

Appendix A

Summary of Adaptation Actions

Introduction

The following series of tables offer potential adaptation actions that could be applicable to the various impacts that may be a threat to sectors in Marin County. The sectors reflect those of importance in the county and the potential impacts are tailored to the climate hazards that may pose a risk to the county, based on the changes in temperature, precipitation, and sea level rise discussed in Chapter 7. This list provides suggested actions to increase resiliency; however, this is not an exhaustive list and is only intended for guidance and to initiate a discussion with relevant stakeholders after a comprehensive vulnerability assessment is completed.

Water

| Climate Hazard | Potential Impacts | Adaptation Options |
|--------------------------|---|--|
| Extreme Heat | <ul style="list-style-type: none"> • Decrease in water supplies as evapotranspiration increases • Depletion of groundwater | <ul style="list-style-type: none"> • Invest in secondary sources of water • Consider desalination as an option for potable water supply, while balancing environmental resource protection and water quality concerns. |
| | <ul style="list-style-type: none"> • Decreased quality because higher temperature can exacerbate eutrophication (algae growth) which can result in low dissolved oxygen • Higher water temperatures can also increase pathogen levels • Higher pollutant concentrations from larger evaporation losses | <ul style="list-style-type: none"> • Anticipate higher water treatment costs |
| | <ul style="list-style-type: none"> • Increase in demand for water e.g., cooling water for industry, irrigation, watering lawns, etc. | <ul style="list-style-type: none"> • Implement water conservation measures to mitigate demand |
| Riverine Flooding | <ul style="list-style-type: none"> • Increase in peak water flows | <ul style="list-style-type: none"> • Establish water management practices • Incorporate low-impact development (LID), best management practices, and other design standards that promote on-site water retention that slows surface water runoff |
| | <ul style="list-style-type: none"> • May dilute pollutant concentrations or increase pollutant concentrations by introducing pollutants from land surface | <ul style="list-style-type: none"> • Anticipate higher water treatment costs |

| Climate Hazard | Potential Impacts | Adaptation Options |
|---|---|---|
| Sea Level Rise (permanent inundation and episodic flooding) | <ul style="list-style-type: none"> Reduction in quality of groundwater by seawater intrusion, reducing the quantity available for consumption | <ul style="list-style-type: none"> Review coastal flood protection measures Install groundwater barriers |
| | <ul style="list-style-type: none"> Increase in demand on other water resource supplies not affected by saline intrusion | <ul style="list-style-type: none"> Develop alternative water supply resources |
| Wildfires | <ul style="list-style-type: none"> Increased land erosion related to rainfall on denuded soils (sedimentation, suspended solids); increase of pollutants (chemicals from firefighting, nitrates from fire) Disruption to reforestation/revegetation | <ul style="list-style-type: none"> Consider erosion control measures, including replanting and non-vegetative measures (e.g., geotextiles) |
| | <ul style="list-style-type: none"> Increase of water pollutants (i.e., chemicals from firefighting, nitrates from fire) | <ul style="list-style-type: none"> Enhance water treatment |
| | <ul style="list-style-type: none"> May result in changes of water flows (e.g., peak-flow increases related to denuded and hydrophobic soils) | <ul style="list-style-type: none"> Implement water catchment features Implement erosion protection measures |
| | <ul style="list-style-type: none"> Decreased sub surface flow and evapotranspiration given denuded land and hydrophobic soils | <ul style="list-style-type: none"> Review forest management practices |
| Shift in Energy Demand and Supply | <ul style="list-style-type: none"> Increase in costs of pumping and delivering water as demand for energy increases | <ul style="list-style-type: none"> Anticipate higher water treatment costs |

Natural Heritage

| Climate Hazard | Potential Impacts | Adaptation Options |
|-----------------------|--|---|
| Extreme Heat | <ul style="list-style-type: none"> Stress on threatened and endangered species (or any species) | <ul style="list-style-type: none"> Consider species monitoring |
| | <ul style="list-style-type: none"> Shifts in species habitat ranges with the possibility of increased human-wildlife interactions and increased stress on species who have nowhere to migrate | <ul style="list-style-type: none"> Increase habitat connectivity or ensure habitat corridors established |

| Climate Hazard | Potential Impacts | Adaptation Options |
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| | <ul style="list-style-type: none"> Decline in number of days (or hours in the day) that visitors can comfortably and safely visit parks | <ul style="list-style-type: none"> Increase the availability of shade and water Consider offering alternative recreational activities |
| | <ul style="list-style-type: none"> Emergence of new plant and animal communities | <ul style="list-style-type: none"> Monitor to track emergence and spread of new species (and determine if management interventions are necessary) |
| | <ul style="list-style-type: none"> Rising water temperatures may stress species | <ul style="list-style-type: none"> Implement cooling techniques (e.g., planting shade trees around streams and small water bodies) |
| | <ul style="list-style-type: none"> Increased threat from heat-tolerant invasive species | <ul style="list-style-type: none"> Deploy best management practices to control and prevent spread of invasive species |
| Riverine Flooding | <ul style="list-style-type: none"> Destruction of habitats due to flooding and landslides Destruction of recreational areas due to flooding and landslides | <ul style="list-style-type: none"> Consider BMPs to improve flood protection Review/revise land management plans and development codes Provide public education to address preparedness for climate hazards and habitat restoration |
| Sea Level Rise (permanent inundation and episodic flooding) | <ul style="list-style-type: none"> Decreasing extent of marsh habitat, affecting ability of species to feed, nest, etc. Cliff and shoreline erosion Combined flooding: where riverine flooding (flowing off the land) can be additive to increased water run-up from the sea (significant problem at Stinson Beach) | <ul style="list-style-type: none"> Acquire and protect areas where marsh can migrate upland as inundation increases Create “no-wake zones” to reduce erosion Ensure adequate sediment supply to promote marsh accretion Establish new setback requirements to reduce susceptibility to erosion risks and combined flooding impacts Consider proactive wetland enhancement |
| | <ul style="list-style-type: none"> Damage to or destruction of beaches used for recreation | <ul style="list-style-type: none"> Consider offering alternative recreational activities |
| Shift in Water Demand/Supply | <ul style="list-style-type: none"> Decreased lake levels, impacting species health | <ul style="list-style-type: none"> Consider species monitoring |
| | <ul style="list-style-type: none"> Decreased lake levels, decreasing recreational opportunities (e.g., boating, rafting) | <ul style="list-style-type: none"> Consider offering alternative recreational activities Consider lake and reservoir management |
| | <ul style="list-style-type: none"> Shift toward more drought-tolerant species | <ul style="list-style-type: none"> Consider water needs of plants when choosing new plants |
| | <ul style="list-style-type: none"> Increased disease in trees due to droughts | <ul style="list-style-type: none"> Consider measures to control the outbreak and spread of disease |

| Climate Hazard | Potential Impacts | Adaptation Options |
|---------------------------------|---|--|
| Wildfires | <ul style="list-style-type: none"> • Destruction of habitat for threatened and endangered species (or any species) • Increased opportunities for establishment and spread of invasive species | <ul style="list-style-type: none"> • Consider species monitoring • Establish good plan to prevent fires from starting (e.g. fire management zones) • Deploy best management practices to control and prevent spread of invasive species |
| Change in Growing Season | <ul style="list-style-type: none"> • Changes in the timing of flowering • Mismatch in timing between blooms and pollinators or availability of food and species that rely upon it | <ul style="list-style-type: none"> • Consider shifts in growing season and likely survivability when selecting and planting new vegetation • Consider species monitoring |

Transportation

| Climate Hazard | Potential Impacts | Adaptation Options |
|--------------------------|---|--|
| Extreme Heat | <ul style="list-style-type: none"> • Transportation workers may be at risk of overheating during maintenance and operations of equipment. Interruptions in service may occur if unsafe conditions prevent workers from performing duties | <ul style="list-style-type: none"> • Develop plan to address worker safety with regards to extreme heat |
| | <ul style="list-style-type: none"> • May cause concrete pavement buckling and loss of non-concrete pavement integrity (e.g., asphalt melt) for roads and sidewalks. • Can lead to rail damage | <ul style="list-style-type: none"> • Review guidelines for materials to ensure those used can withstand increased maximum temperatures. |
| | <ul style="list-style-type: none"> • Increases in lightning activity poses threat to electronic equipment and interferes with operations | <ul style="list-style-type: none"> • Protect electronic equipment |
| | <ul style="list-style-type: none"> • Many types of vehicles can overheat, and tires will deteriorate more quickly | <ul style="list-style-type: none"> • Shorten maintenance schedule • Select equipment that can withstand higher temperatures |
| Riverine Flooding | <ul style="list-style-type: none"> • Heaving rain can cause standing water on runways, sidewalks, and roads, causing transportation delays | <ul style="list-style-type: none"> • Make Public Service Announcements to let drivers know about closures • Reroute or elevate roads • Improve drainage on existing roads • Establish redundant routes |

| Climate Hazard | Potential Impacts | Adaptation Options |
|---|--|--|
| Sea Level Rise (permanent inundation and episodic flooding) | <ul style="list-style-type: none"> Sea level rise in combination with tidal actions and/or subsidence can inundate low-lying transportation systems in coastal areas (such as Highway 101) May disrupt marine transportation facilities | <ul style="list-style-type: none"> Make Public Service Announcements to let drivers know about closures Reroute or elevate roads Establish redundant routes Adapt marine facilities (e.g., ferry terminals) Plan emergency evacuation routes and alternative entrances/exits to Highway 101 |
| Wildfires | <ul style="list-style-type: none"> Post-wildfire debris flow can cause damage to bridge abutments and roads Rail ties and tracks are susceptible to damage from wildfire heat. Wooden ties can combust when exposed to fire. Metal components can warp or melt if exposed to high temperatures. Typical asphalt mixtures have the potential to ignite during tunnel fires | <ul style="list-style-type: none"> Establish good plan to prevent fires from starting (keep underbrush levels low, establish buffer between wild areas and transportation facilities to starve fire) Provide water resources to put out fires Conduct post-event evaluation and maintenance to ensure all facilities are up to standard for safe operations and use |
| Shift in Energy Demand and Supply | <ul style="list-style-type: none"> Rising costs of transportation due to increase in fuel and energy prices, could place additional demand on public transportation services | <ul style="list-style-type: none"> Monitor public transit ridership and shifts in demand |

Agriculture

| Climate Hazard | Potential Impacts | Adaptation Options |
|-----------------------|---|--|
| Extreme Heat | <ul style="list-style-type: none"> Cattle and sheep may experience heat exhaustion, stress, or death that could result in increased vulnerability to disease, reduced fertility, and reduced milk production | <ul style="list-style-type: none"> Identify and establish areas that can provide shade (e.g., trees and manmade structures) for animals to get out of the sun Ensure that animals have consistent access to water to cool off Increase ventilation in barns |
| | <ul style="list-style-type: none"> Extreme heat may reduce yields or cause complete crop loss, depending on the timing of the heat spell during the growing season | <ul style="list-style-type: none"> Adjust growing season or select varieties of plants that are heat resistant Use innovative growing methods that reduce heat locally |

| Climate Hazard | Potential Impacts | Adaptation Options |
|---|--|---|
| Riverine Flooding | <ul style="list-style-type: none"> Contamination of cattle drinking water may result in animal sickness | <ul style="list-style-type: none"> Develop a plan for where to move animals in the event of a flood Remove manure from areas that are likely to flood Monitor animals for sickness Monitor drinking water |
| | <ul style="list-style-type: none"> Damage to barns, other infrastructure, and machinery | <ul style="list-style-type: none"> Move buildings and critical infrastructure out of the floodplain and other low lying areas Keep only movable machinery or structures that can withstand temporary inundation in the floodplain |
| | <ul style="list-style-type: none"> Can result in oxidative stress of plants, which may reduce yields or kill plants, depending on extent and duration | <ul style="list-style-type: none"> Develop a drainage system that can quickly move water away from crops (may want to move water into a location for future use to address flood-drought cycles) |
| | <ul style="list-style-type: none"> All sensitivities mentioned above for animals and crops. | <ul style="list-style-type: none"> Develop a watershed plan to mitigate flooding that is built off existing floodplains and takes into account potential for changes in precipitation patterns (e.g., heavier rainfall events) Use buffers to modify and reduce fertilizer and pesticide application to address potential increases in polluted agricultural runoff |
| Sea Level Rise (permanent inundation and episodic flooding) | <ul style="list-style-type: none"> Salinization of soils from coastal inundation may create parcels that are no longer appropriate for growing plants for grazing or other types of food production. Loss of land due to erosion | <ul style="list-style-type: none"> Construct physical barriers or modify the landscape to protect land from inundation and erosion Develop carbon farming and wetland restoration along Marin's bayshore to restore wetlands, sequester atmospheric carbon, and accrue significant quantities of carbon-rich soil to increase shoreline elevation and buffer storm surges |
| Shift in Water Demand/Supply | <ul style="list-style-type: none"> Lack of access to water can result in dehydration and/or death of animals. | <ul style="list-style-type: none"> Construct water reservoirs for animals to use if naturally occurring water sources are not as reliable as in past Develop methods to collect water during times of drought (e.g., rain barrels, water storage ponds, etc.) Enhance water-holding capacity of Marin's agricultural soils through use of compost and other organic carbon enhancement strategies per Marin Carbon Project Carbon Farm Planning Protocol |

| Climate Hazard | Potential Impacts | Adaptation Options |
|---|--|---|
| | <ul style="list-style-type: none"> Lack of access to water can result in reduced yields or plant death depending on timing and duration. | <ul style="list-style-type: none"> Add irrigation system for crops Plant drought tolerant varieties of crops Develop methods to collect water during times of drought (e.g., rain barrels, water storage ponds, etc.) |
| Wildfires | <ul style="list-style-type: none"> Wildfires can burn/damage/kill cattle and agricultural equipment/barns/etc. Ruin grazing land for short to long term (depending on level of damage). Damage farmland and fruit trees for production. | <ul style="list-style-type: none"> Establish good plan to prevent fires from starting (keep underbrush levels low, establish buffer between wild areas and agricultural areas to starve fire) Provide water resources to put out fires Establish plan to keep animals safe during a fire |
| Change in Growing Season | <ul style="list-style-type: none"> Increased temperatures and shifts in the precipitation and fog patterns could result in periods with insufficient plants for grazing. Temperatures and water availability may reduce or eliminate crop yields depending on length and intensity of shift. | <ul style="list-style-type: none"> Add new plants to the grazing fields that are seasonally insensitive, supplement cattle other food sources Shift planting timing based on weather forecasts and longer term trends in seasonality changes. Grow different varieties that are more tolerant to variability or grow new types of plants that are more tolerant |
| Warming, acidification of Bay and coastal waters | <ul style="list-style-type: none"> Fishing and Mariculture: Warming waters may shift the distribution of target species in the ocean, affect the spawning and rearing of anadromous and stream species such as salmon, and potentially affect shellfish production. | <ul style="list-style-type: none"> Monitor research developments and potential adaptation strategies Consider the potential for shellfish production options within the county to enhance countywide resilience against potential warming/acidification impacts in specific shellfish production waters while balancing environmental resource protection and water quality issues. |

Energy

| Climate Hazard | Potential Impacts | Adaptation Options |
|---------------------|---|---|
| Extreme Heat | <ul style="list-style-type: none"> Decreased energy system efficiency, due to increase in frequency of severity of very hot days and heat waves | <ul style="list-style-type: none"> Diversify energy supply chain (e.g., a new solar farm project capable of powering 500 Marin homes is currently being installed an old quarry in Novato) Build redundancy into facilities Add peak generation, power storage capacity, and distributed generation Add backup power supply for grid interruptions Insulate equipment for temperature extremes |
| | <ul style="list-style-type: none"> Overall increases in cost due to reduced oil, gas, and coal processes efficiency Increased fuel extraction and processing costs | <ul style="list-style-type: none"> Diversify supply chain Increase energy system efficiency |
| | <ul style="list-style-type: none"> Increased temperatures affect the transmission and distribution of energy (e.g., can lead to failure of power transformers; increased stress on transmission infrastructure and grid, leading to disruption of supply; increased sag of overhead line conductors) Heat waves and higher temperatures reduce the longevity of production equipment through reductions in material strength or warping | <ul style="list-style-type: none"> Utilities: <ul style="list-style-type: none"> Improve reliability of grid systems through backup power supply, intelligent controls, and distributed generation Increase transmission capacity between regions Conduct annual review of network loadings to ensure adequate headroom on network Provide annual review of network loadings to ensure adequate headroom on network Institute proactive program replacement driven by monitoring the condition of assets; condition information gathered through combination of thermal imaging, hi-res imaging, and periodic foot and helicopter patrols County/Utilities: Monitor vegetation and review vegetation management in place to maintain statutory clearances to overhead assets. This includes resilience against falling vegetation |

| Climate Hazard | Potential Impacts | Adaptation Options |
|---|--|---|
| | <ul style="list-style-type: none"> Increased energy demand for AC, refrigeration, and water | <ul style="list-style-type: none"> Improve water distribution/reuse efficiency Allow flexible work schedules to transfer energy use to off-peak hours Expand capacity and encourage conservation Set higher temperatures in buildings Improve building energy use Upgrade cooling system and manufacturing efficiencies Employ demand-response capabilities (e.g., smart grid) Enhance urban forestry to reduce the heat-island effect in built-up portions of the County |
| Riverine Flooding | <ul style="list-style-type: none"> Can damage power lines and electricity distribution | <ul style="list-style-type: none"> Move critical infrastructure out of the floodplain Elevate or protect infrastructure that cannot be moved |
| | <ul style="list-style-type: none"> Disruptions in railway, truck, and marine transportation that transport oil, gas, and coal | <ul style="list-style-type: none"> Provide backup power generation for critical systems that rely on the grid. |
| Sea Level Rise (permanent inundation and episodic flooding) | <ul style="list-style-type: none"> Energy infrastructure located in low-lying coastal areas may be temporarily or permanently inundated. Increased energy use for additional pumping requirements related to retention of runoff behind expanded levees. | <ul style="list-style-type: none"> Move critical infrastructure out of low-lying coastal areas Develop land use plans to reduce need for expanded levees |
| Shift in Water Demand/Supply | <ul style="list-style-type: none"> Drought may increase the need for energy-intensive methods of providing drinking and irrigation water that is pumped, transported, and treated. | <ul style="list-style-type: none"> Seek alternative technology that requires less energy to pump, transport, and treat water. Promote water conservation |
| Wildfires | <ul style="list-style-type: none"> Energy infrastructure located in high wildfire risk areas may suffer disruptions or damage. | <ul style="list-style-type: none"> Expand fire prevention plan to include climate projections. |

Human Health

| Climate Hazard | Potential Impacts | Adaptation Options |
|--|---|---|
| Extreme Heat | <ul style="list-style-type: none"> • Extreme heat may cause stress, heat stroke, and mortality. | <ul style="list-style-type: none"> • Provide early-warning systems • Provide cooling facilities • Reduce outdoor activities • Stagger activities such as construction to cooler times of day |
| | <ul style="list-style-type: none"> • Extreme heat degrades air quality with tropospheric ozone and particulate matter, including risks of cardiovascular disease, chronic and acute respiratory disease, lung cancer and preterm birth | <ul style="list-style-type: none"> • Early warning systems • Monitor air quality concentrations • Reduce exposure to outdoors, especially for children, elderly, and other sensitive populations |
| | <ul style="list-style-type: none"> • Algae growth along coastlines (e.g., red tide) due to warmer sea surface temperatures | <ul style="list-style-type: none"> • Monitor coastal conditions • Reduce discharge of warmer waters/fertilizers upstream if applicable • Make announcements to alert public when the water is and is not safe for swimming and fishing |
| Riverine Flooding | <ul style="list-style-type: none"> • Mortality and injury due to flooding • Mental health and stress disorders due to geographic displacement and loss of loved ones | <ul style="list-style-type: none"> • Provide public education to address preparedness for climate hazards • Update building codes to require structural adaptations to withstand flood inundation • Develop managed realignment/relocation plans, which could include transfer of development credits, simple acquisition, and conservation easements • Develop structural and non-structural adaptations to increased risk of flooding • Update zoning to discourage construction in flood-prone areas |
| Sea Level Rise (permanent inundation and episodic flooding) | <ul style="list-style-type: none"> • Mortality and injury due to bigger waves, storm surges, and wave run-up • Mental health and stress disorders due to geographic displacement and loss of loved ones | <ul style="list-style-type: none"> • Provide public education to address preparedness for climate hazards • Update building codes to require structural adaptations to withstand flood inundation • Develop managed realignment/relocation plans, which could include transfer of development credits, simple acquisition, and conservation easements • Develop structural and non-structural adaptations to increased risk of flooding • Update zoning to discourage construction in areas that are prone to inundation from sea level rise |

| Climate Hazard | Potential Impacts | Adaptation Options |
|--------------------------------------|---|---|
| Wildfires | <ul style="list-style-type: none"> • Mortality and morbid impacts • Mental health and stress disorders due to geographic displacement and loss of loved ones | <ul style="list-style-type: none"> • Provide public education to address preparedness for climate hazards • Establish good plan to prevent fires from starting (e.g. fire management zones) |
| Change in Growing Season | <ul style="list-style-type: none"> • Food security as availability and costs may change | <ul style="list-style-type: none"> • Diversify food supply chain; ensure that multiple food source options exist, including local sources |
| | <ul style="list-style-type: none"> • Shift in the timing of outdoor allergens such as pollen | <ul style="list-style-type: none"> • Provide public announcements to alert the public |
| Shift in Energy Demand/Supply | <ul style="list-style-type: none"> • Brownouts could impact the availability of energy for critical health needs, such as air conditioning for sensitive populations during extreme heat events. | <ul style="list-style-type: none"> • Develop contingency plan at hospitals and for patients that receive care at home for situations with loss of power |