Chapter 4
Climate Adaptation

4.1 Introduction

Climate change is a global phenomenon that over the long-term has the potential for a wide variety of impacts on human health and safety, economic continuity, water supply, ecosystem function, and the provision of basic services. Locally, climate change is already affecting and will continue to affect the physical environment throughout California, the San Diego region, and the City of Solana Beach (City). As a result of Executive Order (EO) S-13-08, the California Natural Resources Agency (CNRA) developed the SafeGuarding California Plan (California Natural Resources Agency, 2018), which integrates the State's climate adaptation strategy with public and private entities at the local, regional, state and federal levels. However, because impacts of climate change vary by location due to physical, social and economic characteristics, it is important to identify the projected severity these impacts could have in the City.

Periodic scientific examinations of the potential impacts of climate change in California are carried out by California's Climate Change Assessments (Climate Change California, 2019). The 4th and most recent assessment includes findings for nine regions and different communities, including the San Diego Region and Coast and Ocean Communities. For the San Diego region, these key findings are summarized in Appendix 1. Some of the climate change effects in this report refer to this 4th California Climate Change Assessment (Climate Change California, 2019) and references therein. Additional references are as noted. Furthermore, Cal-Adapt (Cal-Adapt, 2019) a climate change scenario planning tool, was used to acquire city and location specific information which was not available in the Assessment. Using Localized Constructed Analogs (LOCA) Cal-Adapt downscales global climate simulation model data to local and regional resolution for two possible climate change projections, one in which emissions peak around 2040 and then decline (Representative Concentration Pathway (RCP) 4.5) and another in which emissions continue to rise throughout the 21st century (RCP 8.5) in a business-as-usual scenario.

4.2 Climate Effects and Solana Beach Adaptation Strategies

This section describes how the regional climate change effects highlighted in Appendix 1 could be felt locally. It also defines the specific steps necessary to prepare for the future effects of a changing climate. These adaptation strategies build upon current efforts to be proactive, more sustainable and resilient. It is important to note that many of these strategies also have the potential to provide other important co-benefits to the community. The City's General Plan already contains a number of policies aimed at maintaining balanced land use throughout the City's recreational and residential areas; promoting the protection, maintenance, and use of natural resources; preserving and rehabilitating neighborhoods and commercial areas; and achieving and sustaining a high quality of life for citizens and visitors.

The City's climate adaptation strategies are grouped into the nine categories listed below. The effect of these categories on public health and safety will be collectively described in the Public Health and Safety section.

- Increase in Temperatures and Extreme Heat;
- Variable Water Supplies;
- Increased Risk of Wildfire;
- Coastal Erosion and Sea Level Rise;
- Flooding;
- Increased Energy System Demand;

- Threats to Public Health and Safety;
- Threats to Coastal Habitat; and
- Climate Justice.

4.2.1 Increase in Temperatures and Extreme Heat

Climate change will impact regional temperatures in a number of ways including average temperatures, highs and lows, geographic patterns and extreme heat events. Annual temperatures in the San Diego region are projected to climb steadily. By the end of the century, yearly average temperatures are expected to increase by 4-6 ºF (~2.2-3.3 ºC) under RCP 4.5, the low emissions scenario, and by 7-10 ºF (3.6-5.8 ºC) under RCP 8.5, the high emissions scenario.

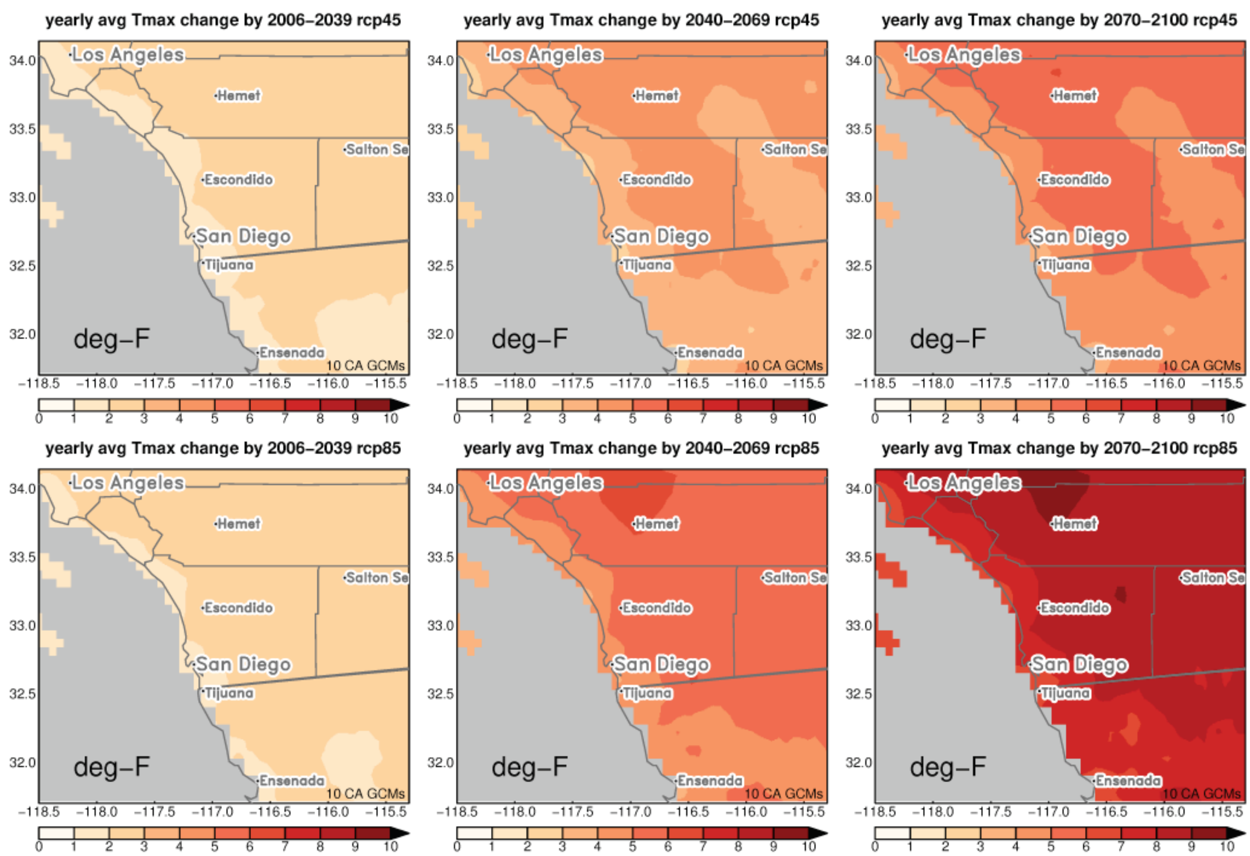

Fig. 1 A map showing the average Tmax increase at early, mid and end of century relative to 1976-2005 climatology for RCP 4.5 (top) and RCP 8.5 (bottom). (Kalansky, et al., 2018)

Increase in lows and highs. In addition to the average temperature, average annual low and high temperatures are also projected to increase, with lows typically associated with nighttime temperatures. Average historical low and high temperatures for Solana Beach over the period of 1961 – 1990 are 53.4 ºF and 73.4 ºF respectively. Cal-Adapt calculations for the period 2070 – 2099 projects an annual average increase in low temperatures from 53.4 to 58.1 (RCP4.5) and 61.2 (RCP8.5) and an annual average high temperature increase from 73.4 to 77.8 (RCP4.5) and 80.6 (RCP8.5) accordingly.

Geographic temperature variations. Atmospheric temperatures vary from the coast to inland areas usually because of prevailing winds bringing cooler oceanic air masses and marine cloud layers. As the planet warms, the amount of summer warming in the interior regions of San Diego County is projected to exceed that along the immediate coastal margin by more than 32.9 ºF by mid-21st century. At the end of the century (2070-2100), under RCP 8.5, the average hottest day per year is projected to increase from 90-100 ºF to 100-110 ºF near the coast and from 105-115 ºF to 110-125 ºF in the deserts (Guirguis, et al., 2018).

Increase in extreme heat events and heat waves. Climate change is also expected to result in an increase in extreme heat events (i.e. days per year when the maximum temperature is above the extreme heat threshold of 92.1 °F.) Historically, Solana Beach has experienced an average of 5 extreme heat days over the years of 1961- 1990. Using LOCA downscaling for Solana Beach, Cal-Adapt projections show average number of extreme heat days increasing to 12 and 31 for RCP 4.5 and RCP 8.5 scenarios respectively, over the period between 2070 and 2099. Similarly, the maximum duration or longest stretch of consecutive extreme heat days is also expected to increase.

Four consecutive extreme heat days is considered to be a heat wave. Although the relationship between background warming and probability of a heat wave occurrence is currently not well understood (Guirguis, et al., 2018) , observations indicate that heat waves in the region have become more humid, with warmer nighttime temperatures (Gershunov, et al., 2009) (Gershunov & Guirguis, 2012). High humidity can exacerbate the impacts of heat on health. Heat Waves, which historically started in late June and ended in mid-October, are also projected to occur both earlier and later in the season.

There are some existing measures in place, regionally, to address the negative impacts of increased temperature. For example, the county has established regional cool zones (San Diego County Government, 2019) to provide residents a refuge during extreme heat events. The Solana Beach Library is the closest cooling zone. As increasingly humid heat waves drive up nighttime temperatures, it will also be important to identify cool zones that may be open at night. A number of other measures relating to human health and energy resources, for example, are addressed in other sections.

STRATEGIES TO PREPARE FOR INCREASE IN TEMPERATURES AND EXTREME HEAT

Strategy 1: Coordinate response with relevant agencies. Coordinate response with relevant agencies to better plan and prepare emergency services associated with extreme heat events including an influx of visitors to the beach. Efforts should include improving Heat-Health Alert Warning Systems and identifying key vulnerable populations and individuals within the City.

Strategy 2: Reduce urban heating and promote passive cooling. Incorporate green infrastructure strategies into new and existing infrastructure to mitigate the effects of extreme heat events by reducing the area of heat-absorbing paved surfaces and increasing landscaping. Examples include 1) climate-appropriate landscaping like shade trees, 2) green and cool roofs, and 3) heat-reflective surfaces and materials and 4) promoting solar carports on new and existing parking lots which both mitigates heat absorption and increases shaded areas.

Strategy 3: Incentivize energy efficient cooling. Use the California Building Standards Code (CalGreen) voluntary measures for residential and nonresidential buildings to improve energy efficiency (e.g. air sealing improvements, whole house fans, energy efficient air-conditioning units).

Strategy 4: Prepare population for extreme heat events. Educate City residents on the health risks associated with extreme heat events and strategies including advertising local cooling zones. Particular focus should be given to educating vulnerable populations including children, those with pre-existing conditions and the elderly. The City should identify organizations who already connect with these individuals to facilitate outreach and education.

Strategy 5: Protect worker safety. Work with local and regional employers to ensure worker protection measures are in place for extreme heat events. Measures may include assurance of adequate water, shade, rest breaks, and training on heat risks for all employees working in the City.

4.2.2 Variable Water Supplies

While projections generally show little change in total annual precipitation in California or the Southwestern United States, climate change is projected to increase temperatures, evapotranspiration and the variability of precipitation in the region leading to periods of prolonged drought and extreme rain events both of which can have significant negative impacts to the City. A decrease in rain will impact local water supplies, habitat, and an increase in wildfire risk whereas an increase in rainfall could lead to localized flooding.

Fresh water is supplied to the City by the Santa Fe Irrigation District (SFID). Only a small proportion of this water supply (10-20%) comes from local sources which are dependent upon local precipitation and, consequently, is highly variable. The majority of water provided by the SFID comes from the San Diego County Water Authority (SDCWA). SDCWA sources most of its water from outside the county, predominantly from the Colorado River. Colorado River water is either provided via the Metropolitan Water District of Southern California (MWDSC) or via water transfer agreements with the Imperial Irrigation District. Additionally, there is a smaller external supplement to the SDCWA from the Sierra snowpack water through the MWDSC. Consequently, water availability to the City is linked both to local and regional changes in precipitation and weather patterns. All of these natural water supplies are projected to decrease due to a combination of the warmer climate in the region, changes in precipitation patterns, increased evapotranspiration, especially in the Colorado River watershed, changes in river flow timing caused by rainfall instead of snow at higher elevations, especially in the Sierras, and more frequent and severe periods of drought in the region. Future water supplies from the Sierras are also expected to be affected by the CALFED program, which is trying to balance water supplies with environmental goals for the Sacramento-San Joaquin River Delta, as well as the amount, timing, and availability of freshwater associated with the Sierra snowpack. Thus, the City will face increasing challenges providing adequate water supplies and users could face shortages in normal or dry years.

In preparation for a reduced and less predictable water supply, local water authorities are working to find alternative sources and diversify the water supply. In 2015 the Poseidon desalination plant in Carlsbad was opened and is currently producing 50 million gallons of water per day in the San Diego County Water Authority supply, which is about 10% of its total. Local water authorities are also moving towards purifying wastewater for potable reuse. The San Diego County Water Authority aims to increase potable reuse to 17% of the county water supply by 2035. Potable reuse is typically less expensive than desalination and is considered an important drought-proof compliment to a portfolio of water sources.

Some adaptation programs targeting variable water supplies are already in place at the City. Solana Beach and Encinitas operate the San Elijo Water Reclamation Project (SEWRP) through the San Elijo Joint Power Authority (SEJPA). Currently, some of the wastewater stream is processed into grey water that can be used for landscaping, agriculture, gardening, etc. by the surrounding communities in place of potable water. Other programs which may be accessed from the City's website include an online water waste reporting form; a City app with a feature to report water waste; information about the potential to capture and use graywater for irrigation; and requirements that new homes use drought tolerant landscape alternatives.

STRATEGIES TO PREPARE FOR VARIABLE WATER SUPPLIES

Strategy 1: Drought related public education. Educate the public about water conservation programs including graywater systems; methods to report water waste; rainwater catchment systems; and provide resources for the conversion to drought tolerant landscaping including type of vegetation and low flow irrigation systems.

Strategy 2: Increase local recycled water supplies. The SFID purchases recycled water from the SEJPA which is jointly owned by the City and its neighbor Encinitas. The City should advocate for increasing recycled water supplies with specific emphasis on the development of potable reuse.

Strategy 3: Enhance recycled water infrastructure and distribution. Increase recycled water distribution infrastructure throughout the City to maximize the use of recycled water that is produced at the SEJPA facility. As part of its 2019-2020 Workplan, the City will analyze the ability to bring recycled water further into the City for potential commercial properties, park/medians and for all City facilities. It will also encourage private properties to hook up to recycled water where it is available.

Strategy 4: Conduct study of stormwater capture and reuse options and costs. Quantify stormwater capture potential and coordinate with SFID and the SEJPA to determine the desirability and feasibility to incorporate rainwater into the City's water supply. Explore centralized versus distributed stormwater capture possibilities. Evaluate costs/benefits of potential projects.

4.2.3 Increased Risk of Wildfire

Drought conditions and rising temperatures associated with climate change have already increased the likelihood of large wildfires. Wildfires in the San Diego region now occur throughout the year, but primarily during late summer and early fall. An increased incidence of wildfires contributes to property damage, direct injuries and mortality, and indirect health effects from air pollution. One of the main areas of concern is the Urban Wildland Interface. In Solana Beach this is the interface along the northern and eastern edge where the City abuts San Elijo Lagoon, San Dieguito Park, and Rancho Santa Fe.

There are a number of entities within and adjacent to the City that have developed strategies to mitigate increased wildfire risk. The village of Rancho Santa Fe has completed a Forest Health Study and is working with adjacent groups, such as the San Dieguito River Park, as well as its residents to remove dead or dying trees and brush on private property or county land, especially in the river valleys, and replant with more sustainable varieties. The Nature Collective (formerly the San Elijo Lagoon Conservancy), in cooperation with the local Fire Department, works with residents to thin excessive vegetation from areas near homes and maintain defensible space.

The San Diego Gas and Electric utility maintains a real time county wide meteorological and wildfire monitoring system (see "Everything in Our Power" video on YouTube produced by SDGE) to suppress wildfire potential and improve response time to fire initiation (www.alertwildfire.org). They also actively remove or trim the trees and other vegetation in the vicinity of the transmission lines and facilities that are part of its electrical grid. As a last resort, SDGE can also cut power to communities to avoid wildfires. Finally, the Solana Beach Fire Department has a list of strategies and goals to both reduce GHG and reduce and plan for increased wildfire risk.

In January 2009, the City along with the United States Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), County of San Diego and the San Elijo Lagoon Conservancy prepared the San Elijo Lagoon Vegetation Management Plan and signed a second more specific MOU for the purpose of establishing a vegetation management program for the lands in and adjacent to the lagoon. This program maximizes the protection of natural resources and minimizes the risk from wildfire in the City at the wildland-urban interface along the San Elijo Lagoon. Fire hazard related policies are consolidated in Chapter 4 of the City's Land Use Plan (LUP) (City of Solana Beach, 2019).

STRATEGIES TO PREPARE FOR INCREASED RISKS OF WILDFIRE

Strategy 1: Increase fire resistance through landscaping and building materials. Conduct a health survey of trees and vegetation within the city boundaries. Promote the use of fire-resistant building design, materials, and landscaping, including defensible space, and provide associated educational materials to residents and those seeking permits. Explore low or no cost incentives. This should include the identification and removal of dead and dying trees and vegetation especially from the wildland-urban interface and replacement with more drought tolerant and appropriate species wherever possible.

Strategy 2: Continue to update the Multi-jurisdictional Hazard Mitigation Plan (MHMP). Update the MHMP (San Diego County, 2020) every five years as required and work to implement all strategies in the City's current MHMP.

Strategy 3: Coordinate with relevant agencies and adjacent communities. Coordinate with agencies including Office of Emergency Services (OES), the California Department of Forestry and Fire Protection (CAL FIRE), the Solana Beach Fire Department, and San Diego Gas and Electric, as well as adjacent communities, such as Escondido, Encinitas, Del Mar, and Rancho Santa Fe on the development of a wildfire action plan, the mapping of areas at a high risk of experiencing wildfire impacts, mitigating risk (fuel reduction strategies) where possible, and protecting vulnerable populations and businesses during scheduled power outages for wildfire threats.

Strategy 4: Increase citizen participation in the Community Emergency Response Team (CERT). Promote and encourage citizens to enroll in the CERT program which educates citizens about disaster preparedness for hazards and trains them in basic disaster response skills.

Strategy 5: Fire prevention awareness. Educate the public on fire prevention and preparedness including 1) mitigation strategies to reduce loss of life, property damage, and impacts to natural resources, 2) evacuations and early warning systems, 3) large animal evacuations, 4) fuel/vegetation management; 5) hardening of structures and 6) ignition source reductions.

4.2.4 Coastal Erosion and Sea Level Rise

One consequence of climate change that will disproportionately impact coastal communities is sea level rise. Sea level rise is primarily caused by the addition of water from the melting of land based ice sheets and glaciers and the expansion of water from warming. While future projections vary, especially because of uncertainties in the rate of ice loss in the major ice sheets of the world, the recent report developed by the California Ocean Protection Council (OPC) projects that by the year 2100, sea levels may rise by approximately 2.4 to 6.9 feet, with the potential for an extreme scenario of 10.2 feet of sea level rise caused by more rapid ice sheet loss in Greenland and Antarctica (Ocean Protection Council, 2018). While the California coast regularly experiences erosion, flooding, and significant storm events, sea level rise will exacerbate these natural forces, leading to significant social, environmental, and economic impacts. The state encourages the use of the more extreme scenarios for local planning of projects with a lifetime greater than 50 years.

Since the City of Solana Beach does not include the estuaries that form the northern and southern boundaries of the City, we focus only on the issues associated with the beaches and bluffs. Solana Beach has 1.7 miles of narrow beach, backed by 75-foot-tall bluffs, of which more than 50 percent are protected by some type of shoreline protection device (e.g., seawall) and nearly all have houses or condominiums built on top. While bluff erosion is a natural process, it has accelerated in Solana Beach over the last several decades due, in part to, the damming of rivers and armoring of bluffs which historically contributed to the natural sand supply. Sea level rise is expected to further accelerate this erosion. One recent USGS study projects that coastal cliffs from Santa Barbara to San Diego may crumble at more than twice the historical rate by the year 2100 as sea levels rise (Limber, et al., 2018).

In recognition of existing and future bluff erosion as a significant concern, the City has taken a number of steps to manage its actively eroding shoreline. For example, it has worked with the California Coastal Commission (CCC) for over a decade to approve its Local Coastal Program (LCP) Land Use Plan (LUP). The City is currently working on the associated Implementation Plan (IP), which is needed before the CCC will certify the LCP. This LUP outlines policies incorporating the best available science to address proposals for improvements to and redevelopment of the existing blufftop homes. These proposals and improvements include long-term shoreline and blufftop development standards that; 1) deter the complete armoring and hardening of the City's bluffs, 2) require alternatives analysis and site reassessment when considering any approval or reauthorization of lower, mid or upper bluff protective work, 3) restrict additions and improvements to non-conforming structures that perpetuate an inappropriate line of development in a hazardous location; and 4) clarify what legitimate repair/maintenance activities can continue on non-conforming blufftop residences (City of Solana Beach Land Use Plan Amendment, 2014).

In addition, the City and Encinitas have been working for almost two decades as the local sponsors of a 50-year U.S. Army Corps of Engineers (USACE) Coastal Storm Damage Reduction Project (US Army Corps of Engineers, 2020). A full array of structural and non-structural measures including, but not limited to, managed retreat, breakwaters, artificial reefs, and seawalls were evaluated to determine if they met the project objectives and were economically justified given different sea level rise scenarios. The preferred alternatives were then evaluated to determine if implementation would result in environmental impacts. Beach nourishment with sand from offshore borrow sites was determined to be the least environmentally damaging and practical alternative. The plan and environmental permitting were completed and in February of 2020, it was announced that the U.S. Army Corps of Engineers would allocate $400,000 in federal funding for the Planning, Engineering & Design (PED) phase of the project. The PED phase will require an additional $1.5 million in federal funding. Once the PED phase is complete, the City and other stakeholders can pursue federal permission to begin construction on the project and the federal funding needed to complete the project. The City recognizes that while beach replenishment is a good option for the short-term, in the long-term other options such as managed retreat will need to be more seriously explored. This is especially true as land reclamation, industrialization, population growth and urbanization also continue to fuel explosive growth in the demand for sand, prompting many to question the sustainability of this valuable global resource (2019 UN Special Report).

Fig. 2 Bluff Collapse in Solana Beach September 13, 2019

STRATEGIES TO PREPARE FOR COASTAL EROSION AND SEA LEVEL RISE

Strategy 1: Infrastructure protection. Incorporate the best available coastal research into long-term, capital improvement projects, such as improvements to public access stairways and the Marine Safety Building.

Strategy 2: Beach replenishment. Implement and expand upon the short- and long-term sediment management programs identified in the Solana Beach & Encinitas Coastal Storm Damage Reduction Project to preserve shorelines and coastal habitat through beach replenishment and nourishment to address impacts of sea-level rise on shorelines. As a part of this process both continue to pursue federal funding and examine other funding mechanisms for beach replenishment, e.g., special taxes or bonds.

Strategy 3: Stakeholder education & outreach: Extend efforts to both coastal and inland communities to maximize opportunities for all stakeholders to participate in and inform coastal planning processes that affect public recreational resources**.** Attempt to warn the maximum number of people about coastal bluff safety. Inform the City's residents and businesses about projected sea level rise and the implications of storm surges, etc. For example, use visual presentations and installations, including signs and displays in the coastal parks and beaches that show expected sea levels and possible surges.

Strategy 4: Regional coordination. Join with other coastal cities in the region to share information and collaborate on adaptation measures and simultaneously monitor coastal erosion and sea level rise science, e.g., OPC 2018 sea level rise projections for La Jolla and risk aversion guidance and adaptation options.

4.2.5 Flooding

Climate change in the region is predicted to modify the frequency, intensity, and duration of extreme storm events. Extreme rain events may be associated with atmospheric rivers of warm, moist, tropical air masses forming narrow streams of warm, concentrated precipitation often resulting in the deposition of considerable rainfall over a short period of time. Under higher emissions scenarios, the intensity and magnitude of atmospheric rivers are expected to become more severe, resulting in increased regional and localized flooding (Dettinger, et al., 2011) (Gershunov, et al., 2019). Currently, the City experiences localized flooding during heavy rainfall in the area around Stevens Creek due to inadequate drainage.

While flooding in urban areas can occur as a result of the natural topography associated with creeks, rivers or coastal areas, "urban flooding" refers specifically to flooding that occurs in urban areas when rainfall, and not an overflowing body of water, overwhelms the local stormwater drainage capacity of a densely populated area. This happens when rainfall runoff is channeled from impervious surfaces such as roads, parking lots, buildings, and rooftops to storm drains and sewers that cannot handle the volume. In many places, swales or bioswales are replacing the traditional concrete curbs and gutters for managing stormwater. Swales are gradually sloping depressions or trenches, often lined with gravel and/or planted with vegetation, that allow rainwater to infiltrate the ground and replenish ground water. Other types of green infrastructure to minimize urban flooding might include multilevel parking lots instead of sprawling single level ones, narrower streets and green islands which also beautify the community and other possibilities. Alternative materials and designs should also be considered for building parking lots, driveways, sidewalks and roads to increase infiltration of rainwater.

Currently, the city is taking a number of steps to reduce urban runoff. Bioswales are required on new residential developments and the amount of impermeable hardscape is limited. In addition, Solana Beach has incorporated green islands in the redevelopment of roadways on Stevens and Coast Highway and proposed them for portions of Lomas Santa Fe Drive.

STRATEGIES TO PREPARE FOR INCREASED FLOODING

Strategy 1: Assess infrastructure risk. Coordinate with relevant agencies such as OES and the Public Works Department to map and identify all critical facilities and infrastructure that may be compromised by increased flood risk including storm and wastewater systems. This should include the Steven's Creek region. The City should plan accordingly for upgrades to infrastructure and coordinate with the City of Del Mar as needed.

Strategy 2: Mitigate flood risk from extreme rain events. Continue efforts for storm water catchment and water reserve system.

Strategy 3: Incentivize green infrastructure. Explore incentives for private residents, businesses and schools to implement elements such as cisterns, rain barrels, or create rain gardens and swales that would help clean stormwater runoff and direct it to landscaping or capture basins. The City should implement green infrastructure additions as part of City projects.

Strategy 4: Increase permeable/pervious pavement surfaces. When feasible, the City should consider using pervious pavement options for City projects. The City should also incentivize the use of pervious pavement options for residential and commercial projects.

4.2.6 Increased Energy System Demand

Changes in temperatures, precipitation patterns, extreme events, wildfire and sea-level rise have the potential to decrease the efficiency of thermal power plants and substations, decrease the capacity of transmission lines, render hydropower less reliable, and put energy infrastructure at risk of flooding and wildfire. According to a study of SDGE's electricity infrastructure, as part of the 4th Climate Assessment (Bruzgul, et al., 2018), thousands of electric substations, transformers, power lines, and other equipment are potentially exposed to damage under scenarios of sea level rise of 0.5 and 2.0 m (1.6 and 6.6 ft.) for both annual and 100-year storm events. The greatest potential of direct physical impacts to assets are damage to 4 substations in the Mission Bay and San Diego Bay areas.

Furthermore, extreme and prolonged high temperatures also threaten local energy supply due to high demand for electricity. A surge in energy use in the City and the San Diego region has the potential to cause brownouts or blackouts. This effect may be exacerbated by a higher proportion of renewable energy such as solar or wind whose generation is variable. In an effort to mitigate some of these effects, in 2013, the California Public Utilities Commission mandated that all investor-owned utilities switch their customers over to Time-Of-Use (TOU) rate plans. Energy pricing in TOU plans vary according to the time of day, day of the week (weekend v. weekday) and season (e.g. summer v. winter). Higher rates are charged during the peak demand hours and lower rates during off-peak (low) demand hours. TOU rate structures provide price signals to energy users to shift energy use from peak hours to off-peak hours.

On December 13, 2017, The City established a Community Choice Aggregation (CCA) framework to procure its own energy consisting of a higher percentage of renewable energy electricity at lower rates than SDGE. This effort was consistent with the City's Climate Action Plan goals to reduce GHG emissions caused by electrical demand. In the Fall of 2019, the City decided to move beyond a Solana Beach-only CCA to enter into a Joint Powers Agreement (JPA) with other regional cities to create a larger CCA.

Ensuring that Utilities and CCA programs have adequate power to meet peak demand periods has been a primary concern of the California Public Utilities Commission (CPUC) since the energy crisis. The processes and methods to ensure Resource Adequacy (RA) by CCA's are still in the process of being determined and negotiated with the CPUC.

Adaptation measures to prepare for extreme heat events listed above, such as reducing urban heat islands and promoting passive cooling, will also help reduce electrical demand.

Additional actions that the City will take to mitigate increased risk to the City's energy supply are listed below.

STRATEGIES TO PREPARE FOR INCREASED ENERGY SYSTEM DEMANDS

Strategy 1: Public education. Educate the public on how to become more energy efficient, reduce demand, and optimize time-of-use. Identify and publicize emergency solutions for vulnerable populations and infrastructure during extended power outages.

Strategy 2: Promote local energy generation and storage. Encourage and incentivize solar-based or other renewable energy sources to supplement the grid and reduce peak demand including the addition of energy storage.

4.2.7 Threats to Public Health and Safety

Climate change has been described as the biggest threat to public health this century (Costello, et al., 2009). In addition to the consequences listed in sections 4.2.1- 4.2.6, we will face new ecological challenges such as increases in vector- and water-borne diseases and food insecurity (Ebi, et al., 2018). Fig 3 (Federal Centers for Disease Control and Prevention) provides a graphic summary of some of these effects.

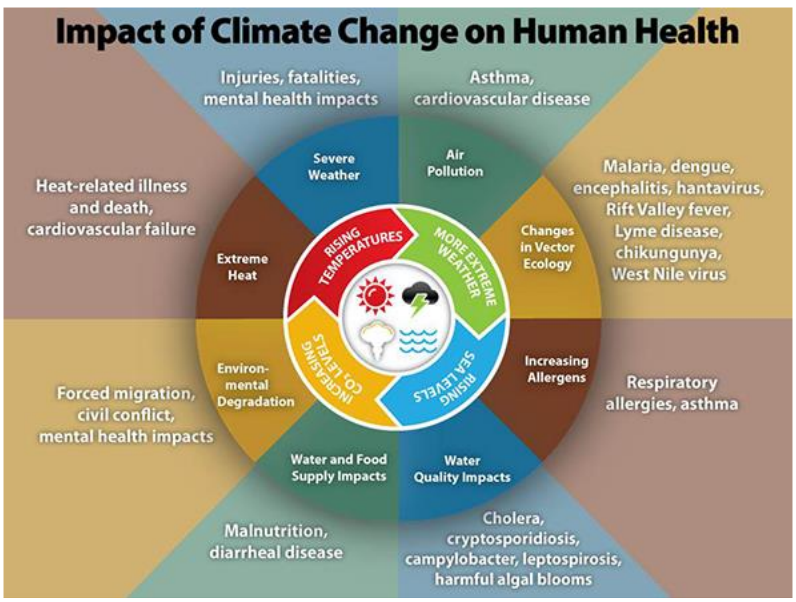

Fig 3 Human Health Impacts of Climate Change

Health impacts. In California, the strongest health impacts from recent heat waves have been found at the coast (Gershunov, et al., 2011) (Guirguis & Gershunov, 2014) (Knowlton, et al., 2009). These warming trends will pose challenges for Solana Beach where physiological acclimatization and air conditioning penetration are lower than the state average (Gershunov & Guirguis, 2012). The need for more air conditioning can stress supplies of electricity.

Prolonged or intense exposure to high temperatures can impact human health in a number of ways. Heat related illnesses include heat exhaustion, heat cramps, and heat strokes.

Environmental impacts include a reduction in air quality due to increasing ozone levels and particulate matter concentrations, which can cause asthma and shortness of breath. Sensitive populations include the young, elderly and those with pre-existing health conditions. Outdoor workers, such as construction and maintenance workers, are also more susceptible due to extended periods of exposure. The 2006 California heat wave resulted in 147 reported deaths, over 1200 hospitalizations, and over 16,000 emergency room visits (Knowlton, et al., 2009). In addition to effects on overall health, excessive heat has been shown to cause an increase in violent crime and mental illness. Studies have found that those living in microclimates that are hotter and less vegetated have higher risk of morbidity or mortality (Schinasi & De Roos, 2018).

Increased risks from wildfires pose both direct and indirect risks to public health. Smoke produced from wildfires can denigrate the air quality throughout the county and is associated with respiratory and cardiovascular disease. The health impacts of the 2015 California wildfires were greatest among adults ≥65 years, indicating that the health effects of climate change impact different population groups differently (Wettstein, et al., 2018).

Climatic change can alter the range, biogeography, and growth of insects, microbes and vector-borne diseases. Changes in aquatic environments may result in increases in harmful algal blooms which in turn lead to increases in foodborne and waterborne illnesses. For California, increased average temperatures and can shift infectious diseases typically found in lower latitudes toward the north. Solana Beach is bounded by two estuaries, San Elijo Lagoon to the north and San Dieguito Lagoon to the south. These bodies of water can provide breeding grounds for mosquitos such as *Aedes aegypti* and *Aedes albopictus* (Figure 4).

Fig. 4 Aedes aegypti and Aedes albopictus.

Both these species have the potential to transmit infectious diseases such as chikungunya, dengue, yellow fever and the Zika virus and both have been undergoing massive expansion as a result of climate change, human migration, and accelerating urbanization (Messina, et al., 2019).

Temperatures and pooling water are two critical factors in a mosquito's life cycle and, subsequently, their potential to spread disease. Warmer temperatures accelerate the life cycle of both the mosquito and the viruses they carry. Increased flooding leaves behind pools of water that provide abundant habitat for mosquitos to breed. Rising seawater levels and high tides can also create brackish water habitat in coastal areas in which certain adapted mosquitos can breed. While, the relationships are complex, the consensus is that mosquito-borne diseases will increase with climate change (Campbell-Lendrum, et al. 2015). Researchers (Kraemer, et al., 2019) concluded that by 2050, *Aedes aegypti* and *Aedes albopictus* will significantly expand their range, posing a threat to 49 percent of the world's population (Yale School of Forestry & Environmental Studies, 2019).

In addition to mosquitos, climate change may also cause a range expansion for ticks. Although Lyme disease carried by ticks is rare in San Diego County – found mostly in coastal and rural areas - the CDC has now determined it to be the most commonly reported vector-borne disease in the United States since it was first identified in Connecticut in 1975. As of April 2019, the County has also found several ticks carrying Tularemia, a bacterial disease which can cause serious illness and even death in humans if not treated with antibiotics.

There are a number of programs already in place to deal with mosquito borne diseases. San Diego County maintains an active Vector Control Program (San Diego County Government, 2020) to mitigate the impacts of vector-borne diseases including spreading larvicide to limit mosquito numbers in critical areas such as San Elijo Lagoon. The County's Department of Environmental Health also includes an in-house diagnostic laboratory that can provide highly sensitive and rapid disease test results so that informed, data-driven control measures can be quickly established.

Mental Health. While most research and communications on the impacts of climate change have emphasized physical health effects, mental health effects are also far-reaching and complex (Clayton, et al., 2017). These range from minimal stress and distress symptoms to clinical disorders, such as anxiety, depression, post-traumatic stress disorders, substance abuse and suicidal thoughts.

The loss of property, homes and lives that occur during natural disasters elicit an increased sense of helplessness, hopelessness or fatalism. This can be accompanied by a feeling of loss regarding one's personal or occupational identity when treasured objects or personally important places are destroyed or disrupted by climate change. Research on adults seeking emergency disaster assistance after a wildland-urban interface fire, have found that a large percentage showed signs of PTSD and depression (Marshall, et al., 2007) (Eisenman, et al., 2015). Long-term drought and/or sea-level rise, unlike sudden extreme weather events, has a slow onset and long duration, interacting over time with multiple environmental and social stressors to disrupt lives and individual function. Prolonged drought can have visible and long-term impacts on landscapes and individual and community resilience, causing anxiety, depression and other mental illnesses.

As with physical health, the mental health impacts of climate change affect some communities or individuals more than others. For example, stress from climate impacts can cause children to experience changes in behavior, development, memory, executive function, decision-making, and scholastic achievement. Some patients with mental illness are especially susceptible to heat. Suicide rates vary with weather, rising with high temperatures (Burke, et al., 2018). Dementia is a risk factor for hospitalization and death during heat waves. Patients with severe mental illness, such as schizophrenia, are at risk during hot weather because their medications may interfere with temperature regulation or even directly cause hyperthermia. Individuals who use alcohol to cope with stress and those with preexisting alcohol use disorders are most vulnerable to increased alcohol use following extreme weather events.

Personal relationships and the ways in which people interact in communities and with each other are affected by a changing climate. Studies have linked extreme heat and increasing violence, aggressive motives, and/or aggressive behavior (Plante, et al., 2017) (Hsiang, et al., 2013). Increases from pre-disaster rates have been observed in interpersonal and domestic violence, including intimate partner violence, particularly toward women, in the wake of climate- or weather-related disasters. Signs of intergroup aggression and hostility have also emerged as climate refugees search for alternative homes.

According to a recent study, psychological responses to climate change, such as conflict avoidance, fatalism, fear, helplessness, and resignation are growing. Our ability to adapt and be resilient is important since these responses may hinder the very efforts to properly address the core causes of and solutions for our changing climate (Clayton, et al., 2017)

Existing measures and new strategies to address health related concerns associated with increases in temperature and extreme heat events are addressed in section 4.2.1. Additional options to mitigate increased risk of vector borne diseases are listed below.

STRATEGIES TO PREPARE FOR THREATS TO PUBLIC HEALTH AND SAFETY

Strategy 1: Education for preventative measures. Educate businesses and residents about actions they can take to reduce mosquito habitat and disease transmission (e.g. elimination of stagnant water around residences).

Strategy 2: Education for protective measures. Urge people to remember to protect themselves and their pets when hiking by wearing insect repellent, proper clothing and by using insect control products on their pets that kill fleas and ticks.

Strategy 3: Encourage citizen participation. Mobilize residents to report mosquito breeding sites, increases in mosquito population, and sentinel dead bird species to the VCP.

Strategy 4: Coordinate efforts with other agencies. Work closely with local and state health agencies (e.g. VCP, San Diego County Dept. of Environmental Health, universities, and research centers) to mitigate vector-borne diseases.

Strategy 5: Support mental health well-being of individuals and the community. The City will assess and provide the community with information about available mental health resources and communicate about climate-mental health issues in order to build mental health resilience. In addition, the City will endeavor to maintain practices that foster optimism and provide a sense of meaning by providing connectedness to place, culture and community.

4.2.8 Coastal Habitat

San Diego County is rich in biodiversity and is one of the most biodiverse counties in North America. While Solana Beach is bounded by two estuaries, the City itself is almost entirely built out, with only a few pockets of native and/or naturalized vegetation remaining. A detailed description of ecosystems and species within the City including maps identifying their locations is included in Chapter 3 of the City's Local Coastal Program – Land Use Plan (LCP-LUP). Much of the information that follows regarding existing conditions comes from that report.

Developed lands in the City account for approximately 1,981 acres, or 90 percent of the City. These lands include paved roadways, parking lots, residences, commercial buildings, plant nurseries, schools, landscaped slopes, maintained yards, golf courses, mowed/maintained parks, and the railroad.

The largest areas of native vegetation communities occur in the northern portion of the City, in and adjacent to the San Elijo Lagoon Ecological Reserve, as well as on canyon slopes within the golf course and adjacent to San Andres Drive. San Elijo Lagoon is approximately 1,000 acres and is vitally important for birds as a stop on the Pacific Flyway, as nesting and foraging areas for endangered species, and as a fish hatchery. The San Dieguito coastal area is also a significant scenic resource for residents and visitors in Solana Beach, Del Mar, and San Diego County.

A 3-acre property at the gateway of Solana Beach and Cardiff-by-the-Sea was purchased by a conservation group in conjunction with the Nature Collective (formerly San Elijo Lagoon Conservancy). Named after a major donor, the Harbaugh Seaside Trails property improvements include the removal of invasive plant species for native plantings that will attract pollinators and link the habitat to San Elijo Lagoon Ecological Reserve.

Environmentally Sensitive Habitat Areas (ESHA) designations were established in the LCP-LUP including lands in the San Elijo Lagoon Ecological Reserve and contiguous areas supporting either functionally intact native vegetation communities or presence of rare species, as well as relatively large areas of southern maritime chaparral and coastal sage scrub communities near and along San Andres Drive.

Increasing temperature and precipitation extremes due to climate change will negatively impact native ecosystems and vegetation by affecting breeding patterns, moisture availability and other factors important to species generation, maintenance and migration. Development and expanding human land use can exacerbate climate change impacts by destroying remaining habitat and limiting species migration to and availability of future climate refuge. Detailed climate effects on various coastal Southern California Habitats are outlined in vulnerability assessments and adaptation strategies (EcoAdapt, 2020) completed by the California Landscape Conversation Partnership (CA LCP) as overseen by a non-profit group called EcoAdapt.

While not included in the ESHA, both the beaches and developed spaces within the City can provide important wildlife habitat. For example, beach wrack is an important part of the marine ecosystem. Beach wrack refers to the piles of seaweed and plant and animal remains that are washed ashore by waves. While this may be unsightly for some visitors, research has found that it is an important nutrient source and provides micro-habitat for a variety of organisms. Regular grooming of sandy beaches and either excavation or deposition of sand can destroy the wrack and degrade the nearshore habitat. These types of activities can also have negative impacts to grunion that deposit their eggs in the sand during high tides.

In addition, while open space in the City is limited, habitat can be created in residential and commercial landscaping in what is not traditionally considered wildlands. There are a number of organizations that promote bird and insect friendly vegetation for landscaping including Xerces (xerces.org) and The National Wildlife Federation (nwf.org). Plant selection, particularly trees, has the added advantage of increasing shade and reducing localized temperatures and can also reduce fire risk.

STRATEGIES TO PREPARE FOR THREATS TO COASTAL HABITAT

Strategy 1: Landscaping. Encourage the use of native landscaping. Educate the public on the LUP requirements to protect native trees including oak, manzanita, sycamore, cottonwood, willow and toyon trees.

Strategy 2: Protect and restore native habitat and ecosystem functioning. Increase public knowledge, engagement and cooperation to support climate-informed restoration. Support and explore the possibilities of activities such as restoring habitat along roadways, managing invasive and/or problematic species, and restoring native plant communities. Restore the open portions of the Stevens Creek drainage.

Strategy 3: Enable wildlife movement. Improve wildlife connectivity passages and riparian corridors and plant native plant species to attract local pollinators including bees and butterfly species.

4.2.9. CLIMATE JUSTICE

Climate Justice embraces "the concept that no group of people should disproportionately bear the burden of climate impacts or the costs of mitigation and adaptation" (Cooley, et al., 2012) (Roos, 2018). It is a term that accentuates the ethical and political issues of climate change in addition to environmental concerns. This is especially true since people who are the most vulnerable to the effects of climate change and have the fewest resources to adapt are also the least responsible for the world's increases in greenhouse gas emissions. At its core, climate justice is fundamentally an issue of human rights and environmental justice that connects the local to the global. Increasingly, climate justice has evolved into a global civil rights movement, demanding action rather than mere discourse. This is evident from the millions of participants that turned out for youth-lead climate strikes around the globe.

Factors that contribute to the differential vulnerability of various populations to climate change include:

- Lack of access to financial resources & good health care
- Age – children and the elderly are more sensitive
- Race/Ethnicity
- Disparities in education and limited English proficiency
- Existing high rates of health issues such as chronic diseases and mental health conditions
- Disproportionate impacts from other pollutants (e.g. freeway derived particulate matter)
- Lack of access to air conditioning and transportation
- Lack of social capital: political involvement, civic representation, and isolation
- Citizenship and immigration status.

Strategies that address climate justice with respect to extreme temperature are included in section 4.2.1. Additional strategies are listed below.

CLIMATE JUSTICE STRATEGIES

Strategy 1: Identify at-risk populations. Determine which individuals or populations in Solana Beach would be sensitive to, and, therefore, vulnerable to extreme weather conditions resulting from climate change. Coordinate with groups currently engaging these populations.

Strategy 2: Target efforts towards at-risk populations. Ensure that vulnerable individuals have the means to respond in threatening climate-driven situations such as being able to evacuate in case of flooding or fires; and/or have the means to protect their respiratory health if a nearby wildfire degrades air quality.

Strategy 3: Perform more education and outreach. Emphasize the benefits and harm of local actions to vulnerable communities worldwide.

APPENDIX 1

California Climate Change Assessment v 4
Highlights for San Diego Region

San Diego County will be increasingly affected by climate change and has begun to prepare on multiple fronts for the panoply of climate related impacts to San Diego's residents, development, infrastructure, and ecosystems. In future decades, San Diego County and adjacent regions will be confronted with, among others, increasingly warmer average temperatures, more frequent and likely more intense heat waves, more intense droughts, occasionally increased heavy rainfall events and floods, continuing Santa Ana winds and wildfire threats. The impacts will play out in different ways across the complex terrain and differing climates within San Diego County. Communities along San Diego County's 70 miles of coastline are planning for substantial sea level rise, which will affect beaches, sea cliffs, real estate, infrastructure and other amenities. The region has many unique characteristics, such as narrow beaches backed by sea cliffs, large percentage of conserved lands, highly populated urban and sub-urban development, small farm dominated agriculture, and large solar power production; these characteristics, amongst others, all determine vulnerabilities to climate changes and related adaptation measures. Below are some highlights of climate impacts, adaptations and gaps.

- Temperature is projected to increase substantially, by 5 ℉ to 10 ℉ by the end of the 21st century. Along with average temperature, heat wave frequency will increase, with more intensity and longer duration. Marine layer clouds can help to mitigate the impacts of temperature change in the coastal regions, though these clouds are not well represented in climate models requiring further research.

- Precipitation will remain highly variable but will change in character, with wetter winters, drier springs, and more frequent and severe droughts punctuated by more intense individual precipitation events. Effects of an altered precipitation regime on ecosystems, water demand and supply, water quality and flooding emergencies are incompletely known and will benefit from cross-disciplinary investigation.

- Broadly, wildfire risk will likely increase in the future as climate warms. The risk for large catastrophic wildfires driven by Santa Ana wind events will also likely increase as a result of drier autumns leading to low antecedent precipitation before the height of the Santa Ana wind season (December and January).

- Sea level along the San Diego County coast is expected to rise approximately 1 ft by mid-21st century, and 3 ft or potentially much higher by 2100. For the next several decades, high tides combined with elevated shoreline water levels produced by both locally and distantly generated wind-driven waves will drive extreme events. Longer-term sea level will increase rapidly in the second half of the century and will be punctuated by short periods of storm-driven extreme sea levels that will imperil existing infrastructure, structures, and ecosystems with increasing frequency. San Diego is testing adaptation approaches, but sustained and improved observations in combination with physics based modeling are needed to evaluate these adaptations measures and guide future planning.

- Development in the San Diego County region is concentrated in the western third of the county with approximately 60% of the land remaining undeveloped. Climate change, along with development and fragmentation, will act as significant stressors to San Diego's natural lands, which are some of the most biodiverse in the United States. San Diego Association of Governments' (SANDAG's) regional planning emphasis on smart growth to concentrate urban development near city and transit centers supports conservation while also mitigating greenhouse gas emissions.

- The San Diego County Water Authority, the region's water wholesaler, continues to diversify its supply by developing and negotiating local and nearby imported sources, developing more recycled water and encouraging greater water conservation. There are several coordinated efforts in the region to build resilience to climate and holistic water management adaptations are becoming more prevalent throughout communities. Continued science and regional coordination to evaluate climate change impacts on future water supply, demand and quality are needed in order to inform adaptation to future climate changes.

- San Diego's energy supply is rapidly changing with renewable energy sources, mostly photovoltaic arrays, increasing by more than 30% since 2010, which introduces novel sensitivities to weather variation and evolving vulnerability to climate changes. San Diego Gas and Electric has installed a high density weather station network that provides a more detailed, real time awareness of weather conditions that could damage the energy system and/or produce unusual supply or demand.

- Recent work in San Diego showed that heat-related health impacts are observed at lower temperatures in the coastal region than in the inland and desert regions. This is in part due to coastal residents being less acclimated to heat and less likely to have air conditioning.

- Climate changes felt by San Diego County will also occur in northern Baja, Mexico. Binational coordination of climate adaptation measures present potential for significant benefit to communities on both sides of the border. However, to be effective the approaches must navigate the complexity posed by different governance and community structures.

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