Orange County Transportation Authority Hazard Mitigation Plan

"Our mission is to develop and deliver transportation solutions to enhance the quality of life and keep Orange County moving"

OCTA

2021

Orange County Transportation Authority 2021 Hazard Mitigation Plan

[Enter Final Approved Month/Year]

Prepared for:

OCTA

Orange County Transportation Authority

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Draft

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Special Acknowledgements

The creation of this plan would not have been possible without the dedication and commitment to the planning process by the personnel and customers of the Orange County Transportation Authority (OCTA), particularly the OCTA 2021 Hazard Mitigation Plan Steering Committee.

We greatly appreciate their time and dedication.

Executive Summary

The Orange County Transportation Authority's (OCTA's) 2021 Hazard Mitigation Plan (HMP) is a stakeholder-driven, risk-informed, and capabilities-based strategic planning document that identifies and prioritizes actions to mitigate the potential impacts of natural hazards within the Authority's service area. This plan demonstrates OCTA's commitment to protecting its customers, assets, and the environment from the effects of natural hazards through mitigation and enables access to federal funding to support this commitment.

Establishing the Hazard Mitigation Plan Steering Committee

To oversee development of the HMP, the OCTA Executive Committee formed an 18-person Steering Committee, listed in Table 0-1. The Steering Committee included personnel from departments across OCTA, local jurisdictions within OCTA's service area, regional bodies, and community-based organizations. The Steering Committee participated in four workshops, beginning July 2020 and ending May 2021. These workshops were:

- **Workshop 1:** Hazard Mitigation Planning Overview and Project Kickoff
- **Workshop 2**: Risk Assessment
- **Workshop 3:** Mitigation Strategy
- **Workshop 4:** Draft Plan Review

Workshop materials (i.e., agenda, slide deck, sign-in sheet, worksheet(s), and summaries) are available in Appendix D for review, documenting the plan development and decision-making process.

Table 0-1 – Steering Committee Members

Name	Entity	Title	Department/Office
Matt Ankley	OCTA	Emergency Management Specialist	Chief Executive Office
Katrina Faulkner	OCTA	Manager, Security, and Emergency Preparedness	Chief Executive Office
Megan Abba	OCTA	Communications Specialist	Chief Executive Office
Jason Lee	OCTA	Project Manager, Metrolink Expansion	Capital Programs
George Olivo	OCTA	Program Manager of Facilities Engineering	Capital Programs
Charlie Larwood	OCTA	Manager of Planning and Analysis	Planning
Marissa Espino	OCTA	Community Relations Specialist	External Affairs
Chris Damyen	OCTA	Manager of Facilities Maintenance	Operations
Cleve Cleveland	OCTA	Manager, OC Streetcar	Operations
Dinah Minteer	OCTA	Manager of Regional Rail	Operations
Ethan Brown	Orange County Sheriff's Department	Emergency Management Coordinator	Emergency Management Division
Randy Harper	Orange County Sheriff's Department	Emergency Management Coordinator	Emergency Management Division

Name	Entity	Title	Department/Office
Rudy Emami	City of Anaheim	Director	Public Works
Mike Davis	City of Irvine	Assistant Director	Transportation
Bill Murray	City of Garden Grove	Director	Public Works
Brett Canedy	City of Mission Viejo	Transportation Analyst	Transportation
Taig Higgins	City Santa Ana	Principal Engineer	Public Works
Anna Lowe	San Diego Association of Governments	Senior Regional Planner	Regional Planning
Dan Phu	OCTA	Program Manager, Project Development	Planning
Lauren Sato	OCTA	Transit Analyst, Project Development	Planning

Defining the Planning Area

During Workshop 1 – Hazard Mitigation Planning Overview and Project Kickoff, the Steering Committee agreed that the OCTA 2021 HMP planning area should be defined by the Authority's service and assets, which operate in all of Orange County, the southern end of Los Angeles County, and a small portion of northern San Diego County. The Steering Committee agreed that the OCTA HMP planning area should include considerations for customers, staff, property, infrastructure, and the natural environment.

Population numbers and past annual bus ridership numbers inform OCTA planning area service and population trends. In 2019, bus ridership was approximately 35.5 million total boardings for the year and 19 average boardings per day for each bus stop. While OCTA owns and maintains the busses, bus bases, and some transit hubs, cities own the bus stops residing in their jurisdictions. Beyond the extensive bus transportation network, OCTA has a partnership with passenger rail carriers Metrolink and Amtrak, who connect major destinations and employment centers in Ventura, Los Angeles, Orange, Riverside, San Bernardino, and San Diego counties (Orange County Transportation Authority). In this case, OCTA maintains the rail right of way in partnership with the shared Metrolink and Amtrak corridors, with Metrolink and Amtrak owning/operating the stations, stops, and trains/train control systems.

OCTA also offers flexible services across the entire area through ride-share and vanpool programs. The OC Streetcar route is projected to be complete in 2022 and will connect to the Metrolink, Amtrak's Pacific Surfliner, and the Santa Ana Regional Transportation Center (Orange County Transportation Authority). These and other transportation services link together to furnish numerous options for travel across the planning area. While the OC Streetcar project rail system was started when this plan was approved, certain components (the Maintenance Facility and Tran Wash Facility) were still in development and not part of this plan. Future revisions of the Hazard Mitigation Plan will incorporate these facilities. Figure 10 is a map of the coverage area and critical transportation systems. OCTA assets directly considered in the development of this plan are listed in Table 0-2 on the following page.

Table 0-2 – OCTA Assets

Facility	Latitude	Longitude
Garden Grove Base	33 45' 49" N	117 55' 25" W
Santa Ana Base	33 42' 12" N	117 55' 32" W
Irvine Sand Canyon Base	33 40' 43" N	117 45' 19" W
Irvine Construction Circle Base	33 41' 46" N	117 49' 24" W
Anaheim Base	33 51' 26" N	117 53' 30" W
Newport Beach Transportation Center	33 36' 51" N	117 52' 06" W
Golden West Transportation Center	33 44' 03" N	117 59' 58" W
Laguna Beach Transportation Center	33 32' 42" N	117 46' 58" W
Laguna Hills Transportation Center	33 36' 25" N	117 42' 20" W
Fullerton Transportation Center	33 52' 10" N	117 55' 20" W
Fullerton Park and Ride	33 51' 31" N	117 58' 44" W
Brea Park and Ride	33 55' 32" N	117 52' 53" W
Administrative Facility 550/600	33 46' 44" N	117 52' 04" W
Transportation Security Operations Center	33 49' 54" N	117 56' 02" W

Identifying + Assessing Natural Hazard Risks in the Planning Area

The purpose of a risk assessment is to describe the type, location, and extent of every natural hazard that could occur in the planning area. Informed by qualitative and quantitative methods, the risk assessment includes information on previous occurrences of hazard events within the planning area and informs the probability of future hazard events. Additionally, the risk assessment consists of an exposure and vulnerability assessment for OCTA customers, assets, and the planning area's environment.

During Workshop 2 – Risk Assessment, the Steering Committee qualitatively identified and assessed natural hazard risks in the planning area. To do so, Steering Committee members independently ranked each hazard based on the perceived severity, magnitude, frequency, onset, and duration for the potential worst-case and the most likely scenarios; Appendix A includes definitions of each criterion. The Steering Committee identified 12 natural hazards of concern within the planning area, which were consolidated into seven (7) to improve the accessibility and utility of the plan. The result is that the hazard profile for flooding includes Sea Level Rise (SLR) and coastal erosion, and the severe weather profile includes drought, extreme heat, and storm surge, as shown in Table 0-3.

Table 0-3 – OCTA Hazard List

No.	Initial HMP Hazard Profile	Consolidated Hazard Profile
1	Earthquake	

No.	Initial HMP Hazard Profile	Consolidated Hazard Profile
2	Epidemic/Pandemic	
3	Flooding	Sea Level Rise and Coastal Erosion
4	Mass Earth Movements	
5	Severe Weather Events	Drought, Extreme Heat, storm Surge
6	Tsunami	
7	Wildfire	

Following the hazards' qualitative identification and scoring, a quantitative analysis used geospatial hazards information where available and generated a series of hazard-specific maps indicating the extent of the hazard risk. Tabular outputs showed the exposure and vulnerability of critical infrastructures and facilities, and customers. The methodology and results of this analysis are discussed further in Part 2 of the plan, Risk Assessment.

Engaging the Authority's Customers and Greater Community

The Steering Committee developed and implemented a community engagement strategy to solicit input from OCTA customers and the greater community throughout the planning process. The strategy included an online survey, an open house, and a 30-day review and comment period of the plan; the strategy and results are discussed at length in Part 1 of the HMP, while the complete materials are available in Appendix D. The following objectives guided the development and implementation of the strategy:

- Identify and engage OCTA customers and community members through a social media campaign
- Distribute a survey to OCTA customers and community members to identify and prioritize hazards, provide mitigation actions, sign-up to stay engaged in the planning process
- Encourage participation in an HMP draft plan review open house, including targeted invites to those persons who signed up to stay engaged in the planning process
- Solicit written feedback on the draft HMP during the open house and by making it available online

Over 300 OCTA customers and community members participated in the survey, approximately one-third of which provided their emails to stay engaged throughout the planning process.

Developing the Mitigation Strategy

During Workshop 3 – Mitigation Strategy, the Steering Committee developed goals and actions for the OCTA 2021 HMP by reviewing the OCTA customer and community member survey responses on risks and actions, comparing them to their own assessment in Workshop 2, and reviewing the Authority's capabilities to mitigate hazards; capabilities include planning and regulatory, administrative and technical, and financial, which are discussed in Section 3.5 of this plan. The stakeholder and community-member driven, risk-informed, and capability-based goals and actions for the OCTA 2021 HMP are:

1. Support OCTA policies, plans, people, and programs to maintain a community transportation system that reduces risk and is resilient now and long term.
2. Minimize vulnerabilities to protect people, property, the natural environment and keep Orange County moving.
3. Ensure resilience-oriented decisions incorporate regional collaboration and enhanced partners.

4. Promote community engagement through transparent public outreach that is equitable and accessible to everyone in the community.

The Steering Committee established 25 to achieve the mitigation goals outlined in this plan, reducing or eliminating losses resulting from natural hazards. The mitigation actions are as follows:

Table 0-4 – OCTA Mitigation Actions

#	Description
1	Increase public education and outreach by creating a new dedicated hazard webpage to share climate information changed and OCTA mitigation/preparedness measures.
2	Contribute to internal and regional after-action reports for the COVID-19 pandemic to identify critical actions that need to be completed to reduce risks to the community from future pandemics. These recommendations should be included in future updates of the HMP.
3	Partner with other agencies to implement additional measures to protect coastal rail infrastructure as appropriate, such as maintaining or improving the existing revetment, improving the revetment, adding a seawall, or relocating the rail line away from the coast in southern Orange County. (Aligns with *OC Rail Defense Against Climate Change Plan*)
4	Partner with other agencies to implement erosion control and stormwater measures for the Mission Viejo Trench and the Oso Creek area as recommended in *the OC Rail Defense Against Climate Change Plan.* (Aligns with *OC Rail Defense Against Climate Change Plan)*
5	Regularly obtain the most recent recommended future heavy precipitation and flow estimates and compare these to the current 100-year high confidence heavy precipitation and flow estimates used for infrastructure design. Determine which estimates should be used to minimize risks to infrastructure over the lifecycle. (Aligns with *OC Rail Defense Against Climate Change Plan*)
6	Regularly review and update the data used to calculate the rail zero-stress temperature to account for current and projected climate change and stress newly installed and existing rail based on this information. (Aligns with *OC Rail Defense Against Climate Change Plan*)
7	Retrofit OCTA critical facilities to address seismic risks.
8	Install back-up and/or redundant power sources for the OCTA data center and other critical facilities and infrastructure. Transition to solar power and battery systems where appropriate. Back-up and redundant power systems would help to ensure continuity of operations in a hazard event.
9	Assess and implement engineering options at OCTA bus bases for hardening fuel storage and fueling facilities against seismic and other hazards.
10	Develop site-specific response plans and structures for worksites using SEMS/NIMS principles.
11	Continue OCTA vulnerability assessments for all hazards.
12	Share vulnerability assessment data with partner Agencies. Encourage train station amenities to help riders during extreme heat and other severe weather events, including additional shaded or covered areas and seating, restrooms, and cooling mechanisms. Provide accurate information on train schedules to minimize waiting times. (Aligns with *OC Rail Defense Against Climate Change Plan*)
13	Expand internal communications and preparedness education about potential hazards, including what to do during and after a hazard event.
14	Perform fuel modifications on OCTA conservation properties to provide proper clearance near habitable structures per local fire authority standards. Assess opportunities to replace invasive species and plant fire-adapted native plants to prevent invasive species from becoming re-established, minimizing the risk of wildfires
15	Upgrade stormwater runoff management around OCTA critical facilities and infrastructure.

#	Description
16	Continue to use the most current Geographic Information Systems (GIS) data layers in the hazard reduction decision-making processes.
17	Regularly assess the planning area’s evacuation routes and pickup points. Coordinate with the County Emergency Management Division and Cities to provide the most efficient and effective evacuation transportation support.
18	Support cities and the county in the planning area with evacuation education and public outreach related to OCTA
19	Expand micro transit service as a potential option for providing transit services during a disaster event. (Aligned with *OC Transit Vision*.)
20	Promote the use of new technology in hazard mitigation and emergency preparedness.
21	Continue to develop new and evaluate existing climate change goals and policies as new scientific data and models become available.
22	Incorporate data from the 2021 OCTA HMP, mitigation actions, and risk reduction principles into future updates of agency plans related to hazard mitigation.
23	Develop and improve communication redundancies to ensure effective internal and external communication in a hazard event.
24	Prepare and implement fire management plans, invasive species control, public education and awareness, and enhanced security measures to mitigate the potential for wildfire on conservation properties. Consider closure of conservation properties during times of high fire risk. (Aligned with resource management plans.)
25	Monitor and address adverse effects from properties adjacent to conservation properties. (Aligned with resource management plans.)

Writing, Implementing, + Maintaining the Plan

The Steering Committee developed the OCTA 2021 HMP over approximately nine months with extensive stakeholder and community member involvement. The planning process, including all workshop and community member engagement materials, is documented in Appendix D. The plan meets or exceeds the requirements established under 44 CFR 201.6 – Local Mitigation Plans (Code of Federal Regulations, 2013), as indicated in the FEMA Region IX Local Mitigation Plan Review Tool in Appendix E.

Once the plan has been approved by OCTA, it is submitted to the California Office of Emergency Services (Cal OES) and FEMA Region IX for review and pre-adoption approval. The review process is documented via the FEMA Region IX Local Mitigation Plan Review Tool and an official Approval Pending Adoption (APA) letter from FEMA. Upon receiving the APA letter, OCTA has 12 months to formally adopt the plan via resolution and inform FEMA that it has been adopted. Once adopted, the Authority is eligible to apply for and receive federal hazard mitigation grant funding.

Over the next five-year period, OCTA will implement the actions listed in the plan to realize its goals. Plan implementation will be led by the OCTA Office of Security and Emergency Preparedness and supported by the Steering Committee. The Steering Committee will meet annually to review action implementation, changes in natural hazard risks, update mitigation capabilities, reassess opportunities to continue engagement of OCTA customers and community members, and integration with other relevant plans and programs; the Progress Reporting template in Appendix B will be used to document this process. In five years, OCTA will undertake a comprehensive plan update informed by these annual reports.

OCTA 2021 Hazard Mitigation Plan

Part 1: Planning Process Overview

Part 1

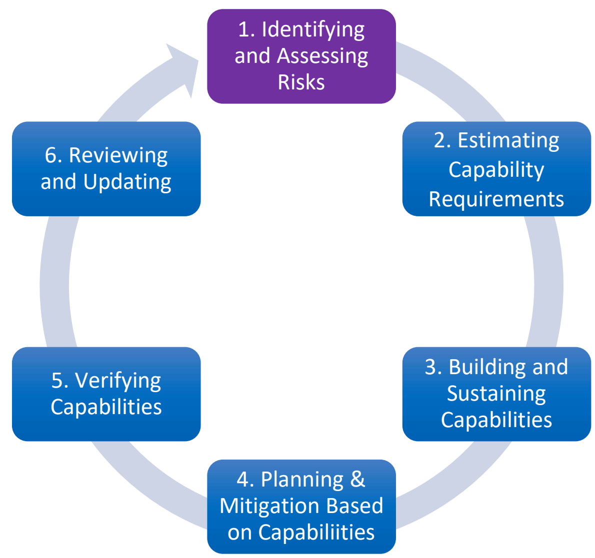
1 Introduction to Hazard Mitigation Planning

1.1 What is Natural Hazard Mitigation Planning?

Hazard mitigation uses long- and short-term strategies to reduce or alleviate the loss of life, personal injury, and property damage resulting from a disaster. It involves planning efforts, policy changes, programs, studies, improvement projects, and other strategies to reduce hazard impacts. Mitigation plans are vital to breaking the cycle of disaster damage, reconstruction, and repeated damage.

The Department of Homeland Security's (DHS) Comprehensive Preparedness Guide (CPG) 201 states that natural hazards are acts of nature, such as earthquakes, tornadoes, pandemics, or epidemics. Additionally, Title 44 of the Code of Federal Regulations (CFR) Part 201 – Mitigation Planning, Section 201.2, defines hazard mitigation as "any action taken to reduce or eliminate the long-term risk to human life and property from natural hazards" (Code of Federal Regulations, 2013, p. 364). There are textboxes throughout this plan highlighting the HMP's compliance with relevant CFRs.

Figure 1-1 National Preparedness System (Department of Homeland Security, 2011)



To develop and implement practical hazard mitigation actions, communities apply a planning process that mirrors the DHS's *National Preparedness System* (Figure 1-1). This system defines the planning steps to prepare for all hazards. These components establish a consistent approach to facilitate decision making, resource allocation, and measure progress towards the *National Preparedness Goal*. The system assesses the Nation's core capabilities across five mission areas. Step four of the system highlights the necessity and application of mitigation measures. Hazard mitigation planning results in a plan with clear actions to reduce natural hazard risks to people, property, assets, and the planning area's environment.

1.1.1 The 2000 Disaster Mitigation Act

Before 2000, federal disaster funding focused on relief and recovery after a disaster occurred, with a limited budget for hazard mitigation planning in advance. On October 30, 2000, Congress passed the 2000 Disaster Mitigation Act (DMA), amending the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 and shifting the federal emphasis toward planning for disasters before they occur (Title 42 of the United States Code Section 5121 et seq.) (Federal Emergency Management Agency, 2019). The 2000 Act replaced the previous mitigation planning section (409) with a new mitigation planning section (322).

44 CFR Section 201.6

Local Mitigation Plans outline an entity's commitment to reducing risks associated with natural hazards.

The DMA requires state, local, and tribal government entities to develop and adopt the Federal Emergency Management Agency (FEMA) approved hazard mitigation plans as a condition for federal disaster grant assistance (Federal Emergency Management Agency, 2007). Section 322 emphasized the need for state, tribal, and local entities to coordinate and collaborate on mitigation planning and implementation efforts (Federal Emergency Management Agency, 2007). Additionally, Section 322 established the legal basis for the Federal Emergency Management Agency's (FEMA's) mitigation plan requirements for the Hazard Mitigation Assistance grant programs.

The DMA encourages cooperation among state, local, and tribal authorities in pre-disaster planning and emphasizes community-based planning before disasters occur. The act also promotes sustainability, including the sound management of natural resources, local economic and social resiliency, and addressing hazards and mitigation in the most extensive possible social and economic context. The enhanced planning network described in the DMA helps local organizations and governments articulate precise needs for mitigation, resulting in a faster allocation of funding and more cost-effective risk-reduction projects.

1.1.2 The Authority's Response to the 2000 Disaster Mitigation Act

The Authority adopted its first HMP in 2021, satisfying the requirements of the 2000 DMA and enabling access to federal hazard mitigation grant funding. This HMP assesses the risks posed by natural hazards and identifies current capabilities for reducing those risks within OCTA's service area (i.e., planning area).

1.2 Purposes for Hazard Mitigation Planning

OCTA developed the 2021 Hazard Mitigation Plan (HMP) to identify and prioritize mitigation actions. These actions reduce or alleviate risks from natural hazards, reducing the loss of life, personal injury, and property damage for the Authority and its customers. The plan establishes a roadmap for OCTA to mitigate hazards within the service area and help OCTA coordinate and collaborate with its planning partners. The HMP meets the following objectives:

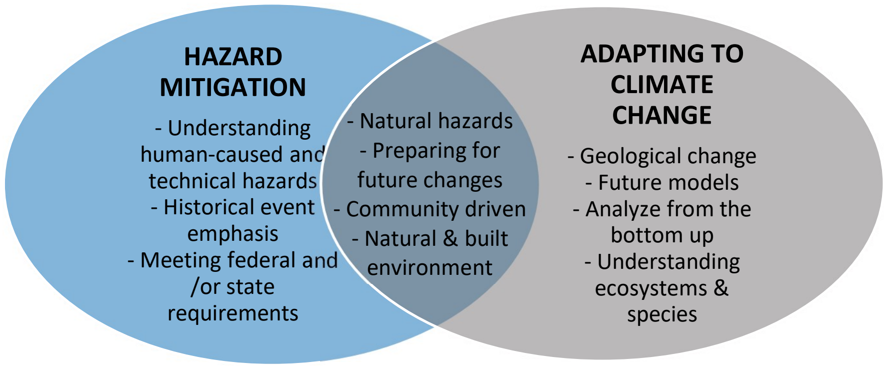
- Enables access to federal grant funding to reduce disaster risk through mitigation actions
- Meet or exceed the DMA 2000 requirements
- Complete a risk assessment focusing on hazards of concern within the planning area
- Ensure compliance with state and federal hazard mitigation planning requirements
- Review existing OCTA policies, plans, and programs to identify opportunities for integration of hazard mitigation principles and cooperation with planning partners
- Identify high-priority projects to mitigate natural hazards that can be funded and implemented

1.3 Hazard Mitigation and Climate Adaptation Planning

1.3.1 Climate Change Adaptation and the OCTA 2021 Hazard Mitigation Plan

Climate adaptation planning is like natural hazard mitigation planning. Both are adjustments in human and natural systems to mitigate the impacts of hazards, except that the former focuses on climate-related hazards. While climate change itself is not a hazard, it may change the characteristics of a hazard within the planning area (e.g., extent). Figure 1-2 shows the similarities and dissimilarities between the two (ICLEI Local Governments for Sustainability USA, 2015).

Figure 1-2 – Hazard Mitigation and Climate Adaption Planning Relationship (ICLEI Local Governments for Sustainability USA, 2015)



Climate change adaptation strategies enable communities to reduce vulnerability to all types of natural hazards by predicting these changes and increasing local capacity to adapt (California Emergency Management Agency and Natural Resources Agency, 2012). The strategies developed may range from short- to long-term and from high-level, broad strategies to detailed, "shovel-ready" projects.

Table 1-1 below describes the California Adaptation Planning Guide, Planning for Adaptive Communities recommendations, and where OCTA's HMP incorporates them.

Table 1-1 – Climate Adaptation Strategies in the Hazard Mitigation Plan (California Emergency Management Agency and Natural Resources Agency, 2012)

Climate Adaptive Planning Recommendations	Location in the OCTA HMP
Assessing exposure to climate change impacts	Sections 5 to 11 – individual hazard profiles
Assessing community sensitivity to the exposure	Sections 5 to 11 – individual hazard profiles
Assessing potential impacts	Sections 5 to 11 – individual hazard profiles
Evaluating existing community capacity to adapt to anticipated impacts	Section 3.5 – hazard mitigation capabilities and capacity assessment
Evaluating risk and onset, meaning the certainty of the projections and speed at which they may occur	Sections 5 to 11 – individual hazard profiles
Setting priorities for adaptation needs	Section 12 – mitigation strategy
Identifying strategies	Section 12.1.1 – mitigation actions
Evaluating and setting priorities for strategies	Section 12.1 – mitigation goals
Establishing phasing and implementation	Section 12.4 – plan implementation and maintenance strategy

1.3.2 Responding to California Senate Bill 379

California Senate Bill 379, which amended Section 65302 of the Government Code, requires the safety elements of city and county general plans to be reviewed and updated to include climate adaptation and resiliency strategies (California Legislative Information, 2015). The updated safety elements must consist of a climate change exposure assessment, adaptation and resilience applications, and manageable implementation measures (Alliance of Regional Collaboratives for Climate Adaptation, 2016).

As an agency, OCTA is not required to complete a general plan under California Senate Bill 379 (Alliance of Regional Collaboratives for Climate Adaptation, 2016). However, OCTA chose to address climate change throughout the HMP in line with the bill to inform future updates of the County of Orange General Plan and city general plans. The correlation between the bill's elements and OCTA's 2021 HMP is in Table 1-2.

Table 1-2 – OCTA Alignment with California's Climate Change Bill 379 (Alliance of Regional Collaboratives for Climate Adaptation, 2016)

New Safety Elements	Location in the OCTA HMP
Assessing exposure to climate change impacts	Part 2 – Risk Assessment
A set of adaptation and resilience goals, policies, and objectives based on the information specified in the vulnerability assessment	Part 3 – Mitigation Strategy
A set of feasible implementation measures designed to carry out the goals, policies, and objectives identified in the adaptation objectives	Part 3 – Mitigation Strategy

1.4 Who Will Benefit from this Plan?

Whole Community Approach

Engaging private and nonprofit sectors in hazard preparedness and mitigation to build a more hazard resilient nation.

All stakeholders and community members that directly or indirectly rely on OCTA's services ultimately benefit from this hazard mitigation plan. The plan strives to reduce the risk for customers of OCTA, particularly within the service area. It provides a viable planning framework for all foreseeable natural hazards that may have a negative effect. Participation in developing the plan by stakeholders and community members ensures that outcomes will be mutually beneficial for the Authority and the whole community. This plan provides solutions that other entities can use and benefit from and can cooperatively implement. The plan's goals and recommendations lay the groundwork for developing and implementing local mitigation activities and partnerships.

1.5 Contents of this Plan

This hazard mitigation plan has three primary parts:

- **Part 1** – Planning Process and Community Profile
- **Part 2** – Risk Assessment
- **Part 3** – Mitigation Strategy

Each part includes elements required under federal guidelines. In addition, DMA compliance requirements are cited at the beginning of plan sections to illustrate compliance and highlight each section's importance and utility to the reader.

The appendices at the end of this plan provide additional details and supporting data:

- **Appendix A** – Acronyms and Definitions
- **Appendix B** – OCTA Hazard Mitigation Plan Annual Progress Report
- **Appendix C** – Mitigation Action Evaluation Forms
- **Appendix D** – Planning Process and Public Outreach
- **Appendix E** – FEMA Review Tool

- **Appendix F** – Plan Adoption Resolution
- **Appendix G** – Hazards
- **Appendix H** – References

1.5.1 Plan Approach

The OCTA 2021 HMP development process followed these steps:

- Secure grant funding
- Form a planning team
- Define the planning area
- Establish a steering committee
- Coordinate with other agencies
- Review existing programs
- Engage the public

1.5.2 Funding

OCTA received a FEMA Pre-Disaster Hazard Mitigation Grant to support plan development. Grant funding covered 75 percent of the cost to create this plan. OCTA provided additional funding through local funds.

2 Plan Methodology

2.1 Overview

The OCTA 2021 Hazard Mitigation Plan process:

- Formed the planning team
- Included OCTA's response to the 2000 DMA
- Defined the planning area
- Established a steering committee
- Conducted a risk assessment
- Reviewed existing programs
- Engaged the public

2.2 Formation of the Project Team

OCTA hired WSP, referred to as the Project Team in this HMP, to develop and implement their first HMP. The Project Team designed the plan sections and facilitated stakeholder workshops. Throughout the planning process, the Project Team reported directly to the OCTA project manager. Primary OCTA and WSP Project Team members included:

- Matt Ankley, Emergency Management Specialist, OCTA
- Eric Grobmyer, Emergency Management Specialist, OCTA
- Katrina Faulkner, Security and Emergency Preparedness Manager, OCTA
- Trevor Clifford, Project Manager, WSP
- Colleen Kragen, Mitigation Planner, WSP
- Brennah McVey, GIS Analyst, WSP

2.3 Formation of the Steering Committee

Hazard mitigation planning enhances collaboration and support among parties whose interests can be affected by hazard losses. A broad range of stakeholders can identify and create partnerships to achieve a shared vision for the community by working together. To oversee the HMP development, OCTA formed an 18-person Steering Committee, listed in Table 2-1. The committee members included local government representatives in the Planning Area and key OCTA staff representing all staff, sites, departments. Sixteen committee members and two WSP Project Team members attended the kickoff meeting.

Table 2-1 – Steering Committee Members

Name	Entity	Title	Department/Office
Matt Ankley	OCTA	Emergency Management Specialist	Chief Executive Office
Katrina Faulkner	OCTA	Manager, Security, and Emergency Preparedness	Chief Executive Office
Megan Abba	OCTA	Communications Specialist	Chief Executive Office
Jason Lee	OCTA	Project Manager, Metrolink Expansion	Capital Programs
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Ethan Brown	Orange County Sheriff's Department	Emergency Management Coordinator	Emergency Management Division
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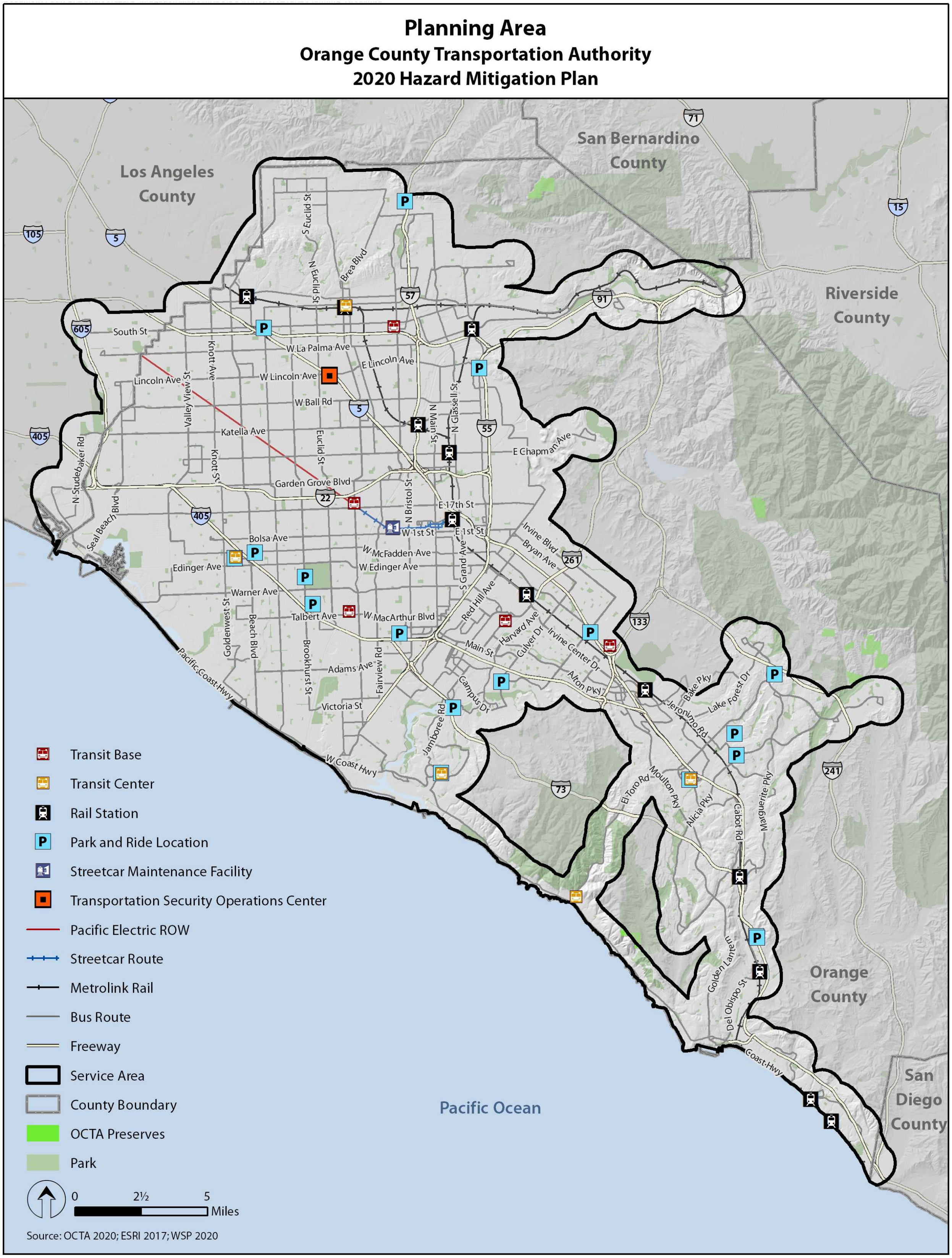
Rudy Emami	City of Anaheim	Director	Public Works
Mike Davis	City of Irvine	Assistant Director	Transportation
Bill Murray	City of Garden Grove	Director	Public Works
Brett Canedy	City of Mission Viejo	Transportation Analyst	Transportation
Taig Higgins	City Santa Ana	Principal Engineer	Public Works
Anna Lowe	San Diego Association of Governments	Senior Regional Planner	Regional Planning

2.4 Defining the Planning Area

The OCTA 2021 HMP Planning Area is synonymous with the OCTA service area; it covers Orange County and small portions of Los Angeles and San Diego County. The Steering Committee agreed that the OCTA HMP should incorporate all customers and owned and operated assets within the service area; Section 3.1.1 further discusses the OCTA service area. Figure 2-1 on the next page illustrates the planning boundary and key area elements.

Figure 2-1 – OCTA Planning Area and Related Transportation Systems Map. Not all items shown are owned by OCTA.



2.5 Community Engagement

44 CFR Section 201.6(b)

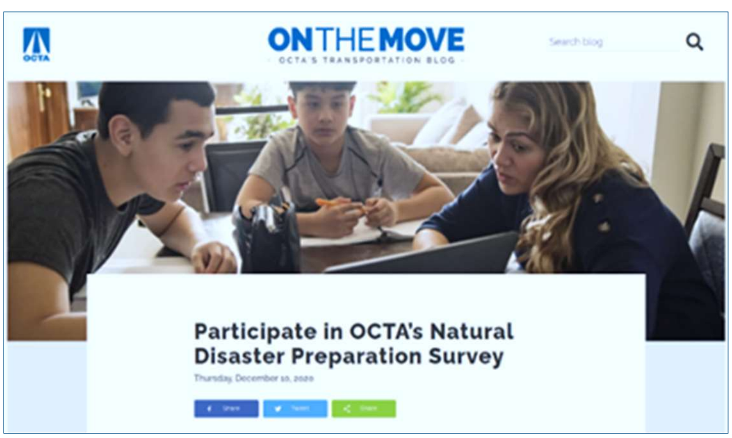
The planning process must include open public involvement with opportunity for the public to comment on the plan draft and before the plan is approved.

The Project Team and OCTA's Department of Community Relations developed and implemented a community engagement strategy to solicit input throughout the planning process. The strategy included an online survey, an open house, and a public review of the plan. Results from these engagements are discussed in sub-sections 2.5.1 to 2.5.3 below, while all materials are available in Appendix D. The following objectives guided the development and implementation of the strategy:

- Identify and engage OCTA customers and community members through a social media campaign
- Distribute a survey to OCTA customers and community members to identify and prioritize hazards, provide mitigation actions, sign-up to stay engaged in the planning process
- Encourage participation in an HMP draft plan review open house, including targeted invites to those persons who signed up to stay engaged in the planning process
- Develop an OCTA Office of Security and Emergency Preparedness webpage to host the plan for review [add in when it is ready]
- Solicit written feedback on the draft HMP during the open house and by making it available online

Figure 2-2 – Orange County Transportation Authority's Public Survey Shared on Twitter

Figure 2-3 – Orange County Transportation Authority's Online Hazard Mitigation Public Survey Available in English, Spanish, and Vietnamese

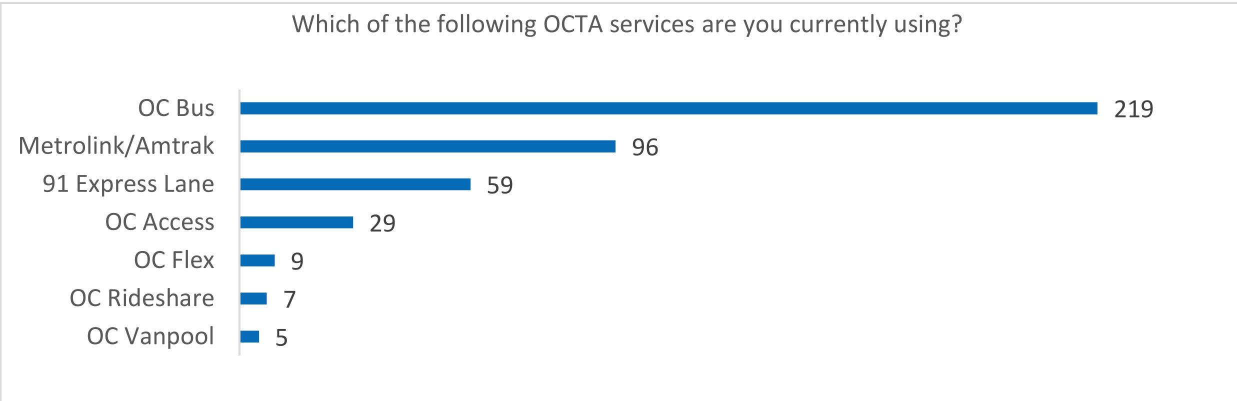


OCTA successfully marketed the hazard mitigation survey to customers and community members through the OCTA Twitter feed (Figure 2-2) and OCTA blog (Figure 2-3). The survey was available in English, Spanish, and Vietnamese to ensure a diverse, equitable, and inclusive community engagement. Doing so ensures the OCTA 2021 HMP is responsive to the whole community's values, concerns, and ideas.

2.5.1 Orange County Transportation Authority Customer Hazard Mitigation Survey Results

In December 2020, OCTA shared the 13-question online OCTA 2021 Hazard Mitigation Survey in English, Spanish, and Vietnamese. OCTA received responses from 348 customers, including five in Spanish and four in Vietnamese. Over 120 survey respondents (~35 percent) indicated that they would like to stay engaged in the planning process and provided their email to do so. The transportation method most used by survey participants is OC buses by far, with Metrolink/Amtrack in second, the OC Vanpool is the least used by respondents. Figure 2-4 shows the Authority's services most used by survey participants.

Figure 2-4 – Customer Survey Response for OCTA Services Used



Customers identified their top three hazards that could impact their commute the most. The top three were earthquakes, which came in at the highest, then epidemic/pandemics, and wildfires not far behind. Conversely, the lowest three hazards were mass earth movements, flood, sea-level rise (SLR), and tsunamis, which were considered least likely to impact participants' commute.

Figure 2-5 – OCTA Survey Results for the Top Three Hazards Potentially Impacting Participants' Commutes

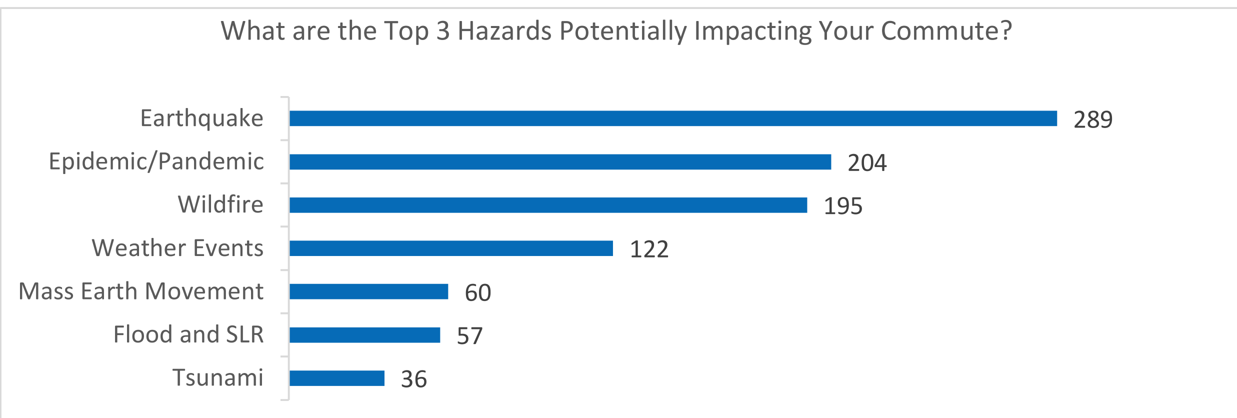
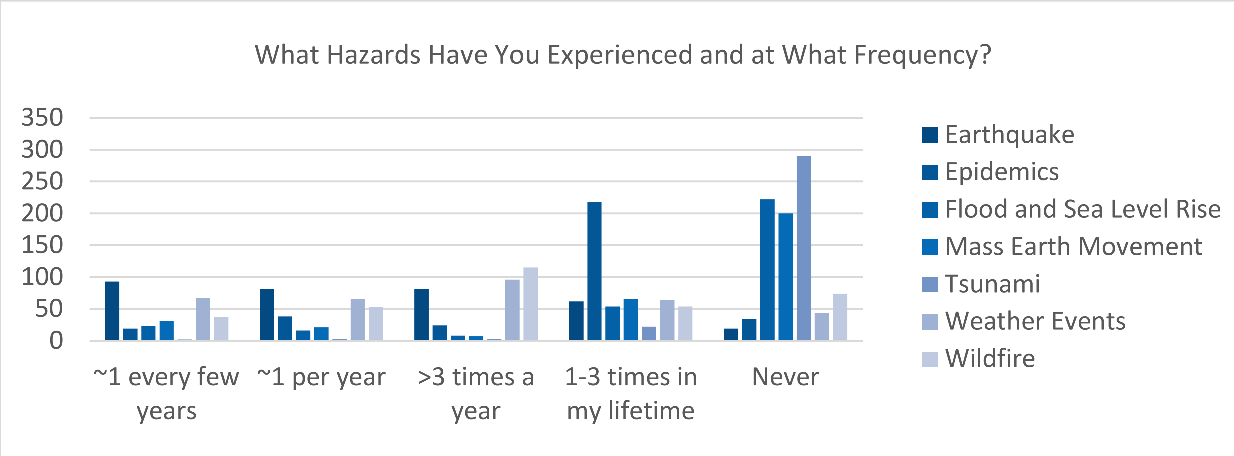


Figure 2-6 reveals the customer survey responses to the hazards they have experienced and how often. Earthquakes were one of the most experienced hazards with the highest frequency, approximately once per year to once every few years. Due to the novel coronavirus (COVID-19) pandemic occurring during the HMP development, most customers reported experiencing an epidemic/pandemic one to three times in their lifetime. In contrast, few participants had personally experienced mass earth movements or a tsunami.

Figure 2-6 – OCTA Survey Results for What Hazards Participants Experienced and at What Frequency



2.5.2 Online Open House

OCTA hosted a one-hour open house with customers and community members on June 16, 2021, to discuss the plan development process and solicit input on the plan. The discussion revolved around natural hazards, exposure, and vulnerability (i.e., risk). The survey also asked participants what actions they would like to see OCTA implement to mitigate risks in the planning area. Similar to OCTA's marketing campaign for the Survey, the Authority leveraged its Twitter and blog platforms to encourage broad participation. [When available: Insert images from OCTA social media/marketing platforms]

2.5.3 Hazard Mitigation Plan 30-day Review Period

Figure 2-8 – Placeholder

OCTA invited customers and community members to participate in all phases of the plan development process and comment on HMP drafts. The OCTA website will continue to provide up-to-date information on the HMP here: [insert link].

Figure 2-7 - Placeholder

[When available: Insert images from OCTA social media/marketing platforms and feedback]

2.6 Coordination with Other Agencies

The Authority invited local jurisdictions, special districts, and community-based organizations to participate in the OCTA 2021 HMP Steering Committee and support the hazard mitigation planning process through workshops, surveys, and the draft plan review. Invitees included but were not limited to:

- The County of Orange
- The San Diego Association of Governments
- The City of Anaheim
- The City of Irvine
- The City of Garden Grove
- The City of Mission Viejo
- The City of Santa Ana, and
- The Orange County for Climate Action group.

> **44 CFR Section 201.6(b)(2)**
>
> Jurisdictions also need to provide an opportunity for neighboring communities, local and regional hazard mitigation involved government agencies, agencies that regulate development, businesses, academia, private, and non-profit groups to be involved in the planning process.

OCTA asked all the above agencies to review the draft plan via email by the Project Team; [insert feedback]. A complete draft plan was sent to Cal OES and FEMA Region IX for pre-adoption review and approval to ensure DMA 2000 compliance.

2.6.1 Review of Policies, Plans, and Programs

The following OCTA policies, plans, and programs informed the HMP development:

- OCTA 2014-2019 Strategic Plan
- OCTA 2018 Long-Range Transportation Plan
- OCTA 2018 OC Transit Vision Plan
- OCTA 2020 Emergency Operations Plan (EOP)
- OCTA 2019 Crisis Communications Annex
- OCTA 2018 Continuity of Operations Plan (COOP)
- OCTA 2016 Threat and Hazard Identification Risk Assessment (THIRA)
- OCTA Capital Programming Policies Update 2019

> **44 CFR Section 201.6(b)(3)**
>
> States that other plans, studies, reports, and technical information related to the mitigation plan should be reviewed and incorporated where applicable.

Other agency policies, plans, and programs that informed the HMP's development include:

- 2015 County of Orange and Orange County Fire Authority Local Hazard Mitigation Plan
- 2019 County of Los Angeles All-Hazards Mitigation Plan Public Draft
- 2018 County of San Diego Multi-jurisdictional Hazard Mitigation Plan
- 2018 State of California Hazard Mitigation Plan
- 2020 City of Garden Grove Local Hazard Mitigation Plan (draft)

The review of these policies, plans, and programs informed the development of the OCTA 2021 HMP. Existing OCTA plans were reviewed to develop the goals in this HMP, supporting the Authority's overarching missions and objectives. The natural hazards and mitigation actions in OCTA's THIRA, EOP, and COOP were evaluated during the HMP initial planning stage to ensure continuity between these plans. Specifically, the 2016 THIRA identified a list of natural hazards and capabilities to mitigate them, creating a baseline for the 2021 HMP hazard identification and risk assessment. Figure 2-1 shows OCTA's planning area and the counties covered; the county HMPs provided foundational information for this plan.

2.7 Plan Development Chronology and Milestones

Table 2-2 – Steering Committee Meetings

Date	Event	Description
June 19, 2020	Release a request for proposals to develop their HMP	Secure contractor support to facilitate the development of the Authority's HMP
August 12, 2020	Steering Committee Workshop #1 Project Kickoff	- Overview of hazard mitigation planning process, purpose, and requirements - Project overview for the HMP - Community engagement - Activity 1, hazard identification and ranking - Activity 2, capability assessment - Next steps and action items
November 3, 2020	Steering Committee Workshop #2 Risk Assessment	- Overview of progress from Workshop 1 - Activity 1, risk assessment worksheet - Reviewed the survey results from MetroQuest - Went through the hazard maps - Next steps and action items
December 2020	Public Survey	OCTA issued a survey to gather public feedback on area hazards. OCTA shared the survey link on its blog and Twitter media accounts.
January 20, 2021	Steering Committee Workshop #3 Mitigation Strategy	- Overview of the planning process since Workshop 2 - Reviewed the public survey results - Identified OCTA's HMP goals - Activity 1, developing mitigation actions worksheet - Activity 2, prioritizing actions worksheet - Next steps and action items
May 25, 2021	Steering Committee Workshop #4 Draft Plan Review	- Reviewed hazard mitigation plan and CFR compliance - Validated hazard mitigation capabilities and capacity - Finalized goals, actions, and implementation - Established plan maintenance protocol and committee - Discussed public open house and 30-day review period - Next steps and action items
[TBD]	Public Open House	
[TBD]	Plan Submission	
[TBD]	Plan Adoption	
[TBD]	Final Plan Approval	

3 Orange County Transportation Authority Profile

3.1 History of the Orange County Transportation Authority

The Authority was established in 1991 when seven separate transportation planning agencies consolidated to become the OCTA (Orange County Transportation Authority, 2018). The service area started in a quiet Los Angeles County community, eventually expanding to all of Orange County and a small section of San Diego County. Since 1991, the Authority was an integral part of the growing community and economy of Orange County, providing vital commuter services to residents and visitors. Over the years, OCTA successfully implemented numerous transportation projects and services directly or in conjunction with other agencies that included over a billion bus passenger trips, an estimated 62 million Metrolink riders, over 200 miles of freeway lanes, and approximately 2,000 synchronized traffic signals installed (Orange County Transportation Authority, 2018).

3.1.1 Orange County Transportation Authority Service Area

Figure 2-1 is the Planning Area map. The Authority administers vital transportation support to the Planning Area and communities by reducing congestion, expanding travel efficiency, and improving travel safety (Orange County Transportation Authority, n.d.). Service includes an extensive bus network of 60 routes that travel in small local areas and throughout the larger Orange County community (Orange County Transportation Authority, n.d.). The OCTA Stationlink connects Metrolink stations with prominent employment centers (Orange County Transportation Authority, n.d.). The Authority is currently expanding services with the addition of a new streetcar.

3.1.2 Geographic Setting and Visitors

Orange County sits along the California coast, with Los Angeles County to the north and San Diego County to the south. The Cleveland National Forest borders the County’s inland side, which runs into San Bernardino County to the east. The County boasts a few major amusement parks, including Disneyland, Knott’s Berry Farm, Soak City Water Park, Knott’s Independence Hall, Pirate’s Dinner Adventure, and Medieval Times Dinner and Tournament (Go-California, n.d.). Additionally, 25 regional and wilderness parks are featured on the County’s visitor website that encompasses 39,000 County acres (Orange County, n.d.). On the Pacific coastline of Orange County are a beautiful 42 mile stretch of recreational beachfront and the coastal cities of San Clemente, Dana Point, Laguna Beach, Newport Beach, Huntington Beach, and Seal Beach (Visit Anaheim, n.d.). ABC Eyewitness News reported on a study by CIC Research that showed Orange County had more than 50 million visitors in 2018 (De Nova, 2019). These visitors have a direct impact on OCTA’s planning area, customers, and infrastructure.

3.1.3 Planning Area Demographics

The 2018 US Census Bureau projected population numbers, past annual bus ridership counts, and GIS layers inform OCTA planning area service trends. Resident population and demographics for the OCTA planning area are from 2018 US Census Data, which estimates nearly three million residents. Bus ridership is the total number of times a bus is boarded in a day. In 2019, OCTA’s annual ridership included approximately 35.5 million boardings.

Protecting vulnerable populations that are at a higher risk is a primary goal of hazard mitigation planning. These populations consist of low-income households, senior citizens, disenfranchised minorities, those that speak English as a second language or not at all, and children (Federal Emergency Management Agency, 2009). Demographics of these vulnerable groups in the planning area are:

- **Hispanic or Latino** – 34.2 percent
- **Black, American Eskimos, or Hawaiian/Pacific Islanders** – less than 0 percent of the population
- **Asian (not mixed)** – 17.7 percent
- **65 years or older** – 11.4 percent
  - This population group is more vulnerable because they may need more support and/or resources after an earthquake, such as medical care, mobility, or transportation support.
- **Under 19 years old** – 26.0 percent
  - The statistics for youth go up to age 19, though only individuals under 18 are vulnerable populations as they are legally dependent on adults, usually require adult supervision, especially during a disaster. Additional challenges arise when children are away from their guardians, such as during daycare or school.
- **Five years and older speak a language other than English at home** – 44.5 percent
  - Residents who speak a language other than English may have difficulty understanding the level of risk related to warnings or alerts.
- **Qualify as living below the poverty level** – 13.0 percent
  - Households below the poverty level are more vulnerable because they have less financial security, which may prevent them from preparing for a disaster. Low-income households are also more likely to rent, potentially leaving them without a home if their rental is significantly damaged (Lazo, Bostrom, Morss, Demuth, & Lazrus, 2015).

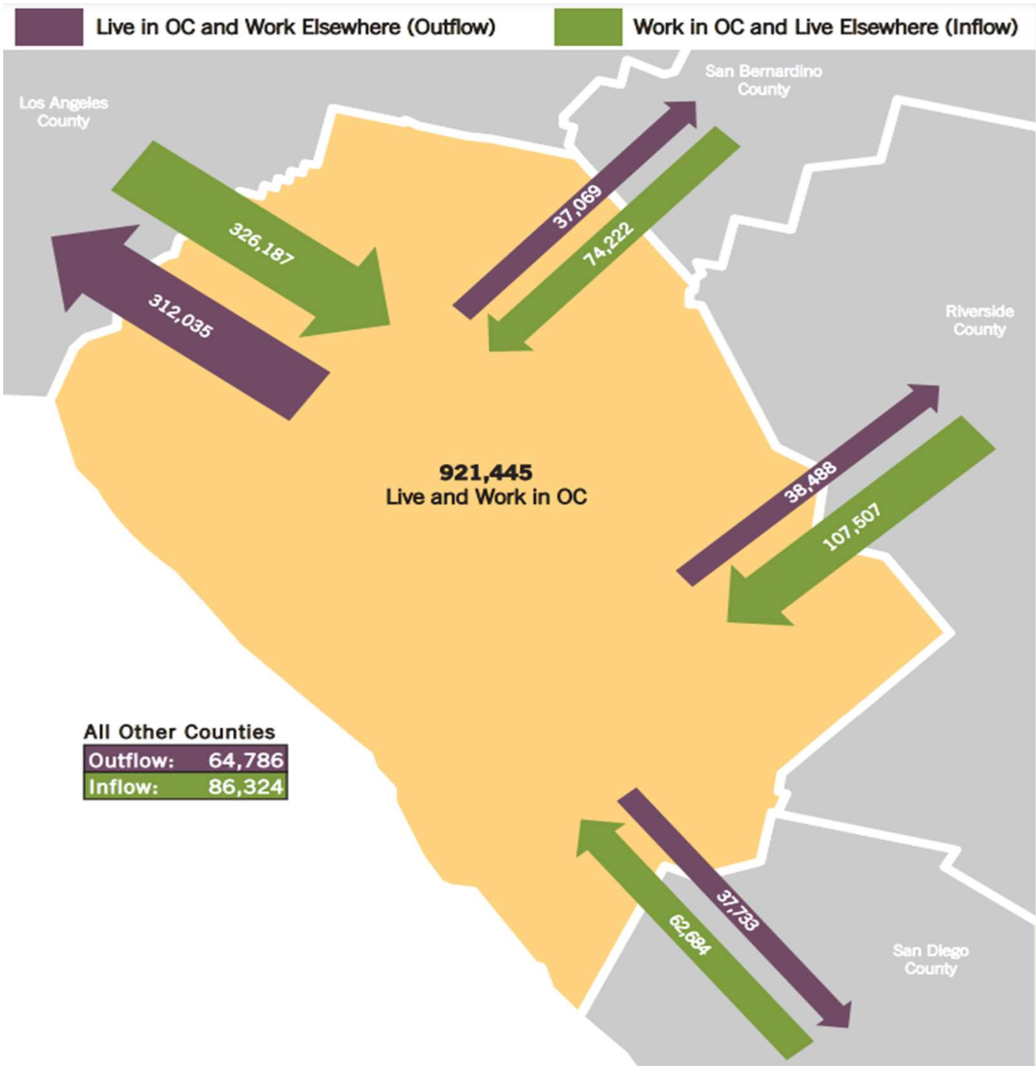
It is critical to identify potentially vulnerable populations during plan development to establish mitigation actions that account for special considerations to protect these populations. Each of the hazard profiles assesses risk for vulnerable populations in Sections 5 to 11.

3.1.4 Daily Commuter Population

Orange County (OC) commuting trends have steadily increased with a rise in employment numbers, 1.39 million in 2010 to 1.52 million in 2015 (Orange County Transportation Authority, 2018). The largest employment centers are in central and north OC, with several other employment areas spread throughout the County. More residents commute into OC than residents in OC commute to other counties.

The OCTA Long-Range Transportation Plan incorporates the California Department of Finance 2016 commuter map for OC, illustrated in Figure 3-1 on the next page (Orange County Transportation Authority, 2018). During these peak transit times, a hazard can significantly impact the transportation infrastructure as more customers rely on OCTA services. OCTA risk assessment and hazard mitigation actions consider the issues associated with high-traffic commuter hours. The OCTA Long-Range Transportation Plan incorporates the California Department of Finance 2016 commuter map for OC, illustrated in Figure 18 on the next page (Orange County Transportation Authority, 2018). During these peak transit times, a hazard can significantly impact the transportation infrastructure as more customers rely on OCTA services. OCTA risk assessment and hazard mitigation actions consider the issues associated with high-traffic commuter hours.

Figure 3-1 – 2016 Commuter Flow in and out of Orange County (Orange County Transportation Authority, 2018)



3.2 Physical Setting

3.2.1 Geology and Topography

The OCTA service area lies between the Pacific Ocean to the west, the Santa Ana Mountain range in the east, and the Puente Hills to the southeast. Historically, shallow seawater covered most of the County (Irvine Valley College). This water coverage influenced the County's coastal geology and topography with marine water deposits, including fossils, shells, sand, and small rocks (Irvine Valley College). As a result, the coastline varies from wide sandy beaches to rocky shores and tall sand and clay cliffs.

The geology of the highest peaks of the Santa Ana Mountain range is metasedimentary rocks (Irvine Valley College). Over time, mass earth movements, erosion, and river flooding, transported boulders, rocks, gravel, sand, and silt to the valleys and coastal plain below (County of Orange and Orange County Fire Authority, 2015). As a result, the range's current geology is primarily rock and sediment washed down and fallen from the mountains (County of Orange and Orange County Fire Authority, 2015).

3.2.2 Climate

Figure 3-2 shows National Climatic Data Center (NCDC) Orange County average annual temperatures. NWS San Diego weather station annual and seasonal statistics are in Table 3-1.

Figure 3-2 – Orange County Average Annual Temperatures From 1981-2021 (National Centers for Environmental Information, 2021)

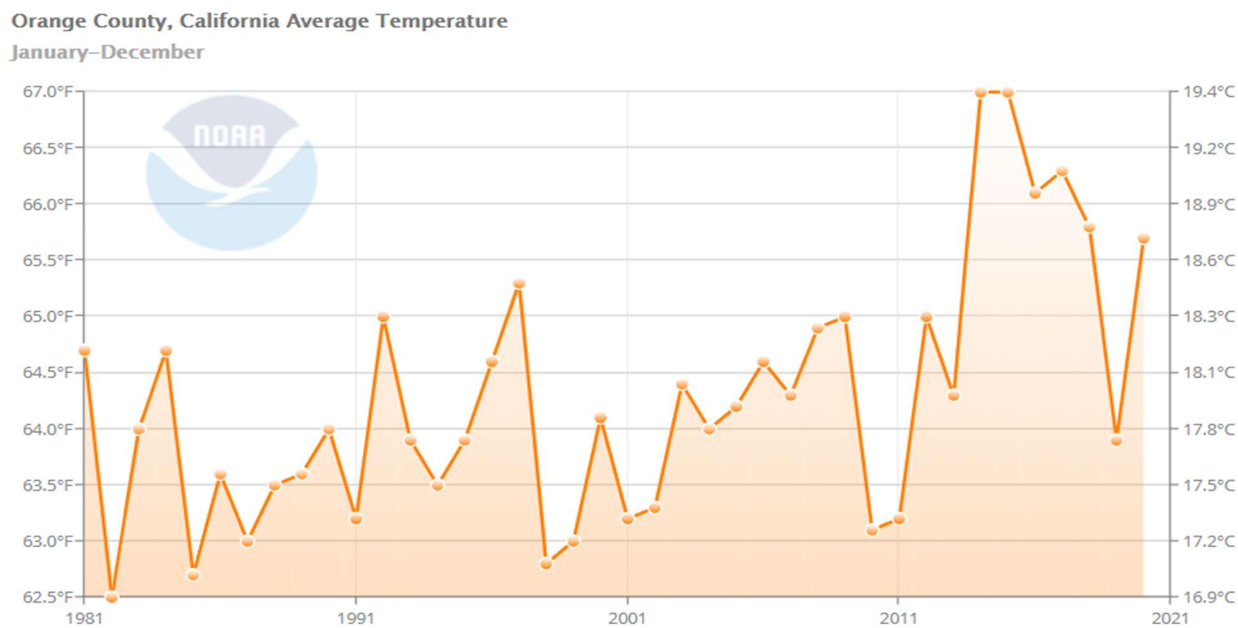


Table 3-1 – Normal Temperatures in °F and Precipitation in Inches Recorded at the San Diego Miramar NAS Weather Station (National Centers for Environmental Information, 2020)

Season	Max Temperature	Minimum Temperature	Average Temperature	Precipitation
Annual	73.4	55.1	64.2	11.48
Winter	67.1	47.1	57.1	6.95
Spring	69.9	52.9	61.4	2.70
Summer	79.3	63.1	71.2	0.19
Autumn	77.1	57.2	67.2	1.64

3.3 Future Trends in Development

44 CFR Section 201.6(c)(2)

Hazard mitigation plan risk assessments must provide a basic description of land use and projected development trends in the community.

Changes in development mean recent development, potential/planned development, or conditions that may affect the jurisdiction's risks and vulnerabilities (e.g., climate change, projected population growth). Ridership has steadily increased since the Authority's inception and will likely continue rising in the future. With the expected growth, continued investment in the transportation system will prevent crowded roadways, increased commute times, and strained infrastructure (Orange County

Transportation Authority, 2018). To manage the expected growth and minimize mass earth movement hazards in the planning area, OCTA follows State and local regulations.

The OC General Plan Chapter X: Housing Element estimates future population numbers, characteristics, and housing needs. Orange County most recently updated the plan's housing element in 2013, where expected growth from 2000-2012 was 7.4 percent (Orange County, 2013). Additionally, the US Census Bureau predicts Orange County's population will increase by 5.5 percent between 2010 and 2019 (United States Census Bureau, 2018). Therefore, it is essential to reevaluate future population predictions when these sources are updated next.

3.4 Orange County Transportation Authority Organizational Structure

3.4.1 Leadership

The OCTA Board of Directors consists of eighteen individuals representing all of Orange County. Elected Orange County Board of Supervisors fill five Board of Director positions. Ten Board of Director positions are filled by City Members appointed by the Orange County City Selection Committee. Two positions are filled by public members appointed by the OCTA Board of Directors. The eighteenth member is the Caltrans District Director, who serves ex-offico (Orange County Transportation Authority, 2020). The Chief Executive Officer (CEO) leads the Authority's staff of 1,500 members and is responsible for projects, programs, and services for the more than three million Orange County residents (Orange County Transportation Authority, n.d.). Along with the Board of Directors, the CEO is responsible for managing an annual budget of $1.4 billion. The Board of Directors applies these funds to freeways, streets, rail, countywide buses, commuter rail, paratransit services, and the 91 Express Lane projects (Orange County Transportation Authority, n.d.).

3.4.2 Public Participation and Committees

The Authority understands citizen feedback is essential to planning and actively encourages public participation and input on programs, studies, and projects. OCTA solicited input through public meetings, open houses, workshops, online surveys, newspaper ads, and focus groups (Orange County Transportation Authority, n.d.). OCTA has three public communities that offer project-specific input from the community. State legislation requires these committees to meet regularly. OCTA committees include the Citizens Advisory Committee, Special Needs Advisory Committee, and Taxpayer Oversight Committee (Orange County Transportation Authority, n.d.).

3.5 Hazard Mitigation Capabilities and Capacity Assessment

To ensure that the OCTA 2021 HMP is a capabilities-based plan, the Project Team, with input from the Steering Committee, completed a comprehensive hazard mitigation capabilities and capacity assessment during Workshop 1 – Project Kickoff Meeting. First, the Steering Committee identified the Authority's current resources, abilities, and local area agreements that support the hazard mitigation plan. Next, OCTA's capabilities were weighed against each hazard, their level of exposure, and the planning area's vulnerability to determine the level of risk. The assessment evaluated the following resource groups:

- Planning and Regulatory
- Administrative and Technical
- Financial
- Education and Outreach

3.5.1 Planning and Regulatory

Planning and regulatory capabilities include the plans, policies, codes, and ordinances that mitigate impacts from hazards.

Plan Title	Yes/No Year	Does the plan address the hazards?	How does the plan identify projects to include in the mitigation actions?	How can the plan be used to implement mitigation actions?
Transit Master Plan	Yes, 2014	The plan does not explicitly identify the hazards in the HMP.	This strategic plan includes a section for other plan integration. This process allows OCTA to assess the HMP mitigation actions in conjunction with the strategic plan updates.	This HMP will be reviewed when the strategic plan is updated. In addition, OCTA will consider how the HMP mitigations support the strategic plan's goals, encouraging mitigation action implementation.
Capital Improvements Plan	Yes, 2011	The plans outline OCTA's goals and objectives to utilize sound business practices and multiple efficient transportation options but do not explicitly identify the hazards in the HMP.	During plan updates, OCTA will review the HMP and identify mitigations actions that help meet OCTA's business plan and capital plan goals.	The business and capital plans are updated regularly. In the next update, OCTA will include identifying beneficial mitigation actions. This process supports mitigation action implementation.
Annual Budget Plan	Yes, 2020	OCTA's annual budget plan incorporates the financial breakdown for projects, including the mitigation actions in the HMP.	The HMP mitigation actions will be evaluated as part of next year's budget planning process.	Next year's budget plan will include the funds allocated for the HMP mitigation actions.
Local Emergency Operations Plan	Yes, 2020	OCTA's EOP contains emergency procedures to prepare for and minimize risks during an emergency, from the following hazards - cybersecurity, earthquake, explosive incident, power outage, and a pandemic.	In the next EOP update, the HMP will be reviewed to include the same hazards and identify mitigation actions related to emergency preparedness.	In the next update, OCTA will consider how the HMP mitigation actions support the EOP goals, encouraging mitigation action implementation.

Plan Title	Yes/No Year	Does the plan address the hazards?	How does the plan identify projects to include in the mitigation actions?	How can the plan be used to implement mitigation actions?
Continuity of Operations Plan	Yes, 2018	OCTA's COOP outlines processes and procedures to continue critical operations during an emergency. The plan refers to the 2016 THIRA for hazards addressed in the COOP.	In the next COOP update, the HMP will be reviewed to include the same hazards and identify mitigation actions related to continuity of operations.	In the next update, OCTA will consider how the HMP mitigation actions support the COOP goals, encouraging mitigation action implementation.
California Regional Transportation Plan	Yes, 2016	This plan improves environmental and health outcomes with climate change considerations for transportation. It does not identify the hazards in the HMP but works to minimize climate change impacts affecting the hazards.	Climate change impacts each hazard, increasing frequency, and severity. This plan supports the HMP mitigation actions with responsible development that protects the environment as much as possible.	This HMP will be reviewed when the transportation plan is updated. OCTA will consider how the HMP mitigations support the transportation plan's goals, encouraging mitigation action implementation.
Environmental Cleanup Program	Yes, 2020	This program allocates funds for controlling transportation-generated pollution, allowing County jurisdictions to meet the Clean Water Act. It does not identify the hazards in the HMP but works to minimize climate change impacts affecting the hazards.	Climate change impacts each hazard, increasing frequency, and severity. This plan supports HMP mitigation actions with clean water projects that protect the environment as much as possible.	This HMP was reviewed alongside the Environmental Cleanup Program. OCTA considered how the HMP mitigations support the cleanup programs' goals, encouraging mitigation action implementation.
Climate Change Resiliency Plan	Yes, Board Approval Pending 2021	This plan is designed around climate change mitigations and protecting the environment.	Climate change impacts each hazard, increasing frequency, and severity. This plan supports the HMP mitigation actions by laying out a plan to reduce climate change's impact on the organization and the planning area.	This HMP will be used to understand climate change impacts on OCTA operations better, thereby helping to anticipate and plan projects required to mitigate the effects of climate change

Plan Title	Yes/No Year	Does the plan address the hazards?	How does the plan identify projects to include in the mitigation actions?	How can the plan be used to implement mitigation actions?
M2 Natural Community/ Habitat Conservation Plan	Yes, 2020	This plan focuses on managing natural preserves and flora, and fauna found there.	As part of the management plan, a separate Fire Management Plan, Fire Response Plan, and Erosion Control plan are maintained.	The HMP can be used to understand further hazards and plan projects to reduce losses in the wildland/urban interface

Rate the Overall Planning Capabilities				
Very Low	Low	Moderate	High	Very High
			X	

How can the OCTA expand Planning Capabilities and reduce risks?
This HMP will help inform planners on OCTA risks, thereby enhancing OCTA's ability to safeguard the community and environment.

3.5.2 Administrative and Technical

Administrative and technical capabilities include staff and their skills and resources that may be leveraged for mitigation planning and implementation.

Administration	Yes/No	Is coordination effective?
Regional Planning Committees and other Groups	Yes	Yes, OCTA participates in several regional committees that address transportation, air quality, and environmental issues.
Mitigation Planning Committee	Yes	Yes. The Mitigation Planning Committee was established during the OCTA 2021 HMP planning process and has agreed to meet annually to review hazards and a hazard mitigation capability.
Maintenance programs to reduce risk (e.g., tree trimming, clearing drainage systems)	Yes	Yes, OCTA has multiple maintenance programs to protect the environment and reduce hazard risks. These programs are in their plans (included in the first table in Section 3.3).
Mutual aid agreements (e.g., inter-local agreements)	Yes	Yes. OCTA remains engaged in local mitigation efforts through the Orange County Operational Area Agreement related to OCTA operations and adjusts accordingly.

Staff	Yes/No	Is staffing adequate to support regulations?	Is coordination effective between staff and agencies?	Are staff trained on hazards and mitigation?
Operations COO	Yes	Yes	Yes	Yes
Government Relations Executive Director	Yes	Yes	Yes	Yes
Emergency Manager	Yes	Yes	Yes	Yes
Capital Programs Director	Yes	Yes	Yes	Yes
GIS Coordinator	Yes	Yes	Yes	Yes
External Affairs Department	Yes	Yes	Yes	Yes
Planning Department	Yes	Yes	Yes	Yes
Risk Management Department	Yes	Yes	Yes	Yes
Health, Safety, and Environmental Compliance Department	Yes	Yes	Yes	Yes

Technical	Yes/No Year Adopted	Has the capability been leveraged to assess or mitigate risk?
Hazard Data and Information	Yes, 2016	Yes
Grant Writing/Management Services	Yes	
HAZUS Analysis	Yes 2021	Yes

Rate the Overall Administrative and Technical Capabilities				
Very Low	Low	Moderate	High	Very High
			X	

How can OCTA expand Administrative and Technical Capabilities and reduce risks?
As hazard datasets continue to be refined, OCTA can use the information to inform and improve the prioritization of projects to mitigate hazard impacts.

3.5.3 Financial

Financial capabilities include funding sources that do not need to be repaid (e.g., government grants, taxes, user fees, and philanthropic sources) and finance (e.g., bonds, private lending).

Funding Resource	Access/ Eligibility (Yes/No)	Has funding been leveraged for hazard mitigation? If so, how?	If not, could funding be used for mitigation, and how?
Capital Improvement Project Funding	Yes		

Funding Resource	Access/ Eligibility (Yes/No)	Has funding been leveraged for hazard mitigation? If so, how?	If not, could funding be used for mitigation, and how?
Authority to levy taxes for specific purposes (e.g., special assessment districts)	Yes	OC Go project added a 30-year half-cent sales tax for transportation improvements. This plan is not directly related to HMP hazards, but environmental care and protection can positively impact natural hazard risks.	
Other Federal Funding Programs			
State Funding Programs			
Insurance Products			
Other	Yes	Special Purpose Taxes	
Hard Dollars			

Rate the Overall Financial Capabilities				
Very Low	Low	Moderate	High	Very High
			X	

How can OCTA expand Financial Capabilities and reduce risks?

OCTA 2021 Hazard Mitigation Plan

Part 2: Risk Assessment

Part 2

4 Risk Assessment

> **44 CFR Section 201.6(c)(2)**
>
> Requires a risk assessment that provides a factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable jurisdictions to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

4.1 Introduction

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage from identified hazards. This process allows emergency management personnel to establish hazard mitigation priorities. The probability of a hazard occurring, exposure, and vulnerability of populations, property, critical infrastructures, and facilities determines the planning area's risk level. The process focuses on these elements:

- **Hazard identification and ranking** – Determine the hazards that may impact a jurisdiction.
- **Exposure identification** – Estimate the total number of people and properties in the jurisdiction likely to experience a hazard event if it occurs.
- **Vulnerability identification and loss estimation** – Assess the potential impact of a hazard on the populations, properties, environment, and critical infrastructures and facilities within a planning area and their capacity to mitigate its effects. Then estimate the potential life and economic losses and possible costs avoided from mitigation actions taken.

4.2 Methodology

Qualitative and quantitative methods for describing and analyzing each hazard informed the hazard profiles in Sections 5 through 11. These profiles included the planning area's hazard risk, exposure, and vulnerabilities of populations, properties, and critical infrastructures and facilities. Risk exists where a structure, population, and/or infrastructure are exposed and vulnerable to a particular hazard. If there is no exposure or vulnerability, there is no risk from the hazard. The HMP incorporates mitigation actions to minimize or remove exposures and/or vulnerabilities, reducing or removing the risk.

4.2.1 Qualitative Methods – Identifying and Prioritizing Hazards of Concern

The Steering Committee identified and prioritized the hazards included in the HMP by assessing the probability, frequency, magnitude, severity, and warning time of each within the planning area. The Committee ranked the hazards based on their subjective assumptions of the most likely and worst-case scenarios. When assessing the hazards, the Steering Committee considered the exposure and vulnerability of populations, properties, and critical infrastructures and facilities within the planning area. In 2016, OCTA completed a Threat Hazard Identification Risk Assessment (THIRA), which identified the following natural hazards with the potential to affect the Authority's service area:

1. Earthquake
2. Epidemic
3. Flood
4. Pandemic
5. Wildfire

The OCTA 2021 HMP aligned with the OCTA 2016 THIRA and expanded the HMP hazards to incorporate sea level rise, coastal erosion, tsunami, and severe weather. The Steering Committee initially defined 12 hazard profiles, and throughout the plan development, condensed a few closely related hazards; the resulting hazard profiles in Table 4-1 below are in the OCTA 2021 HMP.

Table 4-1 – Steering Committee Hazard Ranking Results

Hazard Profiles	Worst-Case	Most-Likely	Section/Page
Earthquake	2	2	5, page 31
Epidemic/Pandemic	3	3	6, page 42
Flooding (including Sea Level Rise, and Coastal Erosion)	5	5	9, page 69
Mass Earth Movement	6	6	8, page 59
Severe Weather (including Drought, Extreme heat, and Storm Surge)	4	4	9, page 69
Tsunami	7	7	10, page 79
Wildfires	1	1	11, page 97

Hazard survey results are in Tables 4-2 and 4-3. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, where one is the lowest and five is the highest. The hazard ranking is from one to seven, where one is at the top and seven is at the bottom

Table 4-2 – OCTA Worst-Case Scenario Hazard Ranking

	Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Wildfire	3.82	4.18	4.55	4.18	2.91	3.93	1
Earthquake	4.09	4.18	2.82	5.00	2.27	3.67	2
Epidemic/ Pandemic	4.18	4.27	1.55	2.91	4.18	3.42	3
Severe Weather	3.05	3.09	3.50	2.57	3.02	3.05	4
Flooding	2.85	2.97	3.18	2.61	3.18	2.96	5
Mass Earth Movement	3.73	3.00	1.45	4.18	1.82	2.84	6
Tsunami	2.55	2.45	1.91	3.73	1.82	2.49	7

Table 4-3 – OCTA Most-Likely Scenario Hazard Ranking

	Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Wildfire	3.73	3.64	4.45	4.00	3.55	3.87	1
Earthquake	3.09	3.82	3.09	4.82	1.91	3.35	2
Epidemic/ Pandemic	4.00	4.00	1.18	3.00	4.09	3.25	3
Severe Weather	2.59	2.75	3.39	2.61	3.05	2.88	4
Flooding	2.64	2.48	3.00	2.39	3.24	2.75	5
Mass Earth Movement	2.18	2.09	1.64	3.36	1.73	2.20	6
Tsunami	2.18	2.18	1.09	3.45	2.00	2.18	7

4.2.2 Quantitative Methods – Map-based Risk Assessment

The HMP includes the most current and accurate scientific data available. However, not all hazards had geospatial data available. Spatial data sets were retrieved from Federal, state, County, and other applicable databases when available. These data sets determined the extent of each hazard, exposure, and vulnerability (i.e., risk). The HMP analysis assessed exposure and vulnerability levels related to people, property, critical infrastructure, and facilities within the planning area. Geographic information system (GIS) software produced numeric results and risk maps added to the hazard profiles in Sections 5 through 11 of this plan. The maps also highlight where the hazards intersected with populations, properties, and critical infrastructures and facilities.

Hazards with available geospatial data were analyzed using GIS software to identify the planning area's risk vulnerability and exposure levels. The risk assessment incorporated the populations and socially and economically vulnerable populations when available, although the data was not available for all hazards. Additionally, the GIS analysis factored in the economic value of exposed structures and the overall hazard exposure of structures in the planning area.

HAZUS-MH Earthquake Assessment

The earthquake hazard risk assessment involved a HAZUS-MH analysis. HAZUS-MH is a GIS-based program used to support the development of risk assessments as required under the DMA. The HAZUS-MH software program quantitatively assesses risk to estimate damages and losses associated with some natural hazards. HAZUS-MH is FEMA's nationally applicable, standardized methodology and software program that contains modules for estimating potential losses from several types of hazards.

Exposures

OCTA Ridership – Annual bus ridership numbers inform OCTA planning area service and population trends. Bus ridership in 2019 was approximately 35.5 million total boardings for the year and 19 average boardings per day for each bus stop. Every time someone rides a bus, it is a "boarding." Boardings do not account for how many individuals ride OCTA buses; for example, one person can ride four buses in a day, which is four boardings.

Population Exposure – To estimate the population exposure for the planning area, the total population was based on US Census Bureau 2018 data and distributed across the OCTA GIS map data. The population data covers the entire service area for OCTA. Each hazard profile lists the population exposed to the hazard, broken down into vulnerable population demographics where the information is available. Socially vulnerable population categories include language, race, age, poverty, and disability. Vulnerable population definitions and demographics for the planning area are in Section 3.1.3. The hazard profiles assess risk for vulnerable populations to each hazard, detailed in Sections 5 to 11.

Structural Economic Exposure – Each hazard profile assesses disaster risk for OCTA owned structures in the planning area and includes potential damage to OCTA assets and critical facilities, their contents (e.g., vehicles), and total economic losses.; they are:

Table 4-4 – OCTA Assets

Facility	Latitude	Longitude
Garden Grove Base	33 45' 49" N	117 55' 25" W

Facility	Latitude	Longitude
Santa Ana Base	33 42' 12" N	117 55' 32" W
Irvine Sand Canyon Base	33 40' 43" N	117 45' 19" W
Irvine Construction Circle Base	33 41' 46" N	117 49' 24" W
Anaheim Base	33 51' 26" N	117 53' 30" W
Newport Beach Transportation Center	33 36' 51" N	117 52' 06" W
Golden West Transportation Center	33 44' 03" N	117 59' 58" W
Laguna Beach Transportation Center	33 32' 42" N	117 46' 58" W
Laguna Hills Transportation Center	33 36' 25" N	117 42' 20" W
Fullerton Transportation Center	33 52' 10" N	117 55' 20" W
Fullerton Park and Ride	33 51' 31" N	117 58' 44" W
Brea Park and Ride	33 55' 32" N	117 52' 53" W
Administrative Facility 550/600	33 46' 44" N	117 52' 04" W
Transportation Security Operations Center	33 49' 54" N	117 56' 02" W

OCTA has identified the following types of facilities from the above list as critical facilities:

- Transportation Security Operations Center (TSOC)
- Transit Bases

FEMA defines critical facilities as all human-made structures or improvements that due to their function, size, service areas, or uniqueness have the potential to cause serious bodily harm, extensive property damage, or impact socioeconomic activities if the facilities are damaged, destroyed, or vital services are impaired (Federal Emergency Management Agency, 2007).

4.2.3 Data Sources

Table 4-4 below lists the data and data sources used to develop maps and tables.

Table 4-5 - Geographic Information System Data Sources

Data	Source
OCTA 2021 Facilities	OCTA 2021
OCTA 2019 Ridership	OCTA 2021
Base Map	ESRI 2017
Wildland Urban Interface (WUI)	CalFIRE 2019
100-Year Storm Surge	US Geological Survey (USGS) 2018
Novel Coronavirus (COVID-19)	California Department of Health 2020
Flood	Federal Emergency Management Agency (FEMA)

Data	Source
Landslide Susceptibility & Mapped Landslide Features	California Department of Conservation 2018, Wills, C. J., Perez, F. G., and Gutierrez, C. I., 2011, Susceptibility to deep-seated landslides in California: California Geological Survey, Map Sheet 58
Average Maximum Temperature Increase	Scripps 2018
Post-Fire Soil Erosion	CalFIRE 2019
Potential Sea Level Rise	National Oceanic and Atmospheric Administration (NOAA)
Tsunami	California Department of Conservation 2009
Fire Hazard Severity Zones	CalFIRE 2019
Responsibility Area	CalFIRE 2019
Vulnerable Populations	US Census Bureau estimates for 2018

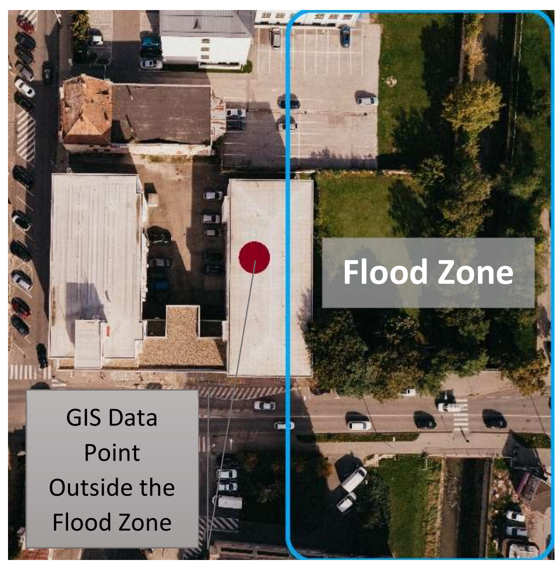
4.3 Limitations

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and can arise from incomplete scientific knowledge concerning natural hazards and/or their effects on the built environment.

4.3.1 GIS Limitations

GIS data and analysis are limited by the scale of hazards and exposures assessed. For example, buildings are often a point on a map rather than shapes showing their entire footprint (i.e., unlike on blueprints or floor plans). Figure 4-1 displays a facility that overlaps a flood zone but would not be identified in that flood zone because the facility's data point is right outside of the flood zone boundary.

Figure 4-1 – GIS Data Point Limitation Diagram



Therefore, maps and analysis should be considered a general representation of risk throughout the service area and do not determine site-specific risks. Potential exposure and loss are also estimated and should be used only to understand relative risk, not absolute risk. The qualitative hazard identification and raking exercise and risk assessment survey completed by the Steering Committee and OCTA community survey responses are essential for addressing these limitations and validating the risk assessments.

4.3.2 HAZUS-MH Limitations

The earthquake risk assessment HAZUS provides a default inventory of critical facilities and infrastructure. These facilities can be augmented with additional inventory. However, the program requires detailed information about the structure to predict how the facility will behave during a hazard event. Therefore, the HAZUS dataset analysis is not as comprehensive as the critical facilities dataset used for GIS assessed hazards because detailed information and economic values were not available for all OCTA structures.

5 Earthquake

5.1 General Background

The Earth's crust is comprised of tectonic plates, constantly moving at a prolonged rate (United States Geological Survey, 2016). Occasionally, the plates get stuck as they push against each other. Friction builds up between the plates when the plates do not move freely. Earthquakes result from friction released as energy that travels in waves through the ground, causing shaking on the surface (United States Geological Survey, n.d.). Surface shaking can be as short as a few seconds or start with one event followed by several more minor earthquakes over several days, known as tremors. These smaller seismic events that follow a more significant initial earthquake are called aftershocks.

Most seismic hazards occur on well-known active faults (Bolt, Earthquake, 2020). However, determining if a fault is active or potentially active depends on geologic evidence, which may or may not be available. Earthquakes are more likely to occur on faults with these conditions (Bolt, Earthquake, 2020):

- Pressure builds up more rapidly
- There were recent earthquakes
- Past earthquakes caused more significant displacements
- Faults are between plates and can relieve accumulated tectonic stresses

The fault types listed above are typically well documented. Depending on the proximity and depth of the earthquake's epicenter, ground shaking can still feel strong. In contrast, large regional faults can generate moderate magnitudes that result in only moderate shaking because of the epicenter's distance and depth. Lesser-known faults are challenging to predict since there is no historic geological data to inform predictions.

5.1.1 Potential Impacts from Earthquakes

Earthquakes can result in changes to the ground surface structure and placement. Ground shaking and displacement from an earthquake can lead to secondary impacts like mass earth movements and cascading effects, such as injuries and death and structural damage

DEFINITIONS

Aftershock – Lower-magnitude earthquakes that follow an initial primary earthquake**.**

Earthquake – A sudden shaking of the ground caused by seismic waves traveling through the earth.

Earthquake Magnitude – The seismic wave/amplitude measured and recorded by seismographs from an earthquake's epicenter. Magnitude is represented by a class name and numerical value from 3 to 8.

Epicenter (seismology) – The point on the ground's surface directly above the focus point where the fault ruptures.

Fault – A fracture in the Earth's crust where compression or tension pressure on causes displacement of soil and rock on the opposite side of the fracture.

Liquefaction – A loss of soil strength or cohesion that results in the soil behaving like a thick liquid (e.g., quicksand).

Modified Mercalli Scale – A measurement of the level of intensity felt on the ground's surface in populated areas, represented by a Roman numeral from I to X.

Surface Rupture – An area of the ground that is offset (raised, lowered, tilted) when a fault rupture reaches the surface of the ground.

to buildings and infrastructure. Earthquakes can disrupt communications and damage utilities such as electricity, gas, sewer, and water lines. Older facilities and infrastructure built before stringent earthquake codes are particularly vulnerable. After an earthquake, entities must check their structures and utility lines for damage (Committee on Consumers and the Public Interest, 2019). Secondary and cascading impacts from earthquakes are addressed further in Section 5.3.

5.2 Orange County Transportation Authority Planning Area Hazard Profile

The California Earthquake Authority (CEA) provides earthquake data and statistics based on California counties. The Southern California Coast region is at risk from the San Andreas fault and more than 100 minor active faults in the area (California Earthquake Authority, n.d.). Although the San Andreas fault only reaches the northern edge of the OCTA planning area, a large earthquake on the fault line would radiate from the epicenter and likely significantly impact the entire planning area.

The CEA's analysis indicates a 75 percent likelihood the Southern California Coast will experience a 7.5 magnitude or greater earthquake on the San Andreas fault-line before 2044 (California Earthquake Authority, 2020). After the San Andreas fault, the next most significant fault affecting the Planning Area is the Newport-Inglewood fault. The Newport-Inglewood fault is 47 miles long; it starts at Culver City, goes through Inglewood, continues through Newport beach in Orange County, and becomes the Rose Canyon fault in San Diego County (California Earthquake Authority, 2020). Locations where earthquakes might occur within the planning area, are discussed in Section 5.2.3.

5.2.1 Hazard Ranking

The Planning Team completed a hazard ranking survey during the OCTA 2021 HMP development process and assessed hazard-related factors based on worst case and most likely scenarios. Hazard definitions and ranking factors are in Appendix G, Table G-1. Survey results were prioritized and ranked based on their averaged score. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, where one is the lowest and five is the highest. Compared to the other hazards in the survey, earthquakes are the second worst-case scenario and the second most likely scenario.

Table 5-1 – OCTA Earthquake Hazard Ranking

Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Worst-Case Scenario						
4.09	4.18	2.82	5.00	2.27	3.67	2
Most Likely Scenario						
3.09	3.82	3.09	4.82	1.91	3.35	2

5.2.2 Past Events

Table 5-2 below includes a few significant earthquakes that affected the Orange County region and the Authority's planning area. Magnitude definitions are in Table 5-3, and modified Mercalli definitions are in Table 5-4.

Table 5-2 – Historical Earthquakes that Affected the Planning Area (Federal Emergency Management Agency, 2020) (Southern California Earthquake Data Center, n.d.) (Scharer)

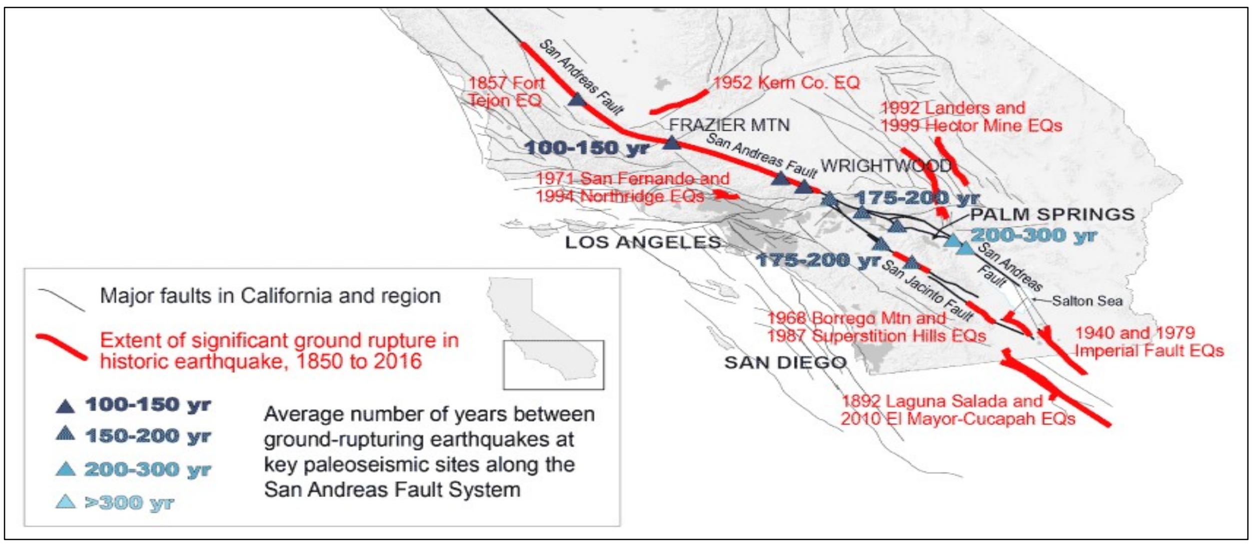
Date	Event Name/Location	Maximum Mercalli Scale Recorded	Magnitude Class	FEMA Disaster Declaration ID
10/1/1987	Whittier Narrows	VIII (severe)	5.9	DR-799-CA
11/23/1987	Superstition Hills Events 1 & 2	VIII (severe)	6.2 & 6.6	-
1/17/1994	Northridge/Reseda	IX (violent)	6.7	DR-1008-CA
4/4/2010	El Mayor-Cucapah	IX (violent)	7.2	DR-1911-CA
7/4/2019	Ridgecrest	IX (violent)	7.1	EM-3415-CA

5.2.3 Locations Where Earthquakes Appear

Southern California Earthquake Zones

The fault map in Figure 5-1 shows the fault lines that can impact the OCTA planning area. The San Andreas Fault runs through the Planning Area, with multiple smaller active faults cutting vertically and horizontally across the entire planning area. Figure 5-1 also shows major faults in southern California that can, and have, affected the planning area as indicated by the events in Table 5-2.

Figure 5-1 – Major Faults in Southern California (US Geological Survey Department of the Interior/USGS) (Scharer)



San Andreas Fault Zone

In the OCTA planning area, the most hazardous and well-known fault line is the San Andreas Fault. This fault occurs where the Pacific Plate and North American Plate meet. This entire San Andreas fault system is more than 800 miles long and, in some areas, as deep as 10 miles. The southern end of the fault runs right through the Planning Area (Schulz & Wallace, 1992). Significant offshoots that can also impact the Authority's planning area include the Garlock and Owens Valley faults north of the Planning Area and the Banning and San Jacinto faults that stretch through the Planning Area from north to south.

The San Andreas fault generates micro earthquakes daily and triggers major earthquakes after decades of pressure buildup (United States Geological Survey, n.d.). The San Andreas fault and its off-shoot faults have triggered events felt in the planning area. The 2010 El Mayor-Cucapah earthquake is the most recent event included in Figure 5-1; it measured a 7.1 magnitude with a modified Mercalli scale of IX (violent) and impacted all three counties in the planning area.

5.2.4 Frequency

In the last 50 years, the OCTA planning area has experienced ten earthquakes registering from a 6.2 magnitude in Coalinga to the 7.2 magnitude earthquake that struck Baja California and was felt throughout the Planning Area (United States Geological Survey). Table 5-2 details these past earthquakes. Based on these events, the Authority's planning area is affected by a moderate to a major earthquake on average once every 6.8 years.

Potentially major (magnitude 7-7.9) or great (magnitude 8 or higher) earthquakes on the San Andreas fault are challenging to predict. The entire fault has numerous segments and offshoots with variable past events, most with decades or hundreds of years between major earthquakes. As shown in Figure 5-1, there were only two historical major earthquakes on the southern end of the fault line, one in 1812 and the other in 1852 (Wald, Scharer, & Prentice, 2017). The USGS and CEA warn the San Andreas section running through the Planning Area is past due for a major earthquake (California Earthquake Authority, 2020).

5.2.5 Severity

The southern end of the San Andreas fault runs through the Planning Area. The fault could rupture and generate a powerful earthquake that would devastate the Planning Area (California Earthquake Authority, 2020). Scientists and planners use different scales to communicate about earthquake power. The audience receiving the information about earthquake risk and hazard determines which scale is used (i.e., scientists or the general public). The most common earthquake measurement scales for hazard mitigation are the Richter Scale and the Modified Mercalli Intensity (MMI) Scale.

Richter magnitude is recorded on a scale of 1 through 9 (Table 5-3). The Richter magnitude is measured by recording the ground vibrations emanating from the source, or epicenter, of an earthquake on a seismograph. The Richter magnitude is an absolute scale, meaning that it will not change with distance from the earthquake epicenter. In recent years, the Richter Scale has been replaced with the Moment Magnitude (M_w) scale. The Moment Magnitude scale is a more effective method for measuring earthquakes at larger distances from the epicenter than the Richter Scale. While the Richter scale is becoming less used, measured Moment Magnitude values are still converted to values comparable to the Richter Scale to determine the earthquake risk.

Table 5-3 – Richter Earthquake Magnitude Classes (United States Geological Survey)

Magnitude Class	Magnitude Range in Numerical Value
Great	M > 8
Major	7 ≤ M < 7.9
Strong	6 ≤ M < 6.9
Moderate	5 ≤ M < 5.9
Light	4 ≤ M < 4.9
Minor	3 ≤ M < 3.9
Micro	M < 3

The MMI scale is an intensity scale ranging from I to X, where X is the most intense earthquake. The MMI scale measures the damage from earthquake shaking in a particular location. The MMI scale is subjective because it is based solely on observable data rather than measurements (Table 5-4). However, the MMI scale may be more effective when using it as a tool to communicate risk and hazard (USGS 2021).

The 2019 Ridgecrest events were the most recent large earthquakes to strike the OCTA planning area. The Ridgecrest earthquakes occurred on July 4 and 5 and consisted of three initial shocks of M_w magnitudes 6.4, 5.4, and 7.1 and several aftershocks. The shaking was felt by millions of people from as far north as San Francisco to as far south as Tijuana, Mexico (Byrd, 2019).

Table 5-4 – Modified Mercalli Earthquake Scale and Descriptions (United States Geological Survey)

Intensity	Shaking	Damage Description
I	Not Felt	Felt by very few under the right conditions
II	Weakest	Felt by a few people at rest, most likely on upper floors of buildings
III	Weak	Noticeably felt by people indoors, especially on upper floors. However, people may not recognize it as an earthquake. Stopped cars may rock slightly. It would feel like a large truck passing.
IV	Light	Many people would feel shaking indoors and could wake people up at night. Loose items could move or fall, like vases or pictures. It might feel like a heavy truck hitting the building. Stopped cars would noticeably rock.
V	Moderate	Nearly everyone would feel this and would wake up many people at night. Items could break like windows and dishes falling out of cabinets. Light and unsecured objects will overturn, like small furniture and bookcases.
VI	Strong	Everyone will feel this. It can move heavy furniture. Older structures can have fallen plaster or masonry.
VII	Very Strong	Newer structures built with high seismic standards and basic building standards will have negligible damage. While older or poorly built structures can have considerable damage.
VIII	Severe	Slight damage to newer structures with high seismic standards. Considerable damage to structures with basic building standards and possible partial collapse. Chimneys, factory stacks, columns, monuments, and walls can fall. Heavy furniture can overturn.
IX	Violent	Newer structures with high seismic standards can have considerable damage. New structures with basic building standards can substantially damage, partial collapse, and/or shift off foundations. Older buildings can be destroyed.
X	Extreme	Some newer, well-built wood structures will be destroyed. Most older buildings with masonry and frame structures will be destroyed. Foundations can be damaged and rails bent.

5.2.6 Warning Time

Earthquakes generally occur with little warning time. However, the CalOES managed Earthquake Warning California provides Californians with seconds to tens of seconds of warning before an earthquake is felt, enabling people to prepare. (California Governor's Office of Emergency Services, n.d.). The warning system combines the MyShake smartphone app, the Android Earthquake Alerts system, and the national Wireless Emergency Alert (WEA) to reach as many Californians as possible. The early warning system uses a network of ground motion sensors located across the state to detect an earthquake's first wave and the hazard (California Office of Emergency Management).

5.3 Secondary Hazards and Cascading Impacts

5.3.1 Secondary Hazards

Earthquakes may cause the following secondary hazards (Bolt, Earthquake: Geology, 2020):

- Surface ruptures (e.g., rising, tilting, dropping)
- Liquefaction
- Mass earth movements (e.g., landslides, rockslides, debris flows, mudflows)
- Dam and levee failure
- Tsunamis and seiches

Surface ruptures

Surface ruptures can alter the ground by pushing the ground up, dropping the ground, and tilting the surface's angle. Ruptures vary dramatically in size and depth. There are records of fault displacements ranging from one mile to 200 miles in length; typically, surface ruptures are found between six feet to 1,000 feet from the fault line (United States Geological Survey). Surface ruptures can damage anything on the impacted area before an earthquake changed the ground's shape.

Liquefaction

Liquefaction occurs when soils lose their shear strength and flow or turn the ground into a pudding-like liquid. Liquefaction can cause buildings and road foundations to lose load-bearing strength, resulting in structures and infrastructure sinking into quicksand-like soil where it was previously solid ground. To determine an area's soil structure and susceptibility to seismic hazards, the US Department of Agriculture, Natural Resources Conservation Service (NRCS) provides a Web Soil Survey library. The NRCS states this library is the single authoritative source for soil information in the US; it contains soil maps and data for more than 95 percent of US counties (United States Department of Agriculture Natural Resources Conservation Service, 2019).

Once the soil composition is determined, the National Earthquake Hazard Reduction Program (NEHRP) soil classification system explains an earthquake's amplifying effect on soft soils. This amplification is the average shear-wave velocity on the upper 100 feet of soil compared to the shaking amplification at the ground's surface (Palmer, et al., 2007). Seismic activity typically does not amplify or reduce B soils. However, earthquakes more easily alter increasingly softer C, D, and E soils. E soils are the most susceptible to liquefaction from seismic activity (Palmer, et al., 2007). Table 5-5 is the NEHRP system.

Table 5-5 – NEHRP Soil Classification System (Williams, Stephenson, Odum, & Worley, 1997)

NEHRP Soil Type	Description	Mean Shear Velocity to 30 m (m/s)
A	Hard Rock	1,500
B	Firm to Hard Rock	760-1,500
C	Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Clays	< 180
F	Special Study Soils (liquefiable soils, sensitive clays, organic soils, soft clays >36 m thick)	

Mass Earth Movements

An earthquake can cause a mass earth movement, such as a debris flow, landslide, rockslide, or mudslide. When the ground shakes, it can shift the earth causing the ground's surface to become unstable and fall or flow. The most common earthquake-caused landslides are rockfalls (United States Geological Survey). The extent of a mass earth movement is dependent on several factors, including the earthquake's magnitude, the focal depth of the epicenter, soil or ground composition, and duration of the shaking (United States Geological Survey). Mass earth movements and their risk to the planning area are covered more in Section 8.

Dam and Levee Failure

An earthquake may result in dam and levee failure. Historically, solid dams made from materials like concrete are minimally affected by earthquakes (Hiner, 2020). However, earthen dams and levees are highly susceptible to a mass earth movement caused by a seismic event. Several earthen dams and levees could impact the Authority's planning area if they were damaged or failed. Examples include, but are not limited to the following (Enjoy OC):

- **The Santiago Dam** – A dam made from excavated dirt and rock that contains a 25,000 acre-feet capacity reservoir
- **Villa Park Dam** – An earthen flood control dam downstream from the Santiago Dam
- **Walnut Canyon Reservoir** – An earth-filled and asphalt-lined structure with a water storage capacity of about 197 acre-feet, used by the City of Anaheim for potable water
- **Sulphur Creek Dam** – A dam made of dirt fill with a capacity of 382 acre-feet and owned by Orange County
- **Peters Canyon Dam** – An earth-filled dam with a capacity of 626 acre-feet depending on seasonal rainfall and owned by Orange County
- **Prado Dam** – An earth-filled dam with water storage capacity of 2,255 square feet located in Riverside County, providing flood control and water conservation storage for Orange County

Tsunamis and Seiches

Depending on the location, earthquakes can also trigger tsunamis and seiches. Seismic seiches are waves generated by an earthquake on lakes, reservoirs, ponds, and rivers (United States Geological Survey). A seismic seiche impact is limited to the area around the water body; although, the waves can cause erosion, flooding, and damage or destroy earthen dams and levees. Shallow marine thrust earthquakes that displace the seafloor are the most likely combination of factors to cause a tsunami; however, major strike-slip earthquakes have occasionally triggered small tsunamis (United States Geological Survey). Tsunamis and their potential impact on the OCTA planning area are discussed further in Section 10. OCTA planning area risks from flooding, erosion and sea-level rise are in Section 6.

5.3.2 Cascading impacts

The earthquake itself and the earthquake's secondary hazards can also cause cascading impacts. The shaking ground from a seismic event can directly damage and/or destroy structures and infrastructure with the movement. Horizontal seismic motion generally causes more damage to structures than vertical movement (United States Geological Survey). Surface ruptures, mass earth movements, and liquefaction can all directly cause structural damage to anything directly over or very near the ground displacement or liquefaction.

Continuing cascading impacts come from the structural damage caused by earthquakes and their secondary impacts. One, or a combination of, these impacts pose a risk of injury or death to people. These issues can include, but are not limited to:

- **Utility failures or outages** – such as electricity, potable water, sewer, stormwater, transportation routes, and systems
- **Hazardous materials spill** – from storage facilities, along transportation routes, in marine environments, etc.
- **Fires** – caused by broken gas and/or power lines (especially dangerous if there are broken water lines feeding fire hydrants)

Al earthquake impacts could affect OCTA staff, customers, and the community. Cascading effects can also, directly and indirectly, impact OCTA's planning area, including facilities, structures, and infrastructure.

5.4 Potential Impacts from Future Climate Conditions

The impacts of climate change on earthquake probability are unknown; however, secondary impacts from earthquakes can be magnified or more possible due to climate change factors (Mauger, Lee, & Won, 2018). For example, earthquakes can instigate fires, as indicated in the section above; this could lead to a significant wildfire event if it is compounded by climate change-influenced droughts. In addition, after an earthquake, mass earth movements may be more likely due to climate change, with increasing factors such as (Mauger, Lee, & Won, 2018):

- Increased wildfires depleting hillside vegetation
- Soil saturation from unusually high precipitation level
- Changes in river hydrology from more frequent and/or intense severe weather
- Weakened coastal slope stability due to SLR

5.5 Exposure and Vulnerability

For the hazard exposure and vulnerability analysis, OCTA used HAZUS-MH to evaluate a magnitude 8.2 earthquake scenario on the San Andreas fault. This earthquake hazard scenario encompasses the entire planning area, and shaking is anticipated to be strong to very strong. The HAZUS-HM description and process are in Section 4.2.2 of this plan. Figure 5-2 shows the planning area exposed to earthquakes.

5.5.1 Population

Exposure

The entire population within the planning area is exposed to earthquakes, including the magnitude 8.2 San Andreas fault scenario used for HAZUS-MH. The HAZUS-MH scenario intersected geospatial hazard data, and 2018 US Census Bureau estimates to assess population exposure and vulnerability in the planning area, covering almost 800 square miles, 582 census tracts, and nearly 3 million residents.

Vulnerability

The entire vulnerable population within the planning area is exposed to earthquakes. As discussed in Section 3.1.3, higher-risk vulnerable populations consist of low-income households, senior citizens, disenfranchised minorities, those that speak English as a second language or not at all, and children (Federal Emergency Management Agency, 2009). Vulnerable population demographic estimates:

- **Persons over 65 years old** – 11.4 percent of the population

- **Persons under 19** – 26.0 percent of the population
- **Hispanic or Latino** – 34.2 percent of the population
- **Black, American Eskimos, or Hawaiian/Pacific Islanders** – Less than 1 percent of the population
- **Asian** – 17.7 percent of the population
- **Persons that speak a language other than English at home** – 44.5 percent of the population
- **Persons living below the poverty level** – 13.0 percent of the population

Property

All OCTA-owned and operated properties are exposed to earthquake hazards.

Vulnerability

Older structures are more vulnerable to damage from seismic activity due to the adequacy of building codes. Table 5-6 lists building code milestones within the planning area, which can inform future property vulnerability analysis.

Table 5-6 – Age of Structures and Building Codes in Orange County (Wiley, 2020)

Date/Range	Significance of Time Frame
Pre-1925	Before 1925, there were no precise earthquake building code requirements in California.
1925-1933	The City of Santa Barbara was the first local government to adopt seismic reduction building codes in 1925.
1933-1960	After the 1933 Long Beach earthquake, the State realized earthquakes in California were not rare or one-time hazards, and the State rapidly enacted earthquake-resistant building codes.
1960-1972	In 1960, the Structural Engineers Association of California published guidelines on recommended earthquake provisions.
1972-1973	The 1971 San Fernando Valley earthquake inspired legislatures to propose 35 pieces of legislation, with more than 5 of these significant seismic safety acts passed in 1972.
1974-2000	California established the Joint Committee on Seismic Safety in 1974. In 1975, lateral force requirements made significant improvements. From 1974 to 2000, legislatures approved approximately 190 pieces of legislation on earthquake safety.
1990	The Seismic Mapping Act was passed in 1990 and addressed earthquake hazards associated with non-surface fault ruptures, liquefaction, and landslides (County of Orange and Orange County Fire Authority, 2015).
1994	In 1994, the Uniform Building Code (International Conference of Building Officials, 1994) was amended to include seismic safety provisions.
2000-Present	Seismic codes are enforced through building permits. The Seismic Safety Commission continues to inform and recommend seismic safety projects and renovations for buildings and infrastructure (Alquist, 2019).

Damage Estimates

Damage estimates for OCTA-owned and operated properties within the planning area were generated using HAZUS-MH for the San Andreas 8.2 magnitude scenario, the results of which are listed in Tables 5-7 to 5-10. The results include property loss for OCTA-owned and operated facilities, the types and counts of facilities impacted by strong shaking, the average probability of structure damage, and the anticipated average probability of full functionality in days after the earthquake scenario.

Table 5-7 – OCTA Facility Value Losses for the HAZUS-MH Scenario in Thousands of Dollars

Facility Type	Facility Loss Value (*in thousands $*)	Content Loss (*in thousands $*)	Economic Loss (*in thousands $*)
Administrative Facility	$3,522	$50,550	$704
Express Lane Project	$216,954	$8,775	$51,528
Metrolink Expansion	$18,312	0	$5,465
Pacific Electric ROW	$54,757	0	$10,444
Park and Ride Facility	$5,232	$51	$1,263
Santa Fe Rail ROW	$112,249	0	$34,070
Transit Base Facilities & Vehicles	$186,567	$368,715	$5,708
Transit Center Facility	$15,575	$100	$1,304
Transportation Security Operations Center	$4,013	0	$154
Unused Land/Property	$13,089	0	$2,358
Total	**$803,946.00**	**$428,735.00**	**$129,376.00**

Table 5-8 – OCTA Facilities Impacted by Strong Shaking in the HAZUS Scenario

Facility Type	Strong Shaking
Administrative Facility	2
Express Lane Project	2
Metrolink Expansion	1
Pacific Electric ROW	1
Park and Ride Facility	4
Santa Fe Rail ROW	1
Transit Center Facility	13
Unused Land/Property	2
Total	**65**

Table 5-9 – OCTA Facility Average Probability of Structural Damage in the HAZUS-MH Scenario

Facility Type	No Damage	Slight Damage	Moderate Damage	Extensive Damage	Complete Destruction
Administrative Facility	39%	29%	28%	4%	1%
Express Lane Project	5%	57%	24%	10%	3%
Metrolink Expansion	4%	54%	26%	12%	4%
Pacific Electric ROW	10%	66%	17%	5%	1%
Park and Ride Facility	30%	38%	22%	7%	2%
Santa Fe Rail ROW	3%	53%	27%	13%	4%
Transit Center Facility	73%	19%	6%	2%	0%
Unused Land/Property	11%	67%	16%	5%	1%
Total	**67%**	**22%**	**8%**	**2%**	**1%**

Table 5-10 – OCTA Facility Average Probability of Full Functionality After the HAZUS-MH Scenario

Facility Type	Day 1	Day 3	Day 7	Day 14	Day 30	Day 90
Administrative Facility	39%	40%	67%	67%	95%	99%
Express Lane Project	5%	8%	62%	62%	87%	97%
Metrolink Expansion	4%	6%	57%	57%	84%	96%
Pacific Electric ROW	10%	13%	76%	76%	93%	99%
Park and Ride Facility	30%	32%	69%	69%	91%	98%
Santa Fe Rail ROW	3%	6%	56%	56%	83%	96%
Transit Base Facility	82%	83%	96%	96%	100%	100%
Transit Center Facility	73%	73%	92%	92%	98%	99%
Transportation Security Operations Center	81%	81%	94%	94%	100%	100%
Unused Land/Property	11%	15%	78%	78%	94%	99%
Total	**67%**	**68%**	**89%**	**89%**	**97%**	**99%**

5.5.2 Critical Facilities and Infrastructures

Damage estimates for OCTA-owned and operated critical facilities and infrastructures within the planning area were generated using HAZUS-MH for the San Andreas 8.2 magnitude scenario, the results of which are listed in Tables 5-11 to 5-14. The results include property loss for OCTA-owned and operated facilities, the types and counts of facilities impacted by strong shaking, the average probability of structure damage, and the anticipated average probability of full functionality in days after the earthquake scenario.

Table 5-11 – OCTA Critical Facility Value Losses from the HAZUS-MH Earthquake Scenario in Thousands of Dollars

Critical Facility Type	Facility Loss *(in thousands $)*	Content Loss *(in thousands $)*	Economic Loss *(in thousands $)*
Transportation Security Operations Center	$4,013	0	$154
Transit Base Facilities and Vehicles	$186,567	$368,715	$708
Total	**$190,580**	**$368,715**	**$862**

Table 5-12 – OCTA Critical Facilities Impacted by Strong Shaking in the HAZUS Scenario

Critical Facility Type	No. Buildings of Experiencing Strong Shaking
Transportation Security Operations Center	1
Transit Base Facilities	35
Total	**36**

Table 5-13 – OCTA Critical Facility Average Probability of Structural Damage in the HAZUS-MH Scenario

Critical Facility Type	None	Slight	Moderate	Extensive	Destruction
Transportation Security Operations Center	81%	13%	5%	0%	0%
Transit Base Facilities	82%	14%	4%	0%	0%

Table 5-14 – OCTA Critical Facility Average Probability of Full Functionality After the HAZUS-MH Scenario

Critical Facility Type	Day 1	Day 3	Day 7	Day 14	Day 30	Day 90
Transportation Security Operations Center	81%	81%	94%	94%	100%	100%
Transit Base Facilities	81%	81%	94%	94%	100%	100%

5.6 Development Trends

Earthquakes are one of the most likely and geographically extensive hazards within the planning area. OCTA understands these risks and will continue to consider seismic hazards in their new and future projects. Building development in earthquake zones is also highly regulated through State and local plans, laws, and building codes. The Authority's Heath, Safety, and Environmental Compliance Department ensure all projects and operations comply with applicable health, safety, and environmental standards, codes, and regulations (Orange County Transportation Authority, 2014).

California Legislature Sec. 65302 Government Code

General plans must identify and protect the community from any unreasonable risks associated with seismic hazards; these risks include earthquakes, tsunamis, mass earth movements, and any other seismic hazards (California Legislative Information, 2018).

The Orange County General Plan directs overall land use, addresses growth management, and establishes standards and regulations to protect the community from hazards (Orange County). Chapter XI Growth Management Element incorporates OCTA in the transportation development sections and includes plans and policies for traffic and public facility improvements to adjust for population increases (Orange County, 2020). The General Plan Chapter IX Safety Element provides building codes and standards to minimize exposure from all identified hazards. This section incorporates County emergency management, law enforcement, and fire management plans (Orange County, 2013).

Development plans include risk reduction measures, and growth management plans specific to transportation. The County states that it may not be responsible for some transportation projects but supports the transportation agencies leading these projects. Land-use planning and growth management are well managed by the County and designed to reduce seismic hazard risks.

5.7 Issues

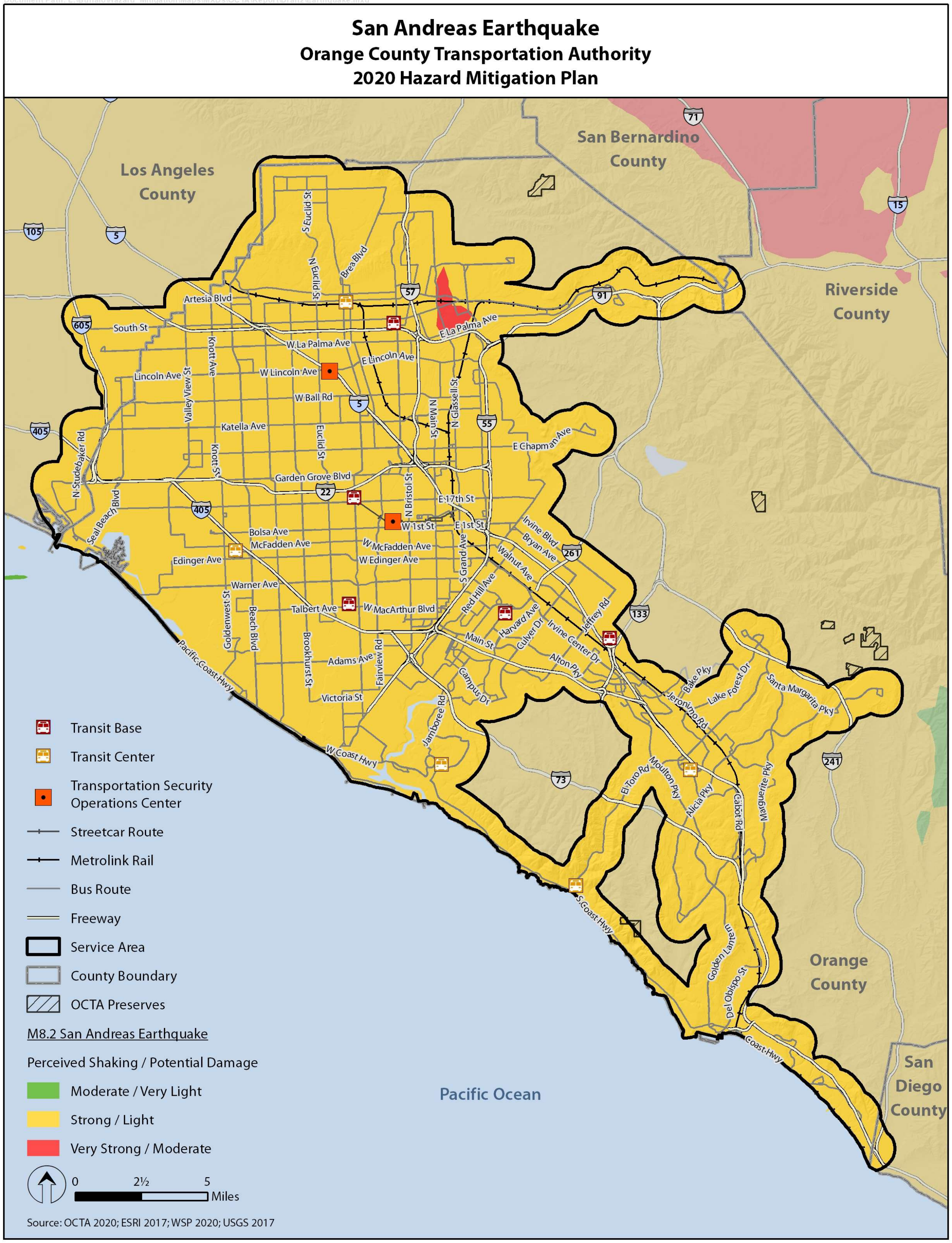
Earthquake considerations in the OCTA planning area (Orange County Transportation Authority, 2020):

- Earthquakes could trigger secondary hazard events such as levee failures, landslides, or damage, potentially impacting the Agency's customers, structures, infrastructure, and operations.
- New or renovated OCTA structures should include appropriate seismic building standards.
- Transportation routes may need to be altered immediately after an earthquake based on damage to infrastructure and Authority's structures.
- Additional transportation services may be needed to support vulnerable populations after a destructive earthquake.
- There could be considerable debris to clean up and possibly hazardous materials mixed, depending on the earthquake's magnitude and areas affected.

5.8 Hazard Maps

The map of earthquake risks impacting the planning area is on the next page.

Figure 5-2 – OCTA HAZUS Earthquake Scenario Map



6 Epidemic/Pandemic

6.1 General Background

In the US, infectious diseases are a significant contributor to illness, disability, and death (Office of Disease Prevention and Health Promotion, 2020). Over the last few decades, outbreaks, epidemics, and pandemic events have increased, spreading faster and farther; this includes re-emerging diseases and recently discovered diseases (World Health Organization, 2018). An epidemic is a significant and unexpected increase in disease cases. An outbreak is like an epidemic, but it is limited to a geographic area or group of people. Pandemics occur when a disease crosses multiple countries and infects a large number of people. For example, the novel coronavirus (COVID-19) started in China in 2019 and spread rapidly across the world, resulting in a global pandemic in 2020 (Centers for Disease Control and Prevention, 2020).

Infectious disease-causing agents can be viruses, bacteria, parasites, fungi, or parasites (Mayo Clinic Staff, 2019). Communicable diseases can be spread by direct contact from animal to person or person to person, indirect contact by touching a contaminated surface or object, insect bites, contaminated food or water, or inadequate medical sanitation (Mayo Clinic Staff, 2019). Chemicals or toxins can also cause outbreaks, such as “Jamaican ginger paralysis,” and on occasion, the cause of a disease is unknown (World Health Organization).

An individual can be at risk from an infectious disease or chemical/toxic agent from ingestion, inhalation, or direct skin contact; radiation is the only exposure that can be external, traveling to the individual (Agency for Toxic Substances and Disease Registry, 2005). Some agents have multiple means of spreading, others only by bodily fluids.

Infectious diseases can be seasonal, such as influenza. In contrast, others may be rare but have a high mortality rate, like Ebola and hemorrhagic fevers (Cole, 2014). Some diseases occur after a disaster due to contaminated food and water, such as E. coli (Centers for Disease Control, 2019). Unfortunately, it is rare to eradicate diseases, and new ones are continually discovered (World Health Organization, 2018).

DEFINITIONS

Communicable Disease – an illness transmitted from an infected agent to an animal or individual through direct or indirect contact.

Disease Vector – an agent that carries and transmits infectious diseases, such as an insect, fungus, or animal.

Epidemic – Happens when there is a significant and unexpected increase in disease cases.

Essential Workers – individuals that work in roles that are critical to infrastructure operations.

Herd Immunity – when enough of the population becomes resistant to a disease by recovering from the illness or vaccination.

Infectious Diseases – Medical conditions/illnesses caused by organisms like bacteria, viruses, fungi, or parasites.

Mortality Rate – a mathematical measure of the frequency that individuals die in a defined population during a specific period of time.

Outbreak – Similar to an epidemic but limited to a specific geographic area or group of people.

Pandemic – Occur when a disease crosses multiple countries and infects a large number of people.

6.1.1 Potential Damage from Epidemics

Epidemics and pandemics can significantly impact mortality rates, social and mental health, the economy, and disrupt travel operations (Madhav, et al., 2017). Diseases and mortality rates can disproportionally affect vulnerable populations. These populations can include younger people who have not built up immunity, older individuals and people with underlying health conditions that lower their immune systems, and low-income or non-citizens who do not have access to affordable medical care (Madhav, et al., 2017). The disproportional impact can exacerbate the over-taxed emergency response and healthcare communities. A single outbreak can overrun a local emergency response and healthcare systems' resources and staff. Additionally, overwhelmed medical facilities reduce non-infectious disease medical and mental care (Bloom, Cadarette, & Sevilla, 2018).

An infectious disease event can have societal impacts that affect individuals and the economy. Infection control measures can lead to a temporary closure of schools and businesses and reduce transportation and public services (Bloom, Cadarette, & Sevilla, 2018). These measures and infectious diseases can cause general stress to an affected community and more severe mental health issues for some individuals. The stress can trigger concerns about a person or loved one's health, changes in sleep and eating, difficulty sleeping or concentrating, chronic medical and/or mental health problems increasing, and increased use of mood-altering substances (e.g., tobacco, alcohol, illegal drugs) (Centers for Disease Control, 2020).

6.2 Orange County Transportation Authority Hazard Profile

Epidemics and pandemics do not need to start in the OCTA planning area to impact the Authority's customers, staff, and operations. The entire OCTA planning area is at risk from known-preventable diseases and newly introduced or reemergent diseases that do not have vaccines yet. Childhood vaccination percentages are a strong indicator of community resilience to known-preventable diseases and a cost-effective method for preventing these dangerous diseases (Office of Disease Prevention and Health Promotion, 2020). Orange County's childhood vaccination statistics are a good representation of vaccine percentages in the planning area.

There are 24 school districts in Orange County. The 2016 records for kindergarteners in these districts showed the percentage of students with the required immunizations ranged between 86.3 percent and 98.2 percent (Orange County's Healthier Together, 2016). Orange County's vaccination percentages are high and a positive indication of vaccination levels in bordering counties. Therefore, the OCTA planning area has a low risk of an outbreak or epidemic from vaccine-preventable diseases. However, unvaccinated visitors and new residents can bring new or variant infectious diseases to the area, as revealed during the COVID-19 pandemic.

OCTA 2020 COVID-19 Pandemic Narrative

March 2020-current, OCTA responded to the COVID-19 Pandemic. Actions taken included specific task forces to address ongoing items (Return to work, local infection rate monitoring, vaccinations, and others), as well as enhanced communications and partnerships with relevant stakeholders in the community. OCTA was asked to assist in transporting medical providers to specific community clinics, as well as partner with other trusted community transportation organizations to get members of the underserved communities to/from vaccination clinics.

6.2.1 Hazard Ranking

The Planning Team completed a hazard ranking survey during the OCTA 2021 HMP development process and assessed hazard-related factors based on worst case and most likely scenarios. Hazard definitions and ranking factors are in Appendix G, Table G-1. Survey results were prioritized and ranked based on their averaged score. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, where one is the lowest and five is the highest. Compared to the other hazards in the survey, epidemics/pandemics were ranked third for the worst-case and the most likely scenarios.

Table 6-1 – OCTA Epidemic/Pandemic Hazard Ranking

Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Worst-Case Scenario						
4.18	4.27	1.55	2.91	4.18	3.42	3
Most Likely Scenario						
4.00	4.00	1.18	3.00	4.09	3.25	3

6.2.2 Past Events

The OCTA planning area was directly affected by two pandemic events in the last decade, H1N1 and COVID-19. In 2009, a pandemic of H1N1 influenza, popularly known as swine flu, resulted in many hospitalizations and deaths. In Orange County, there were 226 cases of severe illness and 57 deaths associated with H1N1 through August 9, 2010 (Orange County Mosquito and Vector Control District, 2020). In Appendix G Table G-6 lists diseases and rates for Orange County.

HMP Planning During COVID-19

This plan was developed during the novel coronavirus 2019 (COVID-19) pandemic. A more in-depth review of COVID-19 and its effects will be in the 2026 HMP update.

Throughout most of 2020 and during the development of this plan, OCTA and the world were responding to the COVID-19 pandemic. This virus had an unprecedented effect globally and directly influenced transportation operations. As of May 4th, 2021, the COVID-19 rates for Orange County is total infection cases are 270,345 and the number of deaths 4,969 (The New York Times, 2020).

6.2.3 Location

While it is difficult to anticipate where an epidemic or pandemic may spread, contact tracing is helpful for mapping out the locations and persons infected with a contagious disease. During an epidemic or pandemic, OCTA can support the CDC and local public health efforts by preparing their staff and operations and providing contract tracing information.

6.2.4 Frequency

Historical events indicate that epidemics and pandemics are happening more frequently and spreading farther over the past century. This increase is likely due to multiple factors, such as increased global travel, economic globalization, urbanization, and increased population growth in natural environment areas (Madhav, et al., 2017). Orange County shows a rise from 2015 to 2019 in certain infectious diseases:

Table 6-2 – Increasing Rates of Infectious Diseases in Orange County from 2015-2019 (Orange County Health Care Agency, 2019)

Disease Name Agent Type	Agent Type	Vector	2015 Total	2016 Total	2017 Total	2018 Total	2019 Total
Campylobacteriosis	Bacteria	Flies	398	488	544	575	651
Coccidioidomycosis "Valley Fever"	Fungus	Mosquitos	186	116	211	242	320
Shigellosis	Bacteria	Flies	69	71	96	178	176

6.2.5 Severity

The severity of an epidemic or pandemic varies for numerous reasons, such as how it is transmitted (e.g., airborne or skin-to-skin contact), how contagious the disease is, how long it can live on surfaces, and how long an individual is contagious before showing symptoms. The CDC's Pandemic Severity Index breaks down severity into five categories:

- **Category 1**: less than 90,000 deaths
- **Category 2**: 90,000 < 450,000 deaths
- **Category 3**: 450,000 < 900,000 deaths
- **Category 4**: 900,000 < 1.8 million deaths
- **Category 5**: > 1.8 million deaths

Figure 6-1 – CDC Workplace and Community Recommendations by Pandemic Severity Category (Centers for Disease Control)

	Pandemic Severity Index		
Interventions by Setting	**1**	**2 and 3**	**4 and 5**
Workplace/Community **Adult social distancing**			
–decrease number of social contacts (e.g., encourage teleconferences, alternatives to face-to-face meetings)	Generally not recommended	Consider	Recommend
–increase distance between persons (e.g., reduce density in public transit, workplace)	Generally not recommended	Consider	Recommend
–modify, postpone, or cancel selected public gatherings to promote social distance (e.g., stadium events, theater performances)	Generally not recommended	Consider	Recommend
–modify workplace schedules and practices (e.g., telework, staggered shifts)	Generally not recommended	Consider	Recommend

The CDC has provided category-specific actions to mitigate the severity of a pandemic/epidemic (Figure 6-1). Additionally, the CDC developed a Pandemic Severity Assessment Framework (PSAF) for public health officials to determine the seriousness of an infectious disease (Centers for Disease Control, 2016). There are two steps for health officials to follow, an initial assessment early on during a pandemic and a refined evaluation that happens when more information becomes available (Centers for Disease Control, 2016). The federal, state, and local public health agencies will provide instructions to all organizations and individuals based on the severity of a pandemic and the infectious diseases' transmission methods.

6.2.6 Warning Time

Warning time for an epidemic or pandemic varies between a few hours to a few months, depending on the disease type, the Authority's proximity to the outbreak's origin, and the disease's contagious properties. The CDC explains that an outbreak will often start in countries with little medical resources.

From there, highly contagious diseases can spread from remote communities to major urban areas around the globe in as little as 36 hours, growing from a localized outbreak to a pandemic (Centers for Disease Control, 2020). To manage potential pandemics in the initial phase, the CDC operates the Health Alert Network (HAN) to share public health information. The network is accessible to government and tribal organizations and furnishes critical data to plan and respond to public health issues (Centers for Disease Control, 2020).

The CDC sends and receives vital epidemic/pandemic data from state and local public health departments. Orange County Public health administers the Communicable Disease (CD) Health Alert system. Any organization can subscribe to this system and receive immediate public health issues (Orange County Public Health, 2020). Infectious disease alerts and warnings give the Authority up-to-date information to support a timely response to an epidemic or pandemic, mitigating the severity and spread as much as possible. Table 6-3 below lists the CDC's Health Alert Network (HAN) levels, also used in the Planning Area.

Table 6-3 – Epidemic/Pandemic Alert Levels (Centers for Disease Control, 2014)

Level	Description
Alert	The highest level of notification and requires immediate action or attention
Advisory	Provides significant information about a specific event or situation, may not need immediate action
Update	Provides new information regarding an incident or situation, unlikely to need immediate action
Info Service	General information that is not necessarily an emergency at the time it is reported

6.3 Secondary Hazards and Cascading Impacts

6.3.1 Secondary Hazards

There are no apparent secondary hazards that an epidemic or pandemic could cause. However, epidemic/pandemics can interfere with mitigation actions for other risks. For example, organizations may prioritize prevention methods and emergency response actions during a concurrent natural hazard or natural hazard season (Quigley, Attanayake, King, & Prideaux, 2020). Organizations may need to balance difficult decisions between pandemic control and protective measures and natural hazard prevention, such as clearing dry vegetation for wildfire fuel management. For example, an epidemic/pandemic can challenge fuel load management to mitigate wildfires due to reduced on-site staff capacity.

6.3.2 Cascading Impacts

Like secondary hazards, cascading impacts may result from diminished staff capacity.

6.4 Potential Impacts from Future Climate Conditions

Climate and land use are significant factors influencing where disease-carrying insects live (Centers for Disease Control, 2020). Even slight temperature differences affect where insect populations live and what diseases they carry. Insects such as fleas, ticks, and mosquitoes can carry diseases like Lyme, West Nile, malaria, Zika, etc. Temperature increases in the OCTA planning area predicted by year and location are in Section 9 and maps in Figures 9-2 and 9-3.

As temperatures in the OCTA planning area rise, these insects carrying diseases will likely migrate in increasing numbers. There are also ideal temperatures where certain diseases spread the most effectively; malaria spreads best at 78 degrees and Zika at 84 degrees (Jordan, 2019). The WHO identified potential climate change factors that would increase the number of infectious disease outbreaks and types of diseases that could occur in the planning area (World Health Organization):

- Increased use of dams, canals, and irrigation to manage water flow changes can increase the risk of schistosomiasis, malaria, and helminthiasis
- As annual average temperatures change, new agricultural areas can succumb to infestation, increasing the risk of malaria and Venezuelan hemorrhagic fever
- Deforestation and populations spreading into wildland interurban areas can cause a rise in insect populations bringing malaria, oropouche, and visceral leishmaniasis
- Conversely, reforestation to combat tree loss can increase the risk of Lyme disease

6.5 Exposure & Vulnerability

6.5.1 Population

All OCTA customers and staff could be at risk from an infectious disease affecting the area. An epidemic or pandemic typically affects vulnerable populations disproportionately, including those with compromised immune systems, pre-existing medical conditions, individuals over the age of 65, and individuals with limited access to adequate health care.

6.5.2 Property

Epidemics and pandemics do not typically impact property directly. However, secondary impacts on the economy and persons can influence property management and operations, such as epidemics/pandemics, making hazard prevention methods more challenging, as discussed in Section 6.3.1. Adjustments can be made to existing buildings and new projects, such as improving HVAC system ventilation and air filtration, increase cleaning and sanitizing procedures and frequency, allowing more space for social distancing, and delaying construction projects (Megahed & Ghoneim, 2020). Additionally, the Authority can consider situational adjustments for concurrent natural hazard prevention with epidemic/pandemic safety procedures.

6.5.3 Critical Facilities

During the COVID-19 pandemic, the Authority implemented safety accommodations to reduce exposure and spread risks at their critical facilities. The mitigation measures did not require significant changes to the structures, and diseases cannot directly damage the facilities. OCTA can consider building these epidemic and pandemic safety measures into future developments where applicable.

6.6 Development Trends

To accommodate the expected development in the planning area, OCTA has undertaken many developments and renovation projects; then, COVID-19 swept through the planning area. The Authority adapted to the pandemic and adjusted projects as needed to continue development and renovations safely. The Authority also communicated all updates through its website, blog, and social media, keeping the public informed (Orange County Transportation Authority, 2020). These adjustments and procedures can inform planning area development in future epidemic/pandemic incidents. Epidemics and pandemics can significantly impact development and community growth, although the impacts are likely temporary, lasting only as long as the infectious disease continues to spread (Derven, 2020). Long-term growth in the Planning Area is still expected (United States Census Bureau, 2019).

6.7 Issues

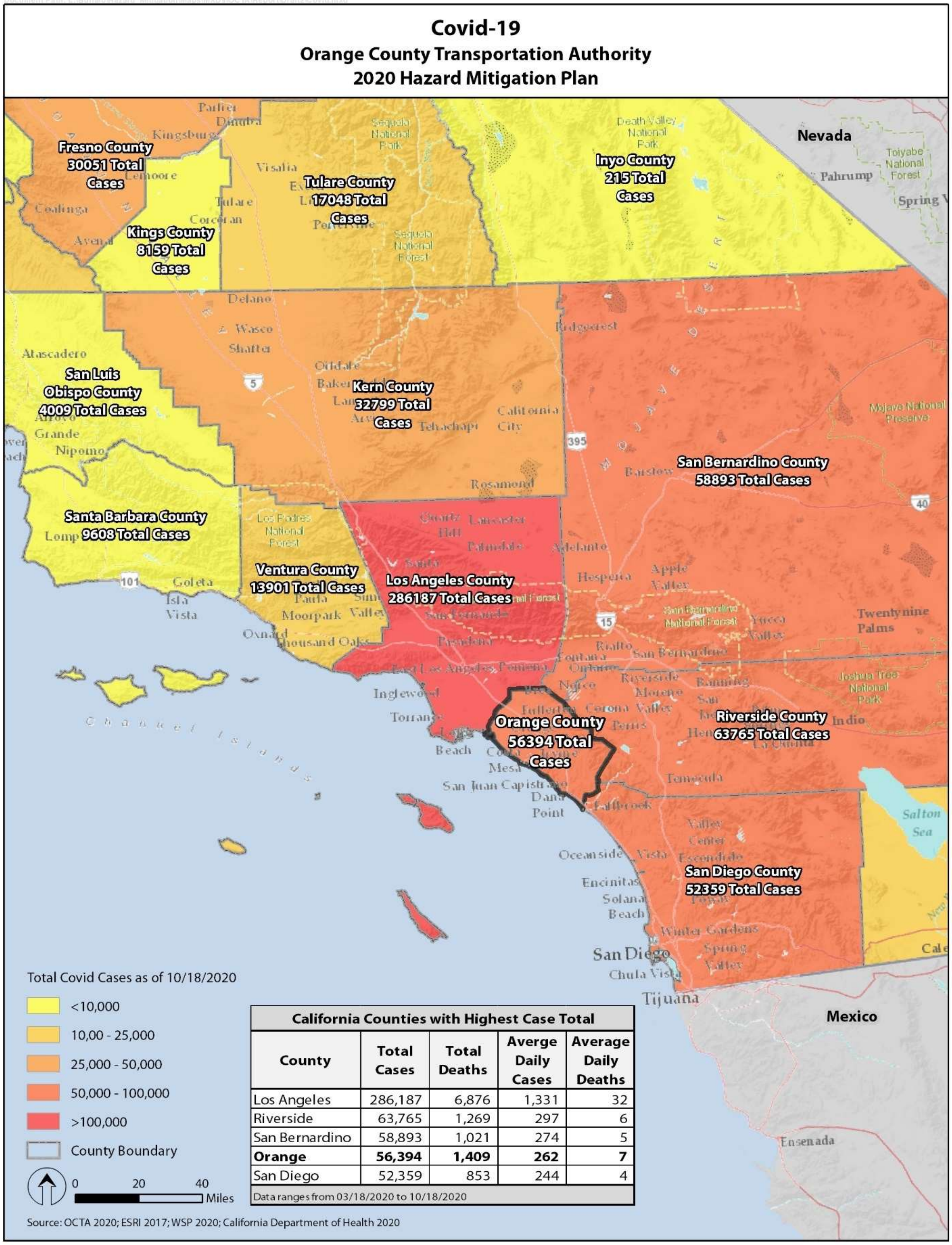
Pandemic/Epidemic considerations in the OCTA planning area (Orange County Transportation Authority, 2020):

- A sharp decline in ridership can mean revenue loss and temporary service changes.
- Safety and operations during an outbreak can require enhanced cleaning, processes, policies and procedures, and health-messaging solid campaigns (e.g., encouraging social distancing, wearing masks, providing PPE equipment to employees).
- Transit agencies must continue to provide critical route services, including carrying health care workers and other essential workers to their jobs and customers to medical services.
- While everyone can use public transportation, low-income and elderly populations typically depend on it as their primary form of transport.

6.8 Hazard Maps

The hazard map for COVID-19 cases in the planning area is on the next page.

Figure 6-2 – OCTA 2020 COVID-19 Hazard Map



California Counties with Highest Case Total				
County	Total Cases	Total Deaths	Averge Daily Cases	Average Daily Deaths
Los Angeles	286,187	6,876	1,331	32
Riverside	63,765	1,269	297	6
San Bernardino	58,893	1,021	274	5
Orange	**56,394**	**1,409**	**262**	**7**
San Diego	52,359	853	244	4
Data ranges from 03/18/2020 to 10/18/2020				

7 Flood, Sea-Level Rise, and Cliff Erosion

7.1 General Background

Floods are the most common hazard in the US, occurring when water overflows onto naturally or altered dry lands (Ready.gov, 2020). Climate change is the primary cause of Sea-Level Rise (SLR). Erosion is the natural process of removing surface ground material (soil, sand, rocks, etc.) from one area and transferring the material to another location, usually by wind or water (Editors of the Encyclopedia Britannica, 2020).

Rain, snow, coastal storms, storm surges, damaged dams and levees, or other damaged water control systems can all cause floods (Ready.gov, 2020). A flood can develop over time, such as during an unusually stormy season, or occur rapidly with little warning, like when a levee breaks and releases all the stored water at once. Depending on the extent of the event that triggers a flood, effects can be localized to a single neighborhood or block or extend as far as an entire region affecting multiple states. Riverine flooding and urban drainage can cause flash floods, depending on the geography and the event triggering the flood. It is the most dangerous type of flood due to the high water flow velocity and large debris the water can carry (Federal Emergency Management Agency). Flooding categories (Federal Emergency Management Agency):

- **Riverine Flooding** – happens when water overtops the banks of a river, lake, or stream and spills onto the adjacent land and is the most common type of flooding. Typically caused by excessive or prolonged rains and can include flash floods, dam and levee failures, and alluvial fan flooding.
- **Urban Drainage** – "stormwater management" is physical and natural systems used by people in developed areas to eliminate surface water and stormwater runoff as quickly as possible by directing it into closed water management systems. Flooding can happen when these

DEFINITIONS

100-Year Floodplain – An area inundated by a flood with a 1 percent chance of being equal or greater each year.

500-year Floodplain – An area inundated by floodwaters that has a 0.2 percent chance of being equal or greater each year.

Alluvial Fans – are found in dry mountainous regions where rock and soil erode from mountainsides and built up on valley floors in a fan shape.

Coastal Flood – Occur by seawater and coastlines, often due to severe weather events and cause coastline erosion.

Flash Flood – A rapid rise in water with a high flow velocity that carries debris. Flash floods have enough force to pull up and carry significant amounts of large debris (e.g., cars and trees).

Floodplain – An area of land neighboring a waterway or waterbody that is known to be flood prone.

Stormwater Management – physical and natural systems used by people to control and regulate the flow of surface and stormwater runoff.

Storm Surge – When a coastal flood happens at the same time as a high-tide, causing the coastal flood to reach father and bring more water than it would during a lower tide.

systems back up or when the incoming water exceeds the system's capacity.

- **Coastal Flooding and Cliff Erosion** – are floods that occur by seawater and coastlines, often caused by severe weather events. When a coastal flood coincides with a high tide, it is called a storm surge. Strong waves from storms can significantly increase the rate of cliff erosion.
- **Ground Failures –** subsidence and liquefaction can cause flooding in the immediate area, while mass earth movements can release or carry water with a mudslide, mudflow, or debris flow. These mass earth movements with flooding can be exceptionally damaging due to the water and ground material's force and the debris they can carry.
- **Fluctuating Lake Levels –** can be a seasonal process with standard weather patterns or can be caused by unusual heavy rainfalls.

SLR is affected by melting ice sheets and glaciers and average annual temperatures increasing brings an influx of water into the oceans, raising seawater levels (Administration, 2020). As sea levels rise, extreme coastal events (e.g., storm surges) can become more frequent and severe (Pörtner, et al., 2019). Additionally, as SLR continues, water that connects to the oceans spreads farther inland, resulting in expanded fluvial flooding (Pörtner, et al., 2019).

Erosion occurs when the movement of water removes the ground and carries it to another location. Water can erode coastlines, bluffs, cliffs above a waterway or body, along rivers and creeks, and anywhere the water movement can remove and transport loose material. The motion and force of sea waves along a coast can significantly alter the shore's shape (Editors of the Encyclopedia Britannica, 2020). Flooding can cause unexpected or increased erosion due to the force of the water's flow and water in unusual locations. Wind erosion is most common in deserts and arid lands where the wind picks up and moves loose ground material (Editors of the Encyclopedia Britannica, 2020).

7.1.1 Potential Damage from Floods, Sea Level Rise, and Cliff Erosion

Several factors influence the type and severity of damage from a flood, such as a floodwater's depth, length of time an area or a structure remains inundated, contents carried in the floodwater, and how rapidly the water moves (Federal Emergency Management Agency). Flood severity is discussed further in Section 7.2.5. Structures often suffer compounding damage the longer they are in the water; wood and carpet are especially susceptible. Structures in standing water can grow mold and fungi quickly and attract insects. These growths and insects can carry infectious diseases, which are covered more in Section 7.3.1. It can also be difficult to tell how deep the flood water is; cars can be submerged even by slow-moving water when it washes away the road or ground beneath, and a driver tried to continue through a flooded roadway.

On the other hand, rapidly moving water carries momentum and force that can damage structures, infrastructure, and injure or cause loss of life from the water impact or the debris carried in the water. Even six inches of fast-moving water can knock a person down, and a foot of water can move a car (Ready.gov, 2020). Erosion and flooding can impact waterways, causing higher than normal water levels for extended periods, harming people, structures, and infrastructure.

7.2 Orange County Transportation Authority Hazard Profile

Flooding, SLR, and cliff erosion can significantly impact OCTA's planning area, structures, and infrastructure. The map in Figures 7-2 displays areas exposed to 100-year and 500-year floods. The primary source of riverine flooding in the planning area is the Santa Ana River and the extended network of channels and flood control systems associated with the river (Orange County Public Works).

To manage and mitigate all sources of flood risks in Orange County, the Public Works Department oversees 350 miles of flood control facilities designed to direct water flow from storm drains and runoff into the bay and ocean (Orange County Public Works). These systems include structures such as dams, levees, drains, and underground pipes.

Despite the mass amount of flood control systems, severe weather can overwhelm them, such as when flash floods damage the systems from the force of the water or debris impact. When water management systems overflow or collapse, they can inundate areas around the systems. Orange County Public Works warns that the East Garden Grove-Wintersburg Channel and Ocean View Channel cannot contain a 100-year flood as water has overtopped several spots already (Orange County Public Works). Areas near Santiago Creek and Collins Channel and unincorporated Orange County sections are also prone to flooding (Orange County Public Works).

Coastal flooding can occur when severe weather causes high waves or storm surges and SLR increases, leading to increased cliff erosion. Therefore, almost all OCTA's coastline rail system is subject to storm surges, coastal flooding, cliff erosion, and SLR. Figures 7-3 show the planning area coastline at risk from 100-year storm surges, and Figure 7-4 estimates SLR at 1, 2, and 3 feet

7.2.1 Hazard Ranking

The Planning Team completed a hazard ranking survey during the OCTA 2021 HMP development process and assessed hazard-related factors based on worst case and most likely scenarios. Hazard definitions and ranking factors are in Appendix G, Table G-1. Survey results were prioritized and ranked based on their averaged score. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, where one is the lowest and five is the highest. Compared to the other hazards in the survey, floods are the fifth worst-case and most likely scenario.

Table 7-1 – OCTA Flood, Sea Level Rise, and Erosion Hazard Ranking

Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Worst-Case Scenario						
2.85	2.97	3.18	2.61	3.18	2.96	5
Most Likely Scenario						
2.64	2.48	3.00	2.39	3.24	2.75	5

7.2.2 Past Events

Since 1969, there have been 15 flood events that have resulted in FEMA disaster declarations in the Planning Area (Federal Emergency Management Agency, 2020). Between 1956 and 2020, NOAA recorded 23 flash floods in the Planning Area, resulting in nine deaths and four injuries. A comprehensive list of disaster declarations is in Appendix G, Table G-4. NOAA records that resulted in an injury, death, or cost equal to or above $25,000 in property damage for both counties are in Table G-5 (National Oceanic and Atmospheric Administration). A few of the most consequential flood events recorded by NOAA or resulting in a disaster declaration since 2000 are in Table 7-2 below.

Table 7-2 – Significant Flood Events in the Planning Area (National Oceanic and Atmospheric Administration) (Federal Emergency Management Agency, 2020)

Date	Severe Weather Type	Deaths/ Injuries	Property Damage	FEMA Declaration
2/10/2000	Heavy Rain	1 death 4 injuries	$300,000	
1/11/2001	Flash Flood	0	$1,000,000	
1/7/2005	Heavy Rain	0	$5,000,000	
1/7/2005	Heavy Rain	0	$15,000,000	
2/18/2005	Heavy Rain	0	$20,000,000	
2/20/2005	Flash Flood	0	$1,000,000	
4/14/2005	Severe storms, flooding, landslides, debris/ mudflows			DR-1585-CA
12/15/2008	Heavy Rain	14 injuries	$250,000	
3/8/2010	Severe winter storms, flooding, debris/mudflows			DR-1884-CA
12/19/2010	Flood	0	$36,000,000	
12/22/2010	Flash Flood	0	$12,300,000	
1/26/2011	Winter storms, flooding, debris/mudflows			DR-1952-CA
3/16/2017	Severe winter storms, flooding, mudslides			DR-4305-CA
1/2/2018	Wildfires, flooding, debris/mudflows			DR-4353-CA

7.2.3 Location

Figures 7-2 to 7-4 are maps of the OCTA planning area exposed to a 100-year and 500-year flood, a 100-year storm surge, and SLR inundation from a 1, 2, and 3-foot increase. The planning area's entire coastline is at risk from coastal flooding, SLR, and cliff erosion. The Authority's critical facilities, structures, parcels, and infrastructure prone to these hazards are in Tables 7-7 through 7-13. Additionally, the Authority identified specific sections of rail exposed to these risks, including:

- Segments of rail in Mission Viejo near where the rail is in the trench
- Downstream of Oso Creek, where it flows into a channel – vertical banks on the west side have experienced erosion, although not infringing on the rail line
- The approximately seven-mile coastal rail section

7.2.4 Frequency

The OCTA planning area is susceptible to seasonal rainfalls and unpredictable severe weather events leading to flooding. Between 1969 and 2010, 17 disaster declarations were for flood events in the Planning Area (Federal Emergency Management Agency, 2020). The average number of disasters declared flooding events in the Authority's planning area is approximately 2.6 per year. However, FEMA's list in Table G-4 does not indicate flood declarations are happening more frequently (Federal Emergency Management Agency, 2020).

NOAA recorded seven flooding events and 24 flash floods that caused a person's injury or death or cost $25,000 or more in property damage (National Oceanic and Atmospheric Administration). Six of the NOAA flood records happen in the last twenty years, and only one occurred in the 44 years prior (National Oceanic and Atmospheric Administration). Many factors could have influenced this significant increase in significant flood events from 2000, such as climate change, growing populations in flood zones, or more structures built in flood zones after 2000.

The NOAA flood reports indicate that flood frequency has increased over time, even though they have not increased disaster declarations. NOAA first recorded flash flood events in 1997; since then, flash floods in the Authority's planning area have occurred on average once every six months (National Oceanic and Atmospheric Administration). Increased populations and new infrastructure and structures that altered water's natural flow could attribute to this rise in records. Development trends are discussed more in Section 7.6.

So far, NOAA only reported one significant coastal flood event in 2005 and two storm surges in 1997 and 2001 (National Oceanic and Atmospheric Administration). SLR predictions for the planning area are in Figure 7-4. Twenty-five years of data from European and National Aeronautics and Space Administration (NASA) satellites revealed that SLR is accelerating faster than expected (Weeman & Lynch, 2018). Currently, NASA estimates SLR could double what it would be if the levels were rising at a constant rate (Weeman & Lynch, 2018).

NOAA's list includes numerous instances of high surf, which can increase coastline flooding and shoreline erosion. OCTA's coastline is likely to be increasingly affected by SLR and erosion as it continues to accumulate, causing more coastal flooding, high surf, and storm surges. Based on NASA's data, climate change significantly accelerated SLR's natural increased rate, which will lead to more frequent and severe SLR events, coastal flooding, and coastline erosion in the Authority's planning area. The effects of climate change, detailed in Section 7.4.

7.2.5 Severity

The severity of a flood is dependent on the amount, velocity, and area covered. One of the most significant flood threats in Orange County is from the Santa Ana River and the extensive network of the river's connecting flood management systems (Orange County Public Works). FEMA states that rivers are the most common source and often costliest type of flooding (Federal Emergency Management Agency). The Santa Ana River extends from the San Bernardino Mountains out to the Pacific Coast through Orange County. Heavy rains can build up vast amounts of water in the mountains and pick up incredible velocity down the steep mountainside (Federal Emergency Management Agency). This rapid influx of water can result in dangerous flash floods and debris/mudflows. As indicated in Section 7.2, although extensive flood control measures are in place, areas connected to the Santa Ana River are also at risk from flooding.

7.2.6 Warning Time

Flooding events can occur quickly or over days to weeks. The cause of the flood typically dictates the length of warning time. For example, there is minimal warning time for flash floods, but slow-moving rainstorms can build up surface water over days and weeks, eventually resulting in flooding (Ready.gov, 2020). Alternatively, SLR and cliff erosion take years to accumulate significant impacts.

The Orange County Public Works department maintains and monitors an advanced flood warning system called ALERT (Automated Local Evaluation in Real-Time), a rainfall and water level sensor network that enables real-time storm tracking.

The ALERT system details (Orange County Public Works):

- **Applies** – 130 sensors in more than 80 locations
- **Measures** – precipitation, the water level in regional flood control channels, temperature, barometric pressure, wind velocity and direction, relative humidity, and snow
- **Updates** – information is sent out every eight minutes during storm events and strategically deploys resources to critical locations

For the Planning Area, the NWS San Diego Office assesses potential weather and flood event factors to determine when to send emergency notifications and what level of warning to set. The NWS San Diego Office lists ten types of warnings and information text notifications they can issue (National Weather Service San Diego, 2020):

- **Flash Flood Warning** – there is an immediate risk to life and property from rapidly moving floodwater
- **Flash Flood Statement** – additional information to the flash flood warning
- **Flood Warning** – sent when floodwaters will affect life and property
- **Flood Statement** – additional information on flooding streams and rivers, risks to urban areas, and updates or cancelation of the flood warning
- **Flood Watch** – when there is a potential for flooding
- **Hydrologic Outlook** – long-range predictions and information on the current conditions
- **River and Lake Summary** – daily observations and predictions for river and lake conditions
- **Hydrologic Summary –** daily observed conditions
- **Hydrologic Statement** – additional forecasts and information
- **Drought Information Statement** – drought information

There are no emergency alert notifications for SLR or cliff erosion. However, OCTA is in the process of developing a rail infrastructure study Defense Against Climate Change Plan that considers the Authority's planning area exposure to flood, SLR, and erosion to mitigate these hazards before becoming an emergency. The planning area counties also have risk assessments and adaptation strategies for flood, SLR, and erosion (County of Orange and Orange County Fire Authority, 2015) (Hazen, 2019).

7.3 Secondary Hazards and Cascading Impacts

7.3.1 Secondary Hazards

Flooding, SLR, and cliff erosion can cause secondary hazards. Slopes destabilized by water inundation can erode and result in mass earth movements (e.g., landslides, mudslides, and debris flow), particularly on steep slopes and in areas with less vegetation after a wildfire. Mass earth movements are discussed further in Section 8 of this plan. Structures exposed to water for a length of time can be prone to growing mold, fungi, and attract insect populations. An outbreak or epidemic can occur due to infectious disease-carrying agents in contaminated water or food, increased insect populations that breed in waterways like creeks and ponds, and mold growing in damp structures. Epidemics and Pandemics are in Section 6.

7.3.2 Cascading Impacts

Flooding can damage infrastructure, resulting in communications, transportation, and utility disruptions. The Authority's structures, land parcels, and infrastructure exposed to 100-year and 500-year floods, 100-year storm surges, and 1, 2, and 3 feet of SLR are in Tables 7-7 to 7-13. These disruptions can directly damage OCTA's structures and infrastructure, challenging operations. Disruptions can also indirectly impact operations through downed communications and services, structures, or infrastructure that OCTA relies on for continuity. SLR and erosion are slower moving hazards yet can result in infrastructure disruptions. OCTA conducts a rail infrastructure defense against climate change plan to understand better where and how these hazards can impact the planning area. According to the plan, the approximately seven-mile rail segment along the coast is at the highest risk from SLR and cliff erosion.

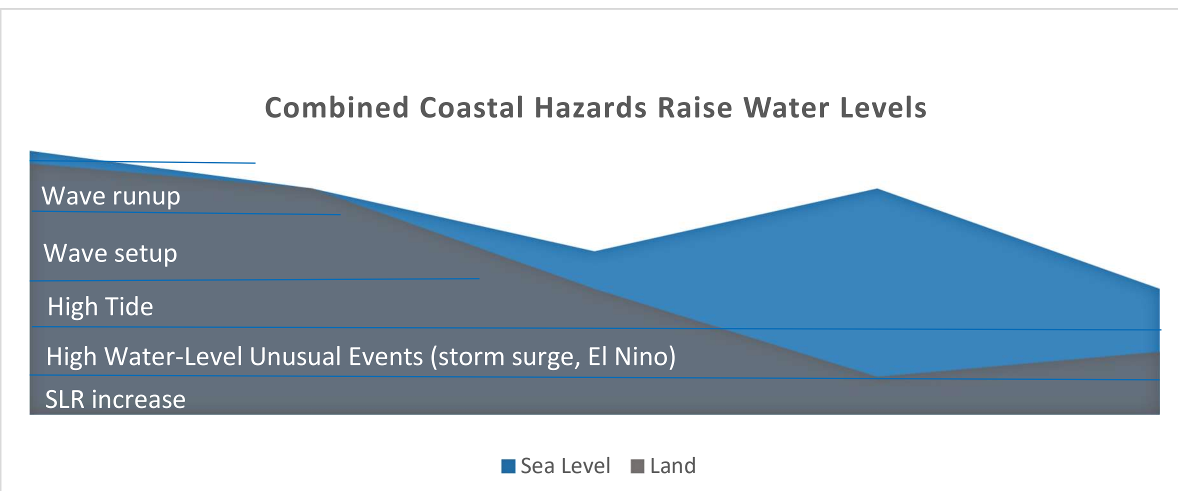
7.4 Potential Impacts from Future Climate Conditions

Climate change's influence will likely increase the Authority's planning area's flood risks, including storm intensity and frequency that will expand flooding areas and depths (Hazen, 2019). More frequent and severe storms will also increase the risk of river flooding and associated secondary hazards in the planning area. Additionally, climate change affected storms and SLR interconnect to increase coastal risks from flooding and erosion. The 2018 California Fourth Climate Change Assessment report stated that out of the five coastal counties in Southern California, the three counties that overlap the OCTA planning area are the most vulnerable to climate change impacts on the coast (Erikson, et al., 2018). These effects include coastal flooding, SLR, and severe coastal weather that can increase storm surges and erosion.

NASA's 2018 research study conservatively predicts that by 2100, sea levels will increase by 26 inches due to climate change (Weeman & Lynch, 2018). On the other hand, SLR predictions vary even between government agencies depending on the climate modeling technology and data sets they use. Although the exact amount of SLR by year is impossible to predict, even a one-foot increase by 2100 will impact the Authority's planning area, as shown in Figure 7-4. A two to three-foot increase is more significant.

Any SLR caused by climate change will permanently expand coastal lines and flooding boundaries, and further erode land along the coast. The Authority's rail infrastructure defense against climate change plan assesses the potential impacts to the planning area coastline. The Rail Infrastructure Defense Against Climate Change Study (completed January 2021) emphasizes the risk of combined coastal hazards influenced by climate change. For example, the Pacific Ocean can produce significantly high waves during storms; in conjunction with SLR and/or heavy precipitation, storms can easily lead to 100-year storm surge inundation levels. An example of combined water-level events is in Figure 7-1 below.

Figure 7-1 – Example of Water-Levels with Combined Coastal Hazards



7.5 Exposure

7.5.1 Population

Intersecting OCTA bus stop ridership and US Census planning area data with geospatial hazard data for flooding (100- and 500-year flood events) and SLR (1, 2, and 3 feet) indicate population exposure to each hazard type and socially vulnerable subgroups. Table 7-3 shows that up to nearly 1.8 million boardings could be impacted by 100-year flood events and more than 16 million for a 500-year flood event.

Table 7-3 – Bus Stop Ridership Exposed to 100 and 500-Year Flood Zones

Ridership	100-Year Flood Zone	500-Year Flood Zone
Total	1,797,145	16,422,896

Table 7-4 – Populations at Risk to 100 and 500-Year Flood Zones

Population	100-Year	500-Year
Black	2,649	27,258
American Eskimo	1,089	8,522
Asian	42,168	261,822
Hawaiian/Pacific Islander	728	5,379
Hispanic	60,025	484,041
Multiple Races	7,694	48,113
Children up to 19 Years Old	49,310	325,854
65 Years and Older	24,265	126,092
Below the Poverty Level	25,967	184,110

Table 7-5 projects that nearly nine thousand OCTA bus stop boardings may be impacted by one foot of SLR, while nearly ten times that amount may be impacted by three feet of SLR. There are nearly 1.7 million minority and mixed-race individuals at risk at one foot SLR, approximately 757 thousand individuals aged 19 and below, over 332 thousand seniors, and over 375 thousand low-income households. As sea-level rises to above two and three feet, these population numbers also increase.

Table 7-5 – Bus Stop Ridership Exposed to Sea Level Rise at 1, 2, and 3 Feet

Ridership	1 Foot SLR	2 Feet SLR	3 Feet SLR
Total	8,808	25,029	82,835

Table 7-6 – Populations Totals Vulnerable to Sea Level Rise at 1, 2, and 3 Feet

Population Type	Above 1 Foot SLR	Above 2 Feet SLR	Above 3 Feet SLR
Black	53,390	52,654	51,359
American Eskimo	17,595	17,376	16,922
Asian	518,728	508,834	499,772
Hawaiian/Pacific Islander	9,392	9,325	9,118
Hispanic	994,775	980,013	954,761

Population Type	Above 1 Foot SLR	Above 2 Feet SLR	Above 3 Feet SLR
Multiple Races	117,721	115,431	111,966
Age 0-19	757,074	743,099	722,633
Age 65 and Over	332,577	327,233	315,674
Below the Poverty Level	375,155	368,467	358,814

7.5.2 Property

GIS analysis indicates five OCTA structures are in the 100-year floodplain, and 12 structures are in the 500-year floodplain, shown in Tables 7-7 and 7-8. Table 7-9 shows the Authority's land-use parcels and acreage within 100-year and 500-year floodplains, while tables 7-10 and 7-11 indicate types and counts of infrastructure in those floodplains. Facilities exposed to sea-level rise from 1 ft, 2 ft, and 3 ft increase are shown in tables 7-12 and 7-13.

Table 7-7 – OCTA Buildings Exposed to 100-Year Floodplain

Building Type	Number of Buildings	Building Value	Contents Value
Fullerton Park and Ride	1	$4,236	$43
Brea Park and Ride	1	$996	$8
Transit Base	1	$25,819	$88,226
Transit Center	1	$436	$8
Total	**4**	**$31,487.00**	**$88,285.00**

Table 7-8 – OCTA Buildings Exposed to 500-Year Floodplain

Building Type	Number of Buildings	Building Value	Contents Value
Fullerton Park and Ride	1	$4,236	$43
Brea Park and Ride	1	$996	$8
Transit Base	3	$77,701	$178,988
Transit Center	1	$436	$8
Total	**10**	**$83,369.00**	**$179,047.00**

Table 7-9 – OCTA Ownership of Environmental Parcels in 100-Year Floodplain

Parcel Type	Acres
Eagle Ridge (proximal to City of Brea)	1.77
Trabuco Rose (proximal to Trabuco Canyon)	5.52
Wren's View (proximal to Trabuco Canyon)	0.27
Total	7.55

Table 7-10 – OCTA Ownership of Environmental Parcels in 500-Year Floodplain

Parcel Type	Acres
Eagle Ridge (proximal to City of Brea)	3.47
Pacific Horizon (proximal to Laguna Beach)	0.06
Trabuco Rose (proximal to Trabuco Canyon)	5.52
Wren's View (proximal to Trabuco Canyon)	0.27
Total	**9.31**

Table 7-11 – OCTA Infrastructure and Related Operations in 100-Year Floodplain

Type	Miles
Bus Route	62.24
I-405 Freeway	4.011
SR-91 Freeway	0.815
Other Freeway	18.176
Metrolink Rail	4.36
Pacific Electric ROW	1.48
Streetcar Route	0.47
Total	**91.552**

Table 7-12 – OCTA Infrastructure and Related Operations in 500-Year Floodplain

Type	Miles
Bus Route	435.88
I-405 Freeway	24.058
SR-91 Freeway	35.600
Other Freeway	121.220
Metrolink Rail	26.33
Pacific Electric ROW	9.69
Streetcar Route	1.72
Total	**654.498**

Table 7-13 – OCTA Infrastructure/Operations Vulnerable to a 1-3 Foot Sea Level Rise in Miles

Type	1 Foot SLR	2 Foot SLR	3 Foot SLR
Bus Route	1.55	4.32	10.99
Other Freeway	0.12	0.14	0.22
Total	**1.67**	**4.46**	**11.21**

Vulnerability

A GIS analysis estimated which structures would be affected by flooding, looking at flooding depth and the type of structure. The analysis is summarized in Tables 7-7 and 7-8 for the 100-year and 500-year flood events, respectively.

7.5.3 Critical Facilities

There are no critical facilities and infrastructure in the 100-year floodplain. Table 7-14 shows the critical facility in the 500-year floodplain.

Table 7-14 – OCTA Critical Facilities Within OCTA's 500-Year Floodplain

Critical Facility Type	Number
Transportation Security Operations Center	1
Total	**1**

Vulnerability

A GIS analysis estimated the flood loss potential to critical facilities exposed to the flood risk. The facilities exposed are in Section 7.5.3 above, and the resulting map in Figure 7-2.

7.5.4 Environment

Environmental changes can be natural or human-made and can shift the frequency, location, and severity of flooding, SLR, and cliff erosion. Environmental influences on these hazards can affect the OCTA planning area in the short and long term, especially structures and infrastructure in the hazards' immediate area. An impaired or modified environment, including land development, can flood new or less common areas, increase coastal and bank erosion, and cause more severe flooding (City of Newport Beach, 2014). Flood control systems can increase stream bank erosion, causing rivers and streams to migrate and permanently change flood patterns.

7.6 Development Trends

As discussed in this section, multiple factors have also increased flooding, SLR, cliff erosion frequency and severity, and expanded flood zone boundaries in OCTA's planning area. The US Census Bureau predicts that Orange County's population will increase by 5.5 percent between 2010 and 2019 (United States Census Bureau, 2019). Therefore, regularly updated risk maps must inform development in an exposed area, particularly as climate change reshapes flood zones and coastlines (Federal Emergency Management Agency). OCTA will minimize flooding, SLR, and erosion risks to future projects in the planning area by following government regulations and incorporating mitigation measures into new and renovated developments.

The Authority's long-range transportation plan lists SLR, and associated cliff erosion is a significant hazard for transportation infrastructure. Structures and transportation infrastructure, designed to last for decades, make it vital to consider the long-term impacts of SLR and erosion, especially on the Pacific Coast Highway and rail sections along the coast (Orange County Transportation Authority, 2018). This HMP identifies and evaluates SLR and erosion risk methods to inform updates to other OCTA plans. The Authority will incorporate development and repair project mitigation actions across organizational plans to avoid and minimize hazards where possible.

State and county land-use requirements guide the Authority's development projects in areas exposed to flooding. California Legislature Section 65302 of the Government Code states that general plans must include land use elements that identify and annually review planning areas vulnerable to flooding, using FEMA's and/or the Department of Water Resources floodplain mapping (California Legislative Information, 2018). In the Orange County Code of Ordinances, Section 7-9-42: FP (Floodplain) Overlay District provides land-use regulations and maps to prevent and reduce the effects of flooding in known hazardous areas (Orange County, 2020).

Another development factor to consider, urban expansion in flood-prone areas increases the impervious surface area preventing water from being absorbed by the ground; this increases the likelihood of flood events and expands flood zones (Konrad, 2016). This condition is exacerbated by peak rain events when the ground around the impervious surfaces is quickly saturated, increasing the storm-runoff rate (Konrad, 2016).

7.7 Issues

Flood, SLR, and cliff erosion considerations in the OCTA planning area:

- Flood control systems will not prevent all flooding in the planning area.
- Continue climate change studies to understand future flood risks, especially new data and improved technology, to provide more accurate predictions.
- Educate customers on flood preparedness and transportation resources available during and after floods.
- Flood, SLR, and cliff erosion hazards overlap other hazards, such as mass earth movements, epidemics/pandemics, and severe weather. There is an opportunity to implement mitigation actions that can reduce risks from multiple hazards.

7.8 Hazard Maps

The hazard maps for flood, storm surges, and SLR are in Figures 7-2 to 7-4, starting on the next page.

Figure 7-2 – OCTA Flood Zone Hazard Map

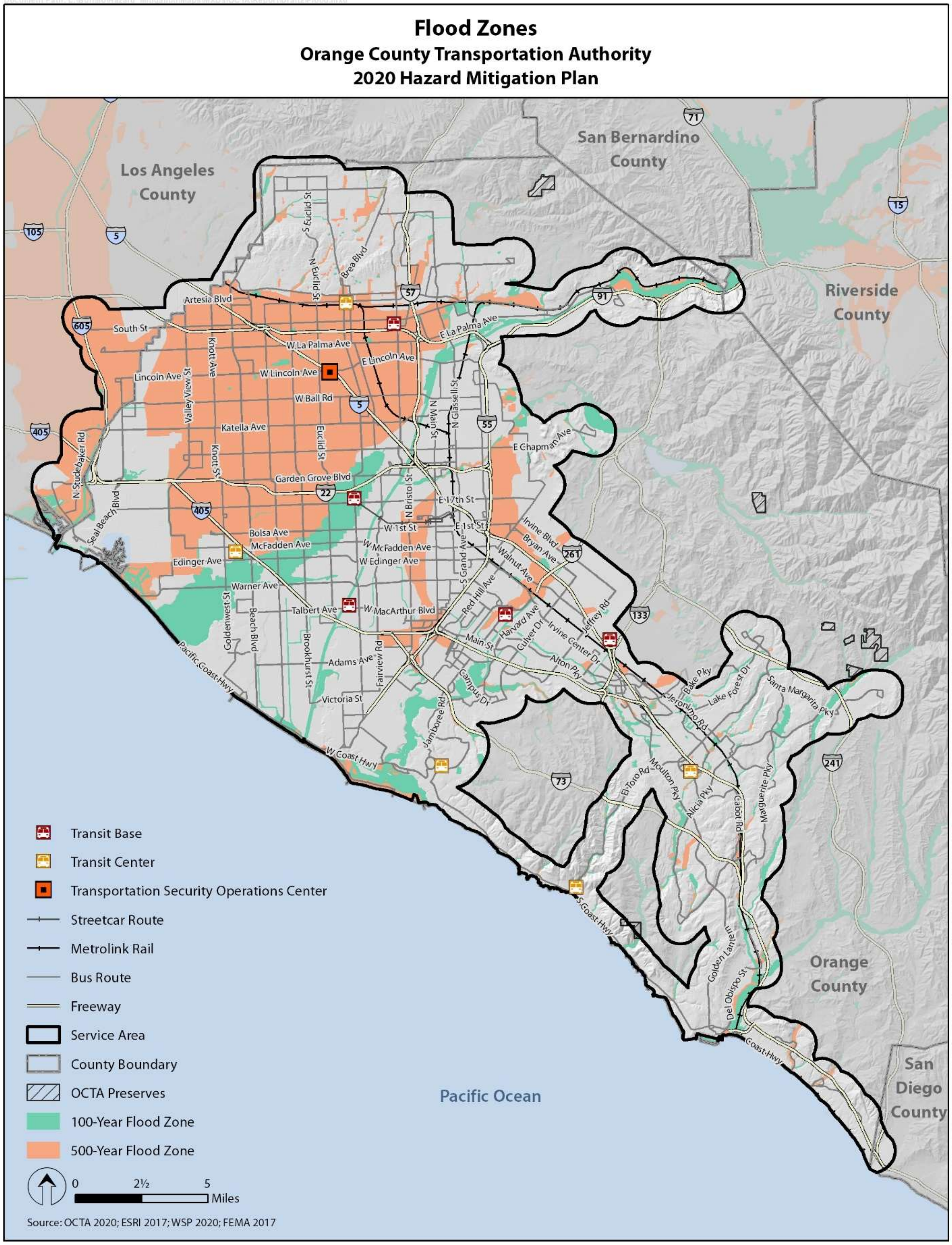


Figure 7-3 – OCTA 100-Year Storm Surge Hazard Map

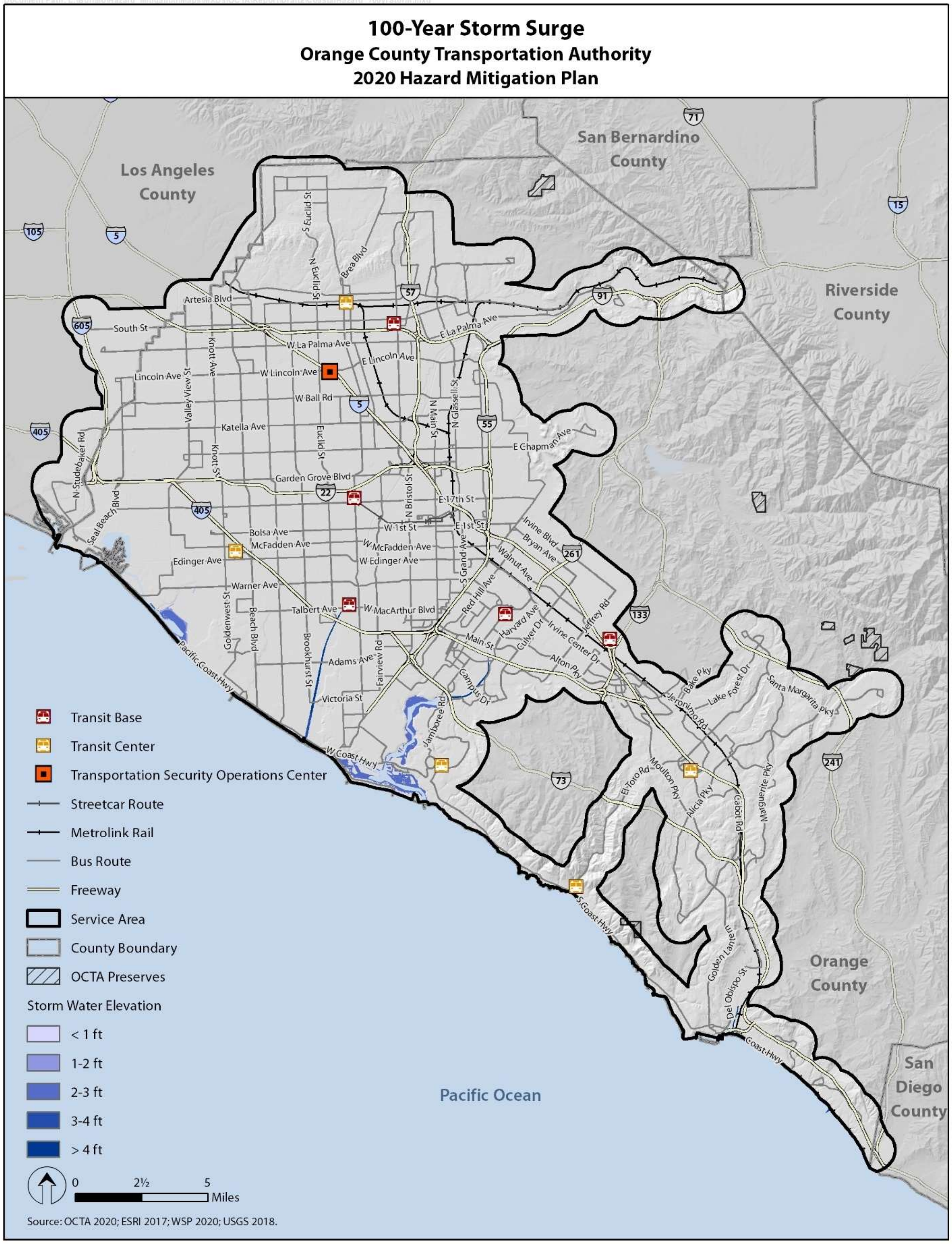
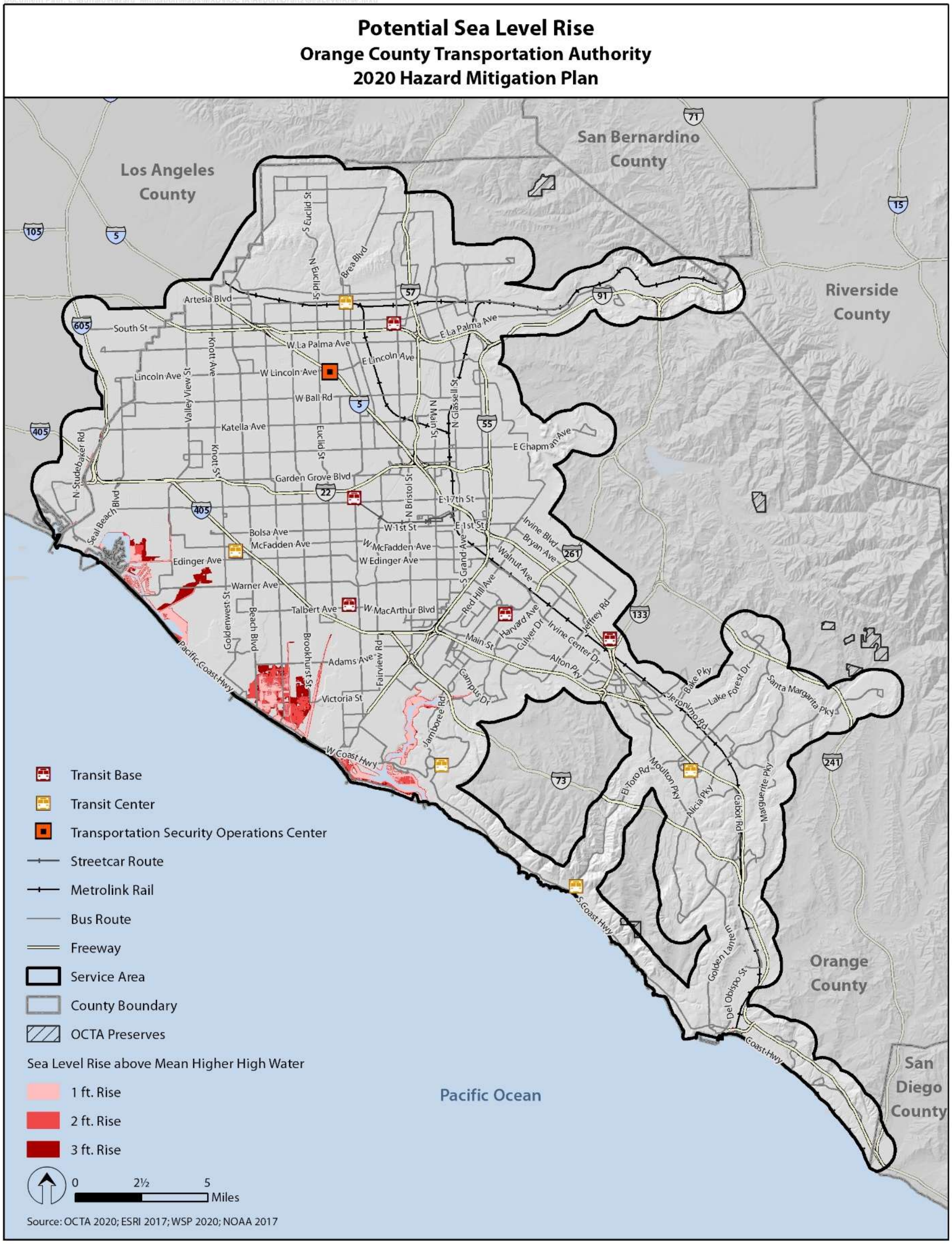


Figure 7-4 – OCTA Potential Sea Level Rise Hazard Map



8 Mass Earth Movements

8.1 General Background

A mass earth movement is defined as a landslide, mudslide, rockfall, sinkhole, or debris flow, and generally occurs for two reasons (United States Geological Survey):

- When up-slope ground material does not have the strength to overcome the downslope gravity pull
- When a force acts on the material (e.g., water, avalanche, earthquake), causing it to detach from the slope and move downhill

Several other hazards can trigger mass earth movements, such as severe weather, SLR, flooding, earthquakes, tsunamis, and wildfires (Editors of Encyclopedia Britannica, 2015). Natural changes to the environment can destabilize slopes and influence mass earth movements, such as surface water levels, stream erosion, groundwater movement, or any combination of these factors (United States Geological Survey). Humans can also generate mass earth movements by modifying the environment by removing vegetation and trees, destabilizing them.

There are three types of geologic materials, bedrock, debris and earth, and five forms of slope movements; examples of these forms are in Figure 8-1 (United States Geological Survey, 2004):

- **Flow** – Includes debris flows, debris avalanches, earth flows, mudflows, and creeps
- **Topples** – Characterized by a rotation of the materials around a pivot point as they move downward
- **Slides** – Refers to an area of weakness where the unstable layer separates from the stable underlying layer
- **Spreads** – Unique because the material moves laterally on gentle slopes or flat ground, caused by liquefaction
- **Fall** – An abrupt down-slope movement of large materials (e.g., rocks and boulders) off steep slopes or cliffs

DEFINITIONS

Debris Flow – A form of rapid mass movement in which loose soil, rock and sometimes organic matter combine with water to form a slurry that flows downslope.

Landslide – A large amount of rock, debris, or earth that travels down a slope.

Mass Movement – A collective term for landslides, debris flows, falls and sinkholes.

Mudslide (or Mudflow) – A river of rock, earth, organic matter, and other materials saturated with water.

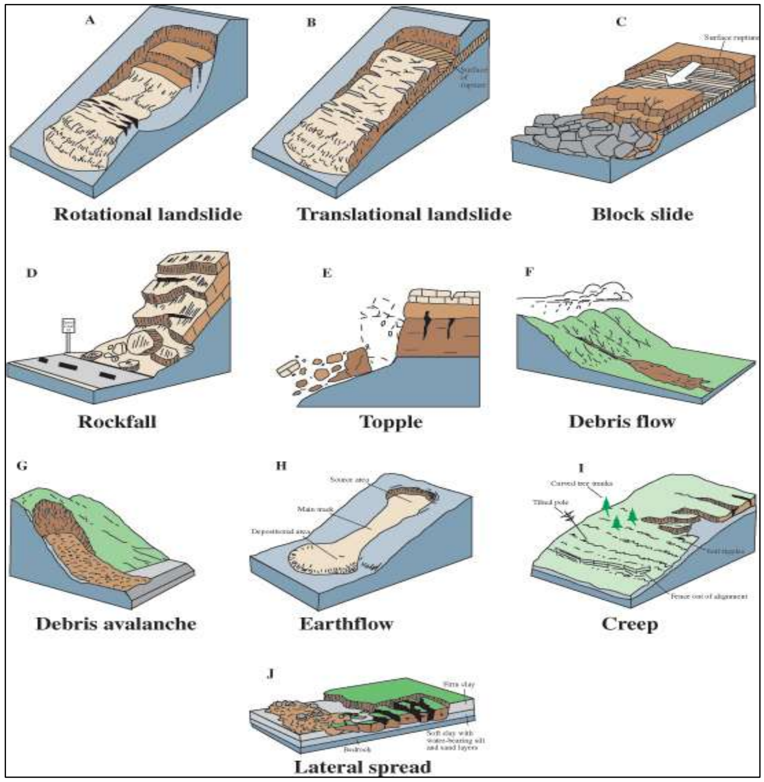
Sinkhole – A collapse depression in the ground with no visible outlet. Its drainage is subterranean. It is commonly vertical-sided or funnel-shaped.

Slope Failures – Occur when the strength of the soils forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.

8.1.1 Potential Damage from Mass Earth Movement

Mass earth movements can damage or destroy infrastructure, structures and cause human injury or loss of life. Mass movements that occur quickly and without warning are the most dangerous and deadly, as people do not have time to react or evacuate the hazard area (Ready.gov, 2020). They can travel several miles from the point of origin and grow as debris is collected and added to the mass movement (Ready.gov, 2020). Displaced ground material can dam waterways, such as rivers, and result in flooding. Blocked or broken roads will delay emergency responders and critical supply shipments. An event can occur with little to no warning, increasing the likelihood of damage from such an event.

Figure 8-1 – Diagrams of Mass Movement Forms (US Geological Survey Department of the Interior/USGS)



8.2 Orange County Transportation Authority Hazard Profile

OCTA's planning area is exposed to all types of mass earth movements (County of Orange and Orange County Fire Authority, 2015). Mapped landslide areas are in Figure 8-3. Deep-seated landslide susceptibility in the planning area is in Figure 8-4. Deep-seated slides are often more than ten to fifteen feet deep and are instigated by deep infiltration of rainfall over weeks or months (United States Geological Survey). Planning areas at risk of soil erosion after a wildfire, shown on the map in Figure 8-5.

Orange County's emergency preparedness program ranks landslides as one of the County's top five hazards, stating the hazard frequently occurs in the area (Ready OC). The Orange County 2015 HMP emphasizes the serious role humans can play in escalating landslide risks through development (County of Orange and Orange County Fire Authority, 2015). In 2019, the California Department of Conservation conducted a landslide hazard mapping study by county and identified the following highway routes in Orange County are exposed – Routes 73, 241, and 246 (Wills, et al., 2019).

A mass movement on these highway routes could impact OCTA customers, staff, structures, and infrastructure or cause potential delays to services and supplies required for business operations. Common causes of movements that can impact the area include heavy or extended rain periods, slopes destabilized due to wildfire, and coastal slopes and cliffs affected by sea waves and erosion (United States Geological Survey). A landslide may take the form of a slide, fall, flow, or a combination of the three.

8.2.1 Hazard Ranking

The Planning Team completed a hazard ranking survey during the OCTA 2021 HMP development process and assessed hazard-related factors based on worst case and most likely scenarios. Hazard definitions and ranking factors are in Appendix G, Table G-1. Survey results were prioritized and ranked based on their averaged score. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, where one is the lowest and five is the highest. Compared to the other hazards in the survey, mass earth movements were the seventh worst-case scenario and sixth most likely scenario.

Table 8-1 – OCTA Mass Earth Movement Hazard Ranking

Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Worst-Case Scenario						
2.55	2.45	1.91	3.73	1.82	2.49	7
Most Likely Scenario						
2.18	2.09	1.64	3.36	1.73	2.20	6

8.2.2 Past Events

In the Planning Area from 1969 to 2020, fifteen FEMA disaster declarations involved mass earth movements (Federal Emergency Management Agency, 2020). Disaster declarations are in Appendix G, Table G-4. Table 8-2 shows some of the significant past landslides and their effects on the Planning Area.

Table 8-2 – Historic Planning Area Landslides (City of Newport Beach, 2014)

Year(s)	Event Name	Total Cost	Damage
1969	Glendora	$26.9 million	175 homes damaged
1977-1980	Monterey Park and Repetto Hills	$14.6 million	100 homes damaged
1979	Big Rock	$1.08 billion	Damage to Highway 1
1980	-	$1.1 billion	
1978-1980	120 slides reported	9 slides cost over $1 million	-
1983	San Clemente	$65 million	Damage to Highway 1
1983	Big Rock Mesa	$706 million	13 condemned houses, 300 houses threatened
2005	Blue Bird Canyon	Billions of dollars, a total number not available	17 homes destroyed, 11 homes damaged, 23 homes threatened

8.2.3 Location

The Authority's critical facilities, structures, parcels, and infrastructure prone to these hazards are in Tables 8-8 through 8-15. It is not always possible to remove the physical geology and natural hazards that instigate mass earth movements. However, quality research studies, effective engineering practices, and robust land-use and management regulations can minimize life, infrastructure, and property risks (United States Geological Survey).

8.2.4 Frequency

In the Planning Area they were 15 mass earth movement disaster declarations through FEMA over the last 30 years; approximately one event every two years. Natural hazards, such as earthquakes, heavy rain, floods, and vegetation loss after a recent wildfire often trigger these events. In general, the frequency of mass earth movement is related to the frequency of these other hazards, which may occur at any time of year.

8.2.5 Severity

Mass earth movements with little or no warning tend to be the most destructive, as it may not be possible to evacuate the area or brace for impact. Other factors contributing to the severity of mass earth movement events include a slope's steepness, which impacts the rate of travel, the amount and size of debris transported, and the development density of the area affected (Ready.gov, 2020). Debris flows are usually the most dangerous mass earth movement as they often start rapidly and may carry large objects like boulders, vehicles, homes, and trees (United States Geological Survey).

8.2.6 Warning Time

The warning time associated with mass earth movements depends on the rate of travel. As noted in the severity section above, the most dangerous movements have a rapid onset since there is little or no warning time. Heavy rains and recent wildfires that make slopes more prone to movement are strong indicators of a possible movement. Movements with the longest warning time happen over an extended period, such as creeps that can move in inches per year.

The San Diego NWS Office and the Operational Area EOC monitor mass earth movement conditions and send out watches, warnings, and evacuation notifications through the EAS when there is an immediate risk (Ready.gov, 2020). Upon receiving these notifications, OCTA actions will range from evaluating the potential impact on OCTA operations and notifying relevant departments to mobilize assets to support evacuating communities if requested. Additionally, the Orange County Public Works Department provides information on mudflow predictions and protection, burned area reports, and burned area maps with recent fire damage to warn residents of potential mass earth movements after wildfires (Orange County Public Works). When received, this information can be used to adjust operations to protect OCTA assets proactively.

8.3 Secondary Hazards and Cascading Impacts

8.3.1 Secondary Hazards

Following a mass earth movement, the most common secondary hazard is flooding from fallen materials blocking waterways such as rivers (United States Geological Survey). Risks from flooding in OCTA's planning area, covered in Section 7, including the Santa Ana River and various water channels, which mass earth movements can block. Mass earth movement materials that get into drinking water supplies can reduce water quality.

8.3.2 Cascading Impacts

Mass earth movements can damage or destroy roads and other transportation infrastructure, utilities, and structures and cause injury or death. Blocked roads can disrupt the Authority's services and delay supplies or other business' services needed for operations. Utility damage or destruction can result in power and communication loss. Energized downed powerlines and broken gas lines can start fires and lead to injuries or death. Mass earth movements can carry large debris, even vehicles and buildings, which means hazardous material inside, potentially releasing them into the environment. There is also a risk of destabilizing structural foundations, making it essential to have a qualified person inspect affected buildings before reentering (Ready.gov, 2020).

8.4 Potential Impacts from Future Climate Conditions

Climate change could cause more mass earth movements due to increased frequency and severity of storms, SLR, erosion, and wildfires, all of which raise the likelihood of mass earth movements (United States Geological Survey). Along the coastline, storms, SLR, and erosion can combine to put coastal cliffs at high risk for landslides. Unlike erosion, which happens slowly over time, these cliff mass movements can happen suddenly, releasing large amounts of ground material at once. Example images of three coastal landslides in southern California are in Figure 8-2.

Figure 8-2 – Coastal Cliff Landslides in Southern California (Collins, 2014)

Droughts may increase in occurrence and duration, increasing the chances for wildland fires, affecting vegetation that helps support steep slopes. Increased frequency and intensity of severe weather can inundate areas with more water than is typical, adding to the risk of slides from water-saturated soils. These factors are projected to increase the probability of a mass earth movement within the OCTA planning area (County of Orange and Orange County Fire Authority, 2015)

8.5 Exposure

8.5.1 Population

Intersecting OCTA bus stop ridership and US Census planning area data with geospatial hazard data for deep-seated landslides and post-fire soil erosion shows population exposure to each hazard type. Post-fire soil erosion classifications delineate the level of risk for a post-fire debris flow, ranked from class one to three. Populations at risk from post-fire landslide susceptibility with soil class one to three (one is the lower risk and three is the highest), in Table 8-6; ridership exposed to post-fire landslides are in Table 8-3.

The soil class map data comes from CalFIRE. Their soil analysis represents soil loss averaged over time in the total area using the Revised Universal Soil Loss Equation (RUSLE) best estimate in a post-wildfire environment. There are nearly 600 thousand individuals at risk from class one post-fire soil erosion and over 45 thousand in a class three soil area. 2019 Ridership in all three classes of post-fire land susceptibility areas was over 41 thousand boardings combined.

Mapped landslide exposure is in areas that have known and mapped landslide features. Mapped landslides in the planning area are in Figure 8-3. These features include deposits, sources, and other mapped signs of landslide risk. Deposits indicate where previous slides left debris at the end of the flow. Landslide sources and other signs are data layers that show where previous landslides came from or started (United States Geological Survey). There were approximately 8.5 thousand boardings in 2019 in areas with mapped landslide features.

Susceptibility to deep-seated landslides was also measured. The levels range from one to ten, where one is the lowest likelihood of sliding and ten is the highest risk. These estimates are based on regional rock strength and slope steepness (California Department of Conservation). Table 8-4 indicates bus ridership susceptibility to landslides from levels three to ten. There were no values for levels one and two. In the level four landslide susceptibility area, there were over 523 thousand boardings in 2019.

Table 8-3 – Bus Stop Ridership Exposed to Mapped and Post-Fire Landslide Susceptibility

Ridership	Post-Fire Landslide Susceptibility	Mapped Landslides
Total	41,911	8,518

Table 8-4 – Bus Stop Ridership Exposed to Landslide Susceptibility from Level 3 to 10

Ridership	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8	Level 9	Level 10
Total	193	523,415	500	409,996	190,200	59,614	193	19,016

Vulnerability

Populations within the OCTA planning area at risk from mapped mass earth movements are in Table 8-5 below. The results show the highest exposure is to "other landslide features." In this category, minority and mixed-race individuals in the zone total almost two hundred thousand, 86 thousand individuals are 19 years old or younger, nearly 44 thousand seniors, and over 37 thousand living below the poverty level.

Table 8-5 – Populations at Risk from Mapped Landslides

Populations	Other Landslide Feature	Landslide Deposits	Landslide Source
Black	7,319	332	162
American Eskimo	1,827	144	78
Asian	77,883	2,773	2,279
Hawaiian/Pacific Islander	1,137	97	49
Hispanic	94,187	4,361	2,247
Multiple Races	14,133	1,460	813
Children up to 19 Years Old	86,001	6,970	3,772
65 Years and Older	43,911	5,152	4,323
Below the Poverty Level	37,187	2,529	1,365

Populations at risk from post-fire landslide susceptibility with soil class one to three (with one as the lower risk and three as the highest risk) are in Table 8-6; soil class one has the highest population.

Table 8-6 – Populations at Risk from Post-Fire Landslides Soil Types 1 to 3

Populations	Soil Class 1	Soil Class 2	Soil Class 3
Black	10,799	7,825	503
American Eskimo	4,100	2,983	183
Asian	102,979	80,205	6,516
Hawaiian/Pacific Islander	2,215	1,695	125

Populations	Soil Class 1	Soil Class 2	Soil Class 3
Hispanic	232,631	174,958	6,741
Multiple Races	24,244	17,998	1,904
Children up to 19 Years Old	161,899	118,323	9,776
65 Years and Older	63,914	52,051	6,441
Below the Poverty Level	90,511	59,165	3,382

Populations at risk from landslide susceptibility levels three and five to ten (with one as the lowest risk and ten as the highest) are in Table 8-7; there is no class one, two, or four population exposure in the planning area. At the highest level of risk, level ten, the vulnerable population numbers are the greatest.

Table 8-7 – Populations at Risk from Landslide Susceptibility Level 3, and 5 to 10

Populations	Level 3	Level 5	Level 6	Level 7	Level 8	Level 9	Level 10
Black	3,133	7,417	1,148	12,391	7,825	6,904	5,501
American Eskimo	958	2,580	330	3,804	2,192	2,500	2,240
Asian	25,615	69,280	15,480	119,406	60,268	61,216	68,357
Hawaiian/Pacific Islander	540	1,432	256	2,177	1,157	1,409	1,007
Hispanic	59,031	132,170	18,886	227,713	123,905	140,513	123,468
Multiple Races	5,680	16,500	2,834	27,003	14,349	16,421	14,727
Children up to 19 Years Old	38,262	101,872	16,697	170,318	91,951	105,133	99,131
65 Years and Older	11,743	46,102	6,107	72,777	43,078	48,899	44,142
Below the Poverty Level	19,922	50,491	8,360	87,328	47,452	45,494	383,905

8.5.2 Property

There are no OCTA-owned buildings exposed to mapped landslide hazards by building type. The planning risk areas are displayed in Figure 8-3. Table 8-8 and 8-9 lists Authority parcels and infrastructure exposed to mapped landslides. Tables 8-10 to 8-11 lists areas vulnerable to a landslide after a wildfire.

The GIS dataset used for the landslide susceptibility combines several layers, including landslide inventory, geology, rock strength, and slope, to generate susceptibility classes from zero at the lowest to ten at the highest (California Department of Conservation, 2018). Tables 8-13 to 8-15 show levels of susceptibility to landslides in the planning area. Landslide susceptibility ranges from levels 3 to 10. OCTA buildings are found in levels 5 and 7.

Table 8-8 – OCTA Owned Environmental Parcels Exposed to Mapped Landslides

Parcel Type	Acres
Eagle Ridge (proximal to the City of Brea)	81.53
Live Oak Creek (proximal to the City of Lake Forest)	8.83
Pacific Horizon (proximal to the City of Laguna Beach)	62.90
Silverado Chaparral (proximal to Silverado Canyon)	49.32
Trabuco Rose (proximal to Trabuco Canyon)	20.95

Parcel Type	Acres
Wren's View (proximal to Trabuco Canyon)	0.21
Total	**223.74**

Table 8-9 – OCTA Infrastructure and Related Operations Exposed to Mapped Landslides

Infrastructure Type	Miles
Bus Route	5.73
Other Freeway	20.25
Metrolink Rail	0.38
Total	**26.36**

Table 8-10 – OCTA Property Exposed to Landslides After a Wildfire with Soil Classes 1-3

Building Type	Soil Class 1	Soil Class 2	Soil Class 3
Park and Ride	1	0	0
Total	**1**	**0**	**0**

Table 8-11 – OCTA Owned Environmental Parcels in Acres Exposed to Landslides After a Wildfire Soil Classes 1-3

Land Use	Soil Class 1	Soil Class 2	Soil Class 3
Bobcat Ridge (proximal to the City of Lake Forest)	4.83	33.36	
Eagle Ridge (proximal to the City of Brea)	38.04	174.10	68.97
Live Oak Creek (proximal to the City of Lake Forest)	12.52	57.85	5.28
Pacific Horizon (proximal to the City of Laguna Beach)	5.80	63.30	66.10
Silverado Chaparral (proximal to Silverado Canyon)	26.84	98.60	77.64
Trabuco Rose (proximal to Trabuco Canyon)	103.65	282.10	7.85
Wren's View (proximal to Trabuco Canyon)	27.21	89.76	
Grand Total	**218.88**	**799.94**	**225.80**

Table 8-12 – OCTA Infrastructure and Related Operations in Miles Exposed to Landslides After a Wildfire

Infrastructure Type	Soil Class 1	Soil Class 2	Soil Class 3
Bus Route	14.31	2.72	0.28
I-405 Freeway	2.293	0	0
SR-91 Freeway	1.764	0	0
Other Freeway	30.451	22.738	1.574
Metrolink Rail	2.293	0	0
Grand Total	**51.111**	**25.458**	**1.854**

Table 8-13 – OCTA Buildings Landslide Susceptibility Class 3 to 10

Building Type	Class 5	Class 7
Brea Park and Ride	1	
Transit Center		1
Total	**1**	**1**

Table 8-14 – OCTA Environmental Areas (Acres) Landslide Susceptibility Class 3 to 10

Land Use Type	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10
Bobcat Ridge (proximal to the City of Lake Forest)	0	7.01	0	0.77	8.33	31.58	0	0.23
Eagle Ridge (proximal to the City of Brea)	0	14.30	0	3.42	19.60	157.80	0	97.95
Live Oak Creek (proximal to the City of Lake Forest)	0	6.50	0	2.85	8.50	49.37	0	14.46
Pacific Horizon (proximal to the City of Laguna Beach)	0	8.23	0	0.64	13.01	63.26	0	66.22
Silverado Chaparral (proximal to Silverado Canyon	2.65	11.30	5.24	18.32	30.26	112.63	2.65	21.71
Trabuco Rose (proximal to Trabuco Canyon)	52.70	18.30	59.78	65.54	40.45	88.40	52.70	35.34
Wren's View (proximal to Trabuco Canyon)	0.08	16.92	0.09	1.70	22.78	73.51	0.08	0.94
Total	**55.43**	**82.56**	**65.11**	**93.24**	**142.93**	**576.55**	**55.43**	**236.85**

Table 8-15 – OCTA Infrastructure in Miles with Landslide Susceptibility Class 3 to 10

Infrastructure Type	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10
Bus Route	0.62	63.08	0.30	91.73	18.11	25.14	0.62	208.30
Freeway	5.24	37.84	4.59	75.78	17.71	36.88	5.24	203.96
Metrolink Rail	0.01	2.82	0.01	6.72	0.72	1.59	0.01	13.07
Pacific Electric ROW	0	0	0	0.20	0	0	0	0.21
Streetcar Route	0	0	0	0.01	0	0	0	0.01
Total	**5.87**	**103.74**	**4.9**	**174.44**	**36.54**	**63.61**	**5.87**	**425.55**

Vulnerability

The definition of exposure and vulnerability in the GIS data includes buildings and critical infrastructure within even a moderate landslide hazard zone.

8.5.3 Environment

Specific environmental impact from mass earth movements within the OCTA planning area is challenging to predict. In general, earth movements can alter the surface topography, smother vegetation underwater or ground materials, and carry new materials into an ecosystem. Mass earth movements that dump materials into rivers can block water flow, causing the flow to reroute or flood the area. Soil and exposed hazardous materials can accumulate downslope, potentially contaminating drinking water supplies (World Health Organization). The Authority's planning area is prone to the risks resulting from a mass earth movement, including flooding, altered waterways, and contaminated water.

8.6 Development Trends

The Orange County Resources and Development Management Department (RDMD) consistently monitors and assesses mass earth movement potential. This Department evaluates the work consultants do on construction projects, including grading plans and soil reports, and corrective measures to mitigate geologic hazards (e.g., landslides and liquefaction) (Orange County).

The State, California Legislature Section 65302 of the Government Code requires general plans to include land use elements that identify and protect the community from any unreasonable risks associated with slope instability that could lead to mass earth movements (California Legislative Information, 2018). Orange County Ordinance NO.15-006, Section 7-10-30 (a) Setback and Slopes address landslide hazards (Orange County, 2020). This regulation states, development must have an acceptable way for water to flow across and away from the site. Any long-term water retention must meet Building Official approval to reduce risks from mass earth movements (Orange County, 2020).

8.7 Issues

Mass earth movement considerations in the OCTA planning area:

- As new data, technology, and science become available, update maps and mass earth movement hazard assessments
- Climate change could increase these trigger events, escalating the likelihood and extent of mass earth movements
- Potential cascading impacts, such as ruptured gas lines, and potential for secondary hazards, such as fires

8.8 Hazard Map

The hazard maps for deep-seated landslide susceptibility and post-fire soil erosion risks in the planning area start on the next page.

Figure 8-3 – OCTA Mapped Landslide Features

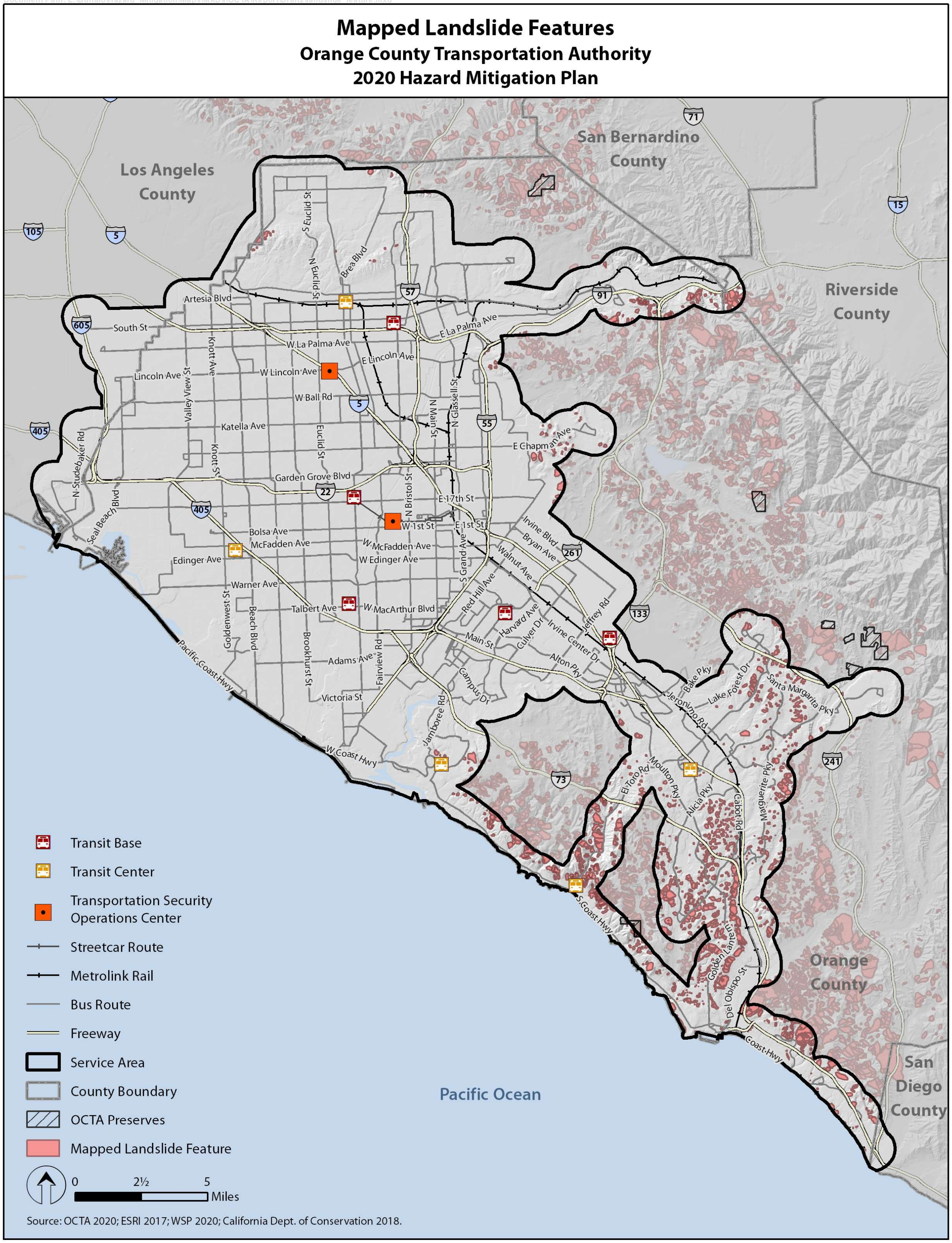


Figure 8-4 – OCTA Deep-Seated Landslide Susceptibility Area Hazard Map

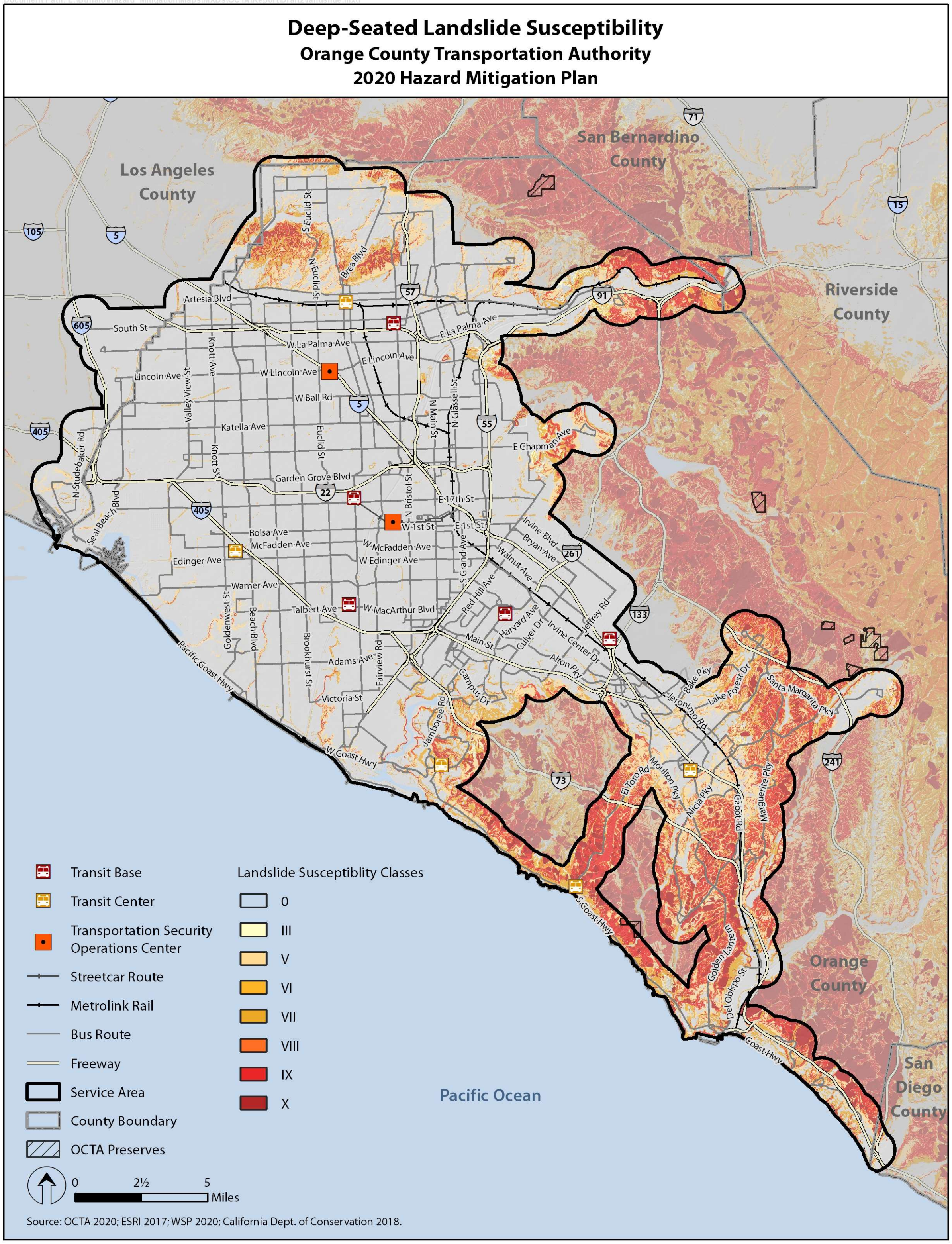
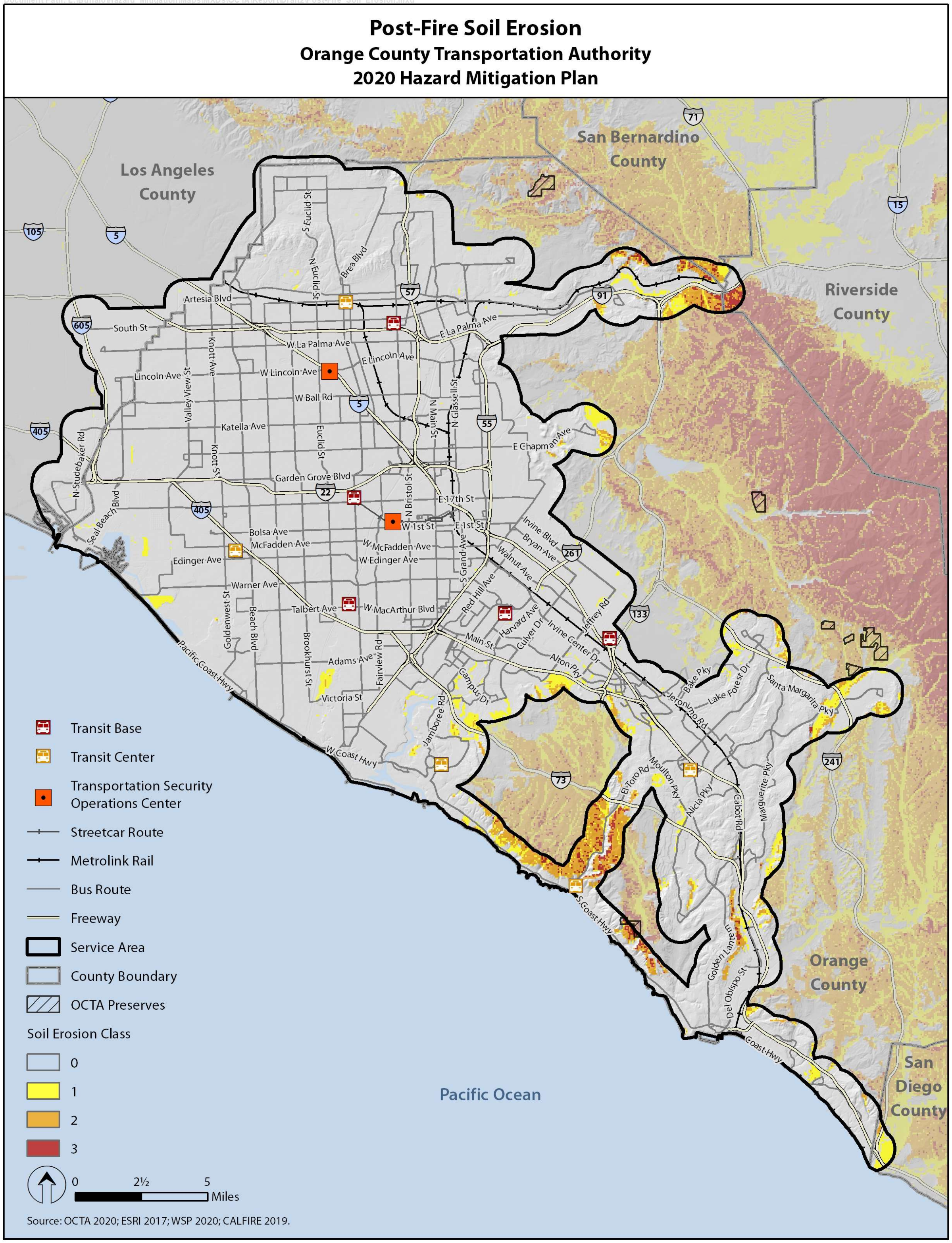


Figure 8-5 – OCTA Post-Fire Soil Erosion Hazard Map



9 Severe Weather Events

9.1 General Background

Severe weather occurs all over the US and can take multiple forms, such as thunderstorms, drought, heatwaves, tornadoes, flash floods, and winter storms (Ready.gov, 2020). These varying types of storms can occur at any time of day or night and throughout the year. Severe weather events can damage or destroy structures, infrastructure, and the environment and result in injuries or loss of life. Severe weather events may be categorized into two groups (World Meteorological Organization, 2004):

- **General Severe Weather** – systems that form over broad geographic areas that can cross regional and jurisdictional boundaries
- **Localized Severe Weather** – storms in a limited geographic area

It is essential to note the distinction between extreme weather and severe weather. The most intense and rare weather events at a particular place and/or time are considered extreme weather; in contrast, common forms of storms that cause significantly more damage than usual are severe weather events (National Academy of Sciences, 2008). For example, in an area that experiences annual windstorms, when one storm is more violent than normal, it is severe weather.

Severe weather can trigger flooding, flash floods, storm surges, and erosion; these flood-related hazards are in Section 7 of this plan. Severe weather identified as a hazard in this plan (National Weather Service, 2009):

- **Thunderstorms** – a local storm with thunder and lightning, can cause tornadoes, heavy rain, flash floods, hail, and high winds
- **Tornadoes** – a destructive rotating column of wind generated by a thunderstorm, shaped in a funnel that reaches the ground
- **Droughts** – extended periods of deficient rainfall and snowpack that lead to groundwater shortages impacting a large area of people, animals, and the environment

DEFINITIONS

Derecho – A widespread and long-lived windstorm associated with thunderstorms that can cause damage similar to a tornado.

Droughts – Extended periods of extremely low rainfall and snowpack that lead to groundwater shortages impacting a large area of people, animals, and the environment.

Excessive/Extreme Heat – a combination of high temperatures and humidity, where the human body cannot maintain internal temperatures and can cause heat-stroke.

General Severe Weather – systems that form over broad geographic areas that can cross regional and jurisdictional boundaries.

Localized Severe Weather – Damaging storms in a limited geographic area, can include all types of severe weather.

Thunderstorm – A local storm with thunder and lightning, can cause tornadoes, heavy rain, flash floods, hail, and high winds.

Tornadoes – A destructive rotating column of wind generated by a thunderstorm, shaped in a funnel that reaches the ground.

Winter Storm – A cold event with significant precipitation in the form of snow, ice, freezing rain, sleet, etc. Higher elevations get more precipitation.

- **Excessive/Extreme Heat** – a combination of high temperatures and humidity, where the human body cannot maintain internal temperatures and can cause heat-stroke

9.1.1 Potential Damage from Weather Events

There are multiple forms of severe weather and a variety of potential damages. Thunderstorms can produce heavy rains, tornadoes, hail, lightning, and high winds. Heavy rains can lead to several secondary hazards, such as flooding, flash floods, mass earth movements, and coastal erosion; secondary hazards are in Section 9.3. Tornadoes are the most violent type of storm (National Weather Service), which can quickly destroy structures, infrastructure, the environment and result in injuries or the loss of life.

Hail are balls of ice that form inside thunderstorms (The National Severe Storms Laboratory). Hail size depends on how long the ice stays in the thundercloud and continues to add layers. Eventually, the weight is too much for the storm to hold, and the hail drops to the ground. The largest hail size recorded had a circumference of 18.62 inches, and it weighed one pound fifteen ounces (The National Severe Storms Laboratory). Hail can significantly damage vehicles, break windows, and cause human injury or death.

If lightning hits a person, it can cause injury or loss of life. The high electrical current running through a body can damage the central nervous system, heart, lungs, and other vital organs (Krider). Lightning striking a building or power line can cause major electrical problems, including power outages, blown breaker boxes, blown transformers, and sometimes electrical fires (Krider). Under certain conditions, lightning-initiated fires can grow into wildfires.

Thunderstorms can bring high winds, sometimes called “straight-line” winds, to distinguish them from circular moving wind resulting in a tornado (The National Severe Storms Laboratory). High winds can reach up to 100 miles per hour and leave a destructive path that can extend hundreds of miles (The National Severe Storms Laboratory). These winds can directly damage structures and infrastructure and indirectly injure people struck by flying objects or cause loss of life.

Droughts are defined by their effects on people, animals, and the environment, which means the impacts determine when a weather event constitutes a drought (National Centers for Environmental Information). Droughts can have significant impacts on agricultural land and economies, animals, and human health. Droughts can also trigger several secondary hazards and cascading impacts; discussed in section 9.3

Excessive or extreme heat can substantially affect every living thing, including humans, animals, and plants. Humans can experience heat-related illnesses such as heat stress, heat exhaustion, heatstroke, and in some cases, lead to loss of life (Centers for Disease Control, 2020). Extreme heat is a combination of temperatures above 90 degrees with high humidity over at least two days (Ready.gov, 2021). Warmer temperatures can reduce air quality and increase ozone levels (Centers for Disease Control, 2020). Excessive heat can lead to secondary hazards like wildfires and cascading impacts like rolling power blackouts, discussed in Section 9.3.

9.2 Orange County Transportation Authority Hazard Profile

The entire OCTA planning area is at risk from severe weather of varying types. In Appendix G Table G-5 lists the severe weather events that caused more than $25,000 in damages or resulted in human injury or death in the Planning Area; they include tornadoes, heavy rain, lightning, thunderstorms, dust storms, heat, hail, and strong wind (National Oceanic and Atmospheric Administration). Storms coming off the Pacific Ocean are hazardous when combined with an El Niño wet season or a warm phase of the Pacific

Decadal Oscillation (California Coastal Commission). An El Niño occurs when the ocean and atmospheric system are disrupted, bringing heavy rains along the coast (County of Orange and Orange County Fire Authority, 2015). These conditions often last one to two years.

Figure 9-2 for the year 2035 and Figure 9-3 for the year 2070 show the predicted average temperature increases in three zones throughout the planning area.

By 2035, the zone increases are predicted to be (in °F):

- **Zone 1** – degrees of warming 1.5-2
- **Zone 2** – degrees of warming 2-2.5
- **Zone 3** – degrees of warming 2.5-3

By 2070 the zones are expected to be (in °F):

- **Zone 1** – degrees of warming 2-2.5
- **Zone 2** – degrees of warming 2.5-3
- **Zone 3** – degrees of warming 3-3.5

Rising temperatures will mean more extended droughts and more extreme heat events. The Planning Area regularly experience periods of drought. The last few were from 2006-2009, 2011-2014, and 2016-2017; although 2018-2019 brought more rain, parts of the Planning Area were still at a moderate drought level (UCLA Institute of the Environment & Sustainability, 2019). Drought-level explanations are in Section 9.2.5.

OCTA 2010 Severe Weather Narrative

December 2010, Orange County experiences severe weather resulting in several road closures, Metrolink Train disruptions, and public evacuations. Multiple regular service routes were detoured due to flooding or accidents, with Laguna Beach being significantly impacted requiring OCTA services to be dramatically detoured. Metrolink services were interrupted in the Laguna Nigel region, and OCTA provided vital bus bridges involving 7 busses and 15 staff, resulting in the transportation of 122 citizens. Santiago Canyon experienced an evacuation due to debris flow and OCTA provided 4 busses and 13 staff to evacuate 49 citizens and 2 dogs.

While average temperatures have gone up, so have record high temperatures in the planning area. During extreme drought events in the area, heatwave incidents also increased from four to six times per year, indicating a correlation between droughts and heatwaves (Hulley, Dousset, & Kahn, 2020). These severe weather events and factors demonstrate the hazard exposure to the entire planning area. Table 9-1 below illustrates the 2020 average weather conditions in the Planning Area.

Table 9-1 – Normal Temperatures in °F and Precipitation in Inches Recorded at the San Diego Miramar NAS Weather Station (National Centers for Environmental Information, 2020)

Season	Max Temperature	Minimum Temperature	Average Temperature	Precipitation
Annual	73.4	55.1	64.2	11.48
Winter	67.1	47.1	57.1	6.95
Spring	69.9	52.9	61.4	2.70
Summer	79.3	63.1	71.2	0.19
Autumn	77.1	57.2	67.2	1.64

9.2.1 Hazard Ranking

The Planning Team completed a hazard ranking survey during the OCTA 2021 HMP development process and assessed hazard-related factors based on worst case and most likely scenarios. Hazard definitions and ranking factors are in Appendix G, Table G-1. Survey results were prioritized and ranked based on their averaged score. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, where one is the lowest and five is the highest. Compared to the other hazards in the survey, severe weather events were the fourth worst-case and most likely scenario.

Table 9-2 – OCTA Severe Weather, Storm Surge, Drought, and Extreme Heat Event Hazard Ranking

Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Worst-Case Scenario						
3.05	3.09	3.50	2.57	3.02	3.05	4
Most Likely Scenario						
2.59	2.75	3.39	2.61	3.05	2.88	4

9.2.2 Past Events

Severe weather and flooding in 1997-1998 impacted Orange County, damaging facilities infrastructure, costing approximately $50 million (County of Orange and Orange County Fire Authority, 2015). In Appendix G Table G-4 lists fifteen severe weather events in the Planning Area that resulted in a FEMA disaster declaration between 1969 and 2020 (Federal Emergency Management Agency, 2020). Table G-5 summarizes the severe weather events in the Planning Area that resulted in deaths, injuries, and/or more than $25,000 in damages. Since 1956, NOAA has recorded 133 of these weather events (National Oceanic and Atmospheric Administration). A few of the most notable events are in Table 9-3.

Table 9-3 – Significant Past Severe Weather Events in the Planning Area (Federal Emergency Management Agency, 2020) (National Oceanic and Atmospheric Administration)

Date	Severe Weather Type	Deaths/Injuries	Property Damage	FEMA Declaration or Scale
2/10/2000	Heavy Rain	1 death 4 injuries	$300,000	
3/6/2000	Hail	1 death	$75,000	
11/12/2003	Hail	0	$3,500,000	
1/7/2005	Heavy Rain	0	$5,000,000	DR-1577-CA
1/7/2005	Heavy Rain	0	$15,000,000	DR-1577-CA
2/18/2005	Heavy Rain	0	$20,000,000	
4/14/2005	Severe storms, flooding, debris/mudflows			DR-1577-CA
3/13/2007	Severe freeze			DR-1689-CA
9/3/2007	Excessive Heat	8 deaths	$0	
1/19/2010	Tornado	0	$500,000	EF-1
3/8/2010	Severe winter storms, flooding, debris/mudflows			DR-1884-CA

Date	Severe Weather Type	Deaths/Injuries	Property Damage	FEMA Declaration or Scale
1/26/2011	Winter storms, flooding, debris/mudflows			DR-1952-CA
3/16/2017	Severe winter storms, flooding, mudslides			DR-4305-CA

9.2.3 Location

The entire OCTA planning area has experienced damage from severe weather, as shown by the emergency declarations and storm database tables in Appendix G. However, the most significant thunderstorms typically occur where the Pacific Ocean's cooler air meets warmer air from the San Gabriel Mountains or farther south of Mexico (Meier & Thompson). These thunderstorms can bring heavy rains, hail, high winds, and lightning to the Santa Anna Mountains and the valleys and plains below. However, the planning area coastline is most at risk from storms coming off the Pacific to bring storm surges and high waves.

Temperature predictions show an increase over the next few decades, overlapping the planning area in three zones. Figures 9-2 and 9-3 show the distribution of predicted temperature increases over the Authority’s planning area. These increased temperatures expand the entire planning area’s exposure to extreme heat and drought events. Additionally, as indicated in the past events section, severe drought conditions in Southern California have crossed the entire planning area (UCLA Institute of the Environment & Sustainability, 2019).

9.2.4 Frequency

On average, OCTA can expect impacts from severe weather at least once a year, as indicated by Tables G-4 and G-5. Severe weather can strike anywhere at any time of day or year; however, certain types of storms happen more often in particular seasons, such as extremely high temperatures and droughts in the summer. The NOAA database shows the types of severe weather events that can happen more often, such as heavy rains and thunderstorms, while hail is uncommon in the planning area.

Droughts are not uncommon in the OCTA planning area, and their frequency will increase in the future. Planning Area drought events are happening more often and lasting longer (UCLA Institute of the Environment & Sustainability, 2019). Higher temperatures and heat waves affect the frequency of droughts and extreme heat events. A report shared by the NASA Earth Observatory states that heatwaves have also increased in frequency, duration, and intensity over the last few decades throughout Southern California, including in the OCTA planning area (Hulley, Dousset, & Kahn, 2020).

9.2.5 Severity

The OCTA planning area can experience damage from all types of severe weather, including thunderstorms, tornados, droughts, and excessive heat. The severity level varies for each type of event. Table 9-4 describes the severe thunderstorm categories. Tornado ratings are in Table 9-5. In the drought severity section is a list of the five drought levels. The Heat-Index risk level is in Figure 9-1.

Severe Storms and Thunderstorms

Heavy rain and hail resulted in the loss of life and injuries in the planning area. Heavy rain, hail, and a tornado also caused significant property damage costs, shown in Table 9-3. Orange County experienced the highest damage cost at $20 million after heavy rain in 2005. NWS has five severity categories:

Table 9-4 – NWS Severe Thunderstorm Risk Categories (National Weather Service)

Risk Severity	Label	Impacts
None	Thunderstorms (no official label)	▪ Severe thunderstorm not expected, winds up to 40 mph, and small hail ▪ Lightning and floods can still occur
1	Marginal (MRGL)	▪ Limited duration and/or intensity isolated severe thunderstorms possible ▪ Winds 40-60 mph ▪ Low tornado risk
2	Slight (SLGT)	▪ Short term and/or not widespread, scattered severe thunderstorms and isolated intense storms possible ▪ Strong wind damage reports, maybe one or two tornadoes ▪ Hail 1-inch diameter, and in isolated areas 2 inches
3	Enhanced (ENH)	▪ Persistent and/or widespread, numerous severe thunderstorms possible ▪ Several strong wind damage reports with a few tornadoes ▪ Damaging hail 1-2-inch diameter
4	Moderate (MDT)	▪ Longer widespread and intense thunderstorms likely ▪ Widespread wind damage and strong tornadoes possible ▪ Destructive hail of 2-inch diameter or more
5	High (HIGH)	▪ Longer, very widespread, and especially intense thunderstorms expected ▪ Tornado outbreak ▪ Derecho

Table 9-5 – Enhanced Fujita Scale for Tornadoes (National Weather Service)

EF Rating	3 Second Gust in mph
0	65-85
1	86-110
2	111-135
3	136-165
4	166-200
5	Over 200

Tornadoes

In the US, tornado intensity measurements are based on the Enhanced Fujita Scale (EF Scale). This scale defines a tornado's severity by the estimated wind speed and damages it causes, as shown in Table 9-5. Previous tornado events in the Planning Area fell within an EF-0 to EF-3 range (National Oceanic and Atmospheric Administration).

Drought

Drought severity depends on several factors, including duration, intensity, geographic extent, and water supply needs in the planning area. The measure of drought magnitude is in length of time and the water deficit severity. Environmental factors can amplify droughts, such as prolonged high winds and wildfires. The US National Integrated Drought Information System measures conditions in five levels related to the OCTA planning area.

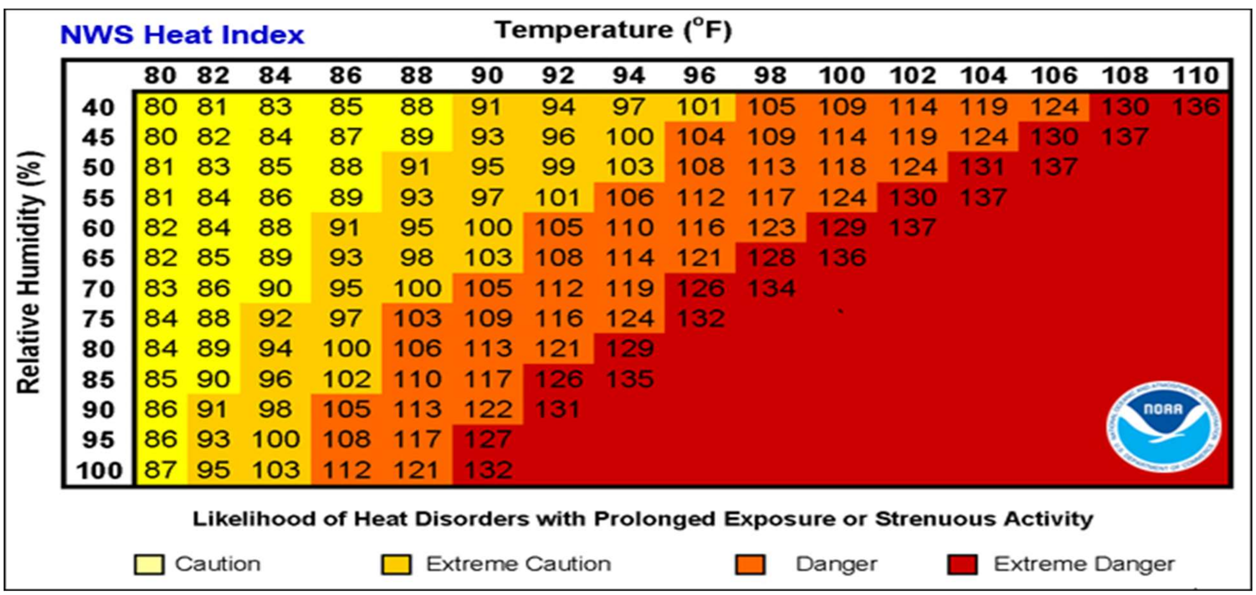
Table 9-6 – Drought Information System Measurements (National Integrated Drought Information System, 2021)

Drought Level	Drought Description
D0 **Abnormally Dry**	- Dry soil, deliver irrigation early - Active fire season begins
D1 **Moderate Drought**	- Dryland pasture growth student, supplemental feed for cattle - Landscaping and gardens need irrigation earlier - Stock ponds and creeks are lower than normal
D2 **Severe Drought**	- Fire season is longer with high burn intensity, dry fuels, and a larger coverage area - More fire crews on staff
D3 **Extreme Drought**	- Federal water is not adequate for irrigation contracts, and extracting extra groundwater is expensive
D4 **Exceptional Drought**	- Many crop yields are low, affecting economies and households with possible food shortages - Fire season is costly and extensive, with numerous fires and large areas burned - Many recreational activities are affected

Extreme Heat

Extreme heat events in the planning area are already occurring and expected to become more common, more severe, and longer-lasting as our climate changes (Environmental Defense Fund). The relationship between high temperatures and high humidity determines the extreme heat severity level. NOAA's table in Figure 9-1 illustrates the relationship between temperatures and relative humidity to provide the Heat-Index output level (National Oceanic and Atmospheric Administration). When the combined heat index reaches 90˚F, many people are at serious risk.

Figure 9-1 – NOAA Heat Index (Leahy, 2019)



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

9.2.6 Warning Time

Meteorologists can often predict the likelihood of a severe storm, providing several days of advanced warning. For example, the NWS Climate Prediction Center issues long-range forecasts, with 8-14 day, monthly, and seasonal outlooks (National Weather Service) (National Oceanic and Atmospheric Administration and National Weather Service, 2021). However, specific aspects of a storm can be challenging to determine, such as where lightning will strike or how large hail will be (The National Severe Storms Laboratory). Numerous scientific factors inform predictions. However, with so many factors to account for, forecasts are not always correct or exact.

Thunderstorm and Tornadoes

The NWS San Diego office assesses potential weather and flood event factors to determine when to send emergency notifications and what warning level to set. The office also provides up-to-the-minute watches, warnings, and advisories for four categories of severe weather, listed in the table below.

Table 9-7 – NWS Warnings and Advisories List (National Weather Service, 2021)

Convective/Tropical	Flooding	Winter Weather	Non-Precipitation
Tornado Watch	Flash Flood Watch	Winter Storm Watch	High Wind Warning
Tornado Warning	Flash Flood Warning	Winter Storm Warning	High Wind Advisory
Severe Thunderstorm Watch	Coastal/Flood Watch	Freezing Rain Advisory	
Severe Thunderstorm Warning	Coastal/Flood Warning	Ice Storm Warning	
Hurricane Watch	Small Stream Flood Advisory	Winter Weather Advisory	
Hurricane Warning			
Tropical Storm Watch			
Tropical Storm Warning			

Drought

The Drought Early Warning System (DEWS) uses climate and drought science to predict future drought conditions, making the data accessible and valuable for decision-makers (National Integrated Drought Information System, 2020). The DEWS goal is to provide as much forewarning as possible to improve stakeholders' capacity to monitor, forecast, plan for, and cope with drought impacts (National Integrated Drought Information System, 2020).

Extreme Heat

When temperatures spike in the summer months, there is a surge of energy use when residents return home from work and turn on appliances, air conditioners, and other cooling devices (California Independent System Operator). Orange County employs a “Flex Alert” (California Independent System Operator) when the grid is taxed or close to maxed out. The alert requests customers to reduce their energy usage during peak energy times and high temperatures.

9.3 Secondary Hazards and Cascading Impacts

9.3.1 Secondary Hazards

Severe weather can trigger several secondary hazards, such as flooding (Ready.gov, 2020), storm surge, and increase coastal erosion; flooding and erosion hazards are in Section 7 of this plan. Heavy rains can also destabilize slopes, resulting in mass earth movements (United States Geological Survey). Drier soil during a drought means less vegetation, increasing the risk of mass earth movements without the vegetation to stabilize slopes and surface erosion due to lose dry soil; Mass earth movements are in Section 8. Lightning strikes, droughts, and heatwaves substantially increase wildfire risks (National Centers for Environmental Information); Section 11 discusses wildfires further.

9.3.2 Cascading Impacts

Cascading impacts from severe weather include damaged or destroyed infrastructure and utilities. Heavy rain, lightning, and tornadoes can knock out power, roads, communications and disrupt water management systems. Damaged or flooded roads can disrupt the Authority's transportation services. High winds can topple trees, communication towers, and power lines. Downed power and broken gas lines can start fires. During heatwaves, people use more electricity when they are at home, especially running air cooling units, which can overwhelm the electrical grid and cause rolling brown or blackouts. Brownouts are when power is still transmitted but at a diminished capacity, while blackouts are a complete shutdown of affected power stations/substations (California Independent System Operator).

9.4 Potential Impacts from Future Climate Conditions

Severe weather will occur more often and be more intense as climate change worsens (Environmental Protection Agency), resulting in more frequent and severe extreme heat days and heatwaves, more droughts, and storms. As a result, the planning area could see more extremely wet winters and springs at the current global carbon emissions rate. These extreme events could increase as much as 50 percent by the 2070s, compared to the increase between 1850 to the present (Constible, 2019). Additionally, higher temperatures for more extended periods in the Authority's planning area mean more moisture evaporated into the atmosphere, amplifying rainfall and creating a cycle of extreme weather (Environmental Defense Fund).

The Planning Area saw three years of continuous drought conditions from 2011-2014 (UCLA Institute of the Environment & Sustainability, 2019). Higher annual average temperatures contribute to drier conditions. The annual increase includes warmer weather in the winter with more precipitation in the mountains falling as rain instead of snow, resulting in less snowmelt in the summer to provide water in the drier summer months. Climate change factors have already increased temperatures and resulted in prolonged dry periods and severe drought conditions. These temperatures will continue to rise in the future, exacerbating already dry periods. Tables 78 to 83 list the Authority's structures, infrastructure, and land-use parcels with the predicted temperature increases due to climate change.

9.5 Exposure

9.5.1 Population

Intersecting OCTA bus stop ridership and US Census planning area data with geospatial hazard data for severe weather events shows population exposure to stormwater inundation and temperature increases. OCTA ridership exposed to stormwater inundation for a 100-year storm is in Table 9-8 below, with a total of 19,672 boardings in areas at risk from the inundation zone. Ridership exposed to predicted temperature increase in the planning area is in Tables 9-9 and 9-10. Ridership in areas predicted to increase by 1.5-2 degrees was over 4 million boardings in 2019 alone.

Table 9-8 – Summary of Ridership at Bus Stops Exposed to 100-year Stormwater Inundation Zone

Ridership at Bus Stops	Within 100-year Zone
Total	19,672

Table 9-9 – Bus Stop Ridership at Risk from Predicted Temperature Increases up to Year 2035

Ridership	1.5-2 Degrees	2-2.5 Degrees	2.5-3 Degrees
Total	4,149,156	14,930	31,278,952

Table 9-10 – Bus Stop Ridership at Risk from Predicted Temperature Increases up to Year 2070

Ridership	2-2.5 Degrees	2.5-3 Degrees	3-3.5 Degrees
Total	27,079,210	824,321	7,539,507

Vulnerability

Vulnerable populations are especially at risk and may require support to evacuate during a 100-year storm inundation event. Individuals with medical conditions or autoimmune deficiencies will be more affected by poor air quality or increased infectious diseases (United States Global Change Research Program, 2016). Although droughts may not directly impact individuals in the planning area, droughts can reduce food and water supplies, raising prices, and disproportionately affecting low-income households (Constible, 2019).

Intersecting OCTA bus stop ridership and US Census planning area data with geospatial hazard data for populations at risk from a 100-year stormwater inundation event are in Table 9-11. As the results show, there nearly 30 thousand households below the poverty level; this group is especially at risk as they may not have the funds to prepare their residences and/or may need assistance with transportation during an evacuation.

Table 9-11 – Vulnerable Populations at Risk from 100-Year Stormwater Inundation

Populations	100-Year Storm Inundation Zone
Black	2,949
American Eskimo	1,166
Asian	21,846
Hawaiian/Pacific Islander	457
Hispanic	76,521
Multiple Races	8,027
Children up to 19 Years Old	52,663
65 Years and Older	20,706
Below the Poverty Level	29,054

Extreme heat exposure is calculated by the length of time people spend in high temperatures (National Integrated Heat Health Information System, 2020). Groups vulnerable to extreme heat exposure include children, emergency responders, the elderly, outdoor workers, athletes, and individuals with existing medical conditions exacerbated by heat. For example, elderly persons that rely on OCTA services for transportation are at higher risk for heat-related illnesses while waiting outside for the transportation to arrive. Additionally, children often rely on adults to identify extreme heat events and take precautions like drinking plenty of water.

Outdoor workers on OCTA projects may have layers of protective clothing and/or need to carry heavy gear, which can escalate their susceptibility to heat illnesses. Additionally, the urban heat island effect can raise temperatures between 18 to 27 degrees during the day in densely populated areas with less vegetation and more asphalt (National Integrated Heat Health Information System, 2018). This heat island effect can impact the densely populated planning area (Orange County Transportation Authority, 2018).

The highest number of populations at risk in Table 9-12 are in the 2-2.5 temperature increase range by 2035. Over one million minority and mixed-race individuals are in areas predicted to warm 2-2.5 degrees by 2035. Table 9-13 shows warming up to the year 2070 and the populations that could be impacted, with nearly 1.3 million minority and mixed-race people at risk from 2.5-3 degree increase by 2070. Additionally, many low-income households are at risk from a 2.5-3 degree warming at 238,447 households.

Table 9-12 – Vulnerable Populations Exposed to Predicted Temperature Increases up to the Year 2035

Populations	1.5-2 Degrees	2-2.5 Degrees	2.5-3 Degrees
Black	20,707	32,515	784
American Eskimo	5,972	11,677	343
Asian	215,163	304,672	4,839
Hawaiian/Pacific Islander	3,475	5,916	126
Hispanic	305,062	692,038	17,502
Multiple Races	52,844	64,529	2,506
Children up to 19 Years Old	304,764	451,273	16,078
65 Years and Older	162,725	167,926	7,555
Below the Poverty Level	139,266	238,447	6,158

Table 9-13 – Vulnerable Populations Exposed to Predicted Temperature Increases up to the Year 2070

Populations	2-2.5 Degrees	2.5-3 Degrees	3-3.5 Degrees
Black	9,333	40,535	4,137
American Eskimo	3,041	13,396	1,555
Asian	137,848	359,480	27,347
Hawaiian/Pacific Islander	1,657	7,247	613
Hispanic	157,486	783,609	73,506
Multiple Races	29,675	79,554	10,650
Children up to 19 Years Old	170,529	535,549	66,307
65 Years and Older	83,233	220,904	34,070
Below the Poverty Level	85,995	272,800	25,076

9.5.2 Property

Table 9-14 shows the Authority's infrastructure vulnerable to a 100-year storm. Tables 9-15 to 9-17 are OCTA's buildings, land parcels, and infrastructure exposed to predicted temperature increases for the year 2035. Tables 9-18 to 9-20 show the areas affected with predicted temperature increases for 2070.

Table 9-14 – OCTA Infrastructure and Related Operations Exposed to Stormwater Inundation in a 100-Year Storm

Land Type	Miles
Bus Route	2.80
I-405 Freeway	0.230
Other Freeway	0.285
Metrolink Rail	0.01
Total	**3.325**

Table 9-15 – OCTA Buildings Exposed to Predicted Temperature Increases to the Year 2035

Building Type	1.5-2 Degrees	2-2.5 Degrees	2.5-3 Degrees
Bus Stops	1242	4236	4
Fullerton Park and Ride	0	1	0
Brea Park and Ride	0	1	0
Streetcar Stop	0	13	0
Transit Base	0	5	0
Transit Center	3	2	0
Total	**1245**	**4258**	**4**

Table 9-16 – OCTA Environmental Areas Exposed to Predicted Temperature Increases to the Year 2035

Land Use Type	1.5-2 Degrees	2-2.5 Degrees	2.5-3 Degrees
Bobcat Ridge (proximal to the City of Lake Forest)	0	48.90	0
Eagle Ridge (proximal to the City of Brea)	0	0	296.90
Live Oak Creek (proximal to the City of Lake Forest)	0	82.54	0
Pacific Horizon (proximal to the City of Laguna Beach)	152.71	0	0
Silverado Chaparral (proximal to Silverado Canyon)	0	204.59	0
Trabuco Rose (proximal to Trabuco Canyon)	0	400.58	0
Wren's View (proximal to Trabuco Canyon)	0	116.96	0
Grand Total	**152.71**	**853.57**	**296.9**

Table 9-17 – OCTA Infrastructure in Miles Exposed to Predicted Temperature Increases to the Year 2035

Infrastructure Type	1.5-2 Degrees	2-2.5 Degrees	2.5-3 Degrees
Bus Route	339.20	1009.59	1.06
I-405 Freeway	19.139	69.314	0
SR-91 Freeway	0	66.538	0

Infrastructure Type	1.5-2 Degrees	2-2.5 Degrees	2.5-3 Degrees
Other Freeway	159.095	375.994	2.206
Metrolink Rail	19.16	44.06	4.17
Pacific Electric ROW	0	11.79	0
Streetcar Route	0	5.05	0
Grand Total	**536.594**	**1582.336**	**7.436**

Table 9-18 – OCTA Buildings Exposed to Predicted Temperature Increases to the Year 2070

Building Type	2-2.5 Degrees	2.5-3 Degrees	3-3.5 Degrees
Fullerton Park and Ride	0	0	1
Brea Park and Ride	0	0	1
Streetcar Stop	0	13	0
Transit Base	0	4	1
Transit Center	2	2	1
Total	**2**	**19**	**4**

Table 9-19 – OCTA Environmental Areas in Acres Exposed to Predicted Temperature Increases to the Year 2070

Land Use Type	2-2.5 Degrees	2.5-3 Degrees	3-3.5 Degrees
Bobcat Ridge (proximal to the City of Lake Forest)	0	48.90	0
Eagle Ridge (proximal to the City of Brea)	0	0	296.90
Live Oak Creek (proximal to the City of Lake Forest)	0	82.54	0
Pacific Horizon (proximal to the City of Laguna Beach)	152.71	0	0
Silverado Chaparral (proximal to Silverado Canyon)	0	33.24	171.35
Trabuco Rose (proximal to Trabuco Canyon)	0	400.58	0
Wren's View (proximal to Trabuco Canyon)	0	116.96	0
Total	**152.71**	**682.22**	**468.25**

Table 9-20 – OCTA Infrastructure in Miles Exposed to Predicted Temperature Increases to the Year 2070

Infrastructure Type	2-2.5 Degrees	2.5-3 Degrees	3-3.5 Degrees
Bus Route	83.36	1023.55	242.95
I-405 Freeway	33.07	501.24	157.97
SR-91 Freeway	0	88.452	0
Other Freeway	0	8.090	58.448
Metrolink Rail	4.30	34.88	28.20
Pacific Electric ROW	0	11.79	0
Streetcar Route	0	5.052	0
Total	**120.73**	**2745.754**	**856.658**

9.5.3 Critical Facilities

Critical facilities vulnerable to temperature increases are in Tables 9-21 and 9-22.

Table 9-21 – OCTA Critical Facilities Exposed to Predicted Temperature Increases to the Year 2035

Building Name	1.5-2 Degrees	2-2.5 Degrees	2.5-3 Degrees
Transportation Security Operations Center			1
Total	**0**	**0**	**2**

Table 9-22 – OCTA Critical Facilities Exposed to Predicted Temperature Increases to the Year 2070

Building Name	2.5-3 Degrees	2-2.5 Degrees	3-3.5 Degrees
Transportation Security Operations Center			1
Total	**1**	**0**	**1**

9.5.4 Environment

Severe storm and drought events can radically affect the physical environment, altering surface geography and temporarily altering waterways. Some severe weather types can influence the environment significantly in a very short time, such as highly destructive tornadoes. Other severe weather forms can have slower harmful impacts, like prolonged heavy rain and more frequent and intense heatwaves. Higher temperatures and prolonged droughts reduce air quality and can be detrimental to vegetation. Secondary hazards such as flooding, coastal erosion, mass earth movements, and wildfires can change the ground's surface, contaminate drinking water, change floodplains and waterways, and reduce vegetation. Cascading issues like downed powerlines can instigate wildfires, damaging the environment. These environmental impacts can impair or destroy the Authority's buildings, infrastructure, alter their land, and adversely affect customers and staff health.

9.6 Development Trends

All future development is at risk of severe weather hazards. Primary hazards from thunderstorms can have immediate effects on OCTA's development projects, such as destructive tornadoes, direct lightning strikes, and large hail; unfortunately, it is impossible to predict precisely when and where these risks will occur. OCTA can mitigate the impacts on development projects by receiving local weather alerts and warnings and following the recommended actions.

OCTA regularly has new projects in development and updating or renovation projects to improve existing development. The Planning area expects future population growth (United States Census Bureau, 2018). To manage growth and minimize the risk of these hazards, OCTA consistently develops and updates development plans with the best available data and science.

These plans include:

- The 2014-2019 Strategic Plan
- 2018 Long-Range Transportation Plan
- 2018 Transit Vision Final Report
- 2019 Capital Programming Policies
- The OC Rail Climate Defense Plan, in progress

9.7 Issues

Issues associated with severe weather in the OCTA planning area:

- The older structures are especially vulnerable to severe weather events.
- Extended droughts and more frequent and intense heatwaves can extend project timelines with heat-illness prevention measures.
- Modern/Current building codes, stormwater management, and electrical systems can minimize the risks associated with lightning, high winds, heavy rains, and hail.

9.8 Hazard Maps

The hazard maps for predicated temperature increases in the planning area start on the next page.

Figure 9-2 – OCTA Average Maximum Temperature Increase: Baseline to the Year 2035

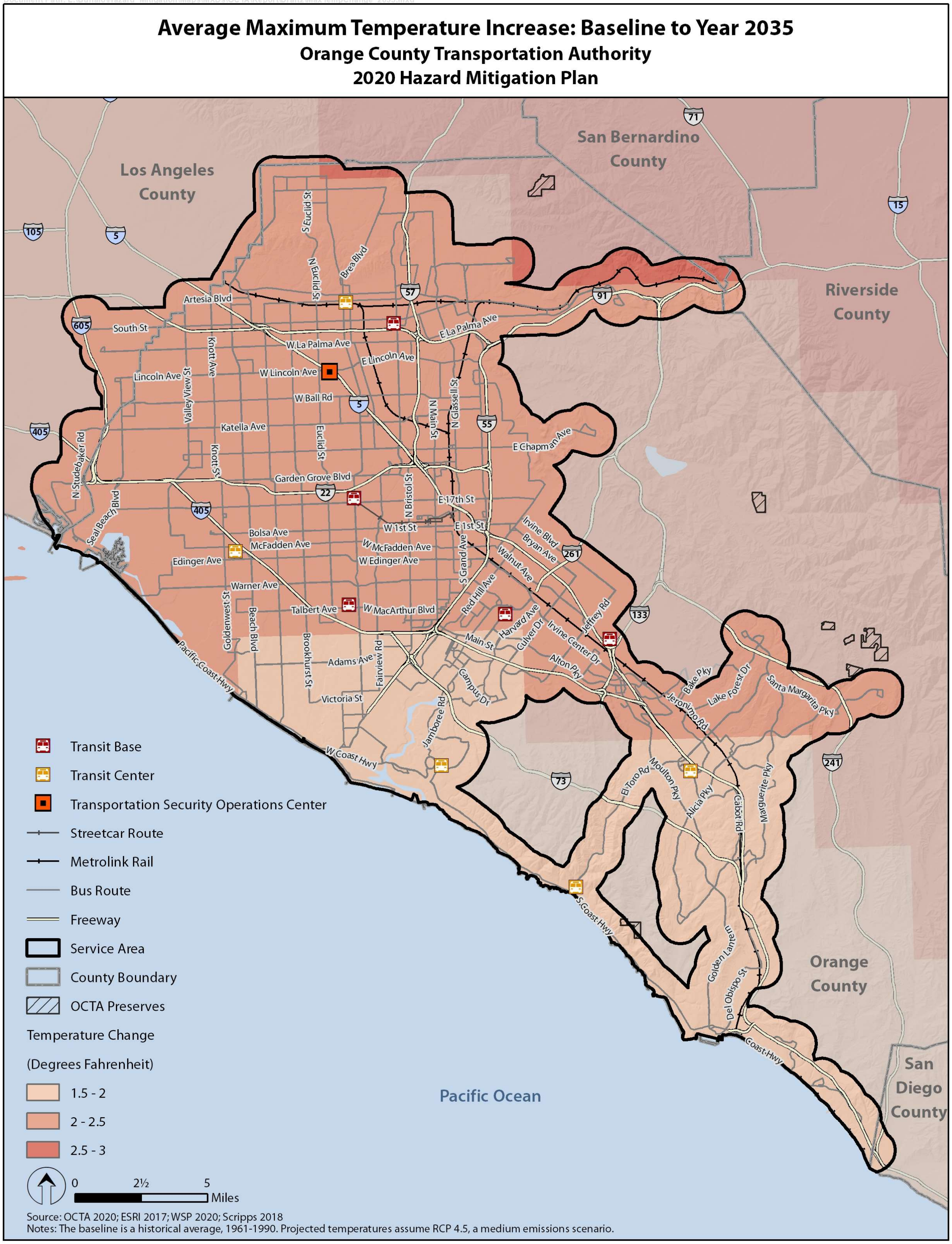
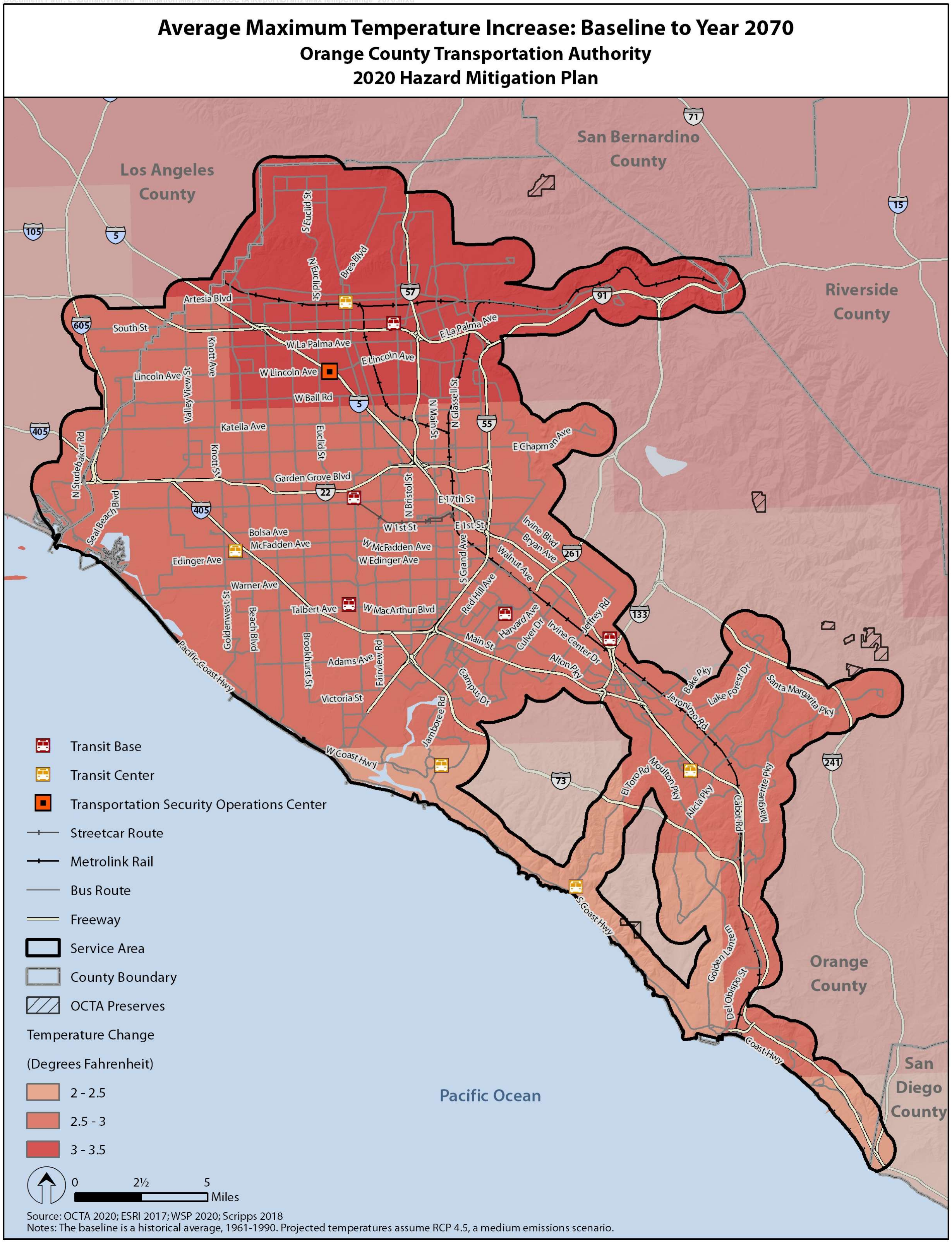


Figure 9-3 – OCTA Average Maximum Temperature Increase: Baseline to the Year 2070

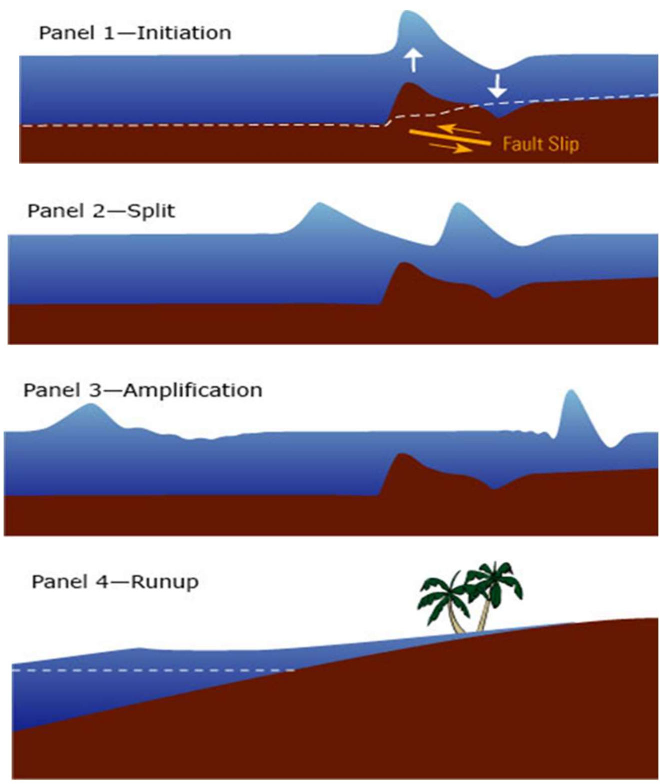


10 Tsunami

10.1 General Background

Tsunamis are sizable waves caused by earthquakes, volcanic eruptions, landslides under the sea that impact coastlines, or major landslides from the shore that drop significant amounts of debris into water bodies (National Oceanic and Atmospheric Administration, 2019). As waves travel inland, they build to higher heights as the ocean's depth decreases (National Oceanic and Atmospheric Administration, 2019). Figure 37 shows how a water body is affected by an earthquake along a fault, generating a tsunami that inundates the coastline.

Figure 10-1 – Earthquake Triggered Tsunami Process (United States Geological Survey, 2006)



DEFINITIONS

Runup – A measurement of the height of the water onshore observed above a reference sea level.

Tsunami – Comes from the Japanese words for *harbor* (“tsu”) and *wave* (“nami”); a long high sea wave caused by an earthquake, submarine landslide, or other disturbance.

Tsunami from a large undersea earthquake – The earthquake must cause significant vertical deformation on the seafloor for a tsunami to occur.

Tsunami Advisory – Issued when strong currents and dangerous waves of 1-3 feet are expected.

Tsunami Warning – Issued by PTWC when a potential tsunami with significant widespread inundation is imminent or expected.

Tsunami Watch – Issued when an event may later impact the watch area; may be upgraded to tsunami warning.

Seiches – A standing wave/oscillation in an enclosed or partially enclosed body of water that varies in a period from a few minutes to several hours.

Tsunami-generated waves can reach heights of over 100 feet and travel at speeds over 500 miles per hour, the same speed as a commercial jet plane (National Oceanic and Atmospheric Administration and National Weather Service, 2018). If a tsunami is close to the coastline, populations may only have minutes to prepare (United States Geological Survey). Major tsunamis occur globally about once per decade; 59 percent of the world’s tsunamis occur in the Pacific Ocean, 25 percent in the Mediterranean Sea, 12 percent in the Atlantic Ocean, and 4 percent in the Indian Ocean (National Oceanic and Atmospheric Administration and National Weather Service, 2020).

10.1.1 Potential Damage from Tsunamis

Areas most at risk are near the coastline and waterways connected to the ocean, such as beaches, bays, lagoons, harbors, river mouths, and areas along rivers and streams. The coastline is where the water surges the highest and with the most force. Tsunamis also increase currents near the coastal waterline, damaging boats in the area and pulling people in the water farther out to sea. Destruction can occur inland as tsunamis carry large amounts of water and debris into coastal waterways and land. As the water surge recedes to the shore, it can also drag debris and people into the water body.

NOAA explains, even six inches of rapidly flowing water can push an adult over, while twelve inches of fast-moving water can carry larger objects like cars, trees, and small boats (National Oceanic and Atmospheric Administration, 2018). The influx of quickly flowing water and everything the water carries can impact anything in its path, including ships, harbors, buildings, infrastructure, natural and cultural resources, and people. Although tsunami waves are known to cause damage, there are other hazards associated with tsunamis, such as land erosion and flooding. Flooding, SLR, and Erosion are in Section 7.

10.2 Orange County Transportation Authority Hazard Profile

The coastline within the OCTA is the most at risk of severe damage due to tsunamis; Although, tsunamis can also push large amounts of water up waterways and flood areas around ocean-connected channels. Figure 10-3 shows land within the planning area that is exposed to a tsunami and associated flood zones.

After the 1864 magnitude 9.2 earthquake in Alaska, there were tidal surges in Huntington Harbor that reached four to five feet (County of Orange and Orange County Fire Authority, 2015). A more recent tsunami in 2010 produced three-foot waves in Orange County, causing officials to close almost every beach and pier in the County (County of Orange and Orange County Fire Authority, 2015). For the same tsunami, the City of Newport Beach sent out automated alerts warning residents to avoid the beaches, and parts of Dana Point Harbor were closed. These events show a precedent for tsunamis in the planning area and examples of how they can impact staff, customers, residents, and visitors.

Earthquakes are the primary cause of tsunamis, and there are hundreds of earthquake zones and active faults in and around the OCTA planning area. These fault zones and seismic hazards, detailed in Section 5 of this plan. Past earthquakes that reached a "great" magnitude class (M > 8) in other regions of the world resulted in tsunamis that struck OCTA's coastline.

OCTA 2011 Tsunami Narrative

March 2011, a massive earthquake occurred off of Japan in the Pacific Ocean. This event devastated the Japanese coastline and sent a significant tsunami across the Pacific to the west coast of the US. OCTA activated its Emergency Operation Center and began pre-planning for the wave's arrival. Coastal bus routes were reviewed and detours implemented; Metrolink operations were consulted and placed on standby; and busses were readied to assist with evacuations if needed. At approximately 1300 on March 11th, all beaches were opened and OCTA operations returned to normal.

10.2.1 Hazard Ranking

The Planning Team completed a hazard ranking survey during the OCTA 2021 HMP development process and assessed hazard-related factors based on worst case and most likely scenarios. Hazard definitions and ranking factors are in Appendix G, Table G-1. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, with one as the lowest and five as the highest. Survey results were prioritized and ranked based on their average score. Compared to the other hazards in the survey, tsunamis were the sixth worst-case scenario and the seventh most likely scenario.

Table 10-1 – OCTA Tsunami Hazard Ranking

Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Worst-Case Scenario						
3.73	3.00	1.45	4.18	1.82	2.84	6
Most Likely Scenario						
2.18	2.18	1.09	3.45	2.00	2.18	7

10.2.2 Past Events

Table 10-2 lists seismic-triggered tsunami events that impacted the planning area between 1900 to 2019 and the damage these events caused.

Table 10-2 – History of Tsunami Events Impacting OCTA's Planning Area (Uslu, Eble, Titov, & Bernard, 2010) (Los Angeles County Office of Emergency Management, 2019) (County of Orange and Orange County Fire Authority, 2015)

Date	Source	Magnitude	Damage/Effect
1922	Chile	8.3	Strong currents all along the coast of CA
1946	Aleutian Islands	8.8	Broke ships from their moorings and had beach run-up heights from 1-6 feet in Catalina Island, Los Angeles, and Long Beach
1952	Kamchatka	9.0	Beach run-up heights of 1-2 feet in Santa Monica, Los Angeles, and Long Beach
1957	Aleutian Islands	8.3-8.6	San Diego had damage to ships and docks, run-up from 1-2 feet in Santa Monica, Los Angeles, and Long Beach
1960	Chile	9.5	Beach run-ups were 2-5 feet in Catalina Island, Los Angeles, Long Beach, and Santa Monica. One death, 800 small marine craft unmoored, 200 boats damaged, and 40 boats sunk.
1964	Alaska	9.2	Beach run-ups were 2-3 feet in Catalina Island, Los Angeles, Long Beach, and Santa Monica. One death, 100 boats unmoored, and 7 boats sunk – approximately $350 thousand in damages.
2010	Chile	8.8	Run-up heights of 1-3 feet in Catalina Island, Los Angeles, Long Beach, and Santa Monica. Minor damage to docks and boats. Orange County closed most beaches. Newport Beach recommended residents avoid the beach. Dana Point Harbor's bait barge was broken into two pieces.
2011	Japan	9.0	Beach run-up of 2-3 feet in Catalina Island, Los Angeles, Long Beach, Redondo Beach, and Santa Monica. Damage to docks and boats.

10.2.3 Location

There are two types of seismic tsunami triggers along the California coast, local sources and distance sources (California Department of Conservation). Local sources of seismic activity are more likely to generate a tsunami affecting the California coast (California Department of Conservation). The 1964 Alaska earthquake is an example of a local seismic tsunami trigger that significantly impacted the California coastline. In contrast, seismic triggers with a high magnitude farther out in the Pacific generally caused smaller tsunamis and less damage to the state (Uslu, Eble, Titov, & Bernard, 2010). The OCTA planning area most susceptible to damage from a tsunami hazard is on the coast, shown in Figure 10-3.

10.2.4 Frequency

As described in Section 10.1, tsunamis occur due to significant water displacement from events such as earthquakes, volcanic eruptions, and landslides; Therefore, the frequency of tsunamis is relative to the frequency of events that cause them. OCTA has experienced tsunamis across the planning area. These events listed in Table 10-2 reveal the risks to the planning area; unfortunately, it is difficult to predict how often or exactly when the next tsunami will happen.

10.2.5 Severity

Tsunami severity depends on three factors: the trigger site's location relative to the impact area, magnitude or size of the triggering event, and depth of the trigger event. Most earthquake-generated tsunamis come from magnitudes 7.0 and greater in shallower water, less than 62 miles below the surface (National Oceanic and Atmospheric Administration). The earthquake must be large enough and close enough to the water surface to generate a significant wave or series of waves classified as a tsunami. A tsunami's height and impacts are influenced by local water depth, sea-floor or ground topography, and the direction the tsunami comes from (National Weather Service). The damage from a tsunami can range from minimal to substantial, depending on the tsunami's severity. Even a six-foot tsunami can bring powerful currents that can knock a person over and carry them away (United States Geological Survey).

10.2.6 Warning Time

The time before a tsunami hits can vary from minutes to hours. However, not every event will produce a tsunami. To produce more accurate predictions, the NOAA tsunami warning centers use a vast network of sensors to determine which events will most likely result in a tsunami; when a tsunami is predicted, the centers then issue warnings to the appropriate locations (National Oceanic and Atmospheric Administration, 2018). There are four tsunami alert types defined by the NWS, listed in Figure 10-2. There are also natural signals before a tsunami arrives, such as (National Oceanic and Atmospheric Administration and National Weather Service, 2020):

- Severe ground shaking from local earthquakes
- Water receding from the coast and exposing the ocean floor, reefs, and fish, and abnormal ocean activity
- A wall of water creating a loud roaring sound like a train or jet aircraft

Figure 10-2 – NWS Tsunami Notification Levels (National Weather Service)

10.3 Secondary Hazards and Cascading Impacts

10.3.1 Secondary Hazards

After the initial wave hitting the coastline, tsunamis can generate several secondary hazards. The most common secondary hazard is flooding. High wave action and strong currents can significantly speed up natural erosion along the coast and connected waterways. Flooding, SLR, and Erosion hazards to the planning area are addressed in Section 7. Water saturated coastal cliffs can have mass earth movements. This hazard is described in Section 8. The extent of these risks depends on the severity of the tsunami and the amount of land inundated.

10.3.2 Cascading Impacts

Tsunamis can carry tons of debris, which endangers human life, and OCTA's property and infrastructure. Damage or destruction of transportation infrastructure can affect OCTA's services, economy, suppliers, businesses, and customers who rely on their services. The seriousness of the impact varies depending on the specific critical structures, infrastructure, and/or hazardous materials in the waves' path. Coastal structures such as breakwaters, piers, port facilities, and public utilities may get swept away by the water or collapse from the foundation, eroding after the water recedes. Ships moored in marinas or harbors may be destroyed or washed up onto the shore. Impacted vessels and coastal facilities can release hazardous materials into the environment. Harmful materials can be structure debris itself or anything hazardous the facilities and vessels contained. These materials could contaminate the floodwater and potentially drinking water.

10.4 Potential Impacts from Future Climate Conditions

Future climate conditions have no known effect on earthquakes that may cause tsunamis (Buis, 2019). However, as SLR increases, so do the tsunami hazard zone; the extent depends on the height of the SLR.

10.5 Exposure

10.5.1 Population

The 2015 Orange County HMP states the County's entire coastline could be impacted, and approximately 80,000 residents would have to be evacuated (County of Orange and Orange County Fire Authority, 2015). This number does not reflect population growth since 2015 or visitors to the area. Orange County alone had more than 50 million visitors in 2018 (De Nova, 2019). Visitors are more vulnerable since they likely do not know the tsunami hazards or evacuation routes or do not receive alert notifications.

Intersecting OCTA bus stop ridership and US Census planning area data with geospatial hazard data for tsunamis show population exposure and social vulnerability. Table 10-3 shows the OCTA bus ridership exposed to a tsunami, approximately a quarter of a million boardings in 2019.

Table 10-3 – Bus Stop Ridership Exposed to the Tsunami Inundation Area

Ridership	Tsunami Exposure
Total	274,235

Vulnerability

The CDC defines three types of human health risks from a tsunami: immediate secondary, and long-lasting (Center for Disease Control, 2013). In the immediate aftermath of a tsunami, people can be trapped by debris or water. The secondary tsunami concern is food and potable water contamination and requires temporary shelter for displaced people.

Direct impacts to OCTA customers could mean adjusting transportation routes to support displaced residents. Secondary problems can include disease and illness spread from contaminated food and drinking water and dead remains of animals or humans before removing or inadequate sanitation in shelters and temporary living situations. Standing floodwater can also cause insect population growth, spreading disease, or consuming food supplies. Epidemic/Pandemic hazards are in Section 6.

Table 10-4 shows the populations at risk from tsunamis, with children, seniors, and those below the poverty level, especially at risk. They may need more assistance with transportation during evacuations.

Table 10-4 – Populations at Risk from Tsunamis

Populations	Tsunami Exposure
Black	3,651
American Eskimo	1,413
Asian	29,826
Hawaiian/Pacific Islander	558
Hispanic	86,939
Multiple Races	10,269
Children up to 19 Years Old	65,208
65 Years and Older	31,284
Below the Poverty Level	34,328

10.5.2 Property

A tsunami on the coastline is likely to significantly impact OCTA property in these inundation zones. The inundation line shows where the water will surge inland along smaller waterways.

Table 10-5 – OCTA Infrastructure Exposed to Tsunami Inundation Zones

Infrastructure Type	Miles
Bus Route	39.95
Other Freeway	0.12
Metrolink Rail	3.20
Total	43.27

Vulnerability

All structures and property located along tsunami inundation areas would be vulnerable, especially during events with little to no warning time.

10.5.3 Environment

A tsunami can change the surface of the land above and below the water. In some areas, the tsunami can push the ground farther up it, and in other areas, the water can erode the ground, lowering the surface. If the tsunami pushes water up waterways, it can expose new areas to flooding. Tsunami debris can clog waterways and leave a path of wreckage on the land when the water recedes. Depending on the severity of the tsunami, environmental changes can include permanent modifications to beaches and coastal features, and freshwater sources can be contaminated by saltwater or hazardous materials released by the tsunami. These environmental impacts can affect OCTA customers and the planning area with changes to the land, flood zones, debris damage, and public health issues.

10.6 Development Trends

In the Orange County General Plan, Chapter X Housing Element estimates future population numbers, characteristics, and housing needs. The plan's housing element was most recently updated in 2013, where expected growth from 2000-2012 was 7.4 percent (Orange County, 2013). The US Census Bureau predicts that Orange County's population will increase by 5.5 percent between 2010 and 2019 (United States Census Bureau, 2018). As indicated in Figure 10-3, the OCTA Planning Area with the highest risk of tsunami damage is the coastline and coastal waterways.

The Orange County *Local Hazard Mitigation Plan* (LHMP) addresses tsunami risks in the planning area (County of Orange and Orange County Fire Authority, 2015). The LHMPs identify the hazard causes, probability, and potential damage. The Orange General Plan directs land use, addresses growth management, and establishes standards and plans to protect the community from hazards (Orange County). Development is safely regulated through building standards and performance measures to reduce risk. OCTA will continue to follow development codes, regulations, and laws to minimize or remove tsunami risks on renovations and new projects.

10.7 Issues

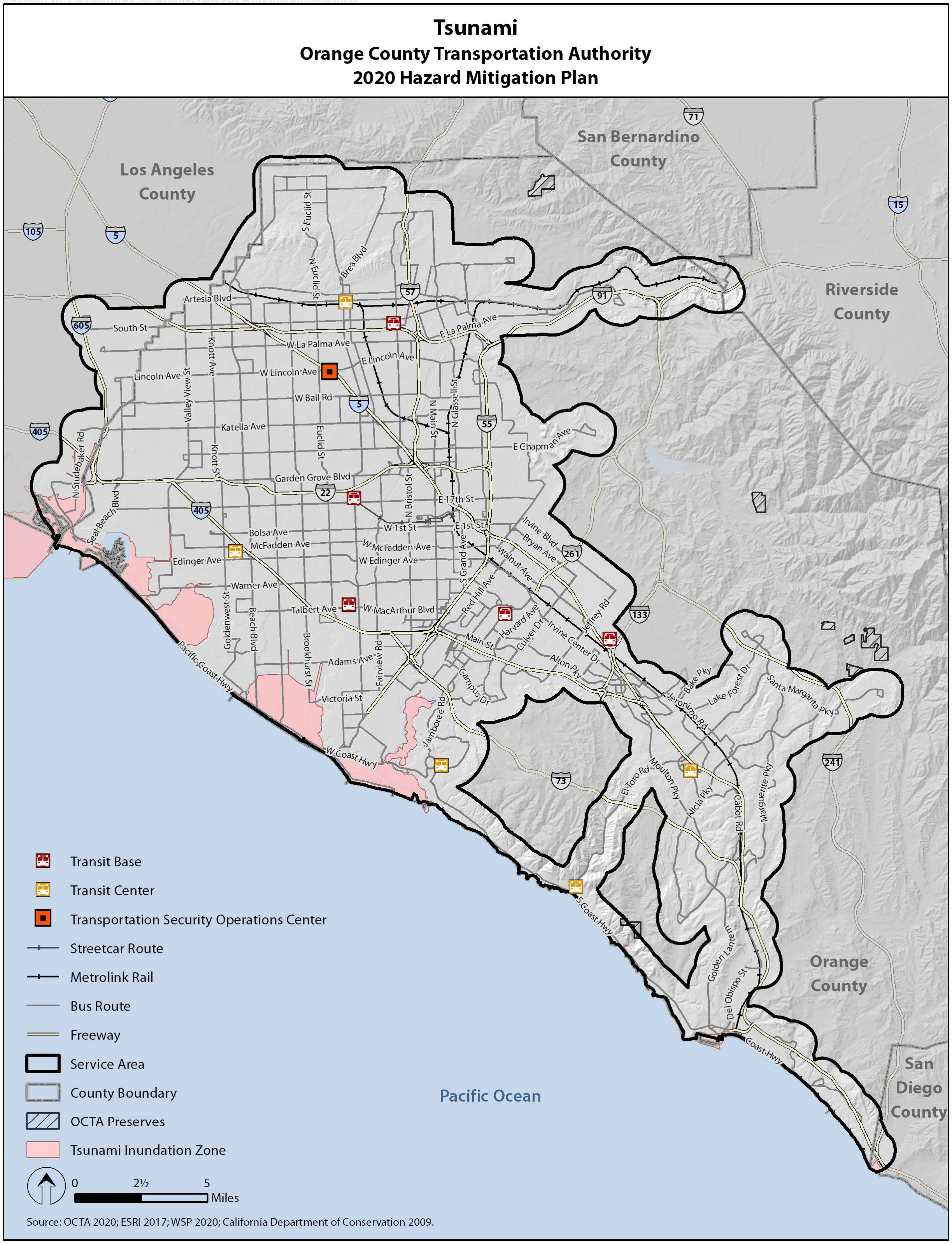
Issues associated with severe weather in the OCTA planning area:

- Tsunami science and technology are continually evolving. Therefore, hazard maps should be regularly reviewed and updated.
- Monitor tsunami warning systems and update as new versions or technologies are released.
- Continue to assess SLR's potential impacts on tsunamis as new data and models update predictions.

10.8 Hazard Map

The hazard map for tsunami risks in the planning area is on the next page.

Figure 10-3 – OCTA Tsunami Hazard Map

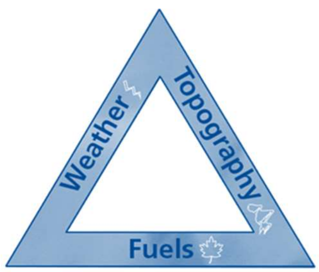


11 Wildfires

11.1 General Background

A wildfire, or wildland fire, is an unplanned fire that burns uncontrolled in forests, grasslands, brushlands, or croplands (Editors of Encyclopedia Britannica, 2020). The name refers to the fire's characteristics and region (Editors of Encyclopedia Britannica, 2020). There are two types of wildfires, ground and surface. Ground fires burn underground into the vegetation's roots; this is most common when a thick layer of flammable organic matter is in the soil's top layer (National Geographic Society, 2019). Surface fires burn vegetation above the soil. A wildfire fire's behavior depends on three key factors, weather, topography, and fuel, in Figure 11-1.

Figure 11-1 – Wildfire Behavior Triangle (National Park Service, 2017)



Wildfires can occur year-round due to natural and human-caused ignitions. The most common natural cause of wildfires is lightning, although volcanoes and meteors can also generate wildfires (United States Department of the Interior Indian Affairs). These natural hazards can ignite fires; however, nearly 85 percent of wildfires in the US are caused by human activity (e.g., campfires and arson) (National Park Service, 2018).

Massive wildfires are more common during droughts and warmer seasons due to drier vegetation and soil, lower groundwater levels, and less precipitation. High winds can exacerbate warm, dry conditions and spread wildfires considerably further. The US Forest Service Southern Research Station administered a report that studied the conceptual model that shows the relationship between ignition types, prevention methods, and extent factors in Figure 11-2 (Prestemon, et al., 2013). This model demonstrates the complicated nature of wildfire causes, severity, spread, and management. It can assist organizations in understanding all aspects of wildfire risks and develop effective mitigation actions.

DEFINITIONS

Crown Fire – A type of fire that burnt through the top layer of trees, called the canopy. They are the most intense and difficult to contain.

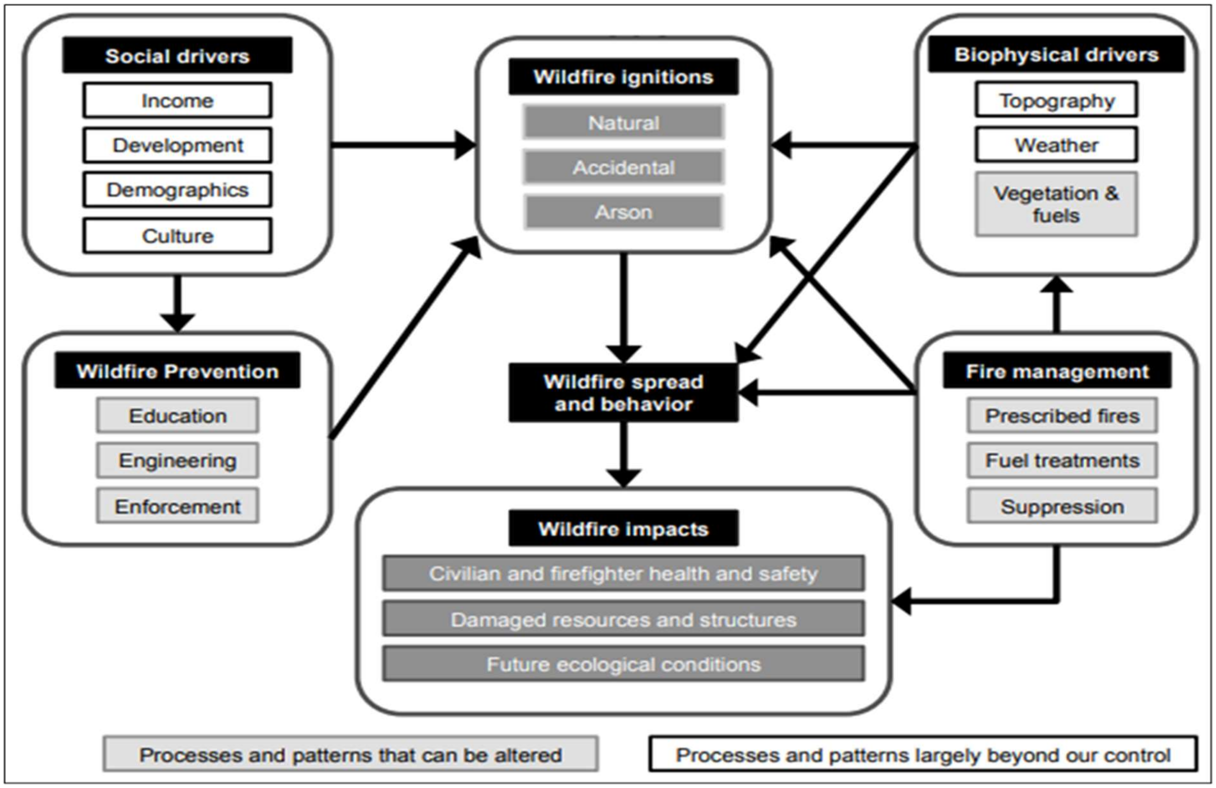
Fuels – Materials that burn in a fire, such as paper products, flammable gases or chemicals, or wood products. The material composition determines how flammable it is, based on moisture level, chemical makeup, and material density. The less moisture and lower density, the faster and hotter it burns.

Terrain/Topography – The ground's slope can help or halt the spread of a wildfire. Large gaps in vegetation or waterways such as rivers and creeks can stop a wildfire from spreading. Fires also move faster upslope than down due to elevation changes and warm air rising.

Wildland Urban Interface Area – An area susceptible to wildfires and where wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

Wildfire – **F**ires that result in uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and cause a great deal of destruction.

Figure 11-2 – Cohesive Strategy Wildfire Ignitions and Prevention Conceptual Model (Prestemon, et al., 2013)



11.1.1 Potential Damage from Wildfire

Wildfires pose a considerable risk to property, human life, and economies, as shown below (Western Forestry Leadership Coalition, 2010):

Buildings:

- Insured and uninsured property loss
- Secondary hazards

People:

- Loss of income
- Healthcare expenses
- Injuries or fatalities
- Evacuation displacement
- Reduced air and water quality

Economies:

- Lost revenues
- Infrastructure disruptions:
  - Communications
  - Transportation
  - Utilities

Wildfires can scorch vast areas of land, timber, and wildlife habitats (United States Forest Service). Fires can reduce the quality of drinking water and the air (World Health Organization). Additional health effects can be injuries, smoke irritation, and exacerbated medical conditions. They can also lead to cascading impacts, such as local businesses closing, hurting the area's economy. Wildfires can be extremely costly for government agencies, public and private businesses, and individuals. US wildfire loss costs from 2010-2019 ranged between a couple of million dollars to $24,000,000,000, with the worst years in 2017 and 2018 by far (Insurance Information Institute, 2020). Hazardous materials can be released into the environment by damage to transportation and buildings that contain the materials. Secondary hazards and cascading impacts are in Section 11.3.

11.2 Orange County Transportation Authority Hazard Profile

Wildfires regularly occur within the planning area on an almost yearly basis. Tables 11-2 and 11-3 list some significant events that occurred in the past, which show how wildfires pose a substantial threat to life and property. Additionally, wildfires can damage or destroy infrastructure, utilities, and transportation services. Figure 11-4 displays those areas exposed to three different wildfire risk zones within the planning area, while Figure 11-5 indicates the Wildland Urban Interface Zones exposed to wildfire risks. The Orange County HMP identifies the WUI as the highest risk from wildfire damage (County of Orange and Orange County Fire Authority, 2015).

The following issues are substantial fire protection challenges in the urban area (County of Orange and Orange County Fire Authority, 2015):

- Multiple story high-density wood frame developments
- Large areas with developments close to each other that have combustible roofing materials
- Transportation of hazardous materials via air, rail, road, water, and pipeline
- Natural disasters that ignite wildfires and can make them more frequent and severe

The summer Santa Ana winds have a significant effect, spreading wildfires in the area. These high winds coming from inland and moving towards the coast spread fires farther, add oxygen to the fires, and the warm temperatures make ignition easier (County of Orange and Orange County Fire Authority, 2015).

11.2.1 Hazard Ranking

The Planning Team completed a hazard ranking survey during the OCTA 2021 HMP development process. The hazard factors are based on the worst-case and most likely scenarios. Definitions of the hazard ranking factors are in Appendix G, Table G-1. The survey results for each hazard were averaged to generate a score and rank, prioritizing the hazards. The variables of severity, magnitude, frequency, onset, and duration are scored one to five, where one is the lowest and five is the highest. When compared against the

OCTA Wildfire Narrative

2020 Bond Fire: Resulted in the evacuation of several WUI communities. This event moved near OCTA's Irvine Sand Canyon Bus Base, which housed paratransit operations. The base and its assets were evacuated for three days as a protective measure. Previous planning efforts meant operations were maintained during the relocation with no disruptions. The fire did not reach the base due to successful firefighting.

2017 Canyon 2 Fire: The fire started in Coal Canyon, spreading rapidly. It impacted several communities and the Operational Area (OA) EOC, triggering multiple city and counties to also activate EOCs. The OC Sheriff requested four cutaway busses to transport responders from Great Park to the OA EOC due to limited parking. Also, there were 40 OCTA busses on standby for evacuations. Bus routes in affected areas were rerouted.

2008 Lake Forest Value Inn Fire: OCTA was requested to transport 14 residents of the Americas Best Value Inn to a local reception site at El Toro High School.

2008 Freeway Complex Fire: OCTA was requested to be on stand by for evacuation support of communities. OCTA responded with 4 vehicles, 15 staff and logged 120.25 staff hours of involvement for the event.

2007 Santiago Fire: OCTA was asked to support emergency worker transportation and James A. Musick detention facility evacuation. Additionally, OCTA provided "bus bridge" services for Metrolink passengers, as rail lines were damaged and unusable. During this event, OCTA applied 695 hours and transported 1264 passengers.

other hazards included in the hazard ranking survey, wildfires were the first worst-case scenario and the first most likely scenario.

Table 11-1 – OCTA Wildfire Hazard Ranking Output

Severity	Magnitude	Frequency	Onset	Duration	Average	Rank
Worst-Case Scenario						
3.82	4.18	4.55	4.18	2.91	3.93	1
Most Likely Scenario						
3.73	3.64	4.45	4.00	3.55	3.87	1

11.2.2 Past Events

In Section 11.1.1, there were several wildfires damage categories identified. The Authority and its customers may experience direct wildfire damage to structures and infrastructure or indirect results across the entire area, such as health risks. Some of the most significant fires that affected the Planning Area. These two counties experienced wildfires that made the top twenty list of largest, most destructive, and deadliest fires, shown in Table 11-2.

Table 11-2 – California's 20 Largest, Most Destructive, and Deadliest Wildfires in the Planning Area (CalFIRE, 2021)

Category	Date	Acres	Structures	Deaths
Deadliest	October 1933	47	0	29
Deadliest	October 1943	13,145	0	11
Deadliest	September 1955	1,150	0	6
Deadliest	November 1956	43,904	0	11
Deadliest	November 1966	2,028	0	12
Deadliest	August 1968	22,197	0	8
Largest	September 1970	175,425	382	5
Deadliest, Most Destructive, and Largest	10/2003	273,246	2,820	15
Deadliest, Most Destructive, and Largest	10/2007	197,990	1,650	2

A comprehensive list of wildfire events between 1969 and 2010 in the Planning Area, resulting in a disaster declaration is in Appendix G, Table G-4. Table 11-3 below shows the 12 wildfire events recorded by NOAA in both counties that resulted in deaths, injuries, and or over $25,000 in damages.

Table 11-3 – Historic Severe Wildfire Events in the Planning Area (National Oceanic and Atmospheric Administration)

Date of Event	Deaths/Injuries	Property Damage Value Above $25,000
10/21/1996	16 injuries	$1,500,000
10/21/1996	0	$3,000,000
8/2/2000	0	$100,000
9/11/2000	2 injuries	-
1/23/2002	1 injury	-

Date of Event	Deaths/Injuries	Property Damage Value Above $25,000
2/9/2002	0	$1,200,000
5/13/2002	0	$250,000
9/1/2002	14 injuries	$12,700,000
1/23/2002	1 injury	-
9/22/2002	14 injuries	$15,300,000
11/20/2002	2 injuries	-
2/6/2006	8 injuries	-

11.2.3 Location

Figure 11-4 shows fire hazard severity zones from moderate to very high within the planning area. Figure 11-5 displays the WIU in the OCTA planning area. CalFIRE also maps California areas with significant fire hazards by weighting fuels, terrain, and weather factors (California State Geoportal, 2020). These areas are divided into three Fire Hazard Safety Zones – moderate, high, and very high (California State Geoportal, 2020). In the Planning Area, WUI areas are often classed as a Very High Fire Hazard Severity Zone, as there are additional risks to people and structures (Orange County, 2017) (California State Geoportal, 2020). The WUI mixed developed land and wildland makes it problematic to predict precisely where and how the fire will spread (Department of Homeland Security Science and Technology, United States Fire Administration, and Federal Emergency Management Agency, 2019).

There are 23 Nationally Recognized Communities at Risk and five communities the Orange County Fire Authority (OCFA) identified as also at risk, in Table 11-4 below.

Table 11-4 – Orange County Communities at Risk from Wildfires (Orange County, 2017)

Nationally Recognized Communities at Risk				
Aliso Viejo	Anaheim	Brea	Costa de Caza	Trabuco Canyon
Cowan Heights	Dana Point	Fullerton	Irvine	Trabuco Highlands
Laguna Beach	Laguna Hills	Laguna Niguel	Laguna Woods	Villa Park
Mission Viejo	Modjeska	Newport Beach	City of Orange	Yorba Linda
Rancho Santa Margarita	San Clemente	San Juan Capistrano	Silverado	
Additional Orange County Fire Authority Recognized Communities at Risk				
Emerald Bay	Lake Forest	Lemon Heights/North Tustin	Santiago Canyon	Tustin Heights

11.2.4 Frequency

Since 1978, Orange County has experienced over 20 wildfires that exceeded 2,000 acres (County of Orange and Orange County Fire Authority, 2015). Approximately one FEMA declared wildfire disaster occurs in and around the Authority's planning area per year (Federal Emergency Management Agency, 2020). Contrary to historical events, current data shows wildfires can happen any time of year, especially in an unusually warm and dry winter. Climate change effects on snowpack levels in the mountain ranges to the east, precipitation patterns across the State, and high winds coming down from the mountains will contribute to more frequent and severe fires. Based on the risk factors presented and past occurrences, it is likely that wildland fires will continue to significantly affect the OCTA planning area, caused by natural events and humans.

11.2.5 Severity

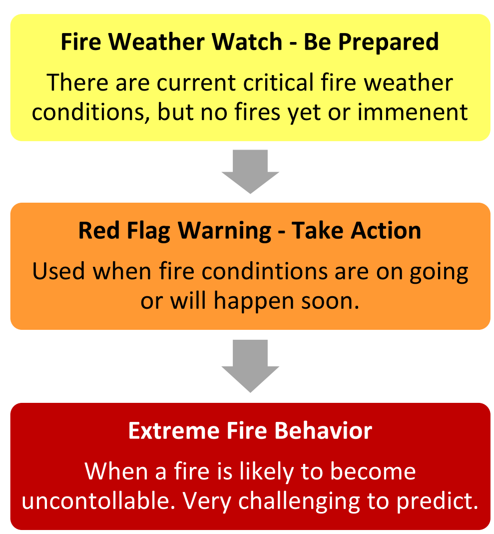
In the Authority's planning area, wildfires have caused injuries and death, destroyed, and damaged or destroyed structures and infrastructure. The past events in Tables 11-2 and 11-3 detail some significant wildfire events in the planning area. However, the largest fires are not always the most destructive fires. There are no injuries or deaths in some instances, but the value of property damage is in the millions of dollars; in other events, the cost is below the $25,000 threshold but injured several people. The severity and extent of a wildfire are influenced by the following factors (National Park Service, 2017):

- **Fuel** – Materials that burn in a fire, such as paper products, flammable gases or chemicals, or wood products. The material composition determines how flammable it is, based on moisture level, chemical makeup, and material density. The less moisture and lower density, the faster and hotter it burns. Additionally, some plants have oils or resin that burn more easily, quickly, and/or intensely.
- **Weather** – Fires spread faster in hot, dry, windy weather. Less humidity and precipitation with warmer temperatures make fires easier to ignite. Strong wind adds lots of oxygen to the fire and carries embers, spreading the fires farther. Any combination of these factors makes wildfires more extensive and more severe.
- **Terrain/Topography** – The ground's slope can help or halt the spread of a wildfire. Significant gaps in vegetation or waterways such as rivers and creeks can stop a wildfire from spreading by removing the fuel to feed the fire or making the vegetation too wet to burn. Fires move faster upslope than down due to elevation changes and warm air rising.
- **Populated Areas** – The largest fires are not always the most destructive. While only a portion of the 30,202-acre Freeway Complex Fire in 2008 burned into the incorporated cities, it was in the cities where most of the structural damage occurred. In moderate and densely populated areas, the effects can be more severe for human injuries, loss of life, and/or property damage values.

11.2.6 Warning Time

Since humans cause most wildfires, there is no way to predict every ignition (National Park Service, 2018). However, weather factors that can lead to fire ignition or increase the spread and severity are more predictable, allowing for one to several days of warning time for current wildfire risks (United States Department of the Interior Indian Affairs). Additionally, organizations such as NOAA and the NWS use climate models to predict the next year's wildfire risk level. Past wildfire and weather data are fed into the models along with current conditions, like droughts. Unfortunately, climate change factors alter these models in unpredictable ways, making the annual prediction results less accurate in recent years (Mulkern, 2020).

Figure 11-3 – NWS Wildfire Notification Levels (National Weather Service)



To estimate wildfire risks for the next 12 to 72 hours, the NWS monitors weather conditions and issue notifications from local NWS offices (CalFire). The NWS San Diego Office covers the Authority's planning area. This office will send out three wildfire notifications depending on the risk level; these levels are described in Figure 11-3. Extreme fire behavior is the most dangerous alert and only happens when one or more of the following conditions exist – spreading fast, significant crowning and/or spotting, there are fire whirls, or there is a strong convection column.

The OCTA planning area can also be at risk from wildfire smoke. The Interagency Wildland Fire Air Quality Response Program, led by the USFS, provides air quality information and maps (United States Forest Service). The program and its prediction models rely on subject matter experts (Air Resource Advisors), air quality monitoring equipment, smoke concentration and dispersion modeling, and coordination with agency partners (United States Forest Service). Predictions and warnings are provided to the public through the EPA's AirNow website.

11.3 Secondary Hazards and Cascading Impacts

11.3.1 Secondary Hazards

Wildland fires can contribute to several secondary hazards such as flooding, mass earth movements, and coastal erosion. Most wildland fires burn hot and long baking soils, especially those high in clay content, increasing the impervious ground area. Impenetrable ground means less water absorbed into the soil, increasing rain and stormwater runoff and raising flood risks (CalFire, 2020).

Vegetation removed by fires increases the risk of flooding frequency and severity. Flooding hazards in the planning area are discussed in Section 7. Less vegetation along slopes also exposes the ground to more water runoff, which increases the potential for mass earth movements and coastal slope erosion. Erosion is addressed more in Section 7. Mass earth movements can even occur several years after a fire before the vegetation has had a chance to extend roots deep into the soil and stabilize the slope. Mass earth movements are covered in Section 8.

11.3.2 Cascading Impacts

Wildland fires can cause cascading impacts such as hazardous materials releases, utility disruptions, higher taxes and utility/infrastructure fees to recoup losses, loss of structures and infrastructure, and water contamination. Hazardous materials can be released when fires spread to buildings, storage areas, or vehicles containing these materials. Depending on the material's reaction to fire, they can be explosive, flammable, release toxic gas or fumes, or contaminate the environment. Wildfires can impair or demolish utilities resulting in cascading impacts such as power outages, broken water lines, natural gas line leaks, structure fires, or communication issues (Sathaye, Dale, Larsen, & Gary, 2011). Ravaged infrastructure can include road and rail transportation systems, earthen dams and levees, water and wastewater systems (Department of Homeland Security, 2016). Damage to public utilities, structures, and infrastructure can raise rates and taxes (California Legislature's Nonpartisan Fiscal and Policy Advisor, 2019).

11.4 Potential Impacts from Future Climate Conditions

Climate change has already made the planning area more prone to wildfires (National Geographic Society, 2019). Historically, fire seasons in the Planning Area were from May and September, with the highest number of events between June to October (Kelly). However, wildfire trends have changed over the past 15 years as climate change variables have altered wildfire behavior (Orange County, 2017). Some predictions indicated that the area burned by wildfires could increase by 77 percent by 2100 (Bedsworth, Cayan, & Franco, 2018) and that wildfire-related insurance costs will rise by an estimated 18 percent price rise by 2055 (Bedsworth, Cayan, & Franco, 2018).

More extreme heat days, higher average annual temperatures, and extended periods of drought will lead to more dry vegetation to fuel fires; weather hazards are discussed in Section 9. Climate change factors such as less rainfall and snowpack can also lower reservoirs and water tables, making it harder to fight wildfires (County of Orange and Orange County Fire Authority, 2015).

11.5 Exposure

11.5.1 Population

Intersecting OCTA bus stop ridership and US Census planning area data with geospatial hazard data for wildfire hazard zones and the WUI shows population exposure and social vulnerability. Specific sections of the planning area will also have a higher risk of secondary hazards such as increased flooding or mass earth movements, shown in the maps in Section 7 for floods and 8 for mass earth movements. Additionally, the entire planning area can be susceptible to cascading impacts of wildfires, such as poor air quality (World Health Organization).

Table 11-5 below shows the 2019 OCTA ridership exposed to wildfire hazards and boardings in the WUI area. There was significant ridership in the WUI through the year, at over a half-million boardings.

Table 11-5 – Bus Stop Ridership Exposed to Wildfires and in the Wildland Urban Interface

Ridership	Wildfire Exposure	WUI
Total	120,016	525,277

Vulnerability

Smoke and air pollution from fires can be a health hazard, especially for children, the elderly, and those with respiratory and cardiovascular diseases. Other symptoms can include:

Table 11-6 – Vulnerable Population Health Risks from Wildfires (World Health Organization)

Irritation	Worsen Cardiovascular Diseases	Lung Conditions	Lung Diseases
Eyes	Heart Failure	Coughing	Pulmonary inflammation
Nose		Wheezing	Bronchitis
Lungs		Sore Throat	Exacerbated Asthma

Vulnerable populations at risk from wildfire hazards are in Table 11-7. The majority of the population falls in the very high-risk zone; nearly 800 thousand minority and mixed-race individuals are in this zone. Additionally, 187,237 households in the very high exposure area are low-income, making them especially vulnerable to fire risks. They may not have the funds for insurance or structural protection methods.

Table 11-7 – Populations Exposed to Wildfire Risks Moderate, High, and Very High

Populations	Moderate	High	Very High
Black	37	1,172	18,395
American Eskimo	11	474	8,135
Asian	149	12,858	232,129

Populations	Moderate	High	Very High
Hawaiian/Pacific Islander	4	233	4,212
Hispanic	365	22,795	483,002
Multiple Races	79	2,672	50,986
Children up to 19 Years Old	571	16,227	339,748
65 Years and Older	260	6,177	141,475
Below the Poverty Level	167	7,382	187,237

The interface is where settled areas run up against wildland vegetation, while the intermix is where the settled land is directly mixed with the vegetation (Radeloff, et al., 2018). Table 11-8 shows the highest population numbers are in the interface.

Table 11-8 – Populations in the Wildland Urban Interface

Populations	Influence Zone	Interface	Intermix
Black	15,102	17,427	4,775
American Eskimo	5,165	5,630	1,824
Asian	153,705	179,101	46,592
Hawaiian/Pacific Islander	2,758	3,200	981
Hispanic	296,164	315,396	117,854
Multiple Races	35,238	36,434	10,862
Children up to 19 Years Old	231,115	234,202	74,724
65 Years and Older	105,969	94,930	27,789
Below the Poverty Level	113,504	116,934	42,675

11.5.2 Property

Exposure and Vulnerability

Intersecting OCTA facilities with geospatial hazard data for wildfire hazard zones and the WUI indicates exposure to this hazard. Property damage from wildland fires can be severe and significantly alter entire communities and transportation infrastructure. Tables 11-9 to 11-14 display the Authority's buildings, land use, and infrastructure exposed to wildfire hazard zones, their risk level, and those in the WUI zone.

Table 11-9 – OCTA Buildings Exposed to a Very High Risk of Least Moderate Wildland Fire Hazards

Building Type	Number of Buildings Exposed
Transit Center	1
Total	**1**

Table 11-10 – OCTA Environmental Areas Exposed to at Least Moderate Wildland Fire Hazards

Land Use Type	Acres
Bobcat Ridge (proximal to the City of Lake Forest)	48.90
Eagle Ridge (proximal to the City of Brea)	296.90

Land Use Type	Acres
Live Oak Creek (proximal to the City of Lake Forest)	82.54
Pacific Horizon (proximal to the City of Laguna Beach)	152.63
Silverado Chaparral (proximal to Silverado Canyon)	204.59
Trabuco Rose (proximal to Trabuco Canyon)	400.58
Wren's View (proximal to Trabuco Canyon)	116.96
Total	**1303.1**

Table 11-11 – OCTA Infrastructure and Related Operations Exposed to a Risk of Wildland Fire Hazards

Infrastructure Type	Moderate	High	Very High
Bus Route	0	0.05	24.42
SR-91 Freeway	0	0	9.461
Other Freeway	4.736	0.020	92.941
Metrolink Rail	0	0.21	3.90
Total	**4.736**	**0.28**	**130.722**

Table 11-12 – OCTA Buildings in the WUI Fire Hazard Zone

Building Type	In the Influence Zone	In the Interface Zone	In the Intermix Zone
Brea Park and Ride	0	1	0
Transit Center	0	1	0
Total	**0**	**2**	**0**

Table 11-13 – OCTA Environmental Areas in the WUI Fire Hazard Zone

Land Use Type	Influence Zone	Interface Zone	Intermix Zone
Bobcat Ridge (proximal to the City of Lake Forest)	48.77	0	0.13
Eagle Ridge (proximal to the City of Brea)	295.84	1.02	0
Live Oak Creek (proximal to the city of Lake Forest)	82.41	0	0.13
Pacific Horizon (proximal to the City of Laguna Beach)	152.27	0	0
Silverado Chaparral (proximal to Silverado Canyon)	204.23	0	0
Trabuco Rose (proximal to Trabuco Canyon)	398.59	0.45	0
Wren's View (proximal to Trabuco Canyon)	115.68	0	0.52
Total	**1297.79**	**1.47**	**0.78**

Table 11-14 – OCTA Infrastructure in Miles and Related Operations in the WUI Fire Hazard Zone

Infrastructure Type	In the Influence Zone	In the Interface Zone	In the Intermix Zone
Bus Route	9.39	103.62	1.98
I-405 Freeway	1.653	9.266	
SR-91 Freeway	0.490	2.114	2.124

Infrastructure Type	In the Influence Zone	In the Interface Zone	In the Intermix Zone
Other Freeway	27.139	67.748	8.588
Metrolink Rail	3.55	5.20	0.07
Total	**42.222**	**187.948**	**10.782**

11.5.3 Environment

Wildfires are a natural process in forest ecosystems; however, massive events can have adverse environmental impacts that may affect the OCTA planning area. Wildlife habitats can be destroyed, and occasionally wild animals might migrate outside of their normal environment and into more urban areas (Kenney, 2019). When fires burn, they release carbon dioxide into the atmosphere, and this greenhouse gas is hazardous to humans and animals that inhale it (United States Forest Service). A massive wildfire release of carbon dioxide can affect the weather and climate (World Health Organization).

11.6 Development Trends

The Authority's planning area is one of California's most rapidly growing regions; this area continues to experience residential, employment, and economic growth, including increasing growth into the WUI (County of Orange and Orange County Fire Authority, 2015). Every year the growing county and city boundaries expand into the hills, mountains, and forest lands. The growing interaction between urban/suburban areas and natural growth areas results in a significant wildfire risk for life and property.

The Orange County LHMP addresses wildfire risks in the planning area (County of Orange and Orange County Fire Authority, 2015). The LHMP identifies the hazard causes, probability, and potential damage. Additionally, the Orange County General Plan directs land use, addresses growth management, and establishes standards and plans to protect the community from hazards (Orange County).

Fire prevention methods are utilized to reduce the level of risk to structures to prevent the spread of wildfire embers and radiant heat (County of Orange and Orange County Fire Authority, 2015). Additionally, the Orange County Fire Authority reviews all land use proposals and site development permits to ensure proper design and build. OCTA will continue to follow State and County regulations and permit requirements in all new developments in the planning area.

11.7 Issues

Issues associated with severe weather in the OCTA planning area (Orange County) (Orange County, 2017):

- Continue to properly manage hazardous materials in transportation and/or facility sites.
- Consider response times for emergency equipment and first responder personnel, especially during a hazardous material release incident.
- Emergency response services require the use of transportation infrastructure that could override OCTA's transportation services.

11.8 Hazard Map

The hazard maps of wildfire hazard severity zones and WUI in the planning area start on the next page.

Figure 11-4 – OCTA Fire Hazard Severity Zones Hazard Map

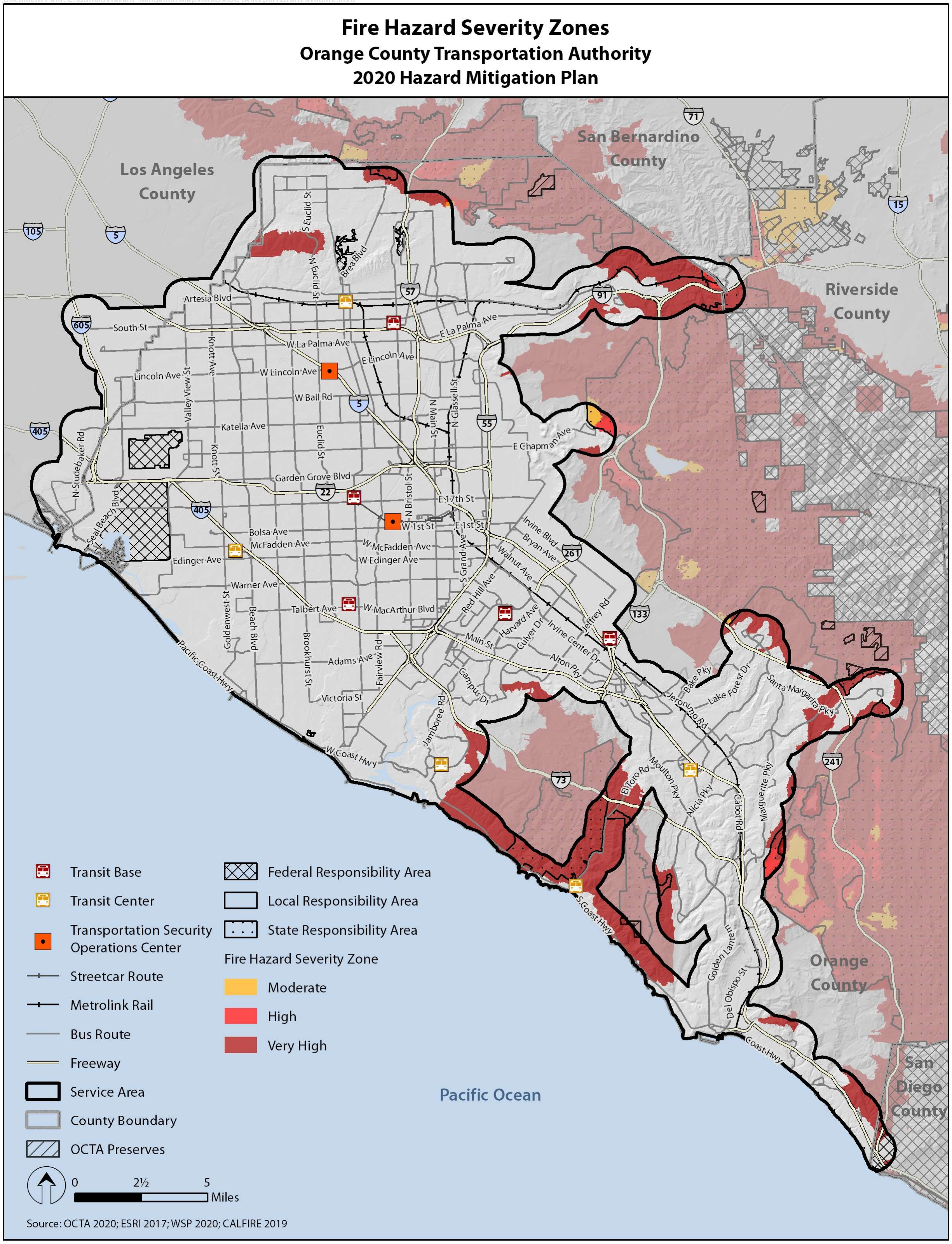
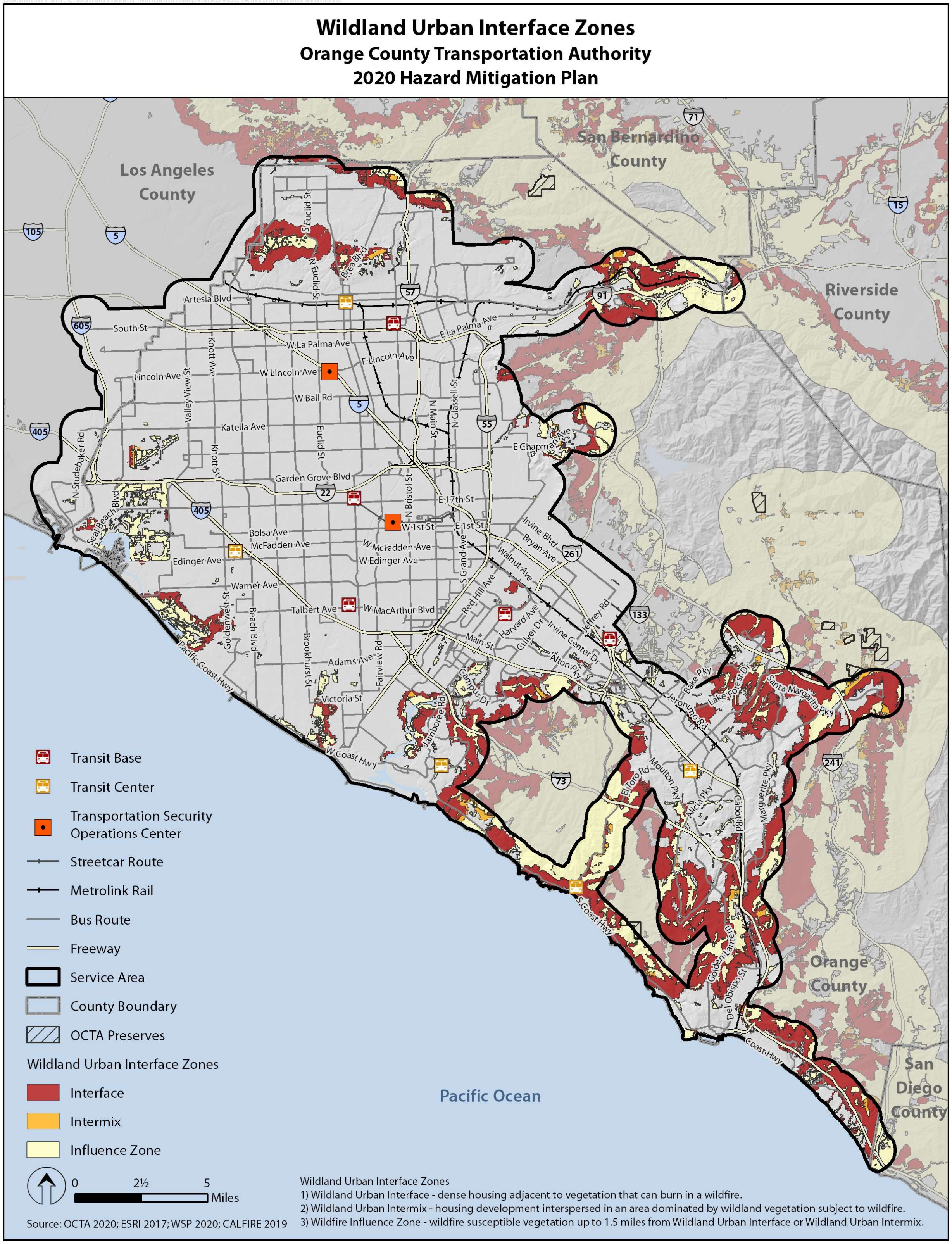


Figure 11-5 – OCTA Wildland Urban Interface Zones



OCTA 2021 Hazard Mitigation Plan

Part 3: Mitigation Strategy

12 Mitigation Strategy

12.1 Orange County Transportation Authority 2021 Hazard Mitigation Goals

44 CFR Section 201.6(c)(3)(i)

States that hazard mitigation plans (HMPs) shall describe mitigation goals to reduce or avoid long-term vulnerabilities to identified hazards.

Below are the four goals developed and adopted by the OCTA 2021 Steering Committee. Achievement of these goals defines the effectiveness of a mitigation strategy. The goals are used to help establish mitigation strategy priorities.

1. Support OCTA policies, plans, people, and programs to maintain a community transportation system that reduces risk and is resilient now and long term
2. Minimize vulnerabilities to protect people, property, the natural environment, and keep Orange County moving.
3. Ensure resilience-oriented decisions are made through regional collaboration and enhanced partnerships.
4. Promote community engagement through transparent public outreach that is equitable and accessible to everyone in the community

12.1.1 Actions

The following table includes hazard mitigation actions for OCTA as informed by the risk and capability assessments, including prioritization for implementation and funding mechanisms. Through collaboration, these projects will positively benefit OCTA, the public, and the environment in Orange County.

Table 12-1 – OCTA Mitigation Actions

ID	Name + Description	Action Status (New, Existing, Complete)	Goals Supported	Hazards Addressed	Lead Entity	Support Entity	Implementation Timeline + Anticipated Cost + Funding Source	STAPLEE + Mitigation Score	Priority: High, Med, Low
1	Increase public education and outreach by creating a new dedicated hazard webpage to share climate information changed and OCTA mitigation/preparedness measures.	New	1, 4	All Hazards	OCTA	-	- Less than 1 year - <$50,000 - Yes: existing budget	23 7	Low
2	Contribute to internal and regional after-action reports for the COVID-19 pandemic to identify critical actions that need to be completed to reduce risks to the community from future pandemics. These recommendations should be included in future updates of the HMP.	New	1, 2, 3	Pandemic	OCTA	County and local governments	- < 1 year - < $50,000 - Yes: existing budget	34 10	High
3	Partner with other agencies to implement additional measures to protect coastal rail infrastructure as appropriate, such as maintaining or improving the existing revetment, improving the revetment, adding a seawall, or relocating the rail line away from the coast in southern Orange County. (Aligns with *OC Rail Defense Against Climate Change Plan*)	New	1, 2, 3	Flood, SLR, and Erosion	OC Parks, OC Public Works	OCTA, Metrolink, Amtrak/LOSSAN	- 3-5 years (ongoing) -< $100,000,000 - Unknown: grants, existing budget	34 8	High
4	Partner with other agencies to implement erosion control and stormwater measures for the Mission Viejo Trench and the Oso Creek area as recommended in *the OC Rail Defense Against Climate Change Plan.* (Aligns with *OC Rail Defense Against Climate Change Plan)*	New	1, 2	Flood, SLR, and Erosion	OC Public Works	OCTA, Metrolink, and Amtrak/LOSSAN, USACE, local jurisdictions	- 1 – 3 years < $100,000,000- - Unknown: grants, existing budget	41 8	High
5	Regularly obtain the most recent recommended future heavy precipitation and flow estimates and compare these to the current 100-year high confidence heavy precipitation and flow estimates used for infrastructure design. Determine which estimates should be used to minimize risks to infrastructure over the lifecycle. (Aligns with *OC Rail Defense Against Climate Change Plan*)	New	1, 2	Flood, SLR, and Erosion	OCTA	OC Public Works	- < 1 year (ongoing) - <$50,000 - Yes: existing budget	32 6	Medium

ID	Name + Description	Action Status (New, Existing, Complete)	Goals Supported	Hazards Addressed	Lead Entity	Support Entity	Implementation Timeline + Anticipated Cost + Funding Source	STAPLEE + Mitigation Score	Priority: High, Med, Low
6	Regularly review and update the data used to calculate the rail zero-stress temperature to account for current and projected climate change and stress newly installed and existing rail based on this information. (Aligns with *OC Rail Defense Against Climate Change Plan*)	New	1, 2	Severe Weather	OCTA	Metrolink	- <1 year (ongoing) - <$50,000 - Yes: existing budget	36 7	Med
7	Retrofit OCTA critical facilities to address seismic risks.	New	2	Earthquake	OCTA		- 3-5 years -< $100,000,000 - Unknown: grants, existing budget	28 7	Med
8	Install back-up and/or redundant power sources for the OCTA data center and other critical facilities and infrastructure. Transition to solar power and battery systems where appropriate. Back-up and redundant power systems would help to ensure continuity of operations in a hazard event.	New	2	Earthquake, Flood/SLR/ Erosion, Severe Weather, Wildfires	OCTA	-	- 3-5 years - < $100,000,000 - Unknown: grant, existing budget	36 7	High
9	Assess and implement engineering options at OCTA bus bases for hardening fuel storage and fueling facilities against seismic and other hazards.	New	2	Earthquake, Flood/SLR/ Erosion, Wildfires, Tsunami	OCTA	-	- 3-5 years - < $100,000,000 - Unknown: grant, existing budget	34 7	Med
10	Develop site-specific response plans and structures for worksites using SEMS/NIMS principles.	New	1	All Hazards	OCTA	State, county, local government	- Less than 1 year - < $10,000 - Yes: existing budget	35 10	High
11	Continue OCTA vulnerability assessments for all hazards.	New	1, 2	All Hazards	OCTA	-	- < 1 year (ongoing) - $3.5 billion (2021 dollars) - Anticipated: grant	39 8	High

ID	Name + Description	Action Status (New, Existing, Complete)	Goals Supported	Hazards Addressed	Lead Entity	Support Entity	Implementation Timeline + Anticipated Cost + Funding Source	STAPLEE + Mitigation Score	Priority: High, Med, Low
12	Share vulnerability assessment data with partner Agencies. Encourage train station amenities to help riders during extreme heat and other severe weather events, including additional shaded or covered areas and seating, restrooms, and cooling mechanisms. Provide accurate information on train schedules to minimize waiting times. (Aligns with *OC Rail Defense Against Climate Change Plan*)	New	1, 2, 4	Severe Weather	OCTA	Metrolink, Amtrak/LOSSAN	- Less than 1 year - < $100,000,000 (estimated $5,555,000) - - Unknown: grants, existing budget	31 8	High
13	Expand internal communications and preparedness education about potential hazards, including what to do during and after a hazard event.	New	1, 2	All Hazards	OCTA	-	- Less than 1 year - < $50,000 - Anticipated: existing budget	37 10	High
14	Perform fuel modifications on OCTA conservation properties to provide proper clearance near habitable structures per local fire authority standards. Assess opportunities to replace invasive species and plant fire-adapted native plants to prevent invasive species from becoming re-established, minimizing the risk of wildfires	New	2	Wildfires	OCTA	County and local governments	- 1-3 years - < $500,000 - Unknown: grants, existing budget	43 9	High
15	Upgrade stormwater runoff management around OCTA critical facilities and infrastructure.	New and Existing	2	Flood/SLR/Erosion, Severe Weather	OCTA	Orange County Public Works, local governments	- 3-5 years - < $100,000,000 - - Unknown: grants, existing budget	39 7	High
16	Continue to use the most current Geographic Information Systems (GIS) data layers in the hazard reduction decision-making processes.	Existing	1, 2	All Hazards	OCTA	Federal and state governments	- < 1 year (ongoing) - < $50,000 - Yes: existing budget	41 8	High
17	Regularly assess the planning area’s evacuation routes and pickup points. Coordinate with the County Emergency Management Division and Cities to provide the most efficient and effective evacuation transportation support.	Existing	1, 3	Flood/SLR/Erosion, Mass Earth Movements, Severe Weather, Tsunamis, Wildfires	OCTA	County and local governments (OCSD EMD, City Emergency Managers)	- < 1 year (ongoing) - < $50,000 - Yes: existing budget	37 9	High

ID	Name + Description	Action Status (New, Existing, Complete)	Goals Supported	Hazards Addressed	Lead Entity	Support Entity	Implementation Timeline + Anticipated Cost + Funding Source	STAPLEE + Mitigation Score	Priority: High, Med, Low
18	Support cities and the county in the planning area with evacuation education and public outreach related to OCTA	New	1, 3, 4	Earthquake, Flood/SLR/Erosion, Mass Earth Movements, Tsunami, Wildfires	OCTA	County governments	- <1 year - < $50,000 - Yes: existing budget	39 8	High
19	Expand micro transit service as a potential option for providing transit services during a disaster event. (Aligned with *OC Transit Vision*.)	New	1, 3	Earthquake, Epidemic/ Pandemic, Flood/SLR/Erosion, Tsunami	OCTA	OCTA Contracted Services	- 1-3 years -$50,000 - Yes: existing budget	37 7	High
20	Promote the use of new technology in hazard mitigation and emergency preparedness.	New	1, 2	All Hazards	OCTA	OCTA IS Department	- < 1 year (ongoing) - < $50,000 - Yes: existing budget	24 6	Med
21	Continue to develop new and evaluate existing climate change goals and policies as new scientific data and models become available.	Existing	1, 2, 3	Flood/SLR/Erosion, Mass Earth Movements, Severe Weather, Wildfires	OCTA	Federal and state governments	- < 1 year (ongoing) - < $50,000 - Yes: existing budget	31 6	Low
22	Incorporate data from the 2021 OCTA HMP, mitigation actions, and risk reduction principles into future updates of agency plans related to hazard mitigation.	New	1, 2	All Hazards	OCTA	-	- < 1 year (ongoing) - < $50,000 - Unknown: grants, existing budget	33 7	Med
23	Develop and improve communication redundancies to ensure effective internal and external communication in a hazard event.	New and Existing	1, 2, 4	All Hazards	OCTA	-	- 3-5 years - $50,000 - Unknown: grants, existing budget	36 8	Low

ID	Name + Description	Action Status (New, Existing, Complete)	Goals Supported	Hazards Addressed	Lead Entity	Support Entity	Implementation Timeline + Anticipated Cost + Funding Source	STAPLEE + Mitigation Score	Priority: High, Med, Low
24	Prepare and implement fire management plans, invasive species control, public education and awareness, and enhanced security measures to mitigate the potential for wildfire on conservation properties. Consider closure of conservation properties during times of high fire risk. (Aligned with resource management plans.)	New	1, 2, 4	Wildfires	OCTA	Orange County Fire Authority, Orange County Sheriff Department	- 1-3 years - <$100,000 - Unknown: grants, existing budget	42 6	High
25	Monitor and address adverse effects from properties adjacent to conservation properties. (Aligned with resource management plans.)	New	1, 2, 4	Wildfires	OCTA	-	- 1-3 years - <$100,000 - Unknown: grants, existing budget	42 6	Low

12.2 Action Plan

> **44 CFR Section 201.7(c)(3)(iii)**
>
> Requires a description of how the actions will be prioritized, implemented, and administered by the Government Agency.

All actions listed above include an action plan of prioritized initiatives to mitigate natural hazards. The Steering Committee was asked to weigh the estimated benefits against the estimated costs of a project to establish a parameter to be used in prioritization. This benefit-cost review was qualitative and did not include the level of detail required under specific FEMA grant programs. This qualitative approach was used because projects may not be implemented for up to 10 years, and the associated costs and benefits could change dramatically in that time. Each project was assessed by estimating the total cost of the initiative and assigning subjective ratings (high, medium, and low) to benefits, as described in the sections below.

12.2.1 Cost

Participants were given a dollar range to choose from to estimate the cost of the proposed initiative:

- < $50,000
- < $100,000
- < $500,000
- < $1,000,000
- >$1,000,000

For many of the initiatives identified, OCTA may seek financial assistance under FEMA's hazard mitigation grant programs and other federal grant programs, including:

- Building Resilient Infrastructure and Communities (BRIC) Program
- Hazard Mitigation Grant Program
- Flood Mitigation Assistance grant program
- Repetitive Flood Claims grant program
- Emergency Management Performance Grant program
- Severe Repetitive Loss grant program
- California Coastal Conservancy – Forest Health and Wildfire Resilience Program
- California Coastal Conservancy – Climate Ready Program
- California Department of Water Resource – Floodplain Management Protection and Risk Awareness Program
- California Natural Resources Agency – Urban Flood Protection Program
- Cal Fire – Fire Prevention Grants Program

12.2.2 Benefit

The Steering Committee evaluated each action using STAPLEE and Mitigation Effectiveness criteria, as described in Tables 12-2 and 12-3. Evaluators were asked to rate each STAPLEE and Mitigation Effectiveness criteria to develop a total score that determined each action's relative suitability and potential effectiveness.

Table 12-2 – STAPLEE Criteria

STAPLEE Criteria	Evaluation Rating
S: Is it Socially acceptable?	Strongly Agree = 5 Agree = 4 Neutral = 3 Disagree = 2 Strongly Disagree = 1
T: Is it Technically feasible and potentially successful?	
A: Does the responsible city agency/department have the Administrative capacity to execute this action?	
P: Is it Politically acceptable?	
L: Is there Legal authority to implement?	
E: Is it Economically beneficial?	
E: Will the project have a positive impact on the natural environment?	
Will historic structures or key cultural resources be saved or protected?	
Could it be implemented quickly?	

Table 12-3 – Mitigation Effectiveness Criteria

Mitigation Effectiveness Criteria	Evaluation Rating
Will the implemented action result in lives saved?	Strongly Agree = 5 Agree = 4 Neutral = 3 Disagree = 2 Strongly Disagree = 1
Could it be implemented quickly?	

STAPLEE scores can range from a low of 9 to a high of 45. Mitigation effectiveness scores can run from a low of 2 to a high of 10. When these scores are combined, mitigation actions can score within a range of 11 to 55 points. Actions were ranked as low benefit if the total score was between 0 and 17, medium benefit if the score was between 18 and 35, and high benefit if the score was 36 to 55.

12.2.3 Benefit-Cost Review

Most of the mitigation actions will require a detailed Benefit-Cost Analysis (BCA) as part of the grant application process, if the OCTA pursues grant funding. Analyses are performed using the FEMA or other applicable model process when preparing funding applications. The Authority commits to implementing mitigation strategies with benefits that exceed their costs. For projects that do not need grant funding that requires a BCA, OCTA reserves the right to define benefits that meet their needs and the goals and objectives of this plan.

12.3 Plan Adoption

OCTA will submit the final HMP to CalOES and FEMA Region IX for official approval prior to formal adoption of the plan by the Authority's Board of Directors. A copy of the adoption resolution will be included in Appendix F. OCTA will also comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, including 2 CFR Parts 200 and 3002, and will amend its plan during regular plan updates to reflect changes in Federal laws and statutes.

12.4 Plan Implementation and Maintenance Strategy

> **44 CFR Section 201.6(d)(3)**
>
> Entities are required to review and update their hazard mitigation plans where there are development changes, priority changes, and progress in local mitigation efforts. Plan updates must be resubmitted to the state and FEMA every five years to continue to be eligible for mitigation project grant funding.

This section details the formal plan implementation and maintenance strategy to ensure that the OCTA's hazard mitigation plan remains an active and relevant document and supports eligibility for relevant funding sources. The plan maintenance process includes monitoring and evaluating the plan annually and submitting an updated plan to CalOES and FEMA for approval every five years. This section also describes how participation from customers and community members will continue to be a part of the plan maintenance and implementation process. The HMP's format allows sections to be reviewed and updated when new data becomes available, ensuring the plan stays current and relevant.

12.4.1 Plan Implementation

The effectiveness of the HMP depends on the implementation of the plan through the initiatives identified in the action plan and the incorporation of mitigation principles and actions into other OCTA and partner plans, policies, and programs. The plan includes a range of actions that, if implemented, would reduce losses from hazard events in the OCTA planning area. The Steering Committee has established plan goals that will be implemented through the development of new plans and incorporation into existing plans, policies, and programs.

The Security and Emergency Preparedness Manager under the OCTA Chief Executive Office will assume lead responsibility for planning and facilitating implementation and maintenance meetings. The OCTA's Security and Emergency Preparedness Manager will serve as the Authority's point-of-contact for this plan. Although the Security and Emergency Preparedness Manager will have primary responsibility for convening these meetings, plan implementation and maintenance will be a shared responsibility among all OCTA Departments identified as leads in the mitigation action plan.

12.4.2 Steering Committee

The Steering Committee is made up of staff from departments all across the OCTA. This committee's purpose was to oversee the plan's development and make recommendations on key elements, including the maintenance strategy. The Steering Committee's position was that a similar oversight committee should have an active role in maintaining this plan. Therefore, it is recommended that the Steering Committee remain a viable body involved in the key elements of the plan maintenance strategy.

Each year, the OCTA Chief Executive Office will appoint a Steering Committee Chair to lead annual progress reporting. The Chair will be responsible for ensuring that the plan is reviewed and evaluated annually. The Security and Emergency Preparedness Manager will be responsible for facilitating annual progress review workshops.

The Steering Committee should include OCTA staff and representatives of key planning partners and stakeholders. The Steering Committee will convene to complete annual reviews at a place and time to be determined. The membership of this committee can be dynamic, which will allow for the representation of different points of view and allow a broad range of participants to have a say in the implementation of the plan. Individuals involved in the plan development process will be contacted and given the option to remain involved in plan implementation.

12.4.3 Annual Progress Report

The minimum task of the Steering Committee will be the evaluation of the progress of the plan during annual reviews. This evaluation will include the following:

- Summary of any hazard events that occurred during the prior year and their impact on the planning area
- A review of successful mitigation initiatives identified in the plan
- A brief discussion about why targeted mitigation actions were not completed, including if planning goals and priorities have changed relative to the targeted action
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term project because of funding availability)
- Recommendations for new projects
- Changes in or potential for new funding options (grant opportunities)
- Impact of any other OCTA or partner planning programs or initiatives that involve hazard mitigation

To support the annual evaluation of the HMP and track progress in implementing individual actions, lead entities listed in the action plan will complete an annual progress report using the Mitigation Strategy Evaluation and Mitigation Action Evaluation forms provided in Appendix C. The Steering Committee will complete, review, and approve progress reports, which will be the foundation of the formal annual progress of the plan. This report will be used made available as follows:

- Posted to the OCTA 2021 HMP webpage
- Provided to the local media through a press release
- Presented to the Board of Directors and Executive Office

12.4.4 Plan Updates

The OCTA intends to update the plan on a five-year cycle from the date of initial plan adoption. This cycle may be accelerated to less than five years based on the following triggers:

- A Presidential Disaster Declaration that impacts the planning area
- A hazard event that causes loss of life

It will not be the intent of this update process to start from scratch and develop a new HMP for the Authority. Based on needs identified by the Steering Committee, plan updates will, at a minimum, include the elements below:

- The Steering Committee will convene the update process.
- The hazard risk assessment will be reviewed and updated as needed using the best available information and technologies.
- The action plan will be reviewed and revised to account for any initiatives completed, dropped, or changed and to account for changes in the risk assessment or changes in planning goals or priorities identified by the Steering Committee or under another planning mechanism, as appropriate (such as OCTA strategic plans).
- The draft HMP will be sent to appropriate partner agencies and organizations for comment.

- Customers and community members will be given opportunities to comment on the update before adoption.
- The Board of Directors will approve a new resolution to adopt the updated plan.

12.4.5 Continuing Patron and Community Member Involvement

OCTA customers and community members will be updated on hazard mitigation actions status through the [webpage link to go here]. Copies of the HMP annual progress reports will be distributed to stakeholders and the media, where appropriate.

Additionally, a new community engagement strategy will be initiated based on guidance from the Steering Committee each time the plan is updated. This strategy will be based on the needs and capabilities of OCTA during the plan update. At a minimum, the strategy will provide multiple opportunities for OCTA customers and community members to comment on the draft plan update online or other methods.

12.4.6 Integration with Other Planning Mechanisms

The information on hazards, risks, vulnerability, and mitigation actions in this HMP is based on the best science and technology currently available. This information can be invaluable in informing decisions made under other planning efforts, such as the OCTA's strategic and facilities planning. The OCTA will use information from this plan as the best available science and data on natural hazards impacting the Authority's service area. As information becomes available from other agency planning efforts to enhance this plan, it will be incorporated in the HMP during the update process.

OCTA 2021 Hazard Mitigation Plan

Appendices

Appendix A. Acronyms and Definitions

Acronyms

Acronym	Definition
ALERT	Automated Local Evaluation in Real Time
BCA	Benefit-Cost Analysis
BCAR	FEMA's Benefit-Cost Analysis Tool
CAHAN	California Health Alert Network
CD	Communicable Disease
CDC	Centers for Disease Control
CEA	California Earthquake Authority
CEO	Chief Executive Officer
CERT	Community Emergency Response Team
CFR	Code of Federal Regulations
CIP	Capital Improvements Plan
COOP	Continuity of Operations Plan
COVID-19	Novel Coronavirus 2019
DEWS	Drought Early Warning System
DHS	Department of Homeland Security
DMA	Disaster Mitigation Act
EAP	Emergency Action Plan
EAS	National Emergency Alert System
EF Scale	Enhanced Fujita Scale
EOP	Emergency Operations Plan
EPA	US Environmental Protection Agency
FCD	Flood Control District
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FP	Floodplain
GIS	Geographic Information System
HAN	CDC Health Alert Network
HAZUS-MH	Hazards United States-Multi Hazard
HHSA	Health and Human Services Agency
HMGP	Hazard Mitigation Grant Program
HMP	Hazard Mitigation Plan
HVAC	Heating, Ventilation, and Air Conditioning
ID	Identification
LHMP	Local Hazard Mitigation Plan

Acronym	Definition
LOC	Location
NASA	National Aeronautics and Space Administration
NCDC	National Climatic Data Center
NEHRP	National Earthquake Hazards Reduction Program
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
OC	Orange County
OCFA	Orange County Fire Authority
OES	Office of Emergency Services
OSHA	US Occupational Safety and Health Administration
PPE	Personal Protective Equipment
PSAF	Pandemic Severity Assessment Framework
RDMD	Orange County Resources and Development Management Department
SEMS	Standardized Emergency Management System
SFHA	Special Flood Hazard Area
SLR	Sea Level Rise
STAPLEE	Social, Technical, Administrative, Political, legal Economic, and Environmental
THIRA	Threat and Hazard Identification Risk Assessment
UCLA	University California, Los Angeles
US	United States
USFS	US Forest Service
USGS	US Geological Survey
WEA	Wireless Emergency Alert
WHO	World Health Organization
WUI	Wildland Urban Interface

Definitions

100-Year Floodplain – An area inundated by a flood with a 1 percent chance of being equal or greater each year.

500-year Floodplain – An area inundated by floodwaters with a 0.2 percent chance of being equal or greater each year.

Aftershock – Lower-magnitude earthquakes that follow an initial primary earthquake**.**

Alluvial Fans – are found in dry mountainous regions where rock and soil erode from mountainsides and build up on valley floors in a fan shape.

Asset – Any human-made or natural feature that has value, including, but not limited to, people, buildings, infrastructure, such as bridges, roads, sewers, and water systems; lifelines, such as electricity and communication resources; and environmental, cultural, or recreational features such as parks, wetlands, and landmarks.

Benefit/Cost Analysis – A systematic, quantitative method of comparing projected benefits to projected costs of a project or policy. It is used as a measure of cost-effectiveness.

Benefit – A benefit is a net project outcome and is usually defined in monetary terms. Benefits may include direct and indirect effects. For benefit-cost analysis mitigation measures, benefits are limited to specific, measurable, risk reduction factors, including reducing expected property losses (buildings, contents, and functions) and protecting human life.

Building – A building is defined as a walled and roofed structure, principally above-ground and permanently fixed to a site. The term includes manufactured homes on permanent foundations on which the wheels and axles carry no weight.

Capability Assessment – A capability assessment provides a description and analysis of a community's current capacity to address threats associated with hazards. The assessment includes two components: an inventory of an Authority's mission, programs, policies and an analysis of its capacity to carry them out. A capability assessment is an integral part of the planning process. A community's actions to reduce losses are identified, reviewed, and analyzed, and the framework for implementation is identified. The following capabilities were reviewed under this assessment: Legal and regulatory capability, administrative and technical capability, and fiscal capability.

Coastal Flood – Occur by seawater and coastlines, often due to severe weather events and cause coastline erosion.

Communicable Disease – an illness transmitted from an infected agent to an animal or individual through direct or indirect contact.

Critical Area – An area defined by state or local regulations as deserving special protection because of unique natural features or its value as a habitat for a wide range of flora and fauna species. A sensitive/critical area is usually subject to more restrictive development regulations.

Critical Facility – Those facilities and infrastructure that are critical to the health and welfare of the population. These become especially important after any hazard event occurs. For this plan, critical facilities include the following:

- Structures or facilities that produce, use, or store highly volatile, flammable, explosive, toxic, and/or water-reactive materials
- Public and private utilities, facilities, and infrastructure are vital to maintaining or restoring standard services to areas damaged by hazard events
- Government facilities

Crown Fire – A type of fire that burns through the top layer of trees, called the canopy. They are the most intense and difficult to contain.

Dam – Any artificial barrier and/or any controlling works, together with appurtenant works, can or do impound or divert water.

Dam Failure – An uncontrolled release of impounded water due to structural deficiencies in the water barrier.

Debris Flow – A form of a rapid mass movement in which loose soil, rock, and sometimes organic matter combine with water to form a slurry that flows downslope.

Derecho – A widespread and long-lived windstorm associated with thunderstorms that can cause damage similar to a tornado.

Disaster Mitigation Act of 2000 (DMA) – A Public Law 106-390 that is the latest federal legislation enacted to encourage and promote proactive, pre-disaster planning as a condition of receiving financial assistance under the Robert T. Stafford Act. The DMA emphasizes planning for disasters before they occur. The DMA established a pre-disaster hazard mitigation program and new requirements for the national post-disaster hazard mitigation grant program (HMGP).

Disease Vector – an agent that carries and transmits infectious diseases, such as an insect, fungus, or animal.

Drainage Basin – The area within which all surface water (whether from rainfall, snowmelt, springs, or other sources) flows to a single water body or watercourse. The boundary of a river basin is defined by natural topography, such as hills, mountains, and ridges. Drainage basins are also referred to as watersheds or basins.

Droughts – Extended periods of extremely low rainfall and snowpack lead to groundwater shortages impacting a large area of people, animals, and the environment.

Earthquake Magnitude – The seismic wave/amplitude measured and recorded by seismographs from an earthquake's epicenter. Magnitude is represented by a class name and numerical value from 3 to 8.

Emergency Operations Plan (EOP) – A formal document that provides an entity's emergency response procedures, structure, and authorities.

Epicenter (seismology) – The point on the ground's surface directly above the focus point where the fault ruptures.

Epidemic – Happens when there is a significant and unexpected increase in disease cases.

Essential Workers – individuals that work in roles that are critical to infrastructure operations.

Excessive/Extreme Heat – a combination of high temperatures and humidity, where the human body cannot maintain internal temperatures and cause heat-stroke.

Fault – A fracture in the Earth's crust where compression or tension pressure causes displacement of soil and rock on the opposite side of the fracture.

Flash Flood – A rapid rise in water with a high flow velocity that carries debris. Flash floods have enough force to pull up and carry significant amounts of large debris (e.g., cars and trees).

Flood – Inundation of ordinarily dry land resulting from rising and overflowing of a body of water.

Flood Insurance Rate Map (FIRM) – The official maps on which the Federal Emergency Management Agency (FEMA) has delineated the Special Flood Hazard Area (SFHA).

Floodplain – An area of land neighboring a waterway or waterbody that is known to be flood-prone.

Focal Depth – The depth from the earth's surface to the hypocenter.

Fuels – Materials that burn in a fire, such as paper products, flammable gases or chemicals, or wood products. The material composition determines how flammable it is, based on moisture level, chemical makeup, and material density. The less moisture and lower density, the faster and hotter it burns.

General Severe Weather – systems that form over broad geographic areas that can cross regional and jurisdictional boundaries.

Hazard Mitigation Grant Program (HMGP) – Authorized under Section 202 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, the HMGP is administered by FEMA. The Act provides grant information to states, tribes, and local governments.

Hazardous Material – Any biological agent and disease-causing material that has the reasonable potential to cause death, disease, behavioral changes, cancer, genetic mutation, psychological problems, or physical deformations to an exposed person or their unborn children.

Hazards US Multi-Hazard (HAZUS-MH) Loss Estimation Program – A GIS-based program to support the development of risk assessments required under the DMA. The HAZUS-MH software program quantitatively estimates damages and losses associated with natural hazards. HAZUS-MH is FEMA's nationally applicable, standardized methodology and software program. It contains modules for estimating potential losses from hazards.

Herd Immunity – when enough of the population becomes resistant to a disease by recovering from the illness or vaccination.

Hypocenter – The region underground where an earthquake's energy originates.

Infectious Diseases – Medical conditions/illnesses caused by organisms like bacteria, viruses, fungi, or parasites.

Inundation Area – The area of land that would be flooded following a dam failure.

Landslide – A large amount of rock, debris, or earth that travels down a slope.

Liquefaction – A loss of soil strength or cohesion results in the soil behaving like a thick liquid (e.g., quicksand).

Local Government – Any county, municipality, city, town, township, public authority, school district, special district, intrastate district, a council of governments (regardless of whether the council of governments is incorporated as a nonprofit corporation under State law), regional or interstate government entity, or agency or instrumentality of a local government. Any Indian tribe or authorized tribal organization, or Alaska Native village or organization. Any rural community, unincorporated town or village, or other public entity.

Localized Severe Weather – Damaging storms in a limited geographic area can include severe weather types.

Mass Movement – A collective term for landslides, debris flows, falls, and sinkholes.

Mitigation – A preventive action that can be taken to reduce or eliminate the risk to life or property in advance of an event.

Mitigation Actions – Specific actions to achieve goals and objectives that minimize the effects of a disaster and reduce life and property loss.

Modified Mercalli Scale – A measurement of the level of intensity felt on the ground's surface in populated areas, represented by a Roman numeral from I to X.

Mortality Rate – a mathematical measure of the frequency that individuals die in a defined population during a specific period.

Mudslide (or Mudflow) – A river of rock, earth, organic matter, and other water-saturated materials.

Objective – For this plan's purposes, an objective is defined as a short-term aim that forms a strategy or course of action to meet a goal when combined with other objectives. Unlike goals, objectives are specific and measurable.

Outbreak – Similar to an epidemic but limited to a specific geographic area or group of people.

Pandemic – Occur when a disease crosses multiple countries and infects a large number of people.

Preparedness – Actions that strengthen an entity's capability to respond to disasters and support their community.

Presidential Disaster Declaration – These declarations are typically made for events that cause more damage than state and local governments and resources can handle without federal government assistance. Generally, no specific dollar loss threshold has been established for such declarations. A presidential disaster declaration puts into motion long-term federal recovery programs, some of which are matched by state programs designed to help disaster victims, businesses, and public entities.

Risk – The estimated impact of a hazard on people, services, facilities, and structures in a community. Risk measures the likelihood of a hazard occurring and resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms, such as a high, moderate, or low likelihood of sustaining damage above a determined threshold due to the occurrence of a specific type of hazard. Risk also can be expressed in terms of potential monetary losses from the hazard.

Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) – Public Law 100-107 signed on November 23, 1988. This law amended the Disaster Relief Act of 1974, Public Law 93-288. The Stafford Act is the statutory authority for most federal disaster response activities, especially for FEMA and its programs.

Runup – A measurement of the height of the water onshore observed above a reference sea level.

Seiches – A standing wave/oscillation in an enclosed or partially enclosed body of water varies in a period from a few minutes to several hours.

Severe Local Storm – Small atmospheric systems, including tornadoes, thunderstorms, and windstorms. Typically, significant impacts from a severe storm are on transportation infrastructure and utilities. These storms may cause many destructions and even death, but the impact is generally confined to a small area.

Sinkhole – A collapse depression in the ground with no visible outlet and underground drainage.

Slope Failures – Occur when the soils' strength forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.

Stakeholder – Individuals and organizations with a vested interest in a project and/or plan, such as business leaders, civic groups, academia, non-profit organizations, major employers, critical facilities managers, farmers, developers, special purpose districts, etc.

Steering Committee – The group that oversaw all phases of the HMP's development. Committee members included key stakeholders and community members in the planning area.

Stormwater Management – physical and natural systems used by people to control and regulate surface and stormwater runoff flow.

Storm Surge – When a coastal flood happens simultaneously as a high tide, causing the coastal flood to reach farther and bring more water than it would during a lower tide.

Surface Rupture – An area of the ground that is offset (raised, lowered, tilted) when a fault rupture reaches the ground's surface.

Terrain/Topography – The ground's slope can help or halt the spread of a wildfire. For example, significant gaps in vegetation or waterways such as rivers and creeks can stop a wildfire from spreading. Fires also move faster upslope than down due to elevation changes and warm air rising.

Thunderstorm – A local storm with thunder and lightning can cause tornadoes, heavy rain, flash floods, hail, and high winds.

Tornadoes – A destructive rotating column of wind generated by a thunderstorm, shaped in a funnel that reaches the ground.

Tsunami – Comes from the Japanese words for *harbor* ("tsu") and *wave* ("nami"). A long high sea wave caused by an earthquake, submarine landslide, or other disturbance.

Tsunami from a large undersea earthquake – The earthquake must cause significant vertical deformation on the seafloor to generate a tsunami.

Tsunami Advisory – Issued when strong currents and dangerous waves of 1 to 3 feet are expected.

Tsunami Warning – Issued by PTWC when a potential tsunami with significant widespread inundation is imminent or expected.

Tsunami Watch – Issued when an event may later impact the watch area; can be upgraded to a tsunami warning.

Vulnerability – A description of how exposed or susceptible an asset is to damage. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. The vulnerability of a community is often related to another's nearby community's vulnerability. Also, indirect effects can be much more widespread and damaging than direct effects.

Watershed – An area that drains downgradient from areas of higher land to lower land areas to the lowest point, a common drainage basin.

Wildland Urban Interface Area (WUI) – An area susceptible to wildfires and wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

Wildfire – Fires result in uncontrolled destruction of forests, brush, field crops, grasslands, and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and cause a great deal of destruction.

Windstorm – A storm featuring violent winds. Southwesterly winds are associated with intense storms moving onto the coast from the Pacific Ocean. Southern winds parallel to the coastal mountains are the strongest and most destructive winds. In addition, windstorms tend to damage ridgelines facing the wind.

Winter Storm – A cold event with significant precipitation in snow, ice, freezing rain, sleet, etc. Higher elevations get more precipitation.

Appendix B. Hazard Mitigation Plan Annual Progress Report

Annual Hazard Mitigation Progress Reporting Form

OCTA Department: ____

Prepared By: ____________________________ Title: _________________________

For the 12-month period ending: ______________________ Date: _______________

Instructions: Complete this form for each entity. Check the box beside the Yes or No options. Complete descriptions for each question to which a Yes response applies, inserting additional lines as needed.

Please answer the following questions to the best of your knowledge for the preceding 12 months:

1. Did the Authority experience any hazard events resulting in losses?

☐ No ☐ Yes – Describe (e.g., deaths, injuries, property damage, and indirect impacts such as loss of use, economic or environmental impacts, if a damage assessment was conducted, emergency or disaster declaration):

2. Have there been any observed impacts, physical changes, or new studies that materially affected the hazards analysis?

☐ No ☐ Yes – Describe:

3. Have any additional mitigation initiatives been identified that were not previously addressed in the Hazard Mitigation Plan?

☐ No ☐ Yes – For each new initiative, complete a Mitigation Action Evaluation Form.

4. Have any identified mitigation initiatives been completed and successful?

☐ No ☐ Yes – Review:

5. Were there targeted strategies in the past year that did not get completed?

☐ No ☐ Yes – Discuss:

6. Do any mitigation strategies in the current plan need timeline amendments (such as changing a long-term project to a short-term project due to funding)?

☐ No ☐ Yes – Describe:

7. Have there been any changes in potential or new funding options, including grant opportunities?

☐ No ☐ Yes – Describe:

8. Were there any other planning programs or initiatives that involved hazard mitigation? If so, what was their impact?

☐ No ☐ Yes – Describe:

9. Has public awareness of hazards improved?

☐ No ☐ Yes – Describe:

Appendix C. Mitigation Action Evaluation Forms

The OTCTA HMP Steering Committee will review the status of hazard mitigation actions using this form, informing the Annual Progress Report.

Mitigation Action Evaluation

Project ID: _______________ Project Name: __________________________________

1. Project Description:

2. Affected Entity: ____

3. Lead Entity: ____

4. Status and Priority Level: ____

5. Anticipated Completion Timeframe: ____

6. Actual Timeframe Completed: ____

7. Anticipated Cost: ____

8. Actual Cost to Complete: ____

9. Funding Source(s):

10. Anticipated Benefit vs. Cost – (For those projects with a measurable benefit in terms of future loss reduction, please quantify. For projects less easily quantified, please provide a qualitative assessment of the benefit to the cost):

9. Other Comments:

Prepared By: ____________________________________ Date: ____________________

Appendix D. Planning Process and Public Outreach

[materials will be included in the longer, PDF version of this plan]

Appendix E. FEMA Region IX Local Hazard Mitigation Plan Review Tool

The *Local Hazard Mitigation Plan Review Tool* records how the Local Hazard Mitigation Plan meets the regulations in 44 CFR §§ 201.6 and offers State and FEMA Mitigation Planners an opportunity to provide feedback to the community.

- The **Regulation Checklist** provides a summary of FEMA's evaluation of whether the plan has addressed all requirements.
- The **Plan Assessment** identifies the plan's strengths as well as documents areas for future improvement. This section also includes a list of resources for implementation of the plan.
- The **Multi-Jurisdiction Summary Sheet** is a mandatory worksheet for multi-jurisdictional plans that is used to document which jurisdictions are eligible to adopt the plan.
- The **Hazard Identification and Risk Assessment Matrix** is a tool for plan reviewers to identify if all components of Element B are met.

Jurisdiction: Orange County Transportation Authority	**Title of Plan:** Orange County Transportation Authority 2021 Hazard Mitigation Plan	Date of Plan: TBD
Authority Point of Contact:	Address:	
Title:		
Agency:		
Phone Number:	E-Mail:	

State Reviewer:	Title:	Date:
Date Received at State Agency		
Date Sent to FEMA		

FEMA Reviewer:	Title:	Date:
Date Plan Received in FEMA Region IX		
Date Plan Not Approved		
Date Plan Approvable Pending Adoption		
Date Plan Approved		

REGULATION CHECKLIST **Regulation (44 CFR 201.6 Local Mitigation Plans)**		**Location in Plan (section and/or page number)**	**Met**	**Not Met**
ELEMENT A. PLANNING PROCESS				
A1. Does the plan document the planning process, including how it was prepared and who was involved in the process for each jurisdiction? (Requirement §201.6(c)(1))	a. Does the plan provide documentation of how the plan was prepared? This documentation must include the schedule or timeframe and activities that made up the plan's development as well as who was involved.			
	b. Does the plan list the jurisdiction(s) participating in the plan that are seeking approval?			
	c. Does the plan identify who represented each jurisdiction? (At a minimum, it must identify the jurisdiction represented and the person's position or title and agency within the jurisdiction.)			
A2. Does the plan document an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development as well as other interests to be involved in the planning process? (Requirement §201.6(b)(2))	a. Does the plan document an opportunity for neighboring communities, local, and regional agencies involved in hazard mitigation activities, agencies that have the authority to regulate development, as well as other interested parties to be involved in the planning process?			
	b. Does the plan identify how the stakeholders were invited to participate in the process?			
A3. Does the plan document how the public was involved in the planning process during the	a. Does the plan document how the public was given the opportunity to be involved in the planning process?			

REGULATION CHECKLIST Regulation (44 CFR 201.6 Local Mitigation Plans)		Location in Plan (section and/or page number)	Met	Not Met
drafting stage? (Requirement §201.6(b)(1))	b. Does the plan document how the public's feedback was incorporated into the plan?			
A4. Does the plan describe the review and incorporation of existing plans? studies, reports, and technical information? (Requirement §201.6(b)(3))				
A5. Is there discussion of how the community(ies) will continue public participation in the plan maintenance process? (Requirement §201.6(c)(4)(iii))				
A6. Is there a description of the method and schedule for keeping the plan current (monitoring, evaluating, and updating the mitigation plan within a 5-year cycle)? (Requirement §201.6(c)(4)(i))	a. Does the plan identify how, when, and by whom the plan will be monitored (how will implementation be tracked) over time?			
	b. Does the plan identify how, when, and by whom the plan will be evaluated (assessing the effectiveness of the plan at achieving stated purpose and goals) over time?			
	c. Does the plan identify how, when, and by whom the plan will be updated during the 5-year cycle?			
ELEMENT A: REQUIRED REVISIONS				
ELEMENT B. HAZARD IDENTIFICATION AND RISK ASSESSMENT (Reviewer: See Section 4 for assistance with Element B)				
B1. Does the plan include a description of the type, location, and extent of all natural hazards that can affect each jurisdiction(s)? (Requirement §201.6(c)(2)(i))	a. Does the plan include a general description of all natural hazards that can affect each jurisdiction?			
	b. Does the plan provide rationale for the omission of any natural hazards that are commonly recognized to affect the jurisdiction(s) in the planning area?			
	c. Does the plan include a description of the type of all natural hazards that can affect each jurisdiction?			
	d. Does the plan include a description of the location for all natural hazards that can affect each jurisdiction?			

REGULATION CHECKLIST Regulation (44 CFR 201.6 Local Mitigation Plans)		Location in Plan (section and/or page number)	Met	Not Met
	e. Does the plan include a description of the extent for all natural hazards that can affect each jurisdiction?			
B2. Does the plan include information on previous occurrences of hazard events and on the probability of future hazard events for each jurisdiction? (Requirement §201.6(c)(2)(i))	a. Does the plan include information on previous occurrences of hazard events for each jurisdiction?			
	b. Does the plan include information on the probability of future hazard events for each jurisdiction?			
B3. Is there a description of each identified hazard's impact on the community as well as an overall summary of the community's vulnerability for each jurisdiction? (Requirement §201.6(c)(2)(ii))	a. Is there a description of each hazard's impacts on each jurisdiction (what happens to structures, infrastructure, people, environment, etc.)?			
	b. Is there a description of each identified hazard's overall vulnerability (structures, systems, populations, or other community assets defined by the community that are identified as being susceptible to damage and loss from hazard events) for each jurisdiction?			
B4. Does the plan address NFIP insured structures within the jurisdiction that have been repetitively damaged by floods? (Requirement §201.6(c)(2)(ii))				
<u>ELEMENT B: REQUIRED REVISIONS</u>				
ELEMENT C. MITIGATION STRATEGY				
C1. Does the plan document each jurisdiction's existing authorities, policies, programs and resources and its ability to expand on and improve these existing policies and programs? (Requirement §201.6(c)(3))	a. Does the plan document each jurisdiction's existing authorities, policies, programs, and resources?			

REGULATION CHECKLIST Regulation (44 CFR 201.6 Local Mitigation Plans)		Location in Plan (section and/or page number)	Met	Not Met
	b. Does the plan document each jurisdiction's ability to expand on and improve these existing policies and programs?			
C2. Does the plan address each jurisdiction's participation in the NFIP and continued compliance with NFIP requirements, as appropriate? (Requirement §201.6(c)(3)(ii))				
C3. Does the plan include goals to reduce/avoid long-term vulnerabilities to the identified hazards? (Requirement §201.6(c)(3)(i))				
C4. Does the plan identify and analyze a comprehensive range of specific mitigation actions and projects for each jurisdiction being considered to reduce the effects of hazards, with emphasis on new and existing buildings and infrastructure? (Requirement §201.6(c)(3)(ii))	a. Does the plan identify and analyze a comprehensive range of specific mitigation actions and projects to reduce the impacts from hazards?			
	b. Does the plan identify mitigation actions for every hazard posing a threat to each participating jurisdiction?			
	c. Do the identified mitigation actions and projects have an emphasis on new and existing buildings and infrastructure?			
C5. Does the plan contain an action plan that describes how the actions identified will be prioritized (including cost benefit review), implemented, and administered by each jurisdiction? (Requirement §201.6(c)(3)(iv)); (Requirement §201.6(c)(3)(iii))	a. Does the plan explain how the mitigation actions will be prioritized?			
	b. Does the plan identify the position, office, department, or agency responsible for implementing and administering each action?			
C6. Does the plan describe a process by which local governments will integrate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when	a. Does the plan identify the local planning mechanisms where hazard mitigation information and/or actions may be incorporated?			
	b. Does the plan describe each community's process to integrate the data, information, and hazard mitigation goals and actions into other planning mechanisms?			

REGULATION CHECKLIST Regulation (44 CFR 201.6 Local Mitigation Plans)		Location in Plan (section and/or page number)	Met	Not Met
appropriate? (Requirement §201.6(c)(4)(ii))	c. The updated plan must explain how the jurisdiction(s) incorporated the mitigation plan, when appropriate, into other planning mechanisms as a demonstration of progress in local hazard mitigation efforts.			
ELEMENT C: REQUIRED REVISIONS				
ELEMENT D. PLAN UPDATES (Applicable to plan updates only)				
D1. Was the plan revised to reflect changes in development? (Requirement §201.6(d)(3))				
D2. Was the plan revised to reflect progress in local mitigation efforts? (Requirement §201.6(d)(3))				
D3. Was the plan revised to reflect changes in priorities? (Requirement §201.6(d)(3))				
ELEMENT D: REQUIRED REVISIONS				
ELEMENT E. PLAN ADOPTION				
E1. Does the plan include documentation that the plan has been formally adopted by the governing body of the jurisdiction requesting approval? (Requirement §201.6(c)(5))				
E2. For multi-jurisdictional plans, has each jurisdiction requesting approval of the plan documented formal plan adoption? (Requirement §201.6(c)(5))				

REGULATION CHECKLIST **Regulation (44 CFR 201.6 Local Mitigation Plans)**	**Location in Plan (section and/or page number)**	**Met**	**Not Met**
ELEMENT E: REQUIRED REVISIONS			
ELEMENT F. ADDITIONAL STATE REQUIREMENTS (Optional for State Reviewers only; not to be completed by FEMA)			
F1.			
F2.			
ELEMENT F: REQUIRED REVISIONS			

Appendix F. Plan Adoption Resolution

Orange County Transportation Authority Plan Adoption Resolution

Resolution #__________

OCTA Hazard Mitigation Plan [Insert Date of Mitigation Plan]

WHEREAS the [insert OCTA governing body name] recognizes the threat that natural hazards pose to people and property within the OCTA.

WHEREAS the OCTA has prepared a hazard mitigation plan in accordance with the Disaster Mitigation Act of 2000 and the requirements in Title 44 Code of Federal Regulations Section 201.6.

WHEREAS the Plan specifically addresses hazard mitigation strategies and plan maintenance procedures for the OCTA.

WHEREAS the Plan recommends several hazard mitigation actions and projects that will provide mitigation for specific natural hazards that impact the OCTA, with the effect of protecting people and property from loss associated with those hazards.

WHEREAS, adoption of this plan will make the OCTA eligible for funding to alleviate the impacts of future hazards in their planning area,

NOW THEREFORE BE IT RESOLVED by the [insert appropriate official titles] of the OCTA that:

1. The Plan is hereby adopted as an official plan of the OCTA.

2. The respective officials identified in the mitigation strategy of the Plan are hereby directed to pursue implementation of the recommended actions assigned to them.

3. Future revisions and plan maintenance required by 44 CFR 201.6 and FEMA are hereby adopted as a part of this resolution for a period of five (5) years from the date of this resolution.

4. An annual report on the progress of the implementation elements of the Plan shall be presented to the OCTA HMP Steering Committee by [insert date] of each calendar year.

5. OCTA will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, including 2 CFR Parts 200 and 3002; and will amend our plan whenever necessary to reflect applicable changes in federal and state laws and statutes.

PASSED by the [insert appropriate title], this ___ day of ____ (month), _____(year).

[Provide various signature blocks as required]

Appendix G. Hazards

Definitions of Hazard Ranking Factors

Table G-1 – Definitions of Hazard Ranking Factors

Rank	Severity	Magnitude	Frequency	Onset	Duration
1	No injuries or deaths expected – minimal damage or impacts on natural systems.	A single or limited number of properties impacted	Less than every 25 years	Greater than 30 days of warning	Only brief moments
2	Between 1 and 5 injuries or deaths. Minimal to moderate damage or impacts on natural systems.	Neighborhood or small community impacted	10–25 years	5–30 days of warning	1–24 hours
3	Between 5 and 25 injuries or deaths. Moderate damage or impacts on natural systems.	City or town impacted	5–10 years	1–5 days of warning	Days to weeks
4	Between 25 and 50 injuries or deaths. Extensive damage or impacts on natural systems.	Entire county impacted	1–5 years	1–10 hours of warning	Weeks to months
5	Greater than 50 injuries or deaths. Catastrophic damage or impacts on natural systems.	State and/or region impacted	Once per year	No warning	Months to years

Original Hazard Identification and Raking Results

Original 12 hazards and output tables, later condensed into the seven hazards profiles in this. The scores were measured with one is the lowest and five is the highest.

Table G-2 – Original OCTA Hazard Ranking Worst-Case Scenario

	Severity	Magnitude	Frequency	Onset	Duration	Average Score	Rank
Wildfire	3.82	4.18	4.55	4.18	2.91	3.93	1
Earthquake	4.09	4.18	2.82	5.00	2.27	3.67	2
Pandemic	4.18	4.27	1.55	2.91	4.18	3.42	3
Severe Weather	3.27	3.18	3.73	3.18	2.55	3.18	4
Flooding	2.85	3.18	3.36	3.36	2.64	3.08	5
Sea Level Rise	3.00	3.36	3.45	1.55	4.18	3.11	6
Storm Surge	3.18	2.73	3.64	3.45	2.18	3.04	7
Extreme Heat	3.18	3.45	3.36	2.18	3.00	3.04	8
Drought	2.55	3.00	3.27	1.45	4.36	2.93	9
Tsunami	3.73	3.00	1.45	4.18	1.82	2.84	10

	Severity	Magnitude	Frequency	Onset	Duration	Average Score	Rank
Cliff Erosion	2.45	2.36	2.73	2.91	2.73	2.64	11
Earth Movement	2.55	2.45	1.91	3.73	1.82	2.49	12

Table G-3 – OCTA Original Hazard Ranking Most-Likely Scenario

	Severity	Magnitude	Frequency	Onset	Duration	Average Score	Rank
Wildfire	3.73	3.64	4.45	4.00	3.55	3.87	1
Earthquake	3.09	3.82	3.09	4.82	1.91	3.35	2
Pandemic	4.00	4.00	1.18	3.00	4.09	3.25	3
Severe Weather	2.55	3.27	3.36	3.09	2.73	3.00	4
Extreme Heat	3.00	2.82	3.64	2.45	2.91	2.96	5
Sea Level Rise	2.82	3.00	2.91	1.55	4.36	2.93	6
Storm Surge	2.55	2.36	3.36	3.55	2.18	2.80	7
Flooding	2.73	2.45	3.36	2.82	2.45	2.76	8
Drought	2.27	2.55	3.18	1.36	4.36	2.75	9
Cliff Erosion	2.36	2.00	2.73	2.82	2.91	2.56	10
Earth Movement	2.18	2.09	1.64	3.36	1.73	2.20	11
Tsunami	2.18	2.18	1.09	3.45	2.00	2.18	12

Comprehensive List of FEMA Disaster Declarations

Table G-4 – FEMA Disaster Declarations for the Planning Area (Federal Emergency Management Agency, 2020)

Type of Incident	Date	Event Effects	Disaster ID
Severe Weather and Flood	1/26/1969	Severe storms and flooding	DR-253-CA
Wildfire	9/29/1970	Brush fires	DR-295-CA
Earthquake	2/9/1971	San Fernando	DR-299-CA
Severe Weather, Flood, Mass Earth Movement	2/15/1978	Coastal storms, mudslides, and flooding	DR-547-CA
Mass Earth Movement	10/9/1978	Landslides	DR-566-CA
Wildfire	10/29/1978	Brush fires	EM-3067-CA
Severe Weather, Flood, Mass Earth Movement	2/21/1980	Severe storms, mudslides, and flooding	DR-615-CA
Wildfire	11/27/1980	Brush and timber fires	DR-635-CA
Fire	4/24/1982	Urban fire	DR-657-CA

Type of Incident	Date	Event Effects	Disaster ID
Severe Weather, Flood, Mass Earth Movement	2/9/1983	Coastal storms, floods, slides, tornadoes	DR-677-CA
Earthquake	10/7/1987	Whittier Narrows	DR-799-CA
Severe Weather, Storm Surge, Flood	2/5/1988	Severe storms, high tides, flooding	DR-812-CA
Wildfire	6/30/1990	Fires	DR-872-CA
Severe Weather	2/11/1991	Severe freeze	DR-894-CA
Severe Weather, Flood, Mass Earth Movement	2/25/1992	Snowstorm, heavy rain, high winds, flooding, mudslide	DR-935-CA
Severe Weather, Flood, Mass Earth Movement	2/3/1993	Severe storm, winter storm, mud and landslides, and flooding	DR-979-CA
Wildfire, Mass Earth Movement, Erosion, Flood	10/28/1993	Fires, mud and landslides, soil erosion, and flooding	DR-1005-CA
Earthquake	1/17/1994	Northridge	DR-1008-CA
Severe Weather, Flood, Mass Earth Movement	1/10/1995	Severe winter storm, flooding, landslides, mudflows	DR-1044-CA
Severe Weather, Mass Earth Movement, Flood	3/12/1995	Severe winter storms, flooding, landslides, mudflows	DR-1046-CA
Wildfire	10/23/1996	Severe fires	EM-3120-CA
Severe Weather and Flood	2/9/1998	Severe winter storms and flooding	DR-1203-CA
Wildfire	5/14/2002	Antonio fire	FSA-2405-CA
Wildfire	6/6/2002	Copper fire	FSA-2417-CA
Wildfire	9/4/2002	Leona fire	FSA-2462-CA
Wildfire	9/24/2002	Williams fire	FSA-2464-CA
Wildfire	1/7/2003	Pacific fire	FM-2466-CA
Wildfire	10/24/2003	Verdale fire	FM-2502-CA
Wildfire	10/27/2003	Wildfires	DR-1498-CA
Wildfire	7/12/2004	Pine fire	FM-2528-CA
Wildfire	7/18/2004	Foothill fire	FM-2534-CA
Wildfire	7/21/2004	Crown fire	FM-2535-CA
Severe Weather, Flooding, Mass Earth Movements	2/4/2005	Severe storms, flooding, debris flows, and mudslides	DR-1577-CA
Severe Weather, Flooding, Mass Earth Movements	4/14/2005	Severe storms, flooding, landslides, mud, and debris flows	DR-1585-CA
Wildfire	9/28/2005	Topanga fire	FM-2583-CA
Wildfire	2/6/2006	Sierra fire	FM-2630-CA
Wildfire	3/11/2007	241 fire	FM-2683-CA
Severe Weather	3/13/2007	Severe freeze	DR-1689-CA
Wildfire	5/9/2007	Griffith Park fire	FM-2691-CA
Wildfire	5/10/2007	Island fire	FM-2694-CA

Type of Incident	Date	Event Effects	Disaster ID
Wildfire	7/8/2007	Canyon fire	FM-2708-CA
Wildfire	10/21/2007	Canyon fire	FM-2732-CA
Wildfire	10/21/2007	Buckweed fire	FM-2733-CA
Wildfire	10/22/2007	Santiago fire	FM-2737-CA
Wildfire	10/22/2007	Ranch fire	FM-2736-CA
Wildfire	10/23/2007	Wildfires	EM-3279-CA
Wildfire	10/24/2007	Wildfires	DR-1731-CA
Wildfire	4/27/2008	Santa Anita fire	FM-2763-CA
Wildfire	10/12/2008	Mareck fire	FM-2788-CA
Wildfire	10/13/2008	Sesnon fire	FM-2789-CA
Wildfire	11/15/2008	Sayre fire	FM-2791-CA
Wildfire	11/15/2008	Freeway complex fire	FM-2792-CA
Wildfire	11/18/2008	Wildfires	DR-1810-CA
Wildfire	8/27/2009	PV fire	FM-2828-CA
Wildfire	8/28/2009	Station fire	FM-2830-CA
Severe Weather, Flood, Mass Earth Movement	3/8/2010	Severe winter storms, flooding, and debris and mudflows	DR-1884-CA
Severe Weather, Flood, Mass Earth Movement	1/26/2011	Winter storms, flooding, and debris and mudflows	DR-1952-CA
Wildfire	6/2/2013	Power House fire	FM-5025-CA
Wildfire	1/16/2014	Colby fire	FM-5051-CA
Earthquake	8/24/2014	South Napa	DR-4193-CA
Wildfire	6/5/2016	Old fire	FM-5124-CA
Wildfire	6/21/2016	Fish fire	FM-5129-CA
Wildfire	7/9/2016	Sage fire	FM-5132-CA
Wildfire	7/23/2016	Sand fire	FM-5135-CA
Severe Weather, Flood, Mass Earth Movement	3/16/2017	Severe winter storms, flooding, and mudslides	DR-4305-CA
Wildfire	9/2/2017	La Tuna fire	FM-5201-CA
Wildfire	9/26/2017	Canyon fire	FM-5213-CA
Wildfire	10/9/2017	Canyon 2 fire	FM-5223-CA
Wildfire	10/10/2017	Wildfires	DR-4344-CA
Wildfire	12/5/2017	Creek fire	FM-5225-CA
Wildfire	12/5/2017	Rye fire	FM-5226-CA
Wildfire	12/6/2017	Skirball fire	FM-5227-CA
Wildfire	12/8/2017	Wildfires	EM-3396-CA
Wildfires, Flood, Mass Earth Movements	1/2/2018	Wildfires, flooding, and mud and debris flows	DR-4353-CA

Type of Incident	Date	Event Effects	Disaster ID
Wildfire	11/9/2018	Wildfires	EM-3409-CA
Wildfire	11/12/2018	Wildfires	DR-4407-CA
Wildfire	10/11/2019	Saddleridge fire	FM-5293-CA
Wildfire	10/24/2019	Tick fire	FM-5296-CA
Pandemic	3/13/2020	COVID-19	EM-3428-CA
Pandemic	3/22/2020	COVID-19	DR-4482-CA

Comprehensive List of Severe Weather Events

Table G-5 – Severe Weather Events in the Planning Area Resulting in Deaths, Injuries, or Costs Equal or Greater Than $25,000 (National Oceanic and Atmospheric Administration)

Date	Severe Weather Type	Deaths/Injuries	Property Damage Value
5/9/1956	Tornado	1 injury	$25,000
5/14/1962	Tornado	0	$25,000
11/7/1966	Tornado	10 injuries	$250,000
3/16/1977	Tornado	4 injuries	$2,500,000
5/8/1977	Tornado	0	$2,500,000
2/9/1977	Tornado	6 injuries	$2,500,000
11/9/1982	Tornado	0	$2,500,000
3/1/1983	Tornado	30 injuries	$25,000,000
9/30/1983	Tornado	0	$250,000
10/1/1983	Tornado	3 injuries	$2,500
3/16/1986	Tornado	0	$2,500,000
6/5/1987	Tornado	0	$25,000,000
1/18/1988	Tornado	0	$25,000
12/7/1992	Tornado	0	$250,000
1/14/1993	Tornado	0	$500,000
1/17/1993	Tornado	0	$50,000
1/17/1993	Tornado	1 injury	$5,000,000
1/18/1993	Tornado	0	$50,000
2/8/1993	Tornado	0	$50,000
2/23/1993	Thunderstorm	0	$50,000
11/11/1993	Tornado	2 injuries	$1,000
2/7/1994	Tornado	0	$50,000
2/7/1994	Tornado	0	$500,000
10/21/1996	Wildfire	16 injuries	$1,500,000
10/21/1996	Wildfire	0	$3,000,000
1/1/1997	Storm Surge/Tide	27 injuries	$0

Date	Severe Weather Type	Deaths/Injuries	Property Damage Value
1/20/1997	Heavy Rain	4 injuries	$0
8/5/1997	Rip Current	1 death/3 injuries	$0
9/14/1997	High Surf	4 injuries	$0
12/6/1997	Flash Flood	0	$17,700,000
1/9/1998	Tornado	1 injury	$0
2/6/1998	Flood	0	$4,290,000
2/6/1998	Flash Flood	0	$880,000
2/7/1998	Flash Flood	1 death/2 injuries	$0
2/9/1998	Flash Flood	1 death	$0
2/23/1998	Flash Flood	3 deaths	$0
2/23/1998	Flash Flood	2 deaths/2 injuries	$29,700,000
5/2/1998	High Surf	1 death	$0
7/20/1998	Lightning	1 injury	$0
12/1/1998	Heavy Rain	0	$140,000
12/6/1998	Thunderstorm	0	$450,000
12/9/1998	High Wind	0	$50,000
12/9/1998	Wildfire	0	$25,000
2/9/1999	Dust Storm	1 injury	$0
2/20/1999	High Surf	1 death/3 injuries	$0
4/9/1999	High Wind	1 injury	$0
5/26/1999	Lightning	1 death	$0
6/23/1999	High Surf	3 injuries	$250,000
6/18/1999	Rip Current	1 death	$0
7/13/1999	Lightning	1 injury	$0
12/27/1999	Wildfire	1 injury	$0
2/10/2000	Heavy Rain	1 death/4 injuries	$300,000
2/23/2000	Thunderstorm	1 injury	$0
3/3/2000	Lightning	0	$50,000
3/5/2000	Thunderstorm	0	$100,000
3/6/2000	Hail	1 death	$75,000
4/17/2000	Rip Current	1 death	$0
5/18/2000	Rip Current	1 death	$0
5/27/2000	Rip Current	2 injuries	$0
6/4/2000	Rip Current	1 death	$0
8/1/2000	Rip Current	2 injuries	$0
8/17/2000	Rip Current	1 death	$0
8/2/2000	Wildfire	0	$100,000

Date	Severe Weather Type	Deaths/Injuries	Property Damage Value
9/11/2000	Wildfire	2 injuries	$0
10/27/2000	Flood	0	$30,000
1/9/2001	Storm Surge/Tide	0	$240,000
1/10/2001	Flood	3 injuries	$0
1/11/2001	Flash Flood	0	$1,000,000
2/11/2001	Heavy Rain	0	$250,000
2/12/2001	Flood	0	$60,000
2/13/2001	Thunderstorm	0	$25,000
2/24/2001	Dense Fog	1 injury	$0
2/24/2001	Tornado	0	$50,000
4/20/2001	Thunderstorm	1 injury	$0
5/12/2001	Rip Current	1 death	$0
9/16/2001	Rip Current	1 injury	$0
9/19/2001	Rip Current	1 death	$0
12/7/2001	Rip Current	1 death/1 injury	$0
1/23/2002	Wildfire	1 injury	$0
2/9/2002	Wildfire	0	$1,200,000
5/13/2002	Wildfire	0	$250,000
9/1/2002	Wildfire	14 injuries	$12,700,000
9/1/2002	Heat	1 death	$0
9/22/2002	Wildfire	14 injuries	$15,300,000
11/03/2002	Dense Fog	41 injuries	$0
11/7/2002	Rip Current	1 death	$0
11/8/2002	Flood	0	$150,000
11/20/2002	Wildfire	2 injuries	$0
12/15/2002	Rip Current	5 injuries	$0
12/16/2002	Flood	0	$150,000
2/25/2003	Heavy Rain	1 injury	$150,000
6/26/2003	Rip Current	1 death	$0
7/1/2003	Rip Current	1 injury	$0
7/21/203	Rip Current	1 death	$0
7/24/2003	Rip Current	1 death	$0
7/28/2003	Lightning	1 injury	$0
11/12/2003	Flash Flood	0	$35,000
11/12/2003	Hail	0	$3,500,000
2/2/2004	Flash Flood	0	$75,000
2/26/2004	Flash Flood	0	$25,000

Date	Severe Weather Type	Deaths/Injuries	Property Damage Value
2/26/2004	Flash Flood	0	$30,000
10/20/2004	Flash Flood	1 death	$0
11/27/2004	Strong Wind	1 death/1 injury	$0
12/28/2004	Thunderstorm	0	$30,000
1/7/2005	Heavy Rain	0	$5,000,000
1/7/2005	Heavy Rain	0	$15,000,000
1/9/2005	Flash Flood	0	$300,000
1/9/2005	Flash Flood	0	$50,000
1/9/2005	Flash Flood	1 death	$0
1/9/2005	Flash Flood	0	$500,000
2/18/2005	Heavy Rain	0	$20,000,000
2/19/2005	Thunderstorm	0	
2/20/2005	Flash Flood	0	$1,000,000
2/20/2005	Debris Flow	1 death	$300,000
2/21/2005	Flash Flood	0	$100,000
2/22/2005	Flash Flood	0	$30,000
4/28/2005	Thunderstorm	0	$45,000
12/21/2005	Coastal Flood	1 injury	$0
2/6/2006	Wildfire	8 injuries	$0
4/10/2007	High Surf	2 deaths	$0
9/3/2007	Excessive Heat	8 deaths	$0
9/22/2007	Flash Flood	0	$300,000
1/6/2008	Flash Flood	0	$40,000
5/22/2008	Flash Flood	0	$500,000
5/22/2008	Flash Flood	0	$150,000
12/15/2008	Heavy Rain	14 injuries	$250,000
1/18/2010	Heavy Rain	0	$100,000
1/19/2010	Tornado	0	$500,000
1/19/2010	Thunderstorm	0	$350,000
1/19/2010	Thunderstorm	0	$25,000
1/20/2010	Heavy Rain	0	$50,000
12/19/2010	Flood	0	$36,000,000
12/22/2010	Flash Flood	0	$12,300,000

Reportable Diseases and Rates

Table G-6 – Orange County 2019 Reportable Diseases and Rates (Orange County Health Care Agency, 2019)

Diseases/ Conditions	Common Name	2015	2016	2017	2018	2019
Amebiasis	Amoebic Dysentery	13	14	11	7	12
Botulism		3	3	3	0	0
Brucellosis		5	2	2	2	1
Campylobacteriosis		398	488	544	575	651
Chlamydial Infection		11459	12837	13997	17277	14139
Coccidioidomycosis	Valley Fever	186	116	211	242	320
Chikungunya	CHIKV	24	2	2	0	2
Creutzfeldt-Jakob Disease	CJD	4	1	1	4	2
Cryptosporidiosis	Crypto	27	26	35	26	43
Cysticercosis	Pork Tapeworm	4	4	5	2	0
Dengue	Dengue Fever	12	12	10	12	19
E. coli, Shiga Toxin-Producing	STEC E. coli	52	50	45	105	140
Encephalitis		17	15	16	9	12
Giardiasis		126	177	126	134	163
Gonococcal Infection	Gonorrhea	2317	3060	3511	3887	3873
Haemophilus influenza, Invasive Disease	Hib	2	1	7	0	6
Hansen's Disease	Leprosy	2	1	0	0	1
Hemolytic Uremic Syndrome	HUS	0	1	0	0	0
Hepatitis A, Acute	HAV	17	26	19	10	18
Hepatitis B, Acute Non-Perinatal	HBV	10	5	13	10	7
Hepatitis B, Perinatal		2	1	4	0	-
Hepatitis C, Acute		5	6	10	5	1
Hepatitis D	HDV	0	1	0	0	2
Hepatitis E	HEV	0	3	1	0	0
Legionellosis	Legionnaires' Disease	33	57	69	40	72
Listeriosis		12	5	16	9	7
Malaria		9	9	3	4	5
Meningitis		281	234	199	172	132
Meningococcal Infections		2	11	2	2	1
Mumps		5	5	27	13	31
Pertussis	Whooping Cough	138	65	182	141	159
Q-Fever		1	0	0	2	2
Respiratory Syncytial virus	RVS	0	1	1	2	0
Rocky Mountain Spotted Fever		2	0	0	0	2
Salmonellosis	Salmonella	489	359	366	437	428

Diseases/ Conditions	Common Name	2015	2016	2017	2018	2019
Shigellosis		69	71	96	178	176
Syphilis		742	904	1130	1221	1437
Typhoid Fever, Case		2	4	7	3	7
Typhus & Other Non-Spotted Fever Rickettsioses		17	15	13	18	18
Varicella Hospitalization	Chickenpox	8	5	7	3	8
Vibrio Infections (non-Cholera)		29	12	19	31	24
West Nile Virus Infections		97	36	38	13	7
Yersiniosis		14	24	14	13	32
Zika Virus Infection		0	30	12	1	2

Appendix H. References

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