Develop processes for collaborative shoreline decision-making	Collaborate with Oakland Airport and Caltrans around planning for the future of Doolittle Drive (which impacts flood risk on Bay Farm Island). Establish a cooperative shoreline management program with City departments, community groups, and landowners for shared decision-making.	$	City of Alameda and EBRPD	Short
Develop processes for collaborative shoreline decision-making	Establish a cooperative shoreline management program with City departments, community groups, and landowners for shared decision-making. Consider the sustainability of management options through the frames of society and equity, economy, environment, and governance.	$	City of Alameda and EBRPD	Short

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Implement nature-based shoreline protection	Establish a City ordinance requiring that project proponents explore the potential for nature-based adaptation measures before considering hardened structures, which can direct wave energy onto adjacent shorelines and exacerbate erosion.[a] Require incorporation of ecologically friendly features along seawalls and hardened shorelines (when possible) and where shoreline hardening exists or is planned, including public access for people walking or bicycling on seawalls or levees.	$	City of Alameda	Short
Implement nature-based shoreline protection	Develop a City grant program to pilot nature-based adaptation projects to foster community involvement and explore creative solutions, tapping community members' enthusiasm for this shoreline adaptation strategy.	$$	City of Alameda	Short

[a] Example ordinances include the *Coastal Alabama Living Shorelines Policies, Rules, and Model Ordinance Manual* and the State of Maryland New Tidal Wetland Regulations for Living Shorelines.

Alameda Point: A Case Study in Adaptive Land Use and Shoreline Management

The City guided the redevelopment of Alameda Point and considered climate change adaptation measures in the Alameda Point MIP, which specifies a perimeter levee around the built environment and shoreline protections that can be increased over time as seas rise. In addition, the MIP dictates improving the large area known as the "Northwest Territories" with passive uses such as wetland restoration, picnic areas, trails, trailheads, etc.

The Town Center and Waterfront Precise Plan covers 150 acres of Alameda Point—specifically the urban core along Ralph Appezzato Memorial Parkway and the waterfront around the historic Seaplane Lagoon. The plan calls for creation of a waterfront park, referred to as De-Pave Park, as it "combines a proactive ecological agenda with a compelling visitor experience by placing a picnic, camping and interpretive program within a large-scale sustainable landscape." The park is specifically designed for sea level rise, with some sections allowed to flood over time and converted into wetlands. The landscape strategy is to transform this vast paved area into a thriving ecology by removing the paving and nurturing ecological succession.

The western land exterior to the perimeter levee has a 300-acre nature reserve around a nesting site for endangered California least terns. The VA owns the nature reserve land, which is currently pavement. If left as so, the area will eventually become inundated with water as a result of sea level rise. This large expanse of obsolete industrial hardscape presents an opportunity to rethink the highest and best use through the lens of climate adaptation while ensuring that any adaptive measures do not compromise the well-being of the endangered California least terns that nest on 10 acres for 4½ months a year.

Existing wetlands at the Alameda Point Nature Reserve. Photo credit: Richard Bangert.

De-Pave Park and the adjacent nature reserve allow for engineered tidal marshes, wetlands, lagoons, and ponds. These resilient water landscape features can absorb changing water dynamics in the San Francisco Bay. They also provide important co-benefits of GHG emissions reduction by sequestering carbon and introducing new wildlife habitat for a wide variety of species whose habitat have been compromised or lost due to climate change and sea level rise.

In addition to new water landscape features, the City could create new elevated dry landscape—in part by using clean dredge sediment from the Bay after designating the nature reserve as an official U.S. EPA beneficial reuse site for dredge material. This soil would provide an opportunity to introduce more plant species and wildlife habitat, provide additional carbon sequestration, and provide water drainage

to the new wetland/marsh water features. Coastal dune and grassland habitat can also enhance the well-being of the endangered California least terns that nest and raise their chicks there.[14]

These adaptive opportunities at De-Pave Park and the nature reserve dovetail with the VA's planned expansion and enhancement of the existing Runway Wetland on the nature reserve directly adjacent to De-Pave Park. They would also expand the adaptive landscape already constructed or planned by the Navy on the airfield at cleanup sites 1, 2, and 32. The designs at these locations, comprising 197 acres, include raised elevation grassland and new and expanded wetland features.

This vision for a comprehensive, adaptive landscape at Alameda Point would create wildlife habitat, recreational benefits (trails), carbon sequestration, and flood protection for the housing, businesses, VA Hospital, and other built infrastructure planned for the area. Materializing this vision will require wading through ownership, jurisdictional, and regulatory realities and complexities. While the City does not own or control this property, the City can take a first step now to engage with key stakeholders.

Figure 4-12. Conceptual map for land exterior to the perimeter levee at Alameda Point.

[14] The U.S. Fish and Wildlife Service's 1999 draft conservation plan for the proposed Alameda National Wildlife Refuge states, "Prey populations in grassy and other vegetated habitats located some distance from the tern colony draw predators away from the terns" (USFWS, 1999).

Transportation

The transportation system in Alameda is a complex network of roads, bridges, tubes, ferries, and bicycle and pedestrian paths. Some residents are transit-dependent and heavily rely on the bus service provided by AC Transit and the ferry service provided by WETA. The transportation sector is particularly vulnerable to flooding that causes disruptions to transportation corridors, bus routes, and ferry terminal access, affecting both the flow of traffic and provision of emergency services. Furthermore, Alameda's location makes it especially reliant on a relatively small number of key transportation assets, specifically bridges, tubes, and ferry terminals connecting Alameda Island and the Bay Farm Island peninsula to the mainland. Increasing the resilience of Alameda's transportation system to climate change will include a combination of large-scale and long-term projects to ensure the future functionality of critical infrastructure, as well as more immediate actions to prevent disruptions due to flooding. While many residents rely on public transit to commute to work, run errands, and move around the city, some community members entirely depend on transit, walking, or bicycling and are particularly sensitive to system disruptions from flooding and other climate impacts. The City should prioritize improvements to the transportation system that ensure long-term continuity of transit services and key corridors, working closely with transit-, bike- and walking-dependent communities to design a system that meets their needs.

Building a Resilient Transportation System: GHG Emissions Reduction and Adaptation Co-benefits

To reach Alameda's GHG emissions reduction target, the CARP calls for actions to improve the city's transit system. Actions to expand BART to Alameda, encourage bus use with *EasyPass*, expand bike lanes, and implement the TCP (described in Chapter 3) also have resiliency co-benefits for the community. These actions increase residents' options for getting on and off Alameda and Bay Farm Islands and create redundancy in the transportation system. This enables the transportation network and the community to adapt and recover more easily in response to a hazard event.

Many of the strategies in Table 4-22 support Alameda's GHG emissions reduction goals by increasing the resilience of its mass transit system.

Social Equity in Transportation Resilience Planning

- The City's maintenance requirements dictate that road projects like paving and culvert repairs are needed, including in areas with known flooding or ponding issues. In the context of projected climate change impacts on the transportation system, the City should consider prioritizing those repairs along roads used by AC Transit to serve transit-dependent communities. In the longer term, the City and key partners like AC Transit and WETA should work together to identify alternatives to traditional transportation planning. For example, a flexible system that can adapt to flooding issues by dynamically rerouting buses, notifying passengers, and activating new stops would allow the system to operate even during a flood event.
- Transit-dependent communities are, by their nature, more vulnerable to climate change because they have less flexibility to adjust their daily travel routes due to disruptions like flooding. In some cases, transit-dependent communities are also vulnerable during a flood event because they are non-English speaking, low-income, or elderly households. Special attention is required for these communities because they are often underserved during general community outreach.

Table 4-22. Increasing Resiliency for Transportation

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Ensure long-term continuity of the transportation network in Alameda	When planning and designing improvements to existing transportation infrastructure, prioritize options that avoid or minimize exposure to high hazard areas (100-year floodplain) and ensure that seismic- and flood-resilient designs and other protective measures are incorporated to enhance the structural integrity, overall performance, and functionality of facilities located in high hazard areas. Emphasis should be placed on ensuring the continuity of operations of critical transportation routes to maintain access and egress for emergency vehicles, transit-dependent populations, and transportation to and from the island.	$$$	City of Alameda, Caltrans, and EBRPD	Medium
Ensure long-term continuity of the transportation network in Alameda	When planning and designing substantial reconstruction or new construction, prioritize options that avoid or minimize exposure to 24 inches above the 100-year floodplain (approximately equal to the mid-century projections under medium-high risk aversion) and have plans to adapt to later exposure. For Caltrans projects, incorporate resilience actions into transportation projects to increase the project lifespan and ensure long-term functionality.	$$$	City of Alameda and Caltrans	Medium
Ensure long-term continuity of the transportation network in Alameda	Immediately after implementation of resilience actions for priority transportation assets, revisit the vulnerability assessment to identify other key roadways and components of the transportation network that may be at risk later in the century (e.g., bridges). Prioritize actions that incorporate a longer-term vision of transportation in Alameda and create redundancy and multiple options in the transit system: bicycle and pedestrian bridges, along with water taxis, expanded ferries, and BART.	$$$	City of Alameda, Caltrans, and County Emergency Operations Center	Medium
Establish protocols to facilitate effective emergency response	Develop/update evacuation plans to accommodate increases in population. Include special consideration for vulnerable community members, including those who do not have access to personal vehicles, homebound individuals, or other special needs community members. Increase the number of small rescue boats to meet needs of growing population.	$	City of Alameda	Medium
Increase vehicle alternatives and access for bicycles and pedestrians	Implement the Transportation Demand Management Plan to facilitate public access and increased use of water transit. Manage public waterfront trails and access to accommodate future flood controls as needed to further adapt to sea level rise.	$$	City of Alameda	Short–Medium

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Increase vehicle alternatives and access for bicycles and pedestrians	Plan and install new pedestrian and bicycle facilities to improve connectivity to key transportation hubs and across the estuary, particularly in the West End. Implement the TCP, the Pedestrian and Bicycle Master Plans, and the results of the West End Bicycle and Pedestrian Crossing Feasibility and Design Study.	$$	City of Alameda	Short
Ensure continuity of service for transit-dependent populations	Plan for temporary transit services in the event of existing system suspensions. Identify ways to provide transit services to dependent communities if existing routes are flooded. Work with AC Transit to define protocols to reroute buses in the event of a disruption to the normal route.	$$	City of Alameda, Alameda County, and AC Transit	Medium
Ensure co-benefits	Incorporate resiliency into the design of city EV infrastructure.	$$	City of Alameda	Medium

Waste and Contaminated Lands

Contaminated lands within Alameda are the result of previous land uses, such as manufacturing, that involved the use, storage, or disposal of hazardous wastes. The City has identified those sites and is in the process of assessing or cleaning them up to meet current environmental and public health standards. Increased flooding from sea level rise and rising groundwater levels can, depending on site-specific conditions, mobilize and release some of those contaminants, potentially creating exposure pathways, or increasing risk of exposure. A two-pronged strategy is needed to increase Alameda's resilience to contaminated lands: 1) all citizens and businesses should properly dispose of waste products to prevent future contamination, and 2) the City should assess timelines for cleaning up existing contaminated lands with regard to the potential for releases from increased flooding due to rising sea and groundwater levels.

Table 4-23. Citywide Adaptation Strategies and Actions for Waste and Contaminated Lands

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Engage socially vulnerable communities and ensure transparency in management of contaminated lands	Encourage residents and landowners to use hazardous waste disposal and drop-off locations to reduce the amount of potentially hazardous materials released during a flood event. Increase the availability of such sites, especially in areas with high levels of transit dependence where residents are unable to drive to disposal facilities.	$–$$	City of Alameda	Short
Address information gaps to support prioritization of contaminated sites	Review remediation timelines for contaminated sites based on a groundwater model with projected sea level rise impacts. Work with applicable agencies to adjust remediation, as applicable.	$	City of Alameda	Short

Utilities

Utility systems—drinking water, sewer, stormwater, energy, communications—in Alameda are managed by a patchwork of entities, including the City of Alameda, EBMUD, AMP, and PG&E. The City of Alameda is responsible for the stormwater system and the sewer collection system, EBMUD is the potable water purveyor for Alameda and manages regional wastewater conveyance and treatment, AMP oversees the electrical system, and PG&E provides natural gas service. Many of these entities have asset management plans and, in some cases (e.g., EBMUD), more detailed climate resilience plans. The heightened risk posed by sea level rise, storm surge, and associated flooding to Alameda makes it especially important to maintain a functioning stormwater system that can accommodate future flows. Several previous assessments and studies in Alameda identified high, medium, and low priority projects within the stormwater system to address both current issues and future concerns (including both sea level rise and storm events). Recommendations presented in this list are not intended to replace any recommendations from previous studies but should be viewed as supplementary.

Green Infrastructure Plan

The City is currently developing a Green Infrastructure Plan that will identify likely and appropriate siting and provide best practices guidance on design. Where the CARP recommends green infrastructure, the Green Infrastructure Plan should serve as the primary guidance document for planning. Upgrades to the stormwater system need to consider the implications of broad green infrastructure implementation in Alameda.

Many of the green infrastructure strategies proposed in Table 4-24 and included in the City's forthcoming Green Infrastructure Plan have GHG emissions reduction co-benefits (e.g., tree plantings, green roofs).

Table 4-24. Increasing Resiliency for Utilities

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Ensure resilience and long-term functionality of stormwater and sewer systems	Conduct comprehensive visual and functional test monitoring and asset condition assessment. Model potential impacts to utility infrastructure under future sea level rise scenarios. Specifically: ■ Consider the impact of rising groundwater levels and increasing salinity on buried utility infrastructure like sewer and stormwater pipes. Prioritize replacement of iron pipes with high-density polyethylene or other non-corrosive materials as appropriate. ■ Consider the impact of flooding on electrical infrastructure (AMP), including utility poles. Develop and implement an asset management plan that prioritizes repairing or replacing infrastructure that flooding is likely to impact.	$$$	City of Alameda and AMP	Short–Medium
Ensure resilience and long-term functionality of stormwater and sewer systems	Improve backup power and reserve fuel capacity at critical utility facilities (note: backup systems are already in place at key sewer pump stations). Implement recommendations from Storm Drain Master Plan to install backup power at pump stations. Purchase and strategically place backup portable pumps in the event of major disruptions to pump stations.	$$$	City of Alameda	Short
Ensure resilience and long-term functionality of stormwater and sewer systems	Incorporate long-term sea level rise and storm projections into upgrades at critical utility facilities, including capacity upgrades to the stormwater system. Ensure electrical infrastructure is flood-proofed or elevated. Where possible, move assets out of the hazard zone, including elevating utility junction boxes and other electrical infrastructure on scaffolding. Prioritize new construction of utility infrastructure outside of the hazard zone if possible. Use flood-resistant building materials like steel utility poles when repairing or replacing existing infrastructure.	$$$	City of Alameda, AMP, and EBMUD	Medium
Ensure resilience and long-term functionality of stormwater and sewer systems	Research the implications of rising groundwater on decisions surrounding infiltration and inflow, specifically whether green infrastructure designed for infiltration may exacerbate flooding due to rising groundwater. In some cases, alternatives like under-drained treatment may be necessary to prevent infiltration in areas with especially high groundwater.	$	City of Alameda	Short
Ensure resilience and long-term functionality of stormwater and sewer systems	Encourage the adoption of distributed green infrastructure solutions on private property (e.g., rain barrels/rain gardens, pervious pavement). Amend the Alameda Municipal Code to prohibit residents from pouring	$	City of Alameda	Medium

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
	concrete (or other non-porous material) in planter strips along public roadways.			
Ensure resilience and long-term functionality of stormwater and sewer systems	Collaborate with and participate in EBMUD wastewater system resiliency efforts. Implement wastewater resilience best practices for the City-owned sewer system by incorporating sea level rise projections into the City's next Sewer Management Plan.	$	City of Alameda	Short
Expand green infrastructure	Implement the recommendations, guidance, and strategies of the City's Green Infrastructure Plan where appropriate. Incorporate green infrastructure into new city buildings and within parks. Continue to expand green infrastructure along roadways as part of a "Complete Streets" design.	$$	City of Alameda	Short–Medium
Participate in regional assistance programs	Develop new and maintain existing mutual aid agreements with adjoining jurisdictions for cooperative assistance and response to flooding events. Continue participation in CalWARN Mutual Aid and Assistance Program, and support EBMUD efforts related to drinking water system preparedness.	$	City of Alameda and EBMUD	Short
Ensure resilience and long-term functionality of energy distribution systems	Encourage PG&E to conduct a more localized assessment of gas lines and their risk to sea level rise in Alameda.	$	City of Alameda	Short

Public Health and Welfare

Extreme heat and increased incidences of wildfires and drought directly impact public health. These climate risks are interrelated. Higher temperatures contribute to drought, and drought and high temperatures create an environment that is conducive to wildfires. Their combined impacts on public health can be serious, but actions are underway to address them. Furthermore, additional strategies and associated actions can be implemented relatively inexpensively and expeditiously, as shown in Table 4-25 below. These strategies can lessen the impacts of heat and reduce Alameda's demand for drinking water to make the city resilient during times of extreme heat and drought. Note that the strategies related to planting trees and composting also support Alameda's GHG emissions reduction goals.

Heat and Drought

Heat and drought are two separate climate change impacts, but strategies to address them often overlap. Severe heat affects the very young, the elderly, those with existing cardiovascular ailments, those who work outdoors, those without air conditioning, and those who live/work in "heat island" areas with massive pavement and little shade. Extreme heat may cause pavement heave and damage to roads, and heat is often associated with—and can exacerbate—drought.

Alameda's dependency on EBMUD for its water supply links the city to EBMUD's long-term water supply sustainability. According to EBMUD's Recycled Water Master Plan Update (February 2019), the City of Alameda will soon participate in the East Bayshore Recycled Water Project. The project will provide up to 2.6 million gallons per day of highly treated wastewater that is recycled and delivered to customers for landscape irrigation and, in the future, other non-potable purposes.

This represents an order of magnitude expansion of EBMUD's current recycled water program, which provides about 0.2 million gallons per day, primarily for landscape irrigation in Oakland and Emeryville. The expansion project, consisting of 21 miles of pipeline in Berkeley, Alameda, and Emeryville, is underway. Recycled water delivery to Alameda is expected to begin in 2030 and will reduce annual average demand by 2.6 million gallons per day. Further expansion is planned from 2030 to 2039.

Table 4-25. Citywide Adaptation Strategies and Actions for Heat and Drought

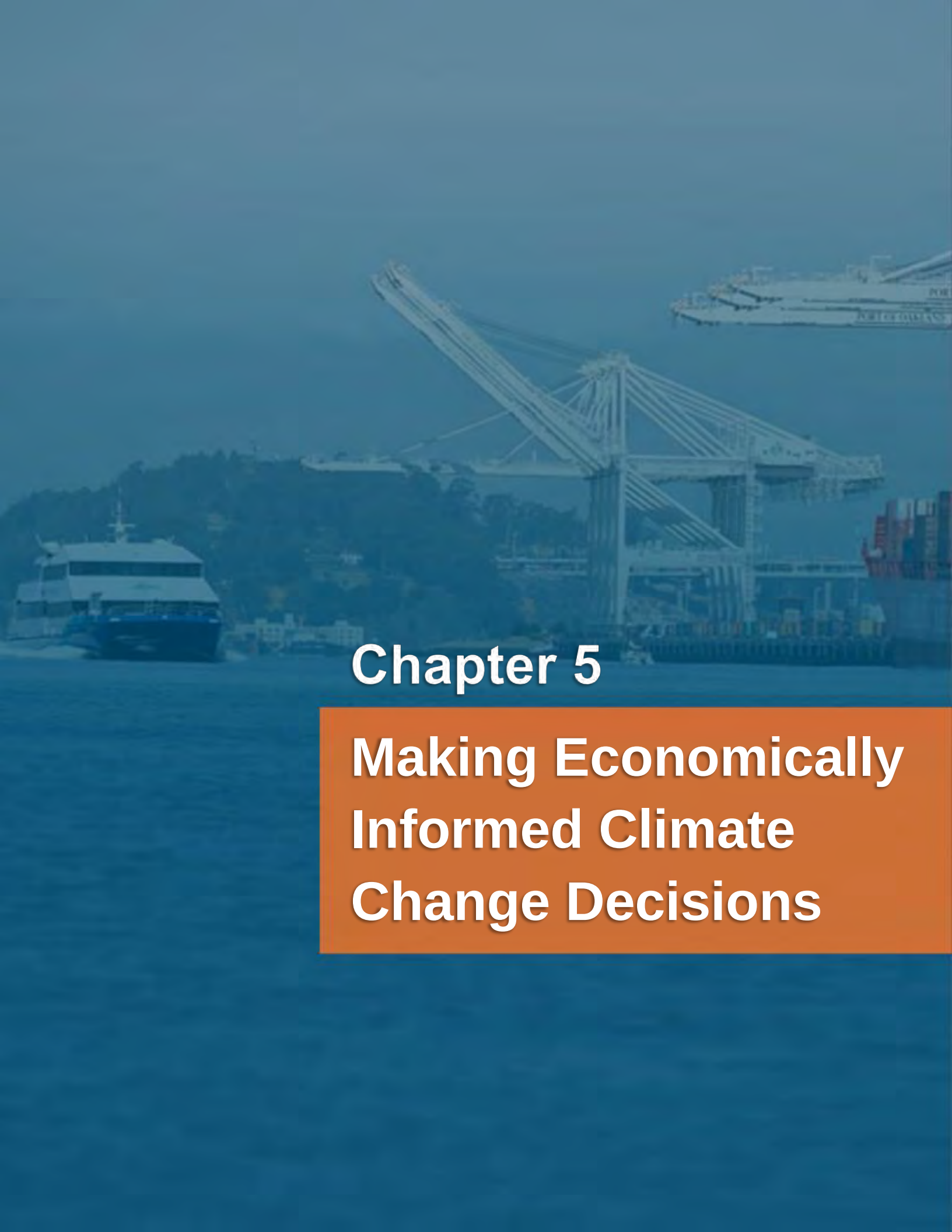
Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Compost	In accordance with the GHG reduction action to divert organic waste from landfills to city parks, target compost for local tree planting and neighborhood projects to optimize co-benefits of composting, stormwater recharge, flood reduction, and heat/drought resilience. Promote organic enrichment of soils (carbon farming) for moisture retention, healthy trees, and carbon sequestration.	$	City of Alameda	Short
Plant trees	In accordance with the GHG reduction action to plant 1,500 new trees by 2030, target the tree-planting program to reduce heat impacts in heavily paved areas (e.g., Alameda Point, along streets, and shopping centers) prone to a localized “heat island” effect.	$	City of Alameda	Medium
Plant trees	Bulk purchase trees for at- and below-cost sales to property owners for planting on private property.	$	City of Alameda	Short
Reduce water use	Benchmark Alameda water use (gallons per capita per day), set goals to reduce water use, and publicize results, especially during droughts.	$	City of Alameda and EBMUD	Short
Reduce water use	Promote a system for rapidly detecting, reporting, and repairing water leaks.	$	City of Alameda and EBMUD	
Reduce water use	Work with EBMUD to improve effectiveness of water conservation programs and increase drought awareness, including neighborhood implementation projects that demonstrate benefits such as cost savings.	$	City of Alameda and EBMUD	Short
Reduce water use	Explore recycled water and use of local groundwater for irrigation of lawns, gardens, parks, playfields, and other open spaces currently irrigated with potable water.	$$	City of Alameda and EBMUD	Medium
Reduce water use	Implement water-saving technologies at all City-owned buildings and post visible signage to educate visitors to those buildings.	$	City of Alameda and EBMUD	Short
Reduce heat island effects	Identify heat islands and implement ways to make those locations cooler (increase street trees, green infrastructure, white pavement, cool/green roofs).	$	City of Alameda	Short
Expand cooling centers	Expand number of cooling centers from two (Mastick Center and Alameda Free Library, Main Library) to three. Determine location based on accessibility to at-risk populations.	$	City of Alameda	Short

Wildfire Smoke

Wildfires are hard to predict, with little lead time to warn and prepare residents for air quality impacts. It is usually not known how bad air quality will be and how long impacts will last. Often wildfires are far away, which lessens the sense of urgency. When winds shift, citizens are taken by surprise. They often don't realize the health impacts of poor air quality. The very young, elderly, non-English speaking, those with existing cardiovascular ailments, and those who work outdoors or do not have air conditioning are particularly vulnerable. The City has programs in place to assist the community during these poor air quality events, such as a fresh air center at the Main Library. The City is seeking funding to create a second fresh air center at the Mastick Senior Center. These adaptation strategies will help Alamedans be more aware of and better prepared for the air quality impacts associated with wildfire smoke. Table 4-26 below summarizes actions the City can take to adapt Alameda to impacts associated with wildfire smoke.

Table 4-26. Citywide Adaptation Strategies and Actions for Wildfire Smoke

Strategy	Action(s)	Relative Cost	Responsible Entity	Timeline
Expand alert system	Collaborate with Alameda County on the effective implementation of an alert system to warn residents of smoke hazards and inform them of actions they should take during an event (multiple languages, multiple media outlets).	$	City of Alameda	Short
Ongoing risk communication	Implement wildfire risk communication messaging that: ■ Occurs throughout high wildfire risk season so people know in advance how to use masks and air purifiers and where to get them. ■ Reaches non-English speaking individuals and those without cell phones. Educate people on severity of smoke impacts using easy-to-understand, comparative risk language (e.g., equivalent to smoking a certain # of cigarettes a day) and publicize fresh air centers—both City-designated and informal ones like movie theatres.	$	City of Alameda	Short
Provide masks and air filters	Provide masks and air filters, with instructions on how to use them and information about their limitations, to the city's vulnerable populations. Develop program for providing air filters at cost or at a reduced cost.	$	City of Alameda	Short
Adopt health-based exposure thresholds	Adopt thresholds for restricting certain activities (outdoor sporting events, outdoor worker exposure).	$	City of Alameda	Short
Plant trees	Support citywide tree planting efforts, as trees can settle particles in the air during wildfire-smoke episodes.	$	City of Alameda	Medium



Chapter 5

Making Economically Informed Climate Change Decisions

Introduction

The speed with which we are able to operationalize the CARP and move forward with key GHG reduction and adaptation actions will be determined, in part, by our ability to allocate existing funds and, more likely, raise additional funds to support this important work. With this in mind, it is important that we make economically informed climate change decisions. There are many important factors—like public health, the environment, and equity—to consider when making investment decisions. In addition, we must demonstrate that investments will achieve maximum benefits and are implemented most cost-effectively. Looking at costs and financing opportunities together can provide the City a starting point for matching GHG reduction and adaptation actions to funding opportunities.

This section explores the following topics related to assessing the costs of CARP implementation and opportunities for financing:

- Costs and benefits of taking action to address sea level rise and storm surge;
- Costs of GHG reduction actions; and
- Funding and financing for the CARP.

This analysis suggests that adaptation strategies are a good investment. The value of buildings and property permanently flooded and lost to sea level rise could be around $1.1 billion by 2050 and $6.8 billion by 2100. This loss is compared to under $100 million in adaptation investment to prevent losses by 2050 and under $1 billion to prevent losses by 2100. A relatively limited analysis comparing only the costs of raising existing shoreline structures (90 percent of the coastline) to the benefit of avoiding flood damage for only land and buildings yields a benefit to cost ratio from about 3.5 to 1 to 8 to 1 in all three sea level rise plus 100-year storm scenarios assessed in this study. While these are some of the major costs and benefits, these benefit to cost ratios exclude costs and benefits of stormwater system upgrades, ecosystem service values, and commerce impacts. These ratios are in line with research FEMA has conducted related to the benefit-cost ratio of $6 dollars saved per $1 invested (NIBS, 2017).

The Cost of Inaction and Action

The purpose of this economic analysis is to understand the costs and benefits of addressing sea level rise and storm surge. Decision-makers require this information to make informed decisions that are fiscally responsible now and for the future. By accounting for the full costs of inundation risks under various scenarios, leaders can make strategic choices about where, when, and how to invest in adaptation responses to maximize benefits and minimize risk.

It is important to understand how climate change and extreme events can cause greater damages and higher costs to infrastructure if we do not prevent or mitigate their impacts. Possible cost increases from unmitigated climate change fall into several categories:

- Increased damages to existing infrastructure and related increases in the costs for operation, maintenance, and repair;
- Increased costs post event due to labor shortages during such times and the emergency nature of the work;
- Increased business interruption costs before, during, and after events;

- Increased costs following infrastructure failures due to possible injuries and loss of life, damages to private property, and reduced safety of communities; and
- Long-term impacts of reduced property value and tax revenue as residents move away due to decreased safety.

Cost of Inaction

For this economic analysis, the City considered several scenarios for coastal flooding that account for sea level rise alone and the combined impacts of sea level rise and a 100-year storm surge. California's OPC Sea Level Rise Policy Guidance provides a range of sea level rise projections with differing probabilities of exceedance (OPC, 2018). Table 5-1 below presents OPC projections (in inches) for key planning horizons of 2030, 2050, and 2100.

Table 5-1. California OPC Sea Level Rise Projections in Inches (Adapted)

Year[a]	Likely Range (66% Chance)[b]	1-in-20 Chance Sea Level Rise Exceeds	1-in-200 Chance Sea Level Rise Exceeds[c]	H++ Single Scenario[d]
2030	4'' – 6''	7''	10''	12''
2050	7'' – 13''	17''	23''	32''
2100	19'' – 41''	53''	83''	122''

[a] All projections are for the high emissions (RCP 8.5) scenario. Projections for low emissions (RCP 2.6) can be found in the OPC sea level rise guidance. The low emissions scenario is considered extremely unlikely given current global emission trends.

[b] OPC considers the top end of the "likely range" to be equivalent to a low risk aversion decision.

[c] OPC considers the 1-in-200 chance to be equivalent to a medium-high risk aversion decision.

[d] OPC considers the H++ single scenario to be equivalent to an extreme risk aversion decision.

[e] Most climate models do not extend past 2100. Longer-range projections have greater uncertainty.

Consistent with the overall approach to the CARP, the economic analysis focused on OPC guidance for planning with a medium-high level of risk aversion, equivalent to the 1-in-200 chance of exceedance. On top of sea level rise, which leads to permanent inundation, there is a risk of storm surge that would result in more extensive temporary flooding. State guidance in California recommends considering the risk of a 100-year storm event, approximately equal to 42 inches above MHHW, in addition to sea level rise. Based on state guidance, the City selected the following scenarios for this economic analysis:

- 2030 sea level rise only = 10 inches;
- 2030 sea level rise + 100-year storm = 52 inches;
- 2050 sea level rise only = 23 inches;
- 2050 sea level rise + 100-year storm = 65 inches;
- 2100 sea level rise = 83 inches; and
- 2100 sea level rise + 100-year storm = 125 inches.

The following analysis assesses the value of the built environment and infrastructure exposed to coastal flooding from sea level rise and storm surge in the City of Alameda. This study did not include market, non-market, and ecosystem services due to budget constraints and lack of visitor data to inform economic valuation of many ecosystem services; however, future updates should consider assessing these costs to present a more accurate picture of true cost. To meet legislative requirements, Appendix L, "Assembly Bill

691 Compliance," includes quantitative market and non-market values or a description (when data were not available) of the impacts associated with commerce on public trust lands, ecosystem services related to recreation at Crown Beach and other parks, and planning level costs for raising the shoreline to mitigate the impacts of sea level rise and surge. Our analysis in Appendix L shows that these non-market benefits and ecosystem service values that are threatened by sea level rise could be well over $100 million per year, with much of that coming from the value of visiting Crown Beach. However, many data gaps need to be filled in terms of visitor data to develop a more accurate and defensible number.

The City used the Coastal Adaptation to Sea Level Rise Tool (COAST) to estimate the impacts of sea level rise and storm surge for 2030, 2050, and 2100. Parcel boundaries with property and building value data for Alameda County were imported into COAST to determine which parcels flooded and the extent of the damage. The parcels data set did not include the value of public property (e.g., schools, some marinas, parks, other public buildings) and some other exempt property types, so the City applied generic costs of $16.07 per square foot for open space/parks and $45.91 per square foot for commercial/residential/government property types for this analysis. These figures are based on comparable sales data.

Table 5-2 presents the COAST analysis results as the total modeled damage to buildings and infrastructure under each scenario. "Value of buildings and land exposed" includes the total value of all buildings and land (and infrastructure in the case of the right four columns) the water touches in that scenario. The table also presents "Damage," which is the sum of 1) 100 percent of any land or building impacted by sea level rise to estimate the value permanently lost and 2) a portion (based on the depth-damage relationship in COAST) of the value of any building flooded only by storm surge to estimate the cost to repair the impacted building.

We also present costs associated with roads, the stormwater system, and City-owned sewer mains, which we calculated separately from COAST. For sewer mains, storm pipes, and roads, we assumed that infrastructure is only lost due to permanent inundation from sea level rise and that the impacts from storm event flooding would be much lower. Table 5-2 presents the length and value of infrastructure exposed at each sea level rise scenario. We used geographic information systems to estimate the length of infrastructure inundated by sea level rise, then multiplied that length by the approximate per-linear-foot cost to rebuild the infrastructure to estimate the value exposed to flooding. However, the true replacement cost is more nuanced. For example, the City could choose to simply not replace roads and lose access to all areas they serve, or the City could choose to raise the roads, which would cost approximately 20 to 30 times more than replacing them in kind at existing elevations. For simplicity, we used an approximate cost of replacing roads in kind, which underestimates the cost of road replacement if we plan for long-term water levels and elevated roadways.

This economic analysis did not consider impacts of higher groundwater levels from sea level rise as well as saltwater intrusion. These impacts might include increased basement flooding, increased flooding of low-lying areas, decreased efficacy of stormwater drainage systems, increased soil liquefaction during a seismic event, and release of hazardous substances from contaminated soils, including the potential to increase groundwater contamination. Thus, the analysis likely underestimates the cost of inaction.

Table 5-2. Property and Infrastructure Damage in Alameda—Cost of Inaction for Selected Scenarios (All Values in $Million)

Scenario[b]	Total Water Level (above MHHW)	Total Exposed Building and Land Value[c]	Damage[c]	Length and Value of Sewer Mains Exposed[a]	Length and Value of Storm Pipes Exposed[a]	Length and Value of Roads Exposed[a]	Total Infrastructure Exposed
2030 sea level rise	10”	$1,081	$1,081	2,923 feet $1.2	2,725 feet $1.6	0 feet $0	$2.8
2050 sea level rise	23”	$1,110	$1,110	19,601 feet $7.8	18,689 feet $11.2	25,136 feet $7.0	$26.1
2030 sea level rise plus 100-year storm	52” (10” + 42”)	$2,610	$1,490 ($409 more than sea level rise only)				
2050 sea level rise plus 100-year storm	65” (23” + 42”)	$4,425	$2,018 ($908 more than sea level rise only)				
2100 sea level rise	83”	$6,828	$6,828	423,895 feet $169.6	501,466 feet $300.9	794,075 feet $222.3	$692.8
2100 sea level rise plus 100-year storm	125” (83” + 42”)	$10,805	$8,061 ($1,232 more than sea level rise only)				

[a] Values per linear foot for infrastructure were taken from the City of Santa Cruz AB 691 Sea Level Rise Assessment: $400/linear foot for sewer mains, $600/linear foot for storm pipes, and $280/linear foot for roads (City of Santa Cruz, 2018).

[b] All “sea level rise” projections are under medium-high risk aversion level in OPC sea level rise guidance.

[c] Exposed building and land value and damage are all based on current value of property with no discounting or increased property values.

The following figures visualize the results of the COAST analysis. The blue represents flooded parcels, which account for the total exposed land and associated property values, as well as the amount of damage contributed by permanent inundation (sea level rise) and temporary flooding (100-year storm). Note that the light blue in Alameda Point for the 2050 and 2100 scenarios represents flooded property with no dollar value assigned to the parcel. Applying the generic value of $2 million per acre for this parcel would skew the economic analysis, so the parcel was left with no valuation. As a result, the COAST results for the 2050 and 2100 scenarios likely underrepresent the total exposed value and damage.

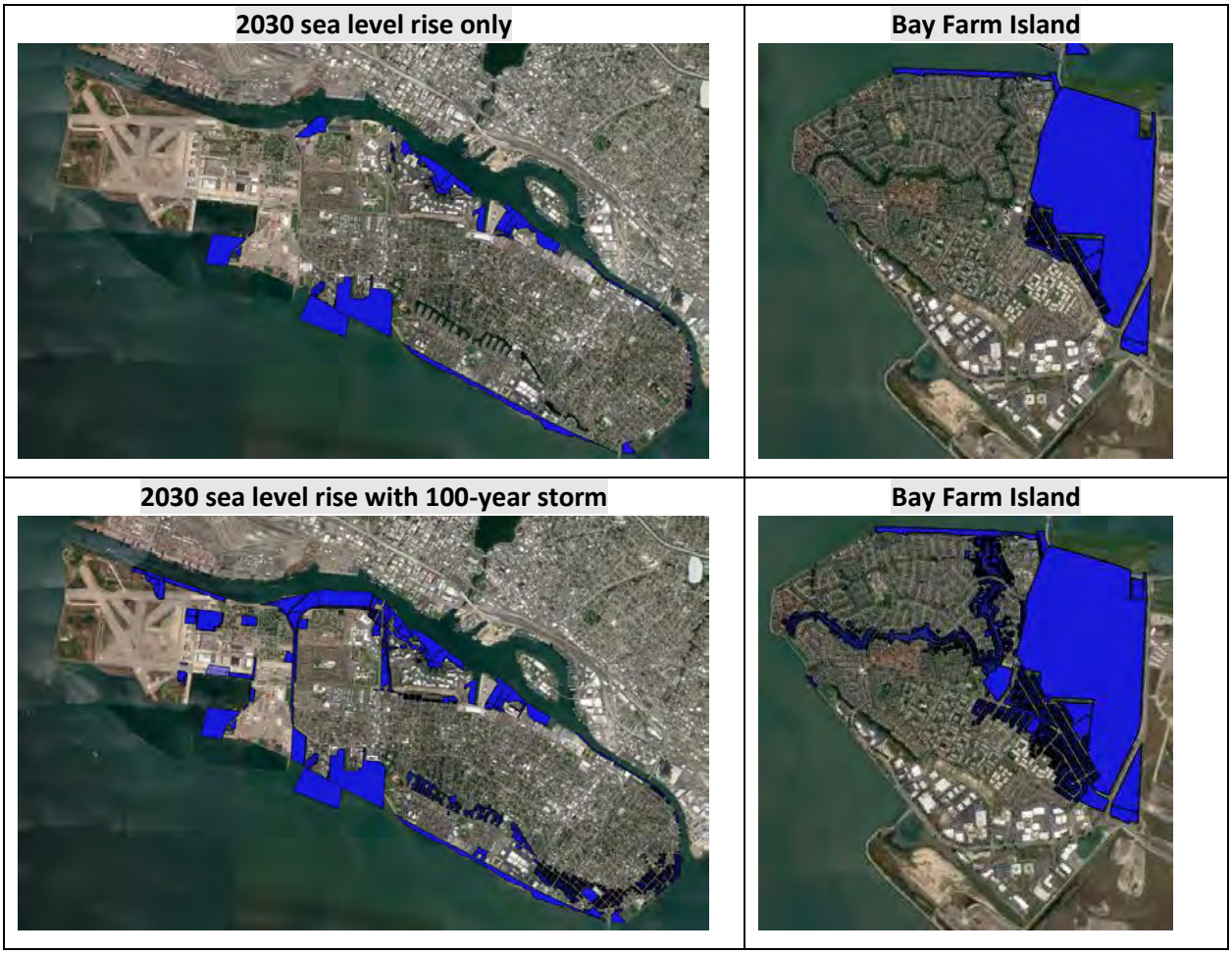


Figure 5-1. 2030 sea level rise only ($1,081 million) with a 100-year storm ($2,610 million).

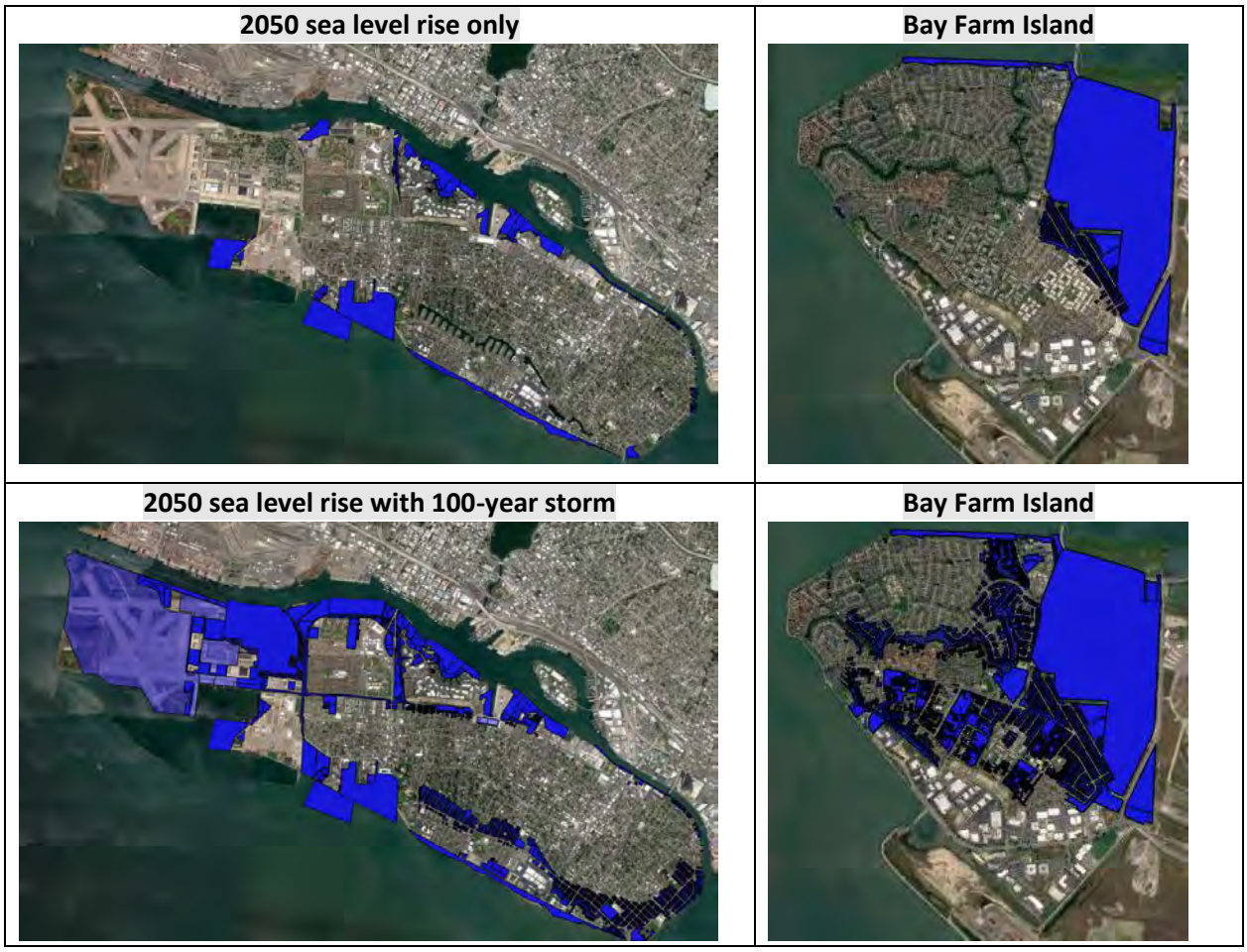


Figure 5-2. 2050 sea level rise only ($2,610 million) with 100-year storm ($4,425 million).

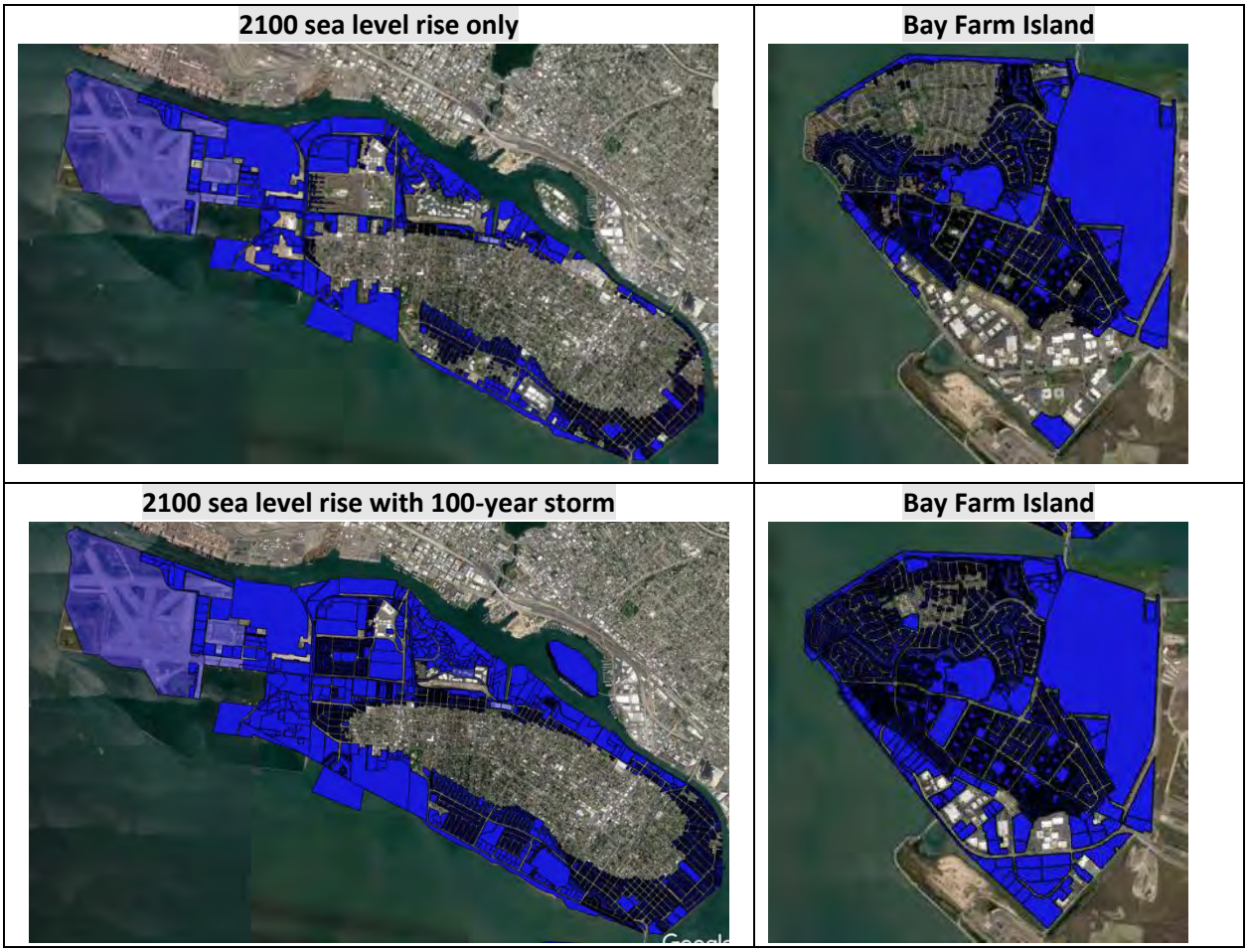


Figure 5-3. 2100 sea level rise only ($6,828 million) with 100-year storm ($10,805 million).

Cost of Action

CARP Appendix L, "Assembly Bill 691 Compliance," includes a cost estimate for raising the entire Alameda shoreline to address sea level rise and storm surge over time. This appendix provides more details about how the costs are derived. The analysis results are summarized in Table 5-3 below. The analysis assumed the City will heighten existing structures (e.g., a seawall would be raised to protect against higher water levels). We estimated the costs using data from similar projects in other communities (which typically include personnel time, engineering, construction, and other upfront costs), presented them in a range to reflect the varying costs across these projects, and based the estimate on both the linear feet of shoreline that needs to be heightened as well as the height to which it needs to be raised to prevent flooding at each scenario in Table 5-3. This analysis only accounts for approximately 90 percent of the overtopped shoreline, as certain shoreline types such as wetlands would require either a retreat policy or a different shoreline solution to prevent flooding in many scenarios. The City is not promoting heightening existing structures, creating natural shorelines, or creating managed retreat. This analysis simply assumes heightening existing shoreline to provide insight about planning-level costs of action.

Importance of Improvements to the Stormwater System

Master planning efforts related to the stormwater system have identified many important upgrades to keep the system functioning properly. Many of these upgrades are needed regardless of climate change, but sea level rise and storm surge risk only heighten their importance.

Rough estimates of the cost to implement capital improvements already identified a range from **around $40 million for high-priority projects only to around $150 million for all improvements**. These upgrades are crucial to ensuring Alameda can manage and recover from flooding that will increase in the future, and they will move Alameda toward climate resilience.

The stormwater system and the shoreline combine to protect Alameda from sea level rise, storm surge, and overland flooding. Upgrading these built and natural systems will help protect Alameda from flooding immediately and as water levels rise, allowing City leaders, planners, and stakeholders to evaluate and prioritize longer-term shoreline projects to prepare the city for future changes that are less certain today.

Table 5-3. Costs to Raise Shoreline to Protect Against Each Sea Level Rise and Storm Surge Scenario

Scenario (Total Water Level)	Low-End Estimate ($Million)	Average Estimate ($Million)	High-End Estimate ($Million)
2030 sea level rise (10")	$5	$11	$16
2050 sea level rise (23")	$17	$34	$51
2030 sea level rise + 100-year storm surge (52")	$93	$188	$285
2050 sea level rise + 100-year storm surge (65")	$183	$368	$559
2100 sea level rise (83")	$245	$493	$748
2100 sea level rise + 100-year storm surge (125")	$346	$696	$1,056

Natural shoreline alternatives. The analysis primarily considered in-kind modifications to Alameda's shoreline. For example, existing levees would be elevated to address future water levels. Although much of Alameda's existing shoreline is hardened, there are several natural alternatives to hardened shorelines that the City could consider across the island. For example, the City could replace or supplement existing traditional engineered levees with horizontal or living levees that provide similar or better flood protection, as well as habitat and erosion reduction.

The CARP economic analysis did not explicitly cost out natural alternatives at a citywide scale because of the highly site-specific nature of designing living shorelines. Many factors come into play when determining whether natural alternatives are feasible, including available space, existing habitat, hydrologic factors, and the proximity of existing buildings to the water. In addition, natural shoreline alternatives are often more expensive than traditional options, particularly when converting hardened shoreline to natural shoreline. However, natural shorelines also offer substantial non-market value and are likely necessary in Alameda to provide multiple barriers and ensure a sustainable and resilient city in the long term. In addition, substantial avoided cost from shoreline adaptation in Alameda makes a higher-cost design economically feasible, as described in the next section.

Cost of Action Compared to Inaction

The previous sections provide insight into the costs of adaptation ("Cost of Action") and the associated benefits of action, which would avoid the costs outlined in the "Cost of Inaction" section. Table 5-4 presents the estimated high-end cost to raise the shoreline and protect it against each sea level rise and surge scenario (from Table 5-3). The benefit only includes the avoided building and land loss costs (from Table 5-2), assuming a total loss of anything flooded by sea level rise and a portion of the value lost (depending on flood height) for flooding from 100-year storm surge. Even when considering a rather high-end cost and a conservative benefit (as this only includes building and land loss), the benefit-cost ratio ranges from about 3.5 to 1 to 8 to 1 in all sea level rise scenarios with a 100-year storm surge. This also excludes the $40 to $150 million cost to improve the stormwater system. Additionally, this comparison does not incorporate additional benefits—such as avoiding impacts of rising groundwater from sea level rise, or avoiding infrastructure loss (quantified earlier in this chapter), commerce disruption, and loss of non-market benefits associated with Crown Beach and other parks—as well as other non-monetized benefits such as improved safety for people within the city. Quantifying these additional benefits would make the benefit-cost ratio even higher (more favorable). This analysis focused on avoided building and land loss because it is anticipated it would be a large portion of the overall benefits. It also focused on the costs of raising infrastructure as it would be a large portion of the cost of action. To meet legislative requirements, Appendix L ("Assembly Bill 691 Compliance") assesses market and non-market values associated with commerce on public trust lands and ecosystem services related to recreation at Crown Beach. We quantified ecosystem service values associated with Crown Beach and a few other ecosystems; however, we did not have visitor data available to quantify several ecosystem services, so we described the impact quantitatively and identified what data would be needed for future studies.

Table 5-4. Cost-Benefit Comparison for Each Sea Level Rise and Storm Surge Scenario

Scenario (Total Water Level)	COST: High-End Cost of Protective Action ($Million)	BENEFIT: Avoided Building Damage and Land Loss ($Million)
2030 sea level rise (10”)	$16	$1,081
2050 sea level rise (23”)	$51	$1,110
2030 sea level rise + 100-year storm surge (52”)	$285	$1,490
2050 sea level rise + 100-year storm surge (65”)	$559	$2,018
2100 sea level rise (83”)	$748	$6,828
2100 sea level rise + 100-year storm surge (125”)	$1,056	$8,061

Cost of Action at Locations of Priority Flooding

The CARP development process identified six areas of location-based priority flooding along the Alameda shoreline. As detailed in Chapter 4, “Adapting to Climate Change,” these areas were selected as priorities for adaptation action because they face risk of flooding from sea level rise and storm surge in the near term. In addition, flooding in these locations would have major consequences for the community. The City proposes a range of adaptation strategies for these areas over the coming decades in Chapter 4 of the CARP. Table 5-5 shows rough cost estimates for these strategies based on surveys of similar projects at similar scales. Most rows in the table do not duplicate costs found in the previous “Cost of Action” section that deal with the 90 percent of existing shoreline structures that were assumed to be heightened.

Cost estimates for nature-based projects are based primarily on reviews of similar projects in San Francisco Bay and California. Cost estimates for engineered (hard) shorelines (e.g., levees) draw on national sources and are based on approximate calculations of barrier length and height. Cost estimates for some infrastructure improvements are based on City staff estimates. Costing strategies beyond 2050 were not estimated because there were too many unknowns. Additionally, a few costing strategies in 2050 were not estimated because there were similar unknowns about the degree to which the strategy would be implemented.

Table 5-5. CARP Adaptation Strategies and Cost Estimates for Addressing Location-Based Priority Flooding

Location	Scenarios		
	2030 Sea Level Rise Plus 100-Year Storm	2050 Sea Level Rise Plus 100-Year Storm	2100 Sea Level Rise Plus 100-Year Storm
Crown Beach Adaptation	Expand dunes Augment salt marshes Redistribute sand	Expand beach into the Bay Add oyster reefs, cobble berms	Allow beach to retreat inland
	$11 million	$7.5 million	Not estimated
Eastshore Drive	Augment mudflats Expand flood protection barriers	Integrate adaptation between public pathways and private parcels	Develop tidal neighborhoods
	$20 million[a]	Not estimated	Not estimated
Shoreline Near Webster and Posey Tubes	Expand levee and seawall to provide 100-year flood protection Flood-proof critical facilities (Hazardous Materials Transfer Station)	Expand levee and seawall to address sea level rise	Develop long-term northern waterfront shoreline strategy
	$1.7 million [a]	$2.2 million [a]	Not estimated
Bay Farm Lagoon Outlet and Seawall	Restore submerged aquatic vegetation Elevate existing seawall and upgrade pump	Explore large-scale shoreline modifications along Bay Farm's northern shore (e.g., living levee)	Coordinate approach to flooding across Bay Farm
	$ 3 million [a]	$9 million [a]	Not estimated
Veteran's Court Seawall	Regrade and elevate road to create flood protection structure Restore submerged aquatic vegetation	Investigate options to convert Veteran's Court area into a living levee	Integrate Veteran's Court flood protection into broader Bay Farm Island flood control strategies
	$4 million [a]	$9 million	Not estimated

Location	Scenarios		
	2030 Sea Level Rise Plus 100-Year Storm	2050 Sea Level Rise Plus 100-Year Storm	2100 Sea Level Rise Plus 100-Year Storm
Bay Farm Island Touchdown and Towata Park	Repair/replace and elevate existing shoreline protection (Additional study is needed on identifying and costing natural shoreline adaptation)	Assess bridge vulnerability	Consider local ordinance requiring or encouraging flood retrofits in this neighborhood
	$300,000 [a]	Not estimated	Not estimated
SR260, Posey and Webster Tubes	Construct floodwalls at exit from/entrance to the tubes	Install separate crossing for bikes/pedestrians (Caltrans Bike Plan)	Investigate long-term options for replacement or reconstruction of tubes
	$2 million	>$7 million	Not estimated
SR61/Doolittle Drive	Augment mudflats	Explore opportunities to collaborate with golf course on flood control	Convert roadways to levees to provide flood control
	$3.3 million	Not estimated	$15 million
Critical and High-Use Roadways	Unable to estimate cost	Unable to estimate cost	Unable to estimate cost
Storm Drains and Pump Station	Implement recommendations in existing stormwater master planning	Not yet planned	Not yet planned
	$40 to $154 million [b] (note that some actions elsewhere in this table are included in this total)	Not estimated	Not estimated
Bayview Weir and Outfall	Install new flap gates, dredge near outfall	Install pump station	Integrate pump station upgrades with Shoreline Drive upgrades
	$1.5 million	$20.5 million	Not estimated

[a] Strategies include cost to raise shoreline (as well as other adaptation actions). Costs to raise shoreline overlap with the cost estimate in Table 5-4.

[b] Stormwater system was discussed in “Cost of Action” section above but was not included in previous Table 5-4.

Note: Details on these adaptation strategies are provided in Chapter 4, “Adapting to Climate Change,” and Appendix J, “Adaptation Strategies and Actions.” In cases where adaptation strategies call for feasibility studies for the sake of costing, it is assumed that these studies will transition into project implementation. For example, it is assumed that the action to study opportunities for mudflat augmentation at Eastshore Drive (in Chapter 4) will transition into implementation of a mudflat augmentation project.

Costs of GHG Reduction Action

The GHG abatement costs associated with implementing the new GHG reduction actions include "planning level" capital, as well as annual operations and maintenance (O&M) costs. Planning level costs are used to estimate the relative costs of actions and as a basis for more specific programming costs that the City would later estimate. In general, capital costs are for one-time activities or investments, such as consultant services to design a program, a purchase of lower emissions replacement equipment (e.g., leaf blowers), and green roof installation costs. O&M costs are generally for City staffing requirements in terms of "full-time equivalent" (FTE) needed to implement the action/program each year or other recurring costs. A fully burdened FTE is estimated to be $120,000 per year. Avoided costs are associated with cost savings, such as less time needed for EV charger installations due to standardized requirements, as well as lower EV maintenance costs as compared to conventional vehicles.

Annual GHG abatement cost is estimated using the following formula, assuming an average 25-year life of the action for purposes of normalizing the GHG reductions and costs of projects over time:

(Capital cost – Avoided cost + (Annual O&M cost × 25 years)) ÷ ((Annual GHG reduction in 2030) × 25 years) = $/MTCO2e reduced

Other costs can be incurred with new action implementation, such as the cost associated with time lost due to traffic congestion, or time attributable to changes in behavior (e.g., effort expended in applying for rebates). These other costs are difficult to quantify and are not included in the planning level costs at this time.

Appendix F, "Greenhouse Gas Emissions Reduction Actions," provides the specific assumptions used to estimate the planning level annual GHG abatement costs for each new reduction action. Table 5-6 summarizes the planning level abatement costs and staffing estimates.

Table 5-6. Summary of Planning Level Abatement Costs for New GHG Reduction Actions

Action (full implementation year = 2030 unless otherwise noted)	$/MTCO2e Reduced	O&M/Year
T1. Telecommuting	$10.44	0.25 FTE
T2. Build additional bike lanes	$10.85	N/A[a]
T3. Traffic signal synchronization	$164.10	1.00 FTE
T4. Citywide *EasyPass* program	$115.04	$25,000[b]
T5. Ban gas-powered leaf blowers	$1,647	1.0 FTE
T6. Increase availability of EV charging stations citywide	$22.41	1.50 FTE
T7. Promote purchase of LEVs and ZEVs	$19.98	1.00 FTE
T8. Continue programs to encourage new EV purchases	$11.74	0.50 FTE
T9. Continue to encourage businesses to install EV charging stations	$90.30	0.50 FTE

Action (full implementation year = 2030 unless otherwise noted)	$/MTCO2e Reduced	O&M/Year
T10. Electrify City's fleet	$23.09	N/A[c]
E1. Fuel switch in existing buildings	$622.46	1.00 FTE
E2. Electrification of new residential construction	$355.17	1.00 FTE
E3. Programs to encourage fuel switching in certain appliances	$520.28	1.00 FTE
E4. Green roof installations on new development at Alameda Point	$45,750	1.00 FTE
S1. Apply compost to Alameda parks and open spaces	$93.53	2.00 FTE
S2. Further develop urban forest	$330.76	$93,750[d]

[a] Staff support to be provided through existing TCP implementation.

[b] Annual cost estimated as $25,000 from TCP Project/program #4.

[c] Staff support to be provided through existing vehicle maintenance program.

[d] Current staff tree planting budget/year plus 12.5 percent.

Financing Energy Efficiency and Fuel Switching in Buildings

A unique set of opportunities are already available to residents, businesses, and the City to help finance energy efficiency and fuel switching. To avoid the need for upfront funding of energy retrofits, building owners can enter into arrangements with energy service companies (ESCOs), whereby the ESCO provides an energy savings guarantee and the building owner secures a loan from a lender based on the guaranteed savings provided. From the owner's perspective, the savings from the retrofits will offset the loan payments. From a lender's perspective, the savings guarantee provided by the ESCO gives the lender confidence that the project will generate a positive cash flow. This kind of assistance for retrofits is essential. Climate adaptation strategies can be more easily incorporated into new construction as projects are planned and designed. Existing facilities pose a greater challenge on many fronts. Major retrofits to an existing facility require a significant investment in time and resources, and typically need to provide clear value to the building owner. ESCOs help fill this gap and provide important assistance.

In addition, the Alameda City Council recently authorized Property Assessed Clean Energy (PACE) programs to offer property owners upfront funding for energy efficiency, water efficiency, and seismic retrofits. Property owners repay the costs at fixed interest rates through a levy on their property tax.

Converting natural gas consumption to electricity consumption in buildings and replacing fossil fuel-powered vehicles with electricity-powered vehicles will increase electricity consumption in Alameda. While efficiency improvements can offset some of this increase, it is highly likely that AMP would have to make capital investments—potentially including a new substation—and increase operating costs to successfully deliver the increased electricity that Alameda customers would demand. Though electrification would also result in increased revenues for AMP, the changes required would be significant; as a result, the City should develop electrification strategies in close collaboration with AMP and the PUB.

Funding and Financing the CARP

Alameda is fortunate to have adopted proactive financial policies that tackle long-term financial obligations. For example, the City commits 50 percent of surplus funds available at year's end to fund long-term pension and health obligations. As the CARP points out, climate change creates a long-term financial obligation. As such, the City should create a new Climate Fund that commits City funds to reducing GHG emissions and adapting to climate change impacts. These funds might be used as local match for grants to:

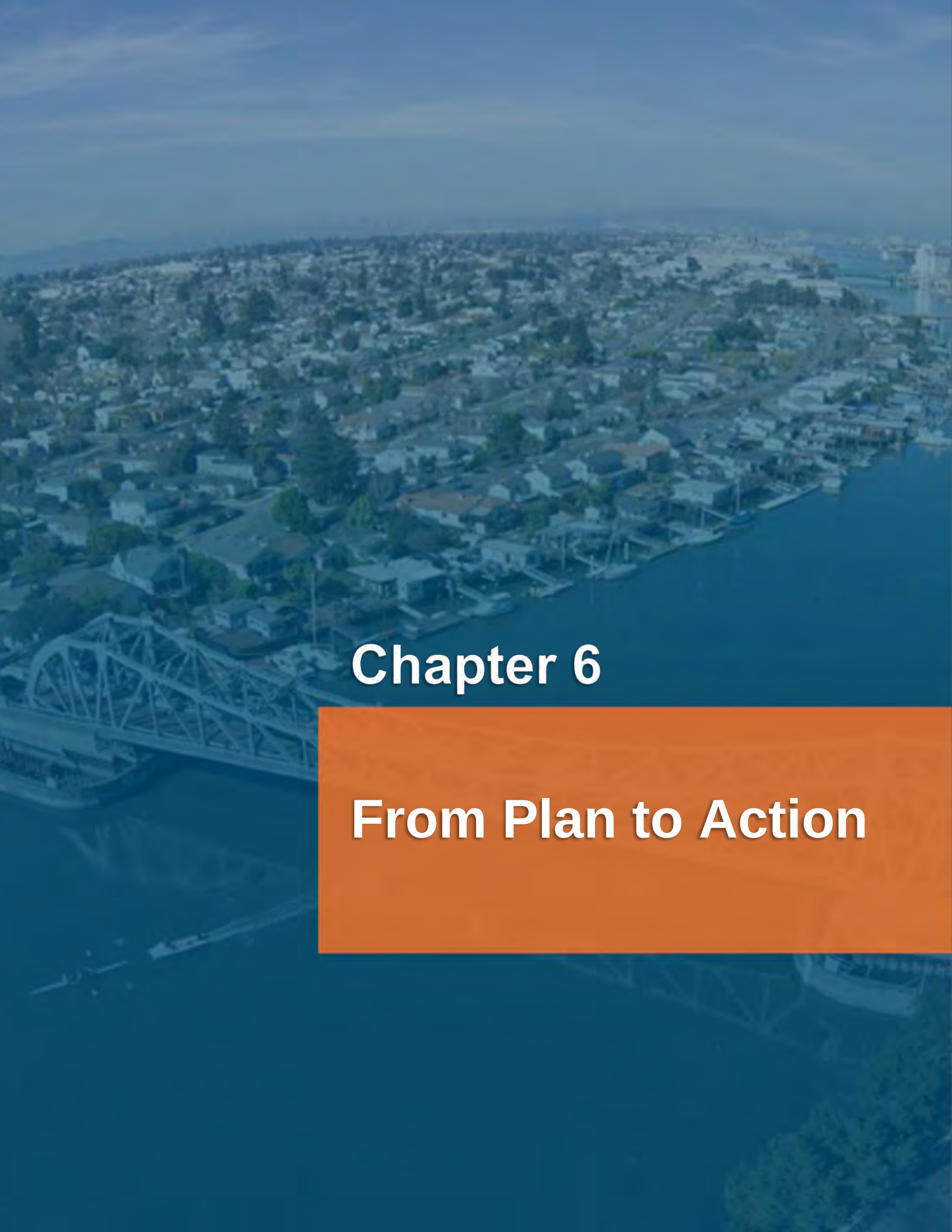
- Implement climate change adaptation measures;
- Offset permit fees associated with building improvements that reduce GHG emissions;
- Retrofit city buildings to switch them from gas to electric power;
- Implement innovative sequestration projects; and
- Implement other measures consistent with the CARP.

Beyond the creation of a City Climate Fund, CARP funding will likely come from diverse sources, including local, state, and federal dollars and grants. Some costs will be borne directly by Alameda residents and business owners. Key steps in financing CARP actions include the following:

- Identify funding shortfalls to reach aspirational GHG reduction goals and to implement priority adaptation strategies. Prioritize top, near-term adaptation projects and cost them out.
- Identify potential funding sources and financing mechanisms to fund priorities (e.g., infrastructure bond for GHG and adaptation projects, flood assessments, and/or special districts).
- Invest design dollars to ensure the City has "shovel-ready" adaptation projects lined up to take advantage of grant opportunities.
- Increase stormwater fees to fund pipe and pump station capacity upgrades.
- Continue Alameda's local investment of general funds in climate change-related work. For example, the City's fiscal year 2019–2021 measures include more than $3 million in general funds committed to actions and projects consistent with CARP and its implementation.
- Impose development impact fees.
- Consider impact of funding sources for climate mitigation and adaptation on vulnerable communities.
- Consider developing Enhanced Infrastructure Financing Districts (EIFDs). EIFDs are new governmental entities made up of one or more jurisdictions within a city or county, and they are used to finance the construction or rehabilitation of a wide variety of public infrastructure. Funding is sourced from the property tax increment of those taxing agencies (cities, counties, and special districts, but not schools) that consent. AB 733 explicitly allows EIFDs to be used for local climate change adaptation projects.

Potential Sources of Grant Funding for Shoreline Adaptation in Alameda

- San Francisco Bay Restoration Authority (projects involving wetlands or natural shorelines)
- FEMA Hazard Mitigation Planning Grants
- California Department of Boating and Waterways (Crown Beach and potentially other locations)
- Caltrans
- Active Transportation Program (for projects related to expanded trails)
- Proposition 68 Grants (administered by the State Coastal Conservancy)
- California State Coastal Conservancy Climate Ready Program (SB 1066)



Chapter 6

From Plan to Action

Introduction

The CARP's success depends on getting many things right. City staff will have to organize themselves and their work to take action in the variety of areas the plan addresses. Monitoring and reporting will be important to ensure the plan stays on track and adapts to changing conditions. The community will also play a vital part in changing behaviors and prioritizing resources to help implement the plan. New revenue will have to be found or, more likely, raised. State, regional, and other local agencies will have to contribute, especially as this plan's strategies require their participation.

At the same time, implementation faces risks. Many important questions will be raised during implementation that we can't anticipate now, not to mention how science may change and climate change impacts may escalate. To successfully implement the plan, public concerns about climate change and resiliency must continue to be a priority, even as our community continues to tackle other priority issues into the future, such as traffic/transportation and the high cost of housing.

One of this plan's key takeaways is that Alameda's biggest GHG reductions are attributable to actions already approved in the City's existing plans, such as AMP's Strategic Plan, the TCP, and the ZWIP Update. New strategies introduced here, and in the future, are important and necessary. However, it will take an incredible amount of focus and effort to accomplish the existing, already committed to activities, and without additional resources, new activities may crowd out existing ones.

While the discussion below will chart the City's course to successful implementation, none are as important as the humility (and requisite flexibility) Alameda will need to change and adapt along the way to implementing this plan.

With that background in mind, the CARP recommends the following framework for implementation.

Responsibilities, Structure, and Staffing

As the CARP implementation planning process begins, it will be important to continually assess the City's current organizational and staffing structure, including governance, staffing, cost, and revenue, and to understand implementation best practices and lessons learned from other cities.

Today, the City has no position dedicated to climate change. Rather, responsibility has been distributed among departments for various initiatives. Three different departments led the original climate plan and its updates, suggesting a "hot potato" approach to delegating this responsibility.

Four City staff members spent significant time drafting the CARP: Public Works Director, Public Works Deputy Director, Public Works Climate Coordinator (part-time position), and Public Works Climate Fellow (limited duration, full-time). It is not the norm for Public Works to lead a climate planning process.

Staff from AMP and Building, Planning, and Transportation have been very involved through the GWT. In addition, Public Works staff chaired a TF composed of community representatives that helped chart the course for the plan. Such a TF would be helpful in supporting implementation and future decisions.

The community, especially the CASA coalition, have been instrumental in pushing this work forward. From adoption of the 2008 plan, to pressing for this update and helping shape the direction of this plan, Alameda is fortunate to have such an active and engaged group of advocates.

To ensure progress, the CARP recommends realigning responsibilities, structure, and staffing, and continuing some of the structures that have helped the CARP's development.

The **City Council** is responsible for adopting this plan, making new policy consistent with the plan, and ensuring resiliency and climate change are high-priority issues for our community and our regional collaborators.

The **City Manager** is responsible for the City achieving this plan's goals, measures, and strategies.

The **Assistant City Manager** is responsible for the plan's implementation. Given the dispersed nature of the plan's activities through various departments and the community, the Assistant City Manager is the right level of responsibility to ensure implementation stays on course. Due to the amount of high-priority issues an Assistant City Manager is responsible for, a **new full-time position titled a Sustainability Coordinator** is necessary for successful implementation. The Sustainability Coordinator will report to the Assistant City Manager and be responsible for annual monitoring and reporting to the City Council on the plan's progress, as well as liaising with the local/state/regional agencies and groups focused on resiliency and climate change. The Coordinator will also develop staff capacity to respond to resiliency issues and coordinate with staff and the Alameda community on progress toward achieving the plan's goals, strategies, and measures. While some larger communities have Chief Resiliency Officers akin to a Director or Assistant City Manager, a Sustainability Coordinator is more in line with the direction of California cities our size and provides the right level to get "into the weeds" of implementation across the City's many departments. This position could be funded for its first year from the adopted fiscal year 2019–2021 budget's allocation to the City's Climate Action Plan Contingency.

The City will continue a GWT with quarterly meetings. The Sustainability Coordinator will chair the team, with the Assistant City Manager as the executive sponsor. Participants will include Directors and their designees from AMP; Public Works; and Building, Planning, and Transportation. The group will expand to include other departments and/or outside agencies or groups as needed. Every other meeting will be open to community group representatives from CASA, Bike Walk Alameda, the Sierra Club, or other groups with a mission to reduce GHG emissions and/or adapt to climate change.

Two working groups will meet more regularly. Public Works will chair the Adaptation/Sequestration Working Group. AMP and Building, Planning, and Transportation will co-chair the Fuel Switching Working Group. At least one of each of these working group meetings per year will be open to community group representatives. Agency partners (e.g., PG&E, EBRPD, Port of Oakland, Caltrans) will be invited as needed to participate in these groups. City staff will identify and include a "Climate Impacts" section in every staff report considered by City Council.

The CARP suggests hiring an additional 11 or more full-time employees for full implementation. As the City implements the plan, the need for additional full-time employees and/or other expenses will become clearer. With this clarity, staff will return to City Council to authorize additional employees or expenses.

Sustained and coordinated commitment from City staff and members of the community (through the TF) is necessary for successful implementation of the CARP moving forward. For this reason, the CARP recommends that the Sustainability Coordinator chair both the GWT and the TF on an ongoing basis.

Building the City's capacity will be necessary to implement the CARP successfully. Some capacity-building opportunities for the City include becoming a member of the American Society of Adaptation Professionals and other professional groups as appropriate, as well as sending staff to trainings,

workshops, and conferences, such as the biennial California Adaptation Forum and other events organized by the ART Program, the Coastal Conservancy, other regional partners, and Alameda County.

Alameda Municipal Power

In adopting the CARP, it is important to recognize the Alameda City Charter's distinctions between the powers vested in the City Council and the powers vested in the PUB.

Under Section 3-1 of the City Charter, all powers of the City are vested in the City Council unless the Charter expressly states otherwise. Article XII of the Charter describes one such area where the City Council's authority is circumscribed. Article XII delegates the power to control and manage the City's public utilities to the PUB. The PUB's authority is broad and, in many areas, it may act in a largely autonomous fashion. For example, Charter Section 12-1 (A) vests the PUB with the authority to "control and manage all public utilities owned by the City established for the purpose of generating, distributing or selling electricity." Charter Section 12-3 (C) provides that the PUB has the power "[t]o fix rates for the services of all utilities and business enterprises under its control and management." Article XII of the Charter also authorizes the PUB to contract for materials and supplies, construct or make improvements to utilities, fix rates for utility services, invest reserves, keep books, store supplies, and adopt an annual budget.

AMP, however, is not a separate legal entity, and the powers of the PUB are generally limited to the day-to-day operations of the utility. The City owns the utility as an asset, with the PUB acting as the manager/operator of that asset.

These Charter-level distinctions explain why the CARP as adopted by the City Council may encourage but not direct the PUB and AMP to implement the objectives discussed herein.

Monitoring, Reporting, and Metrics

It is important for the City to establish a tracking and reporting system to evaluate the efficacy of Alameda's GHG reduction and adaptation actions, maintain transparency with the public, and ensure the equitable distribution of climate-related projects citywide. By designing and tracking metrics aligned directly with CARP goals, the City will manage GHG reduction and adaptation activities in Alameda and adjust management decisions as needed. This section explains how effective monitoring supports the adaptive management approach that is central to the CARP. The City's intent is to:

- Monitor progress toward the CARP vision, goals, and milestones;
- Understand what is working, what is not, and how to adapt to increase effectiveness; and
- Share outcomes, best practices, and lessons learned across networks of stakeholders and partners.

As explained in Chapter 4 ("Adapting to Climate Change"), adaptive management is the process of "iteratively planning, implementing, and modifying strategies in the face of uncertainty." This approach is complemented with adaptation pathways, which specify how existing adaptation strategies can be supplemented, adjusted, or replaced under changing future conditions (Figure 6-1). As demonstrated in the hypothetical example below, metrics such as "erosion of shoreline properties" or "number of flood insurance claims submitted" can be tracked over time. Within those metrics, specific triggers are defined, such as "X feet of land eroded," or "Y insurance claims submitted." If those triggers are reached, we know that the existing adaptation actions are ineffective—either because they were not properly designed to begin with or because climate impacts have escalated. Either way, additional adaptation measures must be in place and adjustments made to monitor them as appropriate.

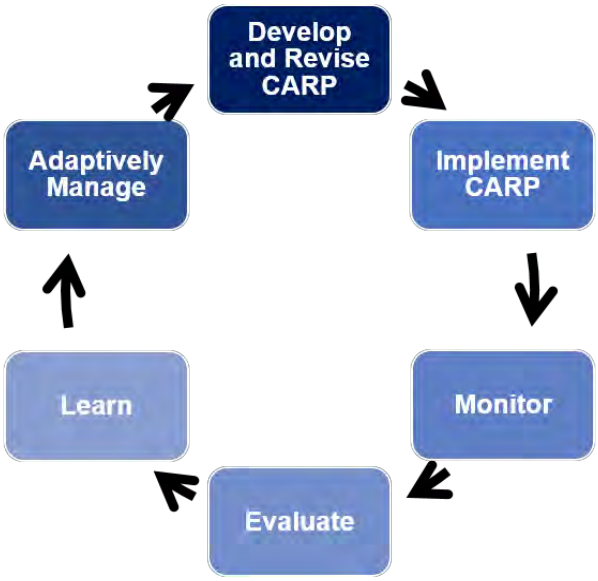


Figure 6-1. Adaptive management process.

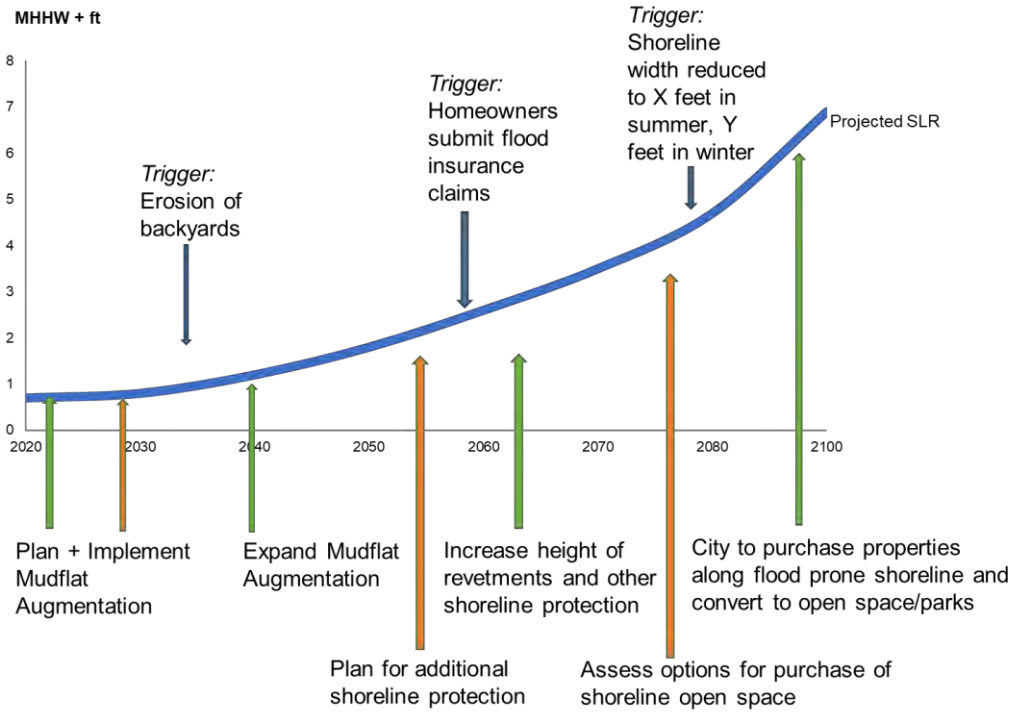


Figure 6-2. Hypothetical example of adaptation pathway for the Alameda shoreline.

While sea level rise is used as an example, the same principle can be applied to other climate impacts. For example, the number of extreme heat days per year could be used to trigger additional cooling centers (County of Ventura, 2019).

The same principle applies to monitoring progress toward reaching the CARP's GHG reduction goals. The CARP has defined metrics such as miles of new bike lanes and number of telecommuting work days to reach GHG reduction goals (see Table 6-1 below).

The Sustainability Coordinator will be responsible for both monitoring the plan's progress and annually reporting to the City Council on progress in achieving this plan's goals, strategies, and measures. Interim shifts in approach are expected as conditions change or as the state or City implements major policy changes that affect the recommendations contained herein. The adaptive management approach allows for such shifts.

A goal of CARP reporting will be integrating lessons learned since the last plan—both in terms of measurable impacts to the physical environment as well as harder-to-measure impacts to community resilience. Through this process of investing in infrastructure, community cohesion, and problem-solving creativity, we can work together to build a more resilient city.

In 2024, the annual report will include updated GHG inventories, including a consumption-based emissions inventory, which are critical to determining whether City actions are yielding the desired results. In 2025, in lieu of an annual report, the Coordinator will share an in-depth update to the plan with recommendations for 2025–2030 actions, 2030 goals, and ways to achieve net zero GHG emissions as soon as possible. For adaptation, the CARP updates will provide an opportunity for the City to reassess priority vulnerabilities that require more immediate action. The update process will also allow the City to step back and look holistically at long-term adaptation strategies.

In coordination with the first annual report after plan adoption, the Coordinator will establish a website devoted to the CARP and its implementation and progress. The website will include a public-facing dashboard to provide information on progress toward GHG reduction and adaptation goals. Building an interactive component into the City's CARP website will help engage the public and foster transparency and trust. This kind of public-facing tracking can empower the community to hold the City accountable for progress and equitable distribution of resources, projects, and benefits. Suggestions for the content, look, and feel of the dashboard are described in Appendix K ("Recommendations for Tracking System Dashboard"). For GHG reduction, the City will focus CARP updates on identifying the portfolio of reductions necessary to keep the City on track to meet 2030, net zero, and later GHG reduction targets, or new targets defined by the community and the State of California.

While establishing a monitoring program, the City will identify key metrics from the outset. Examples of key metrics to be included in the first annual report and the first dashboard are as follows:

- Number of EVs and public charging stations (data source: AMP);
- Number of gas appliances switched to electric (data source: Building/Planning);
- Total number of street trees and new trees planted (data source: Public Works); and
- Number of stormwater system capacity upgrades (data source: Public Works).

While the development of metrics is a challenging task, the four identified above provide a high-level sense of Alameda's trends in climate change and the efficacy of our adaptation and GHG reduction actions. City Council, City staff, and community groups will refine and expand the list over time, especially after hiring the Sustainability Coordinator. As a start to that discussion, Table 6-1 presents a broader list of metrics relevant to the goals and actions presented throughout the CARP. This list is not meant to be comprehensive, and the City will expand and refine it as needed as Alameda prioritizes and implements the specific GHG reduction and adaptation actions found in the CARP.

Table 6-1. Initial Metrics to Address CARP Goals

***GOAL 1: GHG Reduction*—Reduce GHG emissions to 50 percent below 2005 levels by 2030 and achieve net zero emissions as soon as possible. (Metric number same as new GHG reduction action number. Metric quantity provided for 2030 new actions only.)**	
Metrics	■ T1: Number of employee workdays spent telecommuting (631,800 employee workdays). ■ T2: Miles of new bike lanes (10.44 miles). ■ T3: Number of traffic signals synchronized (25 signals). ■ T4: Number of *EasyPasses* distributed to Alameda residents (5,000 passes). ■ T5: Number of electric leaf blowers purchased to replace gas-powered equipment (2,327 leaf blowers). ■ T6: Number of new permitted EV chargers/charging points (2,061 chargers). ■ T7: Number of new LEVs and ZEVs registered (1,950 vehicles). ■ T8: Number of EVs registered (821) based on AMP's program, and number of rebates issued by fleet dealers (1,047 rebates). ■ T9: Number of workplace/retail chargers installed per year (260 chargers). ■ T10: Number of light-duty EVs purchased for the City fleet (208 EVs). ■ E1: Percent reduction in natural gas consumption (12%). ■ E2: Number of residences built as all-electric (2,727 residences). ■ E3: Number of rebates issued for natural gas-to-electric clothes dryers and heat pump water heaters (3,819 clothes dryers and 382 heat pump water heaters). ■ E4: Number or residences and commercial properties installing green roofs (1,909 residences and 25 commercial buildings). ■ S1: Tons of diverted organic waste converted to compost and applied to parks/open areas (66,190 tons). ■ S2: Number of new trees planted each year (1,500 trees).
***GOAL 2: Sea Level Rise and Storm Surge Flooding*—Protect assets from sea level rise and storm surge, plan future land use to avoid impacts, and enhance natural shoreline habitat to mitigate impacts.**	
Metrics	■ Percentage of residential parcels in existing, unprotected, coastal flood-prone areas and within 66" total water level (reflecting mid-century projected water levels). ■ Number of times the emergency operations center is triggered for weather-related events and percentage of community reached during each event. ■ Total losses incurred by the City due to coastal flooding. ■ Percentage of residences or businesses in the FEMA flood zone with flood insurance. ■ Number of shoreline homeowners and businesses who submit flood insurance claims. ■ Percent of sand loss (annually) at Crown Beach.
***GOAL 3: Inland Flooding*—Increase the resiliency and capacity of the stormwater system to prevent flooding of assets during extreme precipitation events.**	
Metrics	■ Number of times the emergency operations center is triggered for flood events and percentage of affected community reached during each event. ■ Impact of weather-related events. Possible metrics include number of basement flooding complaints, number (and duration) of road closures due to street flooding, and number of days schools or businesses are closed due to flood impacts. ■ Percentage of residences or businesses in the FEMA flood zone with flood insurance. ■ Number of stormwater capacity upgrades.

***GOAL 4: Drought*—Reduce water consumption and increase drought-resistant landscaping.**	
Metrics	■ Gallons per capita per day of water use. ■ Percentage of population or businesses participating in water conservation programs offered by the City or EBMUD. ■ Percentage of city land incorporating drought-resistant landscaping practices.
***GOAL 5: Extreme Heat*—Reduce heat island effect and protect vulnerable populations from heat impacts during heat waves.**	
Metrics	■ Number of times the emergency operations center is triggered for extreme heat events and percentage of community reached during each event. ■ Number of people using cooling centers. ■ Acres of roof, parking lot, and roads where heat island adaptation measures (e.g., green/cool roofs, tree plantings, white pavement) are implemented. ■ Total number of street trees and new trees planted. ■ Number of heat-related hospitalizations and mortalities.
***GOAL 6: Wildfires*—Protect public health from smoke impacts during wildfire events, especially vulnerable populations.**	
Metrics	■ Number of times the emergency operations center is triggered for wildfire smoke-related events and percentage of community reached during each event. ■ Number of days air quality index reaches hazardous levels. ■ Number of masks distributed during wildfire smoke events. ■ Number of smoke-related hospitalizations and mortalities.
***GOAL 7: Earthquakes/Liquefaction*—Ensure building and infrastructure retrofit and new design standards in areas at high risk of liquefaction consider both seismic risk and sea level rise impacts.**	
Metrics	■ Percentage of buildings and utility infrastructure designed to address liquefaction risk.
***GOAL 8: City Effective Implementation of CARP and Capacity-Building*—Develop financial and human resources and increase transparency, community engagement, social resilience, and support for effective CARP implementation.**	
Metrics	■ Amount of funding secured for implementation. ■ Number of City staff trained (full- and part-time). ■ Number of other plans aligned with the CARP. ■ Change in community awareness of climate risks and actions to take (e.g., through annual surveys).

The large redevelopment project moving forward at Alameda Point fits broadly within the adaptive management framework described. The MIP for the site calls for reviewing the latest sea level rise projections every five years to re-estimate when improvements to the flood protection system will need to be implemented and confirm that funds are available. As large infrastructure plans like the MIP are planned and updated, they should align with the goals described above and include individual monitoring plans and trigger points for adaptation that align with the citywide monitoring program. This will keep the City on track to meet CARP goals and ensure that projects can be easily integrated into the City's overall reporting framework.

State, Regional, and County Governance

Implementing the CARP actions will require changes to City ordinances, policies, procedures, financial incentives, and funding mechanisms, which could be impacted by changes at the state and regional levels. It will be in Alameda's interest to track the evolving landscape of state, regional, and county

governance structures around GHG reduction and climate adaptation and to seek leadership opportunities to help shape those structures and policies. For example, creation of a regional sea level rise governing body could influence the direction of local shoreline adaptation projects. By participating in such a governing body, the City of Alameda will likely drive changes in local governments around the Bay and be able to bring its overarching commitment to social equity to other Bay Area governments.

New regional governance specifically for climate planning and implementation is under development. BCDC and partners plan to scope development of a regional adaptation plan following a regional sea level vulnerability assessment (the ART Bay Area Project). The City should track this work and engage with local jurisdictions, as there will likely be implications for county and City planning efforts. BayCAN is a new collaborative network of local government staff (including Alameda) helping the Bay Area region respond effectively and equitably to the impacts of climate change. Whether it is BCDC, BayCAN, a different institution, or several in collaboration that drive emerging regional governance structures for climate planning, it is important for Alameda to have a voice at the table as key decisions are made. New structures are likely to impact future regional funding mechanisms and the way cities work with their neighbors. In 2017, as part of the UC Berkeley/UC Davis research project, "Resilient Infrastructure as Seas Rise," a paper was published titled, *The Governance Gap: Climate Adaptation and Sea Level Rise in the San Francisco Bay Area*. The paper concluded that while there is a relatively high agreement of perceived risk in the Bay Area, there is a much lower level of agreement on the appropriate infrastructure and governance actions. A multi-level governance arrangement could enable cooperation within and between local and regional levels of geographic scale. Alameda must participate in the development of these arrangements.

Governance structures are also evolving at the county level. San Mateo County is currently considering a proposal to create a Flood and Sea Level Rise Resiliency Agency. The agency would expand the roles and responsibilities of the County's Flood Control District to manage sea level rise, flooding, and coastal erosion risks across the county. The Sonoma County Regional Climate Protection Authority coordinates climate resilience work across the county's agencies and nine cities. To date, their work has primarily focused on GHG reduction, but they have also done some work on climate adaptation. The City of Alameda can draw on lessons learned from Sonoma County, San Mateo County, and others as it collaborates with Alameda County and considers structures for integrating adaptation and mitigation programs that could be scaled down to the local level.

Emerging Regional Governance Around Sea Level Rise Adaptation Planning

- Potential for stronger leadership from regional agencies like BCDC and MTC.
- Potential for BayCAN's influence to grow. Alameda is a founding member and is well-positioned for a leadership role.

The content of the CARP is shaped by current state policies and governance structures with flexibility to adapt to evolving state climate policies into the future. As explained in Chapter 1, "Background," a range of climate change policies and guidance documents issued by the State of California guide the CARP. The state issued policies requiring climate adaptation plans and focused on providing adaptation planning guidance. To date, the state has done little to establish specific requirements pertaining to climate adaptation. Future requirements can be incorporated via the CARP's adaptive management framework.

Whether at the state, regional, or county level, Alameda has an especially urgent need to raise "its voice" in advocating at all these levels, as our city in the Bay will be particularly impacted by climate change. The Mayor and City Council are the appropriate level of City government to lead this advocacy and ensure the results serve all Alamedans, as well as our neighbors, the region, and the state.

Jurisdictional Complexity to be Addressed During Implementation

- Some CARP actions involve complexities of land ownership, management, and leases (e.g., state lands leases to private property owners).
- Some flooding issues that emerge at the airport (Port of Oakland), Doolittle Drive (Caltrans), MLK Shoreline (EBRPD), and Oakland also impact Alameda.

Under the current regulatory system, some of the climate adaptation and GHG reduction actions included in this plan will require close collaboration with entities that the City shares responsibility with due to ownership, oversight, or financial issues. As such, it is important that the City stay abreast of the changing landscape of policies and regulations and participate in decisions that are being made. For example, some of the nature-based solutions to shoreline adaptation included in this plan (e.g., mudflat augmentation) may be challenging to permit under current BCDC policies that limit fill in the San Francisco Bay. Discussions are currently underway about amending this policy to facilitate permitting of habitat restoration and natural shoreline protection projects. Such an amendment could have significant impacts on CARP implementation.

The process of developing and implementing the CARP places Alameda in a strategic leadership position to take advantage of evolving governance structures and evolving climate policies.

Economic Development Strategic Plan Implementation to Align with the CARP

The CARP is designed to support the Economic Development Strategic Plan. As part of CARP implementation, City staff will be tasked with ensuring that implementation of the Economic Development Strategic Plan and other key City plans are consistent with the CARP.

The Economic Development Strategic Plan states: "Alameda shall continue to evolve into a thriving and resilient economy…while maintaining a commitment to environmental sustainability, climate action, social equity, and fiscal health." It also highlights Clean Tech, Green Tech, and Blue Tech, among others, as business sectors targeted for growth. Alameda's growth in these sectors is an important component of the City's overall performance as a leader in climate action and sustainability.

The CARP also supports the Strategic Plan goals of providing sufficient transportation choices and housing as part of a well-rounded economic development strategy. As detailed elsewhere in the CARP, transportation and housing options that achieve the highest sustainability and resiliency outcomes should be prioritized.

The Economic Development Strategic Plan states that its implementation process should be "consistent with Alameda's Climate Action Plan." Upon adoption of the CARP, City staff will ensure implementation of the two plans are aligned and mutually supportive.

Partners, Stakeholders, and Communities

Approach to Partnership

Climate mitigation and adaptation, by their nature, require solutions that extend beyond city boundaries. Thus, partnerships are essential to Alameda's success. The City's partnership philosophy embraces open and transparent communications, joint goal setting, collaborative problem-solving, and leveraging of resources. The City's role on the BayCAN Interim Steering (referenced above) is a great example of this approach. The success of the CARP will depend on Alameda expanding its existing external partnerships and cultivating new ones, including the following:

- **BCDC and the ART Program:** The ART Program provides guidance to help agencies and organizations understand, communicate, and begin to resolve climate change issues. There are currently opportunities to continue supporting ART with its regional sea level rise vulnerability assessment and adaptation plan by attending workshops. BCDC regulates fill and construction in the Bay as well as public access to the shoreline. Alameda can be involved in discussions on evolving BCDC policy and regulations. BCDC will also be a regulator on all shoreline adaptation strategies.
- **Agency stakeholders:** Alameda will continue to partner on adaptation with key stakeholders, including, but not limited to, Caltrans, EBRPD, Port of Oakland, EBMUD, PG&E, AT&T, and other telecommunications.

One of the most significant challenges in working with these critical partners is highlighting Alameda's priorities. While the CARP's measures and strategies may be Alameda's high priorities, these public agencies—many of whom have no formal representation from the City of Alameda—have separate governing boards and different priorities. Current and future Mayors and City Council members will have a role in increasing representation and/or influence with these partners to ensure Alameda's projects are prioritized and delivered. The City invited staff from these public agencies to participate in the CARP development process with uneven response. This is an area where staff-to-staff interactions will have to be supplemented by interactions with these partners and Alameda's elected representatives.

Stakeholder and Community Engagement

Alamedans are aware of the threat posed by climate change. In a scientific poll of Alamedans conducted in January 2018, 84 percent stated that climate change and its impacts are an important issue: 29 percent said extremely important, 37 percent said very important, and 18 percent said somewhat important. Still, with a project as significant as the CARP, the City adopted a multi-faceted engagement strategy. In addition to establishing a TF composed of key stakeholders, hosting three community input sessions, and creating and implementing a social and print media outreach strategy, staff hosted information tables at farmers markets and meetings with various community groups where residents shared their thoughts and concerns about climate change. Climate change is overwhelming for many, and the City chose to focus on the theme of "building community resilience" as the way to effectively communicate the goal of the CARP. Based on experience developing the CARP, the following best practices for meaningful public engagement are recommended during implementation:

- Meaningful engagement should reach a wide range of communities, including those who are often left out of City planning processes. This requires effort on the part of the City to meet people where they are, such as holding info-sessions at the local library and setting up booths at

community events and community centers, rather than holding meetings in government buildings or at inconvenient times of the day.

- Community engagement efforts should always accommodate different lifestyles and prevent barriers to entry as much as possible. Providing childcare for guardians of young children, translation services, or food and drink creates a welcoming space for all Alamedans to collaborate. The City can use non-English media outlets, newspapers, centers, and places of worship to reach multilingual populations and more equitably distribute outreach information.
- More structured youth engagement is needed. Outreach and education for a broad range of students would be most effective if coordinated with teachers and administrators. Engagement opportunities for the most interested students would be more effective through a formal youth leadership program, perhaps run as a partnership of Alameda Unified School District, the City of Alameda, or a nonprofit partner like the Boys and Girls Club.

It is important to note that achieving more inclusive outreach through the above strategies requires additional resources devoted to engagement. More than anything, effective outreach comes from relationship-building with community members. Attending community events, spending time at Dine 'N Connect or one of Alameda's community gardens, learning about Alameda's history, involving citizens in implementation efforts (e.g., tree planting, community gardens, water conservation), and speaking with community leaders and youth at local gatherings are all ways to build relationships and connect with diverse and more representative audiences. This may be a slow process, but it is necessary for bridging the gap between the City and residents.

The CARP TF, comprising representatives from HOAs, environmental groups, businesses, and other groups, should continue to function as a permanent sounding board for issues related to implementation. It should also specifically focus on broadening to more truly represent all Alamedans. CASA, the core community group involved from the CARP's beginning to end, is an important part of this TF and effort to broaden community participation.

Keep Implementing Best Practices

To successfully implement the CARP, the City will have to continue searching for and applying best practices and lessons learned from other cities. The City will explore organizational structure and staffing of counties and cities in the region that have expanded their climate resilience capacity for lessons learned that specifically apply to Alameda (see "State, Regional, and County Governance" section above). Furthermore, highlighted below are some operational best practices adapted from the City of Santa Cruz (Clark et al., 2012) and City of Santa Monica (Jewel, 2013) that the City will consider:

- **Build on current success:** Focus resources, where possible, on existing Alameda programs and actions that have already shown success. Try to start with some easy wins in CARP implementation and build upon those.
- **Learn from other cities:** By learning from other cities and counties, the City may be able to reduce costs of CARP implementation by replicating successful efforts elsewhere.
- **Partner with cities:** Work with other cities that have adopted, or are in the process of adopting, GHG reduction and adaptation actions to draw on the expertise of partners and realize economies of scale.

- **Commit human and financial resources from the City budget:** The CARP requires committed and long-term staff and resources to successfully implement the plan. Consider grants, utility funding, and innovative resources for financing the CARP implementation.
- **Integrate CARP with other plans:** Connect the CARP and its goals with other planning documents and policies in Alameda. Particularly, incorporate these projects in the City's Local Hazard Mitigation Plan and integrate them with the City's recently adopted Emergency Response Plan where recovery is addressed.
- **Ensure internal communication among responsible City departments:** The City worked closely with the GWT, which is composed primarily of City representatives, for the development of the CARP. Any internal City departments and bodies involved in implementation, like the GWT, should ensure that efforts are implemented successfully through interdepartmental communication, prioritization, and cost sharing. These departments and bodies include Alameda PUB and AMP as well as the Public Works, Community Development, and Recreation and Parks Departments.
- **Seek guidance and leadership from the City Manager's Office:** CARP implementation efforts that are the shared responsibility of multiple departments necessitate the oversight and leadership of the City Manager's Office.
- **Establish necessary advisory bodies and public outreach:** Identify advisory bodies that can help the City implement the CARP and evaluate the results. Advisory bodies can help identify the most effective methods of ensuring that CARP implementation is community-driven and stakeholders are engaged. In addition, advisory bodies can help ensure actions are implemented equitably and prioritize populations most vulnerable to climate change impacts.

Align CARP with Other Plans

Planning and Design

- Storm Drain Master Plan
- Town Center Waterfront Plan
- AMP Strategic Plan

Implementation

- Alameda Point MIP
- Local Hazard Mitigation Plan
- Emergency Response Plan
- TCP
- ZWIP Update

Understanding best practices and lessons learned from other cities implementing climate action plans will help the City plan for a successful implementation process in Alameda.

CARP Timeline and Milestones

Upon approval of the CARP, the City will follow the staffing guidance and processes described above to efficiently and effectively implement the CARP. The timeline below (Figure 6-3) provides a focused look at key phases to make critical early progress and launch CARP implementation over the next five years. To ensure the momentum in developing the CARP continues to implementation, many tasks are front-loaded in the first two years, though some of these tasks will be pushed out unless immediate hiring and resource re-allocation occurs. The focus on implementation in the first five years underlines that this iteration of the CARP is a starting point, not a final answer, for how Alameda will tackle climate change from now until 2030. The timeline of certain actions and GHG emissions reduction goals may advance based on future City Council decisions. The annual reports and 2025 update will provide opportunities to course correct based on emerging science and technology as well as community and City Council priorities.

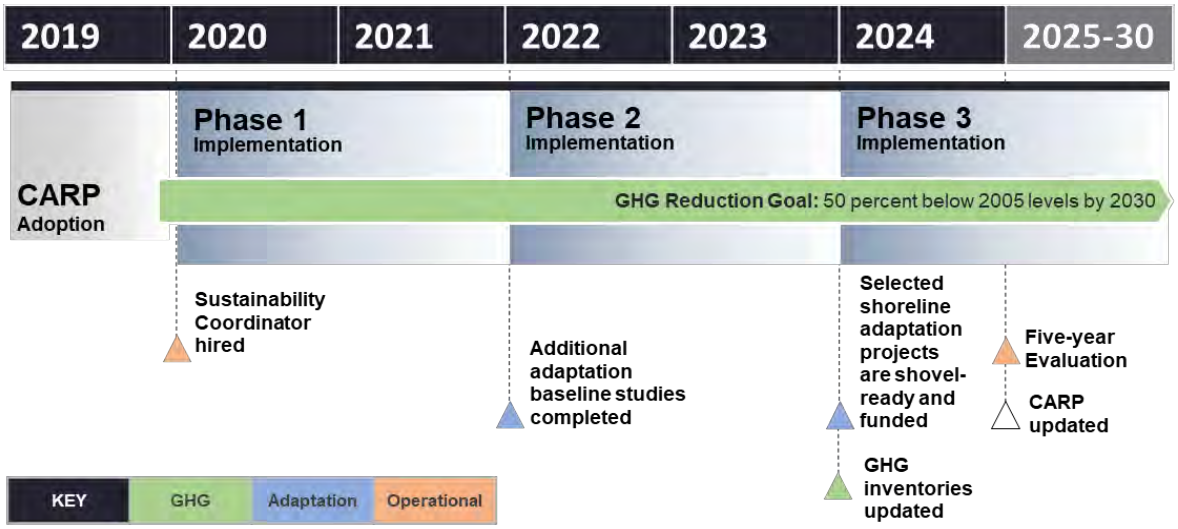


Figure 6-3. Timeline for CARP launch.

Table 6-2 provides details on specific milestones to be achieved within the first several years after CARP adoption. Working toward these early milestones will allow the City to stay on track toward meeting longer-term CARP goals.

Table 6-2. Milestones for CARP Launch (Years 1–5)

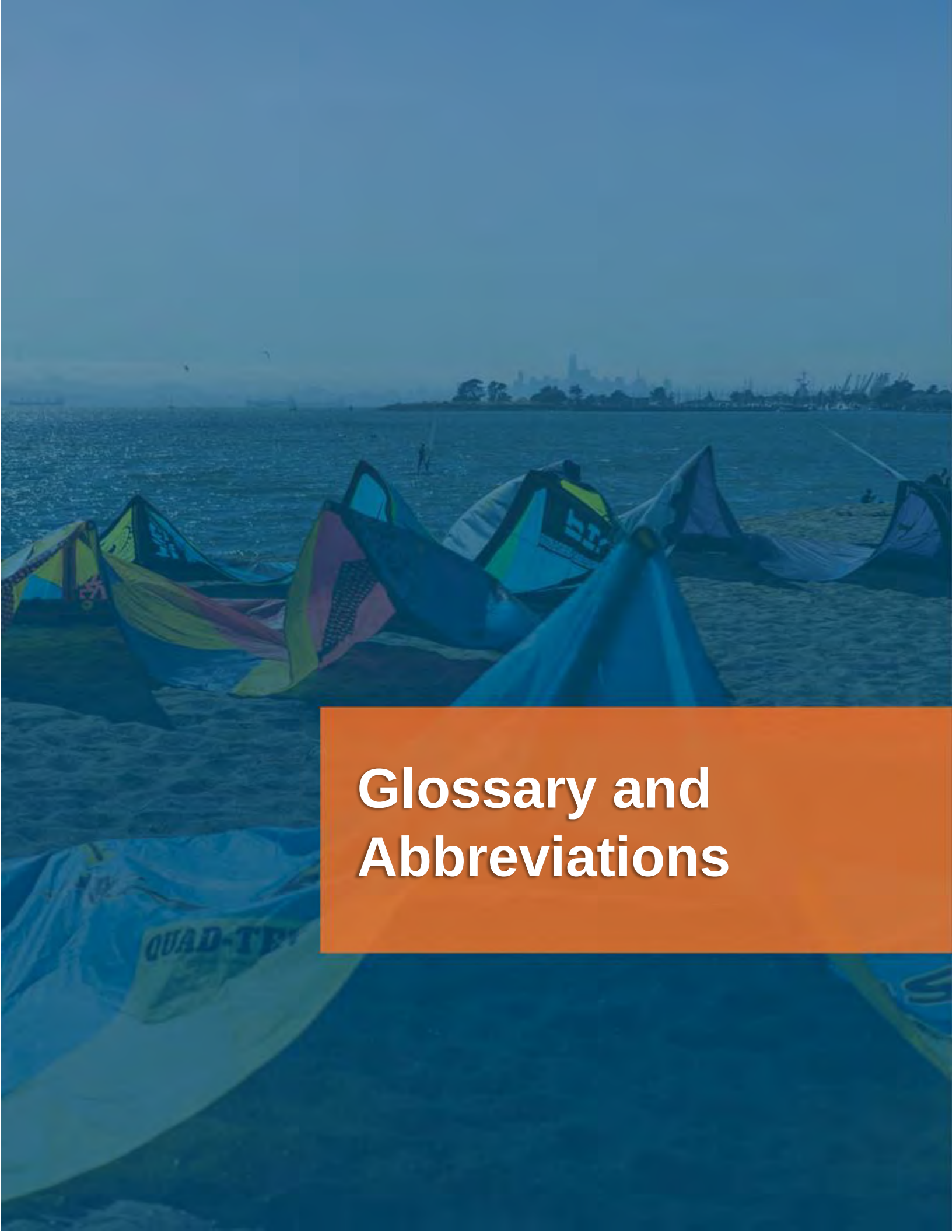
PHASE 1 MILESTONES (Years 1–2 from Plan Adoption)	
Category	**Milestone**
	Reassess City's current organization and staffing structure, including governance, staffing, cost, and revenue, and recommend changes in budget proposals.
	Train staff and implement new "Climate Impacts" section in staff reports.
	Hire a Sustainability Coordinator.
	Reconvene GWT by October 2019.
	Reconvene expanded climate TF by December 2020.
	Submit first annual report by June 30, 2020.
	Continue implementing TCP, including expanding bicycle/pedestrian infrastructure.
	Continue implementing ZWIP Update.
	Continue implementing AMP's Strategic Plan and EV Plan.
	T1: Encourage telecommuting.
	T3: Improve traffic signal synchronization.
	T5: Ban gas-powered leaf blowers.
	T6: Increase availability of EV charging stations.
	T7: Promote purchase of LEVs and ZEVs.
	T8: Continue programs to encourage new EV purchases.
	T9: Continue to encourage businesses to install EV charging stations.
	T10: Electrify City's fleet.
	E1: Fuel switch in existing buildings (including City buildings).
	E2: Require new residential construction to be all-electric.
	E3: Continue programs to encourage fuel switching in certain appliances.

PHASE 1 MILESTONES (Years 1–2 from Plan Adoption)	
Category	**Milestone**
	S1: Complete feasibility study of compost in Alameda parks and open spaces.
	S2: Continue development of urban forest and update Master Street Tree Plan.
	Update Alameda Point MIP for consistency with CARP.
	Develop shovel-ready shoreline adaptation project at Veteran's Court seawall (location-based priority flooding).
	Conduct study on sea level rise impacts on groundwater rise in Alameda.
	Continue working with Alameda County on community outreach during weather and hazard-related emergencies.
	Raise stormwater fees to implement Storm Drain Master Plan.
	Finalize, approve, and begin implementing Green Infrastructure Plan.
	Continue water conservation programs and drought-resistant landscaping programs.
	Voters consider an infrastructure bond to include adaptation and GHG reduction projects.

PHASE 2 MILESTONES *(Years 3–4 from Plan Adoption)*	
Category	**Milestone**
	Annual report to include updated GHG inventory and updates on key issues such as Climate Fund, carbon offsets, status of natural gas bans, and right mix of incentives/requirements for GHG reductions.
	All Phase 1 GHG milestones will carry over into Phase 2.
	T5: Implement ban on gas-powered leaf blowers.
	E2: Implement requirement that new residential construction be all-electric.
	Fill critical information gaps related to shoreline condition and jurisdiction to create additional shovel-ready shoreline adaptation work.
	Integrate findings on groundwater rise into adaptation planning process.
	Continue implementing Storm Drain Master Plan.
	Continue implementing Green Infrastructure Plan.
	S1: Apply compost in Alameda parks and open spaces.
	Construct shoreline adaptation project at Veteran's Court seawall.
	Design and permit shovel-ready adaptation project at areas of location-based priority flooding.

PHASE 3 MILESTONES *(Year 5+ from Plan Adoption)*	
Category	**Milestone**
	Commission five-year evaluation review of CARP implementation and submit CARP update to City Council.
	T2: Build more bike lanes.
	T4: Expand citywide *EasyPass* program.
	E4: Install green roofs on new developments at Alameda Point.
	Design and permit shovel-ready adaptation project at additional priority flooding locations.

By carefully planning and taking incremental steps to achieve these GHG reduction and resiliency goals, the City of Alameda is making an investment today that will ensure we have a vibrant, sustainable community into the future.



Glossary and Abbreviations

Glossary

Action
A specific step taken to implement a strategy.

Adaptation
Actions taken to increase resilience to climate change impacts by reducing vulnerability.

Adaptive capacity
The ability of people, ecosystems, or assets to adjust to climate change to avoid potential damages or cope with the consequences.

Blue carbon
Carbon sequestered and stored by wetlands and other coastal ecosystems helping to mitigate the effects of climate change.

Business as usual
The scenario in which future greenhouse gas emissions are forecast assuming no further mitigating actions are taken other than those mandated by state or federal policy.

Climate model
A quantitative method to simulate interactions of the important drivers of climate—including atmosphere, oceans, land, and ice—to develop projections of future climate.

Climate scenario
A coherent, internally consistent, plausible description of possible climatic conditions.

Co-benefit
Indirect benefits to the community (e.g., public health, economic, equity) caused by climate adaptation and mitigation policies.

Cool roofs
Roof surfaces designed to reflect radiation from the sun, reducing heat transfer into the building.

Ecosystem-based adaptation
Using and enhancing natural systems as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change.

Ecosystem services
Contributions of ecosystems to human well-being. For example, ecosystems produce resources used by humans such as clean air, water, food, open space, flood control, climate mitigation, and other benefits.

Environmental justice
The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Evaluation criteria
Factors to consider in identifying priorities when exploring the benefits and trade-offs associated with options to mitigate or adapt to climate change.

Equity
The state or quality of being just and fair in the way people are treated. This means no group or community faces disadvantages in dealing with environmental hazards or disasters.

Exposure
The presence of people, ecosystems, or assets in places and settings that could be adversely affected by climate change impacts.

Goal
A broad, high-level statement of future outcome that will be achieved through strategies and actions.

Greenhouse gas
Any gaseous compound in the atmosphere that is capable of absorbing infrared radiation, thereby trapping and holding heat in the atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, and other compounds.

Greenhouse gas reduction
Actions taken to reduce the number and severity of potential future climate impacts compared to un-checked greenhouse gas emissions.

Green infrastructure
An approach to water management that protects, restores, or mimics the natural water cycle.

Green roofs
Roofs designed with vegetation to absorb heat, carbon dioxide, and rainwater.

Groundwater
Water that occurs beneath the water table in soils and geologic formations that are fully saturated.

Hazard
The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

Heat island
An area characterized by temperatures higher than those of the surrounding area, usually due to exposed pavement and lack of tree canopy.

Impact
An effect of climate change on the structure or function of a system: for example, environmental consequences of climate change, such as extreme heat waves, rising sea levels, or changes in precipitation resulting in flooding and droughts.

Indicators
Observations or calculations that can be used to track and communicate conditions and trends.

Inundation
The submergence of land by water.

King tide
An especially high tide caused by alignment of the gravitational pull between the sun and the moon.

Living shorelines
A natural alternative to bulkheads and seawalls that uses or mimics natural ecosystems and works within the landscape to provide shoreline protection and maintain habitat.

Managed retreat
Breaching an existing shoreline and allowing the land behind to be flooded as an alternative to reinforcing the shoreline with an engineered approach. This may be accompanied by land use policies to discourage development in the area or buy-back programs.

Metric
A quantitative measure (and units of data) used to determine if progress is being made toward a goal.

Mitigation
A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas emissions.

Net zero greenhouse gas emissions
Balancing the amount of carbon released with an equivalent amount of carbon sequestered.

Objective
A specific aspect of a goal that indicates steps that will be taken or progress that will be made to achieve the goal.

Overtopping
The condition where flood or sea level rise water levels exceed the elevation of the shoreline, allowing water to flow inland.

Performance metrics
Quantitative measures to assess change or progress toward climate goals.

Resilience
The ability to recover quickly from climate change impacts.

Risk
Threat posed by a negative impact or hazard event. It is the combination of likelihood and consequence.

Saltwater intrusion
The movement of saline water into freshwater aquifers.

Scenarios
A plausible and often simplified representation of the future climate based on an internally consistent set of climatological relationships.

Sea level rise
An increase in the mean level of the ocean—a change in global average sea level brought about by an alteration to the volume of the world ocean. Relative sea level rise occurs where there is a net increase in the level of the ocean relative to local land movements.

Sea wall
An artificial structure erected to prevent the sea from encroaching on or eroding an area of land.

Sensitivity
The degree to which people, ecosystems, or assets are affected by climate change.

Storm surge
The temporary increase in the height of the sea due to atmospheric pressure changes and wind associated with a coastal storm that pushes sea water above the level expected from the tidal variation alone.

Strategy
A method or approach taken to achieve a goal.

Total water level
The combination of tides, storm surge, and sea level rise that makes up a single flood scenario (above today's mean higher high-water level. For example, a total water level of 36 inches above today's high tide can result from scenarios such as a 50-year storm today or 36 inches of sea level rise in the long term.

Vision
An aspirational statement that describes the organization's purpose, values, and picture of the future.

Vulnerability
The degree to which a system is susceptible to or unable to cope with, adverse effects of climate change. Vulnerability consists of the following:

- Exposure: The presence of people, ecosystems, or assets in places and settings that could be adversely affected by climate change impacts.
- Sensitivity: The degree to which people, ecosystems, or assets are affected by climate change.
- Adaptive capacity: The ability of assets, systems or people to adjust to an adverse impact.

Vulnerability assessment
A process for identifying who and what is impacted by climate change. It is the combination of exposure, sensitivity, and adaptive capacity.

100-year flood
Severe flood levels with a one-in-100 likelihood of occurring in any given year.

Abbreviations

AB	Assembly Bill (State of California)
ABAG	Association of Bay Area Governments
AMP	Alameda Municipal Power
ART	Adapting to Rising Tides
BART	Bay Area Rapid Transit
BAU	Business as usual
BayCAN	Bay Area Climate Adaptation Network
BCDC	Bay Conservation and Development Commission
BEV	Battery electric vehicle
C&D	Construction and demolition
CalEPA	California Environmental Protection Agency
CalOES	California Office of Emergency Services
Caltrans	California Department of Transportation
CARB	California Air Resources Board
CARP	Climate Action and Resiliency Plan
CASA	Community Action for a Sustainable Alameda
CBP	Commuter Benefits Program
CEC	California Energy Commission
CERT	Community Emergency Response Team
CIS	Community Input Session
CO2	Carbon dioxide
CO2e	Carbon dioxide equivalent
COAST	Coastal Adaptation to Sea Level Rise Tool
DOE	U.S. Department of Energy
DTSC	Department of Toxic Substances Control (CalEPA)
EBMUD	East Bay Municipal Utility District
EBRPD	East Bay Regional Park District
EIFD	Enhanced Infrastructure Financing District
EMS	Emergency medical services
EO	Executive order
EPA	U.S. Environmental Protection Agency
ERG	Eastern Research Group, Inc.
ESCO	Electric service company
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FEMA	Federal Emergency Management Agency
FTE	Full-time equivalent
GHG	Greenhouse gas
GWT	Green Working Team (City of Alameda)
HOA	Homeowners’ association
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour

LEV	Low emission vehicle
MHHW	Mean higher high water
MIP	Master Infrastructure Plan
MTC	Metropolitan Transportation Commission
MTCO2e	Metric tons of carbon dioxide equivalent
NAVD	North American Vertical Datum
O&M	Operations and maintenance
OPC	Ocean Protection Council
PACE	Property Assessed Clean Energy
PG&E	Pacific Gas and Electric
PHEV	Plug-in hybrid electric vehicle
$PM_{2.5}$	Particulate matter with a diameter of 2.5 micrometers or less
PUB	Public Utilities Board
RWQCB	Regional Water Quality Control Board
SAV	Submerged aquatic vegetation
SB	Senate Bill (State of California)
SFEI	San Francisco Estuary Institute
SR	State route
SULEV	Super ultra-low emission vehicle
SVA	Social vulnerability assessment
TCP	Transportation Choices Plan
TCM	Travel-cost method
TF	Task Force (City of Alameda)
UC	University of California
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VA	U.S. Department of Veterans Affairs
VMT	Vehicle miles traveled
WETA	Water Emergency Transit Authority
ZEV	Zero emission vehicle
ZWIP	Zero Waste Implementation Plan

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