2024

Orange County Water and Wastewater Multi-Jurisdictional Hazard Mitigation Plan

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WEROC

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SECTION 1: INTRODUCTION

Across the United States, natural and human-caused disasters have led to increasing levels of death, injury, property damage, and interruption of business and government services. The impact to water and wastewater utilities and the individuals they serve can be immense and damages to their infrastructure can result in regional economic and public health consequences. The water and wastewater utilities are vulnerable to a variety of hazards that can result in damaged equipment, loss of power, disruption to services, contaminated water supply, and revenue losses. By planning for natural and human-caused hazards and implementing projects that mitigate risk, utilities can reduce costly damage and improve the reliability of service following a disaster.

As a best practice Orange County water and wastewater agencies have worked together for decades to improve regional and local reliability and resiliency through joint or collaborative capital improvement projects, planning processes, and emergency management practices. Throughout the county's history the need for, and development of, water and wastewater services has been driven by the principles of economies of scale, and limitations of risk by working together among the wholesale and retail water and wastewater agencies. Below is a brief history of this collaborative process that developed the framework for this multi-agency plan today.

- In 1921 the Orange County Joint Outfall Sewer (JOS) is formed. Santa Ana and Anaheim agree to construct an outfall extending into the Pacific Ocean.
- In 1928 the cities of Anaheim, Fullerton, and Santa Ana realized that groundwater supplies were insufficient to meet the demands of their growing communities, prompting them to join the Metropolitan Water District of Southern California (Metropolitan) in order to get access to water imported from the Colorado River.
- In 1931 local agencies again recognized the importance of economies in scale by forming the Orange County Water District (OCWD). One of the goals of OCWD is to protect Orange County's Santa Ana River water rights from upstream interest.
- Growth in Orange County continued into the 1940s and 1950s when it was realized that the next increment of supplies was needed. That is when portions of what is now Orange County (outside of those original three cities) joined Metropolitan. The Metropolitan was formed for much the same reason, in that it was more economical and less risky to pursue importation of water from the Colorado River and later Northern California as part of a large co-op rather than having each local entity rely on their own planning and development of water supplies.
- The supplemental water supplies of Metropolitan encouraged other Orange County water providers to collaborate, creating the Coastal Municipal Water District (Coastal) in 1941, and Orange County Municipal Water District (OCMWD) in 1951. OCMWD would go on to change its name to Municipal Water District of Orange County (MWDOC).
- Following a 1946 Board of Supervisor's Orange County Sewerage Survey Report, seven individual districts combine into the JOS. While individual cities continue to maintain sewage collection systems, county-wide collections and treatment became a regional operation. And after several reiterations, it became the Orange County Sanitation District (OC San).
- Later, as Orange County continued to develop and expand, these new developments were located further and further from the Metropolitan pipelines bringing water into Orange County. Economically it was again much more efficient, and less risky, for local members to band

together to participate in regional pipelines and jointly use the same water facilities to convey the Metropolitan water from where it was available to where it was needed. Even today, water reliability planning is conducted based on the needs of these original areas, each with its own supply reliability risk profile. The three areas are:

1. The Brea/La Habra service area receives approximately 80% of their supplies from Cal Domestic Water Company groundwater sources in San Gabriel Valley.
2. The OCWD service area receives approximately 75% of their supplies from groundwater sources.
3. The South Orange County service area has few local resources, thereby requiring the import of approximately 95% of their potable water demands.

- In 1983 the Volunteer Emergency Preparedness Organization (VEPO) was formed, creating a mutual aid agreement and communications system for Orange County's 33 water utilities to work together.
- Following the 1994 Northridge Earthquake and subsequent Standardized Emergency Management System in 1996, Orange County water agencies recognized the need to staff the VEPO program as a shared service to support its member agency's disaster readiness.
- VEPO was renamed to the Water Emergency Response Organization of Orange County (WEROC) in 1999 to better reflect its goal and purpose.
- The agency known today as the South Orange County Wastewater Authority (SOCWA) was formed in 2001 when the South East Regional Reclamation Authority (SERRA), Aliso Water Management Agency (AWMA), and South Orange County Reclamation Authority consolidated to meet the wastewater needs of more than 500,000 homes and businesses across South Orange County.
- In 2006, WEROC staff realized the importance of including wastewater agencies in its program, as many of its water utilities also provided wastewater services and because the sectors had similar resources that could support each other. With this change, the program welcomed in wastewater agencies and grew to support 37 agencies in total.
- In 2008, the internationally awarded Ground Water Replenishment System (GWR) was completed. This was a joint project of the OCWD and the OC San enhancing reliability for all of the county.
- In 2019, WEROC supported American Water Infrastructure Act (AWIA) compliance for nearly all agencies within the planning area to ensure timely and accurate completion of Risk Resilience Assessments (RRAs) and Emergency Response Plans (ERPs) in accordance with Environmental Protection Agency (EPA) requirements.
- In 2021, Orange County Local Agency Formation Commission (LAFCO) unanimously approved the annexation of the City of San Juan Capistrano water and wastewater facilities into the Santa Margarita Water District (SMWD), allowing SMWD to manage and operate water and wastewater services to customers within the City of San Juan Capistrano.

As has been demonstrated throughout the history of Orange County, the principles of banding together with neighboring interests to create joint regional infrastructure, connected systems, and economies of scale have been applied time and time again. Working together to develop a Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) focused on the agencies (cities and special districts) that provide drinking water and wastewater services came from an already standing practice of regional planning and coordination to improve resiliency and response. Additionally, it gave the participating agencies the opportunity to focus on risk as it applies specifically to these joint considerations as well as their jurisdiction's individual services.

In 2005, WEROC started to work with its member agencies (MAs), the California Governor's Office of Emergency Services (Cal OES), and the Federal Emergency Management Agency (FEMA) to fund the first MJHMP through a Hazard Mitigation Planning Grant. In 2007, with the assistance of the Mitigation Grant, MWDOC along with 20 MAs prepared an MJHMP that identified critical water and wastewater facilities in the county and mitigation actions in the form of projects and programs to reduce the impact of natural and human-caused hazards on these facilities. The vision of this original MJHMP took into consideration regional and local infrastructure, how it worked together, and how it could be strengthened, while supporting other planning efforts such as the South Orange County Reliability Study and later the Orange County Reliability Study.

This plan builds on the original 2007 MJHMP and previous updates in 2012 and 2019. MWDOC was joined in this current update by 14 participating water and wastewater utilities (see **Section 1.2.2**), the current MAs, which serve communities in Orange County, California. The plan was prepared with input from county residents, Orange County emergency managers, and with the support of the Cal OES and FEMA. The process to develop the MJHMP update included two Planning Team meetings and coordination with representatives from MWDOC and each participating MA.

This MJHMP is a guide for MWDOC and the MAs over the next five years toward greater disaster resistance in harmony with the character and needs of the local community and the MAs. The plan focuses on participating water and wastewater facilities in the county and identifies mitigation actions to reduce the impact of natural and human-caused hazards on critical facilities. In addition, each agency will use current, approved planning documents that identify implementation strategies for capital improvement, risk reduction, system upgrades, and operations. These documents complement the MJHMP and include but are not limited to: Urban Water Management Plans, AWIA RRAs, All Hazards Standardized Emergency Management System (SEMS)/National Incident Management System (NIMS) ERPs, Capital Improvement Plans (CIPs), and Asset Management Plans.

The MJHMP is a working document that will grow and change as our communities and MAs do. This means at times participating agencies may identify a higher priority than noted in this plan, or a redirection of goals based on current information or updated decisions. In consideration of this concept, there may be projects or policies that need to be considered that were not included in this document. These changes will be documented during the MJHMP implementation, and formal updates to the plan will be made every five years as required to maintain a valid plan and FEMA grant eligibility.

1.1 Purpose of the Plan and Authority

Federal legislation has historically provided funding for disaster relief, recovery, and some hazard mitigation planning. The Disaster Mitigation Act of 2000 (DMA 2000) is the latest legislation to improve this planning process (Public Law 106-390). This legislation reinforces the importance of mitigation planning and emphasizes planning for disasters before they occur. As such, DMA 2000 establishes a pre-disaster hazard mitigation program and new requirements for the national post-disaster Hazard Mitigation Grant Program (HMGP). The Pre-Disaster Mitigation Act of 2010 was signed into law in January of 2011 but does not impact the planning process. The 2010 Act reauthorizes the pre-disaster mitigation program.

Section 322 of DMA 2000 specifically addresses mitigation planning at the State and local levels. It identifies the requirements that allow HMGP funds to be used for planning activities and increases the amount of HMGP funds available to States that have developed a comprehensive, enhanced mitigation plan prior to a disaster. States and communities must have an approved mitigation plan in place prior to receiving pre- or post-disaster funds. Local mitigation plans must demonstrate that their proposed mitigation measures are based on a sound planning process that accounts for the risk to and the capabilities of the individual communities.

DMA 2000 is intended to facilitate cooperation between State and local authorities, prompting them to work together. It encourages and rewards local and State pre-disaster planning and promotes sustainability as a strategy for disaster resistance. This enhanced planning network is intended to enable local and State governments to articulate accurate needs for mitigation, resulting in faster allocation of funding and more effective risk reduction projects.

FEMA prepared the Final Rule, published in the Federal Register on September 16, 2009 (Code of Federal Regulations [CFR] at Title 44, Chapter 1, Part 201 [44 CFR Part 201 and 206]), which establishes planning and funding criteria for States and local communities.

According to the updated FEMA Local Hazard Mitigation Policy Guide (FEMA 2022) and 44 CFR § 201.6(a)(4), local governments may work together to create a multi-jurisdictional plan. For multi-jurisdictional plans, one community should be designated as the lead jurisdiction. For this update MWDOC is acting as the lead jurisdiction and is responsible for ensuring each participating jurisdiction meets the requirements laid out in the guidance. MWDOC is also taking on the role of coordinating the plan submission and adoption by all participating jurisdictions (the 15 current MAs).

For Federal approval, the following criteria must be met during the planning process:

- Complete documentation of the planning process.
- Detailed risk assessment of hazard exposures in the community and water and wastewater infrastructure.
- Comprehensive mitigation strategy, describing goals and objectives, proposed strategies, programs, and actions to avoid long-term vulnerabilities.
- A planned maintenance process will describe the method and schedule for monitoring, evaluating, and updating the MJHMP, and the integration of the plan into other planning mechanisms.
- The formal adoption of the governing bodies of each participating jurisdiction.
- Plan review by both Cal OES and FEMA.

As the cost of recovering from natural disasters continues to increase, the MAs realize the importance of identifying effective ways to reduce vulnerability to disasters. HMPs assist communities in reducing risk from natural hazards by identifying resources, information, and strategies for risk reduction, while guiding and coordinating mitigation activities.

The Orange County Water and Wastewater MJHMP provides a framework for participating water and wastewater utilities to plan for natural and human-caused hazards in Orange County. The resources and information within the plan will allow participating jurisdictions to identify and prioritize future mitigation projects, meet the requirements of Federal assistance programs and grant applications, and encourage coordination and collaboration in meeting mitigation goals.

This MJHMP is intended to serve many purposes, including:

- **Enhance Public Awareness and Understanding.** To help county residents better understand the natural and human-caused hazards that threaten public health, safety, and welfare; economic vitality; and the operational capability of important facilities.
- **Create a Decision Tool for Management.** To provide information so that water and wastewater managers and leaders of local government may act to address vulnerabilities.
- **Enhance Local Policies for Hazard Mitigation Capability.** To provide the policy basis for mitigation actions that will create a more disaster-resistant future.
- **Integrate the HMP into Other Plans and Programs.** To provide an opportunity for MWDOC and the MAs to assess their current planning efforts associated with water supply management, infrastructure enhancement, and facilities master planning and to promote the integration of hazard mitigation into these activities.
- **Provide Inter-Jurisdictional Coordination of Mitigation-Related Programming.** To ensure that proposals for mitigation initiatives are reviewed and coordinated among MWDOC and MAs.
- **Promote Compliance with State and Federal Program Requirements**. To ensure that MWDOC and the MAs can take full advantage of State and Federal grant programs, policies, and regulations.

To qualify for certain forms of Federal aid for pre- and post-disaster funding, local jurisdictions must comply with the Federal DMA 2000 and its implementing regulations. The MJHMP has been prepared to meet FEMA and Cal OES requirements, thus making MWDOC and the participating MAs eligible for funding and technical assistance for State and Federal hazard mitigation grant programs.

DMA 2000 requires local HMPs, including this plan, to be updated every five years. This means that this MJHMP is designed to carry the MAs through the next five years, after which its assumptions, goals, and objectives will be revisited, updated, and resubmitted for approval.

1.2 Multi-Jurisdictional Participation

1.2.1 Overview of Water and Wastewater Systems in Orange County

Water distribution and wastewater collection and treatment in Orange County involves dozens of agencies and utilities working together, and relies on integrated, regional systems and facilities. There are several retail water and wastewater utilities in Orange County, each with its own distinct service area and sources of potable water. The retail water agencies include water districts and city water departments (not participating in this update).

MWDOC is a wholesale water supplier and resource planning agency that serves all of Orange County (except Anaheim, Fullerton, and Santa Ana) through 28 retail water agencies. MWDOC purchases imported water from the Metropolitan for distribution to its MAs, which provide retail water services to the public. Local supplies meet more than half of Orange County's total water demand. To meet the remaining demand, MWDOC purchases imported water from Northern California (through the State Water Project) and the Colorado River. This water is provided by Metropolitan, which in addition to Orange County, also serves Ventura, Los Angeles, San Bernardino, Riverside, and San Diego counties (MWDOC 2016).

Local water supplies in Orange County vary regionally and include groundwater, recycled wastewater, and surface water. Water supply resources in MWDOC's service area include groundwater basins, which provide a reliable local source and are also used as reservoirs to store water during wet years and draw from storage during dry years. Recycled water and surface water provide an additional local source to some MWDOC retail agencies, with surface water captured mostly from Santiago Creek into Santiago Reservoir (MWDOC 2016).

The OCWD manages and replenishes the Orange County Groundwater Basin, ensures water reliability and quality, prevents seawater intrusion, and protects Orange County's rights to Santa Ana River water. The Orange County Groundwater Basin contains approximately 500,000 acre-feet (AF) of usable storage water and covers 270 square miles. The basin is a reliable source of water and provides approximately 75% of north and central Orange County's water supply, as South Orange County is virtually 100% dependent on imported water.

MWDOC and OCWD work cooperatively and continue to evaluate new and innovative programs, including seawater desalination, wetlands expansion, recharge facility construction, surface storage, new water use efficiency programs, and system interconnections for enhanced reliability.

Wastewater collection and treatment in Orange County is managed by two regional agencies: OC San and the SOCWA, which cover north and central Orange County and South Orange County, respectively. These districts are responsible for the trunk line collection, treatment, biosolids management, and ocean outfalls for treated wastewater disposal. OC San has two primary treatment facilities, and SOCWA has three primary treatment facilities. Their facilities treat wastewater from residential, commercial, and industrial sources. Costa Mesa Sanitary District (CMSD) is a smaller wastewater provider that primarily supports the City of Costa Mesa. With more than 200 miles of sewer mains, CMSD provides service to more than 47,000 connections within their service area.

1.2.1.1 Potable Water Supplies – Current and Future

Potable water demand for Orange County was about 427,700 acre-feet per year (AF/yr) in 2020. In 2020 MWDOC provided service to approximately 2.34 million residents of the Orange County population, and that number is projected to rise to approximately 2.41 million people by 2025 (3% increase). While potable water demand in 2025 is projected to increase to 486,747 (AF/yr). This constitutes an increase of approximately 145 over 2020 demand. However some of this increase may be attributed to removal of some of the water restrictions put in place due to the drought conditions experienced in Orange County.

With planned local water supply projects plus the continued availability of Metropolitan water to replenish the Orange County Groundwater Basin, demand projections show a 12% decrease in demand for imported, full-service Metropolitan water by 2025. If the local projects do not get built, produce less than planned, or are merely delayed, then additional Metropolitan water will be needed.

1.2.2 Participating Jurisdictions

Following is a list of the jurisdictions participating in the MJHMP update; refer to **Exhibit 1-1:**

- Municipal Water District of Orange County (MWDOC)
- Costa Mesa Sanitary District (CMSD)
- El Toro Water District (ETWD)
- Irvine Ranch Water District (IRWD)
- Laguna Beach County Water District (LBCWD)
- Mesa Water District
- Moulton Niguel Water District (MNWD)
- Orange County Sanitation District (OC San)
- Orange County Water District (OCWD)
- Santa Margarita Water District (SMWD)
- Serrano Water District
- South Coast Water District (SCWD)
- South Orange County Wastewater Authority (SOCWA)
- Trabuco Canyon Water District (TCWD)
- Yorba Linda Water District (YLWD)

It should also be noted that the cities participating in the previous version of the MJHMP (Buena Park, Garden Grove, La Habra, Newport Beach, Orange, and Westminster) are not participating in the latest update to the plan. However, both IRWD and CMSD are participating as MAs for the 2024 MJHMP update. The inclusion of IRWD involves the integration of their recently completed Local Hazard Mitigation Plan (LHMP) from 2021 into this document as an annex. In the case of CMSD, their annex is the first HMP that they have completed in conformance with DMA 2000.

Retailers can be grouped into the following regions based on the availability of local groundwater resources:

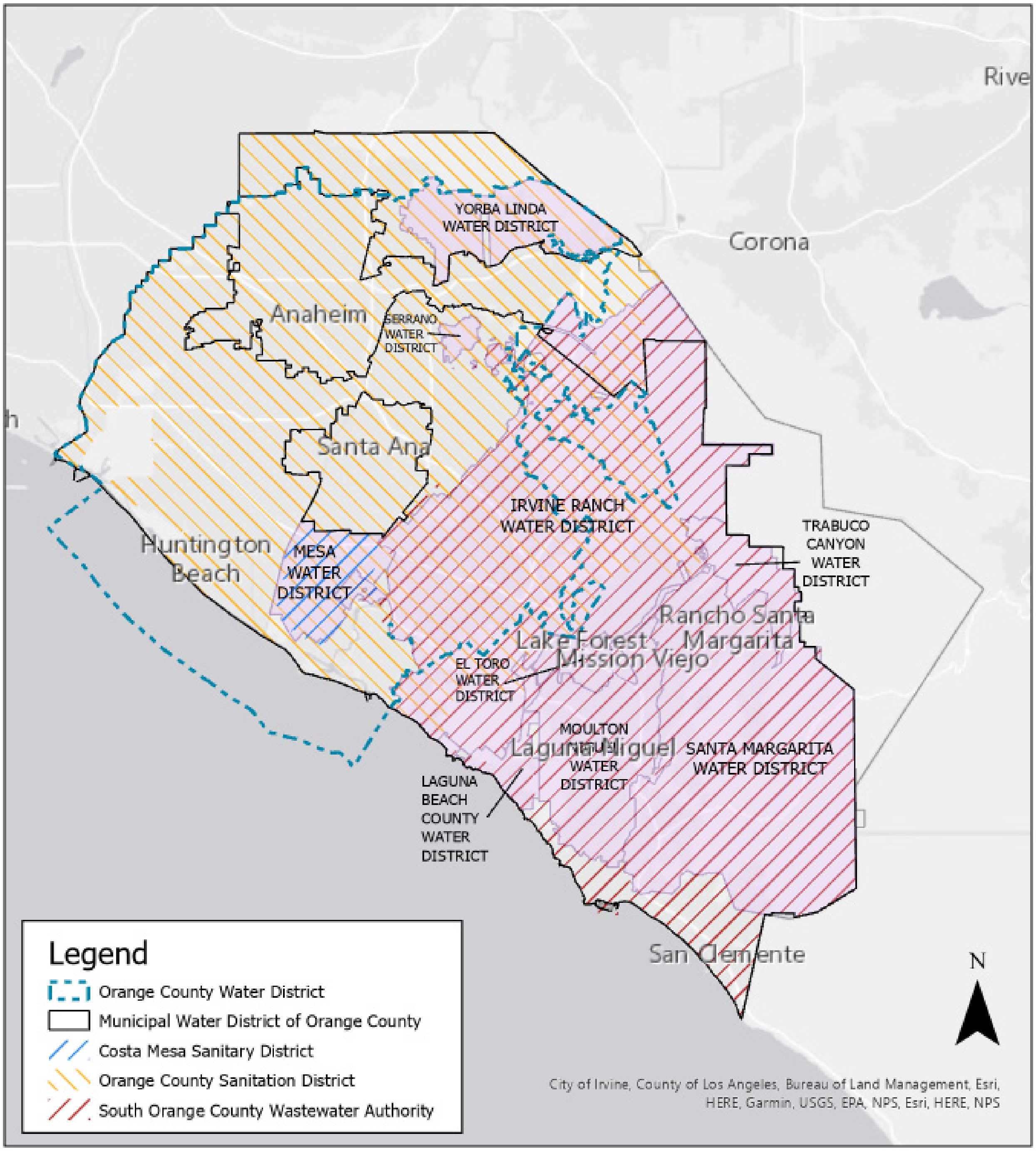
The Orange County Groundwater Basin provides approximately 75% of Orange County's north and central water supply. The rest of their supply is primarily imported water provided by Metropolitan; although Serrano Water District is partly served by local runoff captured in Irvine Lake. Participating MAs within the Orange County Groundwater Basin include the Mesa, Serrano, Yorba Linda, and Irvine Ranch Water Districts.

- South Orange County is almost 100% dependent on Metropolitan for its potable water supply. Parts of this area are within the San Juan Capistrano Groundwater Basin, which is managed by the San Juan Basin Authority. Local groundwater in the area is high in salts and accounts for less of the water supply than utilities in the Orange County Groundwater Basin. MAs include El Toro, Laguna Beach County, Moulton Niguel, Santa Margarita, South Coast, and Trabuco Canyon water districts.

Although located within Orange County, the participating MAs do not comprise or serve the entire county. In addition, the service areas for each of the MAs participating in the MJHMP do not necessarily align with incorporated or unincorporated boundaries or city boundaries. In many cases an MA may serve multiple cities and/or portions of cities/unincorporated areas. Profiles for each of the participating water and wastewater utilities are provided in the Jurisdictional Annexes. The MJHMP must be formally adopted by each jurisdiction's governing body, which may be the Board of Directors for each agency and district.

The resources and background information in the MJHMP are applicable county-wide, providing the groundwork for goals and recommendations for other local mitigation plans and partnerships. In the identification of shared action items, the plan fosters the development of partnerships and implementation of preventative activities. A unified MJHMP will ensure that any proposals for mitigation initiatives are reviewed and coordinated among the participating agencies and utilities.

Exhibit 1-1. Member Agency Plan Participants



1.3 What Is New/What Has Changed from the 2019 MJHMP

Several sections of the 2024 MJHMP have been modified from the previous plan. Changes made to specific sections of the plan are summarized below:

- **Section One:** This section has been modified to clarify the multi-jurisdictional involvement and changes to MAs, update outdated or irrelevant information, and streamline the section.
- **Section Two:** This section includes an updated description of the planning process conducted for this plan update. This section has been completely revised and updated to discuss the process for the MJHMP update, including the Hazard Mitigation Planning Team (Planning Team), meetings, public outreach, and overall process for this update.
- **Section Three:** This section comprises the risk assessment. The hazards have been confirmed with minor updates to better reflect hazards that affect the planning area, as determined by the Planning Team. This includes the addition of extreme heat, and cyber threats, as well as a reorganization of hazards under primary headings for easier reading. In addition, climate change was incorporated into all-hazard profiles instead of a stand-alone profile to better connect how climate change may exacerbate future hazards. Each of the hazard profiles were updated to reflect hazard occurrences (if any) since the 2019 MJHMP was prepared. During this MJHMP update, additional infrastructure analysis was completed for MAs that had built new assets or added assets from other agencies (annexation of one district into another) These new facilities were overlaid on top of the hazard layers to verify potential vulnerability.
- **Section Four.** This section documents the mitigation strategy, which includes overarching hazard mitigation goals for the planning area. It was determined through the Planning Team meetings that the existing mitigation goals are still relevant for all participating MAs, and therefore this set of goals was maintained with minor edits. Some participating MAs identified additional goals specific to their agencies, which have been included in the respective annex. Updated mitigation actions and capabilities assessments specific to each MA are included in their respective annexes. An overview of hazard mitigation is provided, including the methodology for identifying and prioritizing mitigation actions.
- **Section Five.** This section documents the MJHMP maintenance process and includes a reference to a Monitoring and Implementation Workbook developed as part of the update.
- **Section Six:** This section documents the MJHMP references and has been updated to reflect new references used in this 2024 MJHMP.
- **Jurisdictional Annexes:** The annexes have been updated to include new information, updated asset inventories and risk assessment, and updated mitigation strategies.

Appendices: The appendices have been completely updated to include 2024 MJHMP update materials.

1.4 Plan Organization

The Orange County Regional Water and Wastewater MJHMP is organized into the following sections:

- **Section One: Introduction.** Provides an overview of the plan, a discussion of the plan's purpose and authority, a description of the multi-jurisdictional participation, a summary of how this update differs from previous versions of the plan and describes the plan's organization.
- **Section Two: Planning Process Documentation.** Describes the MJHMP planning process, as well as the meetings and outreach activities undertaken to engage the MAs and the public.
- **Section Three: Risk Assessment.** Identifies and profiles the hazards that threaten the area served by the MAs and identifies the vulnerability and risk to critical water and wastewater infrastructure associated with each hazard. Due to the vast planning area associated with the MAs participating in the plan, this section addresses the entire geographic area served by the MAs. The Jurisdictional Annexes detail the hazards, risk assessments, and mitigation strategies specific to each MA.
- **Section Four: Mitigation Strategy.** Includes multi-jurisdictional goals for the 2024 update and summarizes the mitigation action plan process. Mitigation actions and capabilities specific to each MA are detailed in the Jurisdictional Annexes.
- **Section Five: Plan Maintenance.** Discusses how the 2024 MJHMP will be monitored, evaluated, and updated over the next five years.
- **Section Six: References.** Identifies the resources used in preparation of the 2024 update.
- **Appendices.** Provides the 2024 update materials.
- **Jurisdiction Annexes.** Provides a profile of the jurisdiction, describes the hazards of concern, assesses the vulnerabilities to the MA, describes the existing capabilities and proposed mitigation strategies specific to each MA.

Sections one through six plus the appendices comprise the primary MJHMP. It describes the MJHMP planning process and hazard mitigation planning requirements for each MA. The information in this primary MJHMP is applicable to all the MAs. The Jurisdictional Annexes provide hazard mitigation planning information specific to each MA and supplements the information contained in the primary document.

SECTION 2: PLANNING PROCESS DOCUMENTATION

This section describes each stage of the planning process used to update this 2024 MJHMP. The planning process provides a framework to document the plan's update and follows the FEMA-recommended steps. This update follows a prescribed series of planning steps, which includes organizing resources, assessing risk, updating the mitigation actions, updating the plan, reviewing and revising the plan, and adopting and submitting the plan for approval. Each step is described in this section.

Hazard mitigation planning in the United States is guided by the statutory regulations described in the DMA 2000 and implemented through 44 CFR Parts 201 and 206. FEMA's hazard mitigation plan guidelines outline a four-step planning process for the development and approval of HMPs. **Exhibit 2-1, DMA 2000 CFR Crosswalk**, lists the specific CFR excerpts that identify the requirements for approval.

Exhibit 2-1. DMA 2000 CFR Crosswalk

DMA 2000 (44 CFR 201.6)	2024 MJHMP Update Section
(1) Organize Resources	Section 2 (this section)
201.6(c)(1)	Organize to prepare the plan
201.6(b)(1)	Involve the public
201.6(b)(2) and (3)	Coordinate with other agencies
(2) Assess Risks	Section 3
201.6(c)(2)(i)	Assess the hazard
201.6(c)(2)(ii) and (iii)	Assess the problem
(3) Develop the Mitigation Plan	Section 4
201.6(c)(3)(i)	Set goals
201.6(c)(3)(ii)	Review possible activities (actions)
201.6(c)(3)(iii)	Draft an action plan
(4) Plan Maintenance	Section 5
201.6(c)(5)	Adopt the plan
201.6(c)(4)	Implement, evaluate, and revise

As documented in the corresponding sections, the planning process for the 2024 MJHMP was consistent with the requirements for hazard mitigation planning with customizations, as appropriate. All basic Federal guidance documents and regulations were met through the customized process.

2.1 Organizing Resources

One of the first steps in the planning process involved organization of resources, including identifying the Project Management Team, convening the Planning Team, and performing document review.

2.1.1 Project Management Team

The Project Management Team was responsible for the day-to-day coordination of the update work program, including forming and assembling the Planning Team; scheduling Planning Team meetings; preparing, reviewing, and disseminating Planning Team meeting materials; coordinating, scheduling, and participating in community engagement activities and meetings; and coordinating document review. The Project Management Team was led by an emergency coordinator from the WEROC, administered by the MWDOC, who served as project manager and participated on the

Planning Team. The project manager monitored planning progress and met with participating jurisdictions as needed to assist with obtaining and updating information for the plan.

The Project Management Team worked directly with the Consultant Project Management Team throughout development of the plan update. The Consultant Team, consisting of a variety of hazard mitigation/planning professionals, provided guidance and support to MWDOC and the Planning Team through facilitation of the planning process, data collection, community engagement, and meeting material and document development.

2.1.2 Planning Team

The planning process for the MJHMP involved 12 water districts, two regional wastewater agencies, and one sanitary district; a total of 15 special districts participated in the planning process. Representatives from participating MAs provided input into the MJHMP update process. Each MA provided at least one representative to participate on the Planning Team and attend meetings. Each MA local team, made up of staff/officials, met separately and provided additional local-level input to the Consultant Team for inclusion into the MJHMP. The MA participated in the planning process by exchanging information, providing feedback on prior plan progress, discussing planning strategies, sharing goals, resolving issues, and monitoring progress. The MA benefited from working closely together because many of the hazards identified are shared by neighboring jurisdictions and participants were involved in the discussion of potential mitigation actions. Jurisdictional representatives included but were not limited to utility engineers, planners, public information officers (PIOs), and emergency management staff.

The Planning Team worked together to ensure the success of the planning process and is responsible for its implementation and future maintenance. The Planning Team's key responsibilities included:

- Participation in Planning Team meetings.
- Coordination of jurisdiction-specific meetings to relay information and obtain input.
- Collection of valuable local information and other requested data.
- Decision on plan process and content.
- Development and prioritization of mitigation actions for the plan.
- Review and comment on plan drafts.
- Coordination and involvement in the public engagement process.

Exhibit 2-2, **Members of the Planning Team,** identifies the Planning Team members.

Exhibit 2-2. Members of the Planning Team

Name	Title/Position	Organization
Vicki Osborn	Director of Emergency Management	WEROC/MWDOC
Gabby Landeros	WEROC Specialist	WEROC/MWDOC
Janine Schunk	WEROC Coordinator	WEROC/MWDOC
Charles Busslinger	Principal Engineer	MWDOC
Harvey De La Torre	General Manager	MWDOC
Melissa Baum-Haley	Assistant Emergency Manager	MWDOC
Noelani Middenway	PIO	CMSD
Gina Terraneo	Senior Management Analyst	CMSD
Scott Carroll	General Manager	CMSD
Mark Esquer	District Engineer	CMSD

Name	Title/Position	Organization
Sherri Seitz	Public Relations/ Emergency Preparedness Administrator	El Toro Water District
Hannah Ford	Hannah Ford	El Toro Water District
Dennis Cafferty	General Manager/ District Engineer	El Toro Water District
Eric Akiyoshi	Engineering Manager	IRWD
Steve Choi	Director of Safety & Security	IRWD
Bryan Clinton	Operations Manager	IRWD
Robert Meripol	Safety & Security Supervisor	IRWD
Mitch Robinson	Senior Engineer	IRWD
Leo Lopez	Safety Officer	LBCWD
Christopher Regan	Assistant General Manager	LBCWD
Kaying Lee	Water Quality and Compliance Supervisor	Mesa Water District
Andrew Wiesner	District Engineer	Mesa Water District
Bob Mitchell	Water Operations Supervisor	Mesa Water District
Carrie Fesili	Water Operations Coordinator	Mesa Water District
Karyn Igar	Senior Civil Engineer	Mesa Water District
Tyler Jernigan	Water Operations Manager	Mesa Water District
Adrian Tasso	Assistant Director of Operations	MNWD
Cristina Garcia	Administrative Analyst	MNWD
Dan Horn	Water Distribution Supervisor	MNWD
David Larsen	Assistant Director of Engineering	MNWD
Kelsey Coleman	Communications Manager	MNWD
Len Barton	Safety and Emergency Manager	MNWD
Matthew Brown	Information Systems Officer	MNWD
Matthew Collings	Assistant General Manager	MNWD
Ronin Goodall	Assistant Director of Operations	MNWD
Rodney Woods	Director of Engineering	MNWD
Todd Dmytryshyn	Assistant Director of Engineering	MNWD
William Kidd	Information Systems Administrator	MNWD
Dan West	Superintendent of Operations	MNWD
John Frattali	Safety and Health Supervisor	OC San
Krystal Aleman	Security/ Emergency Planning Specialist	OC San
Paula Bouyounes	Risk and Safety Manager	OCWD
Chris Lopez	Safety Officer	SMWD
Daniel Peterson	Regulatory and Logistics Manager	SMWD
Eric Smith	Utilities Manager	SMWD
Jerry Vilander	General Manager	Serrano Water District
Blaise Bautsch	Safety and Health Program Manager	SCWD
Chris Newton	Operations Superintendent	SCWD
Kyle Gough	Transmission Main Manager	SCWD
Steve Dishon	Water Resources Manager	SCWD
Sunny Lee	Compliance and Risk Program Manager	SCWD
Sean Peacher	Environmental Compliance Safety Risk Manager	SOCWA
Ernie Leal	Chief Plant Operator	SOCWA
Jim Burror	Director of Operations	SOCWA
Amber Boone	Acting General Manager	SOCWA
Michael Perea	Assistant General Manager	TCWD
Lorrie Lausten	District Engineer	TCWD
David Rodriguez	Engineering Support	TCWD

Name	Title/Position	Organization
Alex Ramirez	Safety Officer	YLWD

Exhibit 2-3, Planning Team Roles, identifies each member's roles in the plan update.

Exhibit 2-3. Planning Team Roles

Member	Planning Team Role
Vicki Osborn, WEROC/MWDOC	Project Manager/Planning Team Representative – Organization of Planning Team and meetings, development of and participation in community outreach, hazard identification, capabilities assessment, goal development, mitigation actions and prioritization, plan coordination, and review.
Gabby Landeros, WEROC/MWDOC	Project Management Team – Historical knowledge and insight into 2012 plan, overall guidance on 2018 plan, hazard identification, capabilities assessment, goal development, mitigation actions and prioritization, plan review.
All Planning Team Members	Hazard identification, capabilities assessment, goal development, mitigation actions and prioritization, plan review.

It should be noted that through the Orange County Emergency Management Organization (OCEMO), the County of Orange, and all cities within the county were provided the opportunity to participate in the MJHMP development process, including dissemination of the draft plan to OCEMO's distribution list for review and comment. This included all Orange County's cities, colleges, school districts, special districts, water districts, State and county agencies, the hospital association, affiliates, and other approved agencies. Refer to **Appendix A** for outreach content and information.

MWDOC also provided an opportunity for State and county agencies and emergency services providers to be part of the Planning Team and provide comments. This occurred at the OCEMO, Orange County Operational Area Executive Board and WEROC Quarterly Meetings which included:

- State Water Resources Control Board, Division of Drinking Water
- Orange County Health Care Agency
- Orange County Fire Authority
- Orange County Sheriff's Department
- Orange County Public Works
- County of Orange, County Executive Office
- Orange County Department of Education
- Orange County Transportation Authority

Businesses, academia, and other private and non-profit interests were provided notification of the Draft MJHMP's availability via the MA email distribution, notification lists, and social media. Distribution documentation is provided in **Appendix A**.

The Planning Team held three meetings. The meetings were designed to aid the MA in completing a thorough review of the hazards within their jurisdictions, identifying capabilities, understanding and assessing vulnerabilities, and identifying mitigation strategies. **Exhibit 2-4, Planning Team Meeting Summary,** provides a summary of the meetings. Meeting agendas and pertinent materials are provided in **Appendix A.**

Exhibit 2-4. Planning Team Meeting Summary

Date	Meeting	Discussion
June 17, 2024	Planning Team Meeting #1	Introductions Project goals and objectives Roles and responsibilities Data/information needs Plan update and requirements Preliminary discussion of community engagement strategy Hazard identification and prioritization Meeting schedule
July 16, 2024, through July 30, 2024	Planning Team Meetings #2	Review of Compiled Data Tool that discusses hazards of concern, hazard priorities, additional critical facilities, capabilities assessment updates, and mitigation actions status.
October 16, 2024, through November 8, 2024	Planning Team Meetings #3	Review of the Administrative Draft HMP documents (the base plan and annexes) with MAs requesting assistance.
Date TBD	Planning Team Meetings #4	Meeting with specific MA to address comments from FEMA, as necessary.

In addition to the regularly scheduled meetings, Planning Team members coordinated individually with the plan update project manager, as necessary, to resolve any questions or discuss information requested at the Planning Team meetings. This was typically accomplished via telephone or email. Any MA that missed a scheduled planning meeting coordinated with the project manager separately to review what was discussed in the meeting and to obtain jurisdiction-specific information.

2.1.3 Public Outreach

A public outreach and engagement strategy was developed to inform the public and maximize public involvement in the plan-update process. The public outreach strategy included posting information on the MA websites, email and social media distribution, a community survey, and presentations at individual Board meetings and OCEMO meetings, as described below. Refer to **Appendix A.**

Member Agency Websites

Information regarding the MJHMP update was made available on each MA website. The webpages provided information on the plan, the plan update process, and how the public can be involved in the planning process, including a link to the community survey (discussed below). A link to the Draft MJHMP was also made available for review and comment.

Social Media

Social media notifications regarding the MJHMP's update, including a link to the community survey and public review draft distribution were sent to MA social media accounts. Based on the distribution across all 15 MAs' social media platforms (Facebook, Instagram, X, and LinkedIn) over 15,500 impressions occurred, which included 26 post reactions.

Community Survey

A community survey was developed to obtain input from the community about various hazard mitigation topics. The survey was designed to help the MA gauge the level of knowledge the community has about natural disaster issues and to obtain input about areas of Orange County that may be vulnerable to various types of natural disasters. The information provided was used to identify and coordinate projects focused on reducing the risk of injury or damage to property from future hazard events. A link to the survey was provided on each of the MAs' websites, as well as information shared via social media and through newsletters and other communications. The survey received a total of 66 responses from customers of 12 MAs as well as several responses from individuals served by other agencies or unsure of their water agency.

Key takeaways from the responses include:

- Top three hazards identified by respondents include power outage, high winds, and earthquake.
- Over 40% of respondents are very concerned about climate change creating new hazards or worsening existing hazards.
- 62% of respondents are unaware of the access and functional needs of their neighbors in the event of a disaster.

Results from survey participants are provided in **Appendix A.**

Stakeholder Outreach

Water Board Meeting Presentations – Various Dates (Exhibit 2-5)

Between July 30, 2024, and November 25, 2024, the MWDOC Project Management Team attended Board of Directors meetings to discuss the MJHMP update and provide additional information to decision makers regarding the update process and what to expect when the plan is ready for final approval. The following is a list of in-person meetings attended where this information was shared:

Exhibit 2-5. MA Meetings

Date	Agency	Meeting Type
8/15/2024	South Orange County Wastewater Authority	Engineering
8/26/2024	Orange County Grand Jury	Briefing
8/26/2024	Costa Mesa Sanitary District	Board
9/5/2024	South Orange County Wastewater Authority	Board
9/19/2024	MWDOC Managers	General Meeting
9/23/2024	Serrano Water District	Board
10/3/2024	Orange County Emergency Managers Organization	General Meeting
10/24/2024	South Coast Water District	Board
11/13/2024	Operational Area Executive Board	
11/13/2024	Citizen Advisory Committee Meeting	Citizen Advisory Committee
11/18/2024	WEROC Quarterly Meeting	Meeting open to WEROC MAs and any other members of Orange County planning partners

A copy of the presentation provided at these meetings is included in **Appendix A.**

Orange County Emergency Management Organization – October 3, 2024

The plan update project manager presented to the OCEMO during their monthly meeting. OCEMO is a subcommittee comprised of the County of Orange and all subdivisions that ensure the cooperative maintenance of the Operational Area Emergency Operations Plan, policies and procedures, training, and exercises. The presentation included information about hazard mitigation, the planning process, hazards affecting Orange County water and wastewater infrastructure, and the importance of OCEMO's involvement in the development process. As noted previously, the Draft MJHMP was disseminated to OCEMO's distribution list for review and comment. Refer to **Appendix A** for outreach materials and information shared during the planning process**.**

Public Review Draft Hazard Mitigation Plan

The public review Draft MJHMP was made available for review and comment for a 15-day period beginning November 8, 2024, and concluding on November 23, 2024. The draft plan was made available on the MAs' webpages and at the MAs' offices and/or front counters. An online form was created allowing reviewers to easily submit comments and feedback to the Project Management Team. Eight public comments were submitted to MWDOC and the MAs, however after reviewing the information provided no revisions to the Base Plan or annexes were deemed necessary.

2.1.4 Review and Incorporate Existing Information

The Planning Team and each MA local team reviewed and assessed existing plans and studies available from Federal, State, and local sources during the planning process. The types of documents reviewed and incorporated as part of the MJHMP update are listed in **Exhibit 2-6, Existing Plans and Studies.** Due to the number of MAs involved in the plan update, similar plans and studies specific to each district were reviewed and incorporated in the 2024 MJHMP. A complete list of references is included in **Section 6, References.**

Exhibit 2-6. Existing Plans and Studies

Existing Plans and Studies	Relevant Topic
Orange County Water & Wastewater Multi-Jurisdictional HMP	Hazard Profiles; Capabilities Assessment; Mitigation Strategy
State of California Multi-Jurisdictional HMP (2023)	Hazard Profiles
Agency Urban Water Management Plans	Hazard Profiles; Capabilities Assessment
FEMA Hazard Mitigation How-to Guides	Plan Development; Plan Components
FEMA Local Mitigation Planning Handbook (May 2023)	Plan Development; Local Plan Integration Methods
FEMA Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards (September 2021)	Mitigation Strategy Development
Orange County Water and Wastewater GIS Layers with Critical Infrastructure Facilities	Hazard Profiles; Risk/Vulnerability Assessments; Mitigation Strategy
Seismic Hazard Assessment, Orange County Seismic Vulnerability, Mitigation and Recovery Planning Study (August 28, 2015)	Hazard Profiles; Risk/Vulnerability Assessments; Mitigation Strategy
Agency-Specific Reliability Studies	Hazard Profiles; Risk/Vulnerability Assessments; Mitigation Strategy
Agency-Specific Risk and Resilience Assessments	Hazard Profiles, Risk/Vulnerability Assessments, Mitigation Strategy

2.2 Assess Risks

In accordance with FEMA requirements, the Planning Team identified and prioritized the hazards affecting Orange County and assessed the associated vulnerability from those hazards. Results from this phase of the planning process aided subsequent identification of appropriate mitigation actions to reduce risk from these hazards (refer to **Section 3**).

2.2.1 Identify/Profile Hazards

The Planning Team reviewed the hazards profiled in the 2019 MJHMP as well as a list of FEMA-identified hazards to determine which hazards had the potential to impact Orange County and thus should be profiled as part of the plan update. This 2024 MJHMP continues to include natural and human-caused hazards that may threaten all or a portion of the county and individual MAs. It was noted that some location-specific hazards would not be applicable to every MA, but still warranted identification. Through discussions of the hazards, including the probability, location, maximum probable extent, and potential secondary impacts, a list of hazards was developed and prioritized. Content for each hazard profile is provided in **Section 3.** A key update to these hazard profiles is the integration of climate change into each hazard discussion. This approach was agreed upon by the Planning Team to ensure climate change was adequately addressed in relation to the hazards profiled.

2.2.2 Assess Vulnerabilities

Hazard profiling exposes the unique characteristics of individual hazards and begins the process of determining which areas within Orange County are vulnerable to specific hazard events. The vulnerability assessment included input from the Planning Team and a refinement of the GIS overlaying method previously used for hazard risk assessments in the 2019 MJHMP. Using these methodologies, water and wastewater infrastructure impacted by the profiled hazards was identified and potential loss estimates were updated. Detailed information on the vulnerability assessments for each hazard is provided in **Section 3.**

2.3 Develop Mitigation Plans

The 2024 MJHMP was prepared in accordance with DMA 2000 and FEMA's latest HMP guidance documents. This plan provides an explicit strategy and blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs, and resources, and the MAs ability to expand on and improve existing tools. Developing the mitigation plan involved identifying goals, assessing existing capabilities, and identifying mitigation actions. This step of the planning process is detailed in **Section 4** and summarized below.

2.3.1 Identify Goals

The Planning Team reviewed the goals identified in the 2019 MJHMP and determined that the existing goals in the plan were still relevant and meaningful to MWDOC and its MAs. Only minor modifications were included in the 2024 MJHMP goals, which focused on refinement of language. The mitigation goals are presented in **Section 4.2**. For some MAs, it was determined that additional goals specific to their agency were still warranted and are included in the Jurisdiction Annexes, where applicable.

2.3.2 Develop Capabilities Assessment

A capabilities assessment is a comprehensive review of all the various mitigation capabilities and tools currently available to the MA to implement the mitigation actions that are prescribed in the MJHMP. The Planning Team reviewed planning, regulatory, administrative, technical, financial, educational, and outreach capabilities to implement mitigation actions. Each MA reviewed capabilities information from the 2019 MJHMP and worked with their local teams to identify and updated the capabilities assessment specific to their agency. This review also identified potential improvements to better support future mitigation. The capabilities assessments for each MA are included in the Jurisdiction Annexes.

2.3.3 Identify Mitigation Actions

As part of the planning process, the Planning Team worked to identify and develop mitigation actions to address the profiled hazards. The mitigation actions in the 2019 MJHMP were reviewed to determine whether they had been achieved, were still relevant, or were no longer relevant due to changing circumstances. Each MA considered the hazards applicable to their agency and identified and prioritized mitigation actions. The mitigation actions for each MA are included in the Jurisdiction Annexes.

2.3.4 Plan Review and Revisions

Once the Draft MJHMP was completed, a public review period was provided from November 7, 2024, through November 26, 2024, to allow public review and comments. Eight comments were received on the draft plan and reviewed by the Planning Team. The content of the comments did not warrant revisions to the plan.

2.3.5 Plan Adoption and Submittal

Upon completion of the public review period this 2024 MJHMP was submitted to Cal OES on (December 3, 2024). On (insert date), Cal OES approved the plan for transmittal to FEMA for review. FEMA completed their review and provided MWDOC and MAs with an Approvable Pending Adoption letter on (insert date). Final Board adoption by MWDOC and MAs occurred on or after (insert date). **Appendix B** includes copies of the resolutions of adoption from all participating MAs.

2.3.6 Plan Maintenance

Plan maintenance procedures, found in **Section 5**, include the measures each MA will take to ensure the 2024 MJHMP's continuous long-term implementation. The procedures also include the manner in which the plan will be regularly monitored, reported upon, evaluated, and updated to remain a current and meaningful planning document. **Appendix C** includes a "Progress Report Worksheet" intended to support future plan maintenance and implementation by MWDOC and MAs.

SECTION 3: RISK ASSESSMENT

Risk assessment requires the collection and analysis of hazard-related data to enable local jurisdictions to identify and prioritize appropriate mitigation actions and strategies that will reduce losses from potential hazards. FEMA's LHMP How-to Guide recommends four steps for conducting a risk assessment:

1. Describe hazards that pose a threat to the planning area;
2. Identify community assets (for the purposes of this MJHMP this includes water and wastewater infrastructure) in the planning area;
3. Analyze risks associated with the hazards, including describing the potential impacts and estimating losses for each hazard; and
4. Summarize vulnerability to understand the most significant risks and vulnerabilities associated with the identified hazards.

The risk assessment must result in an evaluation of potential impacts and overall vulnerability for each participating jurisdiction to develop specific mitigation actions. The following identifies the hazards for the entire planning area and notes if the hazard is applicable to all jurisdictions or is unique to specific jurisdictions. Hazards applicable to all jurisdictions are described in this section and are not described separately in the Jurisdictional Annexes. Hazards unique to a jurisdiction are further discussed in the Jurisdictional Annexes.

3.1 Hazard Identification and Prioritization

3.1.1 Hazard Identification

Hazard identification is the process of identifying hazards that threaten an area including both natural and human-caused events. A natural event causes a hazard when it harms people or property. Such events would include floods, earthquakes, tsunami, coastal storms, landslides, and wildfires that strike populated areas. Human-caused hazard events are caused by human activity and include technological hazards and malevolent acts such as terrorism. Technological hazards are generally accidental and/or have unintended consequences (for example, an accidental hazardous materials release). Terrorism is defined by the CFR as "…unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." Natural hazards that have harmed Orange County in the past are likely to happen in the future; consequently, the process of identifying hazards includes determining if the hazard has occurred previously.

The Planning Team reviewed the list of FEMA-identified hazards, the 2019 MJHMP, and other relevant information to determine the extent of hazards with the potential to affect the planning area; refer to **Exhibit 2-5, Existing Plans and Studies**. A discussion of potential hazards during the first Planning Team meeting resulted in the identification of the natural and human-cause hazards that pose a potential risk to all or a portion of the planning area and MAs. **Exhibit 3-1, Hazard Identification,** summarizes the Planning Team's discussion and identification of the hazards included in this 2024 MJHMP.

Exhibit 3-1. Hazard Identification

Hazards	Included in 2019 MJHMP?	Included in 2024 MJHMP?	Discussion Summary
Avalanche	No	No	Not applicable. Snowfall is not a typical occurrence in Orange County and there is no historical record of this hazard in the region.
Climate Change	Yes	Yes	Climate change is a phenomenon that could exacerbate hazards. Climate change and how it can potentially affect the severity, intensity, and frequency of a hazard is discussed in each individual hazard profile.
Coastal Erosion	Yes	Yes	Coastal erosion and storms occur within the coastal communities, which include development along the coast. These hazards are combined in **Section 3.2.1, Coastal Hazards** (Coastal Erosion, Coastal Storm, Sea Level Rise, and Tsunami).
Coastal Storm	Yes	Yes	Coastal erosion and storms occur within the coastal communities within the planning area. These hazards are combined in **Section 3.2.1, Coastal Hazards**.
Contamination/ Saltwater Intrusion	Yes	Yes	Water supplies are susceptible to contamination from human activities. In addition, saltwater intrusion is a concern within the planning area as it has occurred previously due to groundwater extraction. This hazard has been combined in **Section 3.2.5, Human-Caused Hazards**.
Cyber Threats (Terrorism)	No	Yes	The growing threat of cyber security and data breaches has increasingly become a potential hazard concern for jurisdictions throughout the planning area. Due to the potential effect on key infrastructure functions this hazard has been included in the plan update.
Dam/Reservoir Failure	Yes	Yes	Several dams and reservoirs are located throughout Orange County or in areas that could impact the county in the event of a failure. Infrastructure located within inundation areas could be impacted. This hazard includes dams and reservoirs.
Disease/Pest Management	No	No	Not applicable. Disease/pest management is not a hazard that impacts water/wastewater facilities and infrastructure.
Drought	Yes	Yes	Water supplies are dependent on groundwater and imported surface water, both of which are susceptible to drought. The county has experienced historical droughts, including the most recent State-declared drought emergency (2014-2017). See **Section 3.2.7, Severe Weather.**
Earthquake Fault Rupture	Yes	Yes	Alquist-Priolo fault zones occur within Orange County. The county has a long history of earthquakes, some resulting in considerable damage. This topic has been in **Section 3.2.6, Seismic Hazards,** which address Fault Rupture, Seismic Shaking, and Liquefaction.
Expansive Soils	Yes	Yes	Expansive soil conditions occur within portions of Orange County and can be exacerbated by periods of rain and drought. This topic is combined in **Section 3.2.4,**

Hazards	Included in 2019 MJHMP?	Included in 2024 MJHMP?	Discussion Summary
			Geological Hazards, which includes Expansive Soils, Land Subsidence, Landslides, and Mudflow.
Extreme Heat	No	Yes	Extreme heat is a hazard that typically affects all of Southern California. Recently portions of Orange County have experienced extreme heat events causing concern. In addition, climate change is anticipated to increase temperatures throughout the planning area. This hazard has been included in this MJHMP and is discussed in **Section 3.2.7, Severe Weather Hazards**, which includes Drought, Extreme Heat, and Windstorms.
Flood	Yes	Yes	Portions of Orange County are located within floodplains and have experienced historic flooding. More localized flooding also occurs during rainstorms.
Geological Hazards	Yes	Yes	Orange County is located in an area of geological hazards, including seismic activity. This topic has been combined to include Expansive Soils, Land Subsidence, Landslides, and Mudflow.
Hailstorm	No	No	Not applicable. Hailstorms rarely occur within Orange County and there is no historical record of this hazard causing significant damage to the planning area.
Hazardous Materials	Yes	Yes	Water supplies could be compromised by accidental or intentional release of hazardous materials. This hazard is addressed in **Section 3.2.5, Human-Caused Hazards**.
Human-Caused Hazards	Yes	Yes	Human-caused hazards are a concern throughout the planning area and Southern California. This category has been expanded to include Contamination/Saltwater Intrusion, Hazardous Materials, Power Outage, Terrorism (Cyber Threat), and Terrorism (Mass Casualty Incident).
Hurricane	No	No	Not applicable.
Land Subsidence	Yes	Yes	Land subsidence conditions occur within Orange County. This topic is addressed in **Section 3.2.4, Geological Hazards.**
Landslide and Mudflow	Yes	Yes	Areas of the county are susceptible to landslides and mudflow, which can be exacerbated by other hazards including seismic ground shaking, drought conditions, and wildfires. See **Section 3.2.4, Geological Hazards.**
Lightning	No	No	Not applicable. Although lightning sometimes occurs during storm events, it is limited within the region and there is no historical record of this hazard significantly impacting the planning area.
Liquefaction	Yes	Yes	Liquefaction zones occur within Orange County. This topic has been combined in **Section 3.2.6, Seismic Hazards,** which includes Fault Rupture, Seismic Shaking, and Liquefaction.
Mass Casualty Incident (Terrorism)	Yes	Yes	Mass casualty incidents and terrorism have been identified as potential hazards of concern for the planning area. This hazard is addressed in **Section 3.2.5, Human-Caused Hazards.**

Hazards	Included in 2019 MJHMP?	Included in 2024 MJHMP?	Discussion Summary
Power Outage	Yes	Yes	Although typically associated with other hazards, power outages can directly impact water and wastewater systems and have been added to **Section 3.2.5, Human-Caused Hazards.**
Sea Level Rise	Yes	Yes	Sea level rise has been identified as a hazard affecting some of the coastal communities. This hazard has been included in the Coastal Hazards profile within this 2024 Multi-Jurisdictional HMP. **See Section 3.2.1, Coastal Hazards.**
Seismic Shaking	Yes	Yes	Orange County has a long history of earthquakes, some resulting in considerable damage. This topic is included the seismic hazards discussion, which includes Fault Rupture, Seismic Shaking, and Liquefaction. **See Section 3.2.6, Seismic Hazards.**
Severe Winter Storm	No	No	Not applicable. Severe winter storms are not common in Orange County, and there are no historical records of this hazard in the region.
Tornado	Yes	No	Tornadoes are not a typical occurrence in Orange County. This topic has been removed from this 2024 MJHMP.
Tsunami	Yes	Yes	Portions of the Orange County coastline are located within tsunami inundation areas. This topic is discussed in **Section 3.2.1, Coastal Hazards.**
Urban Fire	No	Yes	The potential for damage to key facilities and infrastructure has been identified as a potential threat within the planning area. It has been included in **Section 3.2.8, Wildland/Urban Fire.**
Volcano	No	No	Not applicable. There are no active volcanoes in Orange County or the surrounding area.
Wildfire	Yes	Yes	Portions of Orange County are located within fire hazard zones, which are adjacent to existing urban development. Due to the proximity of both development and critical infrastructure to fire hazard zones, this hazard has been profiled in this plan. **See Section 3.2.8, Wildland/Urban Fire.**
Wind	No	No	Regular wind is not a typical occurrence and does not cause severe damage within the area. High winds/Santa Ana winds are common throughout Orange County and are addressed in **Section 3.2.7, Severe Weather.**
Windstorm	Yes	Yes	High Winds/Santa Ana winds are a common occurrence in the planning area and can impact critical infrastructure and services that support water/wastewater operations, see **Section 3.2.7, Severe Weather.**

3.1.2 Hazard Prioritization

The Planning Team used a Microsoft Excel-based tool to prioritize the identified hazards by assigning each hazard a ranking based on probability of occurrence and the potential impact. These rankings were assigned based on a group discussion, knowledge of past occurrences, and familiarity with each MA's vulnerabilities. Four criteria were used to establish priority:

- Probability (likelihood of occurrence)
- Location (size of potentially affected area)
- Maximum Probable Extent (intensity of damage)
- Secondary Impacts (severity of impacts to community)

A value from 1 to 4 was assigned for each criterion. The four criteria were then weighted based on the Planning Team's opinion of each criterion's importance. **Exhibit 3-2, Hazard Rankings,** presents the results of the hazard rankings for the planning area.

Exhibit 3-2. Hazard Rankings

Hazard Type	Probability	Impact			Total Score	Hazard Planning Consideration
		Affected Area	Primary Impact	Secondary Impact		
Human-Caused Hazards: Power Outage	4	3	4	4	57.6	High
Wildfire	4	3	3	4	52.0	High
Human-Caused Hazards: Terrorism (Cyber Threat)	4	3	3	2	44.0	High
Seismic Hazards: Seismic Shaking	3	3	4	4	43.2	High
Seismic Hazards: Liquefaction	3	3	4	4	43.2	High
Severe Weather: Windstorm	4	4	2	1	40.8	Medium
Severe Weather: Extreme Heat	3	3	3	3	36	Medium
Severe Weather: Drought	4	4	1	1	35.2	Medium
Dam/Reservoir Failure	2	3	4	4	28.8	Medium
Flood	3	3	2	1	25.8	Medium
Coastal Hazards: Coastal Storm	3	2	2	2	24.0	Medium
Coastal Hazards: Coastal Erosion	3	1	2	2	19.2	Medium
Seismic Hazards: Earthquake Fault Rupture	2	1	4	2	18.4	Medium
Geological Hazards: Landslide and Mudflow	2	2	2	3	18	Medium
Coastal Hazards: Sea Level Rise	3	1	2	1	16.2	Medium
Human-Caused Hazards: Contamination/Saltwater Intrusion	1	2	3	4	11.4	Low
Human-Caused Hazards: Terrorism (MCI)	1	1	3	3	8.8	Low
Human-Caused Hazards: Hazardous Materials	1	1	2	3	7.4	Low
Urban Fire	1	1	2	1	5.4	Low
Geological Hazards: Land Subsidence	1	1	1	2	5	Low
Geological Hazards: Expansive Soils	1	1	1	2	5	Low
Coastal Hazards: Tsunami	1	1	1	1	4	Low

Scores are based on a scale from 1 to 4, where 4 is the highest score and 1 is the lowest. The total score is based on an equation that weights categories by importance. Refer to ***Exhibit 3-3*** *for additional information.*

Exhibit 3-3, Hazard Ranking Methodology, provides additional detail regarding how the probability, affected area, and impact categories are weighted and how the total score is calculated for the hazard rankings.

Exhibit 3-3. Hazard Ranking Methodology

Probability: Importance 2.0	
Based on estimated likelihood of occurrence from historical data.	
Probability	***Score***
Unlikely (less than 1% probability in next 100 years or has a recurrence interval of greater than every 100 years)	1
Somewhat Likely (between 1% and 10% probability in next year or has a recurrence interval of 11 to 100 years)	2
Likely (between 10% and 100% probability in next year or has a recurrence interval of 10 years or less)	3
Highly Likely (near 100% probability in next year or happens every year)	4
Affected Area: Importance 0.8	
Based on size of geographical area of community affected by hazard.	
Affected Area	***Score***
Isolated	1
Small	2
Medium	3
Large	4
Primary Impact: Importance 0.8	
Based on percentage of damage to typical facility in community.	
Impact	***Score***
Negligible – less than 10% damage	1
Limited – between 10% and 25% damage	2
Critical – between 25% and 50% damage	3
Catastrophic – more than 50% damage	4

Secondary Impacts: Importance 0.5	
Based on estimated secondary impacts to community at large.	
Impact	***Score***
Negligible – no loss of function, downtime, and/or evacuations	1
Limited – minimal loss of function, downtime, and/or evacuations	2
Moderate – some loss of function, downtime, and/or evacuations	3
High – major loss of function, downtime, and/or evacuations	4
Total Score = Probability x Impact, where:	
Probability = (Probability Score x Importance)	
Impact = (Affected Area + Primary Impact + Secondary Impacts), where:	
Affected Area = Affected Area Score x Importance	
Primary Impact = Primary Impact Score x Importance	
Secondary Impacts = Secondary Impacts Score x Importance	

Hazard Planning Consideration			
Total Score	***Range***	***Distribution***	***Hazard Level***
0.0	20.0	7	Low
20.1	42.0	10	Medium
42.1	64.0	5	High

The probability of each hazard is determined by assigning a level, from unlikely to highly likely, based on the likelihood of occurrence from historical data. The total impact value includes the affected area, primary impact, and secondary impact levels of each hazard. Each level's score is reflected in the matrix. The total score for each hazard is the probability score multiplied by its importance factor times the sum of the impact level scores multiplied by their importance factors. Based on this total score, the hazards are separated into three categories based on the hazard level they pose to the communities: High, Medium, and Low.

It should be noted that climate change was not prioritized for the planning area. Instead a discussion regarding climate change considerations has been added to each hazard profile. Regardless of the prioritization (low, medium, or high), it was determined by the Planning Team that all the hazards identified in **Exhibit 3-2** would be profiled. Due to the vast geography and hazards that impact the various MAs, it was recognized by the Planning Team that some hazards that ranked low overall, may be a high priority depending upon the MA.

3.2 Hazard Profiles

This section contains profiles for the hazards identified in **Exhibit 3-2**. Due to the nature of the hazards, some hazards were combined for purposes of the profiles as noted in **Exhibit 3-2**. Information was obtained from various Federal, State, and local sources, as well as the Planning Team. A detailed list of references is provided in **Section 6.**

The service areas for each of the MAs participating in the MJHMP update do not always align with incorporated city or unincorporated county boundaries. In many cases, an MA may serve multiple cities and/or portions of cities/unincorporated areas. For the purposes of this MJHMP, the planning area refers to Orange County, since the MAs provide services and infrastructure throughout most of the county. Because much of the available hazard data is provided by jurisdictional boundary (county or city), it is not always possible to obtain or delineate data specific to the MA jurisdictional (service) boundary. The Jurisdictional Annexes detail the hazards, risk assessments, and mitigation strategies specific to each jurisdiction.

Each hazard profile addresses the following:

- **Description (Nature) of the Hazard:** Describes the hazard and its characteristics.
- **History/Past Occurrences:** Provides a history of the hazard and identifies previous occurrences. Where an occurrence is specific to an MA, this information is provided.
- **Location/Geographic Extent:** Describes the location (geographic) area affected by the hazard. If the hazard affects the entire planning area, it is noted. For geographically specific hazards, the specific MAs affected by the hazard are identified and discussed further in the Jurisdictional Annexes.
- **Magnitude/Severity:** Describes the extent (magnitude or severity) of each hazard. If a hazard has a uniform extent for all the MAs, it is noted. For geographically specific hazards, mapping is provided that illustrates the extent of the hazard for the entire planning area. Mapping for applicable hazards specific to an MA are provided in the Jurisdictional Annexes.
- **Probability of Future Occurrences:** Provides a discussion of the probability of future occurrences of the hazard based on the history of past occurrence, location, and severity. If the likelihood of occurrence is the same for all jurisdictions or varies amongst the jurisdictions, it is noted.
- **Climate Change Considerations:** Provides a discussion regarding the potential effects climate change may have on a specific hazard. In some instances there may be no obvious and direct effect, while in other instances, significant information is available regarding the connections between climate change and the hazard of concern.

3.2.1 Coastal Hazards (Coastal Erosion, Coastal Storms, Sea Level Rise, Tsunamis)

The Coastal Hazards profile includes discussions regarding coastal erosion, coastal storms, sea level rise, and tsunamis.

3.2.1.1 Nature of Hazard

Coastal Erosion/Storms

Erosion is a naturally occurring phenomenon all along California's coastline. Erosion can be severe during winter storms, which are often accompanied by high surf, particularly during El Niño events. Rising sea levels caused by climate change will increase coastal erosion by exacerbating the impact of high tides and waves. Climate change is also expected to increase the frequency and severity of storms. As a result, even areas that have not experienced significant erosion in the past may be at risk in the future.

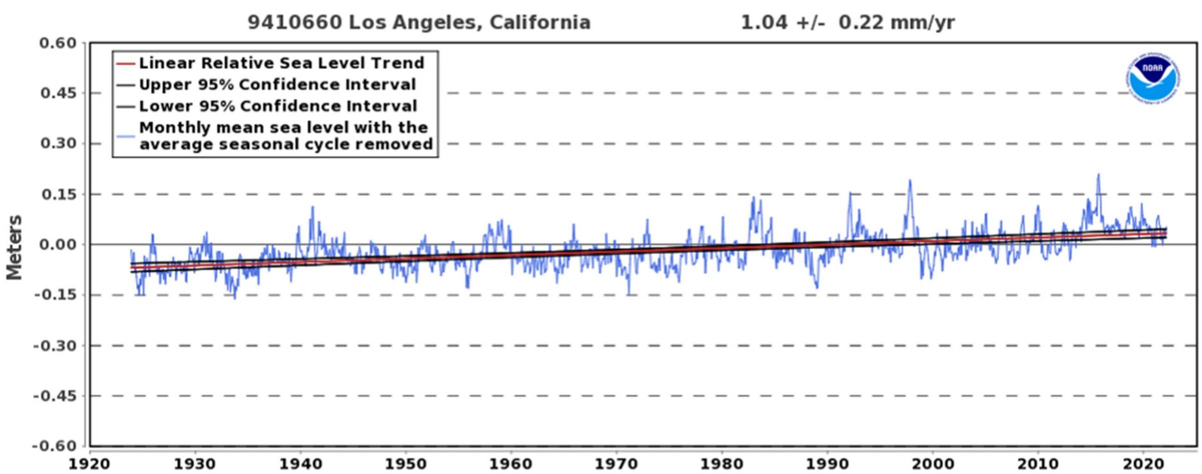
Erosion can also be affected by engineered structures that impede the deposit of new sediment at beaches; these include inland dams, channelized rivers, harbors, jetties, and seawalls/revetments (MWDOC 2019). This has been the case in Orange County, where the channelization of the Santa Ana River has reduced the amount of sediment reaching the coast, while the construction of jetties at Anaheim Bay and breakwaters at Long Beach have changed deposit patterns (MWDOC 2019). This led to the formation of several chronic erosion hotspots along the county's coastline. In some cases, long-term beach replenishment efforts and management plans have been able to counteract or reverse some of these trends.

In addition to the gradual narrowing of sandy beaches, storms and erosion can damage steep coastal bluffs and cliffs. Landforms that appear to have been stable for years may retreat several feet in just a few hours. In either case, erosion can cause considerable damage to coastal infrastructure and property. As Orange County's beaches are centers for recreation and tourism, loss of land has economic consequences, as well.

Sea Level Rise

Sea level rise is the increase in the average height of the ocean's surface. It occurs when global temperatures rise and melt land ice, such as glaciers and the polar ice caps that have formed over land masses. The meltwater runs into the world's oceans, causing a global increase in ocean levels. Additionally, because most materials expand in size when they become warmer, increased temperatures cause ocean water to expand, further raising the height of the ocean's surface. **Exhibit 3-4** shows the sea level trend over the past 100 years.

Exhibit 3-4. Sea Level Trend (1920-2020)



(NOAA 2024b)

While sea level rise can happen naturally, such as at the end of an ice age, the driver of sea level rise at present is global climate change. Unlike many other hazards, sea level rise is very gradual and occurs over the course of decades. Sea level rise itself poses both indirect and direct threats. Indirectly, a higher average sea level means that there is less of a buffer between the ocean and coastal structures or facilities. This can make it easier for coastal flooding, which can occur during storms, high surf, or particularly strong tides, to affect coastal properties since the distance between the ocean and these properties is smaller. Similarly, sea level rise can exacerbate coastal erosion, as discussed above. If sea level rise becomes severe enough, low-lying coastal areas can be semi-permanently or permanently underwater, rendering these areas uninhabitable.

Tsunamis

The phenomenon we call “tsunami” is a series of traveling ocean waves of extremely long length generated primarily by earthquakes occurring below or near the ocean floor. In the deep ocean, the tsunami waves move across the deep ocean with a speed exceeding 500 miles per hour, and a wave height of only a few inches. Tsunami waves are distinguished from ordinary ocean waves by their great length between wave crests, often exceeding 60 miles or more in the deep ocean, and by the time between these crests, ranging from 10 minutes to an hour.

As they reach the shallow waters of the coast, the waves slow down, and the water can pile up into a wall of destruction up to 30 feet or more in height. The effect can be amplified where a bay, underwater features, or harbor or lagoon funnels the wave as it moves inland. Large tsunamis have been known to rise over 100 feet. Even tsunamis 1 to 3 feet high can be very destructive and cause many deaths and injuries.

There are many causes of tsunamis, but the most prevalent is earthquakes. In addition, landslides, volcanic eruptions, explosions, and even the impact of meteorites can generate tsunamis. Not all earthquakes generate tsunamis. To generate a tsunami, the fault where the earthquake occurs must be underneath or near the ocean and cause vertical movement of the sea floor over a large area, hundreds or thousands of square miles. By far the most destructive tsunamis are generated from large, shallow earthquakes with an epicenter or fault line near or on the ocean floor. The amount of vertical and horizontal motion of the sea floor, the area over which it occurs, the simultaneous occurrence of slumping of underwater sediments due to the shaking, and the efficiency with which energy is transferred from the Earth’s crust to the ocean water are all part of the tsunami generation mechanism. The sudden vertical displacements over such large areas disturb the ocean’s surface, displace water, and generate destructive tsunami waves. Although all oceanic regions of the world can experience tsunamis, the most destructive and repeated occurrences of tsunamis are in the Pacific Rim region.

Tsunami waves can travel at the speed of a commercial jet plane, over 500 miles per hour, moving from one side of the Pacific Ocean to the other in less than a day. This great speed makes it important to be aware of the tsunami as soon as it is generated. Scientists can predict when a tsunami will arrive at various locations by knowing the source characteristics of the earthquake that generated the tsunami and the characteristics of the sea floor along the path to the shore from the point of origin.

Offshore and coastal features can determine the size and impact of tsunami waves. Reefs, bays, entrances to rivers, undersea features and the slope of the beach all modify the tsunami as it converges on the coastline. People living near areas where large earthquakes occur may find that the tsunami waves can reach their shores within minutes of the earthquake. For these reasons, the tsunami threat to many areas such as Alaska, the Philippines, Japan, and the U.S. West Coast can be immediate (as tsunamis from nearby earthquakes take only a few minutes to reach coastal areas) or less urgent (as tsunamis from distant earthquakes take from 3 to 22 hours to reach coastal areas). When a tsunami reaches the coastline and moves inland, the water level can rise several feet, flooding homes, businesses, and infrastructure from several thousand feet to miles inland, depending on the topography.

Scientists cannot accurately predict when earthquakes will occur, and as a result they cannot determine exactly when a tsunami will be generated or how destructive it will be. However, past tsunami height measurements are useful in predicting future tsunami impact and flooding limits at specific coastal locations and communities.

3.2.1.2 History/Past Occurrences

Coastal Erosion/Storms

Problems with chronic erosion in Orange County have been recognized since at least 1945, when beach nourishment operations were undertaken to shore up the eroding Surfside-Sunset shoreline (MWDOC 2019). A 2006 U.S. Geological Survey (USGS) assessment of the entire California coast found that, between Los Angeles Harbor and Dana Point, the shoreline had receded since the early 1970s for 35% of the 29-miles coastline. Beach nourishment projects prevented further observable erosion during this period.

California typically experiences the most erosion during significant El Niño events. The three strongest El Niño events on record were during the winters of 1982-1983, 1997-1998, and 2015-2016. Historic erosion was reported all along the west coast in 2015-2016, according to the USGS (USGS 2017b). While the winter storms brought extreme wave action to California’s shores, they featured surprisingly little rainfall. With California in the midst of a major drought, less sediment was washed to the ocean to replenish beaches. Portions of beaches in San Clemente and Laguna Beach were temporarily closed to the public due to hazardous conditions (Connelly 2016).

Sea Level Rise

NASA reports that the global average sea level has risen almost 7 inches in the last 100 years. Rising sea levels have been observed in Orange County, as well. Measurements taken at Newport Beach since 1955 show that the sea level there has risen an average of 2.22 millimeters, or 0.09 inches, per year (MWDOC 2019). NOAA maintains tidal gauges along the coast of California. The closest tidal gauge to Orange County is La Jolla and monitored water levels at the La Jolla tide gauge (Station 9410230) have shown an increase of 0.08 inch per year (2.04 millimeters per year) based on monthly mean sea levels from 1924 to 2021.

King tides have flooded Orange County coastal communities, including Seal Beach, Huntington Beach, Balboa Peninsula and Balboa Island in Newport Beach, and Sunset Beach in the past (OCR 2017). In the last 10 years, the National Centers for Environmental Information (NCEI) Storm Events Database reports four coastal flooding incidents that affected Orange County: in October and November of 2015 and in May and October of 2017. It is difficult to say how higher sea levels may have affected the severity of these events. The independent organization Climate Central estimates that La Jolla, California, located south of Orange County, experienced 60 days of coastal flooding between 2005 and 2014, based on observed impacts such as flooded roads. Of those events, only four would have occurred without climate-linked sea level rise (Climate Central n.d.).

Tsunamis

Tsunamis can be categorized as Pacific-wide or "local." Typically, a Pacific-wide tsunami is generated by a major vertical shift in the ocean floor creating a wave that includes the entire column of water that has the potential to travel long distances. A "local" tsunami can be a component of a Pacific-wide tsunami in the immediate area of the earthquake or a wave that is confined to the area of generation, such as a landslide within a bay or harbor. Worldwide, tsunamis have resulted in the loss of thousands of lives, billions of dollars in damages, and the closure of many local economies.

All of the coastal areas in Orange County are susceptible to tsunamis, although most tsunamis have occurred in Northern California. The Channel Islands were impacted by a tsunami in the early 1800s. In the 1930s, four tsunamis struck the Los Angeles, Orange County, and San Diego coastal areas. In Orange County the tsunami wave reached heights of approximately 20 feet above sea level. In 1964, following the Alaska 8.2 earthquake, tidal surges of approximately 4 feet to 5 feet battered Huntington Harbor causing moderate damage.

According to the OC San Emergency Management Division, the following events generated response by their office (Ethan Miller Brown, OC San Emergency Management Division, pers. comm. Email correspondence. September 5, 2017):

- **April 1, 2014**. An 8.2 earthquake off the coast of Chile had the potential to generate a tsunami that could impact the Orange County coastline. The event was monitored, but no watch, advisory, or warning was issued for the county.
- **September 16, 2015.** An 8.3 earthquake off the coast of Chile triggered a Tsunami Advisory for the Orange County coastline. The Orange County Emergency Operations Center (EOC) was activated, and beaches were closed as a precaution; no evacuation orders were issued, and no damages occurred.
- **January 15, 2022.** A volcanic eruption near the Tonga Islands of the South Pacific generated a tsunami triggering a Tsunami Advisory for Orange County beaches, harbors, and piers (NOAA 2024c).

The National Oceanic and Atmospheric Administration (NOAA) reports one tsunami event in Orange County (MWDOC 2019):

- **September 16-17, 2015.** As described above, an 8.3 magnitude earthquake off the coast of Chile led the National Tsunami Warning Center to issue a tsunami advisory for a portion of California, including Orange County. All beaches, harbors, piers, and marinas in the cities of Seal Beach, Huntington Beach, Newport Beach, Laguna Beach, Dana Point, and San Clemente, including county and State beaches were closed. Tsunami wave heights were observed to be just under 1 foot along the Orange County coast. The Orange County EOC reported no significant coastal flooding, but to be aware of the high likelihood of strong currents and waves dangerous to persons in or near the water.

3.2.1.3 Location/Geographic Extent

Coastal Erosion/Storms

Orange County's coastline includes sand and cobble beaches, rocky cliffs and coastal bluffs, and intertidal areas. In general, beach erosion is more of an issue along Orange County's northern coast, while bluff retreat is a greater concern along the southern portion.

Beginning in 1964, the Orange County Erosion Control Project targeted Surfside-Sunset and West Newport Beach as locations in need of restoration. The U.S. Army Corps of Engineers spearheaded efforts to import sand and install retention devices in these areas.

A 2006 USGS study found that West Newport Beach had the largest measurable erosion rate in Orange County between the early 1970s and 1998.

As part of the Coastal Storm Modeling System (CoSMoS), data available from the USGS shows the projected location of the California shoreline under various scenarios of sea level rise. The Coastal Storm Modeling System (CoSMoS-COAST) shows that with a 3.3-foot rise in sea levels, Huntington State Beach will see the greatest erosion, followed by parts of Huntington City Beach, West Newport Beach, Surfside, and Bolsa Chica State Beach.

Sea Level Rise

Sea level rise presents a risk for all coastal communities with low-lying areas. In Orange County, Huntington Beach is particularly vulnerable. A 2017 report by the Union of Concerned Scientists, "When Rising Seas Hit Home," includes a mapping tool that shows what coastal areas will experience flooding at least 26 times a year under various sea level rise scenarios. Under a moderate scenario of a 4-foot rise, the area of north Orange County roughly bounded by the Santa Ana River and State Route 22 will see 14% of its land chronically inundated by 2100, even with existing levees. With a rise of 6 feet, 24% of the land will be chronically inundated. Affected areas include neighborhoods in Seal Beach, Huntington Beach, and Newport Beach.

NOAA offers another mapping tool to visualize areas vulnerable to flooding due to climate change. Its Sea Level Rise Viewer projects that, with a 1-foot rise in sea levels, there will be flooding through many parts of southeastern Huntington Beach, including neighborhoods between the Talbert Chanel and Huntington Beach Channel. A 2-foot rise will also start to affect parts of Sunset Beach and Balboa Island in Newport Beach, as well as less developed areas of Upper Newport Bay and Bolsa Chica Ecological Reserve.

From 1924 to 2021 NOAA's La Jolla tide gauge (Station 9410230) have shown an increase of 0.08 inch per year (2.04 millimeters per year) based on monthly mean sea levels.

Tsunamis

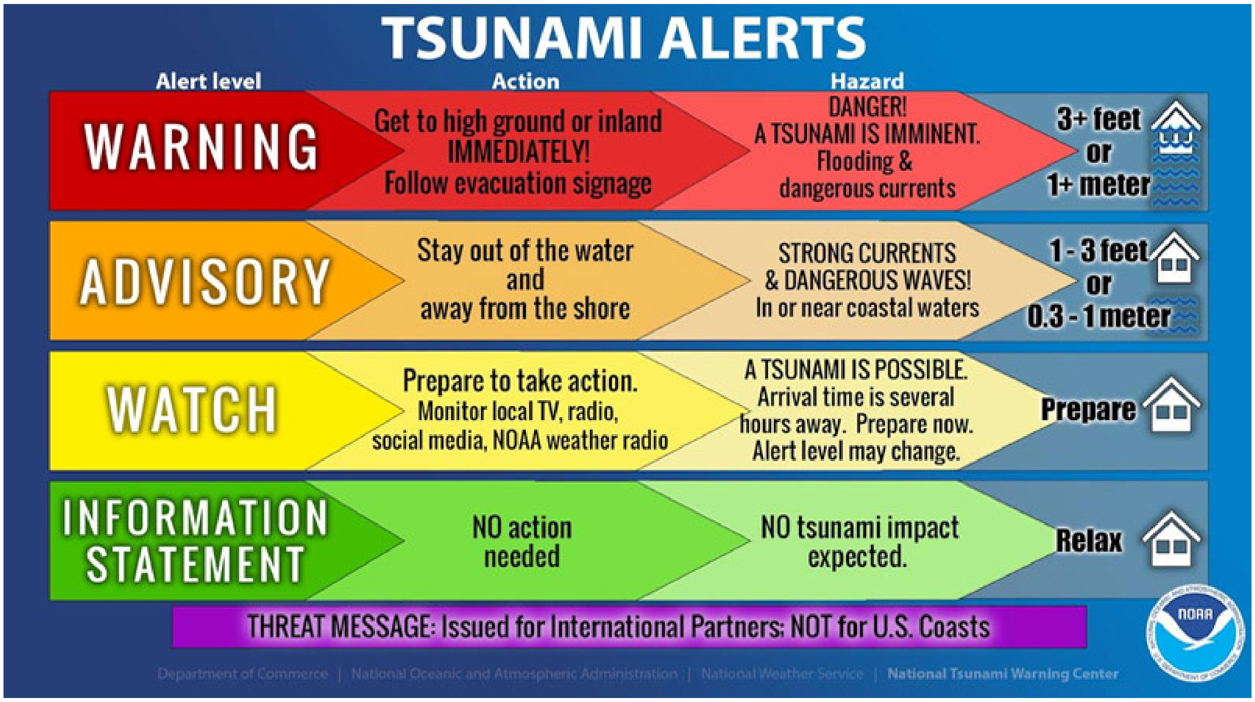
Exhibit 3-5 illustrates the portions of the planning area within a tsunami hazard zone. Tsunami inundation maps are provided by the California Geological Survey and represent a combination of the maximum considered tsunamis for each area.

As illustrated on **Exhibit 3-5**, tsunami inundation areas are contained to the coastal areas of the planning area, extending into the areas of Seal Beach, Huntington Beach, Newport Beach, Laguna Beach, Dana Point, and San Clemente.

To better understand the severity of a tsunami event, NOAA provides an alert scale (**Exhibit 3-6**) that provides four alert levels each with an information statement, watch, advisory, and warning. These levels are based on the hazard level and actions necessary in response to the type of alert provided.

Exhibit 3-5. Tsunami Hazard Zones

Exhibit 3-6. Tsunami Alerts Scale



3.2.1.4 Magnitude/Severity

Coastal Erosion/Storms

Erosion is usually described in terms of how much the beach width deceases per year. The 2006 USGS study, for example, found that erosion at West Newport Beach was at a rate of -2.2 meters per year. Overall, the shoreline of Los Angeles Harbor and Dana Point grew by an average of 0.5 meters per year, the highest rate in all of California, due largely to beach nourishment projects. Among those sections that did experience erosion, it happened at an average rate of -0.5 meters per year.

The volume of sand used to fight erosion can also indicate the magnitude of the problem. For example, from 1945 to 2009, more than 20 million cubic yards of sediment has been added to Surfside-Sunset Beach (Everest 2013).

In November 2023, the U.S. Army Corps of Engineers announced a new beach nourishment project that will dredge roughly 1.2 million cubic yards of sand off the coast of Surfside and Sunset beaches. These dredged materials will be deposited south of the Naval Weapons Station Seal Beach, allowing for sediment to be transported naturally to the Huntington, Bolsa Chica, and Newport Beaches.

Sea Level Rise

Sea level is measured by local tide gauges and satellite. Sea level rise describes projected changes in those measurements based on different climate models. NOAA's Sea Level Rise Viewer projects that the sea level at Newport Bay will rise by at least 0.75 feet and as much as 2.72 feet by 2050, based on different global scenarios. By 2100, the level may rise by as much as 10.14 feet under the most extreme scenario.

Tsunamis

The magnitude/severity of a tsunami would be dependent on the severity and location of the event causing the tsunami. The California Geological Survey tsunami inundation maps (refer to **Exhibit 3-5**) identify the maximum extent of the tsunami inundation area within Orange County, which is primarily contained to the coastline. However, the inundation areas extend into several coastal communities with the largest potential inundation areas occurring within the cities of Seal Beach, Huntington Beach, Newport Beach, and Dana Point.

3.2.1.5 Probability of Future Occurrences

Coastal Erosion/Storm

Climate change all but ensures that the entire Orange County coast will experience some degree of erosion through the end of the century. The amount will depend on how much sea levels rise, which is contingent on global efforts to curb greenhouse gas emissions. An online mapping tool produced by Our Coast Our Future, a collaborative effort of 15 organizations including the USGS and California Coastal Commission, used CoSMoS data to predict that very few sections of the county's shoreline will maintain their current position assuming a 3.3-foot rise in sea level, even with the continuation of current beach nourishment efforts.

A new study released in 2017 using CoSMoS data found that, without human intervention, 31% to 67% of Southern California beaches may be completely eroded by 2100 if sea levels rise by 1 to 2 meters (USGS 2017a).

Sea Level Rise

According to the 4th Climate Change Assessment, thermal expansion was the largest contributor to sea level rise followed by melting ice from glaciers, ice caps, and loss of ice sheets covering Greenland and Antarctica. While the rate of sea level rise has been slow along the Orange County coast in the past, it is expected to accelerate in the future. According to the 4th Climate Change Assessment, by 2050 sea levels could be approximately 1 foot higher than they are now, and by 2100 sea levels could 5.5 feet higher or more (Hall et al. 2018).

Independent of all other factors, sea level rise is expected to cause temporary inundation of large sections of the planning area's beaches, particularly near the piers, during high wave events. However, no substantial permanent inundation is expected at this time. However, the effect of sea level rise is much greater in combination with various flood events, including coastal flooding and extreme high tides.

Climate Central's Surging Sea Risk Finder attempts to estimate the probability that coastal floods will reach elevations above the local high tide line. The tool does not have estimates for every tide gauge, and estimates for Orange County are based on data from the gauge at Los Angeles' Outer Harbor. It shows that, while there is currently less than a 1% chance of coastal flooding reaching areas 3 feet above the tide line in any given year, those chances increase to 6% annually by 2040 under a medium sea level rise scenario. By 2070, these areas will be flooding every year. Under an extreme scenario, annual flooding will happen as soon as 2040.

Tsunamis

The historic record indicates that there is a low probability of occurrence of a major tsunami in Orange County. However, there is the potential for future tsunami events to impact water and wastewater infrastructure located within a tsunami inundation area. This probability is similar for each of the jurisdictions located within these areas.

3.2.1.6 Climate Change Considerations

Coastal Erosion/Storms

Coastal erosion is caused primarily by tides and wave action from storms. While tides are not affected by climate change, some studies suggest that climate change is expected to cause a 10% to 20% increase in the intensity of the severe storms that affect Southern California, as discussed in greater detail in **Section 3.2.3, Flood** (Oskin 2014). This means that the significant wave events that already cause substantial erosion along low-lying coastal areas may become more intense, causing greater loss of beaches and coastal bluffs during these events. Sea level rise, which is caused by climate change, may exacerbate the issue. As the surface of the ocean becomes higher, wave and tidal action will be able to reach farther onto land. As a result, wave and tide events that currently do not reach far enough to cause any erosion may be able to do so in the future, and wave and tide events that already cause erosion will be able to affect areas farther from the water line.

Sea Level Rise

Sea level rise is a direct consequence of climate change and would likely not exist to any substantial degree if climate change was not occurring. Climate change does not create any particular considerations for sea level rise, as the hazard itself is a result of climate change.

Tsunamis

The displacement events that cause tsunamis are geologic in nature and unaffected by climate change to any known degree. However, as sea level rise increases the average height of the ocean, this will allow tsunami waves to reach farther inland. Even though climate change is not expected to affect the severity of tsunamis, sea level rise is likely to create the potential for tsunamis to cause greater damage.

3.2.2 Dam/Reservoir Failure

3.2.2.1 Description (Nature) of the Hazard

Dam failures can result from several natural or human-caused threats such as earthquakes, erosion of the face or foundation, improper silting, rapidly rising flood waters, malicious events, and structural/design flaws. Seismic activity can also compromise dam regulating structures, resulting in catastrophic flooding. A dam failure can cause loss of life, damage to property, the displacement of persons, and other ensuing hazards along the inundation path. Damage to electricity-generating facilities and transmission lines could also impact life support systems in communities outside of the immediate hazard areas.

In the event of a major dam failure, mutual aid from all levels of government would be required for an extended period. Recovery efforts would include the removal of debris, clearing roadways, demolishing unsafe structures, assistance in reestablishing public services, and providing continued care and welfare for the affected population.

There are 33 dams in Orange County with ownership ranging from the Federal Government to homeowners' associations. These dams hold billions of gallons of water in reservoirs. The major reservoirs are designed to protect Southern California from flood waters and to store domestic and recycled water.

In addition to reservoirs with dams in Orange County, there are many water storage tanks that are potentially susceptible to failure or damage by natural or human-caused events. These water tanks contain millions of gallons of water each and provide an important source of water storage. Their capacity is large enough to cause substantial damage down slope from a tank should one fail. Correspondingly, the history of failure of water storage tanks is considered.

Because dam failure can have severe consequences, FEMA and Cal OES require all dam owners to develop Emergency Action Plans (EAP) for warning, evacuation, and post-flood actions. Although there has been extensive coordination with Orange County officials in the development of an Orange County Response Plan, the responsibility for developing potential flood inundation maps and facilitation of emergency response is the responsibility of the dam owner.

3.2.2.2 History/Past Occurrences

Orange County has never experienced a major dam failure, but there have been two deadly incidents involving dams built to supply water for the City of Los Angeles. In addition, the failure of a water tank caused considerable damage within the City of Westminster in 1998. These three disasters are detailed below.

St. Francis Dam, Disaster of 1928

In Los Angeles, the failure of the St. Francis Dam, and the resulting loss of over 500 lives was a scandal that resulted in the almost complete destruction of the reputation of its builder, William Mulholland. It was he who proposed, designed, and supervised the construction of the Los Angeles Aqueduct, which brought water from the Owens Valley to the city. The St. Francis Dam, built in 1926, was 180 feet high and 600 feet long. It was located near the City of Saugus in San Francisquito Canyon.

The dam failed on March 12, 1928 three minutes before midnight. Its waters swept through the Santa Clara Valley toward the Pacific Ocean about 54 miles away. The valley was devastated before the water finally made its way into the ocean between Oxnard and Ventura. At its peak the wall of water was said to be 78 feet high. At the time the water flowed through Santa Paula, 42 miles south of the dam, the water was estimated to be 25 feet deep. Almost everything in its path was destroyed: livestock, structures, railways, bridges, and orchards. In the end Ventura County lay below 70 feet of mud and damage estimates topped $20 million.

Baldwin Hills Dam, Disaster of 1963

The Baldwin Hills Dam collapse sent a 50-foot wall of water down Los Angeles' Cloverdale Avenue on December 14, 1963. Five people were killed. Sixty-five hillside houses were ripped apart, and 210 homes and apartments were damaged. The flood swept northward in a V-shaped path roughly bounded by La Brea Avenue, Jefferson Boulevard, and La Cienega Boulevard.

The earthen dam that created a 19-acre reservoir to supply drinking water to West Los Angeles residents ruptured at 3:38 p.m. A pencil thin crack widened to a 75-foot gash allowing 292 million gallons to surge out in 77 minutes. The cascade caused an unexpected ripple effect that is still being felt in Los Angeles and beyond. It prompted the end of urban-area earthen dams as a major element of water storage systems, and a tightening of the Division of Safety of Dams control over reservoirs throughout the State.

Westminster Water Tank Failure, Disaster of 1998

In September of 1998, a 5-million-gallon municipal water storage tank in the City of Westminster ruptured because of corrosion and construction defects. There was no loss of life, but damage was extensive. The flow of water from the 32-year-old tank destroyed most of the storage facility as well as several private residences. Additionally, there were approximately 30 more homes inundated with water and silt. Through the Public Works Mutual Aid Agreement, the Orange County Public Works Department assisted the City of Westminster in the cleanup and temporary repair of the streets.

City employees, the Orange County Fire Authority, neighboring fire services, and the Red Cross were onsite for days assessing the damage and assisting residents. Water storage for the city was non-existent following this event while the other 5-million-gallon tank of similar age and construction was removed from service as a precautionary measure.

A new reservoir facility began providing services in March 2003, consisting of two 8-million-gallon water storage tanks, a 17-million-gallon-per-day booster station, and a new groundwater well with a capacity of 3,000 gallons per minute. All new construction has passed rigorous inspections and has obtained the required permits from the California Department of Public Health.

3.2.2.3 Location/Geographic Extent

Exhibit 3-7 lists the larger reservoirs and dams in Orange County and their owners/operators.

Exhibit 3-7. Orange County Large Reservoirs and Dams

Name of Facility	Owner/Operator
Santiago Creek Dam/Reservoir (Irvine Lake)	IRWD
Villa Park Dam	County of Orange
Sulphur Creek Dam	County of Orange
Peters Canyon Dam	County of Orange
Walnut Canyon Dam/Reservoir	City of Anaheim
San Joaquin Dam/Reservoir	IRWD
Sand Canyon Dam/Reservoir	IRWD
Rattlesnake Canyon Dam/Reservoir	IRWD
Big Canyon Dam/Reservoir	City of Newport Beach
Lake Mission Viejo	Lake Mission Viejo Association
El Toro R-6 Dam/Reservoir	ETWD
El Toro Reservoir/Rossmoor #1 Dam	ETWD
Diemer Filtration Plant	Metropolitan Water District of Southern California
Palisades Bradt Dam/Reservoir	SCWD
Portola Dam/Reservoir	SMWD
Syphon Canyon Dam/Reservoir	The Irvine Company
Trabuco Dam/Reservoir	TCWD
Dove Canyon Dam	Dove Canyon Master Association/TCWD
Upper Oso Dam/Reservoir	SMWD
Upper Chiquita Dam/Reservoir	SMWD
Brea Dam	U. S. Army Corps of Engineers
Fullerton Dam	U. S. Army Corps of Engineers
Carbon Canyon Dam	U. S. Army Corps of Engineers
Prado Dam	U.S. Army Corps of Engineers

As mentioned above, the responsibility for developing maps showing areas that would be inundated in the event of a failure is the responsibility of the dam's owner. Not all of the dams and reservoirs in **Exhibit 3-7** would impact the planning area. Those that could impact the planning area, should they fail, are described below.

Big Canyon Reservoir is a 600-AF potable water storage facility constructed in 1959 and owned by the City of Newport Beach. It is in the San Joaquin Hills overlooking Newport Bay. Big Canyon Reservoir is retained on three sides by a homogenous earth-filled embankment dam, while the east side was formed by a slope cut. At its maximum section the dam embankment is 65 feet high. The spillway is an ungated concrete lined overflow structure located on the west side of the reservoir. The bottom of the reservoir and the cut slopes are lined with minimum 5-foot-thick clay blanket, and the entire inside surface, including the embankments and cut slopes, is overlain with a 3-inch-thick, porous, asphalt pavement. The reservoir is covered with a reinforced polypropylene weight-tensioned floating cover that was installed in 2004.

Dove Canyon Dam is an earth-filled dam completed in 1990. The dam is in the Dove Canyon residential community within the City of Rancho Santa Margarita, Orange County. The dam is owned by the Dove Canyon Master Association (DCMA). DCMA owns and operates recreational facilities situated immediately downstream of the dam crest on compacted backfill. The recreational facilities were included in the construction documents for the dam and approved by the State Division of Safety of Dams. The impounded reservoir is located on land owned by the TCWD and is used to store up to about 415 AF of runoff. TCWD and DCMA have an agreement to operate and maintain the dam and reservoir. TCWD utilizes storage in the reservoir to supplement its recycled water demands for landscape irrigation. The impounded water can be stored to an elevation of 1,090 feet, approximately 11 feet below the top of the dam crest's elevation of 1,101 feet above mean sea level (MSL).

El Toro Reservoir is an embankment-type dam owned and operated by ETWD. The reservoir is located in the City of Mission Viejo. The impounded reservoir has a storage capacity of 275 million gallons (850 AF) with a surface area of approximately 20.6 acres. The bottom and internal slopes of the reservoir are lined, and the reservoir surface has a floating cover. There is no surface water influent to the reservoir. The reservoir includes an emergency spillway and drainage facilities. Storage capacity in the El Toro Reservoir is owned through a regional partnership between ETWD, SMWD, and MNWD.

Rossmoor #1 Dam is an embankment-type dam, with a height of 36 feet and a length of approximately 305 feet. The dam is located in the City of Laguna Woods. The impounded Holding Pond is used to provide emergency storage of secondary effluent from the ETWD Water Recycling Plant and has a storage capacity of 14 million gallons (43 AF). The reservoir includes an emergency spillway and drainage facilities.

Palisades Bradt Reservoir provides up to 48 million gallons of potable water storage with a 146-foot-high, zoned, earthen embankment dam constructed in 1963. The bottom and internal slopes of the reservoir are lined, and the reservoir surface has a floating cover. The dam has a low-level outlet, an emergency outlet, and an emergency spillway. The upstream watershed that contributes inflow to the reservoir has an area of 19 acres.

Peters Canyon Dam is an earth-filled structure owned by Orange County that has a capacity of 626 AF at the spillway pipe elevation of 537 feet above MSL. Water storage varies from 200 AF to 600 AF depending on seasonal rain amounts. Alerting would come primarily from the Park Ranger at Peters Canyon Regional Park who would notify the Sheriff's Department, Control One of dam failure or possible dam failure.

Prado Dam is owned and operated by the Army Corps of Engineers and provides flood control and water conservation storage for Orange, Riverside, and San Bernardino counties. Prado Dam is a major component of the Santa Ana Mainstem Project, which extends from the upper canyon in the San Bernardino Mountains downstream to the Pacific Ocean at Newport Beach, some 75 miles along the Santa Ana River. The entire system is designed to provide various levels of flood protection ranging from 100 to 190 years for areas most susceptible to damage from flooding. The dam collects upstream water releases from storage facilities and runoff from uncontrolled drainage areas. It primarily benefits Orange County by reducing the potential for flood-induced damage and by providing water conservation storage. The Prado Dam has been undergoing major improvements including raising the embankment and spillway, increasing the maximum discharge capacity, constructing new levees and dikes, relocating and protecting utility lines, increasing reservoir area, and increasing impoundment.

Portola Dam is located near the northern end of Canada Gobernadora in southern Orange County, within the Coto de Caza gated community. Canada Gobernadora flows north to south and confluences with San Juan Creek approximately 7.5 miles upstream of the Pacific Ocean. Portola Dam is an earth-filled structure situated about 8 miles north of San Juan Creek with a maximum recycled water (or domestic water blend) storage capacity of 586 AF and a high-water elevation of 936 feet.

The Canada Gobernadora valley channel area between the dam and San Juan Creek has been developed with a golf course and lined on each side by thousands of homes positioned just at or above the 100-year flood plain. If a Portola Dam break occurred, the flow would likely destroy streets crossing the flood plain; damage the water, sewer, and recycled water pipeline infrastructure in them; and affect some or many home locations near the stream channel. Streets in Coto de Caza certain to be affected are: Trigo Trail, Via Pajaro, Via Conejo, Vista Del Verde, San Miguel, Cantamar, and South Bend. Along with the golf course and the equestrian center, additional SMWD facilities that are anticipated to be damaged or destroyed by a dam break in Coto de Caza and farther downstream are:

- Coto Lift Station and force main
- South Ranch Lift Station and force main
- South county pipeline
- Ortega Lift Station (Talega) force mains
- Talega recycled water transmission main
- Chiquita Land Outfall pipeline

Per the compliance report, after entering San Juan Creek, the dam break inundation flood area would be about the same as the 100-year flood plain all the way down to the Pacific Ocean.

Santiago Creek Dam is an earth-fill dam with a 25,000 AF capacity reservoir (Irvine Lake). The dam is owned by IRWD. **Villa Park Dam** is a flood control dam located downstream from Santiago Dam. It is an earth-fill structure with a capacity of 15,600 AF and is owned by the Orange County Flood Control District. Initial alerting is expected from dam keepers who are on duty at both Santiago Creek Dam and Villa Park Dam.

Trabuco Dam is an earth-filled dam completed in 1984. The dam is located adjacent to the Robinson Ranch residential community within the City of Rancho Santa Margarita, Orange County. The dam and impounded reservoir are owned and operated by the TCWD. TCWD utilizes the reservoir to store up to approximately 135 AF of reclaimed water produced from the Robinson Ranch Wastewater Treatment Plant located adjacent to the reservoir. The reclaimed water can be stored to an elevation of 1,274 feet, approximately 6 feet below the top of the dam crest's elevation of 1,280 feet above MSL.

Upper Oso Reservoir (UOR) and Dam are located within the Cities of Mission Viejo and Rancho Santa Margarita near the northern end of the Oso Creek Watershed in southern Orange County. Upper Oso Dam is an earth-filled structure situated between El Toro Road and Los Alisos Boulevard nearly 10 miles north of the Trabuco Creek confluence point. UOR has a high-water elevation of 953 feet and stores up to 4,000 AF of recycled water for landscape irrigation that is mainly used within SMWD and MNWD.

Immediately downstream of the Upper Oso Dam, a long bridge for State Route 241 crosses the flood channel and may not experience problems during a major flood event. Just upstream of Los Alisos Boulevard, some commercial property lies adjacent to the Oso Creek channel and may be affected. About 3 miles downstream on Oso Creek and upstream of Olympiad Road, a large basin area was created (now a sports park) to capture and attenuate major discharges from UOR before they enter **Lake Mission Viejo (LMV).**

LMV is created by a dam lying under Alicia Parkway. An Upper Oso Dam breach may also overflow LMV and damage the dam to point where it could release stored water and create a catastrophic flood hazard all the way to the Pacific Ocean.

Downstream of LMV, two golf courses have been developed within the Oso Creek channel area and numerous commercial properties are on adjacent sides. Housing tracts have been built above the 100-year flood plain, but, if a dam break occurred, the flow from UOR and LMV would likely destroy streets crossing the flood plain and damage the water, sewer, and recycled water pipeline infrastructure in them. In addition to the many pipelines crossing the flood plain, SMWD facilities that are anticipated to be damaged or destroyed by an Upper Oso Dam break are:

- Eastbrook Recycle Water Pump Station
- Lakeside Pump Station
- South County Pipeline
- Oso Creek Water Reclamation Plant
- Oso Creek Trunk Sewer
- Oso Barrier RW Pump Station and Pipelines

Due to proximity and elevation, a considerable number of the residential and commercial properties in many areas close to the banks of Oso Creek and farther downstream would likely be flooded for a short period of time and damaged. Streets in Mission Viejo and farther south that are likely to be affected by a dam failure are Los Alisos Boulevard, Santa Margarita Parkway, Olympiad Road, Alicia Parkway, Jeronimo Road, Marguerite Parkway, Casta del Sol, La Paz Road, Oso Parkway, Interstate 5, Camino Capistrano, Del Obispo Street, Stonehill Drive, and Pacific Coast Highway.

Upper Chiquita Reservoir (UCR) was constructed by SMWD to provide the South Orange County region with substantial new water reserves to meet customer demand during disruptions of water deliveries. These interruptions can be unanticipated, like the break of the Allen McColloch Pipeline in 1999, or planned, like the shutdowns of the Diemer Filtration Plant in Yorba Linda to complete improvements or maintenance and repairs.

The UCR consists of an earth-fill dam structure and a covered, domestic water reservoir with a storage volume of 750 AF. The reservoir footprint is approximately 19.7 acres with a surface area of approximately 15.4 acres and has a High-Water Level (HWL) of 860 feet.

In addition to the dam and reservoir, the site contains the following facilities:

- Floating cover
- Access roads
- Spillway and drainage facilities
- Inlet/outlet facilities and pipelines
- Pump station
- Disinfection equipment
- Pipeline connection to the South Orange County Pipeline

The UCR site is located on the western side of Chiquita Canyon north of Oso Parkway and west of the current terminus of State Route 241 (SR-241) within the City of Rancho Santa Margarita, east of the community of Las Flores in southern Orange County.

A portion of the site is encumbered within the Transportation Corridor Agency's Chiquita Canyon Perimeter Conservation Easement. The closest developed areas are the Tesoro High School campus (located across Oso Parkway and south of the reservoir site) and the residential community of Las Flores (approximately 0.8-mile west of the site). Additional land uses in the proximity to the reservoir site include a neighborhood park, Crestview Park, located just over 300 feet west of the site, and the SMWD Las Flores Reservoir, located approximately 250 feet west of the site.

Under an extreme catastrophic dam failure scenario, the flood zone would exceed the FEMA 100-year floodplain in the Canada Chiquita Channel. Under this extreme scenario, land use categories that would be affected include the Oso Parkway, SR-241, and the Tesoro High School. Once the flood waters reach the San Juan Creek the flood flows would be less than the FEMA 100-year flood.

The UCR is located on the western slope of Chiquita Canyon, just north of Oso Parkway in the City of Rancho Santa Margarita. Completed in October 2011, the 244 million-gallon UCR is the largest domestic water reservoir built in South Orange County in nearly 45 years. The UCR has:

- A storage capacity of approximately 244 million gallons of domestic water (750 AF) contained in a lined and covered reservoir.

- A surface area of approximately 17.8 acres.

- A regional partnership between SMWD (lead agency) and MNWD, City of San Juan Capistrano, City of San Clemente, and SCWD (storage owners).

- A service base of approximately 168,000 families receiving approximately 200 gallons of fresh water a day for one week.

- A reservoir design that conforms to the rigorous standards set forth by the State of California.

- Safety features, including piezometers (moisture sensors), to continually monitor water levels and test for irregularities.
- An earthen embankment that significantly reduces any visual impacts while traveling west along Oso Parkway near Highway 241.
- A location that is not visible from homes in local neighborhoods, including Las Flores and Wagon Wheel.

The UCR was included in the South Orange County Natural Community Conservation Plan, which designates habitat conservation and species protection measures to ensure an environmentally sensitive design.

3.2.2.4 Magnitude/Severity

Orange County's reservoirs range in capacity from 18 to 196,235 AF of water storage. Inundation maps and studies, when available, indicate the area that would be flooded and can be used to gauge the severity of a dam failure.

A compliance analysis and inundation study report was prepared for Upper Oso Dam in 1979 to allow for construction permitting by the State of California. This study indicated that if the dam was breached, a potential maximum flow rate exceeding 250,000 cubic feet per second may be expected when the water surface elevation drops to about 935 feet. Should such an event occur, the UOR could potentially empty in about a half hour.

A similar report for Portola Dam was done in 1980. This study indicated that if the dam was breached, a potential maximum flow rate of 22,645 cubic feet per second may be expected after about 3 hours once the water surface elevation is at elevation 920 feet. Should such an event occur, Portola Dam would potentially empty in just over 6 hours.

Failure of a reservoir or a dam could extend throughout most of the planning area, depending upon the size of the facility and associated failure.

3.2.2.5 Probability of Future Occurrences

There has been just one incident involving a water storage structure in the 110 years since construction of the first contemporary dam in Orange County. It is expected that future events will remain highly unlikely, with a less than 1% chance of happening in any given year. However, such occurrences have the potential to be highly destructive.

In the more than 50 years since the collapse of the Baldwin Hills Dam, there have been very few incidents in California due to stringent standards, regulations, and regular inspections. The near-catastrophic failure of the main spillway of the Oroville Dam in Northern California in 2017 is a reminder of the ongoing risk presented by dams.

3.2.2.6 Climate Change Considerations

While climate change is not expected to directly affect the risk of dam failure, the risk could increase due to an expected rise in the number of intense storms as a result of climate change, as discussed in **Section 3.2.3, Flood.** For example, an increase in the number of intense storms in the Santa Ana River Basin could place stress on the effectiveness of Prado Dam. More storms could lead to increased usage of the dams by necessity, and potentially require infrastructure to hold back larger amounts of water. As intense storms caused a near-failure of Prado Dam in 2005, it is possible that increases in the number of intense storms may increase the risk of similar events in the future. This scenario can be applied to many of the dams and reservoirs located within the planning area. An increase in both the frequency and intensity of storms could potentially cause failure of the current infrastructure in place.

3.2.3 Flood

3.2.3.1 Description (Nature) of the Hazard

Flooding may result from heavy rains raising water levels in rivers and streams; storms, tides, and weather patterns pushing ocean water into coastal areas; and when debris blocks normal storm water drainage systems. Other causes are discussed in more detail elsewhere in this plan, including sea level rise in **Section 3.2.1** and dam/reservoir failure in **Section 3.2.2**. Flooding can happen fast and with little warning, or water levels may rise slowly over the course of several days.

Orange County's terrain makes it naturally susceptible to flooding. Many of the rivers, creeks, and streams flow through natural floodplains on their way to the ocean. The county's rapid growth and transformation from an agricultural community to an urban community has changed flood control practices in the region. Drainage is managed through reservoirs, dams, diversion structures, and developed plains. In addition, seven pump stations (Huntington Beach, Cypress, Seal Beach, Los Alamitos, Rossmoor, Harbor-Edinger, and South Park) regulate storm water discharge to flood control channels. Although there is a county-wide system of flood control facilities, many of these are not designed for or capable of conveying runoff from major storms.

Orange County also has a warning system in place to detect potential flooding. The county began installing its ALERT (Automated Local Evaluation in Real Time) system in 1983. Operated by the county's Environmental Resources Section of the Resource Development and Management Department (RDMD) in cooperation with the National Weather Service, ALERT uses remote sensors located in rivers, channels, and creeks to transmit environmental data to a central computer in real time. Sensors are installed along the Santa Ana River, San Juan Creek, Arroyo Trabuco Creek, Oso Creek, Aliso Creek, as well as flood control channels and basins. The field sensors transmit hydrologic and other data (e.g., precipitation data, water levels, temperature, wind speed) to base station computers for display and analysis.

3.2.3.2 History/Past Occurrences

Residents reported damaging floods caused by the Santa Ana River as early as 1770 (as recorded by explorer and missionary Father Juan Crespi). Major floods in Orange County along the Santa Ana River occurred in 1810, 1815, 1825, 1862, 1884, 1891, 1916, 1927, 1938, 1969, 1983, 1993, 1995, 1998, 2005, 2010, and 2017. Often these events involved additional hazards, such as landslides, mud flows, and high winds. **Exhibit 3-8, Presidential Disaster Declarations for Flooding in Orange County Since 1969,** lists Presidential Disaster Declarations since 1969 that involved flooding and affected Orange County.

Exhibit 3-8. Presidential Disaster Declarations for Flooding in Orange County Since 1969

Disaster Number	Incident Type	Title	Incident Begin Date	Incident End Date
3592	Flood	Severe winter storms, flooding, landslides, and mudslides.	3/9/2023	7/10/2023
3591	Flood	Severe winter storms, flooding, and mudslides.	1/8/2023	1/31/2023
4305	Flood	Severe winter storms, flooding, and mudslides.	1/18/2017	1/23/2017

Disaster Number	Incident Type	Title	Incident Begin Date	Incident End Date
1952	Flood	Severe winter storms, flooding, and debris/mud flows.	12/17/2010	1/4/2011
1585	Severe Storm(s)	Severe storms, flooding, landslides, and mud/debris flows.	2/16/2005	2/23/2005
1577	Severe Storm(s)	Severe storms, flooding, debris flows, and mudslides.	12/27/2004	1/11/2005
1203	Severe Storm(s)	Severe winter storms and flooding.	2/2/1998	4/30/1998
1046	Severe Storm(s)	Severe winter storms, flooding landslides, mud flow.	2/13/1995	4/19/1995
1044	Severe Storm(s)	Severe winter storms, flooding, landslides, mud flows.	1/3/1995	2/10/1995
979	Flood	Severe winter storms, mudslides, landslides, and flooding.	1/5/1993	3/20/1993
935	Flood	Rain/snow/wind storms, flooding, mudslides.	2/10/1992	2/18/1992
812	Flood	Severe storms, high tides, and flooding.	1/17/1988	1/22/1988
677	Coastal Storm	Coastal storms, floods, mudslides, and tornadoes.	1/21/1983	3/30/1983
615	Flood	Severe storms, mudslides, and flooding.	1/8/1980	1/8/1980
547	Flood	Coastal storms, mudslides, and flooding.	2/15/1978	2/15/1978
253	Flood	Severe storms and flooding.	1/26/1969	1/26/1969

The most significant flood events that affected the county are summarized below:

- **Great Flood of 1862.** The flood of January 1862, called the Noachian Deluge of California, was unusual in two ways: 1) the storm causing the flood occurred during a very severe drought spanning 1856 to 1864; and 2) the flood lasted 20 days, which is considered an extremely long duration. Under normal circumstances, major floods last only a few days. The only structure left standing along this portion of the Santa Ana River was the Aqua Mansa Chapel and residents gathered on a small point of high land to take refuge from the storm. Miraculously, there were no recorded deaths.

- **Great Flood of 1916.** On January 27, 1916, flood waters inundated a large area along the Santa Ana River, including Main Street in downtown Santa Ana, where the water was 3 feet deep. Adjacent farm lands, which later became the City of Westminster, also flooded. Three vehicular bridges and three railroad bridges were washed away by the flood and four people drowned.

- **Great Flood of 1938.** The flood of 1938 is considered the most devastating flood to occur in Orange County during the 20th Century and affected all of Southern California. The storm began on February 27 and lasted until March 3. In the Santa Ana Basin, 34 people died, and 182,300 acres were flooded. All buildings in Anaheim were damaged or destroyed. Two major railroad bridges, seven vehicular bridges, and the town of Atwood were destroyed. The Santa Ana River inundated the northwestern portion of Orange County and train service to and from Santa Ana was cancelled. The maximum discharge on March 3, 1938, was 46,300 cubic feet per second (cfs), with a gauge height at 10.20 feet. Damage exceeded $50 million.

- **Great Flood of 1969.** The floods of January and February 1969 were the most destructive on record in Orange County. Previous floods had greater potential for destruction, but the county was relatively undeveloped when they occurred. During the flood of 1969, rain fell almost continuously from January 18 to January 25, resulting in widespread flooding. Orange County was declared a national disaster area on February 5. A second storm hit on February 21 and lasted until February 25 bringing rain to the already saturated ground. This second storm culminated in a disastrous flood on February 25. The storm resulted in the largest peak outflow from Santiago Reservoir since its inception in 1933. The reservoir at Villa Park Dam reached its capacity for the first time since its construction in 1963; the dam had a maximum inflow of 11,000 cfs. The outlet conduit was releasing up to 4,000 cfs yet the spillway overflowed at 1:30 p.m. and continued for 36 hours. The maximum peak outflow from the dam reached 6,000 cfs. Although the safety of the dam was never threatened, the outflow caused serious erosion downstream in the cities of Orange and Santa Ana and in some parks and golf courses. A Southern Pacific Railroad bridge, water and sewer lines, a pedestrian over crossing, and three roads washed out. Approximately 2,000 Orange and Santa Ana residents were evacuated from houses bordering Santiago Creek.

- **Great Flood of 1983.** An intense downpour and high tides associated with El Niño (due to the presence of a low pressure system) caused intense shoreline flooding. Meanwhile the Santa Ana River crested its sides near the mouth of the ocean, creating a disaster for the low-lying areas of Huntington Beach. Floodwaters were 3 to 5 feet deep.
- **1992 Coastal Storms.** In 1992, several coastal storms affected many coastal utilities' storm drain and sewage treatment processes. SOCWA reported significant cracks and damage to its Aliso Creek Ocean outfall.
- **Great Floods of 1993.** An intense storm was concentrated in the Laguna Canyon Channel area extending from Lake Forest to downtown Laguna Beach. In spite of a valiant effort to save downtown merchants by sandbagging, the stores were flooded. Laguna Canyon Road was damaged extensively, as well as homes and small businesses in the Laguna Canyon Channel. There were no fatalities reported.
- **Great Flood of 1995.** A disaster was declared in Orange County after extremely heavy and intense rains exceeded the storm runoff capacity of local drainage systems in many Orange County cities and regional Flood Control District systems. As a result, widespread flooding of homes and businesses occurred throughout these cities. There were approximately 1,000 people evacuated, and extensive damage sustained to both private and public property.
- **Great Floods of 1997/1998.** El Niño storms that occurred during this period created extensive storm damage to private property and public infrastructure, with damages reaching approximately $50 million. Storm conditions caused numerous county-wide mudslides, road closures, and channel erosion. Hillside erosion and mudslides forced the continual clearing of roads of fallen trees and debris. Protective measures, such as stabilizing hillside road slopes with rock or K-rail at the toe of slopes, were taken to keep the normal flow of transportation. Harbors, beaches, parks, and trails also sustained substantial storm damage.
- **2010/2011 Winter Storms.** On January 26, California received Presidential Declaration for the severe winter storms, flooding, and debris and mudflows that occurred December 17, 2010, through January 4, 2011. At the time of the declaration the State of California incurred well over $75 million in damages, while Orange County sustained more than $36 million in damages. Orange County sustained extensive damage to private and public property, as well as critical infrastructure.

- **2017 Winter Storms.** Southern California experienced three storms over six days starting on January 18, 2016. The heavy rains, combined with already saturated soil, produced flash flooding across much of Orange County. Streets flooded with 1 to 3 feet of water in Huntington Beach, Santa Ana, and Newport Beach. Responders conducted rescue operations on the Santa Ana River in the cities of Orange and Huntington Beach. The storms resulted in a Presidential Disaster Declaration for 16 counties throughout the State (MWDOC 2019; Swegles 2017).
- **2019 Winter Storms.** In January 2019 Southern California experienced intense and heavy rainstorms over the course of a week, bringing with it large amounts of rain to the region and planning area. A nearly 3-mile stretch of Pacific Coast Highway in both directions between Warner Avenue and Seapoint Street in Huntington Beach was closed due to flooding. Seal Beach, Huntington Beach, and Fountain Valley each reported roughly 2 inches of rain in 2 hours. Laguna Beach residents were advised to raise floodgates and place sandbags to divert water flow. Sandbags were made available to all residents at Orange County Fire Authority stations and at most cities' public works yards (Fausto 2019).
- **2021 Winter Storms.** On January 28 and 29, 2021, a powerful winter storm and atmospheric river brought heavy rain. A total of 1.5 inches of rain fell across Santiago Canyon in eastern Orange County. Many areas flooded, including Santiago Canyon where mud and debris flows covered roads and damaged homes (Weather.gov 2024).
- **2023 Winter Storms.** On January 14 and 16, 2023, widespread heavy rainfall came in two waves, with the first occurring the afternoon of January 14 into early January 15, and the second occurring the night of January 15 through 16. Rainfall in the first wave ranged from 1 to 2 inches for the coast, 1 to 2.5 inches in the valleys, 2 to 5 inches in the mountains and up to a half inch of rain in the deserts. The second, colder system again produced widespread moderate to heavy rainfall. There were impressive totals for both waves: 2 to 4 inches at the coast, 2 to 5 inches for the inland valleys and 3 to 8 or more inches for the mountains. A lot of flooding occurred in Orange County, San Diego County, and Riverside County (Weather.gov 2024).

3.2.3.3 Location/Geographic Extent

Orange County covers 789 square miles, and its landscape varies from mountainous terrain (in the northeast and southeast) to floodplains (in the central and western section). **Exhibit 3-9** identifies the 100- and 500-year FEMA floodplains within Orange County. A sizable portion of north Orange County, including some of the county's most densely populated areas, is within a 500-year floodplain, which denotes areas with a 1-in-500, or 0.2%, chance of flooding in any given year.

The Santa Ana River, flowing through the heart of Orange County to the Pacific Ocean, is the county's greatest flood threat. Other areas subject to flooding during severe storms include areas adjacent to Atwood Channel, Brea Creek Channel, Fullerton Creek Channel, Carbon Creek Channel, San Juan Creek Channel, and East Garden Grove-Wintersburg Channel. Areas adjacent to Santiago Creek and Collins Channel in the central portion of the county and large portions of the San Diego Creek Watershed in the City of Irvine and unincorporated areas of the county are also subject to inundation. In the southern portion of the county, canyon areas are subject to flooding. The continued development in these areas has made the flood hazard even greater.

According to the 2014 National Climate Assessment Report, as is common in coastal areas, many roads and bridges, high-priced homes, and wastewater systems are located in low-lying areas near the ocean. Increases in storm water runoff have the potential to overwhelm the capacity of wastewater and drainage systems, flood control channels, and pump stations.

3.2.3.4 Magnitude/Severity

Flood severity is often described in terms of a 100-year flood, describing an event that is likely to occur once in a 100-year period. In other words, there is a 1% probability of an event this severe occurring in any given year. Flood Insurance Rate Map (FIRM) panels produced by FEMA identify areas subject to this level of risk as being within the 100-year floodplain. **Exhibit 3-9** shows these locations throughout Orange County, as well as a 500-year floodplain, which indicates a 0.2% annual chance of flooding.

Floods can also be measured in terms of data collected by U.S. Geological Survey through a nationwide system of stream gauges. The primary gauge on the Santa Ana River is in the City of Santa Ana. During the Great Flood of 1938, this gauge measured a water level of 10.2 feet, compared to a normal height of about 1.44 feet. During both of the two most recent flood events in 2010/2011 and 2017, the river reached 7.6 feet.

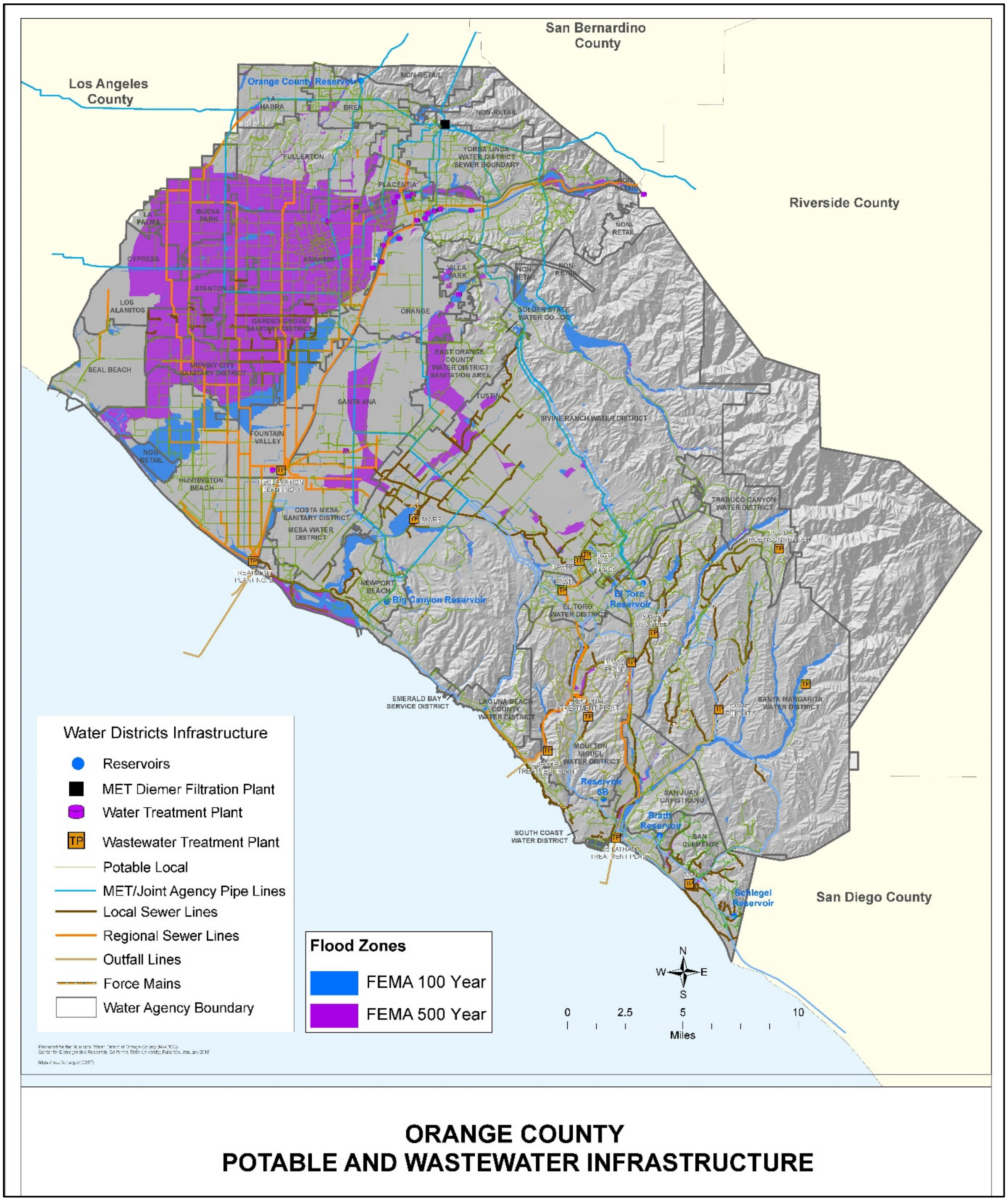
The greatest flood in terms of water flow occurred in 1862, when the Santa Ana River saw an estimated flow rate of 317,000 cfs. This flood was three times greater than the Great Flood of 1938, which had an estimated flow of 110,000 cfs. Peak discharges measured on the Santa Ana River during declared flood disasters since 1993 have ranged from 8,220 to 31,700 cfs.

On December 22, 2010, during the peak of that winter's floods, a weather station in Silverado Canyon recorded more than 7 inches of rain in a single day, according to NOAA climate data. During other flood events in the last 25 years, the maximum daily rainfall recorded within Orange County has ranged from 2 to 4 inches.

3.2.3.5 Probability of Future Occurrences

As mentioned in **Section 3.2.3.4,** FIRM panels depict areas that have a 1% chance of flooding in any given year, identified as a 100-year floodplain, as well as a 0.2% chance, or a 500-year floodplain. Such areas within Orange County are depicted in **Exhibit 3-9.**

Exhibit 3-9. Flood Zones



3.2.3.6 Climate Change Considerations

Climate change is expected to affect California's precipitation patterns, likely influencing future flood events. A 2017 study found that the number of very intense precipitation days in California is projected to more than double by the end of the century, increasing 117%, making it likely that flood events will become more frequent (Polade et al. 2017). More flood events could increase the frequency of maintenance and repair activities and require operational changes in the planning area functions. Portions of the infrastructure may require modification and retrofit to better accommodate changes anticipated from climate change. As a result, significant investment in future infrastructure may become necessary.

In contrast to the Atlantic and Gulf coasts, where coastal flooding is mainly associated with major storms, flooding along the Pacific Coast is the result of a number of more subtle factors, including tidal cycles, the El Niño climate pattern, distant wind-generated ocean swells, local storms, and the time of year.

3.2.4 Geological Hazards (Expansive Soils, Land Subsidence, Landslide and Mudflow)

3.2.4.1 Description (Nature) of the Hazard

Expansive Soils

According to a scientific paper published in the Journal of Geotechnical Engineering (Day 1994), “expansive soil is a worldwide problem that causes extensive damage to civil engineering structures.” Expansive soils are particularly problematic in the southwestern United States and especially in Southern California where there are large clay deposits compounded by “alternating periods of rainfall and drought.” The problem with constructing on expansive soils is that the clay, often referred to as adobe, expands rapidly during the rainy season and contracts gradually during the dry season causing “shrink-swell.” Shrink-swell is particularly problematic for “slab-on-grade” foundations, which can be placed directly on expansive soil that is constantly in a state of movement as the soil expands and contracts causing the foundation to fatigue and crack. Buildings with balloon frame construction are also susceptible to bowing and cracking when built on expansive soils. Shrink and swell can affect water/wastewater facilities particularly buildings or structures built using slab-on-grade or balloon frame construction techniques.

Expansive soil is also known to “creep” on unstable slopes eventually leading to landslides. Typically, this is found when expansive soil underlies compact topsoil. As the expansive soil expands-contracts, the compact topsoil slides or creeps downhill. Facilities built on unstable slopes with underlying expansive soils are prone to movement and can be damaged or destroyed in extreme circumstances.

Land Subsidence

The United States Geological Survey (USGS) defines land subsidence as a gradual settling or sudden sinking of the ground surface because of subsurface movement of underlying geologic units. Scientists at the USGS have determined that nearly 17,000 square miles in 45 States have been directly affected by land subsidence, caused by aquifer-system compaction, drainage of organic soils, underground mining, hydro-compaction, natural compaction, sinkholes, and thawing permafrost. More than 80% of land subsidence is caused by overuse of groundwater, and the increasing development of land and water resources threatens to worsen existing land subsidence problems (while initiating) new ones (USGS 2024).

Land subsidence in California is mainly caused by groundwater pumping in areas where aquifer recharge is exceeded. Known as “over-drafting,” the dewatering of aquifers has led to lower water tables and subsidence, resulting in damage to infrastructure and water quality, and in coastal areas has resulted in the intrusion of seawater. USGS notes “the compaction of unconsolidated aquifer systems that can accompany excessive groundwater pumping is by far the single largest cause of subsidence" and "the overdraft of such aquifer systems has resulted in permanent subsidence and related ground failures," thus "the extraction of this resource for economic gain constitutes 'groundwater mining' in the truest sense of the term" (USGS 2024). Over-drafting is further exacerbated in hot geographic regions with a large population; this includes much of Southern California.

Landside/Mudflow

Landslide is a general term for a falling mass of soil or rocks. Mudflow consists of material that is wet enough to flow rapidly and contains at least 50% sand, silt, and clay-sized particles. The primary effects of landslides/mudflows can include:

- Abrupt depression and lateral displacement of hillside surfaces over distances of up to several hundred feet.
- Disruption of surface drainage.
- Blockage of flood control channels and roadways.
- Displacement or destruction of improvements such as roadways, buildings, and water wells.

Landslides are a type of "mass wasting," which denotes any down-slope movement of soil and rock under the direct influence of gravity. The term "landslide" encompasses events such as rock falls, topples, slides, spreads, and flows. Landslides can be initiated by rainfall, earthquakes, volcanic activity, changes in groundwater, disturbance, and change of a slope by man-made construction activities or any combination of these factors. Landslides can occur underwater, causing tidal waves and damage to coastal areas. These landslides are called submarine landslides (USGS 2000).

Failure of a slope occurs when the force that is pulling the slope downward (gravity) exceeds the strength of the earth materials that compose the slope. They can move slowly (millimeters per year) or can move quickly and disastrously, as is the case with debris flows. Debris flows can travel downhill at speeds of up to 200 miles per hour (more commonly, 30 to 50 miles per hour), depending on the slope angle, water content, and type of earth and debris in the flow. These flows are initiated by heavy, usually sustained, periods of rainfall, but sometimes can happen because of short bursts of concentrated rainfall in susceptible areas. Burned areas charred by wildfires are particularly susceptible to debris flows, given certain soil characteristics and slope conditions.

A debris or mud flow is a river of rock, earth, and other materials, including vegetation that is saturated with water. This high percentage of water gives the debris flow a very rapid rate of movement down a slope. This high rate of speed makes debris flows extremely dangerous to people and property in its path. Earthquakes often trigger flows. Debris flows normally occur when a landslide moves down slope as a semi-fluid mass scouring, or partially scouring, soils from the slope along its path. Flows typically move rapidly and also tend to increase in volume as they scour out the channel. Flows often occur during heavy rainfall, can occur on gentle slopes, and can move rapidly for large distances.

Wildland fires on hills covered with chaparral are often a precursor to debris flows in burned out canyons. The extreme heat of a wildfire can create a soil condition in which the earth becomes impervious to water by creating a waxy-like layer just below the ground surface. Since the water cannot be absorbed into the soil, it rapidly accumulates on slopes, often gathering loose particles of soil into a sheet of mud and debris. Debris flows can often originate miles away from unsuspecting people and approach them at a high rate of speed with little warning.

Natural processes can cause landslides or re-activate historical landslide sites. The removal or undercutting of shoreline-supporting material along bodies of water by currents and waves produces countless small slides each year. Seismic tremors can trigger landslides on slopes historically known to have landslide movement. Earthquakes can also cause additional failure (lateral spreading) that can occur on gentle slopes above steep streams and riverbanks.

3.2.4.2 History/Past Occurrences

Expansive Soils

In 1980, Krohn and Slosson (1980) made an assessment and cost estimate of the damage caused by expansive soils throughout the United States. They estimated that approximately $7 billion in property damage was reportedly attributed to construction on expansive soils. While no recent figures have been identified, the increase in construction activity in areas of expansive soil, especially in Southern California, will undoubtedly cause this number to increase. J. David Rogers of the University of Missouri found that “expansive soils are the second leading cause of property damage in the United States.”

There are no reported occurrences of expansive soils causing considerable damage within Orange County; although expansive soils are known to exist. Typically, expansive soils would be identified at a local level on a site-by-site or area basis and are addressed as part of the development review process.

Land Subsidence

The relationship between subsidence and groundwater pumping was not fully recognized until 1928, when O. E. Meinzer, scientist with the United States Forest Service (USFS), realized that aquifers were compressible (Meinzer 1928). By the 1950s, the USGS made a concerted effort to measure the amount of ground subsidence. In 1952, Joseph Poland studied large discrepancies between the U.S. Coast and Geodetic Survey for the Santa Clara and San Joaquin valleys. Poland noted that the increased use of groundwater correlated with the amount of ground subsidence. Poland’s work led to the verification of “consolidation theory” or compressible aquifers, as well as leading to the development of “definitions, methods of quantification, and confirmation of the interrelationship among hydraulic-head declines, aquitard (clay) compaction, and land subsidence” (Poland 1975).

Subsidence has historically occurred in Orange County associated with groundwater pumping and from peat decomposition. The areas of historic subsidence associated with groundwater pumping are illustrated in **Exhibit 3-10**. Localized subsidence possibly due to peat decomposition has also been reported in scattered areas inland from the coast between Sunset and Newport Beaches.

Landside/Mudflow

The following identifies some of the more major landslide occurrences within Orange County. There have been no disaster declarations within Orange County associated with landslides/mudflows.

- **1978 Bluebird Canyon, Orange County.** The cost of recovery was $52.7 million (in 2000 dollars) with 60 houses destroyed or damaged. Unusually heavy rains in March of 1978 may have contributed to initiation of the landslide. Although the 1978 slide area was approximately 3.5 acres, it is suspected to be a portion of a larger, ancient landslide.

- **1980 Southern California Landslides.** The damage was estimated at $1.1 billion in year 2000 dollars. Heavy winter rainfall in 1979-1980 caused damage in six Southern California counties. In 1980, the rainstorm started on February 8 with five days of continuous rain and 7 inches of precipitation. Slope failures were beginning to develop by February 15, and then very high-intensity rainfall occurred on February 16. As much as 8 inches of rain fell in a 6-hour period in many locations. Records and personal observations in the field on February 16 and 17 showed that the mountains and slopes literally fell apart on those two days.
- **1983 San Clemente, Orange County.** The damage to California Highway 1 was estimated at $65 million in year 2000 dollars. Litigation at that time involved approximately $43.7 million (in 2000 dollars).
- **1994 Northridge, California Earthquake Landslides.** As a result of the magnitude 6.7 Northridge, California, earthquake, more than 11,000 landslides occurred over an area of 10,000 square kilometers. Most were in the Santa Susana Mountains and in mountains north of the Santa Clara River Valley. They destroyed dozens of homes, blocked roads, and damaged oil-field infrastructure. It caused deaths from Coccidioidomycosis (valley fever) due to spores released from soil by the landslide activity and blown toward the populated coastal areas.
- **1995 Los Angeles and Ventura Counties, Southern California.** Above normal rainfall triggered damaging debris flows, deep-seated landslides, and flooding. Several deep-seated landslides were triggered by the March storms, the most notable was the La Conchita landslide, which in combination with a local debris flow, destroyed or badly damaged 11 to 12 homes in the small town of La Conchita, about 20 kilometers west of Ventura. There also was widespread debris flow and flood damage to homes, commercial buildings, and roads and highways in areas along the Malibu coast that had been devastated by wildfire 2 years before.
- **1998 Laguna Niguel and Orange County Landslide.** During the 1997/1998 El Niño season, heavy rainfall increased movement on the site of an ancient landslide in Laguna Niguel. The storms in December 1997 had accelerated the landslides' movement and in early 1998, a crumbling hillside forced the evacuation of 10 hilltop homes and more than 10 condominium units resting below. Ultimately four of the hilltop homes collapsed, falling down the hillside into the void created by the slide area. The condominium complex has since been demolished and the site remains open space.
- **2005 Blue Bird Canyon, Laguna Beach, Orange County Landslide.** On June 1, 2005, Bluebird Canyon in Laguna Beach experienced a landslide. Exceptionally heavy rainfall during the winter period was the underlying cause of the instability in an ancient landslide. A 30-acre piece of hillside between 50 to 60 feet deep broke free and fell on the homes below; 15 homes were destroyed, and 32 others had varying levels of damage. The approximate cost of damage was about $35 million.
- **2005 SCWD Landslide Impact to the Joint Regional Transmission Line.** Following a year of heavy rainfall, a slope failure occurred in Laguna Niguel in an area that included a section of the Joint Regional Transmission Pipeline. The pipeline had to be shut down and a temporary pipeline was routed around the slide area while evaluations of the stability of the area were made. Ultimately, the pipeline will be rerouted around the unstable area or located back in the slope after it has stabilized. Because the problem occurred in the winter/spring period and there are other pipelines into South Orange County, no water shortages were experienced.

- **2018 Cannon Cliff, Dana Point, Orange County Rockslide.** Approximately 18 tons of rocks, including a two-ton boulder dropped from the cliff area under Cannons Restaurant and struck a public restroom across from Baby Beach at the north end of Dana Point Harbor. The rocks are part of a 4-to-5-million-year-old rock formation called the Capistrano Formation.
- **2021 Silverado Canyon, Orange County Mudflow.** A powerful storm contained a heavy burst of rain in eastern Orange County that struck the Bond Fire burn scar in Silverado Canyon. In 15 minutes, 0.20 inch of rain fell. A debris flow went over roads and into homes, damaging six homes and eight vehicles in Silverado. The flow also closed a stretch of Silverado Canyon Road.

Rain-induced landslides were reported in Santa Margarita in 1980, 1993, 1995, and 2005. In 1980 rains washed out an access road in Coto de Caza uncovering an 8-inch water line. The same series of storms also exposed a 21-inch trunk sewer line along the Oso Creek in Mission Viejo resulting in damages of $300,000. In 1993, bank failures caused many pipelines to break that had to be replaced, relocated, or re-protected at a cost of nearly $2.1 million. A slope failure in 1995 caused pipeline failures costing nearly $30,000, and in 2005 a reservoir slope failure in Talega Valley cost $350,000. Landslides, resulting in erosion along Aliso Creek, affected the SOCWA's Aliso Creek Effluent Transmission Main (a 36-inch pipeline carrying treated wastewater).

3.2.4.3 Location/Geographic Extent

Expansive Soils

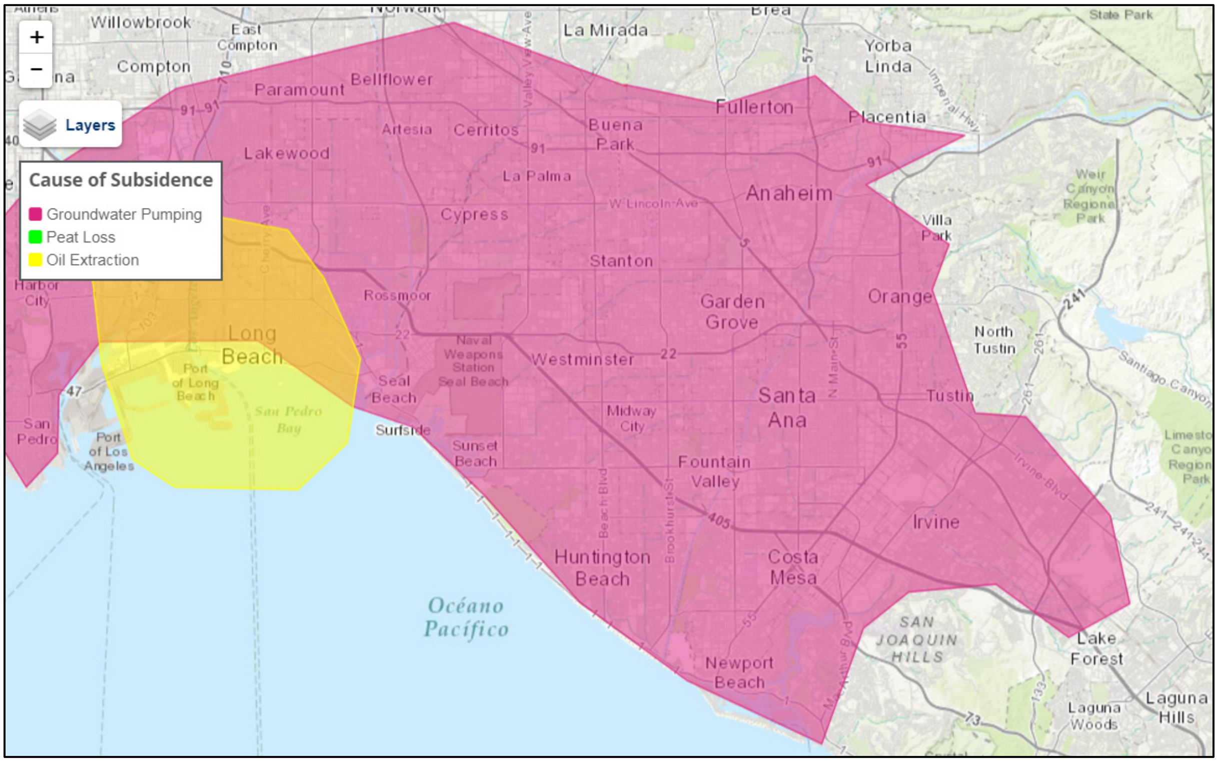
According to the County of Orange General Plan Safety Element (Orange County, 2015), much of Orange County is covered by soil that may cause cracking in concrete foundations. The most prevalent problems occur from clay or "expansive" soils that contract and expand. Problems attributed to expansive soils are usually related to improperly designed or constructed foundations. Due to the diversity of soil conditions, structures are not completely safe from cracking, slipping, or sinking to some degree. Expansive soils are typically mitigated through structural and design regulations as well as through soil treatment techniques. The California Building Code specifically addresses expansive soils in Sections 1804.4, 1806.5, and 1815. The California Health and Safety Code Section 17954 states, "If the preliminary soil report indicates the presence of critically expansive soils or other soil problems which, if not corrected, would lead to structural defects, such ordinance shall require a soil investigation of each lot in the subdivision" and "The soil investigation shall be prepared by a civil engineer who is registered in this state." Expansive soils can impact the entire planning area.

Land Subsidence

Currently, land subsidence affects much of the west coast. The area most affected by land subsidence in Orange County is between Newport Beach and Huntington Beach and 5 miles inland from this point. Referred to as Talbert Gap, this area formed a millennia ago from alluvial deposition from the Santa Ana River.

According to the USGS online map viewer, areas starting from Newport Beach up to Seal Beach, and out east to Placentia, experience subsidence impacts due to groundwater pumping. **Exhibit 3-10** shows the areas impacted by subsidence.

Exhibit 3-10. Subsidence



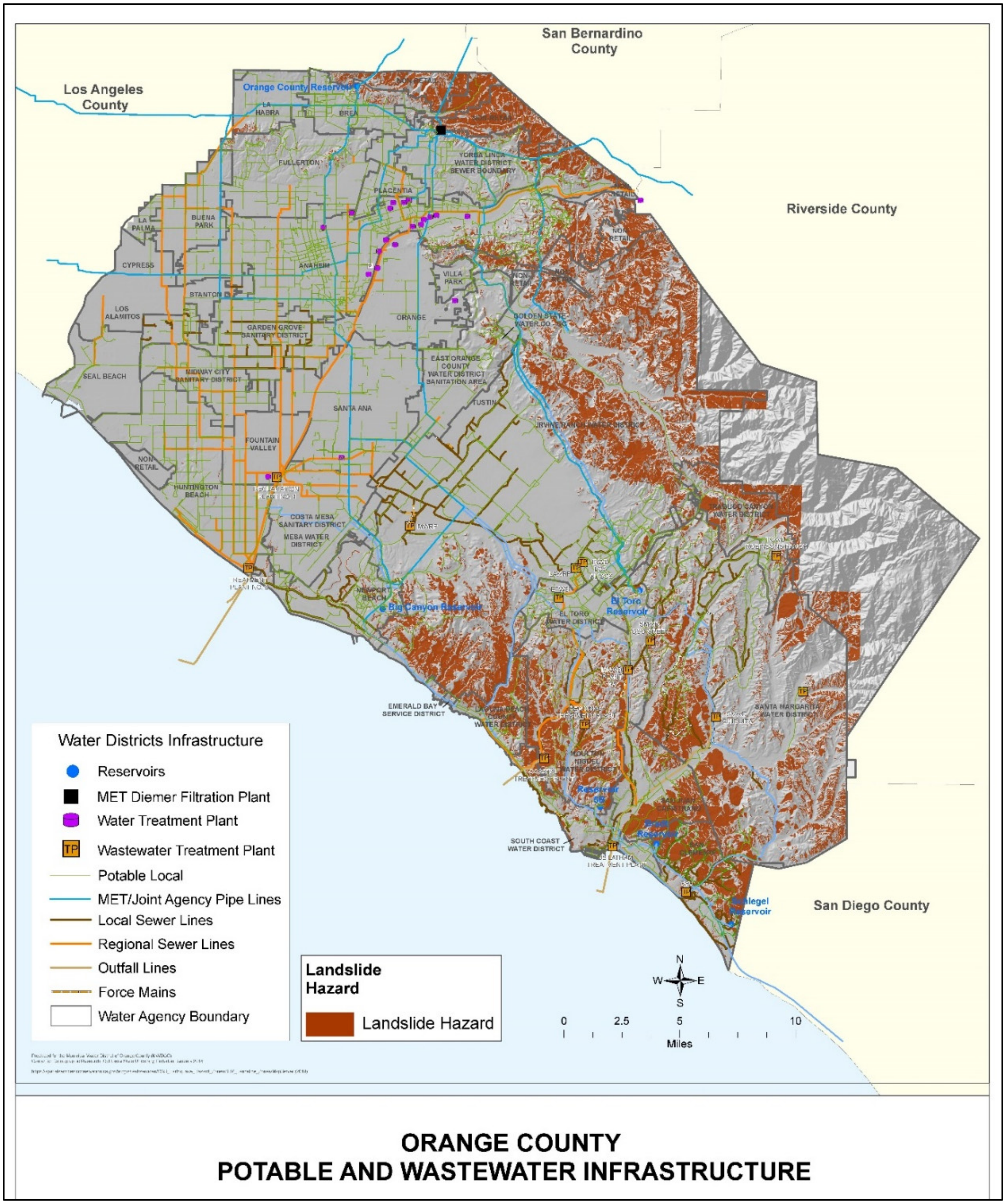
Landside/Mudflow

Exhibit 3-11 illustrates the portions of the planning area susceptible to landslides based upon topography, surface and subsurface geology, borehole data, historical groundwater levels, existing landslide features, slope gradient, rock-strength measurements, geologic structure, and probabilistic earthquake shaking estimates. These areas are primarily comprised of the southern coastal communities and the communities containing steeper topography or located adjacent to mountain areas.

The extent of landslides/mudflows varies throughout Orange County depending on the location and contributing conditions, such as an earthquake, heavy rain, or recent fires. Earthquake-induced landslides are relatively shallow falls and slides, in which highly disrupted masses of rock and soil travel down slopes at high speed. The Northridge Earthquake, in Los Angeles County, triggered more than 11,000 landslides in an area of 6,200 square miles. Most slides were shallow, brittle failures of surficial rock and soil.

Deep-seated landslides are triggered by cumulative rainfall during long periods (weeks to years). Resulting landslides are relatively deep earth flows and translational or rotational earth slides and rock slides. Translational landslides are typically a few meters to tens of meters deep, and rotational slides range in depth from several meters to tens of meters. Deep-seated translational and rotational landslides, including rock slides, tend to fail a little at a time and move more slowly than debris flows, but a few do accelerate to rapid movement. A previous landslide within Orange County due to oversaturated soils resulted in a 40-foot landslide below a 5-million-gallon water tank. Other landslides in the county have measured approximately 3.5 acres and 25 acres.

Exhibit 3-11. Landslide Susceptibility



Similarly, short-duration, intense rainfall, and generally greater than 0.5 inch per hour precipitation has the potential to trigger post-fire debris flows. These flows can extend several miles. Documented debris flows from burned areas in Southern California and the western United States have ranged in volume from as small as 600 cubic meters to as much as about 300,000 cubic meters. This larger volume is enough material to cover a football field with mud, rocks, and debris to about 65 meters deep.

3.2.4.4 Magnitude/Severity

Expansive Soils

Damages to property due to erosion and deposition are usually classified as cosmetic, functional, or structural. Cosmetic damage refers to slight problems where only the physical appearance of a structure is affected (e.g., cracking in plaster or drywall). Functional damages refer to situations where the use of a structure has been impacted due to subsidence. Structural damages include situations where entire foundations require replacement due to subsidence-caused cracking of supporting walls and footings.

Buildings and infrastructure across Orange County are vulnerable to the impacts of soil expansion, instability, and erosion-related hazards. Cities in Southern California have established guidelines for construction in areas of expansive soils. The MAs generally conduct soil surveys prior to construction of water and wastewater facilities and take the specific circumstances into consideration during design and construction. The magnitude and severity of expansive soils are similar throughout the planning area.

Land Subsidence

The Talbert Gap, as described above, has sustained nearly a century of underground water aquifer pumping, which was used to sustain intensive grazing and agriculture practices. By 1956 the water table had lowered to below sea level allowing saltwater from the Pacific Ocean to intrude through the Talbert Gap. Because of studies identifying subsidence and saltwater intrusion in Orange County, OCWD began a massive management program to minimize the loss of aquifer-stored water and reduce saltwater intrusion. Although subsidence is a concern within Orange County, programs have been implemented to address subsidence issues. The MAs within the portion of the planning area identified as having historic subsidence could continue to be impacted if it is not monitored and addressed.

Landside/Mudflow

Factors included in assessing landslide magnitude/severity include population and property distribution in the hazard area, the frequency of landslide or debris flow occurrences, slope steepness, soil characteristics, and precipitation intensity. The California Geological Survey landslide maps prepared as part of the Seismic Hazard Program (refer to **Exhibit 3-11**) indicate the extent of landslide susceptibility within Orange County, which includes the southernmost coastal areas and eastern areas of the county. These areas would also be more likely to experience mudflows due to the topography of the areas.

3.2.4.5 Probability of Future Occurrences

Expansive Soils

Expansive soils will continue to occur throughout the planning area. Potential impacts associated with these hazards will need to be addressed through site design and development review, including preparation and adherence to geotechnical constraints recommendations.

Land Subsidence

In areas that have experienced decreased precipitation in the summer months and reduced surface water supplies, communities are often forced to pump more groundwater to meet their needs. Orange County has historically experienced long-term droughts, especially in recent years. Although specific areas of excessive pumping, such as Talbert Gap, have been addressed, there is still a high probability that communities within the planning area will continue to experience impacts of these events.

It is important that these communities consider future mitigation actions that will address this hazard, particularly in newly developing areas near water. In areas where groundwater pumping has caused subsidence, switching to surface water supplies can be instrumental. Changing climate norms are expected to affect soil resources and especially during hot, dry years annual grasses that stabilize and protect topsoil often fail to germinate or do not grow well. This leaves soil surfaces highly vulnerable to erosion from wind and precipitation and can further exacerbate the consequences of soil expansion and subsidence.

Landside/Mudflow

A study conducted by Nature Geoscience in 2015 indicated that the projected upsurge of El Niño and La Niña events will increase the likelihood that coastal communities will experience erosion and flooding (Barnard, 2015). This is separate from sea level rise, which has also been identified as a cause of future hazard vulnerabilities. In addition to erosion and flooding, the onset of El Niño and La Niña events will also increase the magnitude and severity of mudflow events. The more recent wildfires also contribute to the probability of mudflows in the event of more intense rainfall over a short duration. Earthquakes of magnitude 4.0 and greater have been known to trigger landslides. The potential for an earthquake to induce a landslide is highly dependent on the location of the earthquake and magnitude in relation to a landslide area. Based on previous landslide and mudflow incidents, along with studies predicting future occurrences, it is reasonable to state that these hazards will continue to impact the jurisdictions identified within the landslide susceptibility areas of Orange County. According to the Planning Team ranking, landslides and mudflows are somewhat likely—having between a 1% and 10% probability in next year or a recurrence interval of 11 to 100 years.

3.2.4.6 Climate Change Considerations

Expansive Soils

It is possible that expansive soils may be affected by climate change, as climate change is expected to bring about more frequent drought conditions and contribute to more intense storms, like El Niño. These extreme conditions could further increase the effects of expansive soils on structures since there could be a change in the physical expansion and contraction of soils in affected areas, potentially increasing damage to structures and infrastructure.

Land Subsidence

As temperatures increase so too will the demand for water usage. The potential that precipitation events could decrease in frequency, while experiencing a potential increase in intensity, could result in less water being recharged into the aquifer/basin. If lower water levels occur within the groundwater aquifer the potential for land subsidence could increase within the affected parts of Orange County.

Landside/Mudflow

Due to the wide variety of factors that can lead to landslides and mudflows, it is possible that climate change could indirectly affect the conditions for landslides and mudflows. Increased frequency and more intense storms may cause more moisture-induced landslides. Warmer temperatures and more frequent drought conditions may lead to more fires, destabilizing soil on slopes, and making future landslide and mudflow events more likely.

3.2.5 Human-Caused Hazards (Contamination/Saltwater Intrusion, Hazardous Materials, Power Outage, Terrorism [Cyber Threat], Terrorism [Mass Casualty Incident])

3.2.5.1 Description (Nature) of the Hazard

Human-caused hazards are distinct from natural hazards in that they result directly from the actions of people. Two types of human-caused hazards include: non-malicious and malicious. Non-malicious hazards refer to incidents that can arise from human activities such as the manufacturing, storage, transport, and use of hazardous materials, which include toxic chemicals, radioactive materials, and infectious substances. Non-malicious hazards are assumed to be accidental and their consequences unintended. Malicious, on the other hand, encompasses intentional and criminal acts involving weapons of mass destruction or conventional weapons. WMD can involve the deployment of biological, chemical, nuclear, and radiological weapons with the result of affecting a significant percentage of the population either directly or indirectly. Conventional weapons and techniques include the use of arson, incendiary explosives, armed attacks, intentional hazardous materials release, and cyber terrorism (attack via computer). Typically, conventional weapons have a very specific target and are limited in scope and effect.

Groundwater Contamination

Groundwater contamination occurs when pollutants are released to the ground, navigate through the soil, and ultimately end up in the groundwater. Human activity is almost always the underlying cause of groundwater contamination. In areas where population density is high and human use of land is intensive, groundwater is especially vulnerable. Virtually any activity whereby chemicals or wastes may be released to the environment, either intentionally or accidentally, has the potential to pollute groundwater.

Saltwater Intrusion

When fresh water is withdrawn from aquifers at a faster rate than it is replenished, a draw-down of the water table occurs with a resulting decrease in the overall hydrostatic pressure. When this happens near a coastal ocean area, saltwater from the ocean can intrude into the freshwater aquifer. The result is that freshwater supplies become contaminated with saltwater.

Hazardous Materials

Hazardous materials can include toxic chemicals, radioactive materials, infectious substances, and hazardous wastes. The State of California defines a hazardous material as a substance that is toxic, ignitable, or flammable or reactive and/or corrosive. An extremely hazardous material is defined as a substance that shows high acute or chronic toxicity, carcinogenicity, bio-accumulative properties, persistence in the environment, or is water reactive (California Code of Regulations, Title 22). "Hazardous waste," a subset of hazardous materials, is material that is to be abandoned, discarded, or recycled and includes chemical, radioactive, and bio-hazardous waste (including medical waste). An accidental hazardous material release can occur wherever hazardous materials are manufactured, stored, transported, or used. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas. With respect to water or wastewater systems, concerns arise regarding exposure to these materials via contact or ingestion of drinking water and or discharge of contaminated water into the ocean where exposure to the marine environment and public would be of concern.

Non-malicious hazards can occur because of human carelessness, technological failure, and natural hazards. When caused by natural hazards, these incidents are known as secondary hazards, whereas intentional acts are terrorism. Hazardous materials releases, depending on the substance involved and type of release, can directly cause injuries and death and contaminate air, water, and soils. While the probability of a major release at any facility or at any point along a known transportation corridor is relatively low, the consequences of releases of these materials can be very serious.

The most common sources of contamination to water supply systems are naturally occurring chemicals and minerals (i.e., arsenic, radon, and uranium), local land use practices (i.e., fertilizers and pesticides), manufacturing processes, sewer overflows, and malfunctioning wastewater treatment systems (i.e., nearby septic systems). Although these contaminants present an environmental and human health risk concern, the EPA holds regulations in place to ensure water supply systems do not contain elevated levels of contaminants.

Some hazardous materials also present a radiation risk. Radiation is any form of energy propagated as rays, waves, or energetic particles that travel through the air or a material medium. Radioactive materials (e.g., uranium, plutonium, radium, and thorium) are composed of unstable atoms. An unstable atom gives off its excess energy until it becomes stable. The energy emitted is radiation. The process by which an atom changes from an unstable state to a more stable state by emitting radiation is called radioactive decay or radioactivity.

Radiological materials have many uses including:

- Use by doctors to detect and treat serious diseases,
- Use by educational institutions and companies for research,
- Use by the military to power large ships and submarines, and
- Use as a critical base material to help produce the commercial electrical power that is generated by a nuclear power plant.

Radioactive materials, if handled improperly, or radiation accidentally released into the environment can be dangerous because of the harmful effects of certain types of radiation on the human body and the human environment. The longer a person is exposed to radiation and the closer the person is to the radiation source, the greater the risk. Although radiation cannot be detected by the senses, scientists can easily detect it with sophisticated instruments that can detect even the smallest levels of radiation. Under extreme circumstances, an accident or intentional explosion involving radiological materials can cause very serious problems. Consequences may include death, severe health risks to the public, damage to the environment, and extraordinary loss of, or damage to, property.

Power Outage

A power outage typically occurs during a natural hazard such as extreme weather conditions, earthquakes, flood, fire, or severe winds. An outage can result in damaged power equipment or equipment failures and can affect multiple counties for hours. This type of event can range from a moderate event to a catastrophic regional event that may threaten human life, safety, and health, or interferences with vital services. An outage may occur as a secondary effect of another hazard, or as the result of construction, an accident, or terrorism. Severe winds and flood can bring down trees and tree limbs onto power lines. And these types of events can cause serious safety hazards to the public and emergency responders.

Terrorism (Cyber Threat)

Cyber threats are when an individual or a group threatens or attempts to disrupt the operations and functioning of computer systems belonging to private citizens, religious groups, educational institutions, government agencies, or businesses. These threats include online harassment, hacking, or in-person tampering with electronic equipment. Successful cyber threats can lead to service disruptions, infrastructure damage, and theft and may cause injury or death in severe instances. All of Orange County's water utilities Supervisory Control and Data Acquisition (SCADA) systems, which operate over telecommunication lines and/or radio systems. These systems are vulnerable to hacking and leave utilities open to malicious acts.

Terrorism (Mass Casualty Incident)

Following several serious international and domestic terrorist incidents since the early 2000s, citizens across the United States have paid increased attention to the potential for deliberate, harmful terrorist actions by individuals or groups with political, social, cultural, and religious motives. There is no single, universally accepted definition of terrorism, and it can be interpreted in a variety of ways. However, terrorism is defined in the CFR as "the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives" (28 CFR § 0.85). The Federal Bureau of Investigation further characterizes terrorism as either domestic or international, depending on the origin, base, and objectives of the terrorist organization. However, the origin of the terrorist or person causing the hazard is far less relevant to mitigation planning than the hazard itself and its consequences. Terrorists can utilize a wide variety of agents and delivery systems.

Water supplies and infrastructure, such as dams, in Orange County are considered as potential terrorist targets. The weapon most likely used could include explosives with the goal of collapsing the dam. Such an event would result in a dam failure and an inundation event with little or no warning. The potential of using other types of weapons such as chemical or biological are considered low due to the large amount of material that would be required to contaminate the water system. This scenario would only apply to those dams where the reservoirs are used for drinking water.

A mass casualty incident describes an incident within the United States where emergency medical services resources, such as personnel and equipment, are overwhelmed by the number and severity of casualties. The more commonly recognized events of this type include building collapses, train and bus collisions, plane crashes, earthquakes, and other large-scale emergencies. The most common types are generally caused by terrorism, mass transportation accidents, or natural disasters. Events such as the Oklahoma City bombing in 1995, the September 11 attacks in 2001, and the 2017 Las Vegas Shooting are well-publicized examples of mass casualty incidents.

3.2.5.2 History/Past Occurrences

Groundwater Contamination

Over the last several decades, Orange County's North Basin has experienced industrial solvent spills and leaks from manufacturing, metals processing businesses, and dry-cleaning facilities. As a result, a contamination plume several miles long and over a mile wide currently exists under the cities of Fullerton, Anaheim, and Placentia. The Orange County Groundwater Basin is a source of drinking water for the region, providing most of the water used in 22 cities. The contamination plume has already taken five wells off line, including three of Fullerton's 12 total wells. Those wells draw water from shallower sources closer to the surface and consequently are closer to the pollution. According to the EPA, they have completed the "first phase of the Comprehensive (site-wide) RI/FS, which involved the installation of additional monitoring wells to further characterize the entire site. This report is expected to be completed in December of 2024" (EPA Superfund n.d.).

Saltwater Intrusion

In Orange County, by 1956, years of heavy pumping to sustain the region's agricultural economy had lowered the water table by 15 feet below sea level and saltwater from the Pacific Ocean had encroached as far as 5 miles inland. The area of intrusion is primarily across a 4-mile front between the cities of Newport Beach and Huntington Beach known as the Talbert Gap. The mouth of an alluvial fan formed millions of years ago by the Santa Ana River, the Talbert Gap has since been buried along the coast by several hundred feet of clay. In 1976, the Water Factory 21 Direct Injection Project, operated by OCWD, began injecting highly treated recycled water into the aquifer to prevent saltwater intrusion, while augmenting the potable groundwater supply. This system was shut down to make way for the Groundwater Replenishment System (GWRS) Project, which began operation in 2008. The GWRS provides highly treated water for injection into the seawater barrier system to prevent seawater intrusion into the Orange County Groundwater Basin. As of September 17, 2024, more than 444 billion gallons of water have been successfully treated and injected into the seawater barrier system.

Hazardous Materials

Numerous facilities in Orange County generate hazardous waste in addition to storing and using large numbers of hazardous materials. Although the scale is usually small, emergencies involving the release of these substances can occur daily at both fixed sites and on Orange County's streets and roadways. Facilities that use, manufacture, or store hazardous materials in California must comply with several Federal and State regulations. The Superfund Amendments and Reauthorization Act (SARA Title III), which was enacted in 1986 as a legislative response to airborne releases of methyl isocyanides at Union Carbide plants in Bhopal, India, and in Institute, West Virginia. SARA Title III, also known as the Emergency Planning and Community-Right-To-Know Act (EPCRA), directs businesses that handle, store, or manufacture hazardous materials in specified amounts to develop ERPs and report releases of toxic chemicals. Additionally, Section 312 of Title III requires businesses to submit an annual inventory of hazardous materials to a State-administering utility. The California legislature passed Assembly Bill 2185 in 1987, incorporating the provisions of SARA Title III into a State program. The EPCRA requirements keep communities abreast of the presence and release of hazardous wastes at individual facilities.

Additional information about the chemicals handled by manufacturing or processing facilities is contained in the EPA's Toxic Release Inventory (TRI) database. The TRI is a publicly available EPA database that contains information on toxic chemical emissions and waste management activities reported by certain industry groups as well as Federal facilities. This inventory was established under EPCRA and expanded by the Pollution Prevention Act of 1990. Facilities that exceed threshold emissions levels must report TRI information to the EPA, which is the Federal enforcement agency for SARA Title III.

Over the past several decades, industrial activities have contaminated Orange County's North Basin, which provides much of the water used in 22 Orange County cities, including parts of Fullerton, Anaheim, and Placentia. Over 5 square miles of contaminants, mostly volatile organic compounds (VOCs), have migrated through the soils and are now leaching into the underlying groundwater. These VOCs have impacted nearby water supply wells causing four of them to be taken out of service. The OCWD, under EPA oversight, is currently conducting an interim remedial investigation and feasibility study to determine the extent of groundwater contamination. The report is expected in December 2024 (EPA Superfund n.d.).

Chemical air emissions, surface water discharges, underground injections, and releases to land are considered chemical releases. The release of a biological agent capable of causing illness in people is considered an infectious release. The only known release of radiological agents into the air in Orange County was the result of an accident at San Onofre Nuclear Generating Station (SONGS). In 1981, an accidental "ignition" of hydrogen gases in a holding tank of the SONGS caused an explosion which bent the bolts of an inspection hatch on the tank, allowing radioactive gases in the tank to escape into a radioactive waste room. From there, the radioactive material was released into the atmosphere. The plant was shut down for several weeks following the event (MWDOC, 2019). This incident occurred during operation of the plant's Unit 1 generator, which has since been decommissioned. No serious injuries occurred.

On February 3, 2001, another accident occurred at SONGS when a circuit breaker fault caused a fire that resulted in a loss of offsite power. Published reports suggest that rolling blackouts during the same week in California were partially due to the shutdown of the SONGS reactors in response to the 3-hour fire. Although no radiation was released, and no nuclear safety issues were involved, the Federal Nuclear Regulatory Commission sent a Special Inspection Team to the plant to investigate the accident.

In June 2013, SONGS permanently closed after faulty replacement steam generators were installed at the nuclear facility. SONGS is currently undergoing the process to decontaminate and dismantle the nuclear facility. As of August 2017, a court settlement requires the operators of SONGS, Southern California Edison (SCE), to relocate the 3.55 million pounds of nuclear waste to another facility. One of the possible sites is the Palo Verde Nuclear Generating Station in Arizona, located approximately 330 miles away. Transportation of nuclear waste poses a concern of environmental and human health risk if radiation is released into the environment.

Power Outage

Orange County has experienced many power outages in the past. There have been small to moderate incidents and several extreme incidents that have lasted hours in certain areas. Power outages are most commonly seen in Southern California when Santa Ana wind conditions occur.

One of the most severe events occurred in September 2011 and is referred to as the 2011 Southwest Blackout. This event affected southern Orange County, the San Diego-Tijuana area, Imperial Valley, Mexicali Valley, Coachella Valley, and parts of Arizona. The incident is known to have been an 11-minute system disturbance which led to cascading outages and 2.7 million customers left without power, some for up to 12 hours. The hardest hit areas of San Diego-Tijuana, experienced street gridlock due to loss of traffic signals, school and businesses closing, flights and public transportation delays, and water and sewage pumping station power loss.

In 2013, a blackout resulted in approximately 123,000 homes and businesses losing power for several hours. Faulty circuits affected people in a number of Orange County communities including Mission Viejo, Laguna Niguel, Ladera Ranch, Coto de Caza, Ortega, San Clemente, Talega, San Juan Capistrano, Dana Point, and Capistrano Beach.

Terrorism (Cyber Threat)

Exhibit 3-12 displays a list of water and wastewater utilities, jurisdictions, and local agencies located in Southern California that were victims of cyber threat events since 2019.

Exhibit 3-12. Southern California Cyber Threat Events

Date of Event	Target Organization	Description of Event
3/11/2019	OC San	OC San was the victim of a phishing data breach. More than 1,000 employee records were accessed as part of the breach through the OC San deferred compensation plan.
10/14/2019	Cucamonga Valley Water District	Cucamonga Valley Water District disclosed a data breach that occurred between August 26, 2019, and October 14, 2019. The breach occurred on a server that is used to accept one-time credit card payments from customers.
12/24/2019	City of Seal Beach	City of Seal Beach was the victim of a ransomware attack that affected city computer systems. The attack was targeted at the city's information technology service provider, which allowed the hackers to encrypt city computers with the malware, primarily impacting city email and voicemail functions.
4/23/2023	San Bernardino County Sheriff's Department	The San Bernardino County Sheriff's Department was hit with a cyberattack when a hyperlink loaded with malicious malware was clicked, which resulted in the sudden encryption of many of the department's systems and subsequent ransom demand to restore functionality. San Bernardino County paid a $1.1 million ransom to the hacker, approximately half of which was covered by insurance as Orange County had anticipated the possibility of such an attack.
8/3/2023	California's Prospect Medical Holdings	A California-based company's medical facility services throughout the United States were disrupted by cyber threat event. Seven hospitals in Orange and Los Angeles counties including two behavioral health facilities and a 130-bed acute care hospital in Los Angeles were effected.
11/20/2023	Orange County District Attorney's Office	The Orange County District Attorney's Office was targeted by a cyberattack, prompting a shutdown of its information technology system. The District Attorney's Office immediately coordinated with partner agencies, including all law enforcement entities in Orange County, including the Orange County Sheriff's Department. It was unclear exactly what type of information may have been accessed by hackers.

Exhibit 3-13 displays a list of water and wastewater utilities throughout the United States that were victims of a cyber threat event since 2019.

Exhibit 3-13. U.S. Water and Wastewater Utilities Cyber Threat Events

Date of Event	Target Organization	Description of Event
3/14/2019	Fort Collins Loveland Water District	Fort Collins Loveland Water District and South Fort Collins Sanitation District are the victims of a ransomware attack that occurred on February 11, 2019.
3/27/2019	Post Rock Rural Water District	Kansas Waste Water System (WWS) was hacked by a former employee able to use credentials to remotely tamper with facility processes and threaten safety of drinking water.
6/12/2020	Texarkana Water Utility	Texarkana Water Utility was the victim of a ransomware attack.
8/2/2020	Water facility in the city of Oldsmar	Hackers broke into the computer system of a facility that treats water for the City of Oldsmar, Florida. They tried to increase the concentration of sodium hydroxide (NaOH).
1/3/2021	Nevada Water and Wastewater System	Nevada-based WWS was a victim of an unknown ransomware variant that infected its SCADA system.
4/30/2021	Mount Desert Sewage Treatment Plant	A sewage treatment plant in rural Maine suffered a ransomware attack shutting down the control computer.
5/24/2021	WSSC Water	WSSC Water, which provides water to 2 million customers, was hit with a ransomware attack on its non-essential business systems.
1/7/2021	Maine Water and Wastewater System	Maine-based WWS was targeted with ZuCaNo ransomware on its SCADA computer.
1/8/2021	California Water and Wastewater System	California-based WWS was hit with a Ghost variant ransomware attack.
8/4/2021	Limestone Sewage Treatment Plant	A sewage treatment plant in rural Maine suffered a ransomware attack that shut down its control computer.
7/15/2022	Narragansett Bay Commission	The Narragansett Bay Commission, a Rhode Island sewer system operator, was hit with a ransomware attack.
7/26/2023	Johnstown Regional Sewage	Federal and local law enforcement agencies investigated an alleged phishing scam perpetrated against Johnstown Regional Sewage.
11/1/2023	St. Johns River Water Management District	St. Johns River Water Management District, a regulatory agency in Florida that oversees the long-term supply of drinking water, confirmed that it responded to a cyberattack after the Cyber Av3ngers said it attacked the organization, providing samples of what it stole.
11/25/2023	Municipal Water Authority of Aliquippa	The Municipal Water Authority of Aliquippa reported being hacked by the Cyber Av3ngers Iranian-backed cyber group.
11/28/2023	North Texas Municipal Water District	The North Texas Municipal Water District (NTMWD) had a cyber security incident that caused operational issues. The Daixin ransomware gang said it was behind the attack, adding NTMWD to its list of victims and claiming to have stolen more than 33,000 files containing customer information.
1/19/2024	Veolia North America	Veolia North America, a subsidiary of transnational conglomerate Veolia, disclosed a ransomware attack that impacted systems in its Municipal Water Division and disrupted its bill payment systems.
2/29/2024	Chelan County Public Utility District	The Chelan County Public Utility District was impacted by a cyber security event that kept a nationwide vendor from mailing and emailing statements.
3/1/2024	Muscatine Power and Water	Muscatine Power and Water warned the public of a ransomware attack discovered on January 26.

Date of Event	Target Organization	Description of Event
3/15/2024	Encina Wastewater Authority (EWA)	EWA was hit by the BlackByte ransomware group.

Terrorism (Mass Casualty Incident)

While Orange County has not experienced any high-profile attacks by groups or individuals associated with international terrorist organizations, Orange County has several groups for advisory notification, investigation, and analysis of terrorist events and activities. These groups include:

- **Orange County Joint Terrorism Task Force (OCJTTF).** The OCJTTF was formed by the Orange County Sheriff's Department, FBI, and other local police agencies. The OCJTTF is one of 66 joint terrorism task force groups across the United States and the third largest in the Nation. Team members are tasked with collecting, analyzing, and sharing critical information and intelligence involving matters related to any terrorism investigation occurring in or affecting the Orange County area.
- **Orange County Private Sector Terrorism Response Group (PSTRG).** The PSTRG was formed in December 2001 to create a private sector partnership with the Terrorism Early Warning Group to effectively address private sector safety, incident management, employee education, and public health consequences of potential attacks on the critical infrastructure within Orange County. Two large groups involved with PSTRG are the Orange County Business Council, of which 80% of the major businesses in Orange County are members, and TechNet, a consortium of 28 high-tech firms. The objectives of the PSTRG include physical resource sharing, information exchange, virtual reach-back capabilities, and subject/industry matter experts cross-utilization. The PSTRG is an instrument that allows the Sheriff's Department to maximize all resources and prepare community members for the potential of terrorism and recovery in its aftermath.
- **Orange County Intelligence Assessment Center (OCIAC).** The OCIAC was built on the foundation established by the Orange County Sheriff Department's Terrorism Early Warning Group (TEWG) from 2001 to 2007 and is an Operational Area asset governed by the Orange County Chiefs and Sheriff's Association (OCCSA). The OCIAC is a proactive multi-agency, multi-discipline collaborative that provides comprehensive analysis, intelligence, timely information sharing, and infrastructure protection. Within the OCIAC, the Critical Infrastructure Protection Unit uses a multi-disciplinary team comprised of law enforcement, fire, medical, and private sector experts to conduct vulnerability assessments and provide relevant security updates and training resources to our public and private sector partners in a combined effort to protect Orange County's assets against terrorist attack, criminal activity, and natural disasters.
- **Law Enforcement Mutual Aid.** Orange County law enforcement has long recognized the need for a standardized, uniform, organized response on the part of public safety providers involved in major multi-discipline and multi-jurisdictional incidents. The collaborative efforts of Orange County law enforcement leaders over the past six decades have forged a collective voice in mutual assistance and mutual aid. All major components tasked with public safety (law, fire, health, emergency management) are actively involved in developing emergency plans and insuring emergency preparedness.

3.2.5.3 Location/Geographic Extent

Groundwater Contamination

Groundwater contamination may occur county-wide by means of intentional or accidental spillage to groundwater.

Saltwater Intrusion

Conversely, the coastal area of the Orange County Groundwater Basin is vulnerable to seawater intrusion due to geologic features and increased pumping from inland municipal wells to meet consumer demands. The susceptible locations in the basin are the Talbert, Bolsa, Sunset, and Alamitos Gaps.

Hazardous Materials

Human-caused hazards may affect a specific location or multiple locations, each of which may be a disaster scene, a hazardous scene, and/or a crime scene simultaneously. Accidental hazardous materials release can occur wherever hazardous materials are manufactured, stored, transported, or used. In Orange County, a hazardous material event is most likely to occur within Orange County's industrial areas.

Power Outage

A power outage can cause impacts at the local level and potentially the regional level. As seen from previous occurrences, a severe outage can easily impact several counties at a time. All jurisdictions within the planning area have the potential to be impacted should an event occur; either directly or indirectly. Highly developed communities may see more outage occurrences if a heat wave should occur, due to the number of cooling systems running at once. Water and wastewater facilities with backup generators or alternate power sources are less likely to experience severe losses or disruption.

Terrorism (Cyber Threat)

Since computers are so ubiquitous, a cyber threat could appear in virtually any part of Orange County. In extreme circumstances, a threat could impact the entire county. Cyber threats vary in their length and severity of impact. A minor threat could cause computer systems to slow down for a few minutes and not behave as responsively. On the other hand, a major cyber threat could cause a complete shutdown of critical systems, including those used by banks, healthcare institutions, universities, major businesses, and city governments.

Terrorism (Mass Casualty Incident)

One of the special considerations in dealing with the terrorist threat is that it is difficult to predict. The Department of Homeland Security's National Planning Scenario identifies the possible terrorist strike locations it views as most plausible. Places at risk include cities that have economic and symbolic value, places with hazardous facilities, and areas where large groups of people congregate, such as an office building, sports arena, or amusement park. As such, Anaheim (Disneyland, Angels Stadium, Honda Center), Buena Park (Knott's Berry Farm), and San Clemente (SONGS) are viewed as potential targets.

3.2.5.4 Magnitude/Severity

Groundwater Contamination

The 1974 Safe Drinking Water Act requires the EPA to set standards for contaminants in drinking water that may pose health risks to humans. The EPA standard for lifetime exposures in drinking water, the maximum contaminant level (MCL), is the highest amount of a contaminant allowed in drinking water supplied by municipal water systems (EPA Drinking Water n.d.). In Orange County more than 700 monitoring wells assess water quality conditions (OCWD 2015). Thus, it is unlikely that human consumption of contaminated groundwater will occur. A large environmental spill could result in contamination of groundwater; however, the extent and the severity cannot be predicted. Based on historical occurrences, a contamination in the groundwater basin could extend several miles and result in water wells being unavailable.

Saltwater Intrusion

Massive seawater intrusion has been prevented in Orange County by the Orange County Groundwater Basin management programs. However, the threat of saltwater intrusion along the coast is still present. To prevent further intrusion and to provide basin management flexibility, OCWD operates a hydraulic barrier system. A series of 23 multi-point injection wells 4 miles inland delivers fresh water into the underground aquifers to form a water mound, blocking further passage of seawater. Continued injection of recycled water into the aquifer is essential to keep saltwater from intruding into the groundwater table and contaminating a major source of the county's potable water. OCWD maintains the Coastal Aquifer Mergence Zones and Chloride Concentration map, which indicates a 250 mg/L Chloride Concentration Contour. This contour is used to indicate the approximate leading edge of seawater intrusion. OCWD monitors the movement of the chloride contour to provide an indication of whether seawater intrusion is worsening or improving in a given area.

Hazardous Materials

Human-caused hazards have the potential to directly impact water and wastewater systems. A hazardous material spill could be localized and, depending upon when the spill is identified and addressed, may be contained with limited to no impact on water supplies and systems. However, there is the potential for a hazardous material spill to severely impact water supplies due to groundwater intrusion and direct contamination of a water source. The magnitude and severity of the hazard would be highly dependent upon the type of hazardous material spill, location, and the extent to which the hazardous material extends into the water system. Similarly, an act of terrorism could cause a significant impact to water and wastewater systems depending upon the type of event and whether it occurs at a primary source or is focused to a specific area or system. Human-caused hazards can have a direct impact on water supplies and the ability to provide water services to communities, potentially resulting in significant health and safety issues.

Power Outage

A power outage has the potential to directly impact water and wastewater systems. Disruption of water utilities and systems often requires notification of the public and businesses to curtail usage, boil available water, use bottled water, etc. Firefighting capabilities may also be impacted if an outage causes disruption to water supplies. In areas where telephone service is provided by above-ground lines that share poles with electrical distribution lines, telecommunications providers may not be able to make repairs to the telephone system until electrical utilities restore power lines to a safe condition. This could impact response times to a water or wastewater incident. The impacts of electric utility disruptions are felt most significantly by Southern California communities during the summer months due to cooling demands from higher heat. Any extended electric disruption can also lead to local economic losses when computers, lighting, refrigeration, gas pumps, and other equipment are without power during business hours. A severe power outage also can cause cascading impacts such as transportation incidents, civil unrest, and disease. The magnitude/severity of a power outage would be the same for all jurisdictions within the planning area.

Terrorism (Cyber Threat)

Cyber threats are not measured on any scale, but they can be assessed by determining:

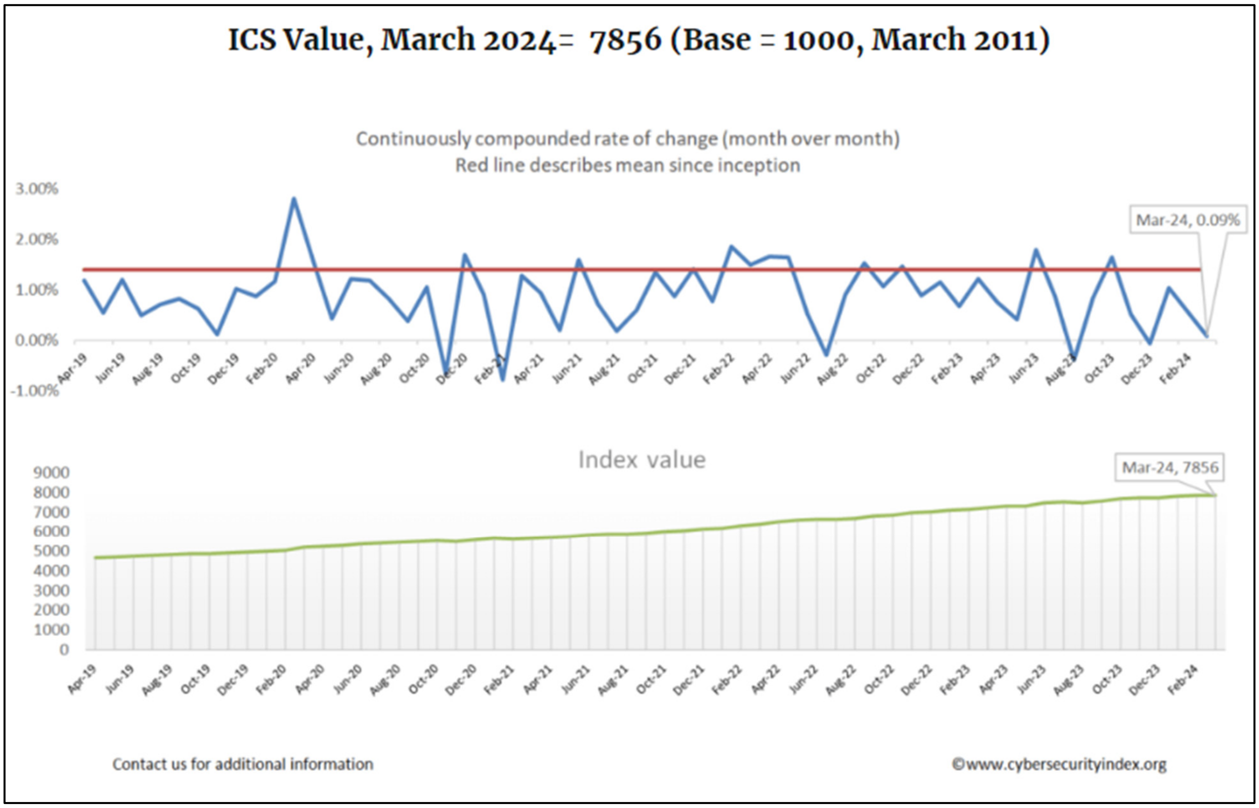
- The type of incident (website defacement, denial of service, unauthorized surveillance)
- The use of malicious software
- The level of security countermeasures that failed to prevent the cyber threat
- The duration of the cyber threat (a few hours, a few days, several weeks, etc.) (Mateski 2012)

Globally, cyber threats are increasing and becoming more sophisticated. The most common types of attacks include:

- Phishing
- Ransomware
- Intellectual Property Theft
- Spyware/Malware
- Unpatched Software

The Index of Cyber Security (NYU 2024) **Exhibit 3-14** can be referenced to understand the status of cyber threats, which identifies the measure of perceived risk. Since 2015, this index has trended upward and appears to have doubled in this timeframe.

Exhibit 3-14. Index of Cyber Security



Source: NYU, 2024

Terrorism (Mass Casualty Incident)

Possible locations that may attract acts of terrorism were discussed in **Section 3.2.5.3**; however, the perpetrators may also choose high-value targets such as electricity-generating facilities, water treatment plants, dams or reservoirs, railroads, highways, and other facilities that could impact governmental operations and services. Mass casualty incidents and acts of terrorism are typically measured by the fatalities, injuries, and destruction they cause, but there is no universally used scale for measuring these events.

3.2.5.5 Probability of Future Occurrences

Groundwater Contamination

Due to the amount and types of urban development that occur within Orange County and the transportation systems that allow for the movement of hazardous materials through the county and greater region, future groundwater contamination is likely. However, as a result of groundwater monitoring and protection systems, human consumption of contaminated groundwater is unlikely.

Saltwater Intrusion

Due to the successful operation of the Orange County Groundwater Basin management programs, the probability of saltwater intrusion in the future is unlikely.

Hazardous Materials

According to the Cal OES, hazardous materials have been released approximately 1,517 times (incidents that were reported to Cal OES) into the environment between the years of 2019 and 2024 in Orange County, for an average of approximately 253 times a year during that period. Thus, the probability of future contamination of the environment is likely. However, human consumption of contaminated groundwater is unlikely due to the constant monitoring of more than 700 wells across Orange County (OCWD 2015).

Power Outage

Power outages are a normal part of life and are unpredictable; they happen for many reasons and can be expected to continue in the future. Water and wastewater systems are most susceptible to failure during extreme weather conditions, fires, and earthquake events. Regional power outages can threaten human life, particularly when outages affect water supply, hospitals, and other healthcare facilities. As both population and climate variability increase across Southern California and puts more pressure on aging distribution systems, it is likely that power outage events will continue to occur. Due to the nature and extent of power outages, the probability for future occurrences would be the same for all jurisdictions in the planning area.

Terrorism (Cyber Threat)

Due to the integrated nature of technology into the everyday lives of residents, businesses, and government operations, it is possible that a cyber incident could emerge in the future as these threats occur on a daily basis across the planning area.

Terrorism (Mass Casualty Incident)

Because of the dynamic nature of the terrorist threat and the open nature of California society, all jurisdictions within California are vulnerable to terrorist attack. One must know the minds and capabilities of various terrorists and terrorist groups; these are characteristics terrorist organizations strive to conceal. Because all terrorists are not the same, the calculation is even more difficult. From the perspective of hazard mitigation, the most often used weapon of terrorists is bombs, and the greatest potential for loss is from weapons of mass destruction.

3.2.5.6 Climate Change Considerations

Groundwater Contamination

Climate change can cause more frequent and intense precipitation, which can lead to increased instances of flooding. Flooding can potentially mobilize contaminants in soil, which can then be transported to aquifers. While more intense precipitation events are anticipated, they could be followed by or preceded by droughts, which can potentially cause groundwater levels to decline. As groundwater levels fall, a greater concentration of contaminants occurs, impacting the ability to provide safe potable water to customers. Rising sea levels can lead to an increase in saltwater intrusion, which can contaminate groundwater aquifer/basins in coastal areas. Rising temperatures can increase the temperature of groundwater, which can potentially affect the levels and concentrations of undesirable substances in the water. Increased rainfall (both in intensity and frequency) can lead to more runoff of nutrients into water bodies, which can cause harmful algal blooms. Climate change may also lead to changes in human activities, such as increased pumping, irrigation, or land use, which can also impact groundwater quality and exacerbate other issues associated with groundwater supplies.

Saltwater Intrusion

Climate change has led to an increase in sea levels. When this is combined with increased groundwater pumping, the potential for saltwater intrusion can increase. Sea level rise may also lead to larger areas of coastal land becoming inundated. With additional areas inundated, the potential for additional seawater displacing fresh water increases. Saltwater intrusion into groundwater aquifers can increase treatment costs for drinking water facilities or render groundwater wells unusable. As sea levels rise, the “salt front” (location of the freshwater-saltwater line) may progress further upstream. This encroachment may be further exacerbated by drought, reduced rainfall, or changes in water use and demand. Saltwater intrusion can result in the need for water utilities to increase treatment, relocate water intakes, or develop alternate sources of fresh water.

Hazardous Materials

Climate change itself has no direct effect on hazardous material releases. However, climate change may increase the frequency or severity of other hazard types, which may result in a hazardous material release as an indirect effect. For example, climate change is expected to cause a 10% to 20% increase in the average intensity of the strong storms that affect Orange County during the winter. An increase in the intensity of these storms increases the chance that such a storm may damage or destroy a hazardous material storage tank, cause a vehicle crash involving hazardous materials, or lead to an incident that results in the release of hazardous materials.

Power Outage

As temperatures increase, so will the demand for utility/energy providers to produce larger quantities of reliable energy to power cooling equipment in homes and businesses. This could cause an increased strain on the current infrastructure and production facilities, possibly leading to an increase in power shortages and a decrease in the current energy grid reliability.

Terrorism (Cyber Threat)

Climate change is not likely to impact cyber threats in the future within Orange County.

Terrorism (Mass Casualty Incident)

Climate change has no direct impact on terrorism, as acts of terror are not directly caused by climate conditions. However, national security experts have raised concerns as early as 2003, if not before, that climate change indirectly affects terrorism by causing food, water, and resource shortages, potentially triggering migrations and economic upheaval that could cause some individuals to commit acts of terror (Schwartz and Randall 2003). More recently, a report prepared by the U.S. Department of Defense (DoD) repeated and expanded upon the connection between climate change and national security, referring to climate change as a “threat multiplier” that can “enable terrorist activity and other forms of violence” (DoD 2015).

3.2.6 Seismic Hazards (Fault Rupture, Seismic Shaking, and Liquefaction)

3.2.6.1 Description (Nature) of the Hazard

Earthquakes are considered a major threat to Orange County, especially when focusing on water and wastewater facilities and pipelines that run throughout the county. A significant earthquake along one of the major faults could cause substantial casualties, extensive damage to infrastructure, fires, and other threats to life and property. Significant damage and outages of water and wastewater facilities could also occur. The effects could be aggravated by aftershocks and by secondary effects such as fire, landslides, and dam failure. A major earthquake could be catastrophic in its effects on the population and could exceed the response capability of the local communities and even the State.

Following major earthquakes, extensive search and rescue operations may be required to assist trapped or injured persons. Emergency medical care, food/water, and temporary shelter would be required for injured or displaced persons. In the event of a truly catastrophic earthquake, identification and burial of the dead would pose difficult problems. Mass evacuation may be essential to save lives. Emergency operations could be seriously hampered by the loss of communications, damage to transportation routes within, to, and out of the disaster area, and by the disruption of public utilities and services. With damage to critical water and wastewater infrastructure there will be significant public health concerns, such as dehydration or exposure to contaminated water, and the potential for reduced fire protection due to limited sources of water. Facilities at greatest risk from severe earthquakes are dams and pipelines. Additionally, damage to water and sewer lines that service commercial and industrial areas could have a significant impact on the economy of the region. Extensive mutual aid for an extended period may be required to bring water and wastewater services back online.

Earthquakes strike with little to no warning, and they can have multiple impacts on an area. After-effects from an earthquake may include impacted roadways, downed power and communication lines, fires, and damage to structures (especially poorly built structures or those already in disrepair). Should a major event occur, major damages and losses should be expected to pumping systems and wastewater treatment infrastructure. Earthquakes are not a seasonal hazard, and thus can be experienced year-round. This fact presents its own set of planning and preparedness concerns.

Seismic-specific building codes can provide MAs with reasonable guidance for structural mitigation. As maintenance and potentially new building occurs within the planning area, seismic retrofitting is highly recommended to prevent extensive damage to essential infrastructure.

For decades, partnerships have flourished between the USGS, Cal Tech, the California Geological Survey (CGS), and California universities to share research and educational efforts with Californians. Tremendous earthquake mapping and mitigation efforts have been made in California in the past two decades, and public awareness has risen remarkably during this time. Major Federal, State, and local government utilities and private organizations support earthquake risk reduction. These partners have made significant contributions in reducing the adverse impacts of earthquakes.

Fault Rupture

Fault rupture occurs when the Earth's surface shifts and cracks along a fault line during a seismic event. While this phenomenon is not especially dangerous in natural environments, issues arise when structures are built near or on top of an active fault. Per the CGS, an active fault has experienced surface movement in the past 11,700 years (CGS, n.d.a)

The shifting and movement of the Earth's tectonic plates are responsible for seismic events. These tectonic plates can pull away from, move toward, or pass by each other. As they do, the plates sometimes lock together. This inability to move creates tension, which is eventually released like a springboard. The tension dissipates into the Earth's crust. The location at which two tectonic plates join is called a fault line. Fault lines are sometimes visible on the Earth's crust as sudden rifts or anomalies in the landscape's continuity. California's major north-south fault line is the San Andreas Fault, where the North American and Pacific Plates meet. However, constant friction between the two plates over the millennia has caused the areas where the two plates intersect to become fragmented, creating new, smaller faults.

The area near a fault line is at risk of damage due to the potential for a fault rupture—the deformation or displacement of land on either side of the fault—and may move a few inches to several feet in opposite directions. Buildings or infrastructure near a fault line could be severely damaged or destroyed. The fault rupture's direction depends on the fault type: dip-slip faults produce vertical shearing, strike-slip faults produce horizontal shearing, and oblique-slip faults produce both vertical and horizontal shearing. A fourth kind of fault, called a "blind" fault, produces virtually no visible land displacement. Some faults have emerged recently in geologic history. Quaternary faults have developed between the Holocene Era and the present (within the last 1.8 million years). These faults are especially concerning since they are the most likely to be active and cause future earthquakes (CGS, n.d.b. "Earthquakes").

Seismic Shaking

Seismic shaking is the motion felt on the Earth's surface caused by an earthquake. In most cases, earthquakes are not powerful enough to cause the feeling of shaking. However, particularly powerful earthquakes can generate significant shaking, causing widespread destruction resulting in property damage.

Liquefaction

Liquefaction is the phenomenon that occurs when ground shaking causes groundwater to mix with the soil. The mixture temporarily becomes a fluid and loses its strength. Liquefaction causes two types of ground failure: lateral spread and loss of bearing strength. Lateral spreads develop on gentle slopes and entail the sidelong movement of large masses of soil as an underlying layer liquefies. Loss of bearing strength results when the soil supporting structures liquefies and causes structures to settle and/or collapse from weakened foundations. Liquefaction can also occur independently of an earthquake, if any sudden and significant stress causes the mixing of groundwater and soil. The risk of liquefaction depends on several factors, including the height of the groundwater table and the types of soil in the area (CGS, n.d.c. "Seismic").

3.2.6.2 History/Past Occurrences

Fault Rupture

There have not been any reports of fault rupture within the planning area, despite some large seismic events in the past. However, the presence of active faults underlying the area make it a very real possibility should a major earthquake occur. The seismic shaking section highlights some of the larger earthquakes that have recently occurred within the planning area.

Seismic Shaking

Southern California and Orange County have experienced several powerful earthquakes. The earliest recorded earthquake in California occurred in Orange County in 1769. To better understand the potential for damaging earthquakes in Southern California, the scientific community has reviewed historical records and conducted extensive research on faults that are the sources of the earthquakes occurring in Southern California. Historical earthquake records can generally be divided into records of the pre-instrumental period and the instrumental period. In the absence of instrumentation, historic records of past earthquakes are based on observations and the level of information is often dependent upon population density in the area of the earthquake. Since California was sparsely populated in the 1800s, detailed information on pre-instrumental earthquakes is relatively sparse. However, two very large earthquakes, the Fort Tejon in 1857 (magnitude 7.9) and the Owens Valley in 1872 (magnitude 7.6) are evidence of the tremendously damaging potential of earthquakes in Southern California. Other notable earthquakes that have impacted Southern California include the 1910 Glen Ivy Hot Springs Earthquake (Elsinore Fault Zone, magnitude 6.0), the 1933 Long Beach Earthquake (Newport-Inglewood Fault Zone, magnitude 6.4), the 1952 Kern County and Lander earthquakes (magnitude 7.3), the 1971 San Fernando Earthquake (San Fernando Fault Zone, magnitude 6.6), the 1987 Whittier Earthquake (Whittier Fault Zone, magnitude 5.9), and the 1994 Northridge Earthquake (Pico Thrust, magnitude 6.7). The 1987 Whittier Earthquake caused damage to the Puente Hills Reservoir in La Habra and after inspection the reservoir was found to have cracks in the concrete lining.(MWDOC 2019)

Damage from some of these earthquakes was limited because they occurred in areas that were sparsely populated at the time they occurred. However, developed areas were much more severely affected. Damage from the 1933 Long Beach Earthquake was estimated at more than $40 million ($970 million in 2024 dollars), and 115 lives were lost. The seismic risk is much more severe today than in the past because the population at risk is in the millions, rather than a few hundred or a few thousand persons. Earthquakes of great magnitudes have caused lasting effects in developed regions.

The most recent significant earthquake event affecting Southern California was the 1994 Northridge Earthquake. At 4:31 a.m. on Monday, January 17, 1994, a moderate, but very damaging earthquake with a magnitude of 6.7 struck the San Fernando Valley. In the following days and weeks, thousands of aftershocks occurred, causing additional damage to affected structures. In this earthquake, 57 people were killed and more than 1,500 people seriously injured. For days afterward, thousands of homes and businesses were without electricity, tens of thousands had no gas, and nearly 50,000 had little or no water. Out of the approximately 66,000 structures inspected, approximately 15,000 structures were moderately to severely damaged, which left thousands of people temporarily homeless. Several collapsed bridges and overpasses created commuter havoc on the freeway system. Extensive damage was caused by ground shaking, but the earthquake triggered liquefaction, and dozens of fires also caused additional severe damage. The extremely strong ground motion felt in sizable portions of Los Angeles County resulted in record economic losses. The fact that the earthquake occurred early in the morning on a holiday considerably reduced the potential effects. Many collapsed buildings were unoccupied, and most businesses were not yet open. The direct and indirect economic losses ran into the tens of billions of dollars. Clearly, no community in Southern California is beyond the reach of a damaging earthquake. The historical earthquake events that have affected Southern California are listed below in **Exhibit 3-15.**

Exhibit 3-15. Magnitude 5.0 or Greater Earthquakes in the Southern California Region

Date Location (Magnitude)	
1769 Los Angeles Basin (6.0)	1952 Kern County (7.7)
1800 San Diego Region (6.5)	1954 West of Wheeler Ridge (5.9)
1812 Wrightwood (7.0)	1971 San Fernando (6.5)

Date Location (Magnitude)	
1812 Santa Barbara Channel (7.0)	1973 Point Mugu (5.2)
1827 Los Angeles Region (5.5)	1979 Imperial Valley (6.5)
1855 Los Angeles Region (6.0)	1986 North Palm Springs (6.0)
1857 Great Fort Tejon (8.3)	1987 Whittier Narrows (5.8)
1858 San Bernardino Region (6.0)	1990 Upland (5.7)
1862 San Diego Region (6.0)	1991 Sierra Madre (5.6)
1892 San Jacinto or Elsinore Fault (6.5)	1992 Landers (7.3)
1893 Pico Canyon (5.8)	1992 Big Bear (6.2)
1894 Lytle Creek Region (6.0)	1994 Northridge (6.7)
1894 E. of San Diego (5.8)	1999 Hector Mine (7.1)
1899 Lytle Creek Region (5.8)	2004 San Luis Obispo (magnitude unknown)
1899 San Jacinto and Hemet (6.4)	2008 Greater Los Angeles Area (5.5)
1907 San Bernardino Region (5.3)	2008 Borrego Springs (5.4)
1910 Glen Ivy Hot Springs (5.5)	2009 El Centro/Baja, Ca (5.9)
1916 Tejon Pass Region (5.3)	2010 El Centro/Baja, Ca (7.2)
1918 San Jacinto (6.9)	2010 El Centro/Baja, Ca (5.7)
1923 San Bernardino Region (6.0)	2014 La Habra (5.1)
1925 Santa Barbara (6.3)	2019 Ridgecrest (6.4)
1933 Long Beach (6.3)	2019 Ridgecrest (7.1)
1941 Carpentaria (5.9)	

Liquefaction

Comprehensive, historic accounts of damage to structures from liquefaction are not readily available. Some damage caused by the Northridge Earthquake of 1994, such as damage to the King Harbor area of Redondo Beach in Los Angeles County, was due to liquefaction, as opposed to ground shaking.

3.2.6.3 Location/Geographic Extent

Fault Rupture

The area at risk of fault rupture is limited to areas in the immediate vicinity of a fault. California began extensive mapping of earthquake faults with the Alquist-Priolo Earthquake Fault Zoning Act of 1972. **Exhibit 3-16** shows both the fault zones in Orange County that have been mapped through the act. The Whittier Fault Zone near the county's northern border passes through part of the YLWD. The Newport-Inglewood Fault Zone parallels the coast in western Orange County.

Exhibit 3-16. Alquist-Priolo Rupture Zones

There are many additional large faults that could affect Orange County in addition to the Whittier and Newport-Inglewood-Rose Canyon faults. These include the Elsinore Fault, Peralta Fault, Puente Hills Fault, San Andreas Fault, and San Jacinto Fault. Smaller faults include the Norwalk Fault and the El Modena Faults. In addition, newly studied thrust faults, such as the San Joaquin Hills Fault could also have a significant impact on Orange County. Each of the major fault systems are described briefly below and are presented in alphabetical order. This order does not place more danger on one fault over another; it is simply for organizational purposes.

- **Elsinore Fault Zone/Whittier Fault/Chino Fault.** Located in the northeast part of the county, the Elsinore Fault Zone follows a general line easterly of the Santa Ana Mountains into Mexico. The main trace of the fault zone is about 112 miles long. The last major earthquake on this fault occurred in 1910 (magnitude 6.0), and the interval between major ruptures is estimated to be about 250 years. Southern California Earthquake Center (SCEC) reports probable earthquake magnitudes for the main trace of the Elsinore Fault to be in the range of 6.5 to 7.5. At the northern end of the Elsinore Fault Zone, the fault splits into two segments: the 25-mile-long Whittier Fault (probable magnitudes between 6.0 and 7.2), and the 25-mile-long Chino Fault (probable magnitudes between 6.0 and 7.0). The location of the Whittier Fault makes it especially critical to the Diemer Filtration Plant in Yorba Linda and pipelines bringing water into Orange County and/or from the Diemer Plant, which is located very near this fault.
- **Newport-Inglewood-Rose Canyon Fault Zone.** This fault zone extends from the Santa Monica Mountains in a southeast direction through the western part of Orange County, then continues offshore (not more than 4 miles from the coast) down to San Diego Bay. Originally, this was thought to have been two separate systems; the Newport-Inglewood Fault and the Rose Canyon Fault Line. However, a study prepared in March 2017 found that they are in fact one continuous fault line with three main stepovers. This fault line was the source of the destructive 1933 Long Beach earthquake (magnitude 6.4), which caused 120 deaths and considerable property damage. SCEC reports probable earthquake magnitudes for the Newport-Inglewood Fault to be in the range of 6.0 to 7.4.
- **Peralta Hills Fault.** Limited information is available to paleo seismically characterize the fault and no studies have been undertaken to determine the timing of earthquakes. There is a strong geomorphic expression along Lincoln Boulevard west of Tustin Avenue in the City of Orange. Some believe the fault is not active while others believe it is active. Ongoing research has linked the fault as a back thrust with the Elsinore Fault, with a potential magnitude of 6.8.
- **Puente Hills Thrust Fault.** This is another recently discovered blind thrust fault that runs from northern Orange County to downtown Los Angeles. It is now known to be the source of the 1987 Whittier Narrows Earthquake. Recent studies indicate that this fault has experienced four major earthquakes ranging in magnitude from 7.2 to 7.5 in the past 11,000 years, but that the recurrence interval for these large events is on the order of several thousand years.
- **San Andreas Fault Zone.** As the dominant active fault in California, it is the main element of the boundary between the Pacific and North American tectonic plates. The longest and most publicized fault in California, it extends approximately 650 miles from Cape Mendocino in Northern California to east of San Bernardino in Southern California and is approximately 35 miles northeast of Orange County. This fault was the source of the 1906 San Francisco earthquake, which resulted in some 700 deaths and millions of dollars in damage. It is the southern section of this fault that is currently of greatest concern to the scientific community. Geologists can demonstrate that at least eight major earthquakes (Richter Magnitude 7.0 and larger) have occurred along the southern San Andreas Fault in the past 1,200 years with an average spacing in time of 140 years, plus or minus 30 years. The last such event occurred in 1857 (Fort Tejon Earthquake). Based on that evidence and other geophysical observations, the Working Group on California Earthquake Probabilities (Field, 2013) has estimated the probability of a similar rupture (magnitude 7.8) in the next 30 years (1994 through 2024) to be

about 50%. The range of probable magnitudes on the San Andreas Fault Zone is reported to be 6.8 to 8.0.

- **San Jacinto Fault Zone.** The San Jacinto Fault Zone is located approximately 30 miles north and east of the county. The interval between ruptures on this 130-mile-long fault zone has been estimated by SCEC to be between 100 and 300 years, per segment. The most recent event (1968 M6.5) occurred on the southern half of the Coyote Creek segment. SCEC reports probable earthquake magnitudes for the San Jacinto Fault Zone to be in the range of 6.5 to 7.5.
- **San Joaquin Hills Fault.** This fault is a recently discovered southwest-dipping blind thrust fault originating near the southern end of the Newport-Inglewood Fault close to Huntington Beach, at the western margins of the San Joaquin Hills. Rupture of the entire area of this blind thrust fault could generate an earthquake as large as magnitude 7.3. In addition, a minimum average recurrence interval of about 1,650 and 3,100 years has been estimated for moderate-sized earthquakes on this fault (Bender, 2000).

In addition to the major faults described above, the rupture of several smaller faults could potentially impact Orange County, including the Norwalk Fault (located in the north of the county in the Fullerton area) and the El Modeno Fault (located in the City of Orange area).

In 2005, MWDOC hired Earth Consultants International to prepare specific ground acceleration and shaking maps for five fault earthquake scenarios in Orange County (Earth Consultants 2005). **Exhibit 3-17, Characteristics of Important Geologic Faults in Orange County**, summarizes the characteristics of these five major geologic faults. Earthquake maps for the individual jurisdictions are included in the Jurisdictional Annexes.

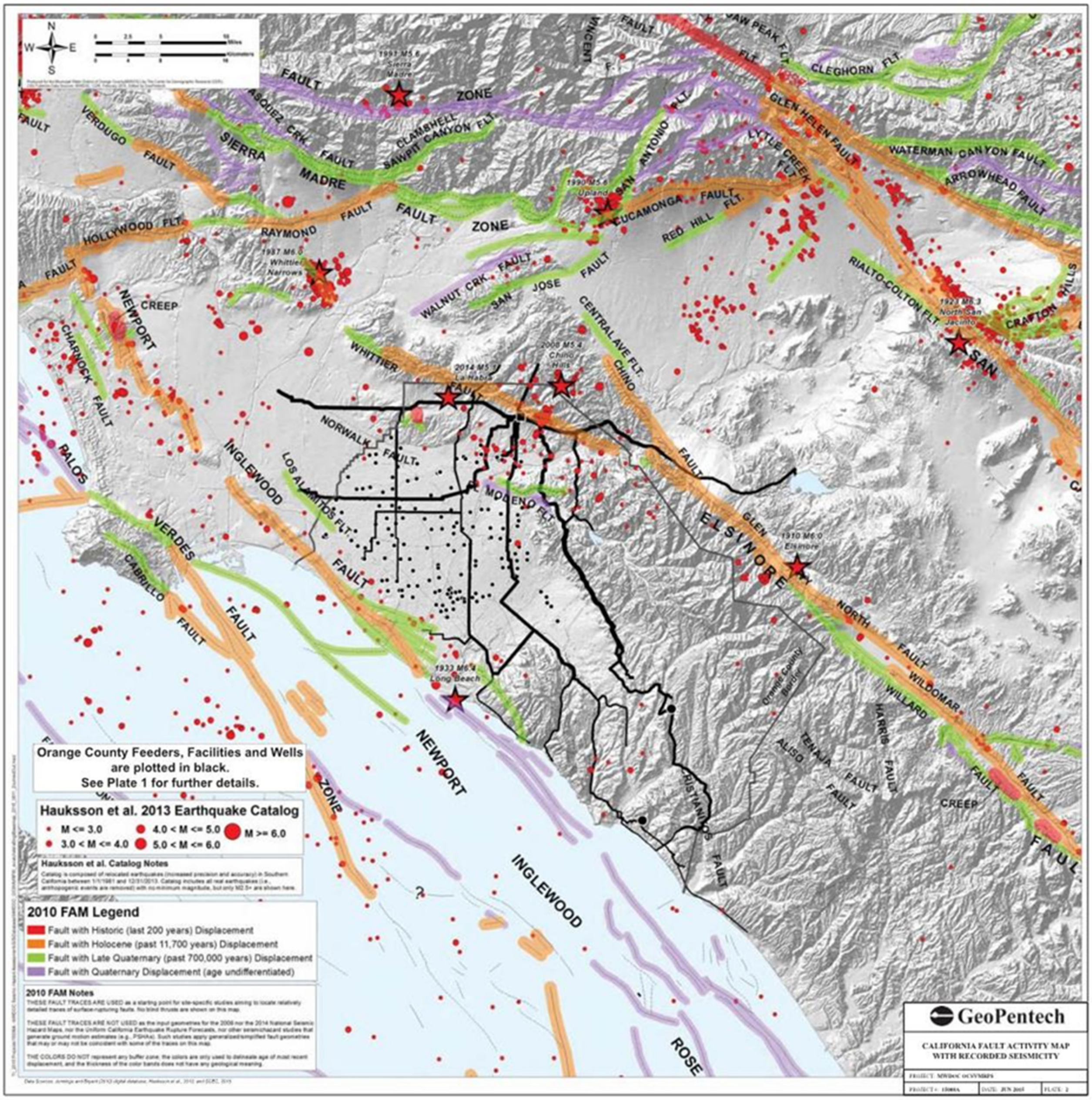
Exhibit 3-17. Characteristics of Important Geologic Faults in Orange County

Characteristic	Newport-Inglewood-Rose Canyon (onshore)	Peralta Hills	Puente Hills	San Joaquin Hills	Whittier
Fault Type	Strike-slip	Thrust	Blind thrust	Blind thrust	Strike-slip
Slip Rate (mm/yr)	1 +/-0.5	Unknown, Prob. <1	0.7 +/-0.4	0.5 +/-0.2	2.5 +/-1.0
Magnitude[1]	6.9	6.8	7.5	6.6	6.8
Recurrence Interval (years)	2,200-3,900	Unknown	2,750	1,600-3,100	1,100
Last Activity (years ago)	6.3 in 1933	Unknown	<3,000	200-300	1,600-2,000

1. The magnitude shown represents the fault's average behavior.
(Earth Consultants 2005)

Exhibit 3-18, prepared for the California Domestic Water Corp., a private wholesaler, shows the location of earthquake epicenters from 1941 to 2013 in and around Orange County, which is outlined in the center of the map.

Exhibit 3-18. Location of Earthquake Faults Bounding the California Domestic Water Corp. Service Area and Orange County

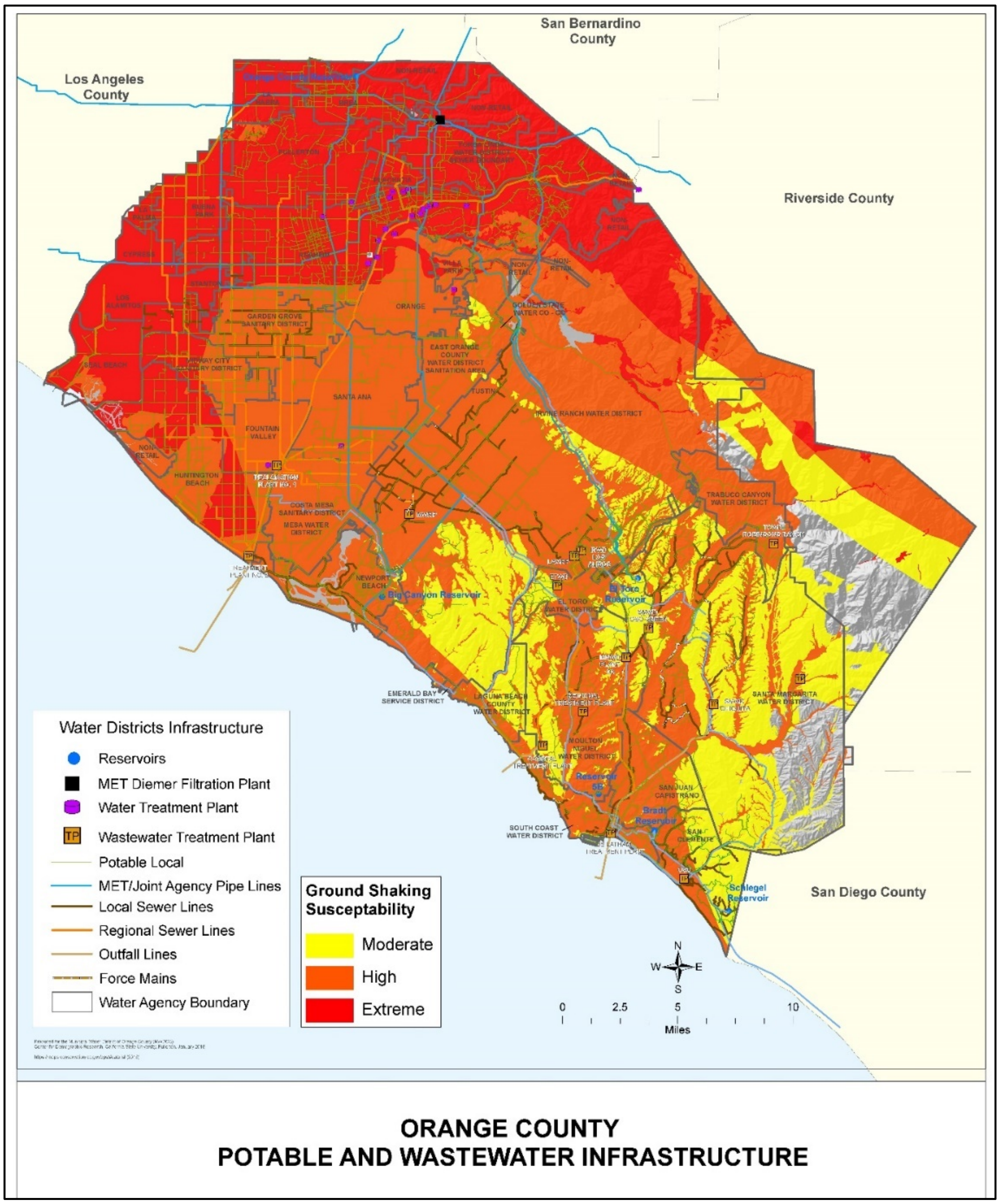


Earthquakes that occur outside of Southern California and Orange County could also have a significant impact on drinking water supplies. Such scenarios include disruptions of the Colorado River Aqueduct, the State Water Project (especially at an area such as the Edmonston Pumping Station and Porter Tunnel bringing water over and through the Tehachapi), and in the Bay-Delta Region, where failure of levees and flooding of islands with saltwater from San Francisco Bay could disrupt water supplies for months or years. Orange County is 50% dependent on supplies from beyond its borders to meet the county's drinking water needs. This leaves it exposed to these occurrences from outside the region.

Seismic Shaking

Nearly all of Orange County is at risk of moderate to extreme ground shaking. **Exhibit 3-19** shows ground shaking severity zones for Orange County. The area's most susceptible to damage from earthquakes based on the shaking intensity hazard map include YLWD and the Cities of La Habra and Buena Park. These communities can be severely impacted by landslides, liquefaction, extensive infrastructure damage, fire, dam failure, and other secondary earthquake effects. A major earthquake could be catastrophic in its effect on the population and could exceed the response capability of the local communities and even the State. Although the above-noted water/wastewater utilities are most likely to experience "extreme" shaking, all of Orange County's water/wastewater utilities fall within a moderate to extreme shaking intensity zone and therefore should expect the potential of damage from an earthquake.

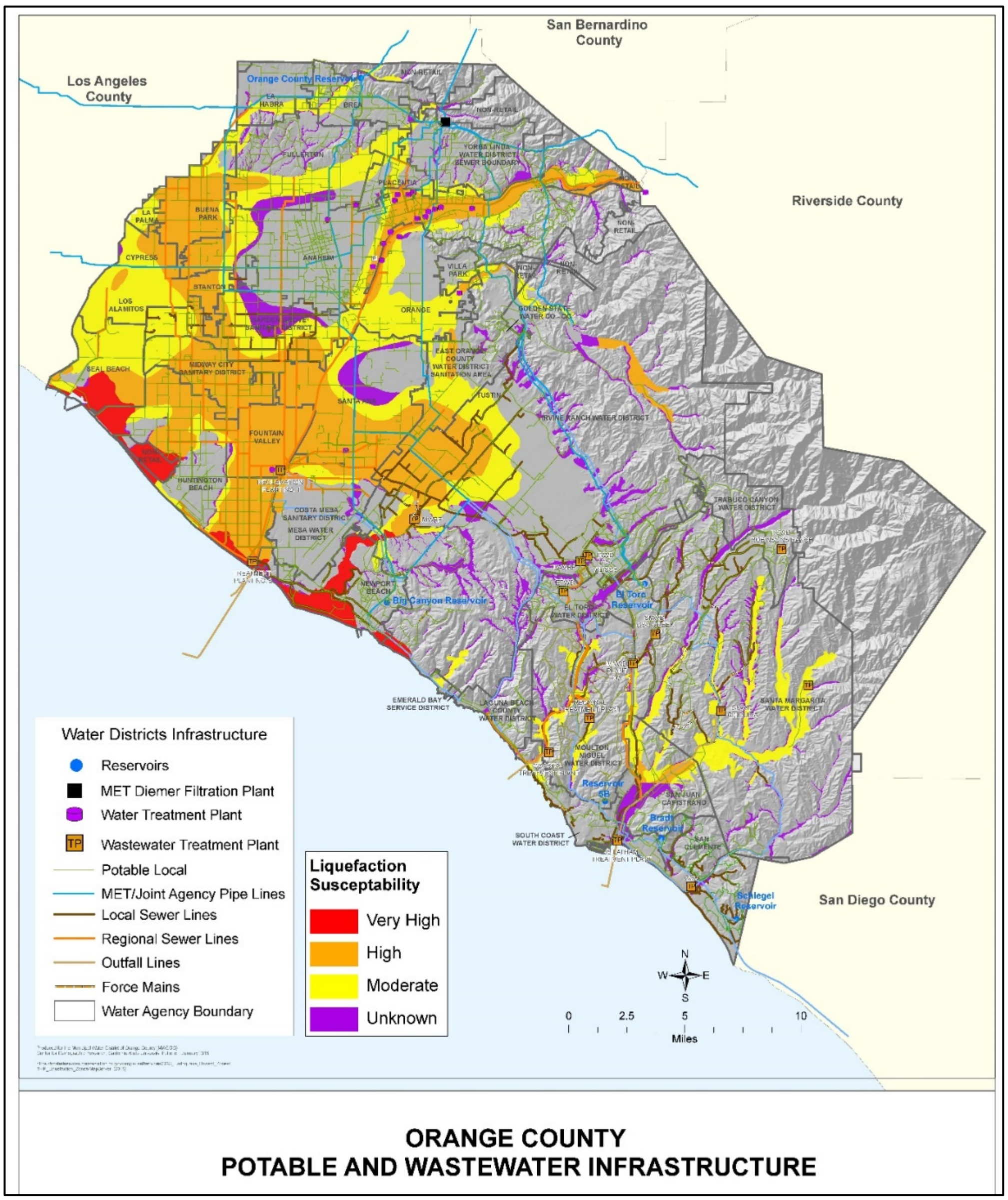
Exhibit 3-19. Ground Shaking Hazard



Liquefaction

The potential for liquefaction exists in areas susceptible to ground shaking with loose soils and/or shallow groundwater. Given the active faults in the region and the presence of geologically young, unconsolidated sediments and hydraulic fills, liquefaction is possible throughout much of Orange County. The California Geological Survey's Seismic Hazards Zonation Program identifies and maps areas prone to liquefaction. These zones for Orange County are shown in **Exhibit 3-20**. The most extensive liquefaction zones occur in coastal areas, including parts of Huntington Beach and Newport Beach, and along Upper Newport Bay. In addition, a 2016 Seismic Hazard Assessment conducted by GeoPentech, Inc., found that the highest liquefaction hazard areas are the flat, coastal portions of the planning area, and the risk decreases moving inland. The areas identified as being highly susceptible to liquefaction are the San Juan Creek/San Clemente Beach areas.

Exhibit 3-20. Liquefaction Susceptibility Zones



3.2.6.4 Magnitude/Severity

Fault Rupture

The planning area has multiple known faults that run through and near the planning area. A significant earthquake along any of these major faults could cause substantial casualties, extensive damage, and other threats to life and property. The shaking of the ground can also damage or destroy underground utilities or pipelines, potentially leading to the release of hazardous materials and flooding if water lines are breached.

The planning area can expect varying degrees of damage depending on the magnitude and duration of an earthquake along one of these faults within the region. The topography in portions of the planning area means there are areas with critical infrastructure and facilities of concern constructed on or adjacent to slopes, which may be subject to earthquake-induced landslides (reference the landslide hazard profile for further discussion).

Seismic Shaking

Ground shaking is measured using either the moment magnitude scale (MMS, denoted as Mw or simply M) or the Modified Mercalli Intensity Scale. The MMS is a replacement for the Richter scale, which is still often referred to but is no longer actively used, as the Richter scale is not reliable when measuring large earthquakes (USGS 2014). The weakest earthquakes measured by the MMS start at 1.0, with the numbers increasing with the strength of the earthquake. The strongest recorded earthquake, which struck Chile in 1960, measured 9.5 on the MMS (MWDOC 2019). Like the Richter scale, the MMS is a logarithmic scale, meaning the difference in strength between two earthquakes is much larger than the difference in their measurements. For example, a 6.0 Mw earthquake is 1,000 times stronger than a 4.0 Mw earthquake and about 1.4 times as strong as a 5.9 Mw event.

The Modified Mercalli Intensity Scale is based on the damage caused by the earthquake and how it is perceived, rather than an actual measurement. When comparing multiple earthquakes, one event may have a higher Mercalli rating than another even if it released less energy, and thus was measured lower on the MMS. The Mercalli scale ranges from I (instrumental, rarely felt by people) to XII (catastrophic, total damage and lines of sight are distorted). **Exhibit 3-21**, **Comparison of MMS and Modified Mercalli Intensity Scale,** shows a general comparison between the MMS and the Modified Mercalli Intensity Scale. Note that there is some overlap toward the higher end of the Mercalli ratings, with certain intensities produced by multiple ranges of magnitude measurements.

Exhibit 3-21. Comparison of MMS and Modified Mercalli Intensity Scale

Magnitude (MMS)	Modified Mercalli Intensity Scale	
	Intensity	Description
1.0 to 3.0	I	Not felt except by very few people under especially favorable conditions.
3.0 to 3.9	II	**Weak:** Felt only by a few persons at rest, especially on upper floors of buildings.
	III	**Weak:** Felt quite noticeably by people indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck.
4.0 to 4.9	IV	**Light:** Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

Magnitude (MMS)		Modified Mercalli Intensity Scale	
		Intensity	Description
		V	**Moderate:** Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 to 5.9		VI	**Strong:** Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
	6.0 to 6.9	VII	**Very Strong:** Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
7.0 and greater		VIII	**Severe:** Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
		IX	**Violent:** Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
		X	**Extreme:** Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
		XI	**Extreme:** Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
		XII	**Extreme:** Damage total. Lines of sight and level are distorted. Objects thrown into the air.
(USGS 2017)			

Several faults in Orange County can produce severe to extreme earthquakes. The SCEC and the Working Group on California Earthquake Probabilities have determined the probable magnitude for an earthquake along these major faults:

- **Elsinore Fault Zone.** SCEC reports probable earthquake magnitudes for the main trace of the Elsinore Fault to be in the range of 6.5 to 7.5. The two northern segments, the Whittier Fault and the Chino Fault, have probable magnitudes of 6.0 to 7.2 and 6.0 to 7.0, respectively. The Whittier Fault location is extremely critical because it crosses the two main sources of untreated water being brought into Orange County (Yorba Linda Feeder and the Lower Feeder) and it passes very close to the Diemer Filtration Plant, which serves as the treatment facility for the bulk of Orange County. Metropolitan does not have a backup system to supply treated water to many parts of central and southern Orange County in the event of an outage of the Diemer Plant.
- **Newport-Inglewood Fault Zone.** SCEC reports probable earthquake magnitudes for the Newport-Inglewood Fault to be in the range of 6.0 to 7.4.
- **Puente Hills Thrust Fault.** Recent studies indicate that this fault has experienced four major earthquakes ranging in magnitude from 7.2 to 7.5 in the past 11,000 years, but that the recurrence interval for these large events is on the order of several thousand years.
- **Peralta Hills Fault.** The Earth Consultants International study for MWDOC indicates that this may be a back thrust fault to the Elsinore Fault and may be capable of a magnitude 6.8 (Earth Consultants 2005).

- **San Andreas Fault Zone.** Based on that evidence and other geophysical observations, the fault has estimated the probability of a rupture with a magnitude 7.8 in the next 30 years (1994 through 2024) to be about 50% (Field 2013). The range of probable magnitudes on the San Andreas Fault Zone during this period is reported to be 6.8 to 8.0.
- **San Joaquin Hills Fault.** Recent reports have determined that the blind thrust fault can generate an earthquake as large as 7.3. In addition, a minimum average recurrence interval of 1,650 to 3,100 years has been estimated for moderate-sized earthquakes on this fault.
- **San Jacinto Fault Zone.** SCEC reports probable earthquake magnitudes for the San Jacinto Fault Zone to be in the range of 6.5 to 7.5.

Although the San Andreas Fault Zone can produce an earthquake with a magnitude greater than 8.0, some of the smaller faults have the potential to inflict greater damage on the urban core of the Los Angeles Basin. Seismologists believe that a 6.0 earthquake on the Newport-Inglewood Fault Zone would result in far more death and destruction than a larger earthquake on the San Andreas Fault Zone, due to the San Andreas' relatively remote location from the urban centers of Southern California.

3.2.6.5 Probability of Future Occurrences

Fault Rupture

Based on the amount of seismic activity that occurs within the region, there is no doubt that communities within the jurisdictional boundaries of MWDOC will continue to experience future earthquake events. It is reasonable to expect that a major event (5.0 magnitude or higher) and possibly even more severe will occur within a 30-year timeframe.

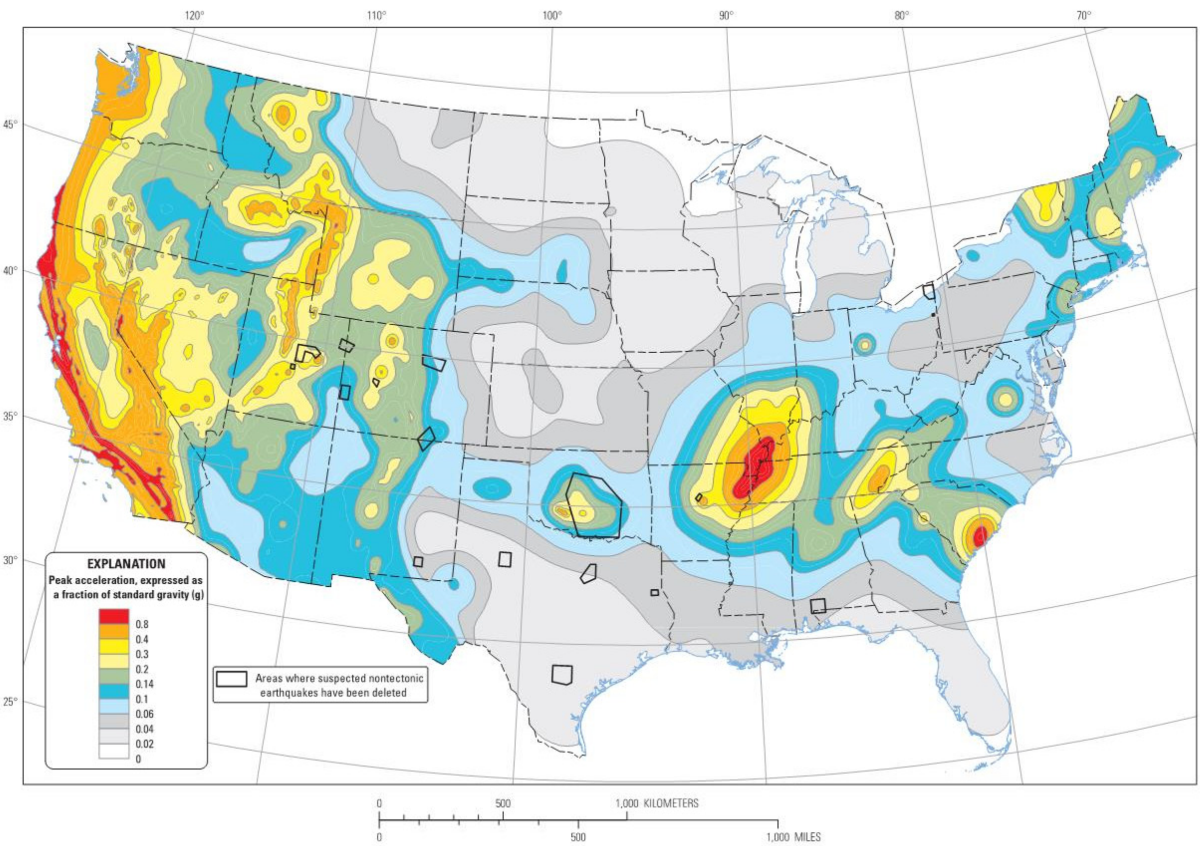
The Third Uniform California Earthquake Rupture Forecast (UCERF3), developed in 2014 by the Working Group on California Earthquake Probabilities and led by the USGS, provides estimates of the magnitude, location, and likelihood of fault rupture for more than 350 fault segments throughout the State. For Southern California, the study estimated the likelihood of a 6.0 magnitude earthquake at 100%, a 7.0 earthquake at 75%, and an 8.0 earthquake at 7% (USGS 2015).

Seismic Shaking

Predicted ground shaking patterns throughout Southern California for hypothetical scenario earthquakes are available from the USGS as part of their ongoing "ShakeMap" program. These maps are provided in terms of Instrumental Intensity, which is essentially Modified Mercalli Intensity estimated from instrumental ground motion recordings. ShakeMaps in graphical and GIS formats are available on the USGS website at: https://earthquake.usgs.gov/data/shakemap/.

In 2014, USGS released a simplified Peak Ground Acceleration (PGA) map to demonstrate the 2% probability of exceedance within a 50-year time period; refer to **Exhibit 3-22**. This analysis was done at the nationwide level. California, and many parts of Southern California, have a risk of high PGA at this probability level.

Exhibit 3-22. United States PGA with 2% Probability in 50 Years



Two-percent probability of exceedance in 50 years map of peak ground acceleration

(Petersen et al. 2014)

Liquefaction

Soil liquefaction is a seismically induced form of ground failure, which has been a significant cause of earthquake damage in Southern California. During the 1971 San Fernando and 1994 Northridge earthquakes, significant damage to roads, utility pipelines, buildings, and other structures in the region was caused by liquefaction (a significant amount of this damage type was reported in Los Angeles County). Research and historical data indicate that loose, granular materials situated at depths of less than 50 feet with fine (silt and clay) contents of less than 30%, which are saturated by a relatively shallow groundwater table, are most susceptible to liquefaction. These geological and groundwater conditions exist in parts of Southern California and the planning area, typically in valley regions, stream and river watersheds, and alluvial floodplains.

For liquefaction to occur, three general conditions must be met. The first condition, strong ground shaking for a relatively long duration, can be expected to occur in the planning area because of an earthquake on any of the several active faults in the region. The second condition, loose or unconsolidated, recently deposited sediments consisting primarily of silt and sand, occurs in many valley floors and the larger canyon bottoms prevalent throughout Orange County and the region. The third condition is water-saturated sediments within about 50 feet of the surface. Liquefaction could occur, but defining the precise likelihood is not possible. Refer to the seismic shaking magnitude/severity section for the probability of a major earthquake occurring in faults within the planning area.

3.2.6.6 Climate Change Considerations

Fault Rupture

Generally, there is no known direct connection between fault rupturing and climate change. Some evidence suggests that greater oceanic pressure on tectonic plates due to melting land ice could influence seismic events' behavior. Still, little indicates that this would play a major factor in any seismic event, including fault rupture.

Seismic Shaking

There is no direct link between climate change and seismic activity, so climate change is not expected to cause any changes to the frequency or intensity of seismic shaking. Some research indicates that climate change could result in "isostatic rebounds," or a sudden upward movement of the crust because of reduced downward weight caused by glaciers. As glaciers are known to melt when global temperatures increase, climate change could indirectly lead to increased seismicity in Southern California. (Masih 2018)

Liquefaction

While climate change may not impact seismic shaking, it can directly impact liquefication. Climate change is anticipated to change the usual precipitation patterns in Southern California. Periods of both rain and drought are expected to become more intense and frequent. This means more precipitation will likely occur during rainy periods, and drought is expected to last even longer. As a result, the water table along the creeks and canyons in Orange County could rise during intense periods of precipitation. Alternatively, a longer-lasting drought may lead to more groundwater withdrawal and could lower the water table. Therefore, climate change could potentially increase during times of intense precipitation or decrease during times of prolonged drought.

3.2.7 Severe Weather (Drought, Extreme Heat, Windstorm [Santa Ana Winds])

3.2.7.1 Description (Nature) of the Hazard

Drought

Many governmental utilities, the NOAA and the California Department of Water Resources, as well as academic institutions, such as the University of Nebraska-Lincoln's National Drought Mitigation Center, generally agree that there is no clear definition of drought. Drought is highly variable depending on one's location.

Drought in its simplest definition is an extremely dry climatic period where the available water falls below a statistical average for a region. Drought is also defined by factors other than rainfall, including vegetation conditions, agricultural productivity, soil moisture, water levels in reservoirs, and stream flow.

In effect, there are essentially three forms of drought: meteorological or hydrological drought, agricultural drought, and regulatory drought.

- **A meteorological or hydrological drought** is typically defined when there is a prolonged period of less than average precipitation resulting in the water level in aquifers, lakes, or above-ground storage reservoirs falling below sustainable levels.
- **An agricultural drought** occurs when there is insufficient moisture for an average crop yield. Agricultural drought can be caused by the overuse of groundwater, poor management of cultivated fields, as well as lack of precipitation.
- **A regulatory drought** can occur when the availability of water is reduced due to imposition of regulatory restrictions on the diversion and export of water out of a watershed to another area. A significant percentage of water in Southern California is imported from other regions (Colorado River and Northern California) via aqueducts. Correspondingly, drought in California can be made worse by water availability conditions in the regions at which the water originates.

An example of regulatory drought occurred between 1999 and 2004. A six-year drought on the Colorado River Basin, a major water supply for Southern California, resulted in a draw-down of Colorado River water storage by more than 50%. More recently, beginning in 2008, regulatory restriction in exporting water via the State Water Project combined with unusually dry weather patterns resulted in two years of water rationing in Southern California. Additionally, a meteorological drought can lead to regulatory restrictions; for example, California experienced prolonged drought from 2013 to 2017, resulting in mandatory water restrictions for residents through November 25, 2017.

Even distant droughts may have consequences for the plan area and participating jurisdictions. The great drought of the 1930s, coined the "Dust Bowl," was geographically centered in the Great Plains yet ultimately affected water shortages in California. The drought conditions in the plains resulted in a large influx of people to the west coast. Approximately 350,000 people from Arkansas and Oklahoma immigrated mainly to the Great Valley of California. As more people moved into California, including Orange County, increases in intensive agriculture led to overuse of the Santa Ana River Watershed and groundwater resulting in regional water shortages.

Droughts cause public health and safety impacts, as well as economic and environmental impacts. Public health and safety impacts are primarily associated with catastrophic wildfire risks and drinking water shortage risks for small water systems in rural areas and private residential wells. Examples of other impacts include costs to homeowners due to loss of residential landscaping; degradation of urban environments due to loss of landscaping, agricultural land fallowing, and associated job loss; degradation of fishery habitat; and tree mortality with damage to forest ecosystems. Drought conditions can also result in damage to older infrastructure that is located within dry soils with potential to leak or break. Dead or dying vegetation poses a risk to falling and damaging water and wastewater infrastructure systems.

In Orange County, drought conditions typically result in implementation of large-scale conservation efforts, reducing water supplies to customers and altering the pricing system by implementing higher rates for water usage that exceeds certain levels (e.g., wasteful). Higher rates that may be imposed during a drought could have disproportionate impacts on lower-income households. Reduction in groundwater supplies during drought conditions can also result in the need for water agencies that have high reliance on local groundwater supplies to purchase larger amounts of imported water. Drought conditions have also resulted in drier brush and an increase in the size and severity of wildfires. Water and wastewater infrastructure systems located within areas susceptible to wildfires are at a greater risk of being impacted. Damage or failure to water and wastewater infrastructure systems can significantly reduce or even interrupt service to customers. For more on wildfire hazards, see **Section 3.2.8, Wildland/Urban Fire.** In addition, climate change may lead to more frequent and persistent droughts in the future.

Several bills have been introduced into Congress to mitigate the effects of drought. In 1998, President Clinton signed into law the National Drought Policy Act, which called for the development of a national drought policy or framework that integrates actions and responsibilities among all levels of government. In addition, it established the National Drought Policy Commission to provide advice and recommendations on the creation of an integrated Federal policy. The most recent bill introduced into Congress was the National Drought Preparedness Act of 2003, which established a comprehensive national drought policy and statutorily authorized a lead Federal utility for drought assistance. Currently there exists only an ad-hoc response approach to drought unlike other disasters (e.g., hurricanes, floods, and tornadoes) which are under the purview of FEMA.

Extreme Heat

Extreme heat is a period when temperatures are abnormally high relative to a designated location's normal temperature range. There are generally three types of extreme heat events:

- **Extreme Heat Days:** A day during which the maximum temperature surpasses 98% of all historic high temperatures for the area, using the time between April and October from 1961 to 1990 as the baseline.
- **Warm Nights:** A day between April to October when the minimum temperature exceeds 98% of all historic minimum daytime temperatures observed between 1961 to 1990.
- **Extreme Heat Waves:** A successive series of extreme heat days and warm nights where extreme temperatures do not abate. Although no universally accepted minimum length of time for a heatwave event exists, Cal-Adapt considers four successive extreme heat days and warm nights to be the minimum threshold for an extreme heatwave.

Extreme heat events will have unique metrics from region to region since different areas have different historic high temperatures. For example, an extreme heat day on the coast will have lower temperatures than an extreme heat day in the High Desert.

Humidity plays a factor in people's perception of heat, as humid conditions will make a day feel hotter than a non-humid day even though the temperature may be the same on both days. The difference between the perceived and actual temperatures is known as the "heat index." To illustrate the effect of the heat index, a 90°F day with 50% humidity feels like 95°F, whereas a 90°F with 90% humidity feels like 122°F. **Exhibit 3-23** shows NOAA's National Weather Service Heat Index.

Extreme heat poses several dangers to public health. The human body is vulnerable to long periods of high temperatures and will eventually enter a state of heat exhaustion and dehydration if exposure to heat is extended. If exposure to high temperatures is particularly prolonged to the point that internal body temperature surpasses 105°F, heatstroke may occur, and organ failure and death may soon follow without intervention.

Exhibit 3-23. NOAA's National Weather Service Heat Index

NWS Heat Index — Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution — Extreme Caution — Danger — Extreme Danger

Windstorm

High winds are defined as those that last longer than 1 hour at greater than 39 miles per hour (mph) or for any length of time at greater than 57 mph. High winds that affect Orange County, notably Santa Ana winds, are generally defined as warm, dry winds that blow from the east or northeast (offshore). Santa Ana winds often blow with exceptional speed in the Santa Ana Canyon and forecasters at the National Weather Service in Oxnard and San Diego usually place speed minimums on these winds and reserve the use of "Santa Ana" for winds greater than 25 knots. The complex topography of Southern California combined with various atmospheric conditions creates numerous scenarios that may cause widespread or isolated Santa Ana events. Commonly, Santa Ana winds develop when a region of high pressure builds over the Great Basin (the high plateau east of the Sierra Mountains and west of the Rocky Mountains including most of Nevada and Utah). Clockwise circulation around the center of this high-pressure area forces air down slope from the high plateau. The air warms as it descends toward the California coast at the rate of 5°F per 1,000 feet due to compression of the air mass. The air is dry since it originated in the desert, and it dries out even more as it is compressed.

3.2.7.2 History/Past Occurrences

Drought

Based on years of recorded water trends in Southern California, it is quite apparent that droughts and water shortages can occur. Paleo records indicate that much more extreme events can occur than those since historical record-keeping began. A significant drought, reported by many of the ranchers in Southern California, occurred in 1860.

The National Drought Mitigation Center maintains a Drought Risk Atlas with historic data on drought classifications throughout the United States. Based on the Palmer Drought Severity Index

(PDSI), there have been eight occasions since records began in 1920 when the monitoring station in the City of Santa Ana recorded "severe" or "extreme" drought conditions for a period of at least 12 months. These periods, based on a "self-calibrating" PDSI, which uses data adjusted to be more sensitive to the local climate, are listed in **Exhibit 3-24**, Severe and Extreme SC-PDSI Drought Periods 1920-2023 Lasting 12 Months or Longer (Santa Ana, California) (NDMC 2024).

Exhibit 3-24. Severe and Extreme SC-PDSI Drought Periods 1920-2023 Lasting 12 Months or Longer (Santa Ana, California)

Drought Start	Drought End	Duration (Months)
February 1961	September 1963	31
March 1971	January 1978	82
May 1984	December 1992	103
January 1994	January 1995	12
December 1999	October 2004	58
January 2006	October 2010	57
December 2011	March 2017	64
January 2020	December 2022	36

Governor Jerry Brown proclaimed a State of Emergency in January 2014; the declaration was not lifted until April 2017. In Orange County, precipitation totals were well below average for five 12-month periods in a row. From July 2013 to June 2014, the weather station in Santa Ana recorded just 4.4 inches or rain, about one-third of the normal annual amount (OC Public Works n.d.). Governor Gavin Newsom issued a series of emergency proclamations beginning in April 2021, initially in only parts of California, but by October of 2021 the drought state of emergency proclamation was extended statewide. Newsom also issued Executive Order N-10-21 in July of 2021, which called for Californians to voluntarily reduce their water use by 15% from their 2020 levels, which was followed by additional water restrictions and regulations. The California Department of Water Resources stated that the State Water Project would not provide water to California farmers unless drought conditions improved in 2022, while many of California's water suppliers were forced to implement water shortage contingency plans to combat low water supplies (Romey et al. 2021).

Extreme Heat

According to NASA's Global Climate Change website, the mean global temperature has increased 1.8°F since 1880, and 17 of the 18 warmest years on record have occurred since 2001 (NASA 2024). The scientific consensus is that these changes are the result of human activity increasing the levels of carbon dioxide and other greenhouse gases in the atmosphere, and that they will intensify. The Intergovernmental Panel on Climate Change forecasts temperatures to rise an additional 2.5 to 10 degrees over the next century. Such drastic changes to the Earth's climate will have significant consequences around the globe. Long-term effects include rising sea levels due to melting ice, changes in precipitation patterns, heat waves, and more frequent and intense storms.

Based on local data from NOAA, Orange County can expect to see its daily maximum temperature increase from a current annual average of 73°F to 78°F by 2100 under a low-emission scenario and 82°F under a high-emission scenario (MWDOC 2019). The county currently experiences an average of 4.5 days a year where temperatures reach 95°F; that is projected to increase to as many as 31 days a year by the end of the century.

Windstorm

Most high wind incidents in the planning area are the result of Santa Ana wind conditions. While high impact wind incidents are not frequent in the area, significant Santa Ana wind events have impacted Orange County. The NOAA Storm Events Database identified 250 events reported within Orange County between January 1, 1950, and June 30, 2024. **Exhibit 3-25**, Major High Wind Events, identifies and describes some of the major events occurring within Orange County.

Exhibit 3-25. Major High Wind Events

Date	Location	Magnitude (kts)	Property Damage (dollars)	Description
12/9/1998	Northeast Orange County	81	50,000	Severely disrupted transportation, power, and daily activities. Broken trees and power poles were common throughout the area and power was knocked out to 180,000 customers. Downed power lines also started several wild fires, damaging one house.
12/3/1999	Santa Ana Mountains and Foothills	104	20,000	Most of the major highways in the Inland Empire and through the Santa Ana Mountains were closed, partially due to two semi-tractor trailers that overturned, partially from blowing dust reducing visibility, and partially from road signs and other debris being blown onto the roads.
3/20 – 3/21/2000	Santa Ana Mountains and Foothills	51	25,000	Damage ranged from downed power poles, trees falling on cars and houses, fruit being knocked off of trees, and blowing sand and dust lowering visibility to zero.
1/5 – 1/7/2003	Santa Ana Mountains and Foothills			Numerous trees and power poles were blown down. At least 60 communities were affected. A commuter train was delayed for several hours in Orange County when power poles were blown down onto the track. A brush fire whipped by the winds, damaged 5 houses and burned 150 acres. Sparks from downed power lines started numerous small brush fires, but these were quickly contained. Many houses and at least 300 parked automobiles were damaged by falling trees.
11/23/03	Santa Ana Mountains and Foothills	50	50,000	Trees, power lines, and signs were knocked down.
12/16/04	Northeast Orange	68	20,000	
2/3/05	Santa Ana Mountains and Foothills	53	5,000	
3/31/05	Northeast Orange	54	5,000	Strong Santa Ana winds caused power outages, blew over big rigs, and knocked down trees.
1/22/06	Santa Ana Mountains and Foothills	62	15,000	Surface high pressure over the Great Basin resulted in gusty Santa Ana winds from the San Bernardino mountains, through the Inland

Date	Location	Magnitude (kts)	Property Damage (dollars)	Description
				Empire, and into Orange County. Wind gusts over 60 mph toppled trees and power poles. Downed power lines caused sporadic power outages. Most of the property damage that occurred came as a direct result of falling trees.
10/21-22/2007	Santa Ana Mountains and Foothills/Orange County Coastal Areas	74	100,000	Santa Ana winds toppled trees, brought down power lines, and knocked out power to thousands in many parts of Orange County. The strongest winds were felt along the foothills of the Santa Ana Mountains and near the Chino Hills area.
12/16/11	Santa Ana Mountains and Foothills	56	15,000	This system set off intense showers and isolated thunderstorms with pea-sized hail (accumulations in Rancho Cucamonga and Mission Viejo), as well as several funnel clouds spotted east of John Wayne Airport. Most of the rain with this system was confined to Orange County, the Inland Empire, and the northern mountains. Heavy rain was observed in Orange County and the Inland Empire on December 15 and 16, with locations there recording between one-quarter and one-half inch. Strong winds were also observed with this storm, especially on December 16, which was a more widespread wind event than early December, impacting all counties, including San Diego County, with warning-level winds. Several wind gusts of 45-65 mph were reported in the Santa Ana Mountains, the Inland Empire and San Diego County Mountains. Several trees and power poles were downed, leaving many without power. Power poles were reported down in Yorba Linda and around 240 customers were reported without power in Tustin.
1/14/14	Santa Ana Mountains and Foothills	67	2,000	The highest wind gusts occurred in the San Diego County foothills and inland Orange County, including the Santa Ana Mountains. Winds downed fiber optic lines near Santiago Canyon in Orange County.
2/12/16	Orange County Inland	52	20,000	Strong northeasterly winds downed numerous trees near Irvine, Santa Ana, and Orange. Approximately 85 customers lost power in the City of Santa Ana.
2/17/17	Orange County Coastal	52	75,000	A strong trough and associated Pacific cold front swept into Southern California from the west, bringing strong winds, heavy snow, and rain. The storm was noteworthy for the strong prefrontal southerly winds that produced significant tree damage over the coast and valleys. In the

Date	Location	Magnitude (kts)	Property Damage (dollars)	Description
				mountains the ski resorts received 1-2 feet of snow, while elevations as low as 5,000 feet saw a few inches of accumulation. Rainfall ranged from 2-6 inches along the coastal slopes to 1-2 inches at the coast. At the beaches surf heights reached 8 to 12 feet. An isolated peak gust of 60 mph occurred at San Clemente Pier. Numerous trees were downed over the coastal areas.
12/4/17	Orange County Inland	52	15,000	Report of a large tree downed by strong winds in Orange. Tree damage, minor roof damage, and an exploding transformer were also reported in Santa Ana.
10/15/18	Orange County Inland	71	Unknown	A deep low pressure axis extending across Southern California produced strong region-wide Santa Ana winds. The strongest gust reached 82 mph in Fremont Canyon, with widespread gusts above 40-50 mph reported in valley locations. In Orange County, more than 200 trees were downed, and one person was killed when a tree fell onto their vehicle.
10/26/20	Santa Ana Mountains and Foothills	61	Unknown	A strong offshore wind, a “cool” Santa Ana, produced many gusts exceeding 70 mph and a top gust of 88 mph at Fremont Canyon. The winds toppled big-rig trucks and downed mature trees in the northern Inland Empire. The dry winds also contributed to spreading two fires, the Blue Ridge and Silverado fires in eastern Orange County.

Notes: kts = knots. One knot is equal to 1.151 mph.
(NOAA 2024a)

3.2.7.3 Location/Geographic Extent

Drought

Droughts occur over large regions and thus can affect the entire planning area.

Extreme Heat

Extreme heat can occur anywhere in the planning area; however, areas farther from the coast are expected to experience hotter temperatures than coastal communities. For many coastal communities, warmer temperatures are expected to have greater impacts on residents living in homes without air conditioning. Extreme heat events occurring throughout the planning area could also impact utilities and infrastructure if power loss occurs either due to grid reliability or the use of a public safety power shutoff.

Windstorm

Santa Ana winds blow westward through the canyons toward the coastal areas of Southern California. Orange County commonly experiences Santa Ana winds between October and March.

The winds are not location specific, but rather impact the entire planning area in different ways based on location, topography, and the nature of the wind event itself.

3.2.7.4 Magnitude/Severity

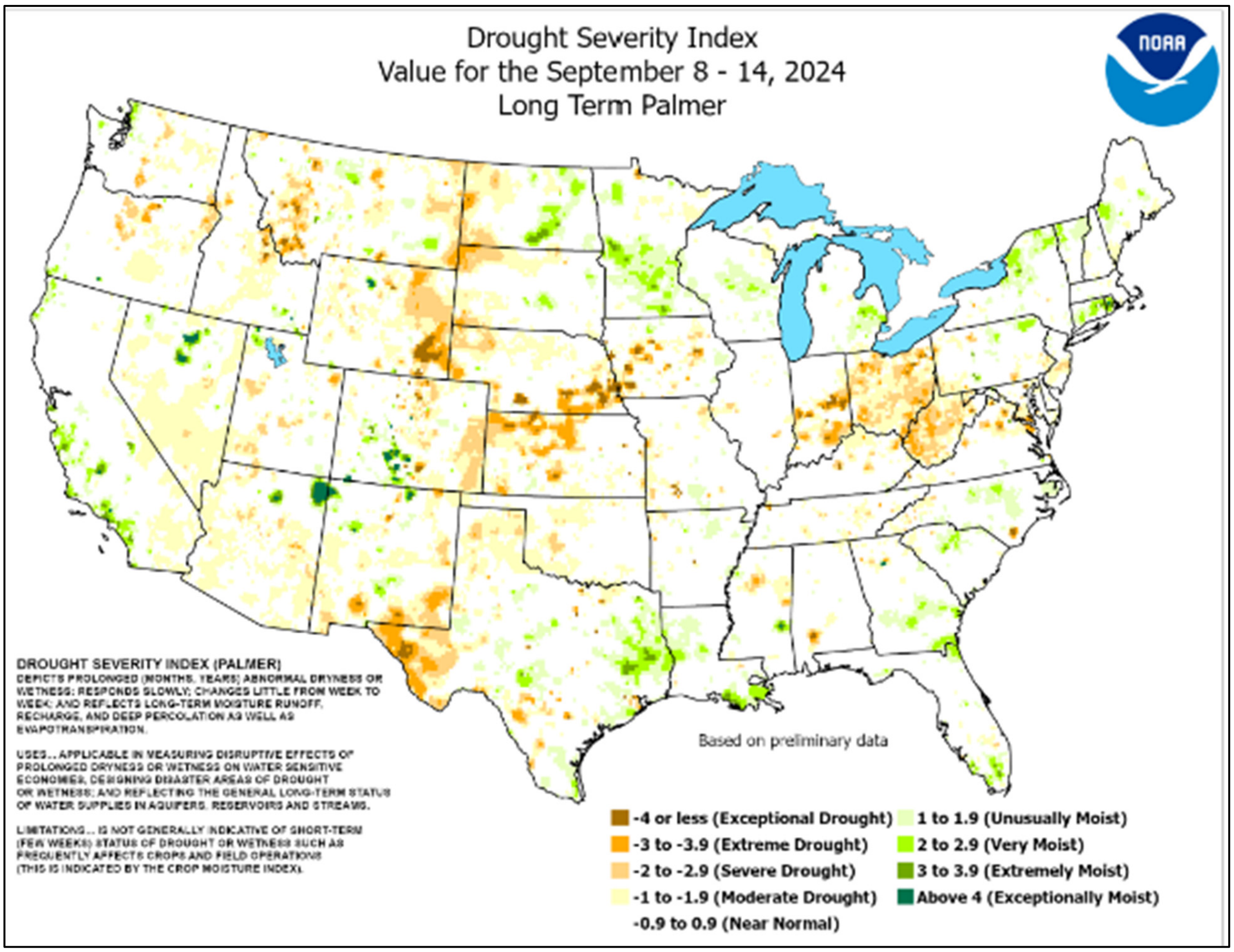
Drought

Of the many varied indexes used to measure drought, the PDSI is the most commonly used in the United States. Developed by meteorologist Wayne Palmer, the PDSI is used to measure dryness based on recent temperature compared to the amount of precipitation. It utilizes a number range, where 0 indicates normal conditions, negative numbers indicate drought, and positive numbers indicate wet spells; refer to **Exhibits 3-26 and 3-27.**

Exhibit 3-26. Palmer Drought Severity Index

Drought	Wet Spells
-4.0 or less (Extreme Drought)	+2.0 or +2.9 (Unusual Moist Spell)
-3.0 or -3.9 (Severe Drought)	+3.0 or +3.9 (Very Moist Spell)
-2.0 or -2.9 (Moderate Drought)	+4.0 or above (Extremely Moist)
-1.9 to +1.9 (Near Normal)	

Exhibit 3-27. September 8, 2024, PDSI



Extreme Heat

The minimum threshold for an extreme heat day in the planning area is 93.4°F. The minimum threshold for a warm night in the planning area is 65.1°F. These values are displayed below in **Exhibit 3-28** and **Exhibit 3-29**.

Exhibit 3-28. Average Number of Extreme Heat Days

Scenario	Historic (1961-1990)	Projected (2020-2050)	Projected (2050-2070)	Projected (2070-2099)
RCP 4.5	3	8	11	16
RCP 8.5	3	9	18	31

Exhibit 3-29. Average Number of Warm Nights

Scenario	Historic (1961-1990)	Projected (2020-2050)	Projected (2050-2070)	Projected (2070-2099)
RCP 4.5	5	22	32	42
RCP 8.5	5	25	54	88

Cal-Adapt uses an emissions scenario when determining the data in its projections. An emissions scenario is a representation of future greenhouse gas emissions and resulting atmospheric concentrations through time. An emissions scenario illustrates a plausible future so that climate projections for that emissions scenario can be generated, used to inform analysis and decision-making, and compared to other scenarios. The data for these scenarios uses what are called representative concentration pathways (RCPs), which are different scenarios for the future severity of climate change, and comes from California's Fourth Climate Change Assessment, which uses two RCPs from the Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment Report on Climate Change (Cal-Adapt 2024).

- **RCP 4.5 (medium emissions scenario):** A mitigation scenario where greenhouse gas (GHG) emissions peak by 2040 and decline. In California, annual average temperatures under this scenario are projected to increase 2°C to 4°C (35.6°F to 39.2°F) by the end of this century, depending on the location.
- **RCP 8.5 (high emissions scenario):** A no-mitigation scenario where global GHG emissions continue to rise throughout the 21st century. In California, annual average temperatures under this scenario are projected to increase 4°C to 7°C (39.2°F to 44.6°F) by the end of this century.

Based on these scenarios, extreme heat days throughout the planning area could increase from three days to 31 days by the end of the century. In addition, the average number of warm nights could increase from five nights to 88 nights during that same period.

Windstorm

Wind speeds are typically 35 knots through and below passes and canyons with gusts to 50 knots. Stronger Santa Ana winds can have gusts greater than 60 knots over widespread areas with gusts greater than 100 knots in some areas. Frequently, the strongest winds in the Orange County Groundwater Basin occur during the night and morning hours due to the absence of a sea breeze. The sea breeze, which typically blows onshore daily, can moderate the Santa Ana winds during the late morning and afternoon hours. Santa Ana winds are an important forecast challenge because of the high fire danger associated with them. Santa Ana winds can adversely affect power utilities that have transformers and power lines, in turn affecting the ability of some water and wastewater utilities to operate when backup generation is unavailable. The magnitude and severity of Santa Ana winds are similar throughout the planning area.

3.2.7.5 Probability of Future Occurrences

Drought

The University of Nebraska-Lincoln has published PDSI maps analyzing trends over the past 100 years (NDMC 2024). In coastal Southern California, from 1895 to 1995, severe droughts occurred 10% to 15% of the time. From 1990 to 1995, severe droughts occurred 10% to 20% of the time.

Based on the droughts listed in **Exhibit 3-24**, Orange County has been in severe or extreme drought for a total of 443 months, or approximately 35.5% of the time since 1920 and approximately 57.7% of the time since 1960.

Extreme Heat

Given past occurrences of extreme heat events in the planning area, it is expected that these types of events will occur in the future. What is expected in the future is that extreme heat events will increase in both frequency and duration. With the projected increases in extreme heat days and warm nights, the probability of future occurrence is highly likely.

Windstorm

High winds, including Santa Ana winds, will continue to occur annually in Orange County. The probability of future occurrence throughout the planning area is high.

3.2.7.6 Climate Change Considerations

Drought

Climate change is anticipated to abate drought in certain situations; however, projections suggest that future drought events could become more frequent and intense. In some cases, climate change-intensified weather patterns, like El Niño Southern Oscillation (ENSO), may bring more rain to California and the planning area, reducing drought conditions. In other years, climate change may also prolong the La Niña phase of ENSO, which could lead to longer periods with no precipitation in California.

Climate change is also expected to increase the average temperature and cause more frequent and prolonged heatwaves in the region. During these events, water supplies may be affected within the planning area. Hotter temperatures may also lead to increased surface water evaporation, which could lead to greater water consumption. If a drought occurs coupled with heatwave events, additional strain could be placed on water and wastewater infrastructure.

From a regional perspective, warmer overall temperatures in California are anticipated to reduce statewide water supplies. Much of California's water comes from melted snow in the High Sierra. As the average temperature grows warmer with climate change, the precipitation that falls as snow is expected to shift towards rain. As less snow falls, the amount of melted water from the snowpack in the Sierra Nevada will decrease, reducing the water that will flow into the reservoirs and aqueducts that supply Southern California. Reductions in water availability could strain supplies, impacting the quality and availability of water within the Orange County Groundwater Basin.

Extreme Heat

The primary effect of climate change is warmer average temperatures. The warmest decade on record is 2011-2020, and the warmest three years on record occurred in 2023, 2016, and 2020. As climate change accelerates in the 21st century, it is anticipated that extreme heat events will become more frequent and intense in California. In the planning area specifically, the projected average number of extreme heat days per year could increase from three to 16 (in 2100), assuming global greenhouse gas emissions peak around 2040, then decline. If global greenhouse gas emissions continue to rise until 2100, the number of extreme heat days could increase to as many as 31 days per year. The number of warm nights could increase from five to 42 (in 2100), assuming an emissions peak and decline in 2040 but could increase to as many as 88 if emissions continue to rise until 2100 (Cal-Adapt 2024).

Windstorm

It is anticipated that the atmospheric rivers that deliver storms to Southern California may intensify because of climate change. While the average number of storms in Southern California will remain the same, storms are expected to increase in intensity between 10% and 20% (Oskin 2014). This increase in storm intensity may also bring more intense winds to the Southern California region, including the planning area.

Studies indicate that Santa Ana wind events may be affected in varying ways by climate change, but it is unknown whether this will affect the frequency and intensity of these events. According to one study that examined two global climate models, there is a projected increase in future Santa Ana events. However, other studies have found that the number of Santa Ana events may decrease by about 20% in the future (Hall et al. 2018). Given the anticipated increases in temperatures throughout the region, future events are anticipated to become more severe in some cases, even if the number of events decreases.

3.2.8 Wildland/Urban Fire

3.2.8.1 Description (Nature) of the Hazard

Wildland Fire

A variety of fire protection challenges exist within Orange County, including structure fires, urban fires, wildland fires, and fires at the wildland/urban interface. This hazard analysis focuses on wildland fires, but also addresses issues specifically related to the wildland/urban interface. There are three categories of interface fires:

- The classic wildland/urban interface exists where well-defined urban and suburban development presses up against open expanses of wildland areas;
- The mixed wildland/urban interface is characterized by isolated homes, subdivisions and small communities situated predominantly in wildland settings; and
- The occluded wildland/urban interface existing where islands of wildland vegetation occur inside a largely urbanized area.

Certain conditions must be present for significant interface fires to occur. The most common conditions include hot, dry, and windy weather; the inability of fire protection forces to contain or suppress the fire; the occurrence of multiple fires that overwhelm committed resources; and a large fuel load (dense vegetation). The three primary factors that lead to severe wildfires in Orange County are drought, insect infestation causing tree decimation (bark beetles), and wildfire suppression. Once a fire has started, several conditions influence its behavior, including fuel topography, weather, drought, and development.

A key challenge Orange County faces regarding the wildfire hazard is the increasing number of houses being built in the wildland/urban interface. Every year the growing population has expanded further and further into the hills and mountains, including forest lands. The increased "interface" between urban/suburban areas and open space areas has produced a significant increase in threats to life and property from fires and has pushed existing fire protection systems beyond original or current design and capability.

Urban Fire

An urban fire is a fire that causes damage to buildings or infrastructure in an urban area. In some minor situations, the fire prompts the evacuation of the building's occupants, and the fire is contained within a short amount of time by firefighting teams or the building's fire suppression systems. In severe cases, the fire leads to the complete destruction of the building and can spread to other surrounding properties. Common causes of urban fires include stoves that are accidentally left on, short-circuited electrical equipment, or mishandling of household tools. Larger urban fires may be caused by breaches in gas pipelines, large transportation accidents, or downed electrical transmission wires. Fires may also be intentionally started by arsonists.

3.2.8.2 History/Past Occurrences

Wildland Fire

Although no federally declared wildfire disasters have occurred in Orange County, significant wildfires have impacted Orange County and surrounding areas. Since 1950, the NOAA reports 28 wildfire events occurring in Orange County. **Exhibit 3-30**, Major Wildfires, identifies significant fires that have occurred since 1950.

Exhibit 3-30. Major Wildfires

Date	Location	Description
8/22/2000	San Clemente	Hot temperatures and dry conditions allowed a brush fire to quickly race uphill and ignite the underside of two roofs. Fifteen families were evacuated as more than 40 firefighters worked for several hours to control the blaze.
9/11/2000	San Clemente	A wild fire was fanned by east winds and burned 500 acres before being contained.
8/7/2001	Laguna Beach	A wild fire in a steep canyon near the main toll plaza on the San Joaquin Hills Toll Road (Highway 73).
9/9/2001	El Toro	A brush fire burned 30 acres before it was brought under control.
1/23/2002	Trabuco	Santa Ana winds gusted between 60 to 70 mph for several days across Southwest California.
5/13/2002	Mission Viejo	Extremely dry conditions, above normal temperatures, and gusty winds helped a brush fire, started by an arsonist, to quickly consume 1,100 acres before being controlled. Two trucks and one structure were destroyed. Many residential homes suffered smoke damage and residents were evacuated. Traffic was halted on Highway 241. No injuries occurred.
2/6-12/2006		Santa Ana winds and Red Flag conditions resulted in the rapid spread of a wildfire in the Santa Ana Mountains. Named the Sierra Fire, this fire burned

Date	Location	Description
		10,854 acres from Sierra Peak to the 241 Toll Road. While evacuations were ordered, no structures were burned. Eight minor injuries were reported.
3/11-14/2007	Santa Ana Mountains and Foothills	The Windy Ridge Fire was intentionally set during the early stages of a Red Flag event at the mouth of Fremont Canyon. Humidity values less than 10% and wind gusts in excess of 40 mph caused the fire to spread quite rapidly across the rain starved hillsides. At the time of the fire, the Santa Ana Fire Station had only measured 1.81 inches of rain on the season, nearly 9 inches below the average rainfall for that date. Mandatory evacuations were posted for 1,200 homes in Anaheim Hills and Orange as the wind-driven fire spread westward. The fire burned 2,036 acres, damaged one home, and destroyed two out-structures before it was extinguished.
10/21/2007	Santa Ana Mountains and Foothills	The Santiago Fire was intentionally set and burned 28,400 acres in Modjeska and Santiago Canyons. The fire destroyed 15 homes and nine outbuildings. An additional 20 structures were damaged. Sixteen firefighters were injured during the blaze.
9/23/2010	Santa Ana Mountains and Foothills	The Long Canyon Fire started in the Cleveland National Forest in eastern Orange County, west of the Ortega Highway near the Riverside County line. Some structures were threatened, but the fire generally burned away from the populated areas, 40 acres total. Three firefighters and one police officer suffered non-life-threatening heat-related and smoke inhalation injuries. One of the Cleveland National Forest's fire engines was destroyed by fire, cause unknown, no injuries.
8/5/2013	Santa Ana Mountains and Foothills	The Falls Fire started off Ortega Highway near Decker Canyon, in Riverside. Due to the fire burning on the Trabuco Ranger District, the San Mateo Wilderness, El Cariso Campground, Blue Jay Campground, the Firefighter Memorial Picnic Area and Wildomar Off-Highway Vehicle area were closed. Road closures included Ortega Hwy 74 from Lake Elsinore west to San Antonio Parkway. Evacuations were ordered for Lakeland Village, Rancho Capistrano and Decker Canyon residents. Evacuation perimeter was between Grand/Ortega and Grand/Corydon. No structures were threatened and no injuries. Minor guardrail damage occurred because of a rock fall along Ortega Highway. The fire burned 1,416 acres before being fully contained.
9/12-13/2014	Santa Ana Mountains and Foothills	The Silverado Fire began along Silverado Canyon Road in the Cleveland National Forest of the Santa Ana Mountains. The fire burned at a critical rate of spread, threatening power lines and forcing evacuations and road closures. Mandatory Evacuations were ordered from 30331 Silverado Canyon east to the end of the road (fire gate) and included 50 residences affecting approximately 220 people. The American Red Cross opened an evacuation center at 3:30 p.m. at El Modena High School at 3920 East Spring Street. The 12kV line servicing Silverado residents was down. One pole and the downed lines required replacement. There were 71 customers without power in Silverado Canyon. After burning a total of 1,600 acres, the Silverado Fire was completely contained.
9/25/2017	Santa Ana Mountains and Foothills	The Canyon Fire began near Highway 91 in Orange County. The fire spread rapidly due to dry fuel conditions and very low humidity, and firefighting efforts were hindered by a transition from light Santa Ana winds to onshore flow. This initially pushed the fire into the foothills before sending it back eastward toward Corona. The fire was estimated at 1,700+ acres and was threatening residences. Winds calmed over the ensuing days and the fire

Date	Location	Description
		was quickly contained at 2,662 acres. The cause of the wildfire was determined to be a roadside flare.
10/9/2017	Orange County Inland	The Canyon Fire began near the 91 Freeway and Gypsum Canyon Road in Anaheim Hills. The fire spread rapidly, threatening numerous structures. In the first 24 hours the fire consumed more than 7,000 acres. In total, 25 structures were destroyed, 55 were damaged, and 9,217 acres burned. Four injuries were also reported. The cause of the fire was reported to be embers from the Canyon Fire which began September 25 and was contained October 4, 2017.
08/06/2018	Cleveland National Forest	The Holy Fire was a wildfire that burned in the Cleveland National Forest in Orange and Riverside Counties, California. The wildfire started on August 6, 2018, at around 1:15 p.m. Pacific Daylight Time (PDT), in the vicinity of Trabuco Canyon. It burned approximately 23,136 acres, destroyed 18 structures, and caused more than $25 million in damages. Three firefighters were injured battling the fire, no fatalities were reported.
10/26/2020	Santa Ana Mountains and Foothills	The Silverado Fire started near Orange County Route S-18 (Santiago Canyon Road) and Silverado Canyon Road, fueled by strong Santa Ana winds gusting up to 80 mph (130 km/h) and low humidity. The fire burned in a path similar to that taken by the 2007 Santiago Fire, mostly through terrain that had not seen significant burning in the 13 years since that fire. The fire consumed over 13,390 acres, destroyed one structure, two minor structures and damaged five others. Two firefighters were seriously burned battling this fire, both men survived. Over 90,000 people were forced to be evacuated as a result.
10/26/2020	Orange County Inland	A second brush fire ignited in Southern California amid dangerous high winds, which prompted evacuation orders for Yorba Linda. The blaze was initially dubbed the Green Fire but was later renamed the Blue Ridge Fire. This brush fire started in the Chino Hills area of Corona, west of the Santa Ana River. Spreading west toward Brea. The fire burned some 13,694 acres destroying one structure and damaging 10 others, as a result over 30,000 people were evacuated.
12/2/2020	Santiago Canyon	The Bond Fire was a wildfire that burned 6,686 acres in the Santiago Canyon area of Orange County, California in December 2020. The fire caused evacuations of 25,000 residents and injured two firefighters. The fire was very close to the burn scar of the Silverado Fire, which took place in October 2020. The fire destroyed 31 structures.
05/11/2022	Laguna Niguel	The Coastal Fire was a brushfire which started in the wilderness area near a Laguna Niguel neighborhood, burned approximately 200 acres and destroyed 20 homes in the neighborhood. One injury to a fire fighter was reported.
09/09/2024	Santa Ana Mountains, Trabuco Canyon	The Airport Fire was unintentionally ignited by an Orange County public works crew using heavy equipment in Trabuco Canyon. The fire burned over 23,000 acres in the Cleveland National Forest, destroying 160 structures and damaging another 34. Although this incident started in Orange County a majority of the affected areas are located in Riverside County on the eastern slopes of the Santa Ana Mountains.

(NOAA 2024a)

At 9:01 a.m. on November 15, 2008, the Corona Fire Department responded to calls reporting a brush fire in Riverside County. Upon arrival it became apparent to first responders the fire would be significant and of a highly destructive nature. At the time of the alarm a Red Flag Warning had been in effect due to low humidity levels, high temperatures, and strong Santa Ana winds. These conditions along with the terrain of the areas burned facilitated the rapid growth and spread of the fire and significantly affected first responder's efforts of containment and in the protection of property and lives. Initial calls reported the fire's location as west of the Green River Exit off the 91 Freeway in Riverside County. From there the fire quickly advanced in a Northwesterly direction towards Orange County where the fire split into two separate branches shortly after crossing over the county line; the first branch of the fire followed the Santa Ana River Basin southwest into Anaheim hills, and the second continued northwest into Yorba Linda. Both branches of the fire became of concern to the water utilities of Orange County as the fire threatened infrastructure or moved into the service areas of Anaheim, Brea, the YLWD, and Metropolitan's Diemer Filtration Plant facility. Eventually, the fire burned through approximately 30,305 acres and damaged or destroyed over 300 structures in Riverside, San Bernardino, Los Angeles, and Orange counties.

A brush fire erupted along State Route 241 near Santiago Canyon Road in Irvine on the morning of July 13, 2015. Campgrounds near Irvine Lake were evacuated, and three abandoned structures caught fire. The blaze encompassed a total of approximately 214 acres. Around one year later, a fire occurred in the Laguna Coast Wilderness Park near Bommer Ridge Trail on June 26, 2017. The fire burned approximately 47 acres and was reported as contained on June 27, 2017. On August 31, 2016, the Holy Fire started in the early morning just east of Trabuco Canyon in the Cleveland National Forest. The blaze did not threaten any homes; however, it was in an area around Holy Jim Canyon that was difficult for firefighters to reach. The fire burned through approximately 150 acres.

Most recently on September 9, 2024, the Airport Fire erupted in the Cleveland National Forest (in the vicinity of Trabuco and Rose Canyons) burning over 23,000 acres in both Orange and Riverside Counties. Impacts associated with the fire included nearly 200 damaged and destroyed structures and 22 injuries. No loss of life was reported as a result of this incident.

Urban Fire

A majority of the water/wastewater infrastructure locations throughout the planning area are located in developed areas. Many of these sites are surrounded by existing developments and run a low risk of ignition due to the use of non-combustible materials, and limited vegetation. Even with these typical site conditions on most utility locations, there is still the potential for fires to occur. To date, no significant fire events within the more developed portions of the planning area have occurred affecting water/wastewater infrastructure.

The Coastal Fire (05/11/2022) took place in a wildland/urban interface area within Aliso and Wood Canyons causing damage to the SOCWA Coastal Treatment Plant and affecting wastewater treatment plant operations.

3.2.8.3 Location/Geographic Extent

Wildland Fire

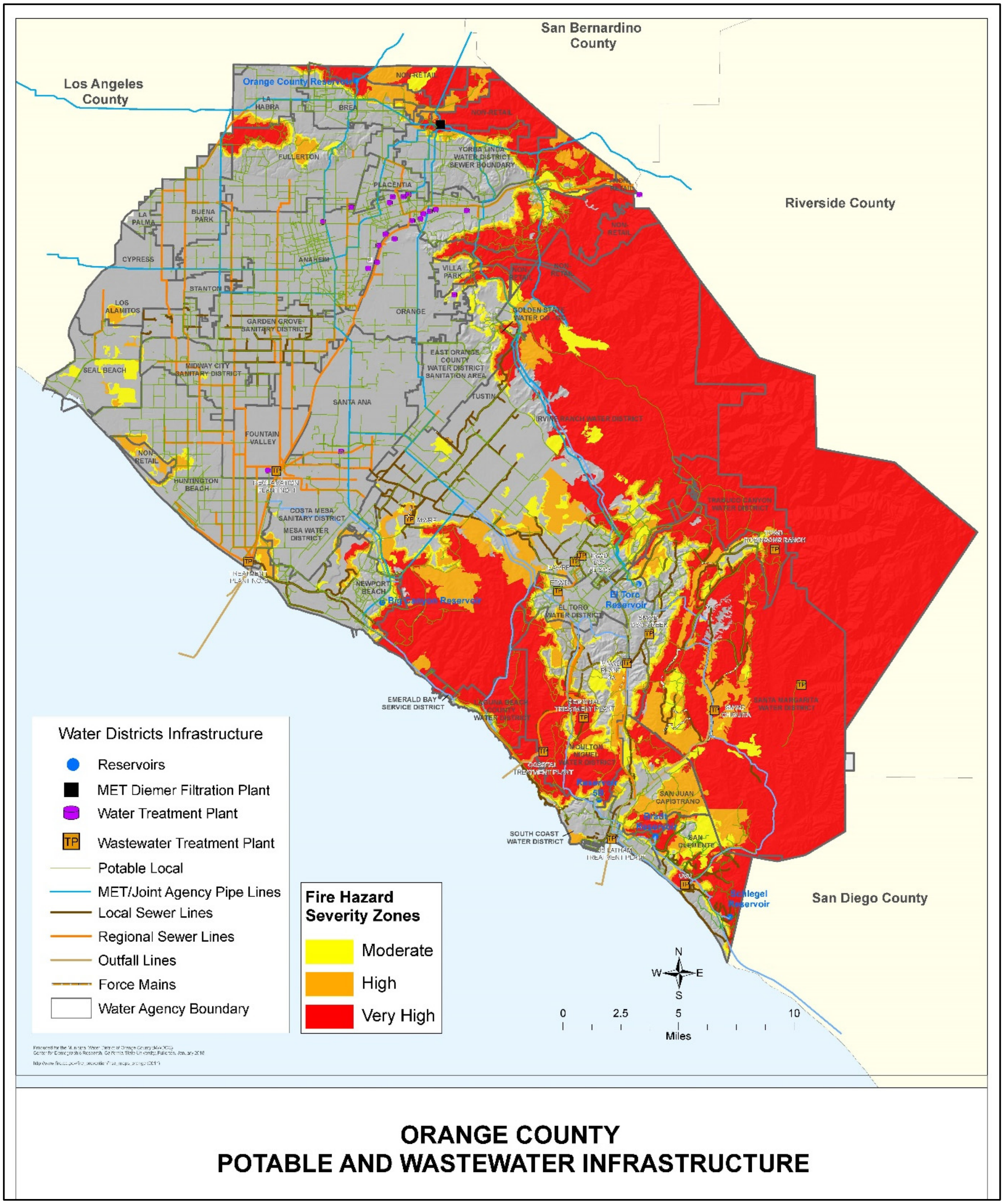
California Department of Forestry and Fire Protection (Cal Fire) prepares fire hazard severity maps including mapping areas of significant fire hazards based on fuels, terrain, weather, and other relevant factors. These zones, referred to as Fire Hazard Severity Zones (FHSZ), define the application of various mitigation strategies, and influence how people construct buildings and protect property to reduce risk associated with wildland fires. According to **Exhibit 3-31**, the southern and eastern portions of Orange County are located within High and Very High Fire Severity Zones.

Urban Fire

Most buildings in the planning area consist of wooden-frame construction, which is vulnerable to catching fire. Structures that do not have wooden frames, such as large wastewater and processing facilities, pumping stations, and other infrastructure are also potentially at risk of urban fires. These locations contain furniture, paper, chemicals, plant material, textiles, and other objects that can be ignited. Given that a very large portion of the planned area is developed, urban fires can occur at any location.

Fires are also likely to occur where there are other types of major infrastructure, such as gas pipelines, power lines, or highways. For example, SCE owns and operates above-ground, high-voltage transmission lines strung from towers on rights-of-way throughout the planning area. The planning area is also crisscrossed by multiple freeways (State routes) and interstates. These freeways/interstates facilitate the transportation of people and goods, which leads to an immense amount of traffic every day. If a major transportation accident were to occur on any of these freeways or roads, it could potentially cause a fire and spread to nearby facilities, buildings, and infrastructure within the planning area.

Exhibit 3-31. Fire Hazard Severity Zones



3.2.8.4 Magnitude/Severity

Wildland Fire

California experiences large, destructive wildland fires almost every year, and Orange County is no exception. Wildland fires have occurred within Orange County, particularly in the fall, ranging from small, localized fires to disastrous fires covering thousands of acres. The most severe fire protection problem is wildland fire during Santa Ana wind conditions. These conditions have been further exacerbated by more recent drought conditions. Drought causes fuels (both live and dead vegetation) to dry out and become more flammable, increasing the probability of ignition along with the rate of fire spread. If drought continues for an extended period, the number of days with elevated probability of ignition and fire spread increases, raising the risk of widespread burning. The combination of drought conditions, need to maintain water fire flow and the potential for power failure due to Santa Ana wind conditions can impact the magnitude and severity of fires within the planning area.

The magnitude/severity of a wildfire would be dependent upon the location and conditions (e.g., Santa Ana winds) in place at the time. The Fire Hazard Severity Zone maps prepared by Cal Fire (refer to **Exhibit 3-31**) identify the extent and severity of the fire hazard zones within Orange County. Although a fire could start and/or extend beyond these areas, they identify the areas of severity so that measures can be identified to mitigate the rate of spread and reduce the potential intensity of uncontrolled fires that threaten to destroy resources, life, or property.

Urban Fire

A fire can only ignite if three elements are present: heat, fuel, and oxygen. If any one of these elements is removed, the fire will extinguish itself. Throughout the planning area, hundreds of thousands of structures have the ability to provide fuel to an urban fire. The National Institute of Standards and Technology, Fire Research Division has developed a scale that measures the increase in temperature and the kind of fire response that develops. **Exhibit 3-32** shows the progression of temperature relative to fire response.

Exhibit 3-32. Fire Susceptibility Based On Temperature Increase

Temperature (°F)	Response
98.6 °F	Average normal human oral/body temperature.
101 °F	Typical body core temperature for a working firefighter.
109 °F	Human body core temperature that may cause death.
111 °F	Human skin temperature when pain is felt.
118 °F	Human skin temperature causing a first-degree burn injury.
130 °F	Hot water causes a scald burn injury with 30 seconds of exposure.
131 °F	Human skin temperature with blistering and second degree burn injury.
140 °F	Temperature when burned human tissue becomes numb.
162 °F	Human skin temperature at which tissue is instantly destroyed.
212 °F	Temperature when water boils and produces steam.
482 °F	Temperature when charring of natural cotton begins.
>572 °F	Modern synthetic protective clothing fabrics begin to char.
≥752 °F	Temperature of gases at the beginning of room flashover.
≈1832 °F	Temperature inside a room undergoing flashover.

Once a fire has been ignited, it could conceivably grow to an indefinite size if abundant fuel and oxygen are available. For example, a fire that ignites in one structure could hypothetically continue to expand and even spread to other adjacent structures if there was enough fuel to link the structures together. Fires in confined spaces may occasionally burn so intensely that they consume all the oxygen available and burn out before they can expand. The magnitude and severity of urban fires would be dependent upon the location and the conditions in place at the time. A fire in or near a small structure in an isolated area would not be as severe as a fire in or near a large facility or piece of infrastructure when considering the monetary cost or replacement. However, that same small structure could be a key piece of infrastructure required to maintain the function of services in the planning area and could be considered a greater concern for the people who rely on it for their daily needs.

3.2.8.5 Probability of Future Occurrences

Wildland Fire

Wildfires are a regular feature of many of California's ecosystems and will continue to be in the future. Since the northern, eastern, and southern portions of Orange County are considered wildland/urban interface areas, the county has a higher probability of wildfire risks in those communities and surrounding areas. The specific chance of wildfire in Orange County's wildland/urban interface is not known, but the general vulnerability of the area to fires means that there is a reasonable possibility such an event will occur. According to the Planning Team and based on conditions experienced within the last several years, the probability of Orange County experiencing wildfires is highly likely—near 100% probability in the next year or happens every year.

Urban Fire

If the conditions for an urban fire exist in the planning area, the planning area will forever be at risk of experiencing an urban fire event. It is impossible to predict the precise likelihood and location of an urban fire emerging in the planning area, given how each fire event has unique origins. However, some areas are at an increased risk, including facilities, buildings, and infrastructure located along or adjacent to natural gas transmission pipelines, powerlines, and the many freeways and roads that run through the planning area. Given the vast amount of activity and fuel and chemicals that pass through the region, the likelihood of an urban fire outbreak in the planning area is probable.

3.2.8.6 Climate Change Considerations

Wildland Fire

Climate change is expected to cause an increase in temperatures and more frequent and intense drought conditions. This increase will likely increase the amount of dry plant matter available for fuel, increasing wildfire risk statewide. Climate change is expected to increase the number of acres burned annually in the foothills and mountainous areas of Orange County, which are already highly prone to wildfires. However, increases in fuel supplies could cause wildfires to move faster or spread into more developed areas, increasing the future threat for the planning area.

Urban Fire

While climate change has been linked to a potential increase in wildfire events, it is not clear exactly how climate change could influence the ignition or behavior of urban fires in the planning area.

3.3 Vulnerability Assessment

Vulnerability describes how exposed or susceptible to damage an asset is, and depends on an asset's construction, condition, contents, and the economic value of its functions. A vulnerability analysis predicts the extent of injury and damage on the existing and future built environment that may result from a hazard event of a given intensity in a given area. Due to the interrelatedness of water and wastewater infrastructure and the role each has in public health and safety, vulnerabilities in one community are often related to vulnerabilities in another. Indirect effects can be much more widespread and damaging than direct effects. For example, damage to a major water utility line could result in significant inconveniences and business disruption that would far exceed the cost of repairing the utility line.

The vulnerability assessment quantifies, to the extent feasible using best available data, assets at risk to hazards and estimates potential losses. This section focuses on the risks to the planning area; data for each of the MAs was also evaluated and is included here and in the Jurisdictional Annexes.

3.3.1 Asset Inventory

Hazards that occur in Orange County can impact critical facilities located throughout the county. For this 2024 MJHMP, a critical facility is defined as public infrastructure used to provide potable water to the public and maintain wastewater services, necessary to maintain public health and safety. Critical facilities associated with potable water services located within the planning area include wells, water storage tanks, reservoirs with dams, water treatment plants, pump stations, pressure reducing stations, emergency interties, service connections, pipelines, and administrative buildings and utility yards; refer to **Exhibit 3-34, Summary Assets,** at the end of this section. Critical facilities associated with wastewater services located within the planning area include wastewater treatment plants, lift stations, pipelines, and administrative buildings and utility yards (**Exhibit 3-35**).

3.3.2 Estimating Potential Exposure and Losses

Orange County covers 948 square miles with several different climate patterns and types of terrain, from the coast to the mountains, which allows for several hazards to affect various parts of Orange County, as described above. Due to the vast area, a hazard event could impact a single jurisdiction or multiple jurisdictions.

To assess the changing conditions within the planning area, an updated analysis of new water and wastewater infrastructure constructed since the last update was developed to inform the 2024 MJHMP update. As part of this update, the infrastructure mapping for new assets was overlaid with hazards having a physical geographic location to estimate exposure to water and wastewater infrastructure. Hazard areas and infrastructure overlays were conducted for wildfires, flooding, fault rupture, earthquakes, liquefaction, landslides, and tsunamis; refer also to the Jurisdictional Annexes. Hazards and infrastructure overlays were not conducted for the remaining hazards because data for these hazards was either not available or is not geographically distinct. Many of these hazards, such as drought, power outage, and high winds/Santa Ana winds affect the entire planning area; therefore, all water and wastewater infrastructure could be potentially susceptible to damage from them. For these hazards, quantitative analyses were not performed. Vulnerability assessments associated with these hazards are based on historic incidents and the knowledge that water and wastewater experts have of their critical facilities and the susceptibility of those facilities to these hazards.

For water and wastewater infrastructure pipelines, the length of exposure/impact is given in miles. Other critical facilities are identified by facility/structure type. Exposure characterizes the value of facilities/structures within the hazard zone and is shown as estimated exposure based on the overlay of the hazard on the critical facilities which are assigned a cost of replacement for each type of facility/structure exposed. These replacement costs for the critical facilities were identified by each MA. The loss or exposure value is then determined with the assumption that the given facility/structure is destroyed (worst-case scenario), which is not always the case in hazard events. This assumption was valuable in the planning process, so that the total potential damage value was identified when determining capabilities and mitigation measures for each MA.

Exhibit 3-33, Unit Replacement Costs of Facilities, provides average replacement costs used for critical facilities and infrastructure listed in all subsequent exposure/loss tables.

Exhibit 3-33. Unit Replacement Costs of Facilities

Abbreviation	Name	Replacement Cost
WST	Water Storage Tank	$20,000,000
RES	Reservoir (with a dam)	$50,000,000
WTP	Water Treatment Plant (Diemer Filtration Plant)	$350,000,000
WTP	Water Treatment Plant by retail agency	$10,000,000
PS	Pump Station (South County Pump Station)	$35,000,000
PS	Retail Water Agency Pump Station	$8,000,000
PRS	Pressure Reducing Station (Metropolitan facility)	$52,000,000
PRS	Pressure Reducing Station for retail agency	$2,000,000
EIT	Emergency Interties	$2,000,000
SC	Service Connector	$3,000,000
ADM	Administration (large administration building)	$8,000,000
LS	Wastewater Pump Station/Lift Station by OC San/SOCWA	$4,000,000
LS	Wastewater Pump Station/Lift Station by retail agency	$5,000,000
WWTP	Wastewater Water Treatment Plant	$30,000,000
WELL	Well	$5,000,000
PP	Power Plant (Metropolitan Yorba Linda Power Plant)	$12,000,000

(1) Based on the highest cost for typical facility from among the MAs' facility values submitted. These results are conservatively high replacement costs for some retail agencies.

Exhibit 3-34 provides the total inventory for the critical facilities and infrastructure by jurisdiction. Estimated exposure for critical infrastructure by MA is provided in the Jurisdiction Annexes. **Exhibit 3-35, Planning Area Critical Facilities and Infrastructure Exposure Costs by Hazard,** provides a summary of exposure for the planning area by hazard. The costs identified reflect cost of replacement in a worst-case scenario (defined as the highest cost submitted from among all the MAs in the study process, excluding the regional facilities, as this would overstate the local costs). For example, Garden Grove may have identified a cost of $3 million to replace a well and Buena Park may identify a cost of $3.5 million to replace a well; however, $3.5 million would be used as the replacement cost for all wells within the planning area. This methodology was used for consistency across the planning area and selection of the highest cost helps ensure that appropriate costs are considered when requesting grants. For any detailed proposals submitted to FEMA, actual costs for mitigation and detailed estimates of the benefits of the mitigation measure will be prepared and submitted. The costs included herein provide a relative measure of the impacts of the various hazards.

For additional detail on the exposure of facilities by MA, refer to the Jurisdictional Annexes. The Jurisdiction Annexes include a discussion of hazards and vulnerabilities specific to each MA, a discussion of their capabilities to address these losses, and identifies the actions to help mitigate damage to their infrastructure against hazards identified in the risk assessment.

3.3.3 Land Use and Development Trends/Changes in Development

The MAs provide water and wastewater services to majority of Orange County, which has a population of almost 3.2 million people. Depending upon the hazard and its magnitude and duration, a considerable number of people and businesses could be impacted. Of primary concern would be a hazard that results in the loss of water supply and wastewater services to the planning area. As discussed previously, a hazard could result in direct physical damage to water/wastewater infrastructure, as well as indirect damage resulting from business disruption.

Although Orange County is urbanized and predominately built out, the Southern California Association of Governments (SCAG) projects continued population, employment, and housing growth into 2040. The County of Orange and its incorporated cities maintain General Plans, which identify the planned growth and development for their respective jurisdictions. The planning area includes a wide variety of residential and non-residential land uses. Water and wastewater service providers will continue to work with the communities they serve to identify service needs, including the construction, expansion, or modification of water and wastewater infrastructure. The construction of new facilities or infrastructure will be completed in coordination with these communities to ensure compliance with appropriate codes and regulations, including consideration of potential hazards.

Population growth and development in Orange County has increased since 2012. According to the Department of Finance, the population for the county is expected to rise by approximately 0.31% in 2024 from the previous year. For a total population of approximately 3,150.835 people living within Orange County. Along with population growth has come an increase in development, increasing demands on water and wastewater infrastructure. Many Orange County cities have seen shifts in development toward higher-density residential and mixed-use development projects in response to the demand for housing.

Due to the highly developed nature of Orange County along with the presence of natural hazards throughout the area such as earthquakes, liquefaction, flood risk, and wildfires, development and population growth has continued to occur within areas of risk. Recent drought conditions have placed greater emphasis on the ability for new development to be served by water supplies and planning for prolonged drought conditions. Water and wastewater agencies continue to coordinate with Orange County, cities, and each other to meet the demands of the respective communities they serve while also strengthening regional and local infrastructure and overall reliability in the event of a hazard. MWDOC and many of the MAs have modified their infrastructure to include EOCs and water infrastructure, to mitigate potential threats.

3.3.4 Vulnerable Populations

Water supplies for safe drinking, sanitation, and hygiene are relied upon by the entire population. However, there are populations within the MA service areas that would be considered more vulnerable in the event of a hazard that affects water and wastewater infrastructure. These populations include those that are reliant on others for their wellbeing, such as young children, individuals with disabilities, individuals' dependent on medical equipment, and individuals with impaired mobility, as well as people with low socioeconomic levels. Vulnerable populations are more significantly impacted in the event of a hazard.

3.4 Summary of Vulnerability

Due to the nature of water and wastewater infrastructure and its location throughout Orange County, there is some form of infrastructure that intersects with a hazard area. **Exhibit 3-34** identifies the infrastructure that intersects with hazards that have a specific geographic area (e.g., fire hazard, liquefaction); however, the entire MA service area also intersects with hazards that are not geographically specific (e.g., drought, power outage). The variety of hazards and the varying magnitude and probability of occurrence make it challenging to assess the hazards that pose the greatest risk to the MAs. The potential losses vary greatly depending upon the hazard and resulting impact to infrastructure. The challenge is further magnified by the potential health and economic impacts that could occur in the event water supplies are disrupted.

Exhibit 3-34. Summary Assets

Member Agency	Facility/Infrastructure																											
	Existing																	Future										
	Wells	Dams/Reservoirs	Water Treatment Plant	Potable Water System Pipeline (mile)	Water Storage Tank	Pump Stations	Pressure Reducing Station	Imported Water Connections	Emergency Intertie	Hydrants	Potable Service Connections	Administrative/ Office/Lab/ Maintenance Facilities	Wastewater System Pipeline (mile)	Wastewater/Water Reclamation Plant	WW Service Connections	Sewer Lift Stations	Heli Pad/Heli Hydrant	Wells	Dams/Reservoirs	Potable Water System Pipeline (mile)	Water Treatment Plant	Administrative/Office/ Maintenance Facilities	Water Storage Tank	Pump Stations	Pressure Reducing Station	Wastewater System Pipeline (mile)	Lab	Sewar Lift Station
Metropolitan Water District of Orange County	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Orange County Water District	901	27	0	15	5	9	0	2	0	0	4	12	40	2	0	0	0	6	0	0	0	0	0	0	1	0	0	0
Orange County Sanitation District	0	0	0	0	0	0	0	0	0	0	0	1	380	2	0	16	0	0	0	0	0	0	0	0	0	0	1	0
South Orange County Wastewater Authority	0	0	0	0	0	0	0	0	0	0	0	6	25	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0
El Toro Water District	0	2	0	168	5	9	19	4	12	1,964	9,871	2	114	1	8,950	11	0	0	0	0	0	0	0	0	0	0	0	0
Laguna Beach County Water District	0	0	3	135	21*	14	19	3	14	952	8,800	2	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Mesa Water District	9	0	1	317	3	2	0	3	15	3,404	25,300	1	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
Moulton Niguel Water District	0	0	0	655	28	25	16	12	19	7,168	53,620	2	501	2	50,682	17	0	0	0	2	0	1	0	0	1	10	1	0
Santa Margarita Water District	0	3	0	626	34	21	25	22	4	4,250	54,254	1	630	3	57,537	19	0	0	2	3	0	0	22	21	25	20	0	0
Serrano Water District	2	1	1	43	2	5	0	1	0	370	2,385	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
South Coast Water District	1	0	2	169	14	9	25	4	18	1,694	17,240	9	140	1	14,764	13	0	1	0	0	0	0	1	0	0	0	0	1
Trabuco Canyon Water District	2	2	2*	65	9	12	11	2	6	600	4,150	2	47	1	3,670	8	0	1	0	2	0	0	2	2	5	2	0	0
Yorba Linda Water District	10	0	1	354	14	12	45	4	9	4,045	25,471	2	269	0	24,291	1	4	1	0	4	0	0	0	0	2	1	0	0
Irvine Ranch Water District	30	5	4	2,034	49	58	363	21	36	18,929	125,404	8	1,496	3	113,945	11	0	2	0	0	0	0	1	2	1	0	0	0
Costa Mesa Sanitary District	0	0	0	0	0	0	0	0	0	0	0	2	224	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0

(1) Regional water systems identified here are co-owned and managed by multiple utilities.

Exhibit 3-35. Planning Area Critical Facilities and Infrastructure Exposure Costs by Hazard

Hazard		Infrastructure Type														Replacement Costs
		Administration Buildings	Interties (#)	Pump Stations (#)	Treatment Plants (#)	Lift Stations (#)	Pressure Control Stations (#)	Reservoirs (#)	Water Storage Tanks (#)	Wells (#)	Effluent Pipeline (miles)	Potable Pipeline (miles)	Wastewater Pipeline (miles)	Manholes	Heli Pad/ Heli Hydrant	
Fire Hazard Zone	Moderate	0	14	13	0	7	0	13	0	0	0.5	45.02	37.78	0	0	$148,340,000
	High	0	5	6	1	0	0	13	0	1	1.0	59.03	66.8	0	0	$172,964,000
	Very High	0	24	48	2	10	1	72	1	5	1.6	151.14	101.75	0	0	$609,812,000
FEMA Flood Zone	100-Year	0	4	2	2	7	0	15	0	9	0.5	38.73	137.84	70	0	$183,256,000
	500-Year	0	18	7	2	11	4	8	0	38	2.1	106.05	308.36	535	0	$297,288,000
Alquist-Priolo Fault Zone		0	0	0	0	0	2	0	0	0	0	4.29	1.81	0	0	$440,000
Ground Shaking	Moderate	0	22	40	0	2	1	50	1	0	0	86.18	53.59	0	0	$391,736,000
	High	4	97	110	11	21	78	55	11	67	5.2	370.53	727.72	5,708	1	$1,387,396,357
	Extreme	1	24	25	1	10	1	43	0	26	0	169.53	391.85	48	2	$561,504,000
Liquefaction	Moderate	0	13	13	3	3	1	14	8	41	0	85.53	484.64	76	0	$321,936,000
	High	3	25	16	6	2	20	17	1	42	0	91.48	198.47	1,075	0	$553,840,000
	Very High	0	0	0	1	0	2	0	0	0	0	10.39	16.74	0	0	$23,104,000
	Unknown	0	13	7	1	1	0	1	0	7	0	54.45	100.4	0	0	$142,080,000
Landslide Zone		0	5	24	0	7	8	28	7	0	2.8	40.83	46.64	17	0	$227,676,000
Tsunami Zone		3	0	58	4	9	77	1	11	10	0.6	6.75	7.42	5,653	4	$299,752,357

(1) Based on the highest cost for typical facility from among the MAs' facility values submitted. These results are conservatively high replacement costs for some retail agencies.

SECTION 4: MITIGATION STRATEGY

Planning is the cornerstone to successful hazard mitigation efforts. Citizens, local government, and private interests with proactive policies can reduce damages and impacts associated with natural and human-caused hazards. Benefits realized by implementing hazard mitigation measures include:

- Saving lives by removing people from hazard-prone situations.
- Limiting property damage by regulating development in hazard areas.
- Reducing economic impacts by minimizing outages of essential services during and after these events.
- Saving money for taxpayers by reducing the need for services during a disaster.
- Speeding disaster recovery and post-disaster relief funds.
- Demonstrating a strong commitment to the health and safety of the community.

Relocating people, institutions, and businesses from hazard-prone areas saves property and lives. Removal or protection of the structures within hazard-prone areas means that there is less to pay for disaster recovery or for service outages during an event. Having alternative service plans for essential services, such as water and sewer operations, protects structures from fire and allows residents and businesses to continue functioning or to restore normal functions quicker following a disaster. Post-event, recovery crews will have less to do because there will be less damage. Implementation of these measures speeds the overall recovery process.

4.1 Hazard Mitigation Overview

The mitigation strategy and actions were developed by the Planning Team based on an in-depth review of the vulnerabilities and capabilities described in the plan. The mitigation actions described in the Jurisdictional Annexes represent each MA's risk-based approach for reducing and/or eliminating the potential losses as identified in **Section 3, Risk Assessment**.

As part of the update process, the hazard mitigation goals were reviewed and refined. It was determined that the overarching mitigation goals were the same for all MAs. Therefore, one set of goals were identified for the MJHMP, as discussed below. If additional, jurisdiction-specific goals were identified by an MA, they are included in the Jurisdictional Annex.

MAs provided a comprehensive review of their mitigation actions to assess their ability to reduce risk and vulnerability to the jurisdiction from identified hazards. Upon review of each mitigation action, an assessment was made as to whether the mitigation action should be carried forward into the 2024 MJHMP and/or be revised/modified or removed to reflect changing conditions or priorities. Mitigation actions that were deemed complete during the current plan period were identified and removed (refer to the Jurisdictional Annexes). New mitigation measures were also identified.

4.1.1 FEMA's National Flood Insurance Program

In 1968, the U.S. Congress created the National Flood Insurance Program (NFIP) to provide affordable insurance to property owners while also encouraging communities to adopt and enforce floodplain management regulations. Community participation is voluntary; however, it is required to receive certain grants and funding from FEMA. The Orange County Flood Division (OC Flood) is a participant in the program and administers the floodplains within the unincorporated areas of Orange County. Within the incorporated areas, Orange County cities administer their floodplains.

Since the creation of NFIP, OC Flood has worked cooperatively with cities in Orange County to reduce the floodplain area by constructing flood control facilities that provide 100-year flood protection. Such facilities typically traverse through the cities and ultimately outlet into the Pacific Ocean. All cities within Orange County are participants in the program. As participants in this HMP update, both water and wastewater districts do not participate in the NFIP nor do they monitor properties within their jurisdictional boundaries as this responsibility falls on the county or cities they support.

Repetitive Loss Properties

According to the NFIP, a repetitive loss structure is an insured building that has had two or more losses of at least $1,000 each being paid under the NFIP within any 10-year period since 1978. MWDOC and MAs are not participants in the NFIP. Based on this status they do not regulate flood management for other property owners and solely focus on flood management of their owner properties/facilities.

4.2 Hazard Mitigation Goals

Mitigation goals are defined as general guidelines explaining what each jurisdiction wants to achieve in terms of hazard risk reduction and loss prevention. Goal statements are typically long-range, policy-oriented statements representing jurisdiction-wide visions. The goals identified in the previous plan were reviewed by the Planning Team. Through the update process, it was determined that these previous goals were adequate and relevant to MWDOC and the MAs. Based on discussions with the Planning Team only minor revisions to two goals were recommended to better align with current priorities. The following hazard mitigation goals have been identified for this 2024 MJHMP:

- **Goal 1:** Minimize vulnerabilities of critical facilities and infrastructure to minimize damages, loss of life, and injury to human life caused by hazards.
- **Goal 2:** Minimize security risks to water and wastewater infrastructure.
- **Goal 3:** Minimize interruption to water and wastewater utilities.
- **Goal 4:** Improve public outreach, awareness, education, and preparedness for hazards in order to increase the community resilience.
- **Goal 5:** Eliminate or minimize wastewater/recycled water spills and overflows (wastewater agencies).
- **Goal 6:** Protect water quality and supply, critical aquatic resources, and habitat to ensure a safe water supply.
- **Goal 7:** Strengthen emergency response services, workforce training, and education enhancement to ensure preparedness, response, and recovery during any major or multi-hazard event.

The MJHMP goals guide the direction of future activities aimed at reducing risk and preventing loss from natural and human-caused hazards. The goals also serve as checkpoints as the MAs begin implementing mitigation action items. Mitigation goals do not account for implementation cost, schedule, funding sources, etc. Goals represent what each MA wants to achieve, whereas the mitigation actions provide the actions needed to achieve the goals.

4.3 Identify and Prioritize Mitigation Actions

Mitigation actions were identified, evaluated, and prioritized by the MAs. They provide a list of activities that the MAs will use to reduce their risk of potential hazards. Some of these actions may be eligible for funding through Federal and State grant programs and other funding sources as made available by the MAs or other agencies/organizations. The mitigation actions are intended to address the comprehensive range of identified hazards for each MA, while some actions may address risk reduction from multiple hazards.

A detailed list of mitigation actions for each MA is provided in their respective Jurisdictional Annexes. The process used by the Planning Team to identify hazard mitigation actions for this MJHMP included the following:

- Review of the risk assessment presented in **Section 3**;
- Review of the capabilities assessment presented for each MA in the Jurisdictional Annexes; and
- Team discussion of new concerns/issues that need to be addressed to reduce hazards to critical water/wastewater infrastructure.

The mitigation actions identify the hazard, proposed mitigation action, location/facility, local planning mechanism, risk, cost, timeframe, possible funding sources, status, and status rationale, as applicable.

MAs conducted a capabilities assessment (provided in the Jurisdictional Annexes), to identify existing local agencies, personnel, planning tools, public policy and programs, technology, and funds that have the capability to support hazard mitigation activities and strategies outlined in this MJHMP. To identify the capabilities, the Planning Team collaborated to identify current local capabilities and mechanisms available for reducing damage from future hazard events. The capabilities and resources were reviewed while developing the 2024 MJHMP, and opportunities to enhance mitigation were identified where applicable. After completion of the capabilities assessment, each jurisdiction evaluated and prioritized their proposed mitigation strategies and actions.

FEMA's Social, Technical, Administrative, Political, Legal, Economic, and Environmental (STAPLEE) criteria was used to identify, evaluate, and prioritize mitigation actions based on existing local conditions. Using this method each MA considered the STAPLEE criteria regarding the feasibility and implementation of a mitigation action; refer to **Exhibit 4-1, STAPLEE Review and Selection Criteria.** This process was used to help ensure that the most equitable and feasible actions would be undertaken based on each MA's unique capabilities.

Exhibit 4-1. STAPLEE Review and Selection Criteria

STAPLEE Review	Selection Criteria
Social	Is the proposed action socially acceptable to the jurisdiction and surrounding community? Any equity issues involved that would mean that one segment of the jurisdiction and/or community is treated unfairly? Will the action cause social disruption?
Technical	Will the proposed action work? Will it create more problems than it solves? Does it solve a problem or only a symptom? Is it the most useful action in light of other jurisdiction goals?

STAPLEE Review	Selection Criteria
Administrative	Can the jurisdiction implement the action? Is there someone to coordinate and lead the effort? Is there sufficient funding, staff, and technical support available? Are there ongoing administrative requirements that need to be met?
Political	Is the action politically acceptable? Is there public support both to implement and to maintain the project?
Legal	Is the jurisdiction authorized to implement the proposed action? Are there legal side effects? Could the activity be construed as a taking? Will the jurisdiction be liable for action or lack of action? Will the activity be challenged?
Economic	What are the costs and benefits of this action? Do the benefits exceed the costs? Are initial, maintenance, and administrative costs taken into account? Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? How will this action affect the fiscal capability of the jurisdiction? What burden will this action place on the tax base or local economy? What are the budget and revenue effects of this activity? Does the action contribute to other jurisdiction goals? What benefits will the action provide?
Environmental	How will the action affect the environment? Will the action need environmental regulatory approvals? Will it meet local and State regulatory requirements? Are endangered or threatened species likely to be affected?

In some instances, MAs revised the priorities of mitigation actions or removed mitigation actions all together. If the mitigation action was completed and no further action would be needed, the action was removed. However, in some instances it was determined that a mitigation action was no longer relevant due to technical changes or advances, a change in service conditions, or the cost associated with a mitigation that would not result in the benefits needed. To document these instances an additional table was included in the Jurisdictional Annex that highlights actions removed due to completion or if it was deemed unnecessary or infeasible. Some actions that may have been considered lower in priority during the last plan update were elevated due to conditions that either allowed for the action to be prioritized, such as the potential for funding or completion of other mitigation actions that preceded them. Mitigation actions were also prioritized based on more recent experiences associated with drought conditions and wildfires. These hazards and the impact they have had throughout Orange County and the State have resulted in new requirements in how these hazards are addressed in water supply and water and wastewater infrastructure systems.

4.3.1 Hazard Mitigation Benefit-Cost Review

FEMA requires local governments/agencies to analyze the benefits and costs of a range of mitigation actions that can reduce the effects of each hazard within their communities. Benefit-cost analysis is used in hazard mitigation to show if the benefits to life and property protected through mitigation efforts exceed the cost of the mitigation activity. Conducting benefit-cost analysis for a mitigation activity can assist communities in determining whether a project is worth undertaking now to avoid disaster-related damages later. The analysis is based on calculating the frequency and severity of a hazard, avoided future damages, and risk.

An HMP must demonstrate that a process was employed that emphasized a review of benefits and costs when prioritizing the mitigation actions. The benefit-cost review must be comprehensive to the extent that it can evaluate the monetary as well as the nonmonetary benefits and costs associated with each action. The benefit-cost review should at least consider the following questions:

- How many people will benefit from the action?
- How large of an area is impacted?
- How critical are the facilities that benefit from the action (e.g., which is more beneficial to protect, the fire station or the administrative building)?
- Environmentally, does it make sense to do this project for the overall community?

These questions were used to help determine the appropriateness of mitigation actions. Benefits and costs are a primary motivation for implementing mitigation projects at water and wastewater utilities. Past disasters have shown the benefit-cost of mitigating water utilities against identifiable hazards. For example, a cold weather system that impacted most of the United States resulted in pipeline breaks across the State of California. Those ruptures primarily occurred on a specific type of pipeline that has been gradually phased out of use in California. The replacement of this type of pipeline prior to the cold front could have not only prevented the cost of pipeline breaks, but also costs related to flooding, landslides, loss of water supply, other secondary effects of the broken pipelines.

The final prioritization completed by each MA depended on the direct loss estimations for water/wastewater critical infrastructure along with the secondary costs associated with business loss and recovery. Much of this effort was completed with informal cost-benefit analysis based on the knowledge and expertise of the participants (many of them certified operators, water quality experts, or engineers), previous planning documents, and the concepts identified above. Those actions that did not have adequate benefits were excluded from the list of mitigation actions.

4.4 Regional Considerations

It is envisioned that the mitigation actions for the most part will be implemented on a district-by-district basis. MWDOC will provide facilitation, as appropriate, of this process to help reduce duplication of efforts between jurisdictions and to spearhead coordination of initiatives and action items that could be accomplished more efficiently on a regional level. In its role as a regional planning agency, MWDOC will act as lead on water-related hazard mitigation projects that are regional in nature, such as projects that cross several jurisdictional boundaries and work planned on behalf of Metropolitan. OC San, CMSD, and SOCWA will take the lead on wastewater related hazard mitigation projects that are regional in nature and within their individual service areas.

Section 3: Risk Assessment and Jurisdictional Annexes indicate that each MA is susceptible to a variety of potentially serious hazards in the region. The approach to emergency planning in California has been comprehensive in its planning for and preparedness to respond to all hazards utilizing the SEMS and a coordinated Incident Command System. A program managed by MWDOC, the WEROC, acts as a coordination point (Area Command) to support an effective emergency response to major disasters by the Orange County water and wastewater utilities. WEROC provides services that promote planning and preparedness activities for both the utilities, as well as its own EOC staff. WEROC also helps maintain a turn-key EOC as well as other preparedness and response resources throughout Orange County. WEROC receives guidance from a steering committee, which includes representatives from Orange County water utilities, Metropolitan, the

County of Orange and the California Department of Health Service's Office of Drinking Water. WEROC and its steering committee help ensure water and wastewater utilities remain current with Federal and State emergency response procedures and plans for potential disasters.

The Disaster Mitigation Act of 2000 requires that in addition to having emergency response and emergency preparedness documents, regions should develop and maintain a document outlining measures that can be implemented before a hazard event occurs that would help minimize the damage to life and property. MWDOC has accepted the role of coordinating the development the HMP as a multi-jurisdictional plan. All-hazard mitigation planning efforts within the region are the responsibility of the jurisdictions. As noted, the capabilities of the jurisdictions to perform hazard mitigation planning are detailed in the Jurisdictional Annexes.

4.4.1 Regional Fiscal Resources

One of MWDOC's primary roles in coordinating the development of the MJHMP is to identify and obtain grant funding for preparing and implementing certain aspects of the plan. This is consistent with WEROC's role, as a program managed by MWDOC, for hazard mitigation and preparedness. WEROC has received grants to improve the EOCs and to secure water trailers for distribution of drinking water during disasters and will continue to provide guidance to the MAs with hazard mitigation project grant applications and their implementation. Additional fiscal capabilities of the jurisdictions when implementing a hazard mitigation project are detailed in their individual capabilities assessments.

Potential Funding Sources

The following are potential funding sources that may be used to implement mitigation strategies. These funding sources include the following Federal and State sources:

- **Building Resilient Infrastructure and Communities (BRIC):** A competitive FEMA grant program to support States, local communities, tribes, and territories.
- **Hazard Mitigation Grant Program (HMGP):** Provides funding to local, State, tribal, and territorial governments to rebuild in a way that reduces or mitigates future disaster losses in their communities. This grant funding is available after a presidentially declared disaster.
- **Emergency Management Performance Grant (EMPG) Program:** The Federal Government, through the EMPG Program, provides necessary direction, coordination, and guidance and provides necessary assistance, as authorized in this title, to support a comprehensive all hazards emergency preparedness system.
- **Other Grants:** Other grants may include State of California grants associated with climate change, water infrastructure, homeland security, transportation, or other funding sources that periodically become available. The list below provides some common sources:

    1. Climate Adaptation Planning Sustainable Transportation Planning Grant Program – Department of Transportation
    2. Sustainable Communities Competitive – Department of Transportation
    3. CAL FIRE Wildfire Prevention Grants Program – Department of Forestry and Fire Protection

4. Integrated Climate Adaptation and Resiliency Program's Climate Adaptation Planning Grant – Office of Planning and Research
5. Small Community Drought Relief Program – Department of Water Resources
6. Addressing Climate Impacts – Department of Fish and Wildlife
7. Cleanup Loans and Environmental Assistance to Neighborhoods (CLEAN) Program – Department of Toxic Substances Control
8. Clean Water State Revolving Fund (CWSRF) Program Construction – State Water Resources Control Board
9. Drinking Water State Revolving Fund (DWSRF) Construction – State Water Resources Control Board
10. Water Recycling Funding Program (WRFP) Construction Grant – State Water Resources Control Board
11. Equitable Community Revitalization Grants (ECRGs) – Department of Toxic Substances Control
12. Water Recycling Funding Program (WRFP) Planning Grant – State Water Resources Control Board
13. Infrastructure State Revolving Fund (ISRF) Program – Infrastructure and Economic Development Bank

SECTION 5: PLAN MAINTENANCE

This section of the MJHMP describes the formal process that will ensure this plan remains an active and relevant document. The maintenance process includes a schedule for monitoring and evaluating the MJHMP annually and producing a plan revision every five years. This section describes how the MAs will integrate public participation throughout the plan maintenance process. It also describes how the MAs intend to implement the MJHMP and incorporate its mitigation actions into existing planning mechanisms and programs. The MJHMP format, organized with Jurisdictional Annexes, allows the MAs to readily update sections when new data becomes available, ensuring the plan remains current and relevant.

5.1 Monitoring, Evaluating, and Updating the Plan

5.1.1 Plan Maintenance

MWDOC will be responsible for initiating plan reviews and coordinating with the MAs. The internal planning teams for each jurisdiction will meet bi-annually to review progress on plan implementation. MWDOC and the MAs will meet annually, or following a hazard event as described below, to monitor the plan's progress and implementation. This will also allow the opportunity for updates to hazards, jurisdictional goals, and mitigation action items, as necessary. If needed, the MAs will coordinate with MWDOC to integrate updates into the plan.

5.1.2 Plan Evaluation

The plan will be evaluated by the MAs at least annually to determine the effectiveness of the plan, and to reflect changes in land development or programs that may affect mitigation priorities. MWDOC and the Planning Team leads (or their jurisdictional representative) will also review the goals and action items to determine their relevance to changing situations in Orange County, as well as changes in State or Federal regulations and policy. MWDOC and MA representatives will also review the risk assessment portion of the plan to determine if this information should be updated or modified, given any new available data or incidents. The MAs will report on the status of their projects, the success of various implementation processes, difficulties encountered, success of coordination efforts, and which strategies should be revised. Any updates or changes necessary will be forwarded to MWDOC for inclusion in further updates to the plan.

MWDOC, with input from the Planning Team, will use the progress report template provided in **Appendix C** to report on annual progress. This will help to ensure consistent and accurate tracking of the plan implementation by each of the MAs. Each MA will coordinate with their responsible departments/agencies identified for each mitigation action. These responsible departments/agencies will help to monitor and evaluate the progress made on the implementation of mitigation actions and report to the MA's Planning Team representative on a semi-annual basis. These responsible departments/agencies will be asked to assess the effectiveness of the mitigation actions and modify the mitigations actions as appropriate. The MJHMP Mitigation Action Progress Report worksheet will assist Planning Team representatives in reporting the status and assessing the effectiveness of the mitigation actions.

The following questions will be considered in evaluating the plan's effectiveness:

- Has the nature or magnitude of hazards affecting the planning area/jurisdiction changed?
- Are there new hazards that have the potential to impact the planning area/jurisdiction?
- Do the identified goals and actions address current and expected conditions?

- Have mitigation actions been implemented or completed?
- Has the implementation of identified mitigation actions resulted in expected outcomes?
- Are current resources adequate to implement the HMP?
- Should additional local resources be committed to address identified hazards?

Future updates to the MJHMP will account for any new hazard vulnerabilities, unusual circumstances, or additional information that becomes available. Issues that arise during monitoring and evaluating the MJHMP, which require changes to the risk assessment, mitigation strategy, and other components of the plan, will be incorporated into the next update of the MJHMP, described below.

5.1.3 Plan Updates

Title 44 CFR § 201.6(d)(3) requires that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for mitigation project grant funding. Monitoring the progress of the mitigation actions, as described above, will be ongoing throughout the five-year period between the adoption of the HMP and the next update effort. The five-year cycle may be accelerated to less than five years based on the following triggers:

- A Presidential Disaster Declaration that impacts one or more of the MAs.
- A hazard event that causes loss of life.

Should a significant hazard occur within the planning area, the MJHMP Planning Team will reconvene within 60 days of the disaster to review and update the HMP, as required.

MWDOC, working in conjunction with the MAs, will serve as the primary responsible agency for updates to the plan. All MAs will be responsible to provide MWDOC with jurisdictional-level updates to the plan when/if necessary, as described above. Every five years the updated plan will be submitted to Cal OES and FEMA for review.

The intent of the update process will be to add new planning process methods, MA profile data, hazard data and events, vulnerability analyses, mitigation actions, and goals to the adopted plan so that the MJHMP will always be current and up to date. Based on the needs identified by the Planning Team, the update will, at a minimum, include the elements below:

- The update process will be convened by MWDOC and a Planning Team comprised of at least one representative from each MA.
- The hazard risk assessment will be reviewed and updated using best available information and technologies on an annual basis.
- The evaluation of critical infrastructure and mapping will be updated and improved as funding becomes available.
- The mitigation actions will be reviewed and revised to account for any actions completed, deferred, or changed to account for changes in the risk assessment or new policies identified under other planning mechanisms, as appropriate.
- The draft update will be made available to appropriate agencies for comment.
- The public will be given an opportunity to comment prior to adoption.
- The governing bodies for each MA will adopt the updated MJHMP.

5.1.4 Adoption

Each jurisdiction is responsible for adopting the MJHMP. This formal adoption should take place every five years. Once the plan has been adopted, MWDOC will be responsible for final submission to Cal OES. Cal OES will then submit the plan to FEMA for final review and approval.

5.1.5 Implementation Through Existing Programs

The effectiveness of the nonregulatory MJHMP depends on the implementation of the plan and incorporation of the outlined mitigation action items into existing plans, policies, and programs. The plan includes a range of action items that, if implemented, would reduce loss from hazard events in the planning area. Together, the mitigation action items in the MJHMP provide the framework for activities that the MAs may choose to implement over the next five years. The MAs have identified the plan's goals and prioritized jurisdiction-specific actions that will be implemented (resources permitting) through existing plans, policies, and programs.

Implementation of the plan will be the responsibility of each MA. Successful implementation is more likely if the plan recommendations are integrated into other plans and mechanisms, such as water and wastewater master plans, urban water management plans, administrative codes, strategic plans, CIPs, and budgets for each of the participating jurisdictions. Upon adoption of the 2024 MJHMP, the MAs can use the MJHMP as a baseline of information on the hazards that impact their jurisdictions. The MJHMP can also build on related planning/design efforts and mitigation programs that are already occurring within the planning area. This will also facilitate applying for funding opportunities as they become available. Progress on implementing mitigation actions through other planning programs and mechanisms should be monitored and integrated into future updates.

By adopting a resolution approving this MJHMP, each MA agrees to reference and incorporate the document into their future local planning documents, codes, decisions, processes, and regulations. The MJHMP will be reviewed and considered by each MA, as applicable plans are created or updated in the future. Upon creating or updating new plans or policies, each MA will review this MJHMP and consider the following:

- What hazard and/or vulnerability information should be considered and/or integrated into this plan?
- Are there opportunities for this plan to support and/or implement mitigation actions?
- What mitigation actions can and should be integrated into this plan?
- Are there other community mechanisms that mitigation can be integrated?
- Is there information from this plan or policy that can be integrated into the next MJHMP update?

Further, the WEROC program manager will establish as an annual agenda item to review and discuss incorporation of the MJHMP into local planning efforts and processes.

Some of the ways each MA will integrate information from this MJHMP into their planning mechanisms are described below.

The timing of updates to plans, programs, and regulatory documents vary depending upon the document and statutory requirements. The information provided in the hazards profiles, vulnerability assessment, and the mitigation actions will be integrated directly or incorporated by reference to support and enhance goals/policies and specific actions for each MA. This will be done as the documents are updated by each MA.

For water and wastewater service providers the most common plans, programs, and regulatory documents expected to integrate information from the MJHMP include water and wastewater master plans, urban water management plans, risk and resilience assessments, and capital improvement programs.

Water and Wastewater Plans will integrate more current hazard and vulnerability information and establish or update their framework for implementing actions identified in the MJHMP. Upon creating or updating any plans, water and wastewater agencies will review this MJHMP to consider the various hazards of concern as part of system design and programming and ensure integration of the mitigation actions into the respective plans. As staff assesses the information and analysis in the current plan it is anticipated that updated hazard information and mitigation actions would allow the MA to modify assumptions on their proposed systems that could increase resilience from potential hazard events.

The Urban Water Management and Planning Act was passed in 2010 and requires water suppliers to estimate water demands and available water supplies. Each water district has an Urban Water Management Plan (UWMP). UWMPs are required to evaluate the adequacy of water supplies including projections of 5, 10, and 20 years. These plans are also required to include water shortage contingency planning for dealing with water shortages, including a catastrophic supply interruption.

UWMPs are intended to be integrated with other urban planning requirements and management plans. Some of these plans include city and county General Plans, Water Master Plans, Recycled Water Master Plans, Integrated Resource Plans, Integrated Regional Water Management Plans, Groundwater Management Plans, ERP, and others. Each water district will review the MJHMP in coordination with preparation of UWMP updates to ensure the most current hazard information is provided and that the appropriate mitigation actions are incorporated.

Additionally, all water utilities are required to conduct RRAs and corresponding ERPs every five years in accordance with the AWIA. The RRAs include a risk assessment process that focuses on potential physical and cyber components of operations and business continuity. AWIA requires water utilities to assess their facilities for all-hazard risks, but specifically calls attention to malevolent acts, physical security, natural hazard risks, cyber security, and fiscal processes security. The corresponding ERP typically addresses protocols for potential emergency events. Both the RRA and the ERP are documents that are considered Protected Critical Infrastructure Information (PCII) due to information within the documents related to the water infrastructure. However, MAs will integrate pertinent information from this mitigation plan into their updated RRAs and ERPs, as well as utilize those documents to continue to update and enhance the MJHMP.

Wastewater agencies are also required to maintain current Sewer Master Plans; Sanitary Overflow Response Plans; and Fats, Oils, and Grease Ordinances. These plans can help to support hazard mitigation efforts, as well as shape future policy to reduce the impacts of sewer system failures.

Each MA has its own budget process, including CIPs that identify capital projects and equipment purchases. These systems provide a link between an MAs general and/or strategic plan and annual budget. As part of the annual review and update of the CIP, the mitigation actions identified in this HMP will be reviewed to determine which actions should be included within the CIP.

This HMP will be added or incorporated by reference into each MA's emergency plans (e.g., Emergency Operations Plans, ERPs, and Emergency Evacuation Plans) as they are updated. The hazard profiles, risk assessment, and mitigation actions will be reviewed during updates to these plans. Further, mitigation actions not currently provided in the HMP will be identified for consideration as part of the MJHMP update.

Other opportunities for integration of this MJHMP include education programs and continued coordination between MWDOC, the MAs, and other agencies. Each MA maintains a website and utilizes social media to provide updated information to its community and service area. Hazard information and opportunities for the community to reduce individual exposure to hazards will be provided. Some MAs will also provide in-person educational events and activities to further inform the community.

5.1.6 Continued Public Involvement

MWDOC is dedicated to involving the public directly in review and updates of the plan. MWDOC and a representative from each participating jurisdiction will be responsible for monitoring, evaluating, and updating the plan as described above. During all phases of plan maintenance, the public will have the opportunity to provide feedback.

The most current copy of the plan will be publicized and permanently available for review on MWDOC's website at https://www.mwdoc.com/your-water/emergency-management/emergency-management-resources/. The site will contain contact information to which people can direct their comments and concerns. All public feedback will be forwarded to the appropriate jurisdiction for review and consideration for incorporation (if deemed appropriate) into the next plan update. This information will also be forwarded to MWDOC, responsible for keeping track of public comments on the plan. In addition, copies of the plan will be catalogued and kept at all the appropriate agencies in the county. The existence and location of these copies will also be posted on the MWDOC website. This will provide the public an outlet for which they can express their concerns, opinions, or ideas about any updates/changes that are proposed to the plan.

Point of Contact

The primary point of contact for the HMP is MWDOC Emergency Manager Vicki Osborn. Ms. Osborn (or their designee) provides oversight and support for maintenance and implementation efforts as well as future updates. To contact Ms. Osborn and other MWDOC staff, please use weroc@mwdoc.com or 714.963.3058.

SECTION 6: REFERENCES

Barnard, P., A. Short, M. Harley, Kristen D. Splinter, Sean Vitousek, Ian L. Turner, Johnathan Allan, *et al*. 2015. "Coastal vulnerability across the Pacific dominated by El Niño/Southern Oscillation." *Nature Geosci* 8: 801–807.

Bender, E. E. 2000. "Late Quaternary uplift and earthquake potential of the San Joaquin Hills, southern Los Angeles basin, California: Comment and Reply: COMMENT." *Geology* 28 (4): 383.

Cal-Adapt. 2024. "Extreme Heat Days & Warm Nights" webpage. Cal-Adapt website. https://cal-adapt.org/tools/extreme-heat/.

Cal Fire (California Department of Forestry and Fire Protection, Fire and Resource Assessment). 2023. Fire Hazard Severity Zones. September 2023. https://osfm.fire.ca.gov/what-we-do/community-wildfire-preparedness-and-mitigation/fire-hazard-severity-zones/fire-hazard-severity-zones-maps-2022.

Cal Fire. 2024. Fire Incident Results. Accessed October 2024. https://www.fire.ca.gov/incidents.

Cal OES (California Governor's Office of Emergency Services). n.d. Spill Release Reporting. Accessed October 1, 2024. https://www.caloes.ca.gov/office-of-the-director/operations/response-operations/fire-rescue/hazardous-materials/spill-release-reporting/.

CDC (Centers for Disease Control and Prevention). n.d. Drinking Water FAQ. Accessed January 10, 2018. https://www.cdc.gov/drinking-water/.

CGS (California Geological Survey). n.d.a. "Alquist-Priolo Earthquake Fault Zones." Accessed October 1, 2024. https://www.conservation.ca.gov/cgs/alquist-priolo.

CGS. n.d.b. "Earthquakes." Accessed October 1, 2024. https://www.conservation.ca.gov/cgs/earthquakes.

CGS. n.d.c. "Seismic Hazard Zones." Accessed October 1, 2024. https://www.conservation.ca.gov/cgs/sh/seismic-hazard-zones.

Climate Central. n.d. "Huntington Beach, California, USA." Surging Seas Risk Finder. https://riskfinder.climatecentral.org/place/huntington-beach.ca.us?comparisonType=place&forecastName=Single-year&forecastType=NOAA2017_int_p50&level=3&unit=ft. Accessed March 2018.

Cocca, Christina. 2013. "Power Back on After Massive Blackout Hits South Orange County, San Diego" webpage. NBC website. July 19, 2013. https://www.nbclosangeles.com/news/local/Massive-Blackout-Hits-South-orange-county-San-Diego-216115731.html.

Connelly, Laylan. 2016. "Our Eroding Coastline: Recent storms are reshaping beaches, and some are getting tougher to visit." *Orange County Register*. February 9, 2016. Accessed August 2017. https://www.ocregister.com/2016/02/09/our-eroding-coastline-recent-storms-are-reshaping-beaches-and-some-are-getting-tougher-to-visit/.

County of Orange. 2015. General Plan, Chapter IX: Safety Element. https://ocds.ocpublicworks.com/service-areas/oc-development-services/planning-development/codes-and-regulations/general-plan

Day, Robert W. 1994. Performance of Slab-on-Grade Foundations on Expansive Soil. *Journal of Performance of Constructed Facilities*, pp. 129-138.

DoD (Department of Defense). 2015. National Security Implications of Climate-Related Risks and a Changing Climate. http://archive.defense.gov/pubs/150724- congressional-report-on-national-implications-of-climate-change.pdf?source=govdelivery.

Earth Consultants. 2005. Five Earthquake Scenarios Ground Motion Maps for Northern Orange County. Prepared for MWDOC by Earth Consultants International. July 22, 2005.

EPA (Environmental Protection Agency). n.d. “National Primary Drinking Water Regulations” page. EPA website. Accessed on October 14, 2024. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations.

EPA. n.d. “Orange County North Basin, Orange County, CA, Cleanup Activities” on Superfund Site webpage. EPA website. https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.cleanup&id=0900251.

EPA. 2017. “EPA Prioritizes Cleanup of Orange County North Basin Groundwater” article on News Releases webpage. EPA website. December 8, 2017. Accessed January 10, 2018. https://www.epa.gov/newsreleases/epa-prioritizes-cleanup-orange-county-north-basin-groundwater.

Everest. 2013. Orange County Coastal Regional Sediment Management Plan. June 2013. Everest International Consultants, Inc., in association with Science Applications International Corporation Dr. Philip King. Prepared for the U.S. Army Corps of Engineers. https://danapointboaters.org/documents/government%20affairs/OCCRSMP_Report_Final.pdf.

Faunt, Claudia C., and Michelle Sneed. 2015. “Water Availability and Subsidence in California's Central Valley.” *San Francisco Estuary and Watershed Science*. Volume 13, Issue 3, Article 4.

Fausto, Alma. 2019. “Stretch of Pacific Coast Highway.” *Orange County Register*. January 16, 2019. https://www.ocregister.com/2019/01/16/stretch-of-pacific-coast-highway-in-huntington-beach-closed-because-of-rain-flooding/.

FEMA (Federal Emergency Management Agency). 2019. *Flood Insurance Study, Orange County, California and Incorporated Areas*. March 21, 2019. https://ocpl.org/sites/ocpl/files/2021-07/flood_insurance_study_06059cv001c.pdf

FEMA. 2016. *Flood Risk Report, Orange County, CA, Open Pacific Coast Flood Insurance Study*. Report Number 01. October 4, 2016.

FEMA. 2022. *Local Mitigation Planning Policy Guide*. FP 206-21-0002 (OMB Collection #1660-0062). https://www.fema.gov/sites/default/files/documents/fema_local-mitigation-planning-policy-guide_042022.pdf.

Field, E. H., G. P. Biasi, P. Bird, T. E. Dawson, K. R. Felzer, D. D. Jackson, K. M. Johnson, T. H. Jordan, et al. 2013. *Uniform California earthquake rupture forecast, Version 3 (UCERF3)—The time-independent model.* U.S. Geological Survey Open-File Report 2013–1165, p. 97, California Geological Survey Special Report 228, and Southern California Earthquake Center Publication 1792. http://pubs.usgs.gov/of/2013/1165/.

Hall, Alex, Neil Berg, and Katherine Reich. 2018. *Los Angeles Summary Report: California's Fourth Climate Change Assessment*. Publication number: SUM-CCCA4-2018-007. University of California, Los Angeles.

Hapke, C. J., D. Reid, B. M. Richmond, P. Ruggiero, and J. List. 2006. *National Assessment of Shoreline Change: Part 3: Historical Shoreline Change and Associated Coastal Land Loss Along the Sandy Shorelines of the California Coast.* U.S. Geological Survey Open-file Report 2006-1219. https://pubs.usgs.gov/of/2006/1219/.

Hernandez, Salvador. 2013. "Cleveland National Forest Fire 78% Contained." *Orange County Register*. August 7, 2013. https://www.ocregister.com/2013/08/07/cleveland-national-forest-fire-78-contained/.

Penn, Ivan. 2016. "AECOM, EnergySolutions win bid to decommission San Onofre nuclear plant." *Los Angeles Times*. December 20, 2016. http://www.latimes.com/business/la-fi-san-onofre-decommission-20161220-story.html.

Krohn, J. P., and J. E. Slosson. 1980. "Assessment of expansive soils in the United States," In Proceedings of the 4th International Conference on Expansive Soils. New York: ASCE. pp. 596–608.

Lee, Greg, ABC 7. 2015. "Brush fire erupts on State Route 241 near Irvine Lake; campgrounds evacuated" webpage. ABC 7 website. July 13, 2015. http://abc7.com/news/brush-fire-erupts-on-state-route-241-near-irvine-lake/848365/.

Masih, A. January 2018. "An Enhanced Seismic Activity Observed Due to Climate Change: Preliminary Results from Alaska." IOP Conference Series: Earth and Environmental Science. doi :10.1088/1755-1315/167/1/012018. https://iopscience.iop.org/article/10.1088/1755-1315/167/1/012018/pdf.

Mateski, M., C. Trevino, C. Veitch, J. Michalski, J. Harris, S. Maruoka, and J. Frye. 2012. "Cyber Threat Metrics." Sandia National Laboratories. https://fas.org/irp/eprint/metrics.pdf.

Meinzer, Oscar Edward. 1928. "Compressibility and elasticity of artesian aquifers." *Economic Geology* 23 (3): 263–291.

MWDOC (Municipal Water District of Orange County). 2016. 2015 Urban Water Management Plan. May 2016. https://www.mwdoc.com/wp-content/uploads/2017/06/FINAL-MWDOC-UWMP-May-2016.pdf.

National Climate Assessment. 2014. Coastal Zone Development and Ecosystems. http://nca2014.globalchange.gov/report/regions/coasts.

NASA. 2024. Global Climate Change Vital Signs of the Planet website. Accessed October 14, 2024. https://climate.nasa.gov/.

NDMC (National Drought Mitigation Center). 2024. Drought Risk Atlas website. https://droughtatlas.unl.edu/Data.aspx.

NOAA (National Oceanic and Atmospheric Administration). n.d. "Tides and Currents" webpage. NOAA website. Accessed October 2024. https://tidesandcurrents.noaa.gov/

NOAA. n.d. United States Climate Resilience Toolkit, The Climate Explorer. Managed by NOAA's Climate Program Office and hosted by the National Environmental Modeling and Analysis Center (NEMAC) at the University of North Carolina Asheville. https://toolkit.climate.gov/climate-explorer2/.

NOAA. 2015. "Drought Monitoring" webpage. National Weather Service Climate Prediction Center website. January 13, 2015. Accessed March 2018. http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml.

NOAA. 2024a. Storm Events Database. National Centers for Environmental Information website. June 2024. https://www.ncdc.noaa.gov/stormevents/.

NOAA. 2024b. Sea Level Rise Trends, Los Angeles, CA. https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9410660

NOAA. 2024c. National Geophysical Data Center (NGDC)/World Data Service: NCEI/WDS Global Historical Tsunami Database. NOAA National Centers for Environmental Information. doi:10.7289/V5PN93H7. Accessed August 17, 2024.

NYU. 2024. Index of Cybersecurity. Accessed October 1, 2024. https://wp.nyu.edu/awm1/

OC Public Works. n.d. "Rain & Stream Data." OC Environmental Resources webpage. OC Public Works website. Accessed on October 14, 2024. https://ocerws.ocpublicworks.com/service-areas/oc-environmental-resources/oc-watersheds/rain-stream-data.

OC San (Orange County Sanitation District). 2023. Annual Report 2022-2023.

OC San. 2023. Five Year Strategic Plan. https://www.ocsan.gov/home/showpublisheddocument/34283/638357197431730000.

OCWD (Orange County Water District). n.d. "Orange County North Basin Superfund Site" webpage. OCWD website. Accessed October 15, 2024. https://www.ocwd.com/what-we-do/water-quality/groundwater-cleanup/north-basin/.

OCWD. 2015. Groundwater Management Plan 2015 Update. https://www.ocwd.com/wp-content/uploads/groundwatermanagementplan2015update_20150624.pdf.

Orange County Sheriff's Department. JTTF. Accessed August 24, 2017. http://www.ocsd.org/divisions/fieldops/security/terrorism/jttf.

Orange County Sheriff's Department. Orange County Intelligence Assessment Center. Accessed August 23, 2017. http://www.ocsd.org/divisions/fieldops/security/iac.

Oskin, B. 2014. "No Evidence of Megatsunamis Slamming California Coast." *Live Science*. May 19, 2014. http://www.livescience.com/45864-california-ancient-tsunamis-evidence.html.

OCOF (Our Coast, Our Future). 2024. Interactive Map. Accessed October 2024. https://ourcoastourfuture.org/hazard-map/.

Petersen, M. D., M. P. Moschetti, P. M. Powers, C. S. Mueller, K. M. Haller, A. D. Frankel, Yuehua Zeng, et al. 2014. *Documentation for the 2014 update of the United States national seismic hazard maps*. U.S. Geological Survey Open-File Report 2014–1091. p. 243. http://dx.doi.org/10.3 33/ofr20141091.

Polade, S.D., A. Gershunov, D. R. Cayan, M. D. Dettinger, and D. W. Pierce. 2017. "Precipitation in a warming world: Assessing projected hydro-climate changes in California and other Mediterranean climate regions." *Scientific Reports* 7: article number 10783. https://www.nature.com/articles/s41598-017-11285-y.

Poland, J. F., R. L. Lofgren, and R. G. Pugh. 1975. *Land Subsidence in the San Joaquin Valley, California, as of 1972.* Geological Survey Professional Paper 437-H. Prepared in cooperation with the California Department of Water Resources. U.S. Government Printing Office, Washington, DC.

Rocha, Veronica. 2016. "Where is the Holy fire burning?" *LA Times*. September 27, 2016. http://www.latimes.com/local/california/la-me-updates-wildfire-season-where-is-the-holy-fire-1472674601-htmlstory.html#nt=card.

Romey, Michael G., Cody M. Kermanian, and Lucas I. Quass. 2021. "A Dry 2021 in California Prompts Water Conservation Response." Environment, Land & Resources website. Latham & Watkins LLP. December 13, 2021. https://www.globalelr.com/2021/12/a-dry-2021-in-california-prompts-water-conservation-response/.

Salazar, Denisse. 2013. "Silverado fire battle continues overnight." *Orange County Register*. October 7, 2013. https://www.ocregister.com/2013/10/07/silverado-fire-battle-continues-overnight/.

Nikolewski, Rob. 2018. "Court Settlement looks to move nuclear waste from San Onofre." *San Diego Union-Tribune*. Accessed January 10, 2018.http://www.sandiegouniontribune.com/business/energy-green/sd-fi-songs-agreement-20170828-story.html.

Schwartz, P., and D. Randall. 2003. *An Abrupt Climate Change Scenario and Its Implications for United States National Security*. Jet Propulsion Laboratory, Pasadena, California. October. https://apps.dtic.mil/sti/pdfs/ADA469325.pdf.

SCAG (Southern California Association of Governments). 2012. Regional Transportation Plan 2012-2035 Sustainable Communities Strategy, Growth Forecasts. https://scag.ca.gov/post/2012-2035-regional-transportation-plansustainable-communities-strategy-executive-summary.

State of California. 2024. Department of Conservation website. http://www.conservation.ca.gov/.

Sudock, Joshua. 2016. "Laguna Wilderness Park fire nearing containment; roads open." *Orange County Register*. June 27, 2016. https://www.ocregister.com/2016/06/27/laguna-wilderness-park-fire-nearing-containment-roads-open/.

Swegles, Fred. 2017. "Flooding, mudslides, power outages follow torrential rainstorm." *Orange County Register*. January 23, 2017. https://www. ocregister.com/2017/01/23/flooding-mudslides-power-outages-follow-torrential-rainstorm/.

Union of Concerned Scientists. n.d. When Rising Seas Hit Home website. https://ucsusa.maps.arcgis.com/apps/MapSeries/index.html?appid=64b2cbd03a3d4b87aaddaf65f6b33332.

USDA (United States Department of Agriculture). 2015. *Effects of Drought on Forests and Rangelands in the United States: A Comprehensive Science Synthesis*. November 2015. https://www.fs.usda.gov/sites/default/files/GTR-WO-93a.pdf.

USGS (United States Geological Survey). 2014. ‘‘Moment Magnitude, Richter Scale.’’ https://www.usgs.gov/faqs/moment-magnitude-richter-scale-what-are-different-magnitude-scales-and-why-are-there-so-many.

USGS. 2015. *UCERF3: A New Earthquake Forecast for California’s Complex Fault System*. Fact Sheet 2015-3009. ISSN 2327-6916. March 2015. http://dx.doi.org/10.3133/fs20153009.

USGS. 2017a. “Disappearing Beaches: Modeling Shoreline Change in Southern California” webpage. USGS website. May 31, 2017. https://www.usgs.gov/programs/cmhrp/news/disappearing-beaches-modeling-shoreline-change-southern-california.

USGS. 2017b. “Severe West Coast Erosion During 2015-16 El Nino.” *Sound Waves*. March 31, 2017. Coastal and Marine Hazards and Resources Program. https://www.usgs.gov/programs/cmhrp/news/severe-erosion-us-west-coast-during-2015-16-el-nino.

USGS. 2000. Landslide Hazards (Fact Sheet 0071-40, Version 1.0). May 2000. https://pubs.usgs.gov/fs/fs-0071-00/fs-0071-00.pdf.

USGS. N.D. Coastal Storm Modeling System: CoSMoS. Accessed October 2024. https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos.

USGS. 2024. Land Subsidence. Accessed October 1, 2024. https://www.usgs.gov/special-topics/water-science-school/science/land-subsidence.

University of California San Diego. 2016. *Santa Ana Winds of Southern California: Historical Variability and Future Climate Projections*. June 1, 2016. Accessed October 2024. https://escholarship.org/content/qt6hm499nj/qt6hm499nj_noSplash_2bb235bdd62bbb3fa12f96fcd60de8ab.pdf.

Weather.gov. 2024. *A History of Significant Weather Events in Southern California: Organized by Weather Type*. March 2024. https://www.weather.gov/media/sgx/documents/weatherhistory.pdf.

Williams, Lauren. 2017. “Orange County Beach Cities Bracing for 7-foot King Tides; Flooding Possible.” *Orange County Recorder*. January 10, 2017. https://www.ocregister.com/2017/01/10/orange-county-beach-cities-bracing-for-7-foot-king-tides-flooding-possible/.