Memo

455 Capitol Mall, Suite 300
Sacramento, CA 95814
916.444-7301

Date: September 7, 2018

To: Paul Swancott (City of Murrieta)

From: Ricky Williams, Poonam Boparai, and Honey Walters

Subject: City of Murrieta Climate Action Plan Technical Memorandum: Climate Change Vulnerability Assessment

INTRODUCTION

Climate change is a global phenomenon that has the long-term potential to cause a variety of consequences, including detrimental impacts on human health and safety, economic continuity, water security, provisions of basic services, and economic function (California Natural Resources Agency [CNRA] 2012). The effects of climate change will continue to impact the physical environment throughout California, Riverside County, and the City of Murrieta (City). The magnitude and timing of climate change effects will vary by location; therefore, it is important to identify the projected severity of these impacts specific to the City. The first step in adapting to climate change is to analyze these impacts and the vulnerabilities they create.

In accordance with Senate Bill (SB) 379, this Vulnerability Assessment follows the recommended format and methods described in the most recent Cal-Adapt tool and California Adaption Planning Guide. SB 379 requires that jurisdictions update their safety elements and local hazard mitigation plans, as necessary, to address climate adaption and resiliency strategies. The update is required to include a set of goals, policies, and objectives based on a vulnerability assessment.

CLIMATE CHANGE ADAPTATION PLANNING PROCESS

The California Adaption Planning Guide (APG), developed by California Governor's Office of Emergency Services (Cal OES) and CNRA, helps communities throughout California plan for and adapt to the impacts of climate change. The APG includes a nine-step process, illustrated in Figure 1, which allows communities to assess their specific climate vulnerabilities and provides strategies for communities to reduce climate-related risks and prepare for current and future impacts of climate change.

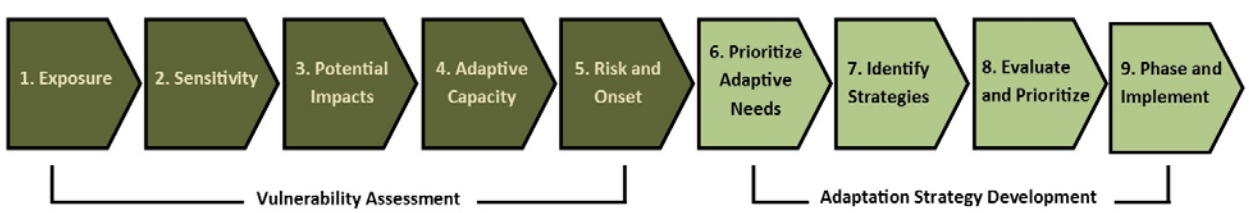

Figure 1: The Nine Steps in the Adaptation Planning Process

The first phase of the nine-step process focuses on preparing a Vulnerability Assessment, which is a method for determining the anticipated impacts of climate change on community assets and populations. This phase evaluates a community's level of exposure to climate-related impacts and analyzes how these impacts will affect a community's populations, functions, and structures. The second phase of the process uses the information gathered in the Vulnerability Assessment to develop adaption strategies and measures to help the community prepare for, respond to, and adapt to local climate change impacts. The strategies support a collaborative planning process that involves a variety of City departments and State agencies, including, but not limited to Cal OES, CNRA, and the California Department of Public Health (CDPH). This memorandum follows APG's nine-step process and includes a Vulnerability Assessment, identifying key climate-related risks faced by the City.

1 VULNERABILITY ASSESSMENT

This Vulnerability Assessment for the City involves the first five steps in the adaption planning process. Based on the work of International Panel on Climate Change (IPCC) and research conducted by the State and partner agencies and organizations, climate change is already affecting the City (as described in the following sections) and will continue to further in the future.

1.1 STEP 1: EXPOSURE

The effects of climate change can be described in terms of primary exposure to various physical changes in the climate and environment caused by global climate change, such as temperature, precipitation, and sea level rise. Secondary consequences, such as reduced water supply, impacts on structures from erosion and sea-level rise, increased frequency and duration of heat waves, and increased fire risk, occur as a result of one or a combination of these primary effects (California Governor's Office of Planning and Research (OPR) 2018).

The impact of climate change in California varies across the state due to diversity in biophysical setting, climate, and jurisdictional characteristics. The Desert Region, as designated by CNRA includes San Bernardino, Riverside, and Imperial Counties. The Cal-Adapt tool, developed by the California Energy Commission (CEC) and University of California (UC) Berkeley is used to project the impacts of climate change at a local and regional level. This tool provides climate change-related projections for a variety of impacts including maximum and minimum temperature and precipitation, extreme heat days and warm nights, snowpack, sea level rise, wildfire risk, and streamflow. These impacts are projected for two scenarios: High-Emissions Scenario, which assumes that emissions will continue to rise through 2050 and plateau in 2100, then decline, and Low-Emissions Scenario, which assumes emissions will peak around 2040, then decline. Because the degree of effectiveness of programs implemented to reduce GHG emissions is not yet known, results from both emissions-scenarios are considered in the Vulnerability Assessment and distinguished, where possible (CEC 2018).

1.1.1 Increased Temperature

Increases in average temperatures can result in multiple negative effects on the built and natural environment. These secondary impacts of increased temperature include increased frequency of extreme heat events and heat waves, and exacerbation of the urban heat island effect. In Riverside County, projected increases in temperatures will be higher further inland and closer to desert regions.

Annual temperatures in the City are projected to increase steadily under both Low- and High-Emissions scenarios. The City's historical average annual maximum and minimum temperatures, based on data from 1950 to 2005, are 79.8 degrees Fahrenheit (°F) and 47.1 °F, respectively. By 2099 the annual average maximum temperature is projected to increase by 5.1 to 10.4 °F, and the annual average minimum temperature is project to increase by 5.9 to 10.3 °F (CEC 2018). A summary of the historical average and 2050 and 2099 minimum and maximum temperature projections is shown in Table 1.1-1.

Table 1.1-1 Maximum and Minimum Temperatures for the City of Murrieta

	Historical Average (Max/Min)	2050 Projected (Max/Min)	2099 Projected (Max/Min)
Low-Emissions Scenario	79.8°F/47.1°F	84.6°F/51.8°F	84.9°F/53.0°F
High-Emissions Scenario		84.7°F/52.2°F	90.2°F/57.4°F

°F = Degrees Fahrenheit

Source: CEC 2018 data for City of Murrieta Grid Cell (33.59375,-117.21875)

EXTREME HEAT EVENTS AND HEAT WAVES

Increased temperature is expected to lead to secondary climate change impacts, including increases in the frequency, intensity, and duration of extreme heat days and heat waves. Cal-Adapt defines the extreme heat day threshold for the City as 105.1 °F or higher, between April 1st and October 31st. The City historically has averaged five extreme heat days per year between 1950 and 2005. The City is projected to experience an average of 26 to 36 extreme heat days per year by 2050, and 27 to 62 extreme heat days per year by 2099, depending upon the emissions scenario used for projections (CEC 2018).

Heat waves, which can be defined as five or more consecutive extreme heat days, have been historically infrequent in the City, with no more than one heat wave occurring in a year. However, a rise in the frequency of heat waves from two to five heat waves per year by 2050 and two to 11 heat waves per year by 2099 is projected, depending upon the emissions scenario used for projections (CEC 2018).

URBAN HEAT ISLAND EFFECT

Urbanized areas can experience higher temperatures, greater pollution, and more negative health impacts during hot summer months when compared to more rural communities. This phenomenon is known as an urban heat island. Heat islands are created by a combination of heat-absorptive surfaces (such as dark pavement and roofing), heat-generating activities (such as engines and generators), and the absence of vegetation (which provides evaporative cooling). According to the U.S. Environmental Protection Agency (EPA), daytime temperatures in urban areas are on average 1 to 6 °F higher than in rural areas, while nighttime temperatures can be as much as 22 °F higher as the heat is gradually released from buildings and pavement (California Environmental Protection Agency [CalEPA] 2018a).

The CalEPA's Urban Heat Island Index shows urban heat islands in California. The Urban Heat Island Index is calculated as a temperature differential over time between an urban census tract and nearby upwind rural reference points. Local wind patterns dissipate the adverse impacts of urban heat island effects. The index is reported in degree-hours per day on a Celsius scale, as a measure of heat intensity over time. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period (CalEPA 2018b). The City generally experiences mild winds from the southwest which provide little relief from the urban heat island effect (National Oceanic and Atmospheric Administration [NOAA] 2018). The heat index for the City is 131.6 degree-hours per day, which is approximately equal to a 9.9 °F average temperature difference between the City and nearby rural areas (CalEPA 2018b).

1.1.2 Changes in Precipitation Patterns

The City's water supply comes from local sources of groundwater and surface water, imported water from the Metropolitan Water District's Colorado River Aqueduct and the State Water Project, recycled water reclamation facilities, and water transfers and exchanges (City 2011). Increased temperatures, particularly in the Sierra Nevada region, which supports the State Water Project, as well as the Rocky Mountains, which heads the Colorado River, will lead to earlier and faster snowmelt and could leave the City vulnerable to water resource fluctuation during historically dry months (July-September). Additionally, as temperatures rise and snowpack decreases, the dry season may manifest earlier in the year and extend later, leading to a longer season of water insecurity.

While projections generally show little change in total annual precipitation in California, even modest changes could have a significant effect on California ecosystems that are conditioned to historical precipitation levels. Reduced precipitation could lead to higher risks of drought, while increased precipitation could cause flooding and soil erosion (CNRA 2014). The City has an historical annual average (1950 to 2005) precipitation of 15.0 inches. The annual precipitation in the City is projected to be 15.7 to 17.8 inches by 2050, and 15.0 to 21.4 inches by 2099, depending upon the emissions scenario used for projections (CEC 2018).

DROUGHT AND GROUNDWATER

As of early 2018, the National Drought Mitigation Center classified a majority of Riverside County as being in a "severe drought," the third-most intense drought condition classification (National Integrated Drought Information System [NIDIS] 2018). Although precipitation projections tend to be less certain than other types of climate change projections, a slight decrease in average precipitation is expected in the region through midcentury (CEC 2013).

The City relies on numerous wells within the local groundwater basin as an important source of water supply to each of the retail water purveyors that serve the City and its sphere of influence. Major groundwater basins underlying the City include the Murrieta-Temecula Basin and the French Basin, which rely on surface streams for groundwater recharge (City 2011b). Increased average temperatures and changes in the timing, amounts, and snow/rain form of precipitation could affect local groundwater recharge. Groundwater use typically increases during droughts, which due to the uncertainty in the amount and timing of water availability could result in challenges in providing adequate groundwater supply to meet future demand (Western Riverside Council of Governments [WRCOG] 2014).

EXTREME STORMS

Changes in precipitation patterns may result in less frequent, but more extreme storm events (EPA 2017). The City is projected to experience a slight increase in overall precipitation which may fall with more intense characteristics (i.e., high volume over a short period of time with stronger wind patterns). These storms may produce higher volumes of runoff and contribute to increased flood risks and associated impacts.

1.1.3 Increased Wildfire Risk

Increased temperatures and frequency of extreme heat events, along with changes in precipitation patterns, can lead an increase in the frequency and intensity of wildfires (Governor's Office of Planning and Research

[OPR] 2018). The City is surrounded by relatively rural and undeveloped hillsides and ranches with a high potential for wildfires which can exacerbated by occasional Santa Ana winds and high temperatures (City 2011). Additionally, extreme weather conditions, such as high temperature, low humidity, and/or winds of extraordinary force, may cause an ordinary, localized fire to expand into a more intense and difficult to control wildfire.

The California Department of Forestry and Fire Protection (CAL FIRE) has developed the City's Fire Hazard Severity Zone Map, identifying Very High Fire Hazard Severity Zones in the City that are included in the Local Responsibility Area. The map shows that a substantial portion of the City, including areas along the western edge of the City at the base of the Santa Rosa Plateau and the northeastern rural City neighborhoods, are identified as Very High Fire Hazard Severity Zones (CAL FIRE 2009). The historic annual (1950 to 2005) mean hectares burned in Riverside County is 4,861.1 hectares or approximately 12,012 acres. The annual mean area burned is projected to increase by 15 percent by 2050 and by 11 percent by 2099 under the high-emissions scenario (CEC 2018).

In addition to increased threats to human safety, the increased threats to human safety, the increased frequency of wildfire results in the release of harmful air pollutants into the atmosphere, which dissipate and can affect the respiratory health of residents across a broad geographical scope. Particulate matter (soot and smoke), carbon monoxide, nitrogen oxides, and other pollutants are emitted during the burning of vegetation and can cause acute (short-term) and chronic (long-term) cardiovascular and respiratory illness, especially in vulnerable populations such as the elderly, children, agricultural and outdoor workers, and those suffering from pre-existing cardiovascular or respiratory conditions (OPR 2018).

1.1.4 Increased Flood Risk

Climate change is predicted to modify the frequency, intensity, and duration of extreme storm events, such as sustained periods of heavy precipitation and increased rainfall intensity during precipitation events. These projected changes could lead to increased flood magnitude and frequency. (IPCC 2014). The City lies within the inland portion of the Santa Margarita River Basin. Murrieta Creek and Temecula Creek are primary tributaries to this basin and flow through the City. Stream flows in Murrieta Creek, which flows southeasterly through the portion of the City that lies between Interstate 15 (I-15) and the base of the Santa Rosa Plateau, have been highly variable, and flooding frequently occurs in Historic Murrieta. Most areas along this creek and its associated tributaries lack formal flood control systems, as a result, drainage in some areas is dependent on natural features and can result in flooding in less developed areas, even with moderate rain (City 2011).

Increased precipitation and extreme storm events because of climate change, as described previously, would result in increased flood scenarios and major flooding events. The City's flooding potential will be exacerbated when experiencing atmospheric rivers, or narrow streams of warm, concentrated precipitation often resulting in the deposition of considerable rainfall over a short period of time. Expected increases in average temperature would increase the intensity and magnitude of atmospheric rivers, resulting in increased regional and localized flooding (Dettinger 2011).

1.2 STEPS 2 AND 3: SENSITIVITY AND POTENTIAL IMPACTS

For the purposes of this Vulnerability Assessment, Steps 2 and 3 are discussed together as they are closely related. Step 2 includes the use of systematic evaluation to identify populations, functions, and structures that may be affected by projected exposures to climate change impacts and their degree of sensitivity. These determinations are made with a simple “yes” or “no” answer. This evaluation uses the APG's recommended sensitivity checklist, and focuses specifically on resources in the City potentially affected by climate change impacts identified in Section 1.1, "Step 1: Exposure."

APG's sensitivity checklist is organized into three main categories: Population, Functions, and Structures. These categories are described in detail below.

- Population: Includes both the general human population and segments of the population that are most likely to be sensitive or vulnerable to climate change impacts. This applies, particularly to non-English speaking or elderly populations who may require special response assistance or special medical care after a climate-influenced disaster, and disadvantaged communities.
- Functions: Includes facilities that are essential to the health and welfare of the whole population and are especially important following climate-influenced hazard events. These facilities include hospitals, medical facilities, police and fire stations, emergency operations centers, evacuation shelters, and schools. Transportation systems, such as airways (e.g., airports and highways), bridges, tunnels, roadways, railways (e.g., tracks, tunnels, bridges, and rail yards), and waterways (e.g., canals, seaports, harbors, and piers) are also important to consider. Lifeline utility systems such as potable water, wastewater, fuel, natural gas, electric power, and communications are also critical for public health and safety. Functions also include other economic systems such as agriculture, recreation, and tourism, as well as natural resources within a community, including various plant and animal species and their habitat.
- Structures: Includes the structures of essential facilities noted above such as residential and commercial infrastructure, institutions (i.e., schools, churches, hospitals, prisons, etc.), recreational facilities, transportation infrastructure, parks, dikes and levees, and water and wastewater treatment infrastructure. It also includes high potential loss facilities, where damage would have large environmental, economic, or public safety considerations (e.g., nuclear power plants, dams, and military installations). This category also includes hazardous material facilities that house industrial/hazardous materials.

An evaluation of the severity of climate change impacts on the sensitive populations, functions, and structures is included in Step 3. Given that climate change exposures at the local scale are inherently uncertain, the APG recommends that communities conduct a qualitative assessment that describes the potential impacts based on the exposure (CNRA 2012). This assessment is not meant to be exhaustive and prescriptive, rather, it is intended to provide a high-level view of potential impacts that occur as a result of identified climate change exposures. Further evaluation and research would be needed to more precisely identify points of sensitivity and potential impacts, including specific facilities, structures, and areas of concern.

1.2.1 Increased Temperature

The average maximum and minimum temperatures in the City are project to rise between approximately 5 to 10 °F by 2099. Increased temperatures can lead to secondary climate change impacts including increases in the frequency, intensity, and duration of extreme heat events and heat waves.

POPULATIONS

Higher frequency of extreme heat conditions can cause serious public health impacts, increasing the risk of conditions directly related to heat such as heat stroke and dehydration (OPR 2018). Exposure to excessive heat may lead to heat-related illnesses such as heat cramps, heat exhaustion, and heat stroke. The most serious reaction to extreme heat and heat stroke results in severe mental status changes, seizure, loss of consciousness, kidney failure, abnormal cardiac rhythm, and death (CalEPA 2013).

Higher temperatures also result in worsened air quality through increased air pollution. Ozone formation and particulate matter generation (e.g., from wildfire smoke), pose health hazards to vulnerable populations including children, the elderly, pregnant women, and persons with pre-existing chronic diseases. Based on the 2010 U.S. census, the City's population is 103,606 residents, approximately seven percent of which are children (under five years) and approximately 12 percent are elderly (65 years and over) (U.S. Census Bureau 2017).

Extreme heat events pose greater challenges to disadvantaged communities due to sub-standard living environments and limited access to resources. Low income populations living in aging buildings with poor insulation experience higher costs associated with air conditioning; some populations in these buildings may refrain from turning on air conditions to reduce these costs, making them more susceptible to health condition risks (Singer et al. 2016). Approximately nine percent of the City's population is currently considered to be living in poverty, and approximately 11 percent of the population under 65 years is without health insurance (U.S. Census Bureau 2017).

The climate change—related impacts to populations in the City would have the greatest impact on vulnerable populations. Approximately 20 percent of the City's population is considered vulnerable population (i.e. children and elderly), and at least 11 percent of the population is considered to live in poverty or does not have access to health insurance. Climate change will result in increased temperatures in the City, including increased heat waves and extreme heat events. Further, the City experiences large temperature increases compared to the adjacent rural areas due to the urban heat island effect. This urban heat island effect, on average, increases the temperature in the City an average of nearly 10 °F higher than the adjacent rural areas.

Severity of Impacts on Populations: ***High***

FUNCTIONS AND STRUCTURES

High temperatures decrease the efficiency of power transmission lines, while demand for electricity simultaneously goes up as operation of air conditioners and cooling equipment increases. This may result in increased risk of power outages and blackouts, affecting the operation of infrastructure. Prolonged exposure to heat can exacerbate roadway degradation, as asphalt and concrete can deform at a faster rate under high temperatures and can impact bridge expansion joints as they experience expansion and contraction as temperatures fluctuate.

Energy use in buildings increases as temperature increases as a result of increased demand for cooling systems. Temperature-related power failure can adversely affect the quality of working and living environments in residential, commercial, and industrial buildings. In periods of extreme heat, loss of electricity inhibits cooling of inside areas resulting in a lack of refuge from dangerous heat. Further, economic losses may be incurred from loss of productive work time due to downed communication systems or dangerous work conditions, or in residential buildings from an inability to properly store foods susceptible to spoiling in heat.

The production of agricultural products is a major activity in Riverside County. Agricultural activities can be highly vulnerable to the impacts of climate change, including drought conditions and extreme heat. In 2014, drought conditions cost agriculture in California approximately $2.2 billion, and costs may be substantially higher in the future if continued drought further depletes groundwater supplies (WRCOG 2014). Though agriculture represents a large portion of the regional economy, it is a relatively small sector of employment for individuals working or living in the City (U.S. Census Bureau 2015).

Severity of Impacts on Structures and Functions: ***Medium***

1.2.2 Changes in Precipitation Patterns

Increased average temperatures and a hastening of snowmelt in the Sierra Nevada, Rocky Mountains, and distant portions of watersheds could affect the flows of the State Water Project and the Colorado River upon which the City relies. Reduce flow of fresh water, more persistent drought conditions, and increased water demands due to population growth will likely affect the quality and quantity of water supplies.

POPULATIONS

Increasing temperatures and changes in precipitation may lead to intensified drought conditions, which decreases the availability and quality of water for human use. This includes increased exposure to health hazards including wildfires, dust storms, extreme heat events, flash flooding, and degraded water quality (CDPH 2017). Most of the imported water used in the region comes from the Sierra Nevada range. Reduced winter precipitation levels and snowpack reduction have resulted in less fresh water available for communities throughout California. Continued decline in snowpack is expected, which may lead to lower volumes of water available for City residents (WRCOG 2014).

Severity of Impacts on Populations: ***High***

STRUCTURES AND FUNCTIONS

Extreme weather events (e.g., storms, flooding) cause fatal and nonfatal injuries from drowning, being struck by objects, fire, explosions, electrocution, or exposure to toxic materials. A widespread weather-related natural disaster may destroy or ruin housing, schools, and businesses and cause temporary or permanent displacement (CDPH 2017). Changes in precipitation patterns may increase the presence of weeds, pest insects, and other organisms that damage agricultural products as well as affect agricultural yields and increase stress on crops and animals (WRCOG 2014)

Severity of Impacts on Structures and Functions: ***Medium***

1.2.3 Increased Wildfire Risk

Increased temperatures and changes in precipitation associated with climate change are expected to increase the potential severity of wildland fires both within and beyond the boundaries of the City. As previously described, the annual mean hectares burned is projected to increase by 15 percent by 2050 and by 11 percent by 2099 under the high-emissions scenario. As higher temperatures last for longer periods of time, dead fuels of wider diameter will also become drier and contribute to increased wildfire intensity (CAL FIRE 2009).

As the climate changes, the amount of area at elevated risk for such spatially limited hazards such as wildfires increases (CEC 2012). Areas that are currently vulnerable to wildfires may face more frequent hazards, and the wildfires themselves may be more severe. Wildfires may also begin to affect areas that are not currently vulnerable, and these risks may be exacerbated by high development pressure, resulting in more buildings and infrastructure built in high-risk areas (WRCOG 2014).

POPULATIONS

Different areas of the community and populations are especially vulnerable or resilient to wildfires in the City, particularly for hazards where rapid evacuation may be necessary. Factors that make residents or employees more vulnerable to wildfire include individuals with disabilities, access to vehicles, income levels, buildings located in high-risk areas, and working conditions (WRCOG 2014).

Six percent of the City's population under 65 lives with a disability, and approximately nine percent of the City's population lives below the poverty level (U.S. Census Bureau 2017). Individuals with disabilities could have limited mobility and could be medically dependent on electronic devices. Physically disabled individuals may have limited mobility in case of evacuation, and respiratory problems could be aggravated by smoke. Low income individuals are less likely to have access to high quality housing units, support networks, or other resources that limit exposure to poor air quality or protect against fire. They are also less able to recover and rebuild their quality of life if fire results in the destruction of their property or affects their health.

In addition to increased threats to human safety, the increased risk of catastrophic wildfire results in the release of harmful air pollutants into the atmosphere, which dissipate and can affect the respiratory health of residents across a broad geographical scope. Particulate matter (soot and smoke), carbon monoxide, nitrogen oxides, and other pollutants are emitted during the burning of vegetation and can cause acute (short-term) and chronic (long-term) cardiovascular and respiratory illness, especially invulnerable populations such as the elderly, children, agricultural and outdoor workers, and those suffering from preexisting cardiovascular or respiratory conditions (CDPH 2017).

Severity of Impacts on Populations: ***High***

STRUCTURES AND FUNCTIONS

While periodic fires originate from natural processes and provide important ecological functions, catastrophic fire events that cannot be contained or managed can cause serious threats to homes and infrastructure, especially for properties located at the wildland-urban interface. Damage to ecological functions may result as the risk of fire increases. When rain falls in burn scarred areas, there is a higher potential for soil erosion and mudflows into roads, ditches, and streams, and potentially resulting in property damage or loss.

Increased industrial complexes, transportation networks, utility networks, and general development along the wildland-urban interface increases the risk for wildfires to affect structures. Hazardous materials, associated with the development of industrial buildings and potentially present along transportation networks could increase the risk associated with wildfires (County of Riverside [County] 2012). The undeveloped hillside areas in and adjacent to the City present a potentially serious hazard due to the high potential for large scale wildland fires. The western boundary of the City has high wildland fire threats and is currently developed with various low-density residential neighborhoods.

Wildfires often result in the closure of roadways and/or damage to transportation infrastructure which may cause increased congestion or delay during and for months after a wildfire event. Road closures could create additional issues related to evacuating affected areas, and providing emergency vehicle access to affected buildings and populations.

Severity of Impacts on Structures and Functions: ***High***

1.2.4 Increased Flood Risk

The City is located within the inland portion of the Santa Margarita River Basin. Murrieta Creek and Temecula Creek are the main tributaries of the Santa Margarita River. Stream flows for Murrieta Creek have been highly variable and flooding frequently occurs along sections that lack formal flood control, even in moderate rain. A total of 1,021.2 acres in the City are within the 100-year flood zone. Portions of the City are also subject to potential flooding in the event of dam failure at Lake Skinner or Diamond Valley Lake (City 2012). While it is uncertain exactly how climate change will affect flooding events in the City and to what extent, any increase in flooding is likely to have serious ramifications as the area is already vulnerable.

The rivers in western Riverside County are typically dry or nearly dry for most of the year and generally only pose flood threats to developments within the floodplain during general storms of long duration. Increased urbanization and the resulting increase in impervious surfaces has increased flood potential (County 2014).

POPULATIONS

Flooding will most adversely affect populations living in 100-, 200-, and 500-year floodplains. Flood events can result in population displacement, death from drowning, injuries, and water- and food-borne diseases from sewage overflow (CDPH 2017). Populations with limited mobility (e.g., dependent on public transportation, without a vehicle) are considered more vulnerable to flood events because the ability to use sandbags or evacuate is reduced. Flooding could result in the release of sewage and hazardous and/or toxic materials if wastewater treatment plants are inundated, storage tanks are damaged, or pipelines are severed (WRCOG 2014). Flash flooding could occur as a result of heavy rain on burn scarred areas, and regular flooding already occurs in certain areas of the City. In the event of a normal flood condition, residents would have advanced notice to the threat of rising flood waters, providing adequate time to prepare and/or evacuate. While areas of the City are threatened by increased flooding, the population would generally have adequate time to identify and react to direct threats to their health and safety.

Severity of Impacts on Populations: ***Medium***

STRUCTURES AND FUNCTIONS

Increased flooding associated with climate change will stress communities and infrastructure, and may also threaten the biodiversity that occurs along the streams and creeks within the City. Unlike natural flooding regimes, wherein seasonal flooding results in the deposition of useful sediment (resulting in increased soil fertility as well as groundwater recharge), flash flooding and increased flood events could lead to the destruction of crops along streams, erosion of topsoil, and excessive soil saturation.

Flooding may also result in economic losses through closure of businesses and government facilities, disrupt communications and the provision of utilities, and result in increased expenditures for emergency services. Roadways exposed to high volumes of water become more susceptible to damage from excess moisture (California Department of Transportation [Caltrans] 2013).

Severity of Impacts on Structures and Functions: ***Medium***

1.3 STEP 4: ADAPTIVE CAPACITY

The evaluation of the adaptive capacity of populations, functions, and structures identified in Steps 2 and 3 involves determining a community's current ability to address the points of sensitivity and impacts associated with climate change. This step includes a review of the City's existing policies, plans, programs, resources, and institutions to reflect its current ability to adapt to climate change and reduce vulnerability. Adaptive capacity to each of the climate change impacts is rated low, medium, or high. A low adaptive capacity indicates that a community is unprepared, while a high adaptive capacity indicates that sufficient measures are already in place to address the points of sensitivity and impacts associated with climate change.

The City, County, and WRCOG address current and future impacts related to existing natural hazards through their planning processes. The following plans, produced by these agencies, address various hazards and climate change impacts at local and regional levels.

- The City Safety Element (Chapter 14 of the City's General Plan Update) describes hazards that exist in the City and the measures being taken to address them.
- The City Emergency Operations Plan (EOP) addresses the planned response to extraordinary emergency situations associated with natural disasters, technological incidents, and national security emergencies in or affecting the City. The EOP establishes the framework for implementation of State emergency management systems.
- The City of Murrieta Local Hazard Mitigation Plan (LHMP), produced by the County, identifies vulnerabilities, provides recommendations for prioritized mitigation actions, evaluates resources and identifies shortcomings, and provides future mitigation planning for the City.
- The WRCOG has created the Subregional Climate Action Plan (Subregional CAP) Adaption and Resiliency Strategy, providing an overview of expected climate change effects, assets in the subregion that are vulnerable to climate change effects, and adaptation strategies intended to reduce vulnerability and increase resilience. The strategies provided represent actions that increase resilience to natural hazards regardless of the rate and severity of climate change.

1.3.1 Adaptive Efforts Related to Increased Temperature

Efforts occurring in the City to adapt to or reduce the impacts of extreme heat days, heat waves, and urban heat islands are summarized below:

- The U.S. Department of Energy (DOE) Weatherization Assistance Program (WAP) provides grants to states, territories, and Native American tribes to improve the energy efficiency of low-income homes. Recipients then contract with local governments and nonprofit agencies to provide weatherization services to low-income homes in need of energy upgrades (DOE n.d.). The California WAP program allocates funds to various local governments, which provide grants to the entities that apply for them. WAP-related upgrades (e.g., replacing windows, weather-stripping, insulating attics and water heaters) in Sacramento County are provided by various organizations such as the Community Resource Project, Inc. and GRID Alternatives. Increasing the affordability of energy appliances provides low-income residents the financial capacity to air condition their homes during times of high heat. The State Greenhouse Gas Reduction Fund (GGRF) also provides funding for weatherization, residential rooftop solar and tree planting in disadvantaged communities.
- The County and City participate in the Home Energy Opportunity (HERO) Program, which is a part of the Property Assessed Clean Energy Program. HERO helps homeowners reduce energy bills and decrease water consumption through special financing options.
- WRCOG, in collaboration with Riverside Public Utilities, offers incentives for residential customers to upgrade the efficiency of a variety of equipment within eligible homes. The program encourages residents to upgrade appliances, building materials, and home furnishings with high-efficiency products to reduce water and energy use.
- The Subregional CAP includes the following recommended adaption strategies related to increased temperatures, extreme heat days, heat waves, and urban heat islands:
    - Strategy 1.3: Incorporate extreme heat and air quality annexes into emergency management plans.

- Strategy 2.4: Identify and map cooling centers in locations accessible to vulnerable populations and establish standardized temperature triggers for when they will be opened.

- Strategy 2.5: Identify ways for individuals with restricted mobility to reach cooling centers.

- Strategy 3.4: Work with local volunteer emergency response teams to include extreme heat as a hazard of concern and update core competencies to address the health-related risks of extreme heat events.

- Strategy 4.1: Use materials and features in transportation infrastructure that can improve resiliency to extreme heats.

- Strategy 6.1: Promote and expand the use of drought-tolerant green infrastructure, including street trees, and landscaped areas as part of cooling strategies in public and private spaces.

- Strategy 6.2: Amend the local development code to require high-reflectivity pavement or increased tree cover in large commercial parking lots.

The City and region have numerous adaptation plans and services available for extreme heat events and heat waves (i.e., cooling centers, heat wave advisories), and the City is improving the means by which residents are educated about existing plans (i.e. improved alert systems to notify residents of cooling center locations and extreme temperature events). In general, many of the policies and plans provide only recommendations to improve energy efficiency and reduce the impacts of temperature increases.

Adaptive Capacity for Increases in Temperature: ***Medium***

1.3.2 Adaptive Efforts Related to Changes in Precipitation

Efforts occurring in the City to adapt to or reduce the impacts of precipitation changes, extreme storms, and droughts are summarized below:

- The City has one designated severe weather center which is open and accessible when a Public Health "Heat/Cold Warning" is issued. The City utilizes the County Public Health Department heat and cold advisories to activate the center. The City also utilizes protocols to ensure the safety of residents during extreme residents such as "spray downs" during extreme heat events at large gatherings.

- The County and City participate in the HERO Program, which is a part of the Property Assessed Clean Energy Program. HERO helps homeowners reduce energy bills and decrease water consumption through special financing options.

- The City and its Community Services District have taken proactive measures to reduce water costs and use by replacing old technology for irrigation, exchanging overhead spray systems with drip (point-to-point) irrigation, and by replacing outdated landscaping with water-wise material. The City also provides information to residents on water consumption rebates provided by the various water districts serving the community.

- WRCOG, in collaboration with Riverside Public Utilities, offers incentives for residential customers to upgrade the efficiency of a variety of equipment within eligible homes. The program encourages residents to upgrade appliances, building materials, and home furnishings with high-efficiency products to reduce water and energy use.

- The Subregional CAP includes the following recommended adaption strategies related to changes in precipitation, extreme storms, and droughts:
  - Strategy 4.1: Use materials and features in transportation infrastructure that can improve resiliency to extreme events.
  - Strategy 5.5: Encourage the use of low-impact development practices in new development.
  - Strategy 6.1: Promote and expand the use of drought-tolerant green infrastructure, including street trees, and landscaped areas as part of cooling strategies in public and private spaces.
  - Strategy 6.3: Identify and implement municipal renewable energy projects for daily and emergency operations.
  - Strategy 7.2: Encourage efficient irrigation techniques and identify financial resources to support installation.
- Beginning in 2016, all retail water suppliers were required to comply with the water conservation requirements in Senate Bill X7-7 to be eligible for state water grants or loans. Each district is required to set targets and track progress toward decreasing daily per capita urban water use in an effort to meet the State's 20 percent water reduction goal. The City receives its water supply from four water districts: Rancho California Water District, El Sinore Valley Municipal Water District, Western Municipal Water District, and Eastern Municipal Water District. Each district has prepared and updated an urban water management plan for their respective service areas.

The City and region provide opportunities to reduce water usage in the community. The City is served by multiple retail water provides which reduces the City's ability to control the adaptability of its water supply to meet future demands or respond to threats. The City participates in various programs that assist with the reduction in residential energy and water usage. The City's municipal code has also incorporated adaptation measures into building and infrastructure design to improve water and landscaping efficiency (City municipal code 16.28 "Landscaping Standards and Water Efficient Landscaping")

Adaptive Capacity for Changes in Precipitation: ***Medium***

1.3.3 Adaptive Efforts Related to Increased Wildfire Risk

Efforts occurring in the City to adapt or reduce the impacts of wildfires are summarized below:

- The Murrieta Fire Department (Murrieta Fire and Rescue, MFR) engages in activities that are aimed at preventing fires and compliance with California Building Standards Code, Chapters 7 and 7A, and the California Fire Code. The MFR provides fire protection engineering, building inspections for code compliance, and hazardous materials inspections. The MFR also provides education and training in public safety and emergency preparedness.
- The MFR implements a Weed Abatement Program to reduce weed and brush fire hazards. This program provides for property inspections and enforcement on properties that pose a potential fire hazard due to weeds and brush.
- Conditions of development are currently required in the City under Title 15.24, "California Fire Code and California Fire Code Standards", of the City municipal code, such as Class A roofing (defined as the highest level of fire resistant roofing material, rated by ASTM E108) noncombustible siding, and 100-foot fuel buffer zones.

- The Subregional CAP includes the following recommended adaption strategies related to wildfire risk:
  - Strategy 5.1: Continue to provide information to homeowners about statutory vegetation management requirements.
  - Strategy 5.3: Establish neighborhood and building design standards that minimize fire hazards in high wildfire risk areas
- The City's LHMP includes the following objectives related to wildfire risk:
  - Objective 5.1: Continue efforts to reduce fire hazards associated with older buildings, multifamily housing, and fire-prone industrial facilities throughout the City.
  - Objective 5.2: Provide public safety education programs through the MFR to reduce accidents, injuries and fires, as well as train members of the public to respond to emergencies.
  - Objective 5.3: Continue to coordinate fire protection services with Riverside County, CAL FIRE, and all other agencies and districts with fire protection powers.
  - Objective 5.4: Ensure that outlying areas in the City can be served by fire communication systems as new development occurs.

A majority of the City's efforts to adapt to wildfire impacts of climate change correspond with general best practices for wildfire management and prevention. The City's adaptation strategies provide measures that reduce wildfire risk to people and property within the City. Climate change is projected to exacerbate the risk due to increased temperatures and changes in precipitation patterns. The City, with the assistance of the County, will need to continue to adapt to reduce these effects. The City currently has no defined emergency routes which reduces the capacity of the City to react during wildfire events.

Adaptive Capacity for Wildfire Risk: ***Medium***

1.3.4 Adaptive Efforts Related to Increased Flood Risk

Efforts occurring in the City to adapt or reduce the impacts of flooding are summarized below:

- The City's regulations with respect to flood damage prevention are included in the Murrieta Municipal Code Chapter 15.56, "Flood Damage Prevention Regulations." The purpose of this chapter is to promote the public health, safety, and general welfare, and to minimize the public and private losses due to flood conditions in specific areas.
- The City is located within Flood Control District Zone 7 of the Riverside County Flood Control and Water Conservation District. A Master Drainage Plan prepared for Murrieta Creek by the District evaluates drainage needs and proposes an economical drainage plan to provide flood protection for both existing and future development in the City. Improvements proposed for Murrieta Creek consist of the channelization of the creek and its major tributaries and include several concrete- lined open channels and a small network of underground storm drains.
- The City participates in the National Flood Insurance Program's (NFIP) Community Rating System (CRS) which provides a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed minimum NFIP requirements. Participation in this program provides discounted flood insurance premium rates to reflect the reduce flood risk resulting from the community actions.

- In 1997, the U.S. Army Corps of Engineers initiated studies on Murrieta Creek resulting in the Murrieta Creek Flood Control, Environmental Restoration and Recreate Project. Limited funding has been appropriated for the construction of this project.

- The Subregional CAP includes the following recommended adaption strategies related to flood risk:

  - Strategy 5.2: Encourage retrofits of hardscaped areas to use permeable paving.

  - Strategy 5.4: Restore riparian corridors, soft-bottomed streambeds, and seasonal flood basins that reduce flood hazards.

  - Strategy 5.5: Encourage the use of low-impact development practices in new development.

  - Strategy 5.6: Avoid siting important infrastructure in or near flood areas.

- The City's LHMP includes the following objectives related to flood risk:

  - Objective 3.1: Cooperate with the Riverside County Flood Control and Water Conservation District to evaluate the effectiveness of existing flood control systems and improve these systems as necessary to meet capacity demands.

  - Objective 3.2: Actively participate in and strongly promote timely completion of regional drainage plans and improvement project which affect the City.

  - Objective 3.3: Identify natural drainage courses and designate drainage easements to allow for their preservation, or for the construction of drainage facilities if needed to protect the health, safety, and welfare of the community.

  - Objective 3.4: Require new construction within the 100-year floodplain to meet National Flood Insurance Program standards.

  - Objective 3.5: Develop and maintain floodplain inundation evacuation plans in cooperation with the Riverside County Flood Control and Water Conservation District and the Murrieta Fire Department.

  - Objective 3.6: Maintain an active swift water rescue response in the Murrieta Fire Department.

City residents living in areas at high-risk for flooding or dam inundation have limited adaptive capacity to deal with flooding. Structural improvements to modify or elevate homes and other structures as well as the purchase of flood insurance can reduce the financial burden of recovering from flooding, however, these options are not universally acquirable. Low-income, mobility-challenged, and physically- or linguistically-isolated persons are particularly vulnerable. Ultimately, the safety of City residents will be dependent on proper execution of evacuation procedures and durability of the systems in place to prevent flooding. Localized and tributary flooding will impact those living in near proximity to creeks and streams, as well as areas with older and constrained infrastructure that could back up when capacity is reached. The City is currently in the process of upgrading drainage infrastructure.

Adaptive Capacity for Flood Risk: ***Medium***

1.4 STEP 5: RISK AND ONSET

Risk and the project timeframe for which impact would occur is ranked by the likelihood or probability that a certain magnitude/extent/scale of a potential impact would occur. Risk is determined by a combination of the estimate certainty of the science projecting the climate change impact and the certainty of sector (i.e., population, function, structure) sensitivity. This risk is ranked low, medium, or high. Certainty ratings are based on percent probability of global models created by IPCC (CNRA 2012a:29). The timeframe in which the impact is most likely to occur (based on risk) can be categorized as:

- Current: Impacts currently or imminently occurring (2018-2020)
- Near-term: 2020-2040
- Mid-term: 2040-2070
- Long-term: 2070-2100

The risk certainty for the City and the timeframe of potential climate change exposures is summarized in Table 1.4-1

Table 1.4-1 Risk and Onset for the City of Murrieta Climate Change Impacts

Impact	Certainty Rating	Timeframe
Increased Temperatures	High	Current
Increased Frequency in Extreme Heat Events	High	Near-Term
Increased Frequency in Heat Waves	High	Near-Term
Increased Urban Heat Island Effect	High	Current
Changes to Precipitation Patterns	Medium	Current
Increased Frequency in Drought	Medium	Mid-Term
Increased Frequency of Severe Storms	Medium	Mid-Term
Increased Wildfire Risk	High	Near-Term
Increased Flood Risk	Medium	Mid-Term

The table shows that increased temperature, increased frequency of heat waves and extreme heat events, and the increased wildfire risk are of high certainty rating. Temperature- and wildfire-related impacts are the most likely near-term climate change exposures facing the City and should be addressed and prioritized first in future adaption planning efforts. With populations increasing and water supply already strained in the region, future meteorology, snowpack, streamflow, and groundwater conditions should continue to be examined more closely with actions taken to enhance the conservation and management of water supply and storage.

REFERENCES

CAL FIRE. *See* California Department of Forestry and Fire Protection.

CalEPA. *See* California Environmental Protection Agency.

California Energy Commission. 2018. *Cal-Adapt Web API*. Available https://cal-adapt.org/. Accessed on September 5, 2018. Prepared under contract by UC Berkeley Geospatial Innovations Facility.

_______. 2012. *Our Changing Climate: Vulnerability & Adaption to the Increasing Risks of Climate Change in California.* Available: http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf. Accessed September 5, 2018.

_______. 2013. *Building Energy Efficiency Standards for Residential and Nonresidential Buildings*. Available: https://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf. Accessed September 5, 2018.

California Department of Forestry and Fire Protection. 2009. *Very High Fire Hazard Severity Zones in LRA, Western Riverside County*. Available: http://www.fire.ca.gov/fire_prevention/fhsz_maps_riversidewest. Accessed September 4, 2018.

California Department of Public Health. 2017. *Climate Change and Health Profile Report for Riverside County*. Available: https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHPRs/CHPR065Riverside__County2-23-17.pdf. Accessed on September 4, 2018.

California Department of Transportation. 2013. *Addressing Climate Change Adaptation in Regional Transportation Plans*. Available: http://www.dot.ca.gov/hq/tpp/offices/orip/climate_change/documents/FR3_CA_Climate_Change_Adaptation_Guide_2013-02-26_.pdf. Accessed April 25, 2017.

California Environmental Protection Agency. 2013. *Preparing California for Extreme Heat: Guidance and Recommendations*. Available: http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_He at.pdf. Accessed September 4, 2018.

_______. 2018a. *Understanding the Urban Heat Island Index*. Available: https://calepa.ca.gov/climate/urban-heat-island-index-for-california/understanding-the-urban-heat-island-index/. Accessed September 5, 2018.

_______. 2018b. *Urban Heat Island Index Map for Southern California.* Available: http://climatechange.ca.gov/climate_action_team/urban_heat_island/Data_13-001/ALL_DATA_DH_Day_2/43_Southern_CA/43_Southern_CA_UHII.jpg. Accessed September 5, 2018.

California Governor's Office of Planning and Research. 2018. *California's Fourth Climate Change Assessment, Statewide Summary Report*. Available: http://resources.ca.gov/climate/safeguarding/research/. Accessed September 5, 2018.

California Natural Resources Agency. 2012. *California Adaption Planning Guide: Planning for Adaptive Communities*. Available: http://resources.ca.gov/docs/climate/01APG_Planning_for_Adaptive_Communities.pdf. Accessed on September 5, 2018.

_______. 2014. *Safeguarding California: Reducing Climate Risk. An Update to the 2009 California Climate Adaption Strategy*. Available: http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf. Accessed on September 5, 2018.

Caltrans. *See* California Department of Transportation.

CDHP. *See* California Department of Public Health.

CEC. *See* California Energy Commission

City. *See* City of Murrieta.

City of Murrieta. 2011a. *Murrieta General Plan 2035*. Available: https://www.murrietaca.gov/civicax/filebank/blobdload.aspx?BlobID=5188. Accessed on September 4, 2018.

_______. 2011b. *Murrieta General Plan 2035 – Final EIR*. Available: https://www.murrietaca.gov/civicax/filebank/blobdload.aspx?BlobID=5189. Accessed on September 4, 2018.

_______. 2012. *City of Murrieta Local Hazard Mitigation Plan*. Available: http://www.murrietaca.gov/documents/Fire/Local%20Hazard%20Mitigation%20Plan/Murrieta%20LHMP%202012%20-%20Rev.%2010.24.13.pdf. Accessed September 4, 2018.

County. *See* County of Riverside.

County of Riverside. 2012. *County of Riverside Multi-Jurisdictional Hazard Mitigation Plan*. Available: https://www.riversideca.gov/fire/oem/pdf/Completed-MJHMP-7-18-12.pdf. Access on September 4, 2018.

_______. 2014. *Riverside County General Plan Update Environmental Impact Report No. 521*. Available: http://planning.rctlma.org/ZoningInformation/GeneralPlan/GeneralPlanAmendmentNo960EIRNo521CAPMarch2014/DraftEnvironmentalImpactReportNo521.aspx. Accessed on September 4, 2018.

CNRA. *See* California Natural Resources Agency.

Dettinger, Michael. 2011. Climate Change, Atmospheric Rivers, and Flooding in California—A Multimodal Analysis of Storm Frequency and Magnitude Changes. Journal of the American Water Resources Association. Volume 47, No. 3, pp.514-523. Available: https://ca.water.usgs.gov/pubs/2011/climate-change-atmospheric-rivers-floods-california-dettinger.pdf. Accessed: May 31, 2017.

DOE. *See* U.S. Department of Energy.

Intergovernmental Panel on Climate Change. 2014. *Climate Change 2014. Mitigation of Climate Change.* Available: https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/WGIIIAR5_SPM_TS_Volume.pdf. Accessed on September 5, 2018.

IPCC. *See* Intergovernmental Panel on Climate Change.

National Integrated Drought Information System. 2018. *U.S Drought Monitor – Western RCC.* Available: https://www.drought.gov/drought/rcc/west. Accessed on September 5, 2018. Last updated August 28, 2018

National Oceanic and Atmospheric Administration. 2018. *NOAA Graphical Forecast for Southern California*. Available: https://graphical.weather.gov/sectors/southcalifornia.php#tabs. Accessed on September 6, 2018.

NIDIS. *See* National Integrated Drought Information System.

NOAA. *See* National Oceanic and Atmospheric Administration.

OPR. *See* California Governor's Office of Planning and Research.

Singer, Merrill et al. 2016. *"I Feel Suffocated:" Understandings of Climate Change in an Inner City Heat Island*. Medical Anthropology, 35:6, 453-463, DOI: 10.1080/01459740.2016.1204543.

U.S. Census Bureau. 2015. *OnTheMap - Home Area Profile Analysis*. Available: https://onthemap.ces.census.gov/. Accessed on September 6, 2018.

_______. 2017. *Quick Facts*, *Murrieta city, California*. Available: https://www.census.gov/quickfacts/fact/table/murrietacitycalifornia/PST045217. Accessed on September 4, 2018.

U.S. Department of Energy. No Date. *Weatherization Assistance Program.* Available: http://energy.gov/eere/wipo/weatherization-assistance-program. Accessed: August 24, 2016.

U.S. Environmental Protection Agency. 2017. *Climate Change Indicators: Heavy Precipitation*. Available: https://www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation. Accessed on September 6, 2018.

Western Riverside Council of Governments. 2014. *Subregional Climate Action Plan, Adaptation and Resiliency Strategy*. Available: http://www.wrcog.cog.ca.us/DocumentCenter/View/186/Climate-Adaptation-and-Resiliency-Study-PDF?bidId=. Accessed on September 4, 2018.

WRCOG. *See* Western Riverside Council of Governments.