OCTA
2024

CLIMATE ADAPTATION AND SUSTAINABILITY PLAN

Orange County Transportation Authority

CONTENTS

1 EXECUTIVE SUMMARY

The Orange County Transportation Authority (OCTA) is Orange County's primary transportation agency, serving the third most populous county in the state of California.

OCTA's mission is to develop and deliver transportation solutions to enhance the quality of life and keep Orange County moving.

As the impacts of a changing climate become more pronounced in Orange County, OCTA understands that in order to champion its mission, it is critical for the agency to also champion sustainability and climate adaptation.

HISTORY OF ENVIRONMENTAL STEWARDSHIP

OCTA has a long-standing history of environmental stewardship and has been proactively laying the groundwork for a resilient transportation system. This includes several key efforts, such as:

1) Since 2011, OCTA has been tracking and reporting its greenhouse gas (GHG) emissions.
2) Over two decades ago, OCTA adopted its first Long Range Transportation Plan (LRTP), which lays out an agency-wide strategy to address the growing transportation needs of Orange County's population while ensuring that transportation options are sustainable, equitable, and innovative.
3) Two environmental programs were integrated into the Measure M (or OC Go) sales tax: the Environmental Mitigation Program and Environmental Cleanup Program. These programs ensure sensitive species in the region are protected in their native habitat and help improve overall water quality in Orange County.
4) In 2020, OCTA adopted its *Zero-Emission Bus (ZEB) Rollout Plan*, which commits the agency to transitioning to a **100% zero-emission bus fleet by 2040**.
5) In 2021, OCTA, in partnership with the State of California Department of Transportation (Caltrans), developed the *Rail Defense Against Climate Change Plan,* which identified climate-change-related opportunities and challenges.
6) In 2021, OCTA issued its *Natural Hazard Mitigation Plan* to support current OCTA emergency and crisis management plans and strengthen the agency's preparedness in the face of natural hazards, including climate change.
7) OCTA voluntarily transitioned its coach operator relief vehicles to 100% battery-electric and is in the process of converting its remaining non-revenue gasoline-fueled fleet to zero-emission.

CLIMATE ADAPTATION & SUSTAINABILITY ASSESSMENTS

The 2023 *Climate Adaptation and Sustainability Plan* (CASP) builds upon these environmental stewardship efforts by compiling a comprehensive inventory of all efforts to date and establishes an exploratory framework of potential strategies in two key areas: **Climate Adaptation** and **Sustainability** (focused on mitigating the effects of climate change). To develop the CASP, OCTA undertook two parallel studies to establish a data-informed foundation for the exploration of potential strategies:

(1) Climate Vulnerability Assessment

Through this assessment, OCTA evaluated the vulnerability of the agency's key assets, including infrastructure, service operations, and ridership population, to climate-related risks and stressors in the next few decades while also considering the severity of these hazards. OCTA identified 34 unique assets across 19 asset types and evaluated them against the following climate hazards: air quality, precipitation changes and drought, flooding (riverine), severe storms and extreme weather, storm surges, temperature changes (warming and high heat), and wildfires.

Using a set of impact and adaptive capacity scores as described in this plan, and through a robust stakeholder engagement process, OCTA determined the vulnerability of each asset and ranked overall risks. Adaptation strategies were then developed for assets with a vulnerability rating above V3—with V1 being the lowest and V5 the highest ratings—for each of the seven climate stressors studied.

The results of the Climate Vulnerability Assessment determined that OCTA is at risk to various natural hazards presented by climate change, which if not addressed, could potentially lead to customer hardship, increased operating and maintenance costs, damaged infrastructure, and widespread operational disruption. However, the changes in climate for Orange County are predicted to happen relatively slowly, giving OCTA an important opportunity to develop and implement tailored strategies to effectively minimize the impacts associated with each hazard.

This assessment serves as the basis for exploring flexible adaptation strategies tailored to the agency's specific vulnerabilities and is intended to guide both the planning and implementation processes.

(2) GHG Emissions Inventory and Forecasting

OCTA has been reporting its GHG emissions for over a decade. However, as part of the development of the CASP, OCTA fine-tuned its methodology and data quality to improve the accuracy of its previous inventories. A GHG inventory covering the agency's daily operational emissions was developed for Scopes 1 and 2[1] emission sources using a 2021 baseline year. This includes the agency's facilities, vehicle and equipment fuels, refrigerants, and purchased electricity. The total emissions for 2021 are equivalent to **22,494 $MTCO_2e$[2]**, the majority of which are associated with the agency's consumption of fuels to power the transit and non-revenue fleet vehicles.

The 2021 emissions baseline reflects a significant reduction in emissions compared to prior years due to the use of low-carbon renewable natural gas (RNG) in the bus fleet and reductions in service due to the COVID-19 pandemic. In fact, RNG contributes a similar quantity of emissions as unleaded gasoline, despite the RNG-powered fleet being significantly larger (over 515 vehicles) than the vehicle fleets fueled by gasoline (over 395 revenue and non-revenue vehicles)[3]. Overall, these two fuels are the agency's largest sources of emissions, with RNG contributing 34% and gasoline contributing 39% to OCTA's total carbon footprint. The remaining emissions come from OCTA's facility electricity and natural gas consumption, and a small portion from refrigerants. This emissions profile is the basis for the identification of the strategies laid out in the CASP, and 2021 will thus serve as the agency's emission baseline for monitoring performance improvements in future years.

CLIMATE ADAPTATION & SUSTAINABILITY STRATEGIES

Building upon the climate adaptation and sustainability assessments, the CASP explores several strategies for OCTA's consideration.

[1] Scope 1 emissions include direct emissions from stationary combustion (i.e., OCTA facilities), mobile combustion (i.e., vehicle and equipment fuel), and fugitive emissions (i.e., refrigerants). Scope 2 emissions include indirect emissions from purchased electricity (i.e., for facilities and rail). Scope 3 emissions, which would include indirect emissions that are tied to OCTA's value chain, are not included in the baseline inventory.

[2] MTCO2e, or Metric Ton of Carbon Dioxide equivalent, is a unit of measurement that is used to standardize emissions from different greenhouse gases based on their global warming potential. More detail is available in Appendix F.

[3] Number of vehicles is based on 2022 OCTA Transit Asset Management (TAM) Plan

The strategies were developed through close collaboration with OCTA's internal and external stakeholders and are intended to serve as an exploratory framework for future decision making regarding OCTA's climate adaptation and sustainability initiatives.

Through the development of the CASP, OCTA is taking a proactive approach to be more sustainable and resilient by developing flexible adaptation strategies that could be implemented across short-, medium, and long-term planning horizons. Consistent with the California Governor's Office of Emergency Services (Cal OES) Adaptation Planning Guide (2020)[4], which recommends climate action/adaptation plans consider time horizons to at least 2050, and often to 2100, these timeframes are defined as follows:

- **Short-Term** refers to the timeframe between 2023 – 2035.
- **Medium-Term** refers to the timeframe within 2035 – 2070.
- **Long-Term** refers to the timeframe between 2070 – 2100.

Some adaptation strategies are intended to be iterative or initiated at a later date, and therefore may be implemented across several of these time frames, while others are intended to respond to specific future trigger points.

The adaptation strategies presented in the CASP are organized around the specific climate hazards they are intended to address: Air Quality, Drought, Extreme Weather, High Heat, Flooding, Storm Surge, and Wildfire. Different OCTA assets experience these hazards to different extents and at different time frames, because each asset category has varying characteristics related to physical structure, operations, geographic location, and current conditions. As such, measures are further tailored to specific asset categories.

The sustainability strategies outlined in the CASP are centered around actions the agency can take to reduce its operational GHG emissions. The sustainability strategies were evaluated and are presented using a three-tiered scenario approach, where each exploratory strategy presents a conservative, moderate, and aggressive option. This is intended to give OCTA flexibility through the strategy prioritization and implementation phases.

Based on the results of the baseline GHG inventory, the specific sustainability strategies outlined in this plan address both emissions from revenue and non-revenue fleets, as well as emissions generated by OCTA's facilities. Strategies that address vehicle emissions include a transition to a Zero Emission Bus Fleet (which is already in progress) and mitigating non-revenue vehicle emissions through the use of alternative fuels or electric vehicle options. Strategies to reduce facility emissions include implementation of energy efficiency measures (e.g., LED lighting, controls, and retro-commissioning), electrifying facilities by replacing gas-powered equipment with electric alternatives, and on-site renewables (e.g., onsite rooftop solar). To further reduce emissions beyond the aforementioned measures, OCTA may also explore options for purchasing renewable energy directly from the utility or purchasing renewable energy certificates (RECs) to further offset the emissions from the agency's purchased

[4] Governor's Office of Emergency Services (Cal OES). California Adaptation Planning Guide. 2020. <California Adaptation Planning Guide>

electricity (which may not be feasible to offset through the other measures presented in this plan). Unlike the adaptation strategies, the identified sustainability strategies could likely be implemented in the short-term.

A summary of potential adaptation and sustainability strategies for OCTA's consideration are listed in the figures below.

Climate Adaptation Strategies:

1. Air Quality & Emissions Management
2. Building & Infrastructure Development
3. Emergency Preparedness
4. Human Comfort & Health Enhancement
5. Greenery & Landscape Management
6. Energy Efficiency & Renewable Energy

Sustainability Strategies:

1. 100% Zero-Emission Bus Fleet
2. Cleaner Non-Revenue Fleet
3. Facility Energy Efficiency
4. Facility Electrification
5. Onsite Renewables
6. Purchase Renewable Energy
7. Purchase Renewable Energy Credits

RESULTS & NEXT STEPS

Based on the results of the Climate Vulnerability Assessment and GHG Emissions Inventory, and through extensive engagement with OCTA staff and key external stakeholders, the CASP outlines exploratory targets and strategies that could be implemented to advance adaptation and sustainability at OCTA.

The strategies identified to promote resilience utilize a flexible adaptation approach. Preventive measures are identified in the short term and key triggers are monitored that may indicate the need for additional action to respond to climate stressors in the longer term.

As previously mentioned, the sustainability strategies outline potential carbon mitigation measures that OCTA could pursue to reduce its operational emissions using a three-tiered scenario of conservative, moderate, and aggressive implementation targets. If OCTA decides to pursue all measures as outlined in the CASP, the results of the analysis show that the agency could **reduce its GHG emissions by 80% (down to 1,674 MTCO_2e) by 2045,** compared to the forecasted 2045 business-as-usual scenario.

Through this plan, OCTA aims to safeguard the community it has served with dedication for over 50 years and prepare for a resilient and sustainable future. While this plan does not establish commitments on behalf of the agency, it is intended to identify potential pathways and facilitate goal setting as a next step.

In the next phase of implementation of the CASP, OCTA will strive to establish goals, and conduct more financial and feasibility analysis on potential projects and actions in support of the strategies laid out in the CASP.

2 INTRODUCTION

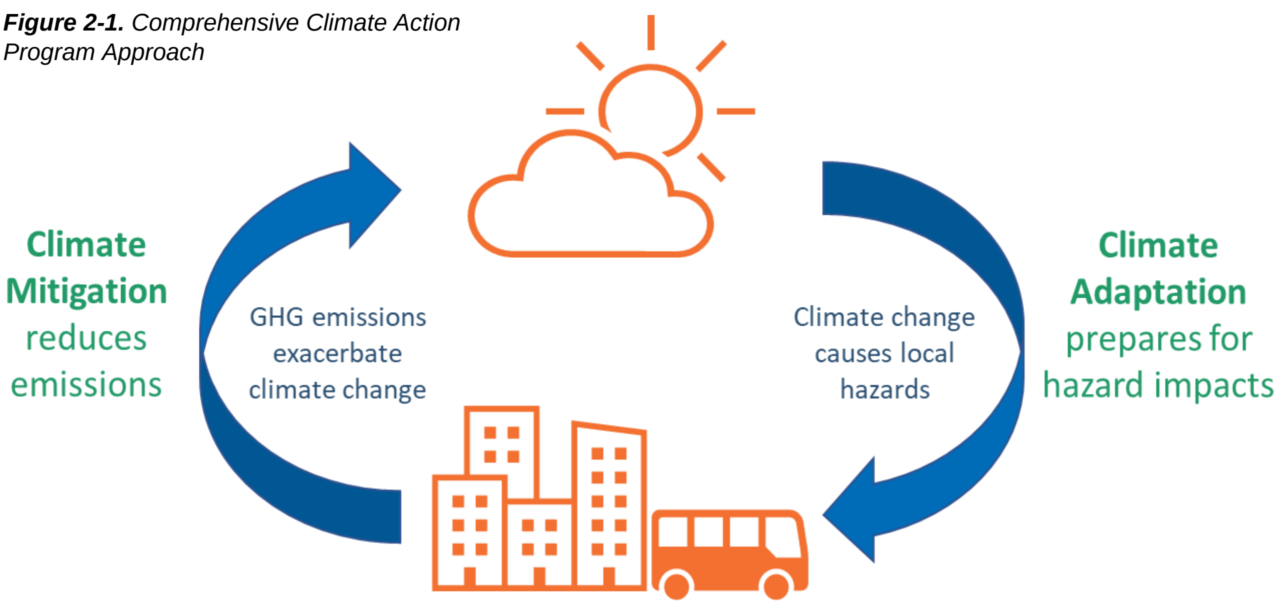
The Orange County Transportation Authority (OCTA) is Orange County's transportation planning agency, responsible for funding, implementing, and operating transit and capital projects to deliver a balanced and sustainable transportation system for the county's 34 cities and unincorporated communities and more than 3.17 million residents[5]. OCTA serves the transportation needs of tens of millions of the traveling public each year through bus and rail transit, freeways, express lanes, rideshare, commuter rail, and active transportation.

As the climate in Southern California changes, it could pose significant risks and challenges to the employees, customers, essential workers, and communities that OCTA serves. Therefore, it is paramount that OCTA's operations and infrastructure are made more resilient. OCTA recognizes the urgent need to identify current and future climate hazards and their frequencies, assess relevant transit system vulnerabilities, and develop concrete adaptation strategies to protect OCTA's transit system and reduce service disruptions.

Additionally, as the primary public transportation provider in Orange County, OCTA has an important role to play in addressing its share of the underlying cause of climate change by reducing greenhouse gas (GHG) emissions, both directly from its transit operations and indirectly by providing alternatives that help reduce vehicle miles traveled (VMT) across the region. OCTA not only offers low-emission, energy efficient alternatives to driving for Orange County residents but also provides funding for regional projects that improve the transportation network. The benefits of the services provided by OCTA are not limited to GHG mitigation, but also include better air quality, congestion reduction, improvements in traffic safety, and increasing accessibility to work or education opportunities in Orange County.

OCTA is taking a two-pronged approach to climate action consistent with national, state, and local policies and best practices by preparing to adapt to the impacts caused by climate change while simultaneously mitigating GHG emissions at the source (Figure 2-1).

Figure 2-1. *Comprehensive Climate Action Program Approach*



[5] United States Census Bureau. "Quickfacts: Orange County, California." n.d. <https://www.census.gov/quickfacts/orangecountycalifornia>.

In 2010, OCTA publicly acknowledged its commitment to addressing climate change by signing the American Public Transportation Association (APTA) Sustainability Commitment, which dedicates the agency to pursuing sustainable operations and practices, enhancing the resiliency of its operations and infrastructure against extreme weather events, and protecting the health and safety of its employees and riders. For the last several years, OCTA has been actively operationalizing this commitment by planning and implementing GHG reduction measures, including transitioning to low-carbon vehicle fuels, piloting zero-emission bus technologies, and converting its operator relief vehicles to battery-electric with ongoing plans to replace the remaining non-revenue vehicle fleet to zero-emission vehicles.

Building on this history of environmental stewardship, in early 2022, OCTA initiated the development of the Climate Adaptation and Sustainability Plan (CASP or Plan), which explores pathways and potential strategies for OCTA to further reduce GHG emissions and climate impacts resulting from its operational and maintenance programs, while establishing processes to ensure agency resilience to severe climate events, such as extreme heat, wildfires, and flooding.

2.1 OCTA's ROLE IN REGIONAL CLIMATE ACTION

Transportation agencies are vulnerable to the impacts of climate change, and because OCTA provides critical services across the region, the agency must address its own vulnerability and implement climate adaptation strategies to ensure continuity of services in response to these hazards. In California, these climate hazards include (but are not limited to):

- Sea-level rise that threatens coastal wetlands, infrastructure, coastal access, sensitive habitat areas, and property;
- Increased storm activity, together with sea-level rise, which could increase beach erosion and cliff undercutting;
- Warmer temperatures and more frequent storms due to El Niño that bring more rain instead of snow to the Sierra Nevada Mountains, reducing supply of water for summer needs;
- Increased frequency and severity of major wildfires that can disrupt public infrastructure, deteriorate air quality, and result in the loss of property, crops, resources, animals, and people.

These extreme weather events can damage transit infrastructure, such as roads, bridges, tunnels, and rail lines, and disrupt services. These impacts can cause delays, cancellations, and schedule interruptions, which could have significant economic and social impacts on the communities that depend on these services. In addition to infrastructure impacts, climate change can also affect transit-dependent populations, such as low-income or elderly communities, who rely on public transportation for their daily needs. These populations may be more vulnerable to the impacts of extreme weather events, such as heatwaves or floods, which can cause health risks or other difficulties in accessing OCTA services. By implementing adaptation strategies, OCTA can prepare for climate change and minimize these impacts on its infrastructure and the communities it serves.

Foremost amongst OCTA's contributions to climate action is supporting mode shift: promoting its high-capacity public transit system, carpooling, and active transportation modes (e.g., walking, biking, rolling) as affordable and accessible alternatives to single-occupancy vehicles (SOVs). Mode shift is critical to reducing GHG emissions from the transportation sector, which is responsible for 40% of all GHG emissions in California.[6] Through its bus and rail services (i.e., OC Bus, OC ACCESS, OC Flex, OC Streetcar, Metrolink), rideshare services (i.e., OC Rideshare, OC Vanpool), and its active transportation programs (i.e., OC Bike, OC Walk), OCTA is providing mobility alternatives to Orange County residents that take vehicles off the road and prevent both GHG emissions and harmful criteria air pollutant emissions.

OCTA also displaces emissions through mobility improvement projects and programs, such as congestion management (e.g., express lanes), signal synchronization, and transportation infrastructure. To date, OCTA has leveraged more than $6 million from the Low Carbon Transit Operations Program (LCTOP) for these types of improvements – a Caltrans program designed to assist transit agencies like OCTA with reducing emissions and improving mobility with a focus on disadvantaged communities (DACs).[7] LCTOP funds have been crucial to supporting initiatives that enable more residents to use OCTA services (such as the OCTA College Pass Program).

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[6] California Air Resources Board. "Current California GHG Emission Inventory Data." 2021. <https://ww2.arb.ca.gov/ghg-inventory-data>.

[7] Caltrans. "Low Carbon Transit Operations Program (LCTOP)." n.d. <https://dot.ca.gov/programs/rail-and-mass-transportation/low-carbon-transit-operations-program-lctop>.

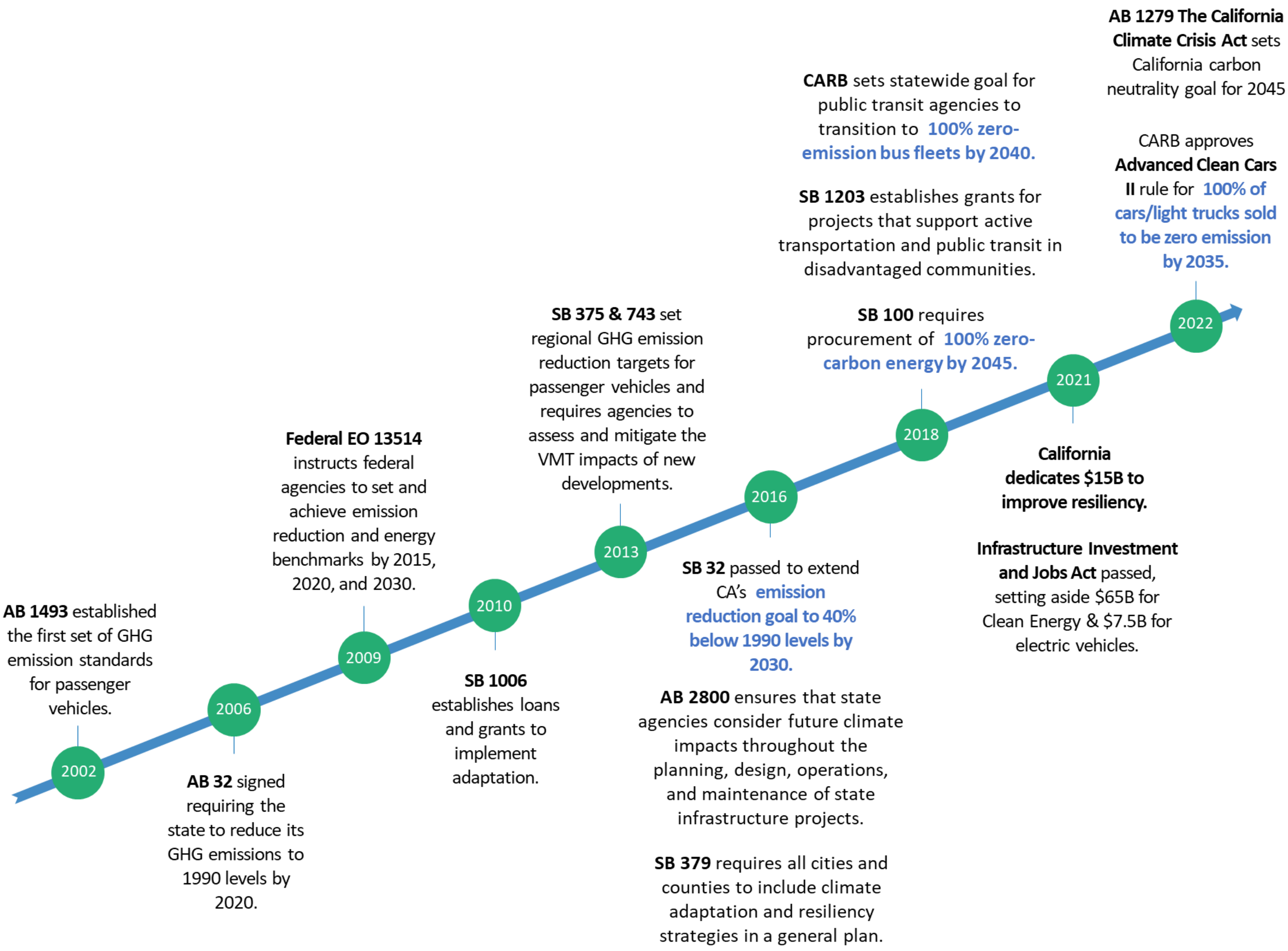
OCTA also has an important role in supporting local and regional climate policy goals. Through several legislative actions, California has set mandatory cross sectoral GHG emissions reduction targets. Senate Bill (SB) 32 (2016) set a target to reduce statewide emissions to 40% below 1990 levels by 2030, and SB 100 (2018) requires all retail electricity to be sourced from 100% zero-carbon sources by 2045. Additionally, OCTA is subject to regulations issued by the California Air Resources Board (CARB), such as the Innovative Clean Transit Rule adopted in 2018 that requires public transit agencies to gradually transition to a 100% zero-emission bus fleet by 2040.

These regulatory responsibilities and prescribed timelines, combined with rapidly evolving technology in the transportation sector, underscore OCTA's role as a significant contributor and facilitator of action and collaboration with and among its peer agencies in Orange County, to achieve federal and statewide sustainability and climate action goals.

The CASP is the next step on OCTA's path forward as a regional leader on climate action. Serving as an exploratory framework, the CASP will allow OCTA to build on its efforts to protect the integrity of its system from the impacts of climate change and provide emissions-free and resilient transportation and improved mobility to Orange County residents now and into the future.

Figure 2-2 shows a timeline of international, federal, and California state action on climate change. The blue text in Figure 2-2 indicates quantitative and time-bound, emissions reduction targets established by climate policies.

Figure 2-2. *Timeline of Federal and State Action on Climate Change*



2.2 PLAN PURPOSE & OBJECTIVES

OCTA's Commitment:

Provide equitable, sustainable, and environmentally conscious public transportation throughout vibrant, diverse Orange County.

Plan Vision:

Champion sustainability and environmental stewardship, while planning and adapting to a changing environment in order to maintain reliable, accessible, and balanced transportation choices.

The purpose of this *Climate Adaptation and Sustainability Plan* is to build on OCTA's sustainability and climate action efforts and explore additional strategies that will enable the agency to adapt to the current and future climate-related risks and hazards and mitigate the agency's contribution to climate change — all while serving the transportation and mobility needs of Orange County. This plan is an exploratory, strategic framework that establishes guiding principles and potential strategic pathways by which the agency can further incorporate sustainability (GHG emissions mitigation) and climate adaptation into its planning, facilities operations, resource use, and services through 2045.

The core objectives of this plan are to:

1) Establish a formal 2021 performance baseline and reporting framework to track the agency's progress over time.
2) Explore potential goals, targets, and strategies for climate adaptation and sustainability.
3) Provide a tool to inform the planning and decision-making process.
4) Ensure consistency and compliance with applicable state and federal climate adaptation and sustainability requirements.

Rigorous analyses of OCTA's current practices, observed climate impacts, and climate-related vulnerabilities informed the development of this CASP. OCTA also compiled and assessed best practices and recommended climate action guidance from its peer transit agencies, municipal governments, regional and state agencies, and peer organizations (e.g., Los Angeles County Metropolitan Transportation Authority, Sound Transit, the Santa Clara Valley Transportation Authority, Caltrans, Metrolink, etc.), which guided development of the adaptation and sustainability measures in this plan.

While OCTA's sustainability efforts will mainly focus on operations and assets directly owned and operated by the agency, other assets across Orange County that fall within OCTA's sphere of influence are also considered. Due to OCTA's prior development of the *Rail Defense Against Climate Change Plan*, the adaptation portion of the CASP focuses on areas that were beyond the shared railway asset in the Climate Vulnerability Assessment itself.

2.3 PLANNING PROCESS OVERVIEW

OCTA employed a holistic approach to planning through all four phases of the CASP's development processes, drawing not only from current data and best practices, but also from internal and external stakeholders. The CASP planning process is shown below in Figure 2-3.

Phase 1 featured a thorough review of OCTA's operations and assets to appropriately scope the Plan. Through this review, OCTA identified operational activities and assets where the agency has the greatest level of control that could then be prioritized for implementing climate adaptation and sustainability strategies. OCTA invited internal stakeholders to participate in a targeted scoping workshop to set plan boundaries based on operational control, gaps between other existing plans, and other considerations.

Phase 2 consisted of a current state assessment to capture OCTA's existing efforts around climate adaptation and mitigation within the context of pertinent regional and state policy drivers. The purpose of this assessment was three-fold:

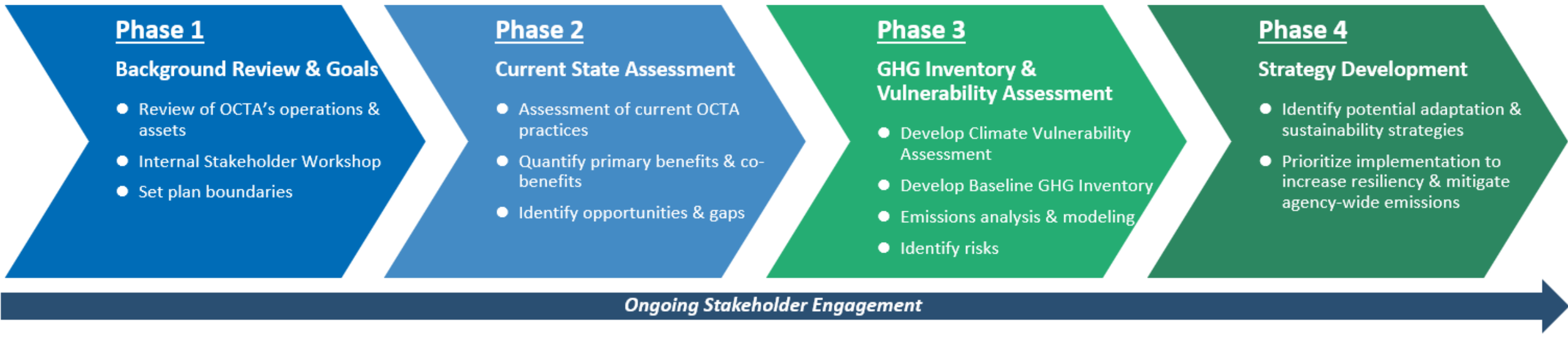
1) To determine how well OCTA programs were performing with respect to achieving regional and statewide goals.
2) To quantify the primary benefits and co-benefits of existing projects and programs.
3) To identify opportunities and gaps to be addressed by the CASP.

Phase 3 focused on the development of a climate vulnerability assessment and baseline GHG emissions inventory to serve as the foundations for exploring potential adaptation and sustainability targets and measures. During this phase, OCTA also developed emissions reduction models and scenario pathways to forecast both future climate risks and GHG emissions trajectory through mid-century based on the potential scope of OCTA's activities.

Phase 4 concluded the planning process by identifying and vetting a menu of potential flexible adaptation and sustainability strategies to increase resiliency and mitigate agency-wide emissions in collaboration with internal and external stakeholders.

Stakeholder Engagement: Through the creation of two advisory bodies – the Internal Advisory Group and the External Stakeholder Group – OCTA engaged more than 50 internal staff members and external stakeholder representatives throughout the development of the CASP. The Internal Advisory Group is comprised of OCTA staff representing various divisions and departments. The External Stakeholder group includes representatives from local and regional agencies such as cities. Throughout this process, agency leadership, staff members, and external groups provided routine input that helped align the Plan with existing agency plans, ongoing/upcoming external efforts, and current policies and regulations.

Figure 2-3. *CASP Planning Process Overview*



2.4 LAYOUT OF THIS PLAN

This plan is focused on the two key aspects of climate action:

CLIMATE ADAPTATION

OCTA defines climate resilience as the ability to provide core functions in the face of threats and to recover quickly from major shocks or changing conditions. The Climate Adaptation portion of the CASP evaluates the potential future climate-related risks and vulnerabilities across three main categories: assets (excluding railways), transit service, and population. These categories cover the built, natural, and human elements pertinent to OCTA and its mission. **Adaptation** strategies refer to programs, projects, or approaches that are developed to respond to anticipated climate change impacts, and thus increase the climate resiliency of OCTA. The scope of this portion of the plan includes both OCTA's directly owned and operated assets, as well as categories of potential influence beyond its direct control.

SUSTAINABILITY

A significant component of OCTA's commitment to sustainability is mitigating the agency's climate impacts. **Climate change mitigation** refers to the practice of reducing GHG emissions resulting from an entity's operations. While OCTA recognizes that sustainability is a broad term that connects issues across a variety of natural and human made systems, the scope of sustainability in the CASP is primarily focused on GHG mitigation, both within the agency's directly owned and operated business functions and across the region, as well as the social equity impacts associated with these emissions. As an exploratory framework, the CASP outlines strategies under three potential mitigation scenarios: conservative, moderate, and aggressive.

This plan is an exploratory, strategic framework that establishes guiding principles and potential strategic pathways by which the agency can further incorporate sustainability, GHG emissions mitigation, and climate adaptation into its planning, facilities operations, resource use, services, and regional collaboration.

- **Section 3** – Provides historical context on OCTA's Adaptation and Sustainability efforts to date, summarizing existing initiatives and related programs to provide the foundation for the CASP.
- **Section 4** – Focuses on Climate Adaptation, including identification of critical assets, results of the climate vulnerability risk assessment, and exploration of potential flexible adaptation pathways and strategies.
- **Section 5** – Focuses on Sustainability, including a baseline GHG inventory of operational emissions, forecasting of future operational emissions out to 2045, and exploration of potential targets and strategies OCTA may consider implementing to reduce its operational emissions.
- **Section 6** – As an exploratory framework, this section outlines recommended next steps to facilitate decision-making on agency commitments, prioritization of strategies, and development of an implementation roadmap.

3 HISTORY OF ENVIRONMENTAL STEWARDSHIP

For many years, OCTA has been proactively implementing sustainability measures to reduce its contribution to regional GHG emissions while working to build climate resilient infrastructure. This history of environmental stewardship not only provides the technical basis upon which the CASP was developed, but also paves the way for OCTA to take the next step in its climate action journey. Several key programs, projects, and accomplishments related to OCTA's climate action program to date are summarized in the sections below.

3.1 CLIMATE ADAPTATION EFFORTS TO DATE

CLIMATE ACTION AND RESILIENCY STRATEGY GAP ANALYSIS

As a starting point in preparation for the development of the CASP, OCTA undertook a gap analysis study to outline OCTA's general approach to climate action and summarize all relevant internal policies, projects, and studies/plans developed to date in support of climate adaptation and sustainability at OCTA.

The gap analysis also identified all external drivers supporting the agency's climate action program, including regulatory requirements, regional climate action initiatives, and local, state, and federal plans and guidance frameworks.

With a focus on inventorying OCTA's existing assets and operational needs, the gap analysis provided an important foundation for the climate vulnerability study and identified key questions to be further explored in the development of the CASP.

OCTA RAIL DEFENSE AGAINST CLIMATE CHANGE PLAN

In 2021, OCTA partnered with Caltrans District 12 to develop the *Rail Defense Against Climate Change Plan*. The study identifies climate-change-related opportunities and challenges for a 25-mile section of the rail corridor in Orange County, along with 12 Metrolink Stations, which are used by over 40,000 passengers daily and are likely to be impacted by severe weather conditions.[8]

In consultation with the public and key stakeholders, OCTA and Caltrans identified strategies to reduce the risk to rail infrastructure from extreme weather conditions, as well as opportunities for service, operations, and infrastructure improvements. The preventive measures identified by this study were classified based on near-, mid-, and long-term adaptation strategies, and are designed to provide guidance in the investment decision-making process.

As an outcome of the final study, OCTA has laid out its strategy to respond to and prepare for future climate-related risks to rail infrastructure.

The CASP will refer to the conclusions and recommendations of the Rail Defense Against Climate Change Plan for analyzed Metrolink assets.

OCTA SOUTH ORANGE COUNTY COASTAL RAIL STUDIES

In September of 2021, a landslide south of San Clemente shut down the rail line in the area for nineteen days while emergency repairs were completed. This closure prevented both passenger and freight rail trips between the Los Angeles and San Diego regions. As sea level rise continues, coastal erosion will continue to impact vulnerable rail infrastructure unless serious mitigation work is undertaken.

In September 2022, the track experienced movement again and was shut down temporarily to enable emergency repairs. OCTA, in partnership with the Southern California Regional Rail Authority (SCRRA), performed emergency work to stabilize the railroad tracks in southern San Clemente. Ground anchors were installed in the slope between the railroad tracks and the Cyprus Shore community to prevent further track movement. This work has been completed, and rail service restoration commenced in April 2023.

In October 2023, OCTA retained an engineering consultant to assess short- to medium term solutions that would protect the railroad in place.

[8] Orange County Transportation Authority. "OCTA *Rail Defense Against Climate Change* Plan." 2021. <https://www.octa.net/pdf/OCTA_RailDefAgainstCC_FinalReport_wAppendix.pdf>.

The objective of this study is to develop options to protect seven miles of coastal rail infrastructure at various sea levels. The study strives to gain an understanding of climate effects on coastal rail infrastructure. The anticipated outcome of this effort will be to identify potential solutions to protect the railroad in place for up to 30 years. Coordination with key stakeholders and agencies will be vital to a successful outcome. This planning study is expected to take approximately two years and will assess existing and future risks and identify challenges to maintenance and operations of rail service along the coastal rail line through Orange County.

Collaboration with local, state, and federal partners will be more firmly established throughout this planning process. It will provide the framework for future efforts to mitigate the risk to track stability. This study is the first step of a phased approach to examine short- to medium-term solutions to protect the existing rail line in place for the foreseeable future.

A separate second-phase study will look at longer-term options including potential relocation of the rail line between San Juan Capistrano and San Onofre State Beach. The second-phase study would need to consider the broader Los Angeles–San Diego–San Luis Obispo Rail (also known as LOSSAN) Corridor vulnerabilities and involve state and federal partners. This effort is funded by the Transit and Intercity Rail Capital Program. An action plan for key elements to determine the long-term disposition of the rail line will be developed. In addition, partnering and engaging with LOSSAN, state and federal agencies, and key stakeholders and agencies will be vital to the success of this effort.

OCTA HAZARD MITIGATION PLAN

OCTA developed a *Natural Hazard Mitigation Plan* (HMP) to support current OCTA emergency and crisis management plans and strengthen the agency's preparedness in the face of natural hazards, such as climate change. With financial support from the California Governor's Office of Emergency Services (Cal OES), the HMP will enable OCTA to establish specific courses of short-, mid-, and long-term actions to reduce vulnerability and exposure to hazards now and in the future.

The strategies included in the HMP focus on updating protocols, identifying at-risk transit infrastructure, incorporating climate-proof design features in infrastructure, and coordinating with local and regional partners. The finalized plan will make OCTA eligible to receive future Federal Emergency Management Agency (FEMA) funding to mitigate risks and address threats and vulnerabilities. The CASP plan builds upon the analysis of potential impacts from future climate conditions and hazards. The CASP also aligns with strategies outlined in the final HMP to ensure consistency in approach across plans.

FIRE MANAGEMENT PLANS (FMP)

As a requirement of OCTA's Natural Community Conservation Plan/Habitat Conservation Plan, wildland fire management plans (FMPs) are being completed for each of the seven OCTA Preserves, which are part of the agency's OC Go Environmental Mitigation Program (see *Environmental Mitigation Program* section below for more detail). FMPs are step-down plans from higher-level planning efforts and contain direction and guidance on how and where to make planned fire management actions on the ground. The FMP goals and outcomes include:

- Policies and approaches to maximize protection of biological resources during fire suppression activities.
- Guidelines for decision making at all stages, including fire prevention, pre-fire vegetation management, suppression activities, and post-fire responses, which are compatible with conservation and stewardship responsibilities.
- Identifies best management practices that increase the resiliency of natural ecosystems, minimize human ignitions, and protect urban interface areas.

As one of the identified climate hazards expected to affect OCTA is wildfire, the CASP will inform OCTA of the current and future vulnerability of its assets and align with goals and strategies from the FMPs to ensure consistency in approach. It is noted that at the time of the development of the CASP, the FMPs are in draft phase and are expected to be finalized in 2023.

3.2 SUSTAINABILITY EFFORTS TO DATE

ZERO-EMISSION BUS PROGRAM

In accordance with CARB's Innovative Clean Transit rule, OCTA adopted its *Zero-Emission Bus (ZEB) Rollout Plan* in June 2020, committing the agency to transitioning its bus fleet to 100% zero-emission buses (ZEBs) by 2040.[9] OCTA is currently conducting a pilot program with 10 hydrogen fuel cell electric buses and 10 plug-in battery-electric buses to test the technology in action. Further, OCTA is in the process of expanding the pilot to test a total of 70 ZEBs to assess the performance of the respective bus types in the OCTA operating environment. OCTA staff are monitoring these pilot programs to assess the operational maintenance and cost impacts of each technology, which is informing concurrent searches for external funding to support the ZEB transition. While already in process, this program is included as one of the most important emission reduction measures for OCTA as part of the CASP.

The rollout plan is the culmination of a longer-term effort on behalf of the agency to reduce emissions from its bus fleet, which is one of the most significant sources of OCTA's operational emissions. As an interim solution, OCTA has transitioned the fuel sourcing of its entire bus fleet from diesel to renewably sourced compressed natural gas (RNG), which eliminated more than 200,000 metric tons of carbon dioxide equivalent ($MTCO_2e$) annually and earned the agency the Crystal Award from Element Markets in 2021.[10]

The use of renewably sourced compressed natural gas (RNG) is eliminating more than 200,000 metric tons of carbon dioxide equivalent (MTCO2e) annually.

QUANTIFYING OPERATIONAL GREENHOUSE GAS EMISSIONS

The development of GHG inventories provides valuable insight into emission-intensive activities and a means of quantifying and tracking emissions over time. OCTA assembled its first GHG inventory in 2011, quantifying the agency's annually generated and displaced GHG emissions for the years 2005 through 2010.[11] OCTA has consistently produced annual inventories since 2013, when the agency began voluntarily reporting its annual Scope 1 (direct) and 2 (indirect) GHG emissions to The Climate

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[9] Orange County Transportation Authority. "Zero-Emission Bus Draft Rollout Plan." 3 June 2020. <https://ww2.arb.ca.gov/sites/default/files/2020-09/OCTA%20ZEB%20Rollout%20Plan_ADA08122020.pdf>.

[10] Orange County Transportation Authority. "OCTA's 2021 Sustainability Accomplishments Contribute to a Resilient Future." 2021. <https://blog.octa.net/posts/octas-2021-sustainability-accomplishments/>.

[11] OCTA's GHG emissions inventories included Scope 1 and Scope 2 emissions, select Scope 3 emissions associated with supply chain, solid waste, and construction and activities, and displaced emissions from mode shift and land use. These terms and the underlying methodology are defined under Section 4 of this plan.

Registry (TCR), the leading voluntary GHG registry in North America.

The CASP facilitated development of an updated methodology and improved data quality standards for the establishment of OCTA's updated 2021 baseline in alignment with standards and guidance provided by the Greenhouse Gas Protocol,[12] TCR's Performance Metrics for Transit Agencies,[13] and the APTA *Recommended Practice for Quantifying Greenhouse Gas Emissions from Transit*.[14]

ENVIRONMENTAL MITIGATION PROGRAM

Since 2010, OCTA's Environmental Mitigation Program (EMP) has been working in collaboration with state and federal wildlife agencies to acquire land and fund habitat restoration projects to offset the environmental impacts of OC Go (also known as Measure M) freeway projects.

To date, OCTA has acquired 1,300 acres in Brea, Laguna Beach, Silverado Canyon, and Trabuco Canyon, which will be permanently preserved as open space (collectively known as the Preserves). While the emissions impacts of the EMP have not been quantified, preserving and restoring natural areas prevents emissions that could result from future development. Resource Management Plans were developed for each of the Preserves which outline how they are protected and managed, as well as how public access is addressed on the acquired properties.

OCTA has also funded 12 habitat restoration projects throughout Orange County, restoring approximately 350 acres of land to their native condition and removing invasive plant species. This vegetation provides additional benefits by removing carbon from the atmosphere through the process of photosynthesis, and acts as a sink for harmful particulates, such as those resulting from Orange County freeways, thus promoting improved air quality in the region.

An endowment has been established to pay for the long-term management of the Preserves.

ENVIRONMENTAL CLEANUP PROGRAM

OCTA also established its Environmental Cleanup Program (ECP), as part of OC Go, to help improve water quality in Orange County from transportation-generated pollution. Using a two-tier grant funding approach for the program, ECP funds are allocated on a countywide competitive basis to supplement existing transportation-related water quality programs.

The Tier 1 Grant Program is designed to reduce more visible forms of pollutants, such as litter and debris collecting on roadways and in catch basins prior to being deposited in waterways and the ocean. The Tier 2 Grant Program provides funding for larger projects, which allows for multi-jurisdictional, capital-intensive structural treatment best management practice projects.

Since the inception of the ECP in 2011, it is estimated that nearly 60 million gallons of trash have been captured.

AIR QUALITY INITIATIVES

As previously mentioned, OCTA provides cleaner travel alternatives that help to reduce harmful air pollutant emissions. Other efforts, such as managed lanes and signal synchronization, also enable the agency to contribute to improved air quality.

For instance, OCTA has employed managed lanes (e.g., tolled express lanes and High Occupancy Vehicle lanes) to encourage carpooling and promote transit usage, improve travel-time reliability, reduce GHG emissions and VMT, and maximize the efficiency of

[12] The Greenhouse Gas Protocol. <https://ghgprotocol.org/>.
[13] The Climate Registry. <https://theclimateregistry.org/>.
[14] APTA Climate Change Standards Working Group. "APTA CC-RP-001-09: Recommended Practice for Quantifying Greenhouse Gas Emissions from Transit." 14 August 2009. <https://www.apta.com/wp-content/uploads/Resources/resources/hottopics/sustainability/Documents/Quantifying-Greenhouse-Gas-Emissions-APTA-Recommended-Practices.pdf>.

freeways while reducing congestion and delay. OCTA's vanpool program is an example of one of the ridesharing options that contributes to VMT reduction. Since 2007, the OC Vanpool Program, subsidized in part by OCTA, has provided a convenient and cost-effective transportation alternative to single-occupant vehicles for commuters with similar work and home destinations. Consequently, the program helps to reduce congestion and improve air quality. Traffic light synchronization also relieves congestion and reduces delays and travel time, thus reducing fuel consumption and GHG emissions.

LONG RANGE TRANSPORTATION PLAN

More than two decades ago, OCTA adopted its first *Long Range Transportation Plan* (LRTP),[15] which lays out an agency-wide strategy to address the growing transportation needs of Orange County's population (which is expected to grow by 9% by 2045) while ensuring that transportation options are sustainable, equitable, and innovative. The LRTP reflects current OCTA policies and commitments, transportation study findings, as well as input from local jurisdictions, business leaders, community leaders, county residents, and transportation planning professionals.

OCTA developed an updated 2022 LRTP (released in 2023) that further defines the agency's vision for meeting Orange County's future transportation and mobility needs, considering regional growth, changing demographics, available revenues, and other factors.

While not directly included in the scope of the CASP, the programs outlined in the 2022 LRTP, particularly those that promote active transportation such as the Bicycle Corridor Improvement Program, will support OCTA's regional contribution to reducing and displacing GHG emissions associated with transportation.

The CASP is intended to supplement the LRTP and other planning documents to quantify the VMT displaced from OCTA's programs and services.

TRANSIT ASSET MANAGEMENT PLAN

While the Transit Asset Management (TAM) Plan issued in 2022 is not a direct climate mitigation effort, a cohesive planning process for capital improvements and new capital projects facilitates the implementation of mitigation measures. The TAM plan includes specific details related to the agency's ZEB plan and outlines the agency's procurement strategy for transitioning its bus assets to zero-emission alternatives at end-of-life. Additionally, the plan provides important context related to OCTA's facilities and thus facilitates the prioritization of projects, such as energy efficiency or facility decarbonization projects, which may be selected for implementation as a result of the CASP.

[15] Orange County Transportation Authority. "2022 Long-Range Transportation Plan." 2022. <https://www.octa.net/programs-projects/programs/plans-and-studies/long-range-transportation-plan/overview/>.

4 CLIMATE VULNERABILITY ASSESSMENT & ADAPTATION PLANNING

Climate change is happening now, and its impacts will affect Orange County residents, businesses, and governments for generations to come. The impacts of climate change stand to affect the ability of OCTA to meet its mission: to develop and deliver transportation solutions that enhance quality of life and keep Orange County moving.

To better understand how climate change will affect OCTA, as well as to begin determining how the agency can mitigate the associated risks and preserve service continuity, the agency completed its *Rail Defense Against Climate Change Plan* in 2021, specifically evaluating how climate change will affect the agency's rail corridor and will continue assessing potential solutions to protect the coastal rail line in south Orange County. Furthermore, OCTA developed its *Natural Hazard Mitigation Plan* to support current OCTA emergency and crisis management plans and to strengthen the agency's preparedness to natural hazards.

While the insights from these plans have proven meaningful and actionable, there remained significant segments of OCTA operations and services that had not been fully assessed for vulnerability and resilience to climate change hazards. Thus, in addition to this CASP's assessment of agency wide GHG emissions and accompanying climate change mitigation strategies, OCTA conducted a comprehensive Climate Vulnerability Assessment (CVA) to assess the vulnerability of OCTA assets, services, and served populations to climate hazards.

4.1 CLIMATE VULNERABILITY OVERVIEW

Climate vulnerability refers to a heightened risk of an individual, group, community, geographic area, asset, or activity to the adverse impacts of climate change, referred to as **climate hazards** or **stressors**. Climate hazards include, but are not necessarily limited to precipitation, extreme cold or heat, extreme weather, inland or coastal flooding, wildfire, and sea level rise. This heightened risk can be attributed to a mix of physical, environmental, social, political, cultural, and economic factors.

Assessing vulnerability requires an understanding and measurement of three key concepts:

- **exposure**, or the degree to which an asset, population, or system is exposed to climate hazards;
- **sensitivity**, or the degree to which an asset, population, or system is affected by certain climate hazards; and
- **adaptive capacity**, or the ability of that asset, population, or system to adjust to, mitigate, or endure the consequences of climate hazards.[16]

Thus, climate vulnerability can be considered as a measurement of exposure and sensitivity compared to adaptive capacity. High exposure and/or high sensitivity to climate hazards indicate high climate vulnerability. However, investments into services, infrastructure, or resources that increase adaptive capacity lowers or mitigates that vulnerability.

ASSESSMENT SCOPE

Climate change not only poses threats to OCTA's services and infrastructure, but can also adversely affect human safety, property, the economy, and ecological processes. As such, OCTA developed a methodology for this CVA to specifically focus on key assets, services, and populations within OCTA's operational boundary and service area, and their exposure, sensitivity, and adaptive capacity relative to select climate hazards or stressors.

Assets

Assets refer to infrastructure needed to deliver OCTA's transit services, including vehicles, transit and office facilities, roadways, infrastructure (including utilities such as storm drains and flood channels), and energy distribution. For this CVA, assets included:

- assets **owned and operated** by OCTA, including fixed-route vehicles, fleet vehicles, bus maintenance and operations bases, transit centers, and OCTA Preserves;
- assets **owned but not operated**, such as the Orange and Olive subdivision rail lines[17]; and
- assets and infrastructure that are **operated, shared use, and/or relied upon, but not owned**, such as roads and highways, utility infrastructure, administrative offices, Metrolink stations, and most park-and-ride facilities.

Service

Service specifically refers to the delivery of services and is analyzed separately in this CVA, as services may be impacted differently than physical assets. Assessed services included, but are not limited to:

- Bus operations and fixed bus routes
- Rail operations (e.g., commuter rail, OC Streetcar)

[16] Additional details on definitions and climate hazards are included in the appendices.

[17] As described in Assessment Methodology, assets were screened from additional analysis if they scored below a V3 in climate vulnerability.

- Paratransit and on-demand shuttle services (e.g., OC Access and OC Flex)
- Highway and road operations
- OC Go Environmental Mitigation Program

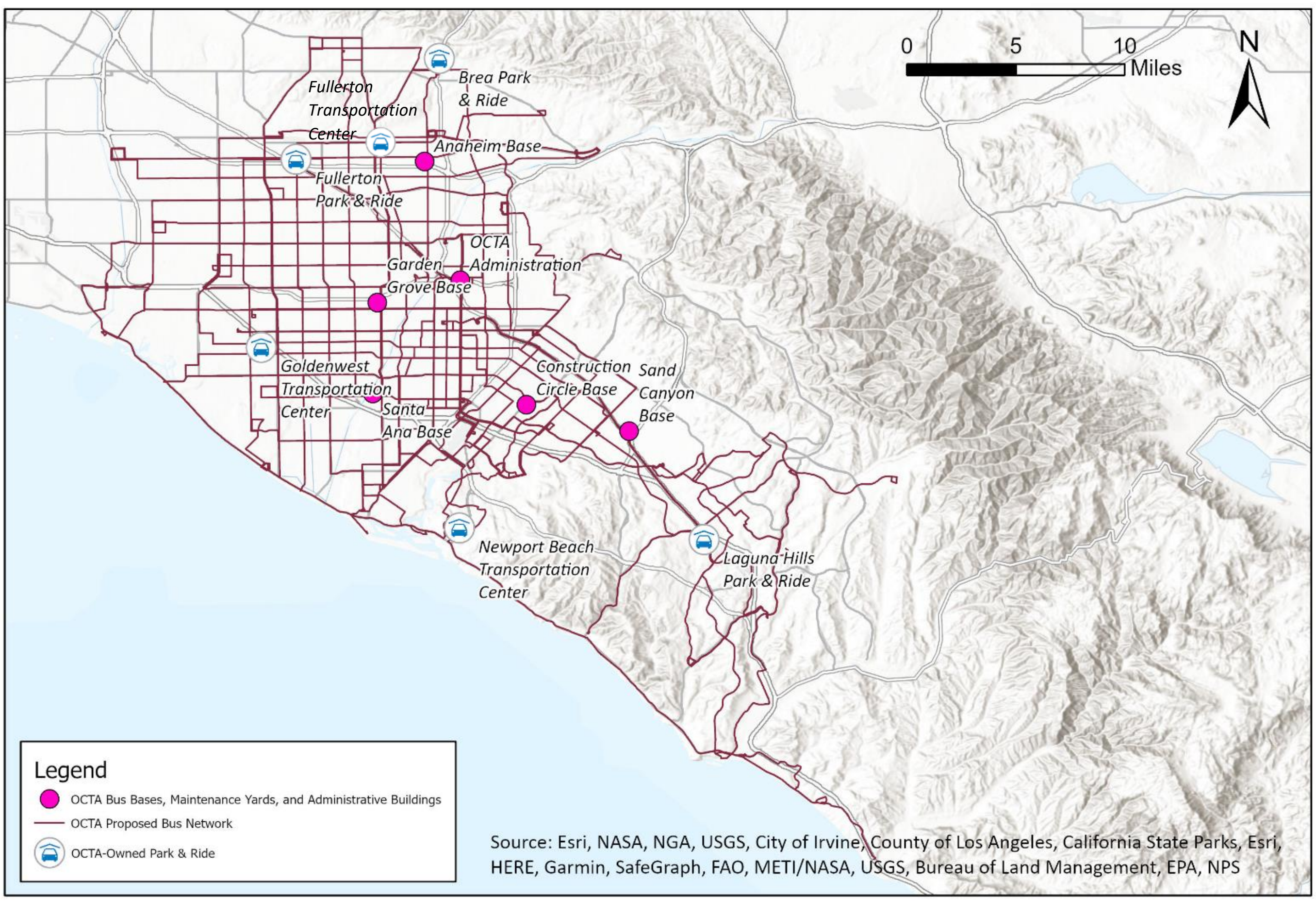
Since the development of the CASP, service route data has been updated. As such, the implementation of adaptation strategies as discussed throughout this Plan should also consider any ongoing or future changes to the bus network when applicable. In October 2022, the OCTA Board approved the final service plan for the bus restructuring plan, known as the Making Better Connections Study. The final service plan for the Study would be implemented over a two-year period (between 2023 and 2025), as resources permit.

Figure 4-1[18] shows the most recent proposal for the future OCTA bus network, which may differ slightly from the data used in this assessment.

Population

Population includes both employees and customers. Orange County is home to nearly 3.2 million residents, cutting across both 34 incorporated cities and unincorporated county areas. The effects of climate change may be experienced unevenly amongst different individuals, groups, and communities, and the most severe harms are expected to fall disproportionately on underserved communities. Therefore, the approach of the CVA provides more emphasis on disadvantaged communities (DACs) and other vulnerable populations.

Figure 4-1. *Proposed Bus Network as a Result of the Making Better Connections Study*



[18] OCTA GIS Open Data Portal, Accessed September 7, 2023.

Climate Stressors

Table 4-1 provides a consolidated summary of the climate-related hazards included in this CVA. Based on guidance from the *California Adaptation Planning Guide*,[19] OCTA selected these hazards on the basis that they would be most applicable to OCTA given its geography and service area, as well as its population and served communities. The table also includes a non-exhaustive list of secondary hazards that may immediately or most directly result from the primary hazards selected. The applicable climate stressors are discussed more in-depth in Section 4.2.

Table 4-1. *Climate-Related Hazards Potentially Applicable to OCTA*

Applicable Climate-Related Hazards	
Primary Hazard	**Secondary Hazard**
Air quality	Public health effects
Precipitation changes	Drought, snowpack loss, agricultural pests and disease, subsidence
Flooding (riverine)	Erosion, mud- or land- slides, and infrastructure disrepair
Severe storms and extreme weather	Intense rainstorms, severe wind, flood, lightning, hail
Storm surge	Flooding, erosion, mud- or land- slides
Temperature changes – warming	Extreme heat/heat waves, and power grid disruption
Wildfire	Erosion, landslide, and power grid disruption

ASSESSMENT METHODOLOGY

After identifying assets, services, and populations for assessment, OCTA utilized climate data to assess the exposure, sensitivity, and adaptive capacity of OCTA assets, services, and populations to projected climate stressors.

The methodology applied for this CVA generally aligns with federal and statewide guidance, drawing on methodology recommendations from the Federal Transit Administration (FTA), the Federal Highway Administration (FHWA), the 2020 *California Adaptation Planning Guide* (prepared by the California Governor's Office of Emergency Services), and the Southern California Association of Governments (SCAG). In addition, OCTA reviewed the methodology and results of studies by other similar agencies, such as Caltrans and cities within Orange County, to ensure a comprehensive and informed approach.

Exposure

OCTA used projections of the likelihood, timing, and severity of primary and secondary hazards based on Representative Concentration Pathways or RCPs (as adopted by the Intergovernmental Panel on Climate Change) to measure exposure. RCPs represent a combination of historical data and future estimates of atmospheric concentrations of greenhouse gases through 2100 based on a set of formulated human behaviors. Each pathway represents a different climate future, all of which are considered possible depending on the volume of greenhouse gas emissions in the coming decades. While there are no State regulations or mandates for adaptation planning at this time, this analysis referenced guidance from SCAG. Based on SCAG's "Southern California Climate Adaptation Planning Guide",[20] the following three RCPs were determined to be the most relevant for this assessment:

1) **RCP 2.6 (low emissions scenario)**: RCP 2.6 represents an aggressive emissions reduction scenario that assumes global greenhouse gas emissions will be significantly curtailed. RCP 2.6 most closely corresponds to the aspirational goals of the United Nations Framework Convention on Climate Change (UNFCCC) 2015 Paris Agreement.
2) **RCP 4.5 (medium emissions scenario):** RCP 4.5 represents a mitigation scenario where global greenhouse gas emissions peak by 2040 and then decrease through the rest of the century.
3) **RCP 8.5 (high emissions scenario):** RCP 8.5 represents a "business-as-usual" scenario where global greenhouse gas emissions continue to rise throughout the 21st century.

OCTA assessed exposure using climate data in Cal-Adapt focusing on the RCP 8.5 scenario. As with any predictive tool, there are inherent uncertainties. Thus, the climate hazards identified above are those that are most likely to impact OCTA operations, assets, employees, and customers in the future, assuming a trajectory of GHG emissions and the likely resultant changes in Orange County's climate.

Sensitivity

Sensitivity or impact (IM) was evaluated using a qualitative ranking of high (IM-H), medium (IM-M), and low (IM-L). OCTA created specific definitions for each score and customized them to reflect the sensitivities of each evaluation segment (i.e., assets, service, population). These are summarized in Table 4-2. To determine potential impacts, OCTA conducted several internal stakeholder engagement sessions, as well as informational interviews, with OCTA employees. OCTA also completed

[20] SCAG. "Southern California Climate Adaptation Planning Guide." 2020. <https://scag.ca.gov/sites/main/files/file-attachments/socaladaptationplanningguide_oct2020_0.pdf>.

field visits to inform the assessment of impact severity and adaptive capacity.

For assets and services, this evaluation considered the following:

- Potential for partial or total loss of asset
- Location of asset (current or future hazard zone)
- Potential for temporary or permanent loss of use or service
- Consequence of loss or disruption (secondary impacts)
- Ease of restoration of service or repair/replacement of asset
- Asset value and intangible importance

For population, this evaluation considered:

- What hardships would be felt by the population due to exposure to the hazard? Would it result in decreased quality of life or productivity, threaten damage, and/or destroy property?
- Is there a risk of mortality or morbidity to the population due to the stressor?
- How many people are affected by the stressor? Is it a relatively small group within the community or organization, or is it most/all of the population?
- If hardships occur, for how long would the population be affected? Would hardships diminish in severity over time or remain at the same level of severity during the impact?

Adaptive Capacity

OCTA also assessed the **adaptive capacity** (AC) of the selected assets, services, and populations, which measures the capacity of each to adapt to predicted changes in climate.

Through a largely qualitative process, OCTA evaluated adaptive capacity for assets and services with the following considerations:

- Are there existing policies, plans, or programs in place being considered to guide response? How complete are these resources (e.g., do they allow for a full or partial recovery)?
- Do asset owners or operators have the financial means to respond to impacts completely or partially? Would recovery be voluntary (i.e., can the owner/operator choose if and to what degree recovery occurs)?
- Are there existing laws and regulations that require/support recovery?
- Are there alternatives to the asset upon which the community can rely while service is restored? Do these alternatives adequately meet community needs?

OCTA used the following considerations to evaluate the adaptive capacity of populations:

- Are there any existing/planned policies or programs to assist individuals with the response?
- Do community members and employees have easy access to such services or are there difficulties associated with receiving assistance?
- Does the population have the financial means to respond to the impact? How complete would the response be?
- What alternatives exist to reduce or eliminate the hardships caused by the climate stressor?
- Do other barriers exist to the response, including technological capabilities and/or political will?

Based on the above questions, Adaptive Capacities for OCTA assets were categorized into a ranking of high (AC-H), medium (AC-M), or low (AC-L) based on the definitions in Table 4-3. Adaptive Capacities for OCTA services and populations were categorized based on the definitions in Table 4-4.

Vulnerability Score

The combination of the sensitivity/impact score and the adaptive capacity score for each element results in a vulnerability score, ranging from V1 (low) to V5 (high). A low impact score and high adaptive capacity score results in a low vulnerability score, while the inverse results in a higher vulnerability score. A V0 score is used when the climate stressor is not applicable to the OCTA asset. Table 4-5 shows how the impact and adaptive capacity scores combine to create the vulnerability scores.

Table 4-2. *Sensitivity/Impact Scores and Definitions*

Impact Score	Impact Score Definitions		
	Assets	**Service**	**People (Employees and Riders)**
High (IM-High)	Significant impact requiring reconstruction of parts or a whole asset. Extensive rehabilitation of assets outside routine maintenance and repairs. Major expenses required/substantial repair costs.	Long delays in service. Effects experienced system wide. Major re-routing required. Substantial loss in revenue due to reduction of service.	Moderate to substantial loss in ridership from inconvenience of route disruptions. Inconvenience to employees (i.e., overtime, days off suspended) to maintain level of service. Poses significant health and safety risks.
Medium (IM-Medium)	Temporary loss of use. Moderate repairs and replacements required outside of routine maintenance. Expensive repairs.	Temporary re-routing of buses and other delays in service. Localized effects. Minor route disruption. Potential revenue reduction.	Moderate and temporary inconvenience to employees to work overtime to maintain level of service. Notification of bus stop closure to riders. Poses some health and safety risks.
Low (IM-Low)	Minor repairs consistent with routine maintenance. Slight increase in repair frequency or severity and associated costs.	Minor delays/brief traffic control measures, but no re-routing of buses. Localized effects but return to "normal" is relatively quick. Potential minor revenue reduction.	Minor effects. Temporarily re-assigning field supervisors (i.e., managers) as coach operators. Health and safety risks are minimal.

*Table 4-3. Adaptive Capacity Scores and Definitions for **Assets***

Adaptive Capacity	Adaptive Capacity Definitions – Assets		
	Owned and Operated Assets	Operated, Shared Use, or Relied Upon	
High (AC-High)	Assets can adapt with little or no effort. There is direct influence on the implementation of strategies or solutions on the property. There is also a range of feasible solutions. Adaptive solutions are feasible for most or all sensitivities with ability to re-route and shift. Some sensitivities may face limited challenges.	Assets can adapt with relatively minor effort, but some assets may face limited challenges due to required agency coordination. Adaptive solutions are feasible for most or all hazards with multiple agency coordination.	Assets can adapt with little or no effort. There is some influence on the implementation of strategies or solutions on the property. There is also a range of feasible solutions, which may be dependent on the coordination/cooperation of third parties. Adaptive solutions are feasible for most or all hazards. Cost sharing for implementation should/may be pursued.
Medium (AC-Medium)	Threats can be reduced or mitigated, but solutions are only feasible for some assets. Assets may face difficulties in adapting, including but not limited to service delays and employee safety requirements. In addition, this may require some level of coordination with a third party to concur with the overall decision.	Threats can be reduced or mitigated, but solutions are only feasible for some assets. Many assets are likely to face substantive difficulties in adapting with owner unable to shift or accommodate.	Threats can be reduced or mitigated, but solutions are only feasible for some assets. Many assets are likely to face substantive difficulties in adapting. Assets may face difficulties in adapting, including but not limited to service delays and employee safety requirements. In addition, this would require some level of coordination with a third party to concur with the overall decision. Depending on the circumstances, third parties may only be able or willing to accommodate limited solutions.
Low (AC-Low)	Adaptive solutions are expensive and/or technologically challenging, but feasible. Approach may require multiple agency coordination and potential disruption of service, and long lead time to implement.	No method of adapting is currently feasible, with owner unable to shift or accommodate, although solutions may be possible in the future. Feasibility of solutions and funding may be a limiting factor. Approach will require multiple agency coordination and extended disruption to service.	Adaptive solutions are expensive and/or technologically challenging, but feasible. Approach may require multiple agency coordination, cost sharing, or minor disruption of service. Depending on the circumstances, third party may not be willing or able to accommodate change.

Table 4-4. Adaptive Capacity Scores and Definitions for ***Service and Populations***

Adaptive Capacity	Adaptive Capacity Definitions – Service & Population	
	Service	**Population**
High (AC-High)	Delivery of service can adapt with little or no effort. Overall quality of service may remain the same or have the potential to improve as a result of adaptation efforts. Adaptive solutions are feasible for most or all hazards with ability to re-route and shift.	People can adapt with little or no effort. Overall quality of experience and employee welfare may remain the same or have the potential to improve as a result of adaptation efforts.
Medium (AC-Medium)	Threats can be reduced or mitigated, but solutions are only feasible for some services. Assets may face difficulties in adapting due to service delays and employee safety requirements.	Threats can be reduced or mitigated, but solutions are only feasible for some people. Many people are likely to face substantial difficulties in adapting and may require adaptations that are inconvenient or undesirable.
Low (AC-Low)	Adaptive solutions are expensive and/or technologically challenging, but feasible. Approach may require multiple agency coordination and potential disruption of service.	Adaptive solutions are expensive and/or technologically challenging, but feasible. Approach may require politically unpopular actions or widespread lifestyle changes, including re-location or closing of facilities.

Table 4-5. *Climate Vulnerability Scoring Matrix*

Vulnerability Scoring Matrix			
	Low Impact (IM-Low)	**Medium Impact (IM-Medium)**	**High Impact (IM-High)**
Low Adaptative Capacity (AC-Low)	V3	V4	V5
Medium Adaptive Capacity (AC-Medium)	V2	V3	V4
High Adaptive Capacity (AC-High)	V1	V2	V3

Asset Screening

In conducting this CVA, OCTA screened assets to determine their level of vulnerability and prioritize actions accordingly. However, assets exhibiting low vulnerability, defined as below a V3, to climate change impacts were excluded for additional consideration for vulnerability and adaptation. This screening does not preclude assets from achieving low vulnerability score for specific climate stressors. Factors were considered such as asset location, ownership relationship to OCTA, or existing resilience measures that made them less susceptible to climate-related risks.

Assets excluded include:

- Orange and Olive Subdivision Railroad Lines
- Individual bus-stops
- Individual roadways

Adaptation Strategies

OCTA defines climate resilience as the ability to provide core functions in the face of threats and to recover quickly from major shocks or changing conditions. An adaptation strategy is a program, project, or approach that has been developed to respond to anticipated climate change impacts, and thus increase the climate resiliency of OCTA.

Exploratory adaptation strategies were developed and organized by climate stressor for several important reasons. By focusing on specific climate hazards, OCTA adopted a targeted approach for adapting its planning and developed tailored strategies to effectively minimize the impacts associated with each hazard. Moreover, this approach enables OCTA to comprehensively assess risks, ensuring a holistic understanding of vulnerabilities and potential impacts. By developing potential strategies in this manner, OCTA enhances its preparedness for specific threats, engages stakeholders more effectively, and communicates clearly about the risks and measures in place. Ultimately, organizing adaptation strategies by climate hazard facilitates OCTA's ability to address vulnerabilities and enhance resilience (summarized in Figure 4-2).

Equity Considerations

The FTA encourages transit providers to ensure that the impacts of service and fare changes are not discriminatory and that minority, low-income, and limited English proficient communities have an equal opportunity to participate in the public involvement process that often precedes a decision to change service and fares. Minority and low-income populations are more likely to experience heightened risk and increased sensitivity to climate change and have less capacity and fewer resources to cope with, adapt to, or recover from climate impacts. Transit-dependent populations, including older adults, persons with disabilities, or low-income households without private vehicles, may face increased challenges during heightened climate events. Disruptions to transit services can significantly impact their ability to meet their daily needs and access necessary services. Further, these communities may have limited resources to adapt to climate risks, making them more susceptible to disruptions in transit services. Reduced access to public transportation can hinder their ability to access essential services, employment opportunities, healthcare, education, and social activities, further widening the equity gap.

The asset category of Transit Stops, Centers, and Park-And-Ride Facilities most directly interact with and service OCTA riders. Since climate vulnerability is intertwined with social vulnerability factors such as age, disability, language barriers, or limited mobility, it is important for the assets most closely linked to transit mobility for these communities to integrate equity considerations into climate resilience planning. For this reason, OCTA assigned the "+" equity rating to the climate stressor vulnerabilities that are likely to impact OCTA riders and their transit serviceability.

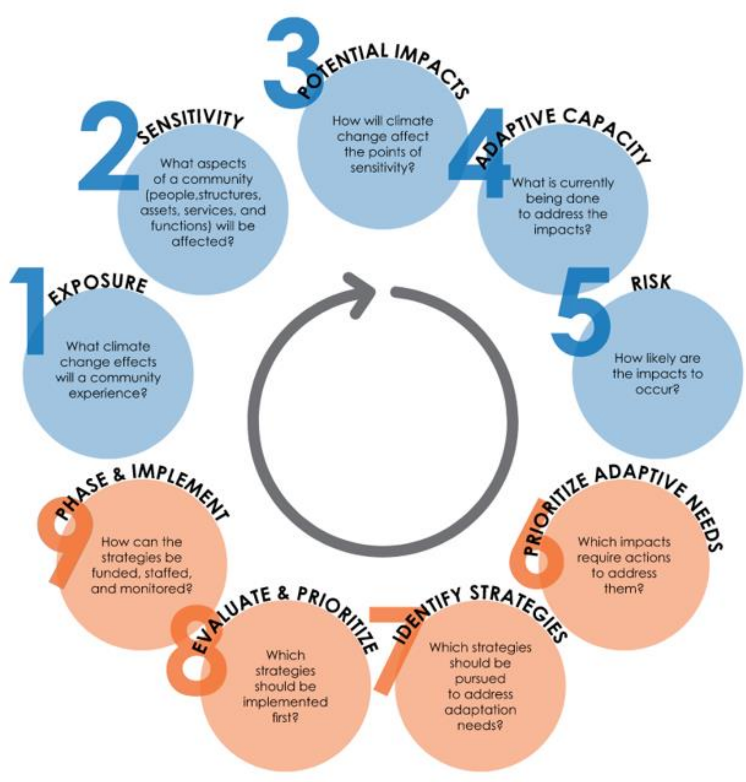


Figure 4-2. *Assessment Methodology*

4.2 CLIMATE STRESSORS

The first step in a climate change vulnerability assessment is to identify the ways in which climate change may affect OCTA over different time horizons, specifically the mid-century time frame of approximately 2035-2070, and the end-century time frame of 2070-2099.

OCTA is at risk to various natural hazards presented by climate change. If not addressed, these could have potential to lead to increased operating and maintenance costs, damaged infrastructure, customer hardship, and widespread operational disruption.

In accordance with guidance from the California Governor's Office of Emergency Services (Cal OES) *California Adaptation Planning Guide* (APG)[21] and the *Southern California Climate Adaptation Planning Guide*[22], OCTA reviewed data from sources including Cal-Adapt and California's Fourth Climate Change Assessment, 2018[23] to determine which climate stressors should be considered in this detailed exposure assessment. The following seven climate-related stressors were included for selection in the CASP.

AIR QUALITY

All of Orange County falls within the South Coast Air Basin (SoCAB), which is classified by the U.S. Environmental Protection Agency (EPA) as an "extreme" nonattainment area for specific criteria air pollutants (i.e., ozone, and PM 2.5). Cities and communities that fall within the basin, especially in inland areas, face significant pollution burdens. Poor air quality (AQ) can have harmful impacts on health, including but not limited to reduced lung function, pneumonia, asthma, cardiovascular disease, and premature death.

Rising temperatures have the potential to exacerbate air pollution and trap harmful ground level ozone in the air due to increased water vapor. OCTA used CalEnviroScreen 4.0 data to evaluate air quality as a climate stressor and its expected impact on OCTA assets, services, and populations.

PRECIPITATION CHANGES AND DROUGHT

Orange County experiences short, warm, and arid summers, as well as long, cool, and partly cloudy winters, with approximately half of the annual precipitation occurring December through February. To evaluate precipitation as a climate stressor, OCTA used Cal-Adapt to identify and evaluate historic and projected precipitation changes using inches of annual rainfall.

While climate change is expected to have long-term effects on precipitation with respect to both magnitude and frequency statewide, annual precipitation in Orange County is not expected to change dramatically. It is projected that the average precipitation in inland Orange County will decrease slightly from the 30-year modeled baseline (1961-1990) of 13.4 inches to 13.1 inches in the mid-century time frame (2035-2064), and to 13.0 inches in the end-century time frame (2070-2099) under the RCP 8.5 scenario.[24] For

[21] Governor's Office of Emergency Services. "California Adaptation Planning Guide." June 2020. <https://www.caloes.ca.gov/wp-content/uploads/Hazard-Mitigation/Documents/CA-Adaptation-Planning-Guide-FINAL-June-2020-Accessible.pdf>.

[22] Southern California Association of Government (SCAG). "Southern California Climate Adaptation Planning Guide." October 2020. <https://scag.ca.gov/sites/main/files/file-attachments/socaladaptationplanningguide_oct2020_0.pdf>.

[23] OPR. "State of California Energy Commission, and California Natural Resources Agency, California's Fourth Climate Change Assessment." 2018. <https://www.climateassessment.ca.gov/>.

[24] Cal-Adapt, Annual Averages.

coastal Orange County, the annual precipitation levels are predicted to fall to 11.6 and 11.7 inches in the mid-century and end-century time frames, respectively.

While drought is not considered a primary climate hazard, it is widely recognized that dry conditions may be experienced more regularly in the future given the impact of climate change on California's snowpack. Drought can lead to reductions in the quality and quantity of water, degradation of air quality, increase in agricultural vectors and disease, and decreases in crop yield.[25]

As reported in California's Fourth Climate Change Assessment, "[Global Climate Models] project significantly drier soils in the future over the Southwest (including California), with more than an 80% chance of a multidecadal drought during 2050–2099 under RCP8.5." Decreased soil moisture at depth can result in foundation failure for buildings, retaining walls, bridges, sidewalks, and pavement. Road buckling, as shown in Figure 4-3, is a common example caused by high heat and drought conditions.

Figure 4-3. *Road Buckling*[26]

Annual precipitation levels can exacerbate the infrastructure damage caused by other climate hazards, yet precipitation levels are expected to change minimally by the end of the century, while drought is a persistent climate hazard for the Southern California region. For these reasons, OCTA focused its climate vulnerability assessment for this climate hazard category on drought impacts and adaptive capacity.

FLOODING (RIVERINE)

Excess water due to increased precipitation or natural water flow can result in flooding within nearby floodplains and/or low-lying valleys. While these areas are especially susceptible to flooding, flooding can occur more quickly and with minimal warning in steep, mountainous areas as well. To evaluate flooding as a stressor, OCTA used data and flood maps from FEMA and assessed flooding potential under three different climate scenarios (see "Assessment Methodology" in this section) using the National Oceanic and Atmospheric Administration's (NOAA) climate risk and vulnerability mapping tool.[27]

SEVERE STORMS AND EXTREME WEATHER

Extreme dry and wet patterns are expected to increase in the future across Orange County. Ranging from severe rainstorms to extreme weather and strong winds (i.e., the Santa Ana winds), these severe weather events, hail, and lightning, can pose hazards resulting in injury or death, damage to buildings, structures, infrastructure, trees, fires, and diminished or blocked transportation access. Figure 4-4 provides an example of disruptions such as downed tree limbs resulting from extreme weather. OCTA modeled extreme weather potential under three different climate scenarios using NOAA's climate risk and vulnerability mapping tool. For the vulnerability scoring, OCTA shortened this climate hazard category title to "Extreme Weather".

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[25] California Department of Public Health (CDPH). "California Building Resilience Against Climate Effects (CalBRACE) Project." <https://www.cdph.ca.gov/Programs/OHE/CDPH%20Document%20Library/CHVIs/Drought_802_Narrative_11-8-2016.pdf>.

[26] NBC15. "Risk of Pavement Buckling Rises with the Heat." 9 May 2022. <www.nbc15.com/2022/05/10/risk-pavement-buckling-rises-with-heat/>.

[27] National Oceanic and Atmospheric Administration. "Billion-Dollar Weather and Climate Disasters." 2023. <https://www.ncei.noaa.gov/access/billions/>.

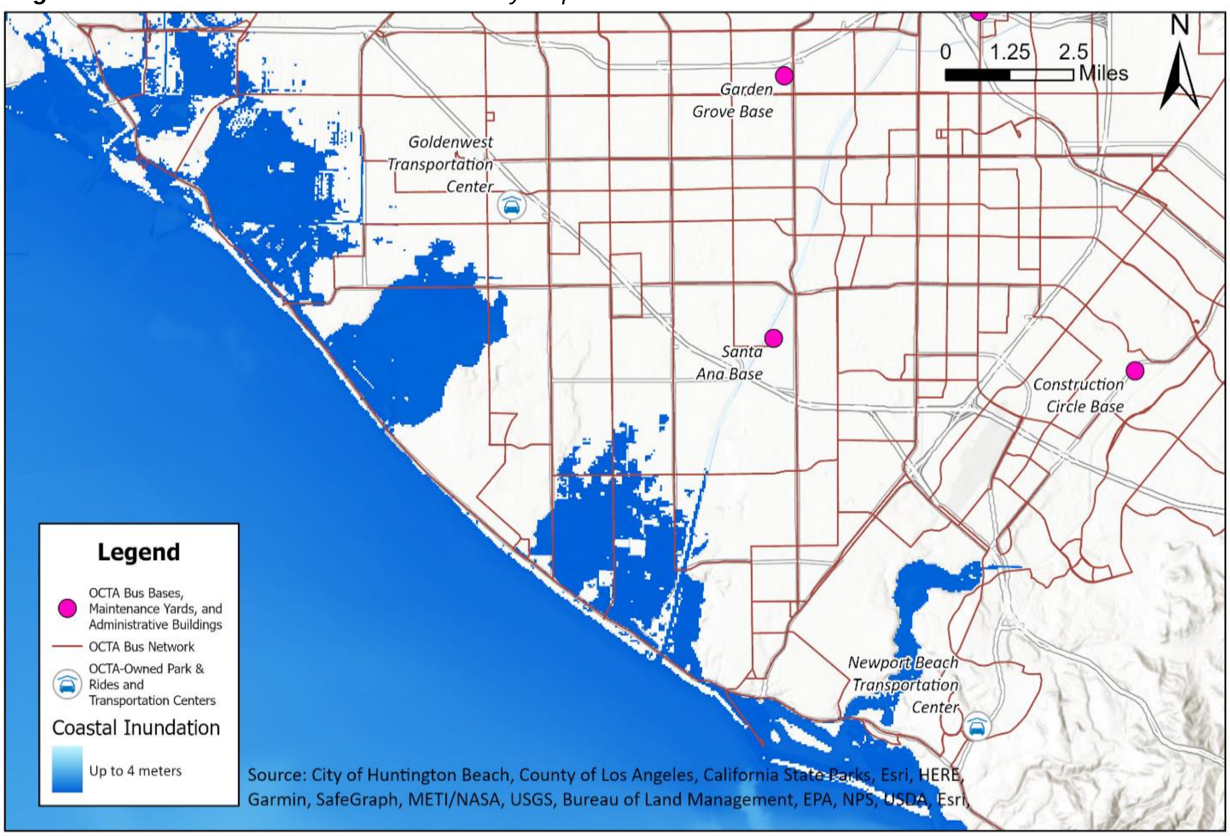
Figure 4-4. *Extreme Weather Disruptions[28]*

STORM SURGE

Storm surge is the abnormal rise in seawater level during a storm, caused by a storm's winds pushing water onshore. These sudden and significant rises in water level can lead to extreme flooding in coastal areas, particularly when the storm surge coincides with high tide.

Nuisance flooding can lead to road closures, overwhelmed water systems, damage to transportation infrastructure, and coastal erosion. OCTA evaluated storm surge as a stressor under three different climate scenarios using NOAA's climate risk and vulnerability mapping tool. For example, Figure 4-5a[29] and Figure 4-5b[29] below show storm surge risk as related to OCTA assets by century's end, and Figure 4-6[30] shows sea level rise (SLR). Although these figures show only North County impacts from storm surge and sea level rise, OCTA has studied impacts along the entire Orange County coast. The OCTA Rail Defense Against Climate Change Plan (RDCC) assessment focuses on the

Figure 4-5a. *Coastal Inundation – North County Map*



[28] United States Environmental Protection Agency. "Climate Change Impacts on Energy." May 2023. <https://www.epa.gov/climateimpacts/climate-change-impacts-energy>.

[29] Data Source and Year: Cal-Adapt, CalFloD3D-TFS Mosaics, data for CalFloD3D-TFS (50m) under a median flood scenario for the 2080–2100 period, Accessed September 7, 2023.

[30] Data Source and Year: Cal-Adapt, Inundation Depth Layer Mosaics for San Francisco Bay, Sacramento-San Joaquin Delta and California Coast, data for a SLR scenario of 1.0 meters for 100 year storm, Accessed September 7, 2023.

OCTA-owned ROW and rail that follows along the Pacific Ocean shoreline in South Orange County (i.e., the cities of Dana Point and San Clemente). The section below provides a summary of the RDCC's findings. More details can be found in the RDCC report.

The segment of interest in the RDCC corresponds to a roughly seven-mile portion of the line between milepost (MP) 200.2 at the north end in Dana Point and MP 207.4 at the south on the border with San Diego County. The assessment conducted a detailed analysis on SLR and coastal inundation and chose to focus on the two of the most prominent given available climate data and project resources:

1) Sea level rise coupled with storm surge.
2) Precipitation change (short-duration events).

Coastal impacts on the asset were assessed using National Oceanic and Atmospheric Administration (NOAA), CoSMos, and other data sources to determine localized interval deep water wave heights, wave runup on beaches, and beach recession from SLR.

The RDCC determined that the combination of SLR, erosion, and flooding could threaten not only the rail and embankment, but also associated infrastructure, such as bridges, culverts, stations, signaling and communications infrastructure, and pedestrian crossings. Sea level rise projections along this southern stretch were calculated out to year 2100 calculated against a baseline year of 2000. For example, the RCP 8.5 scenario projections show 2.8 feet of change by 2050, 10.2 feet by century end.

Figure 4-5b. *Coastal Inundation – South County Map*

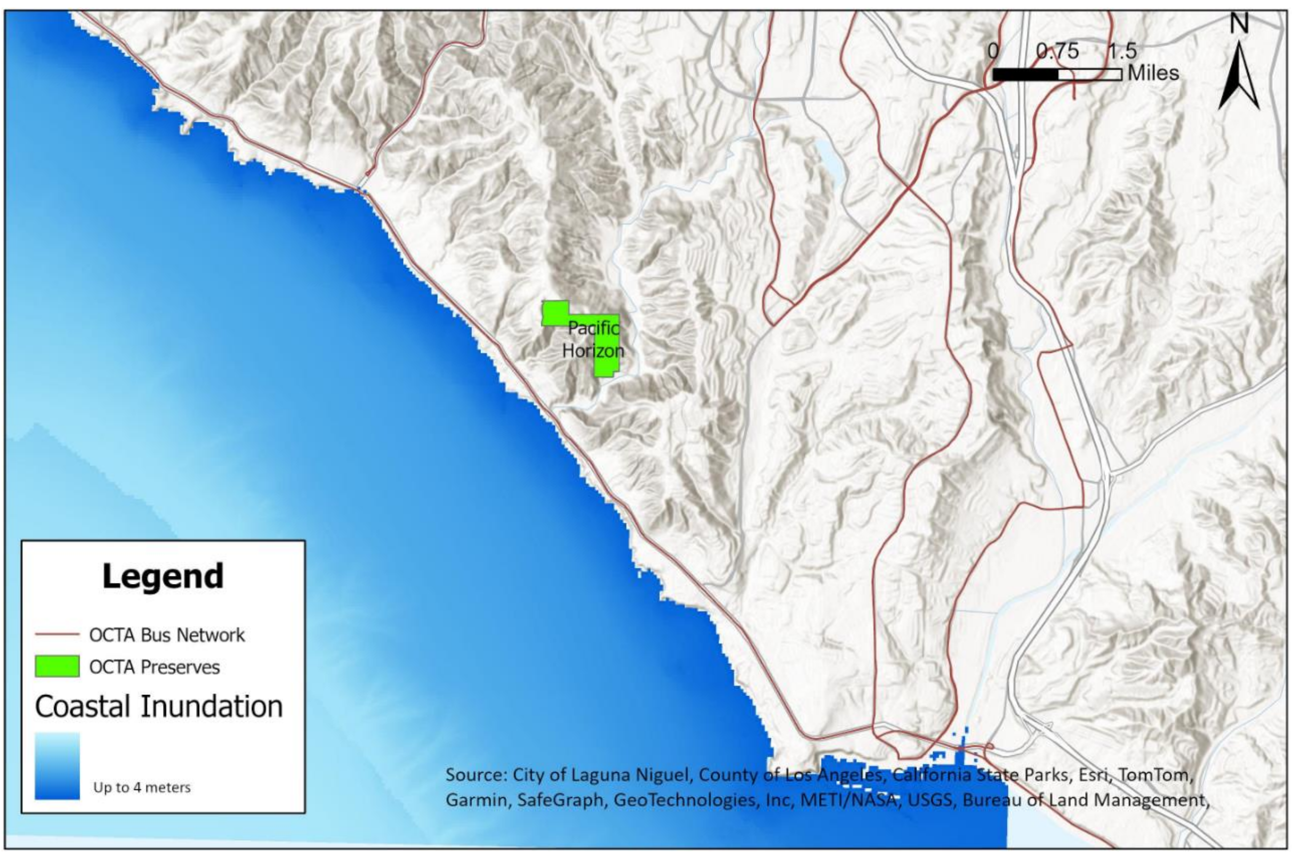
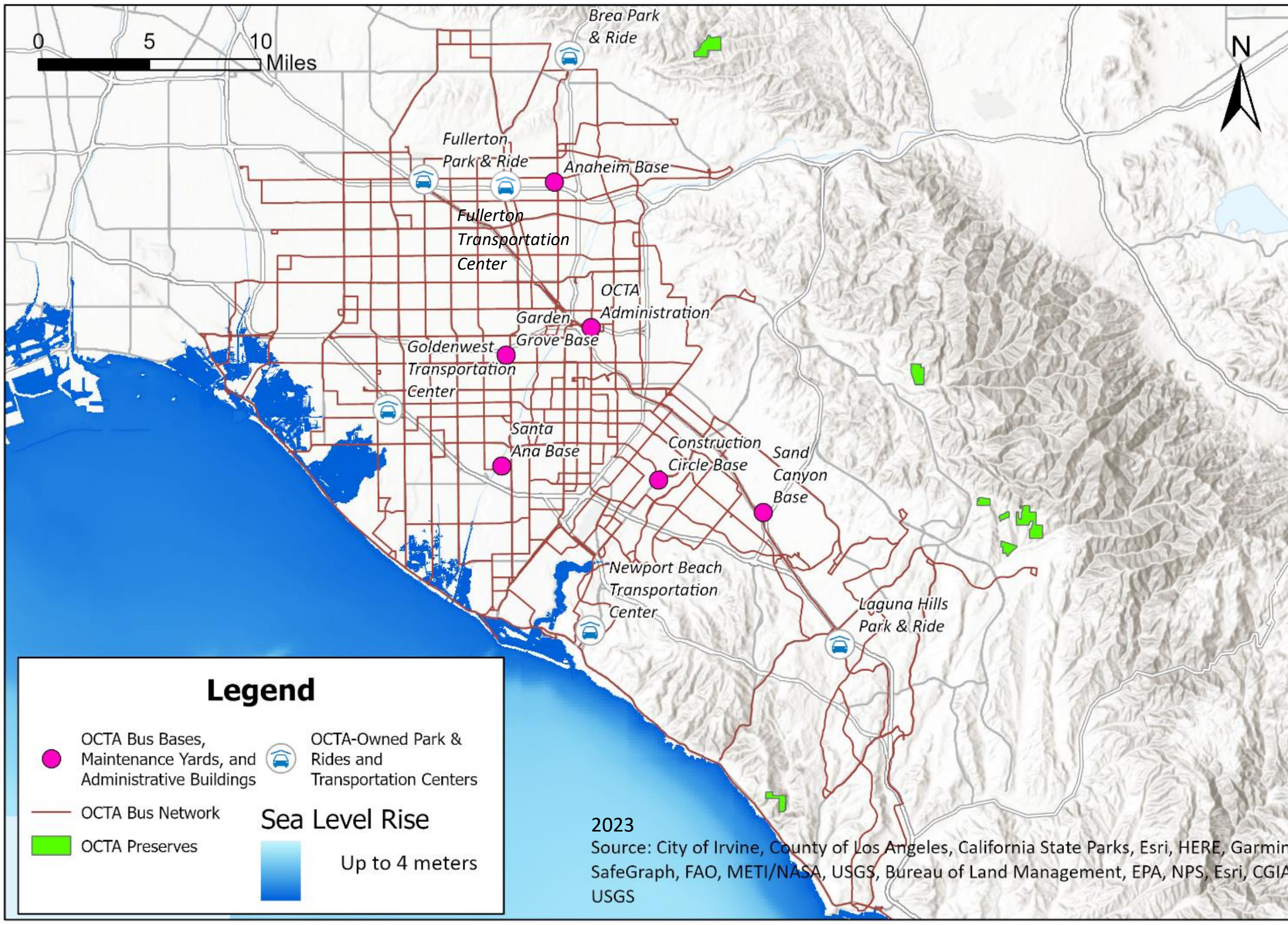


Figure 4-6. *Sea Level Rise Map*



TEMPERATURE CHANGES – WARMING AND HIGH HEAT

Rising temperatures have been observed in many Orange County communities. Since 1896, annual average temperature, maximum temperature, and minimum temperature have all risen by 0.16°C, or 0.29°F, every ten years.[31]

Consequently, as it is correlated with increases in overall temperature, the number of high heat days is anticipated to continue increasing across Orange County. High heat days are defined as days (for any day from April through October) when the maximum temperature exceeds the 98th historical percentile of maximum temperatures recorded between 1961 and 1990.

A heightened frequency of high heat days poses both health (heat-related illness) and financial risks (increased reliance on air conditioning and refrigerants) to sensitive communities such as homeless residents, senior citizens, outdoor workers, the elderly, youth, and people with disabilities. Increased use of electricity for cooling will also increase the risk of blackouts and brownouts due to increased demand and strain on the region's power grid.

For this assessment, OCTA used data from Cal-Adapt to inform temperature change impacts, using increases in average temperature and the number of high heat days.[32] An example is shown in Figure 4-7 below.

***Figure 4-7**. Examples Showing High Vulnerability to Heat Versus Low Vulnerability and Bus Stops*

[31] California Office of Planning and Research, California Energy Commission, and California Natural Resources Agency. "California's Fourth Climate Change Assessment, Los Angeles Region Report." 2018. <https://www.energy.ca.gov/sites/default/files/2019-11/Reg%20Report-%20SUM-CCCA4-2018-007%20LosAngeles_ADA.pdf>.

[32] High heat days are labeled as "extreme" within Cal-Adapt.

WILDFIRE

Wildfire season in California typically runs between late summer to early spring, but CalFire reports that the season is starting earlier and ending later with each passing year. Intense dry seasons, warmer spring and summer temperatures, reduced snowpack, and earlier snowmelt are making forests and vegetation more susceptible to wildfire. In California, this has resulted in an increase to the areas burned by wildfires each year, and the frequency and intensity of wildfires is only expected to increase due to climate change.[33] Natural events, such as warm and dry Santa Ana winds that typically occur in the fall, further increase the growth of these fires, and thus increase risk to urban areas. Another metric for wildfire risk and vulnerability is the Wildland-Urban Interface (WUI). WUI is where buildings and wildland vegetation meet or intermingle and environmental risks can be concentrated, including the loss of houses and lives to wildfire. OCTA used data from Cal-Adapt and CalFire to evaluate wildfire as a climate stressor.

Wildfire behavior and urban vulnerability are influenced by multiple factors, including vegetation patterns, weather patterns, land management practices, and human behavior. As a result, climate change models do not capture local-scale variations and extreme weather events. Wildfire vulnerability was assessed using present-day risk and severity data. Figure 4-8[34] below depicts fire hazard severity in relation to OCTA assets, and Figure 4-9[35] shows wildland urban fire (also in relation to OCTA assets). The WUI can also be subdivided into two categories: intermix and interface.

- An **intermix WUI** is where development, such as structures, is interspersed or scattered throughout wildland vegetation. An intermix WUI is often found in rural, exurban, or large-lot suburban developments.
- An **interface WUI** is where development, such as structures, is in the vicinity of contiguous wildland vegetation. There is a clear line of demarcation between development and vegetation, which may appear as an abrupt edge between a highly urbanized or suburban neighborhood and a wildland area.

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[33] U.S. Department of Transportation Federal Highway Administration. "California Prepares for Increased Wildfire Risk to Air Quality From Climate Change." 22 Feb. 2023 <www.epa.gov/arc-x/california-prepares-increased-wildfire-risk-air-quality-climate-change#:~:text=Wildfires%2C%20a%20longstanding%20and%20frequent,of%20particulates%20in%20the%20air>.

[34] Data Source and Year: Cal Fire, 2022 Fire Hazard Very High Hazard Severity Zones (VHFHSZ) Map, data for Orange County, Accessed September 7, 2023.

[35] Data Source and Year: Silvis Lab for Spatial Analysis for Conservation and Sustainability, University of Wisconsin-Madison, Wildland-Urban Interface (WUI) Change 1990-2020, data for California 2020, Accessed September 7, 2023.

Figure 4-8. *Fire Hazard Severity Zone Map*

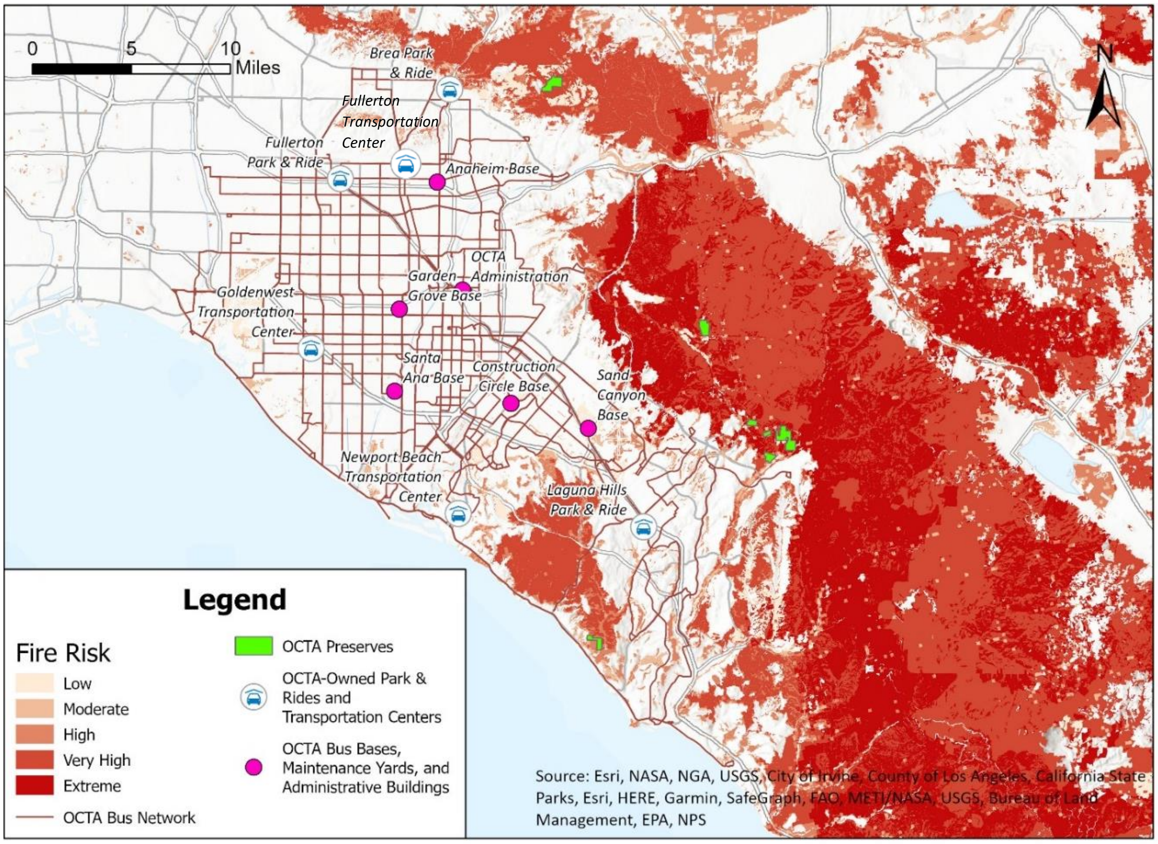
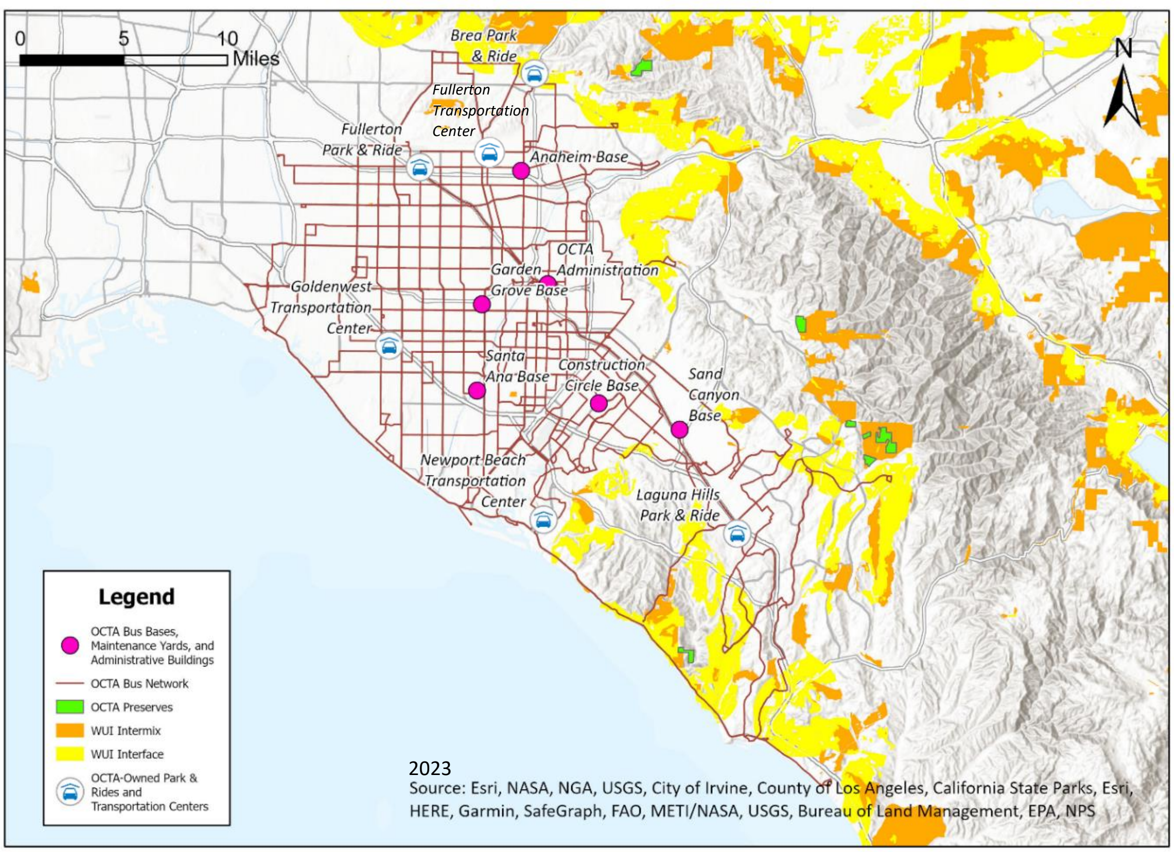


Figure 4-9. *Wildland Urban Fire Zone Map*



4.3 CLIMATE VULNERABILITY RESULTS

The results of the CVA for each climate stressor are summarized by asset category in the following sections. As certain assets fall within different climate zones, ("Inland" and "Coastal") some were given combined vulnerability scores. These climate zones are separated and defined by the California Energy Commission (CEC), shown in Figure 4-10. While there are several unique vulnerability scores across all assets, many scored similarly as they followed similar patterns and relied on the same or similar source data. Assets and services were consolidated into overarching asset categories, and thereafter specific population considerations were embedded into the vulnerability scoring.

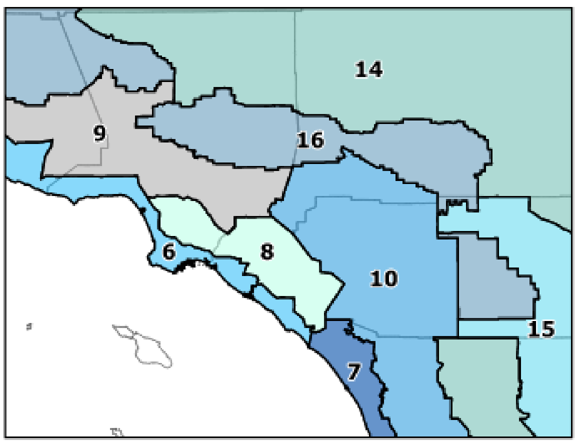


Figure 4-10. *CEC Climate Zone - Zoomed In (see Appendix E for the full CEC map)*[36]

Asset Categories

Assets and services were categorized based on function, adaptive capacity, protocols, physical outputs, and financial mechanisms. For each climate hazard, vulnerability was assessed by climate zone and out to mid-century, except for flooding, which shows present vulnerability.[37] Asset categories are listed below in Table 4-6. As a note, only assets with a vulnerability rating above V3 were considered for specific adaptation measures.

Table 4-6*. Asset Categories*

Asset Categories
Bus Maintenance and Operations Bases
OCTA Administrative Headquarters
Transit Centers and Stops
Park-and-Ride Facilities
Metrolink Stations
Roadways and Managed Lanes (91 and 405 Express Lanes)
OCTA Preserves
Other Critical Infrastructure

OCTA Populations: Employees, Riders, And Service Customers

Populations within OCTA's service area required separate considerations for vulnerability but are similarly susceptible to the effects of climate change. OCTA infrastructure and services can also influence the vulnerability of community members and employees. The populations considered in this assessment are ones that interact with infrastructure assets and services and would be affected by disruptions to infrastructure. These populations include OCTA employees, contracted employees, transit riders, other service customers, and community members.

While these are analyzed separately from assets and services, the employees and community members within OCTA's service area are included as part of the potential sensitivity for each asset category, and each category's vulnerability rating accounts for the vulnerability of populations that serve and are served by OCTA assets.

[36] California State Geoportal. "Building Climate Zones." January 2022. <https://gis.data.ca.gov/documents/CAEnergy::building-climate-zones/about>.

[37] Flooding vulnerability and established flood zones are determined by statistical data for river flow, storm tides, hydrologic/ hydraulic analyses, and rainfall and topographic surveys. This holistic statistical analysis is infeasible to conduct into future scenarios.

BUS MAINTENANCE AND OPERATIONS BASES

Bus maintenance and operations bases are OCTA-owned-and-operated facilities which serve as hubs for maintenance, repair, cleaning, refueling, and vehicle storage. In addition, OCTA-owned non-revenue vehicles may also be serviced or stored at these locations. Facilities include amenities for OCTA employees and coach operators (e.g., restrooms, showers, lockers, breakrooms, vehicle service bays, parts and materials storage, on-site fuel storage and dispensing, wash racks, etc.). Maintenance and repair services performed at bus maintenance and operations bases include inspections, preventive and routine maintenance, and minor repairs.

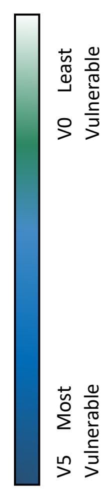
OCTA owns and/or operates the following facilities, bus bases, and maintenance yards:

- Garden Grove (GG) Maintenance and Operations Base
- Santa Ana (SA) Maintenance and Operations Base
- Anaheim Maintenance and Operations Base
- Irvine Sand Canyon Maintenance and Operations Base
- Irvine Construction Circle Maintenance and Operations Base
- OCTA Administrative Headquarters[38]

It should be noted that the future Transit Security Operation Center (TSOC) facility was not included in this CVA as the facility was note yet operational at the time of the development of this plan but will be considered in future assessment. Table 4-7 summarizes the Impact, Adaptive Capacity, and resulting vulnerability scores for the Bus Maintenance and Operations Bases. Below the table are descriptors for the Impact and Adaptive Capacity scoring, as well as a Vulnerability summary.

Table 4-7. *Summary of Bus Maintenance and Operations Bases Vulnerability*

Bus Maintenance and Operations Bases			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	IM-Medium	AC-Low	V4
Drought	IM-Low	AC-Low	V3
Extreme Weather (GG Only)	IM-Medium	AC-Low	V4
Extreme Weather (Other Assets)	IM-Low		V3
Flooding (SA Only)	IM-Low	AC-Medium	V2
Flooding (Other Assets)	N/A	N/A	V0



[38] The OCTA Administrative Building is located adjacent to the Garden Grove base and serves as an administrative and corporate office space. The building is leased by OCTA and experiences similar climate risks as other inland bus maintenance and operations bases.

Bus Maintenance and Operations Bases			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
High Heat	IM-Medium	AC-Low	V4
Storm Surge	N/A	N/A	V0
Wildfire	IM-Low	AC-Medium	V2

Impacts

Bus Maintenance and Operations Bases do not have exposure to the climate stressors of **Flooding** (except for the Santa Ana facility) and **Storm Surge** because most assets under this category are not located near rivers, channels, or shoreline.

High Heat and **Air Quality** received a score of IM-Medium due to modeled moderate and temporary impacts to employees with potential health and safety risks.

Extreme Weather Events, for the Garden Grove (GG) asset, received a score of IM-Medium because temporary loss of use is possible during events and storms, especially because the maintenance facility is open to the environment. Unlike the other Bus Maintenance Bases (covered below), there is specific asset concern for street flooding at the bus entrance to the GG Bus Maintenance Base.

Extreme Weather Events (for all assets under this asset class except Garden Grove) and **Drought** received a score of IM-Low due to possible minor increases in maintenance and repair costs to the facility possible resulting from climate stressor exposure.

Flooding for the Santa Ana (SA) asset received a score of IM-Low because of its proximity to the Santa Ana River. However, FEMA flood maps show reduced flood risk from the Santa Ana River levee. See Figure 4-11 for the FEMA Flood Map.

Wildfire (for all assets under this asset class except Sand Canyon Base) received a score of IM-Low because assets are located far from the Wildland-Urban Interface (WUI), a zone of transition between wilderness (unoccupied land) and land developed by human activity. However, regional effects are possible.

Wildfire, for the Sand Canyon Base, received a score of IM-Medium because the asset is located near the Wildland-Urban Interface (WUI), a zone of transition between wilderness (unoccupied land) and land developed by human activity. Additionally, regional effects are possible.

Adaptive Capacity

Bus Maintenance and Operations bases do not have exposure to **Flooding,** or **Storm Surge** because most assets under this category are not located near rivers, channels, or shoreline (except for the Santa Ana facility).

High Heat and **Air Quality** received a score of AC-Low because the ability to mitigate exposure of employees to high heat and poor AQ is limited due to ventilation needs and physical constraints (i.e., overhead fans would interfere with safety harnesses) of the service bays.

Extreme Weather Events received a score of AC-Low for all assets because surface street flooding during extreme rainstorms impacts the street entrance to the Garden Grove facility, and feasible adaptation methods would require actions by other entities. Further, bus maintenance facilities must be well-ventilated (open bay doors) for employee comfort and safety; therefore, the asset has limited adaptive capacity to external environmental conditions.

Drought received a score of AC-Low due to the stressor's regional nature of exposure, which requires multi-agency coordination for adaptation methods.

Wildfire received a score of AC-Medium due to the stressor's regional nature of exposure and operational capacities during wildfire emergencies.

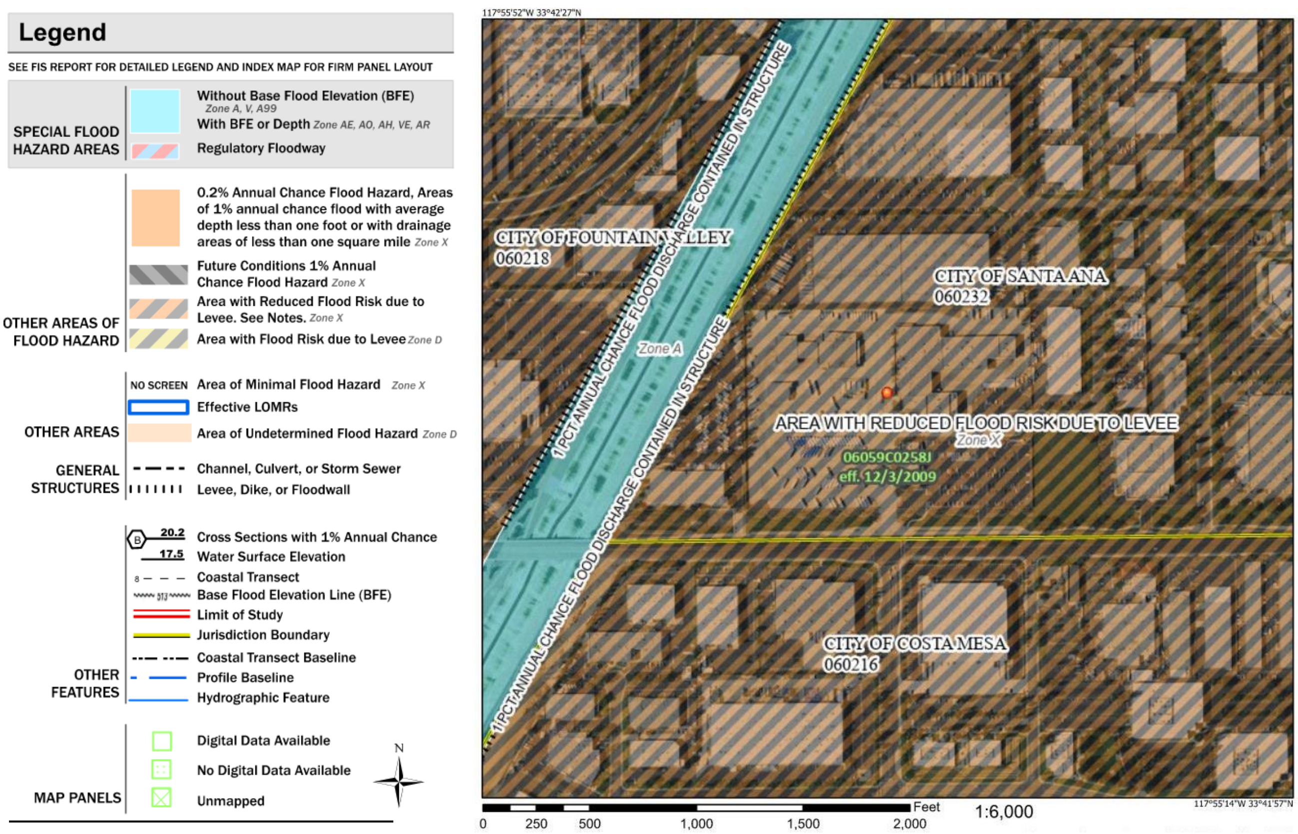
Flooding for the Santa Ana asset received a score of AC-Medium due to a maintained levee in close proximity to the asset and solid fencing on the SA base property between the Santa Ana River.

Vulnerability Summary

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the Bus Maintenance and Operations Bases is heavily influenced by the physical design and operation of each asset. Two stressors (**Flooding**, for assets except the SA base, and **Storm Surge**) score as a V0, two stressors (**Wildfire** and **Flooding** for the SA Base only) score as a V2, two stressors (**Extreme Weather**, for assets except GG, and **Drought**) score as a V3, three stressors (**Extreme Weather**, for GG only, **Air Quality**, and **High Heat**) score as a V4, and no stressors score as a V1 or V5.

The assets under Bus Maintenance and Operations Bases are expected to experience a number of vulnerabilities, particularly among surface flooding from extreme storms and high heat concerns, warranting consideration of adaptation strategies (see Section 4.4).

Figure 4-11. FEMA *National Flood Hazard Layer Map*[39]



[39] FEMA. "Flood Maps.". <www.fema.gov/flood-maps>.

TRANSIT STOPS, CENTERS, AND PARK-AND-RIDE FACILITIES

Transit stops, transit centers, and park-and-ride facilities refer to any location or structure, including any ancillary facilities, which enable passengers to board or alight from transit vehicles. These facilities can be further broken down by the facility use and transit vehicle type that services the facility.

Bus transportation centers are major transfer hubs that provide restroom facilities and covered shelter while passengers wait for a bus. Park-and-Ride facilities allow community members to drive their car to the nearest transit facility where they then take a bus or train to complete their trip. Metrolink Stations provide rail and bus connections. Stationlink bus routes provide a link between train stations and major employment/activity centers and are designed to meet selected trains.

The assets considered under this category include the following owned and operated, and operated, shared use, and/or relied upon, but not owned facilities:

- Brea Park-and-Ride (P&Rs)
- Fullerton Park-and-Ride (P&Rs)
- Fullerton Transportation Center
- Goldenwest Transportation Center
- Laguna Beach Transportation Center (Laguna Beach Bus Station)
- Laguna Hills Transportation Center
- Newport Transportation Center (NTC)
- Anaheim Canyon Station
- Anaheim Regional Transportation Intermodal Center (ARTIC)
- Buena Park Station
- Irvine Station
- Laguna Niguel / Mission Viejo Station
- Orange Station
- San Clemente Pier Station
- San Clemente Station (SC)
- San Juan Capistrano Station
- Santa Ana Regional Transportation Center
- Tustin Station
- OC Streetcar Stations

While only a few of these facilities are OCTA-owned-and-operated, most are owned and operated by the host cities. However, OCTA would most likely be called upon to help with protection and/or restoration efforts should service be threatened, disrupted, and/or halted due to climate stressor impacts.

It is important to note that inland Stationlink bus routes (Buena Park, Orange, Tustin, and others) were determined to have similar impacts and adaptation as other assets in this category. To condense this analysis, inland Stationlink assets were omitted. However, they would share the same considerations as other inland assets. Since transit stops, transit centers, and park-and-ride facilities are areas most likely to experience the effects of climate change and are stationary waypoints through which transit vehicles can be monitored, transit vehicles are also included within this asset category.

The impacts and adaptive capacity to the climate stressors of Storm Surge, Wildfire, Flooding, and Drought required special consideration. Because Metrolink Stations are also served by OCTA bus service, the vulnerabilities of Metrolink Stations to Storm Surge and Wildfire impacts, which have been extensively analyzed in the previous *OCTA Rail Defense Against Climate Change* report, were carried forward into this study. As discussed above, prolonged drought can lower the groundwater table underneath OCTA assets and is expected to contribute to reduced soil moisture, which may result in foundation failure for buildings, retaining walls, bridges, sidewalks, and pavement. However, because this infrastructure is owned and managed by other agencies, the adaptive capacity of OCTA to adequately respond and implement preventative measures to potential ground failures is limited. Adaptation strategies to implement water use mitigation and agency coordination were considered within this study.

Due to the wide geographic area covered by this asset category, and FEMA flood maps showing a significant amount of OCTA service area existing within 100-year flood zones, Flooding impacts and adaptive capacities were consolidated for the purposes of this report and rely on guidance from the HMP. Assets near the Santa Ana River are at risk of riverine flooding, even with the current extensive flood control measures in place. Future risk assessments should consider programmatic approaches to reducing flood risks.

The Transit Centers and associated vehicles vary between “operated and owned,” “owned and not operated,” and “operated, shared use, or relied upon and not owned,” as well as between the “Inland” and “Coastal” climate zones. For consistency of analysis and to avoid repeated scores for similar assets, vulnerability scores that were consistent between stressors were consolidated between the coastal zones, the relation of ownership to OCTA, and subcategories. Table 4-8 organizes assets within this category by their ownership relation to OCTA.

Table 4-8. *Transit Stops, Transit Centers, and Park-and-Ride Facilities by Ownership Relation to OCTA*

Ownership Relation to OCTA	Assets

Owned AND Operated	• Transit Centers (except Laguna Beach Bus Station)
	• Park-and-Ride Facilities
	  ○ Brea
	  ○ Fullerton
	• Bus Signage/Post
	• Changeable Message Signs

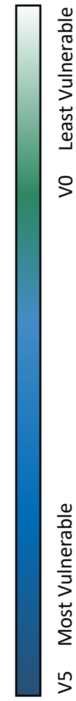
Operated, Shared Use, or Relied Upon and NOT Owned	• Transit Stops
	  ○ Shelters and other amenities (City owned)
	  ○ Signage
	• Metrolink Stations
	  ○ Platforms, shelters, etc. (others)
	  ○ Bus signage, etc.
	• OC Streetcar Stations
	• Park-and-Ride Facilities (except Brea and Fullerton)
	  ○ Caltrans, or
	  ○ Private

Owned and NOT Operated	• Orange subdivision railroad line • Olive subdivision railroad line

Table 4-9 and Table 4-10 summarize the Impact, Adaptive Capacity, and resulting vulnerability scores for the Transit Stops, Centers, and Park-and-Ride Facilities for assets located Inland and within the Coastal Region, respectively. Below the tables are descriptors for the Impact and Adaptive Capacity scoring, as well as a Vulnerability summary.

__Table 4-9.__ Summary of Transit Stops, Centers, and Park-and-Ride Facilities Vulnerability – __Inland__

Transit Stops, Centers, and Park-and-Ride Facilities – Inland Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	IM-Medium	AC-Low	$V4^{+}$
Drought	IM-Low	AC-Low	V3
Extreme Weather Events	IM-Medium	AC-Medium	$V3^{+}$
Flooding (ARTIC)	IM-Low	AC-Low	V3
Flooding (Other Assets)	N/A	N/A	V0
High Heat (Other Assets)	IM-Medium	AC-Medium	$V3^{+}$
High Heat (P&R Only)		AC-Low	$V4^{+}$
Storm Surge	N/A	N/A	V0
Wildfire	IM-Low	AC-Low	$V3^{+}$



<u>Impacts (Inland)</u>

Transit Stops, Centers, and Park-and-Ride (P&R) Facilities do not have exposure to the climate stressors of **Flooding** (except for ARTIC) and **Storm Surge** because assets under this category are not located near rivers, channels, or shoreline.

High Heat and **Air Quality** received a score of IM-Medium with moderate and temporary impacts to employees and riders with potential health and safety risks. Air Quality and High Heat are expected to disproportionately affect populations of equity concern.

Extreme Weather Events received a score of IM-Medium due to temporary loss of use possible during events and storms, especially because assets like the P&R facilities have limited enclosed spaces for riders. Additionally, assets such as transit centers and transit stops have limited options for riders to select other locations to their desired destination.

Flooding (for ARTIC only) and **Drought** received a score of IM-Low due to minor increases in maintenance and repair costs to the facility possible resulting from climate stressor exposure.

Wildfire received a score of IM-Low because assets are located far from the WUI. However, regional effects are possible. See Figure 4-9 for the specific location within.

<u>Adaptive Capacity (Inland)</u>

Transit Stops, Centers, and Park-and-Ride Facilities do not have exposure to **Flooding** (except for ARTIC) or **Storm Surge** because assets under this category are not located near rivers, channels, or shoreline.

High Heat (for P&R assets only) and **Air Quality** received a score of AC-Low because the ability to mitigate exposure of employees to high heat and poor AQ is limited due to ventilation needs to protect riders and physical constraints of the outdoor transit centers and P&Rs.

High Heat (for all assets except the P&R facilities) receives a score of AC-Medium because vehicles and transit facilities with enclosed structures can protect employees and riders from effects of high heat. Maintenance needs of facility infrastructure will accelerate.

Extreme Weather Events received a score of AC-Medium because Stationary transit facilities have limited capacity to manage risks from external environmental conditions like storms and Santa Ana winds. Vehicles are likely to experience delays to service provisions.

Drought and **Wildfire** received a score of AC-Low due to the stressor's regional nature of exposure, which requires multi-agency coordination for adaptation methods.

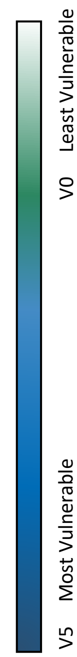
Vulnerability Summary (Inland)

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the Transit Stops, Centers, and Park-and-Ride Facilities is heavily influenced by the physical design, operation, and location of each asset. **Storm Surge** and **Flooding** (except for ARTIC) score as a V0 for inland assets, five stressors (**Drought**, **Extreme Weather**, **Flooding** for ARTIC only, **High Heat** for all assets except the P&R facilities, and **Wildfire**) score a V3, two stressors (**Air Quality** and **High Heat** for the P&R facilities only) score as a V4, and no stressors score as a V1, V2, or V5. The assets included under Transit Stops, Centers, and Park-and-Ride Facilities located in inland zones are expected to experience a number of relatively high vulnerabilities, warranting consideration of adaptation strategies.

Further, most assets within the Transit Stops, Centers, and Park-and-Ride Facilities category are directly linked to the serviceability of OCTA riders. Some OCTA riders are expected to disproportionately rely on OCTA services for transportation and can be susceptible to climate vulnerability; both directly themselves and through disruptions to OCTA assets. The equity "+" consideration has been added to the climate stressors of **Air Quality**, **Extreme Weather Events**, **High Heat**, and **Wildfire**. Adaptation strategies for this asset category considered the equity additions.

__Table 4-10.__ Summary of Transit Stops, Centers, and Park-and-Ride Facilities Vulnerability – ***Coastal***

Transit Stops, Centers, and Park-and-Ride Facilities – Coastal Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	IM-Medium	AC-Low	V4^{+}
Drought	IM-Low	AC-Medium	V2
Extreme Weather Events	IM-Medium	AC-Medium	V3^{+}
Flooding	N/A	N/A	V0
High Heat	IM-Low	AC-Medium	V2^{+}
Storm Surge (SC)	IM-High	AC-Low	V5
Storm Surge (Other Assets)	N/A	N/A	V0
Wildfire (NTC and SC)	IM-High	AC-Low	V5^{+}
Wildfire (Other Assets)	IM-Low	AC-Medium	V2^{+}



__Impacts (Coastal)__

Transit Stops, Centers, and Park-and-Ride Facilities do not have exposure to the climate stressors of **Flooding** and **Storm Surge** (for all assets except SC) because assets under this category are not located near rivers, channels, or shoreline nor are they located near WUI and regional effects of wildfire in the coastal zone are limited to specific local city and county roads.

Air Quality received a score of IM-Medium with moderate and temporary impacts to employees and riders with potential health and safety risks. Air Quality is expected to disproportionately affect populations of equity concern.

High Heat receives a score of IM-Low due to possible minor increases in maintenance and repair costs to the facility. While the average number of high heat days annually is expected to triple, the actual impacts of those high heat days are minimal.

Extreme Weather Events received a score of IM-Medium due to possible temporary loss of use during events and storms, especially because assets have limited enclosed spaces for riders.

Drought and **Wildfire** (for other non-specified assets) received a score of IM-Low due to minor increases in maintenance and repair costs to the facility possible resulting from climate stressor exposure and because assets are located far from the WUI. However, regional effects are possible.

Wildfire (for NTC and SC) and **Storm Surge** (for SC only) received a score of IM-High because assets are located within the WUI and as analyzed in the *Rail Defense Against Climate Change* study, and "Based on an exposure scan using modeled sea level rise data from the U.S. Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) (USGS, 2020), almost all of the coastal rail corridor is exposed to future coastal flooding under at least some increment of SLR."

Adaptive Capacity (Coastal)

Transit Stops, Centers, and Park-and-Ride Facilities do not have exposure to **Flooding** or **Storm Surge** (for all assets except SC) because assets under this category are not located near rivers, channels, or designated areas of storm surge risk.

Air Quality received a score of AC-Low because the ability to mitigate exposure of employees to poor AQ is limited due to ventilation needs to protect riders and physical constraints of the outdoor transit centers and P&Rs.

High Heat receives a score of AC-Medium because vehicles and transit facilities with enclosed structures can protect employees and riders from effects of high heat. Maintenance needs of facility infrastructure could accelerate.

Extreme Weather Events received a score of AC-Medium because Stationary transit facilities have limited capacity to manage risks from external environmental conditions like storms and Santa Ana winds. Vehicles are likely to experience delays to service provisions.

Wildfire (for assets other than NTC and SC) and **Drought** received a score of AC-Medium due to the stressor's regional nature of exposure, which requires multi-agency coordination for adaptation methods. See Figure 4-9 for the specific location of NTC adjacent to the WUI. While not listed in the Figures 4-8 and 4-9, SC is directly within both severe wildfire hazard zones and WUI.

Wildfire (for NTC and SC) received a score of AC-Low due to the stressor's regional nature of exposure, the NTC and SC proximity within the WUI and difficulty to prevent, which requires multi-agency coordination for adaptation methods.

Vulnerability Summary (Coastal)

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the Transit Stops, Centers, and Park-and-Ride Facilities is heavily influenced by the physical design, operation, and location of each asset. Two stressors (**Storm Surge,** for assets other than SC, and **Flooding)** score as a V0 for coastal assets, three stressors (**Wildfire**, for assets other than SC and NTC, **High Heat**, and **Drought**) score as V2, one stressor (**Extreme Weather**) scores a V3, one stressor (**Air Quality**) scores as a V4, two stressors (**Storm Surge** for SC and **Wildfire** for NTC and for SC) score as V5, and no stressors score as a V1. The assets under Transit Stops, Centers, and Park-and-Ride Facilities for coastal assets are expected to experience a number of relatively high vulnerabilities, warranting consideration of adaptation strategies. Flooding is not expected to impact OCTA assets because they are not within recognized FEMA flood zones. Likewise, storm surge is not expected to impact assets other than SC, because permanent locations are largely outside of the 8.5 RCP storm surge predictions. Bus stops can easily be moved if storm surge becomes a chronic condition at specific bus stop locations, and other Agencies responsible for shoreline protection have been unable to increase the resiliency of public roads along the coast.

Further, most assets within the Transit Stops, Centers, and Park-and-Ride Facilities category are directly linked to the serviceability of OCTA riders. Some OCTA riders are expected to disproportionately rely on OCTA services for transportation and can be susceptible to climate vulnerability; both directly themselves and through disruptions to OCTA assets. The equity "+" consideration has been added to the climate stressors of **Air Quality**, **Extreme Weather Events**, **High Heat**, and **Wildfire**. Adaptation strategies for this asset category considered the equity additions.

ROADWAYS AND MANAGED LANES

A roadway is a linear way for the conveyance of traffic that mostly has an improved surface for use by vehicles (motorized and non-motorized) and could include pedestrians. A managed lane is a public or private road (almost always a controlled-access highway in the present day) for which a fee (or toll) is assessed for passage. While some are priced to recoup the costs of road construction and maintenance, others may be priced for congestion management. For instance, the 91 and 405 Express Lanes are part of a managed lanes network whereby high-occupancy vehicles can utilize the lanes with either a discounted rate or free of charge depending on the day and time of day. Solo drivers are required to pay a toll.

OCTA does not own most roadways that intersect the use of other OCTA assets. Even so, their climate vulnerability considerations are important to the serviceability and functioning of OCTA assets, employees, and riders. Additionally, only the 91 and 405 Express Lanes franchise rights are owned and operated by OCTA and have a unique history.

OCTA Assets that fit within this asset category and were analyzed as part of this report include:

- 405 Express Lanes (405 EL)
- 91 Express Lanes (91 EL)
- Caltrans-Owned Highways
- Pacific Electric Right of Way
- City or County-Owned (CC) Roadways

The Roadways and Managed Lanes assets listed above vary between “operated and owned,” “owned and not operated,” and “operated, shared use, or relied upon and not owned,” as well as between the “Inland” and “Coastal” climate zones. For consistency of analysis and to avoid repeated scores for similar assets, vulnerability scores that were consistent between stressors were consolidated between the coastal zones, relation of ownership to OCTA, and subcategories. This ownership relation determined how impacts and adaptive capacities were scored.

Due to the unique ownership arrangement and background of the **91 and 405 Express Lanes**, they warrant further explanation and consideration of climate vulnerability. Given the predicted ownership changes within the long-term planning horizon, special consideration was also given to climate vulnerability and adaptation. Through a franchise agreement with Caltrans that will sunset in 2065, OCTA owns and operates the 91 Express Lanes in the Orange County portion of the State Route (SR)-91 freeway. This 10-mile stretch extends from SR-55 to the Orange-Riverside County line. However, the entire 91 Express Lanes system exists as a four-lane, 18-mile-high occupancy toll road that extends through SR-91 between the SR-55/SR-91 interchange and the SR-91/Interstate (I)-15 interchange. Each quarter, the toll pricing is adjusted based on a congestion management approach that is dictated by traffic volumes. Thus the 91 Express Lanes enable congestion relief to users of the SR-91 corridor.

OCTA has since been enhancing the corridor by improving mobility to aid growing transportation demands and improve traffic flow between Orange and Riverside counties. Today, both OCTA and the Riverside County Transportation Commission (RCTC) service both segments of the 91 Express Lanes, with RCTC owning the remaining eight miles of the segment from the Riverside-Orange County line to McKinley Street.

Tables 4-11 and Table 4-12 summarize the Impact, Adaptive Capacity, and resulting vulnerability scores for the Roadways and Managed Lanes for assets located Inland and within the Coastal Region, respectively. Below the tables are descriptors for the Impact and Adaptive Capacity scoring, as well as a Vulnerability summary.

__Table 4-11.__ Summary of Roadways and Managed Lanes Vulnerability – __Inland__

Roadways and Managed Lanes – Inland Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	N/A	N/A	V0
Drought (91 EL Only)	IM-Medium	AC-Low	V4
Drought (Other Assets)	IM-Medium	AC-Medium	V3
Extreme Weather Events	IM-Medium	AC-Medium	V3
Flooding (CC Roadways Only)	IM-Low	AC-Low	V3
Flooding (Other Assets)	N/A	N/A	V0
High Heat	IM-High	AC-Medium	V4
Storm Surge	N/A	N/A	V0
Wildfire (91 EL Only)	IM-High	AC-Low	V5
Wildfire (Other Assets)	IM-Low		V3

V0 Least Vulnerable

V5 Most Vulnerable

Impacts (Inland)

Roadways and Managed Lanes do not have exposure to the climate stressors of **Flooding** (for assets other than CC Roadways), **Air Quality**, and **Storm Surge** because Air Quality is not a concern to assets on the roads themselves and assets under this category are not located near rivers, channels, or shoreline.

High Heat received a score of IM-High because the increased number of high heat days may cause concrete assets to contract and expand.

Extreme Weather Events received a score of IM-Medium due to possible temporary loss of use during events and storms, especially surface flooding of entryways for critical paths.

Flooding (for CC Roadways only) received a score of IM-Low due to possible minor increases in maintenance and repair costs to the facility resulting from climate stressor exposure. 91 ad 405 Express Lanes on highway sit much above grade, reducing exposure to flooding compared to CC roadways.

Drought received a score of IM-Medium due to possible increased formations of sinkholes resulting from subsidence as more groundwater is removed.

Wildfire (for the 91 EL only), received a score of IM-High because assets are located within the WUI.

Wildfire (for all other assets except 91 EL) received a score of IM-Low because assets are located far from the WUI. However, regional effects are possible.

Adaptive Capacity (Inland)

Roadways and Managed Lanes do not have exposure to the climate stressors of **Flooding,** for assets other than CC Roadways, **Air Quality**, and **Storm Surge** because Air Quality is not a concern to assets on the roads themselves and assets under this category are not located near rivers, channels, or shoreline.

High Heat received a score of AC-Medium because the increased number of high heat days could cause the concrete to contract and expand, inducing road buckling. Precipitation can exacerbate degradation of roads due to cracks formed by high heat.

Flooding (for CC Roadways only) received a score of AC-Low because surface street flooding during rainstorms and riverine flooding from the Santa Ana River may impact transit lines and vulnerable infrastructure, and feasible adaptation methods would require actions by other entities.

Extreme Weather Events received a score of AC-Medium because Stationary transit facilities have limited capacity to manage risks from external environmental conditions like storms and Santa Ana winds. Vehicles are likely to experience delays to service provisions.

Drought (for the 91 EL only) and **Wildfire** received a score of AC-Low due the ownership requirements of to maintain at scale and multi-agency coordination.

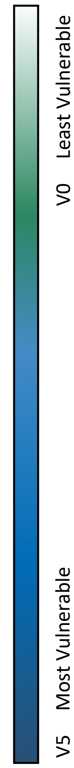
Drought (for all other assets except 91 EL) received a score of AC-Medium due to the stressor's regional nature of exposure, which requires multi-agency coordination for adaptation methods.

Vulnerability Summary

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the Roadways and Managed Lanes is heavily influenced by the physical design, operation, and location of each asset. For the inland assets, three stressors (**Air Quality**, **Flooding** for assets except CC Roadways, and **Storm Surge**) score as a V0, four stressors (**Drought** for assets other than the 91 EL, **Extreme Weather**, **Flooding** for CC Roadways only, and **Wildfire** for assets other than the 91 EL) score as a V3, two stressors (**Drought** for the 91 EL only, and **High Heat**) score as a V4, and one stressor (**Wildfire** for the 91 EL only) scores as V5 and no stressors score as V1 or V2. Adaptation strategies are considered for inland Roadways and Managed Lanes for the climate stressors scoring a V3 or higher.

__Table 4-12.__ Summary of Roadways and Managed Lanes Vulnerability – __Coastal__

Roadways and Managed Lanes – Coastal Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	N/A	N/A	V0
Drought (405 EL Only)	IM-Medium	AC-Low	V4
Drought (Other Assets)		AC-Medium	V3
Extreme Weather Events	IM-Medium	AC-Medium	V3
Flooding (CC Roadways Only)	IM-Low	AC-Low	V3
Flooding (Other Assets)	N/A	N/A	V0
High Heat	IM-Medium	AC-Medium	V3
Storm Surge	IM-Medium	AC-Medium	V3
Wildfire (CC Roadways Only)	IM-High	AC-Low	V5
Wildfire (Other Assets)	IM-Low		V3



__Impacts (Coastal)__

Roadways and Managed Lanes do not have exposure to the climate stressors of **Flooding**, for assets except CC Roadways, and **Air Quality** because Air Quality is not a concern to assets on the roads themselves and assets under this category are not located near rivers or channels.

High Heat received a score of IM-Medium because the increased number of high heat days could cause the concrete assets to contract and expand.

Extreme Weather Events and **Storm Surge** received a score of IM-Medium due to possible temporary loss of use during events and storms, especially surface flooding of entryways for critical paths.

Flooding, for CC Roadways only, received a score of IM-Low due to possible minor increases in maintenance and repair costs to the facility resulting from climate stressor exposure.

Drought received a score of IM-Medium due to possible increased formations of sinkholes resulting from subsidence as more groundwater is removed.

Wildfire, for CC Roadways only, received a score of IM-High because assets are located within the WUI.

Wildfire, for assets except CC Roadways, received a score of IM-Low because assets are located far from the WUI. However, regional effects are possible.

<u>Adaptive Capacity (Coastal)</u>

Roadways and Managed Lanes do not have exposure to the climate stressors of **Flooding,** for assets except CC Roadways, and **Air Quality** because Air Quality is not a concern to assets on the roads themselves, and assets under this category are not located near rivers or channels.

High Heat received a score of AC-Medium because the increased number of high heat days could cause the concrete to contract and expand. Precipitation can wash out soil and increase degradation of concrete due to cracks formed by high heat.

Flooding, for CC Roadways only, received a score of AC-Low because surface street flooding during rainstorms and riverine flooding from the Santa Ana River may impact transit lines and vulnerable infrastructure, and feasible adaptation methods would require actions by other entities.

Extreme Weather Events and **Storm Surge** received a score of AC-Medium because stationary roadway assets have limited capacity to manage risks from external environmental conditions like storm surges, storms, and Santa Ana winds. Vehicles are likely to experience delays to service provisions.

Drought, for the 405 EL asset, and **Wildfire** received a score of AC-Low due the ownership requirements to maintain at scale and multi-agency coordination.

Drought, for assets other than the 405 EL, received a score of AC-Medium due to the stressor's regional nature of exposure, which requires multi-agency coordination for adaptation methods.

<u>Vulnerability Summary (Coastal)</u>

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Two stressors (**Air Quality** and **Flooding** for assets except CC Roadways) score as a V0, six stressors (**Drought**, for assets except the 405 EL, **Extreme Weather**, **Flooding**, for CC Roadways only, **High Heat**, **Storm Surge**, and **Wildfire** for assets except CC Roadways) score as a V3, one stressor (**Drought** for the 405 EL only) scores as a V4, and one stressor (**Wildfire** for CC Roadways only) scores as a V5. No stressors score as a V1 or a V2. For the climate stressors scoring a V3 or higher, OCTA prioritized development of preliminary strategies.

OCTA PRESERVES

Working in collaboration with State and Federal wildlife agencies, OCTA established OC Go's Environmental Mitigation Program, which allocates funds to acquire land and fund habitat restoration projects to offset the environmental impacts of OC Go freeway projects. This Program represents the culmination of years of collaboration and support of environmental communities.

In November 2010, the Board allocated $42 million to purchase open space in Orange County. To date, OCTA has acquired more than 1,300 acres in Brea, Laguna Beach, Silverado Canyon, and Trabuco Canyon (collectively named the Preserves).

Additionally, a total of 12 restoration projects have been funded throughout Orange County. Approximately $10 million has been allocated to restore about 350 acres of open space land. Together, this effort ensures 13 sensitive species are protected in their native habitat.

An endowment has been established to pay for the long-term management of the Preserves. Additional preserve acquisitions will be dependent on the sales tax revenue stream and a fully funded endowment, which is estimated by 2030.

OCTA Assets that fit within this asset category and were analyzed as part of this report include:

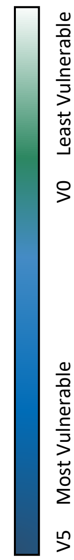
- Pacific Horizon (formerly Aliso Canyon) Preserve
- Eagle Ridge (formerly Hayashi) Preserve
- Silverado Chaparral (formerly MacPherson) Preserve
- Four properties in the Foothill-Trabuco area:
    - Trabuco Rose (formerly Ferber Ranch) Preserve
    - Wren's View (formerly O'Neill Oaks) Preserve
    - Live Oak Creek (formerly Saddle Creek South) Preserve
    - Bobcat Ridge (formerly Hafen) Preserve

While OCTA would not be solely responsible for the remediation and immediate response should the Preserves be impacted by a climate stressor, the agency would be called upon to partake in the response efforts.

Table 4-13 and Table 4-14 summarize the Impact, Adaptive Capacity, and resulting vulnerability scores for the OCTA Preserves between assets located Inland and within the Coastal Region, respectively. Below the tables are descriptors for the Impact and Adaptive Capacity scoring, as well as a Vulnerability summary.

__Table 4-13.__ Summary of OCTA Preserves Vulnerability – ***Inland*** *(includes* ***Eagle Ridge, Silverado Chaparral, Trabuco Rose, Wren's View, Live Oak Creek, Bobcat Ridge****)*

OCTA Preserves – Inland Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	N/A	N/A	V0
Drought	IM-High	AC-Low	V5
Extreme Weather Events	IM-Low	AC-Medium	V2
Flooding	N/A	N/A	V0
High Heat	IM-High	AC-Low	V5
Storm Surge	N/A	N/A	V0
Wildfire	IM-Medium	AC-Low	V4



Impacts (Inland)

OCTA Preserves do not have exposure to the climate stressors of **Flooding, Air Quality**, and **Storm Surge** because Air Quality is not a concern to the Preserves themselves and assets under this category are not located near rivers, channels, or shoreline.

High Heat received a score of IM-High because the increased number of high heat days will cause stress to the ecosystems.

Extreme Weather Events received a score of IM-Low because vegetation impacts from extreme weather are minimal.

Drought received a score of IM-High due to possible increased formations of sinkholes resulting from subsidence as more groundwater is removed and decreased water availability to vegetation.

Wildfire received a score of IM-Medium because assets already exist in a very high fire hazard zone. Increases from existing impacts are minimal, but frequency will increase.

Adaptive Capacity (Inland)

OCTA Preserves do not have exposure to the climate stressors of **Flooding, Air Quality**, and **Storm Surge** because Air Quality is not a concern to the Preserves themselves and assets under this category are not located near rivers, channels, or shoreline.

High Heat received a score of AC-Low because maintenance needs of natural upkeep may accelerate. Disruptions and health of vegetation will depend on native and diverse mixes within the properties. Increased water needs are also expected.

Extreme Weather Events received a score of AC-Medium because Stationary Preserves have limited capacity to manage risks from external environmental conditions like storms and Santa Ana winds. Maintenance needs of natural upkeep accelerate. Varied precipitation can wash out soil and disrupt ecosystems.

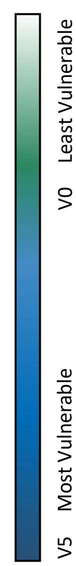
Drought and **Wildfire** received a score of AC-Low due to the stressor's regional nature of exposure, which requires multi-agency coordination for adaptation methods.

Vulnerability Summary (Inland)

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the inland OCTA Preserves is heavily influenced by the management and location of each asset. Three stressors (**Air Quality**, **Flooding**, and **Storm Surge**) score as a V0, one stressor (**Extreme Weather**) scores as a V2, one stressor (**Wildfire**) scores as a V4, and two stressors (**Drought** and **High Heat**) score as a V5, and no stressors score as a V1 or V3. The OCTA Preserves located inland are expected to experience a number of relatively high vulnerabilities, warranting consideration of adaptation strategies.

Table 4-14. *Summary of OCTA Preserves Vulnerability –* ***Coastal*** *(includes* ***Pacific Horizon****)*

OCTA Preserves – Coastal Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	N/A	N/A	V0
Drought	IM-High	AC-Low	V5
Extreme Weather Events	IM-Low	AC-Medium	V2
Flooding	N/A	N/A	V0
High Heat	IM-Low	AC-Low	V3
Storm Surge	N/A	N/A	V0
Wildfire	IM-Medium	AC-Low	V4



Impacts (Coastal)

OCTA Preserves do not have exposure to the climate stressors of **Flooding, Air Quality**, and **Storm Surge** because Air Quality is not a concern to the Preserves themselves and assets under this category are not located near rivers, channels, and are elevated from the shoreline.

High Heat received a score of IM-Low because the increased number of high heat days will cause stress to the ecosystems. However, the high heat days in the coastal climate zone are very moderate.

Extreme Weather Events received a score of IM-Low because vegetation impacts from extreme weather are minimal.

Drought received a score of IM-High due to possible increased formations of sinkholes resulting from subsidence as more groundwater is removed and decreased water availability to vegetation.

Wildfire received a score of IM-Medium because assets already exist in a very high fire hazard zone. Increases from existing impacts are minimal, but frequency will increase.

Adaptive Capacity (Coastal)

OCTA Preserves do not have exposure to the climate stressors of **Flooding, Air Quality**, and **Storm Surge** because Air Quality is not a concern to the Preserves themselves, and assets under this category are not located near rivers and channels and are elevated from the shoreline.

High Heat received a score of AC-Low because maintenance needs of natural upkeep may accelerate. Disruptions and health of vegetation will depend on native and diverse mixes within the properties. Increased water needs are also expected.

Extreme Weather Events received a score of AC-Medium because Stationary Preserves have limited capacity to manage risks from external environmental conditions like storms and Santa Ana winds. Maintenance needs of natural upkeep may accelerate. Varied precipitation can wash out soil and disrupt ecosystems.

Drought and **Wildfire** received a score of AC-Low due to the stressor's regional nature of exposure, which requires multi-agency coordination for adaptation methods.

Vulnerability Summary (Coastal)

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the OCTA Preserves is heavily influenced by the management and location of each asset. Three stressors (**Air Quality**, **Flooding**, and **Storm Surge**) score as a V0, one stressor (**Extreme Weather**) scores as a V2, one stressor (**High Heat**) scores as a V3, one stressor (**Wildfire**) scores as a V4, and one stressor (**Drought**) scores as a V5, and no stressors score as a V1. The OCTA Preserve located in the Coastal Region is expected to experience a number of relatively high vulnerabilities, warranting consideration of adaptation strategies.

UTILITIES

OCTA relies on several public utilities to support operations. Public utilities are meant to supply goods/services that are considered essential; water (including stormwater), gas, electricity, telephone, and other communication systems represent much of the public utility market. The transmission lines used in the transportation of electricity, or natural gas pipelines, have natural monopoly characteristics. OCTA acknowledges that its dependency on these utilities exposes it to the vulnerabilities experienced by the utilities.

OCTA does not own any utilities that intersect the use of other OCTA assets. Even so, their climate vulnerability considerations are important to the serviceability and functioning of OCTA assets, employees, and riders.

Should utilities experience an interruption in service as a result of climate hazards, this will disrupt OCTA's operations. As such, utilities were included in the CVA.

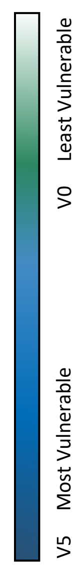
OCTA Assets that fit within this asset category and were analyzed as part of this report include:

- Electrical Grid and Distribution (EGD)
- Storm Drain Systems (SDS)

Table 4-15 and Table 4-16 summarize the Impact, Adaptive Capacity, and resulting vulnerability scores for the Utilities between assets located Inland and within the Coastal Region, respectively. Below the tables are descriptors for the Impact and Adaptive Capacity scoring, as well as a Vulnerability summary.

Table 4-15. *Summary of OCTA Preserves Vulnerability -* ***Inland***

Utilities – Inland Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	N/A	N/A	V0
Drought	N/A	N/A	V0
Extreme Weather	N/A	N/A	V0
Flooding	IM-Medium	AC-Medium	V3
High Heat	IM-Medium	AC-Low	V4
Storm Surge	N/A	N/A	V0
Wildfire	N/A	N/A	V0



<u>Impacts (Inland)</u>

Utilities are not expected to have appreciable vulnerability to the climate stressors of **Air Quality, Drought, Extreme Weather Events, Wildfire**, and **Storm Surge** in ways that would impact OCTA operations. Thus, they screened out of further consideration in this assessment. Utility vulnerability to **High Heat** and **Flooding** could impact OCTA assets and operations and were carried forward for further adaptation strategy consideration.

High Heat received a score of IM-Medium because the increased number of high heat days can lead to an overloaded electrical grid and increased demand for cooling.

Flooding received a score of IM-Medium because varied precipitation and riverine flooding can overwhelm existing storm drains.

Adaptive Capacity (Inland)

Utilities are not expected to have appreciable vulnerability to the climate stressors of **Air Quality, Drought, Extreme Weather Events, Wildfire**, and **Storm Surge** in ways that would impact OCTA operations. Thus, they screened out of further consideration in this assessment.

High Heat received a score of AC-Low because maintenance needs of system upkeep could accelerate and would require multi-agency coordination for upgrading and expanding utility systems.

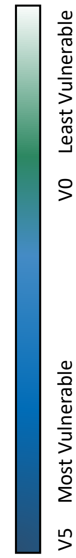
Flooding received a score of AC-Medium because maintenance needs of system upkeep could accelerate, which may require increased redundancy and damage mitigation.

Vulnerability Summary (Inland)

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the Utilities is heavily influenced by the physical design and operation of each asset. Five stressors (**Air Quality**, **Drought**, **Extreme Weather**, **Storm Surge**, and **Wildfire**) score as a V0, one stressor (**Flooding**) scores as a V3, one stressor (**High Heat**) scores as a V4, and no stressors score as a V1, V2, or V5. Adaptation strategies are considered for inland Utilities for the climate stressors scoring a V3 or higher.

Table 4-16. *Summary of Utilities Vulnerability –* ***Coastal***

Utilities – Utilities Assets			
Climate Stressor	**Impact Score**	**Adaptive Capacity**	**Vulnerability Score**
Air Quality	N/A	N/A	V0
Drought	N/A	N/A	V0
Extreme Weather Events	N/A	N/A	V0
Flooding	IM-Medium	AC-Medium	V3
High Heat	IM-Low	AC-Low	V3
Storm Surge	N/A	N/A	V0
Wildfire	N/A	N/A	V0



Impacts (Coastal)

Utilities are not expected to have appreciable vulnerability to the climate stressors of **Air Quality, Drought, Extreme Weather Events, Wildfire**, and **Storm Surge** in ways that would impact OCTA operations. Thus, they screened out of further consideration in this assessment.

High Heat received a score of IM-Low because the increased number of high heat days can lead to an overloaded electrical grid and increased demand for cooling, though moderately.

Flooding received a score of IM-Medium because varied precipitation and riverine flooding can overwhelm existing storm drains.

Adaptive Capacity (Coastal)

Utilities are not expected to have appreciable vulnerability to the climate stressors of **Air Quality, Drought, Extreme Weather Events, Wildfire**, and **Storm Surge** in ways that would impact OCTA operations. Thus, they screened out of further consideration in this assessment **High Heat** received a score of AC-Low because maintenance needs of system upkeep could accelerate and would require multi-agency coordination for upgrading and expanding utility systems.

Flooding received a score of AC-Medium because maintenance needs of system upkeep could accelerate, which may require increased redundancy and damage mitigation.

Vulnerability Summary (Coastal)

The combination of impact and adaptive capacity scores results in the vulnerability scores for each climate stressor. Vulnerability of the Utilities is heavily influenced by the physical design and operation of each asset. Five stressors (**Air Quality**, **Drought**, **Extreme Weather**, **Storm Surge**, and **Wildfire**) score as a V0, two stressors (**Flooding** and **High Heat**) score as a V3, and no stressors score as a V1, V2, V4, or V5. Adaptation strategies are considered for inland Utilities for the climate stressors scoring a V3 or higher.

4.4 CLIMATE ADAPTATION MEASURES

Based on the prioritization of vulnerabilities described above, OCTA developed a preliminary list of potential adaptation measures—for climate stressors scoring a V3 or higher—the agency could consider implementing to increase the resiliency of its assets now and in the future.

Adaptation measures have been developed for each of the seven climate stressors studied: air quality, precipitation changes and drought, flooding (riverine), extreme weather, storm surge, high heat, and wildfires. Because the changes in climate for Orange County are predicted to happen relatively slowly, OCTA developed measures that could be implemented in the short-, medium- and long-term planning horizons.

A description of each strategy, including the timeframe, key performance indicators (KPIs) and co-benefits, are presented below in Table 4-20. The subsequent asset category sub-sections below detail the relevance of each strategy to the specific asset category and provide example measures for each medium- to high-vulnerability score. The identified strategies are applicable across both inland and coastal climate zones. The acronym used for each climate stressor is laid out in Table 4-17.

Table 4-17. *Adaptation Measure Key*

Measure Abbreviation	Descriptor
AQ	Air Quality
D	Drought
EW	Extreme Weather
HH	High Heat
FL	Flooding
SS	Storm Surge
WF	Wildfire

Each measure has been assigned a rough order of magnitude (ROM) implementation and capital cost estimate using the scale as described in Table 4-18 below. It is noted that the ROM costs referenced in this report reflect full, upfront investment costs only, and do not include associated cost-savings.

Table 4-18. *ROM Cost Ranges*

ROM Cost	Cost Range
$	$0 - $500,000
$$	$500,000 - $1.5 million
$$$	$1.5 million - $25 million
$$$$	$25 million - $100 million
$$$$$	$100 million+

Additionally, through the development of the measures, OCTA considered several co-benefits in addition to adaptation to further its holistic approach to sustainability. The co-benefits considered are shown in Table 4-19.

Table 4-19. *Co-Benefits*

Icon	Co-Benefit
	Regulatory Compliance
	Cost Savings
	Equity
	GHG Mitigation
	Air Quality Improvements

Table 4-20. *Climate Adaptation Measures*

Measure	Implementation Horizon	KPI	Costs		Co-benefit
			Plan	Capital	
AQ-1: Outdoor Exposure and Emissions Reduction	Short to long-term	Reduction in lost productivity due to respiratory ailments. Revenue stabilization on days with poor air quality	$	$	
AQ-2: Indoor Air Quality	Short to medium-term	Improvement to productivity due to reduction in respiratory ailments and complaints from employees	$	$	
D-1: Facilities	Short to long-term	Reduction in potable water consumption and resource efficiency	$	$ to $$	
D-2: Routes and Roads	Medium to long-term	Avoidance of closures and re-routing and reduced maintenance on roadways	$	$$$$	
D-3: Vegetation	Medium to long-term	Reduction of water demand at assets and reduced maintenance from soil stabilization	$	$ to $$	
EW-1: Emergency Operations	Medium to long-term	Maintained productivity and improved response to extreme weather events	$	Unknown	
HH-1: Employee Cooling	Short to Medium Term	Maintaining productivity and increasing employee health	$	Unknown	
HH-2: Ventilation	Short to Long Term	Decreased temperatures and improvement in indoor air quality	$	$ to $$	
HH-3: Shading	Medium Term	Reduced energy consumption in buildings	$	Unknown	
HH-4: Shade Trees	Short to Medium Term	Decreased temperatures	$	$ to $$	
HH-5: Urban Heat Island Effect Reduction	Medium to Long Term	Building performance	$	$ to $$	
HH-6: Maintenance	Medium to Long Term	Reduced major maintenance costs	$	$$ to $$$	
HH-7: Power	Medium to Long Term	Increased redundancy and continuity of service	$	$$$	

Measure	Implementation Horizon	KPI	Costs		Co-benefit
			Plan	Capital	
HH-8: Weatherizing	Short to medium-term	Continuity of service	$	$$	
FL-1: Facilities	Short to long-term	Reduction in lost productivity due to flooding	$	$ to $$$	
FL-2: Routes and Roads	Medium to long-term	Avoidance of closures and re-routing during storm and flood events	$	Up to $$$$$	
FL-3: Infrastructure	Medium to long-term	Reduction in lost productivity due to flooding	$	$$$	
SS-1: Warning System	Medium to long-term	Reduction in lost productivity due to flooding	$	Unknown	
SS-2: Routes and Roads	Short to long-term	Avoidance of closures and re-routing during storm and flood events	$	Up to $$$$	
WF-1: Vegetation Management	Medium Term	Reduced fire risk	$	$$	
WF-2: Power	Medium to Long Term	Increased redundancy and continuity of service	$	$$$	

BUS MAINTENANCE AND OPERATIONS BASES

The adaptation strategies provided below identify possible ways to address the vulnerability of the Bus Maintenance and Operations Bases to future climate stressors. Numbering associated with the applicable adaptation strategies to the Bus Maintenance and Operations Base asset class corresponds with the global numbering within each climate stressor. This section organizes the strategies that apply to the asset category and provides measures to consider for specific implementation. A more in-depth discussion of the adaptation strategies, including considerations of performance metrics and key performance indicators (KPIs), estimated implementation horizons, costs, and co-benefits, can be found in Table 4-20.

Bus Maintenance and Operations Bases are expected to be most vulnerable to Air Quality, High Heat, and Extreme Weather (for Garden Grove only). Maintaining employee productivity and health during exacerbated air quality and high heat days overlap each other with potential options. Strategies to reduce precipitation related infrastructure damage and serviceability interferences may also operate in tandem with flood and extreme weather strategies. Strategies to reduce subsidence from drought are outside the reach of OCTA and were omitted from consideration. Wildfire was omitted from consideration due to limited adaptive needs.

Adaptation Measures

- During poor air quality days (as defined by the South Coast AQMD forecasts, predictions, and measurements of 100+ Air Quality Index [AQI]), consider strategies to reduce employee and rider exposure through operational means, such as increased rest periods for employees. (AQ-1)
- During poor air quality days, reduce emissions by reducing idling of vehicles. (AQ-1)
- Add high performance air filtration systems to indoor stations/facilities. (AQ-2)
- Explore additional options to reduce water consumption at bus bases for washing buses or other service/maintenance activities. (D-1)
- Choose plant palettes that are native and drought tolerant (D-3)
- To combat high heat, incorporate employee training regarding managing heat stress and consider providing additional cooling measures. (HH-1)
- To mitigate the human health effects and energy demands of high heat, determine feasibility of new design parameters for increased ventilation. (HH-2)
- Explore facility surface and building improvements to reduce urban heat island effect. (HH-5)
- Investigate feasibility of fuel diversification and battery energy storage systems (BESS) onsite of facilities and yards. (HH-7)
- Weatherize electrical components of signal/communication systems at bus bases. (HH-8)
- Explore design and retrofit capabilities to improve flood resiliency of operations and infrastructure. (FL-1)
- Explore means to protect fueling and recharging systems from flood potential. (FL-1)
- Consider flood risks when placing new routes and assets in flood prone areas. (FL-2)
- Consider implementing operational redundancy to allow for quick assistance to emergency situations. (EW-1)
- Consider back-up power needs for fueling and other critical functions during potential energy disruption events. (WF-2)

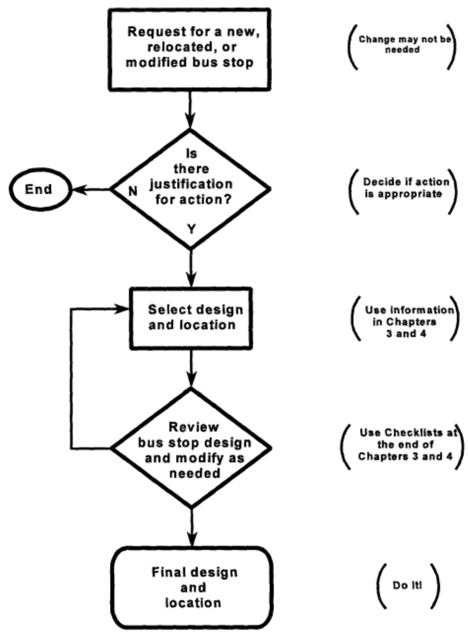
TRANSIT STOPS, CENTERS, AND PARK-AND-RIDE FACILITIES

Transit Stops, Transit Centers, and Park-and-Ride Facilities vulnerability differs significantly between the climate zones. Maintaining serviceability and health of employees and riders during exacerbated air quality and high heat days overlap with potential options. Strategies to reduce precipitation related infrastructure damage and serviceability interferences can operate in tandem with flood and extreme weather strategies, even if vulnerability varies between these stressors. Strategies to reduce subsidence from drought are outside the reach of OCTA and were omitted from consideration.

This section organizes the strategies that apply to the asset category and provides measures to consider for specific implementation. A more in-depth discussion of the adaptation strategies can be found in Table 4-20.

FTA supports advances in technology to enhance public transportation operations across all aspects of system services — designing buses, maintaining and managing important transit assets, and ensuring a state of good repair. Guidelines provided by the FTA include design of bus stop spacing and locations, merge rules, bus bulbs, and bus shelters. Decision-making processes may also rely on FTA guidance and funded research guidelines by the Transit Cooperative Research Program (TCRP). For example, bus stop design and location decisions begin with the request or the recognition that a new or modified bus stop is needed. The process concludes with the implementation of numerous interrelated decisions. It is important to note that while OCTA may provide input into the process, stops are located and designed by local agencies. Figure 4-12 below shows the decision-making diagram.[40]

Figure 4-12. *Decision Diagram – TCRP Guidelines for the Location and Design of Bus Stops*



Adaptation Measures

- During poor air quality days, consider strategies to reduce employee and rider exposure through operational means, such as increased rest periods for employees. (AQ-1)
- Exploring the feasibility of replacing water fixtures, toilets, and urinals at bus bases and facilities with low-flow options. (D-1)
- To mitigate the human health effects of high heat, determine feasibility of active or passive methods in the design of structures, buildings, and shelters at transit stops and centers. (HH-2)
- Considering active or passive methods in the design of structures, buildings,

[40] The Federal Transit Administration. "TCRP Report 19." 1996. <https://nacto.org/docs/usdg/tcrp_report_19.pdf>.

shelters, and passenger waiting areas that block, diffuse, or otherwise limit direct sunlight. (HH-3)

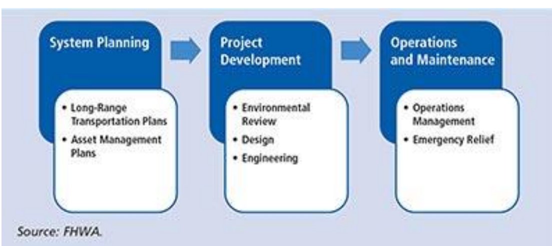
- Determine the feasibility of planting shade trees and heat and drought tolerant, low-maintenance native plant species at stations and/or facilities. (HH-4)
- Explore facility surface and building improvements to reduce urban heat island effect. (HH-5)
- Increasing permeable surface area on site. (FL-1)
- Explore design and retrofit capabilities to create flood-resilient operations and infrastructure. (FL-1)
- Avoid placing new routes and assets in flood prone areas. (FL-2)
- Investigate implementation of a storm surge forecasting and early warning detection system. (SS-1)
- Advocate and coordinate with responsible agencies for protective measures along coastal routes and transit stops, considering both human-made and nature-based solutions. (SS-2)
- Manage vegetation in the right-of-way in high wildfire exposure areas. (WF-1)
- Consider implementing operational redundancy to allow for quick assistance to emergency situations. (EW-1)

ROADWAYS AND MANAGED LANES

The adaptation measures provided here identify possible ways to address the vulnerability of Roadways and Managed Lanes to future climate stressors. However, OCTA has limited control over any changes as these assets must meet local or state design standards.

Roadway and Managed Lanes vulnerability somewhat differs between the climate zones. Maintaining serviceability and health of employees and riders during exacerbated air quality and high heat days overlap with potential options. Measures to reduce precipitation infrastructure damage and serviceability interferences can operate in tandem with flood and extreme weather strategies, even if vulnerability varies between these stressors.

Figure 4-13. *FHWA Integration of Climate Change into Transportation Decision-making Outline*



Source: FHWA.

FHWA strives to sustainably strengthen the resiliency of the U.S. highway system by mitigating the impacts weather can have on it and the environment. FHWA has developed and tested a Climate Change and Extreme Weather Vulnerability Assessment Framework which consists of a report and an online virtual framework; both serve as a guide and a collection of resources for use by transportation professionals when analyzing the impacts of climate change and extreme weather on transportation infrastructure. They have also developed an Integration of Climate Change into Transportation Decision-making outline.[41] These guidelines and outlines help identify key considerations, questions, and resources that can be used to design and implement infrastructure and investment decisions.[42] These guidelines and other tools can serve as resources for climate adaptation.

This section organizes the measures that apply to the asset category and provides measures to consider for specific implementation. A more in-depth discussion of the adaptation measures can be found in Table 4-20.

Adaptation Measures

- Explore surface improvements to reduce urban heat island effect. (HH-5)
- Follow U.S. DOT FHWA recommendations on the design and maintenance of roadways exposed to high heat. (HH-6)
- Explore design and retrofit capabilities to create flood-resilient operations and infrastructure. (FL-1)
- Avoid placing new routes and assets in flood-prone areas. (FL-2)
- Investigate the implementation of a storm surge forecasting and early warning detection system. (SS-1)
- Advocate and coordinate with responsible agencies for protective measures along coastal routes and transit stops, considering both human-made and nature-based solutions. (SS-2)
- Manage vegetation in the right-of-way in high wildfire exposure areas. (WF-1)
- Advocate and coordinate with responsible agencies for protective measures against subsidence. (D-2)

[41] U.S. Department of Transportation Federal Highway Administration. “Climate Change Adaptation Guide for Transportation Systems Management, Operations, and Maintenance.” 17 August 2015. <ops.fhwa.dot.gov/publications/fhwahop15026/fhwahop15026.pdf>.

[42] U.S. Department of Transportation Federal Highway Administration. “Public Roads - January/February 2017.” January 2017. <highways.dot.gov/public-roads/januaryfebruary-2017/preparing-change>.

OCTA PRESERVES

Existing strategies for the OCTA Preserves strive to maintain natural habitats and prevent degradation from climate stressors.

A conservation plan developed to protect the natural habitat and wildlife on OCTA's Preserves was finalized in spring 2017. In conjunction with the conservation plan, Resource Management Plans were developed for each of the Preserves that identify site-specific management strategies for species and habitat protection, as well as public access and education. Additionally, Fire Management Plans (FMPs) for each of the Preserves are underway. They will provide guidance on planning for appropriate fire management actions to protect biological resources during fire suppression activities. The FMPs will also aim to increase the resiliency of the natural ecosystems on the Preserves in the event of a wildfire.

This section organizes the strategies that apply to the asset category and provides measures to consider for specific implementation. A more in-depth discussion of the adaptation measures can be found in Table 4-20.

The adaptation measures provided below identify possible ways to address the vulnerability of the Preserves to future climate stressors.

Adaptation Measures

- Increase in maintenance protection and replacement of infrastructure and natural resources. (HH-6)
- Manage vegetation in the right-of-way in high wildfire exposure areas. (WF-1)
- Advocate and coordinate with responsible agencies for protective measures against subsidence. (D-2)

UTILITIES

The adaptation measures provided below identify possible ways to address the vulnerability of Utilities to future climate stressors.

This section organizes the measures that apply to the asset category and provides measures to consider for specific implementation. A more in-depth discussion of the adaptation strategies can be found in Table 4-20.

Adaptation Measures

- Coordinating with utility providers to protect critical infrastructure. (HH-6)
- Coordinating with local public works departments to proactively reduce potential flood risks of nearby channels and storm drain systems. (FL-3)
- Consider renewable energy production (such as solar PV, micro wind turbines, and fuel cell electric technology) and energy storage on-site. (WF-2)

5 SUSTAINABILITY & CLIMATE CHANGE MITIGATION

Transportation agencies are responsible for two key categories of GHG emissions:

1) Emissions generated as an outcome of the agency's operations, resulting from fuel and resource use in its vehicles and facilities.
2) Emissions displaced across the region as a result of transit reducing the number of single-occupancy vehicles (and associated emissions) on the road.

The CASP quantifies OCTA's operational GHG emissions and provides an analysis of the regional GHG emission benefits resulting from OCTA's transit services, which is OCTA's most significant contribution to climate action in the region. Building on OCTA's sustainability efforts to date and the results of the updated emission baselines, the CASP explores additional strategies to mitigate operational emissions from combusted fuels that power OCTA facilities and fleets, as well as from purchased electricity.

5.1 BASELINE & FORECAST OPERATIONAL GHG EMISSIONS

The CASP builds on and improves OCTA's prior GHG inventory accounting practices and establishes a new GHG emission performance baseline for the 2021 calendar year. This updated baseline is the foundation of the agency's forecasted emissions through 2045, as well as the three-tiered exploratory GHG emission reduction targets and strategies outlined in this plan; it will also serve as the point of reference in future years to measure and report on the emission reductions achieved as a result of selected strategy implementation.

SCOPE AND METHODOLOGY

As the sustainability portion of the CASP focuses on emission sources owned or controlled by the agency, the inventory boundary is limited to all OCTA-owned or leased assets, including building infrastructure, bus and rail infrastructure, and revenue and non-revenue vehicles.

Emissions inventories are typically organized into three emissions 'scopes' per industry best practice. For the purposes of this CASP, OCTA is primarily reporting on and exploring potential targets for operational Scope 1 and 2 emissions and is not including Scope 3 emissions in its baseline inventory (Summarized in Table 5-1 and Figure 5-1).[43] This inventory does not include any insets or offsets, and only includes actual emissions from agency operations.

In addition to establishing an updated baseline, a forecast of OCTA's operational emissions through 2045 was developed based on a business-as-usual (BAU) scenario. 2045 was selected as the horizon year because it aligns with the statewide Renewable Portfolio Standard (RPS) and with California's overarching goal of carbon neutrality by 2045, In a BAU scenario, it is assumed that the agency is taking no additional actions to reduce GHG emissions apart from existing internal initiatives and external regulatory drivers of emission reductions. OCTA's 2045 BAU Scenario considers the projected growth in mobility services and ridership, the transition to a 100% zero-emission bus fleet, construction of new facilities, and the statewide RPS target of 100% emissions-free electricity by 2045. The transition to a 100% zero-emission bus fleet is specifically included in the BAU (despite also being listed as a strategy to reduce emissions) because it is an existing commitment on behalf of OCTA as part of the ZEB Plan submitted and approved by CARB prior to the development of the CASP.

The 2021 emissions baseline and 2045 forecast were calculated following industry-standard methodology and guidance from the U.S. EPA, the Greenhouse Gas Protocol and World Resources Institute, the American Public Transportation Association (APTA), and CARB. All emissions are displayed in metrics tons of carbon dioxide equivalent ($MTCO_2e$). Additional detail on methodology, including assumptions, estimates, and exclusions, are outlined in Appendix F.

2021 BASELINE GHG EMISSIONS INVENTORY

In 2021, OCTA emitted 22,494 MTCO2e from its operational activities.

As detailed in Table 5-1, the vast majority of OCTA's emissions (over 85%) are generated onsite from Scope 1 sources, including agency owned and operated vehicles and infrastructure. Over 73% of all OCTA emissions come from mobile combustion, or the use of fuels for the vehicles and equipment that make up OCTA's

[43] As explained in later footnotes, lifecycle emissions from renewable natural gas are included under Scope 1. However, these emissions technically fall under Scope 3. Lifecycle emissions from hydrogen (also Scope 3) are not yet included as regulatory guidance for calculations is not yet available. In future inventories, lifecycle emissions (excluding tailpipe emissions) from renewable natural gas and hydrogen will be appropriately categorized as Scope 3.

revenue and non-revenue fleets. The remaining emissions in OCTA's baseline inventory come from the indirect emissions from purchased electricity.

The baseline inventory reveals that vehicle and equipment fuels, especially with respect to the bus and non-revenue vehicle fleets, are the greatest areas of opportunity for OCTA to reduce its GHG emissions. While OCTA has already transitioned its entire operator relief vehicle fleet to 100% battery-electric vehicles, replacing the remaining non-revenue vehicles powered by unleaded gasoline with electric or alternative fuel alternatives, as well as executing OCTA's zero-emission bus transition to power all buses with battery electric or fuel cell electric technologies by 2040, will produce the greatest emissions reductions.

Emissions Scope and Source	Emissions ($MTCO_2e$)[44]	% Contribution
Scope 1 Emissions	**19,208**	**85%**
Stationary Combustion (Facilities)	1,450	6%
Facility Natural Gas	1,450	6%
Mobile Combustion (Vehicle & Equipment Fuel)	16,472	73%
Unleaded Gasoline	8,679	39%
Renewable Compressed Natural Gas (RNG) [45]	7,702	34%
Diesel Fuel	86	0.4%
Propane Fuel	5	>0.1%
Hydrogen Fuel[46]	0	0%
Fugitive Emissions	1,286	6%
Refrigerants	1,286	6%
Scope 2 Emissions	**3,287**	**15%**
Indirect Emissions from Purchased Electricity	3,287	15%
Facility & Rail Electricity	3,287	15%
Total	**22,494**	**100%**

Table 5-1. *2021 OCTA Baseline GHG Emissions by Scope and Source*

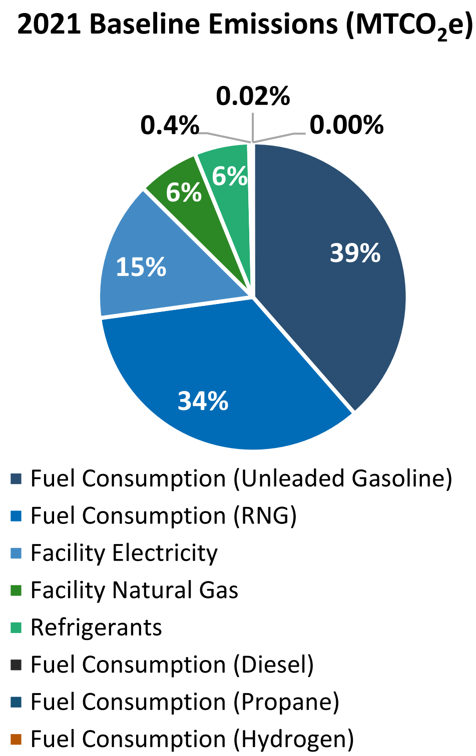


Figure 5-1. *2021 OCTA Baseline GHG Emissions by Source*

The inventory also highlights OCTA's significant emission reduction achievements to date. The use of Renewable Natural Gas (RNG) in the revenue bus fleet constitutes a significant emissions savings when compared to conventional, fossil-derived compressed natural gas (CNG). In 2021 alone, it is estimated that the use of RNG instead of CNG prevented nearly 42,000 metric tons of tailpipe emissions—which would have virtually tripled the agency's emissions.

[44] Emissions totals may not add up exactly due to rounding.
[45] Tailpipe emissions from RNG are significantly lower than fossil CNG, as carbon dioxide emissions from RNG are considered biogenic (or naturally occurring) and thus are not included in the inventory. However, guidance from CARB suggests including emissions from production and distribution of RNG, as the RNG production sources (e.g., dairy farms, methane from landfill) have vastly different emissions outputs. As such, the emissions as calculated here consist of full lifecycle emissions, not just tailpipe emissions (which are close to zero).
[46] As with renewable natural gas, while tailpipe emissions from hydrogen are assumed to be zero, lifecycle emissions are likely to vary based on production source. At the time of drafting, regulatory guidance is not yet available on lifecycle emissions from hydrogen production, and thus only tailpipe emissions are included in this baseline inventory.

2045 EMISSIONS FORECAST

This BAU scenario is intended to provide a rough order of magnitude estimate of how OCTA's emissions will change over time, and to provide a baseline from which to model the impacts of emissions mitigation strategies. BAU scenarios represent a snapshot in time and are not expected to reflect reality over time as operational changes, population/ridership trends, and technological improvements emerge that cannot be predicted at present.

In the BAU scenario, as shown in Table 5-2 and Figure 5-2, OCTA's total emissions are projected to decrease by **63%** from the 2021 baseline by 2045. This is due to emissions from purchased electricity being eliminated in alignment with the 2045 RPS standards requirements, as well as a significant emissions reduction associated with the implementation of the agency's ZEB Plan. In fact, a transition to a zero-emissions bus fleet captures one of the largest carbon reduction opportunities as fossil fuels have a high carbon intensity and are required in large amounts to support major bus fleets such as OCTA's (when such fleets are fueled by CNG, diesel, or gasoline). It is noted that OCTA has not yet selected which technology (plug-in electric or hydrogen fuel cell electric) will be best suited for the agency's needs. For the purpose of the BAU scenario, it was assumed that 40% of buses will be battery-electric, and 60% will be fuel cell electric by 2040.

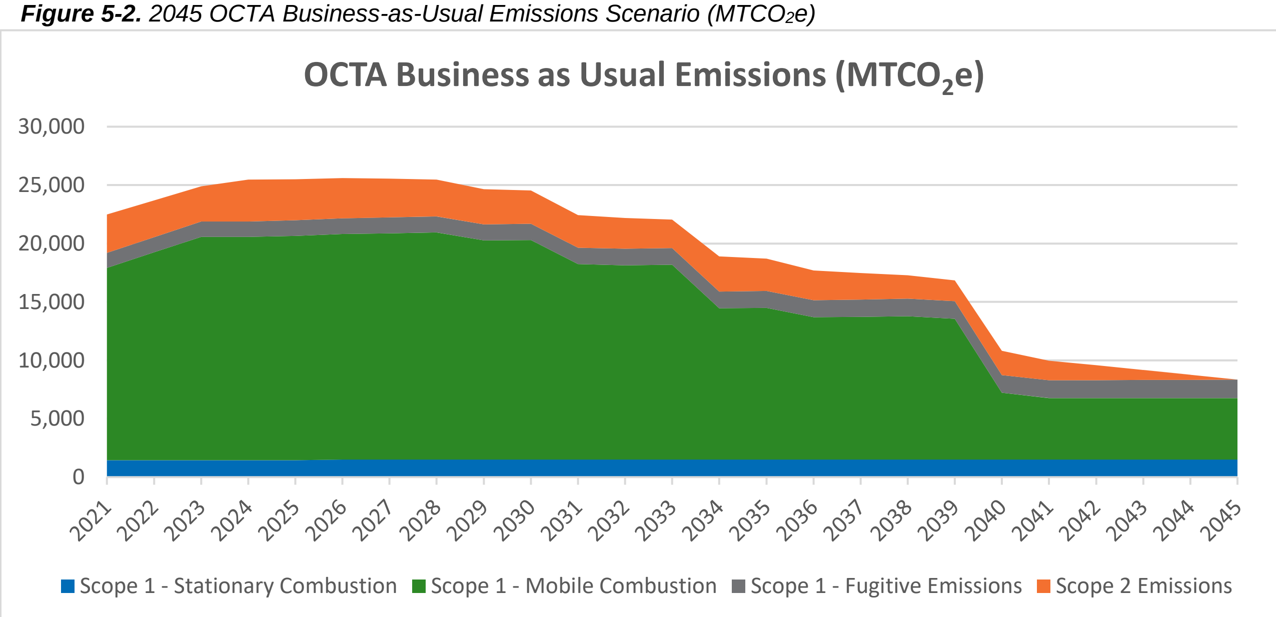
The remaining emissions in 2045 are equivalent to **8,339 $MTCO_2e$**, and are associated with facility natural gas usage, gasoline or diesel used to fuel non-revenue vehicles, and refrigerants. The CASP is intended to address these remaining emissions through actionable climate mitigation measures as described in subsequent sections of the plan.

While significant reductions are projected by 2045, emissions from certain sources may increase in nearer-term milestone years due to expanded service levels, new facilities, and increased electricity consumption.

Table 5-2. *OCTA BAU Emissions Forecast by Source ($MTCO_2e$)*

Emissions Scope and Source	2021	2035	2045
Scope 1 Emissions	**19,208**	**16,091**	**8,339**
Stationary Combustion (Facilities)	1,450	1,509	1,509
Facility Natural Gas	1,450	1,509	1,509
Mobile Combustion (Vehicle & Equipment Fuel)	16,472	9,189	5,263
Unleaded Gasoline	8,679	5,981	5,253
Renewable Compressed Natural Gas (RNG)	7,702	3,199	0
Diesel Fuel	86	4	4
Propane Fuel	5	5	5
Hydrogen Fuel	0	0	0
Fugitive Emissions	1,286	1,450	1,567
Refrigerants	1,286	1,450	1,567
Scope 2 Emissions	**3,287**	**3,943**	**0**
Indirect Emissions from Purchased Electricity	3,287	3,943	0
Facility & Rail Electricity	3,287	3,943	0
Total	**22,494**	**20,034**	**8,339**

Figure 5-2. *2045 OCTA Business-as-Usual Emissions Scenario ($MTCO_2e$)*



5.2 DISPLACED GHG EMISSIONS

Looking beyond operational boundaries, OCTA has quantified the agency's contribution to regional GHG emissions, which not only includes its own generated emissions, but the emissions displaced due to OCTA's transit operations that take people out of cars and encouraging alternative modes of mobility. As transportation is one of the largest sources of GHG emissions in the region, quantifying the emission reductions delivered through OCTA's transit program is important to understanding the agency's net impact in the region. Displaced emissions will provide a metric to measure the effectiveness of OCTA's transit service as a regional climate action strategy.

SCOPE AND METHODOLOGY

Displaced Emissions (also referred to as avoided emissions) refer to emissions that are prevented due to specific organizational activities, programs/policies, or services. In the case of public transportation agencies like OCTA, there are two primary sources of displaced emissions:

- **Mode Shift** – Refers to the reduction of vehicle miles traveled (VMT) due to passengers not driving their own vehicles and using public transit or other mobility alternatives.
- **Land Use Benefit** (sometimes referred to as land use efficiency) – Pertains to the "denser land-use patterns [enabled by public transit] that promote shorter trips, walking and cycling, and reduced car use and ownership."[47]

The methodology for calculating displaced emissions from mode shift and land use benefit is based on guidance from APTA's Recommended Practice: *Quantifying Greenhouse Gas Emissions from Transit.* While the actual boundary of displaced emissions is likely to exceed the physical boundaries of OCTA assets and operations, displaced emissions are calculated based on the total annual passenger miles traveled on OCTA services, all of which fall within the agency's physical boundary.

2021 OCTA DISPLACED EMISSIONS

OCTA was responsible for displacing more than double the emissions that it generated in 2021.

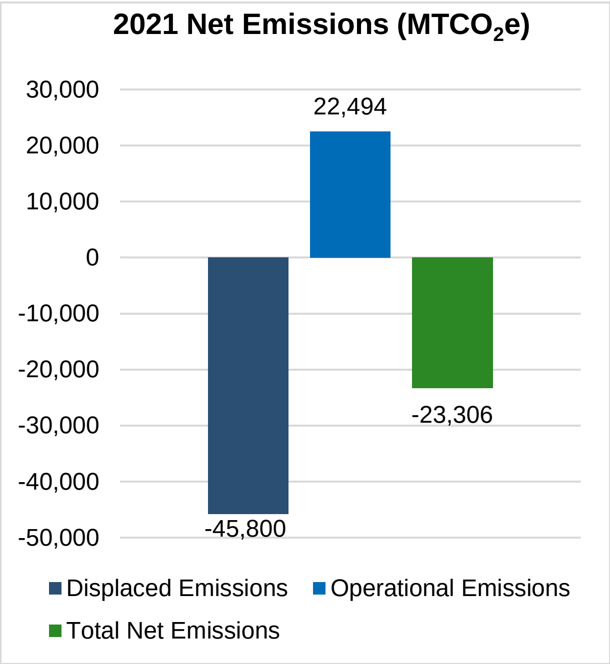
In 2021, it is estimated that OCTA's transit services were responsible for the displacement of **45,800 $MTCO_2e$**, reflecting both mode shift and land use benefits. This figure implies that OCTA displaced more than double the emissions that it generated in 2021, producing a net negative emissions contribution in the region, as summarized below in Table 5-3 and Figure 5-3.

Table 5-3. *2021 OCTA Displaced Emissions by Source*

Emissions Displacement Source	Emissions Displaced ($MTCO_2e$)
Mode Shift	**36,495**
Land Use Benefit	**9,305**
Total	**45,800**

[47] American Public Transportation Association. "Quantifying Greenhouse Gas Emissions from Transit. APTA SUDS CC-RP-001-09." Rev. 1. 2018. <https://www.apta.com/wp-content/uploads/Standards_Documents/APTA-SUDS-CC-RP-001-09_Rev-1.pdf>.

Figure 5-3. 2021 OCTA Net Emissions



However, it is important to note that a negative contribution with respect to regional emissions does not equate to carbon neutrality or net zero carbon emissions, as these terminologies relate to emissions generated and have specific definitions. As such, estimating a net negative regional emissions contribution does not exempt OCTA from its obligation to reducing its generated emissions. Instead, calculating this contribution is important in conveying to stakeholders, riders, and the broader population the importance of public transit as a highly effective strategy to combat climate change and reduce GHG emissions from the transportation sector.

5.3 SUSTAINABILITY & CLIMATE MITIGATION MEASURES

Building on the baseline emission inventory and 2045 BAU scenario, OCTA analyzed potential sustainability strategies, measures, and associated targets and actions the agency could consider implementing to reduce its emissions through 2045.

In line with the exploratory framing of this plan, the CASP utilizes a three-tiered approach to outlining potential measures and targets for adoption, as shown in Table 5-4. Each identified sustainability measure presents a conservative, moderate, and aggressive target for the agency's consideration. A description of each measure, supporting actions, and associated emissions reductions are presented in alignment with this three-tiered approach.

Table 5-4. *Three-Tiered Scenario Approach*

Conservative Scenario	These scenarios generally present the least costly and resource-intensive option due to the scale of commitment levels and/or extended implementation timeframes, which are more likely to align with existing processes and seamlessly integrate into day-to-day operations
Moderate Scenario	These scenarios contain moderate commitment levels and/or mid-range implementation timeframes that are more aggressive and have larger emission reduction potential than the conservative scenarios, and therefore may require additional resources and planning.
Aggressive Scenario	These scenarios present the largest potential for emissions reduction based on the viable strategies identified, compared to Conservative and Moderate scenarios. As the commitment levels are more advanced, these scenarios are likely to be the costliest or resource intensive.

The strategies selected for inclusion in the CASP reflect the main sources of OCTA emissions, industry best practices, planned agency initiatives, and significant vetting and input from both internal and external stakeholders. The measures identified under each strategy are intended to be supported by specific actions, or projects, as deemed appropriate by the agency throughout its planning and operations process.

The three-tiered targets, developed in accordance with each scenario, use levers of increasing commitments and shortening timelines for implementation of potential measures.

Each scenario has been assigned a rough order of magnitude (ROM) implementation cost estimate using the scale as described in table 5-5 below. It is noted that the ROM costs referenced in this report reflect full, upfront capital investment costs only. They do not include associated cost-savings, or considerations for the fact that many strategies may already be partially funded in OCTA's state of good repair and vehicle transition program budgets. Cost savings and additional costs of inaction should be considered by OCTA when evaluating and selecting projects for implementation.

Table 5-5. *ROM Cost Ranges*

ROM Cost	Cost Range
$	$0 - $500,000
$$	$500,000 - $1.5 million
$$$	$1.5 million - $25 million
$$$$	$25 - $100 million
$$$$$	$100 million+

Table 5-6. *Co-benefits*

Icon	Co-Benefit
	Regulatory Compliance
	Cost Savings
	Equity
	Adaptation
	Air Quality Improvements

Additionally, through the development of the measures, OCTA considered several co-benefits in addition to emissions reduction to further its holistic approach to climate change and sustainability. These co-benefits are summarized in Table 5-6. Table 5-7 in the pages that follow provides an overview of the sustainability strategies, measures, costs, and benefits.

Table 5-7. *Summary of Sustainability Strategies*

Exploratory Sustainability Strategies, Measures & Target Scenarios				
Strategy	**Measure**	**Scenario**	**ROM Cost**	**Co-Benefits**
Zero-Emission Bus Fleet (ZEB)	**Transition to a 100% Zero-Emission Bus Fleet**	100% Zero-Emission Buses by 2040	**$$$$ to $$$$$**	
Cleaner Non-Revenue Fleet	**Adopt Cleaner Light Duty Vehicle Standards and Alternative Fuels for the Non-Revenue Fleet & Equipment**	100% of gasoline Light-Duty Vehicles (LDV) become electric by 2045	**$$$**	
		100% of gasoline Light-Duty Vehicles (LDV) become electric by 2040	**$$$**	
		100% of gasoline Light-Duty Vehicles (LDV) become electric by 2035	**$$$ to $$$$**	
	Adopt Cleaner Heavy Duty Vehicle Standards and Alternative Fuels for the Non-Revenue Fleet & Equipment	100% of Heavy-Duty Vehicles use Renewable Diesel by 2045	**$**	
		100% of Heavy-Duty Vehicles use Renewable Diesel by 2040	**$**	
		100% of Heavy-Duty Vehicles use Renewable Diesel by 2035	**$ to $$**	
Energy Efficiency	**Increase Energy Efficiency of Facilities and Operations**	5% reduction in Facility electricity consumption through Energy Efficiency initiatives.	**$$**	
		10% reduction in Facility electricity consumption through Energy Efficiency initiatives.	**$$$**	
		15% reduction in Facility electricity consumption through Energy Efficiency initiatives.	**$$$**	

Exploratory Sustainability Strategies, Measures & Target Scenarios				
Strategy	**Measure**	**Scenario**	**ROM Cost**	**Co-Benefits**
Facility Electrification	**Electrify OCTA Facility Equipment**	Electrify all plumbing and HVAC units upon reaching end-of-life by 2038 (within 15 years)	**$$$**	
		Electrify all AC units by 2028 (within five years) and all HVUs and water heating units at end-of-life by 2038	**$$$**	
		Electrify all units by 2028	**$$$**	
Onsite Renewable	**Install Onsite Rooftop Solar**	10% of the Facility electricity consumption met by solar production.	**$$$**	
		15% of the Facility electricity consumption met by solar production	**$$$**	
		25% of the Facility electricity consumption met by solar production	**$$$**	
Procure Renewable Energy	**Procure Offsite Renewable**	10% of the electricity consumption met through Clean Power purchase from SCE.	**$**	
		15% of the electricity consumption met through Clean Power purchase from SCE	**$**	
		20% of the electricity consumption met through Clean Power purchase from SCE	**$**	
Purchase Renewable Energy Certificates (RECs) & Offsets	**Purchase RECs & Offsets**	200,000 kWh worth of REC's procured by OCTA for 5 years starting from 2023.	**$**	
		200,000 kWh worth of REC's procured by OCTA for 10 years starting from 2023.	**$ to $$**	
		200,000 kWh worth of REC's procured by OCTA for 15 years starting from 2023.	**$ to $$$**	

ZERO-EMISSION BUS FLEET

Table 5-8. *ZEB Fleet Measure Scenarios*

Transition to a Zero-Emission Bus Fleet		
Conservative	100% Zero-Emission Buses by 2040	$$$$ to $$$$$
Moderate	100% Zero-Emission Buses by 2035 **(not feasible)**	$$$$ to $$$$$
Aggressive	100% Zero-Emission Buses by 2030 **(not feasible)**	$$$$ to $$$$$

Emissions from OCTA's bus fleet have historically been the largest contributor to the agency's emissions portfolio, but the agency has made great strides to reduce bus fleet emissions. First, OCTA has replaced diesel-powered buses with CNG buses, significantly reducing both GHG emissions and criteria air pollutant emissions. Second, OCTA has transitioned away from regular CNG and now uses renewable CNG, or RNG, to power its bus fleet.

The emissions benefit of this fuel is derived from its production, whereby natural gas is captured from naturally occurring or biogenic sources (e.g., dairy farms, landfills) and used as fuel. Consequently, because carbon dioxide emissions from RNG are considered biogenic and not anthropogenic (or human-caused), these emissions are not considered part of the agency's emissions portfolio (though lifecycle emissions and emissions from methane and nitrogen dioxide are still included from combustion).

To build on these efforts and to align with State regulations, OCTA plans to transition to a 100% Zero-Emission Bus (ZEB) Fleet by 2040, which includes the use of both battery-electric and fuel cell electric buses[48]. This measure is unique, as it is the only one within the CASP to which OCTA is committed through its ZEB plan.

[48] For the purpose of this analysis, it was assumed that 40% of buses will be battery-electric, and 60% will be fuel cell battery-electric by 2040.

Battery-electric and fuel cell electric buses do not produce any tailpipe GHG emissions. Battery-electric buses can be charged directly from the grid, and while electricity still has an attributable carbon intensity based on its power sources, all grid electricity is mandated to be zero-emission by 2045 per state regulation. While hydrogen fuel that is used to generate the electricity to charge the fuel cell battery can be produced from fossil fuels, it can also be produced using zero-emission energy such as solar, wind, and biomass. The federal government, as well as the State of California, are investing billions of dollars into the development and deployment of clean hydrogen. Consequently, the execution of OCTA's ZEB plan will ensure that OCTA's bus fleet is truly zero-emission by 2045.

OCTA reviewed the potential to accelerate implementation of the current ZEB plan, but deemed it infeasible for the following reasons:

1) Existing ZEB technology does not include options for cutaway buses, which are included in OCTA's bus fleet.
2) Vehicle useful life, procurement lead times, and budget planning timelines prohibit accelerating the transition, as indicated by stakeholders through the stakeholder engagement process.
3) OCTA has yet to determine which technology—or mix of technologies—will be best suited for the agency's needs, which takes into consideration factors, such as cost, range, and useful life.
4) The existing capabilities of the power grid and hydrogen fuel generation are currently not at sufficient capacity to meet the demands of a statewide transition to ZEB. As such, the moderate and aggressive scenarios as described in Table 5-8 are not being considered at this time.

CLEANER NON-REVENUE FLEET

Emissions from gasoline and diesel used to power OCTA's non-revenue fleet vehicles account for 39% of the agency's baseline emissions. However, in recent years, zero-emission vehicle (ZEV) technology is increasing its market share and California has surpassed one million EVs sold.[49] This technology is becoming more readily available, as well as more affordable as the state seeks to comply with CARB's statewide Advanced Clean Cars regulation mandates that all new passenger vehicles sold shall be zero-emission by 2035. As such, this strategy explores two mitigation measures focused on alternative vehicle technologies and fuels to reduce the significant contribution of these sources to the agency's overall carbon footprint and align with state regulations.

Light-Duty Vehicles

Table 5-9. *Light Duty Vehicle Measure Scenarios*

Adopt Cleaner Light Duty Vehicle Standards and Alternative Fuels for the Non-Revenue Fleet & Equipment		
Conservative	100% of gasoline Light-Duty Vehicles (LDV) become electric by 2045	$$$
Moderate	100% of gasoline Light-Duty Vehicles (LDV) become electric by 2040	$$$
Aggressive	100% of gasoline Light-Duty Vehicles (LDV) become electric by 2035	$$$ to $$$$

This measure explores replacing existing gasoline-powered light-duty vehicles and equipment with zero-emission, electric alternatives and transitioning to clean, alternative fuels where feasible. As part of the analysis of this measure, OCTA analyzed three scenarios with various timelines (as shown in Table 5-9), with the aggressive scenario completing this transition in 2035 as opposed to the conservative scenario which explores a target of 2045. It is noted that the emission reduction is calculated on a fleet-level basis.

[49] California Governor's Office. California Leads The Nation's ZEV Market, Surpassing 1 Million Electric Vehicles Sold. 2022. < https://www.gov.ca.gov/2022/02/25/california-leads-the-nations-zev-market-surpassing-1-million-electric-vehicles-sold/>

Heavy-Duty Vehicles

Table 5-10. *Heavy Duty Vehicle Measure Scenarios*

Adopt Cleaner Heavy Duty Vehicle Standards and Alternative Fuels for the Non-Revenue Fleet & Equipment		
Conservative	100% of Heavy-Duty Vehicles use Renewable Diesel by 2045	$
Moderate	100% of Heavy-Duty Vehicles use Renewable Diesel by 2040	$
Aggressive	100% of Heavy-Duty Vehicles use Renewable Diesel by 2035	$ to $$

In addition to considerations related to light-duty vehicles, OCTA may consider replacing the diesel fuel used for heavy-duty fleet vehicles and equipment with renewable diesel. Renewable diesel is considered a drop-in fuel, and as such may be used in existing diesel equipment without the need for any equipment upgrades or purchase of new equipment. Renewable diesel itself is also cost competitive, making this a very cost-effective strategy. Estimated costs are based on incremental costs only.

As part of the development of this measure, OCTA analyzed three scenarios with various timelines (as shown in Table 5-10), with the aggressive scenario completing this transition to 2035, as opposed to the conservative scenario which explores a target of 2045. While options may exist in the future to replace existing heavy-duty vehicles and equipment with zero-emission technology, this was not explored or modeled as part of the CASP scenarios due to current technology limitations. It is noted that specific vehicle data was not available at the time of the development of the plan, and as such the emission reduction is calculated on a fleet-level basis.

ENERGY EFFICIENCY

Table 5-11. *Energy Efficiency Measure Scenarios*

Increase Energy Efficiency of Facilities and Operations		
Conservative	5% reduction in Facility energy consumption through Energy Efficiency initiatives.	$$
Moderate	10% reduction in Facility energy consumption through Energy Efficiency initiatives.	$$$
Aggressive	15% reduction in Facility energy consumption through Energy Efficiency initiatives.	$$$

Based on the 2021 GHG emissions inventory, purchased electricity used at OCTA's facilities accounts for approximately 15% of OCTA's emissions, and natural gas accounts for an additional 6%. As part of its holistic approach to sustainability, OCTA understands the importance of prioritizing efficiency as one of the first steps to addressing the emissions related to the operation of its facilities. This measure encompasses various actions, including but not limited to:

LED Lighting Replacement: Upgrading all lighting to LEDs presents a large efficiency improvement opportunity, as modern LED bulbs have several characteristics that allow them to save electricity compared to traditional bulbs. LED lights do not require reflectors, which build up dust and impose an efficiency loss. Additionally, LED chips burn cooler, allowing them to consume less energy and achieve maintenance cost savings by lasting much longer than traditional bulbs. In air-conditioned spaces, the cooler LED lights will also reduce HVAC loads by emitting less heat. To pursue this action, OCTA would need to conduct facility audits to identify any lighting that has not yet been converted to LED.

Lighting Controls: To reduce the electric load associated with lighting, lighting controls may be installed across facilities. Lighting controls include technologies such as occupancy sensors which will automatically shut off lighting in unoccupied spaces. Lighting controls are an effective way to prevent unnecessary electricity usage and associated GHG emissions. Modern occupancy sensors use multiple types of detection (passive infrared, microwave, ultrasonic) to prevent false-off commands.

Like-for-Like Replacement of Mechanical Systems: This option explores replacing outdated and low-efficiency HVAC systems with premium efficiency systems. High efficiency units utilize variable speed compressors, variable volume fan systems, and economizers to reduce HVAC energy consumption and improve their spaces' ventilation, while reducing maintenance costs. Electrification options, such as heat pumps, are also considered in this plan, but are included as a separate strategy under Section 5.4.4.

Energy Management System (EMS) & Controls: This action explores the installation of EMS Systems to optimally control the sites' mechanical equipment, where an EMS system is not already installed. During the Facilities Condition Assessments conducted in 2022, it was noted that the systems at OCTA's facilities are largely controlled by Thermostats, and excess cooling and heating was observed. As such, this presents OCTA with an opportunity to install EMS controls that would allow for remote equipment monitoring, variable air volume controls, and temperature reset controls, which all result in more efficient use of the systems and a reduction in utility costs as well as emissions.

Retro-Commissioning: Retro-commissioning (RCx) is the process to ensure that a facility is operated and controlled per its design intent and the owner's project requirements. The RCx process also ensures that the facility and its systems are operating to achieve optimum energy efficiency through advanced designs, building code compliance, and best operational practices.

OCTA may explore a combination of these actions and projects to improve efficiency and reduce consumption of natural gas and electricity. OCTA may consider options for achieving a 5%, 10%, or 15% overall reduction in its energy usage (as summarized in Table 5-11 above). Specific projects will be identified through the implementation of OCTA's capital improvement process and in alignment with the agency's Transit Asset Management (TAM) Plan.

FACILITY ELECTRIFICATION

Table 5-12. *Facility Electrification Measure Scenarios*

Electrify OCTA facilities		
Conservative	Electrify all plumbing and HVAC units upon reaching end-of-life by 2038 (within 15 years)	$$$
Moderate	Electrify all AC units by 2028 (within five years) and all HVUs and water heating units at end-of-life by 2038	$$$
Aggressive	Electrify all units by 2028	$$$

This strategy explores the potential benefits of electrifying OCTA's facilities by replacing any gas-powered systems with electric alternatives. The benefits of this strategy are directly related to the transition of the California grid to zero-emission sources. Analysis of this measure was conducted based on the Facilities Condition Assessment data collected in 2022, which included a complete HVAC and plumbing equipment inventory.

Two common strategies exist for equipment replacement: end-of-life replacement and accelerated replacement. An end-of-life replacement approach implements equipment upgrades when existing equipment fails, while accelerated replacement would replace existing equipment prior to failure. The analyzed scenarios fall on a gradient between end-of-life and accelerated, as detailed below:

The conservative scenario is directly aligned with the expected lifetime of the HVAC units, which have an average expected useful life of approximately 15 years, at which point OCTA would benefit from replacing them and may consider an electric heat pump alternatives to existing gas-fired heating systems. In the moderate scenario, OCTA may expedite the timeline for the replacement of AC units to 2028 and continue to replace other types of units at end-of-life. The aggressive scenario of this measure entails the replacement of all units with electric alternatives by 2028. The scenarios are summarized in Table 5-12. The main emissions reduction benefit of the moderate and aggressive scenarios is that OCTA would be able to achieve the maximum reduction sooner.

ONSITE RENEWABLES

Table 5-13. *Onsite Renewable Measure Scenarios*

Install Onsite Solar		
Conservative	10% of the Facility electricity consumption met by solar production.	$$$
Moderate	15% of the Facility electricity consumption met by solar production.	$$$
Aggressive	25% of the Facility electricity consumption met by solar production.	$$$

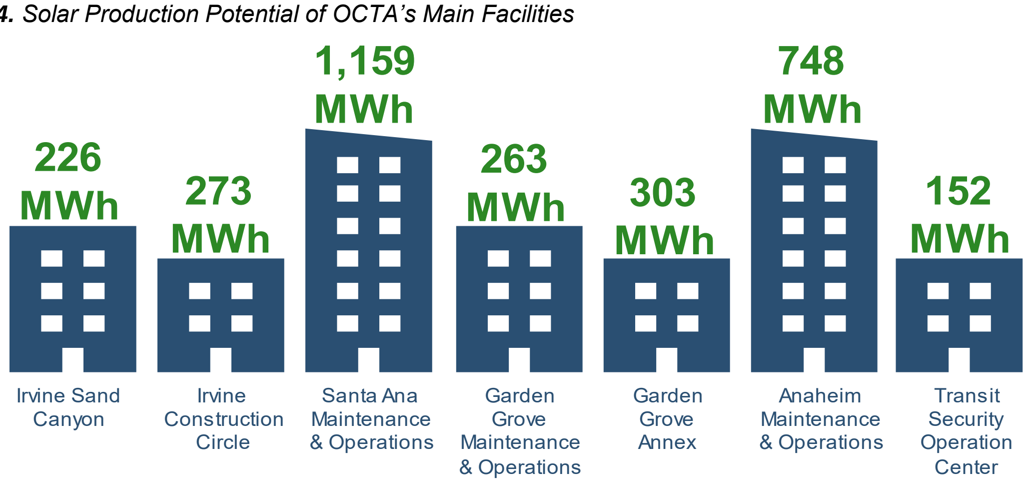
Installing onsite renewable energy systems would provide OCTA with a zero-emission electricity source, replacing electricity currently purchased from the grid. While California's grid is on track to be zero carbon by 2045, this strategy of installing onsite renewables, specifically solar photovoltaics (PV), would enable OCTA to expedite its transition to cleaner power and thus reduce its emissions faster. Additionally, onsite solar PV has significant financial benefits and results in utility cost savings, as well as protecting OCTA from the impacts of utility cost escalation.

This strategy also has the potential to provide OCTA with resiliency benefits if the solar PV is paired with battery storage. These batteries could provide emergency back-up power to critical assets during planned or unplanned grid outages, including those resulting from extreme weather events.

In order to develop the conservative, moderate, and aggressive scenarios as described in Table 5-13, OCTA conducted an analysis to identify potential locations to install rooftop solar and modeled potential production across its larger facilities. Based on the rooftop locations identified, OCTA has sufficient space to install 1.83 MW of solar PV arrays as shown in Figure 5-4, which could generate and cover up to 25% of the agency's baseline facilities electricity consumption. Carports were omitted from this study, as bus movement on OCTA sites would require additional analysis; however, this is an additional opportunity for OCTA to explore, which would go above and beyond the aggressive scenario as detailed in this plan.

Furthermore, carport solar may offer compounded benefits for electric bus charging as the agency transitions its buses to ZEBs. As such, it is recommended that OCTA conduct a more in-depth solar feasibility analysis, including formal utility analysis and considerations for electric bus fleet size (which is still to be determined at the time of drafting of this plan), as well as options for solar carports. Battery storage should also be considered under this feasibility analysis to maximize solar benefits and leverage batteries to further offset utility costs.

Figure 5-4. *Solar Production Potential of OCTA's Main Facilities*



PURCHASE OF RENEWABLE ENERGY

Table 5-14. *Purchase of Renewable Energy Measure Scenarios*

Procure Offsite Renewable Energy		
Conservative	10% of the electricity consumption met through Clean Power purchase from SCE.	$
Moderate	15% of the electricity consumption met through Clean Power purchase from SCE.	$
Aggressive	20% of the electricity consumption met through Clean Power purchase from SCE.	$

OCTA facilities are currently serviced by Southern California Edison (SCE), and there is potential for future facilities to be serviced by Anaheim Public Utilities (APU). Both utilities offer options for green power purchase agreements, under which OCTA may purchase power generated from renewable sources directly from the utility providers. This strategy, if implemented, would reduce OCTA's emissions associated with purchased power and allow OCTA to incorporate higher levels of clean power sooner than the grid will transition to zero-emission sources. The emission reductions are modeled based on a 100% clean energy option.

For this strategy, OCTA is considering three target scenarios, ranging from purchasing 10% of its electricity demand through these agreements in the conservative scenario to 20% in the aggressive scenario. The cost of implementing this strategy is based on current costs of purchasing clean power through OCTA's utilities and reflects incremental costs only. OCTA will need to continue monitoring projected changes to energy rates to determine the financial feasibility of implementing this measure (summarized in Table 5-14).

PURCHASE OF RENEWABLE ENERGY CERTIFICATES (RECs)

Table 5-15. *Purchase of RECs Measure Scenarios*

Purchase RECs and Offsets		
Conservative	200,000 kWh worth of RECs procured by OCTA for 5 years starting from 2023.	$
Moderate	200,000 kWh worth of RECs procured by OCTA for 10 years starting from 2023.	$ to $$
Aggressive	200,000 kWh worth of RECs procured by OCTA for 15 years starting from 2023.	$ to $$$

OCTA currently purchases Renewable Energy Certificates (RECs), which are environmental commodities that allow purchasers like OCTA to count the emissions benefits of renewable energy production against the anticipated emissions from energy consumption. In other words, for every REC OCTA purchase, a certain segment of the agency's energy use can be considered to be zero-emission. RECs are useful to offset those emissions that OCTA may not be able to offset through the other sustainability measures presented in this case. For example, installation of solar in certain areas may not be feasible, or physical space may limit the size of the solar PV system OCTA is able to install, in which case OCTA may purchase RECs to minimize its emissions from purchased electricity as much as possible.

OCTA currently purchases RECs to offset 100% of the electricity used for bus charging, which in 2021 equated to roughly 200,000 kWh.

However, as OCTA's electric vehicle fleet scales up, it would not be feasible or sustainable to offset OCTA's entire portfolio of emissions from electricity for two reasons:

1. REC pricing is expected to increase significantly in the coming years and thus presents a potential financial burden to the agency.
2. The carbon intensity of grid electricity is expected to decline to zero per state regulation, rendering the ongoing purchase of RECs to be unnecessary.

Consequently, OCTA explored the scenarios shown in Table 5-15 for offsetting a finite amount of electricity—200,000 kWh—for varying lengths of time.

5.4 EMISSION SCENARIO SUMMARY

Implementing the measures outlined in the CASP, regardless of which scenario OCTA ultimately pursues, is forecasted to deliver an 80% reduction compared to the business-as-usual scenario in 2045, and the agency's total emissions would fall to 1,674 $MTCO_2e$.

As OCTA plans and implements the measures described in the previous section, it is important to note that the largest impact from selecting an aggressive scenario is that emissions reductions may be achieved at a faster rate, as shown in Tables 5-16 and 5-17. The aggressive scenario has the highest reduction potential in the interim years, and the conservative scenario has the lowest. In fact, the aggressive scenario will achieve the same emissions reduction in 2035 that the conservative scenario is not expected to achieve until after 2040. Figure 5-5 summarizes these results.

The residual emissions in 2045 in all scenarios are largely from refrigerants. Many of OCTA's existing building systems, as well as vehicles, require refrigerant recharge in the case of leakage. OCTA would need to explore additional carbon reduction measures to reduce, eliminate, or offset these residual emissions.

Implementation of mitigation measures will result in an 80% reduction from the BAU in 2045.

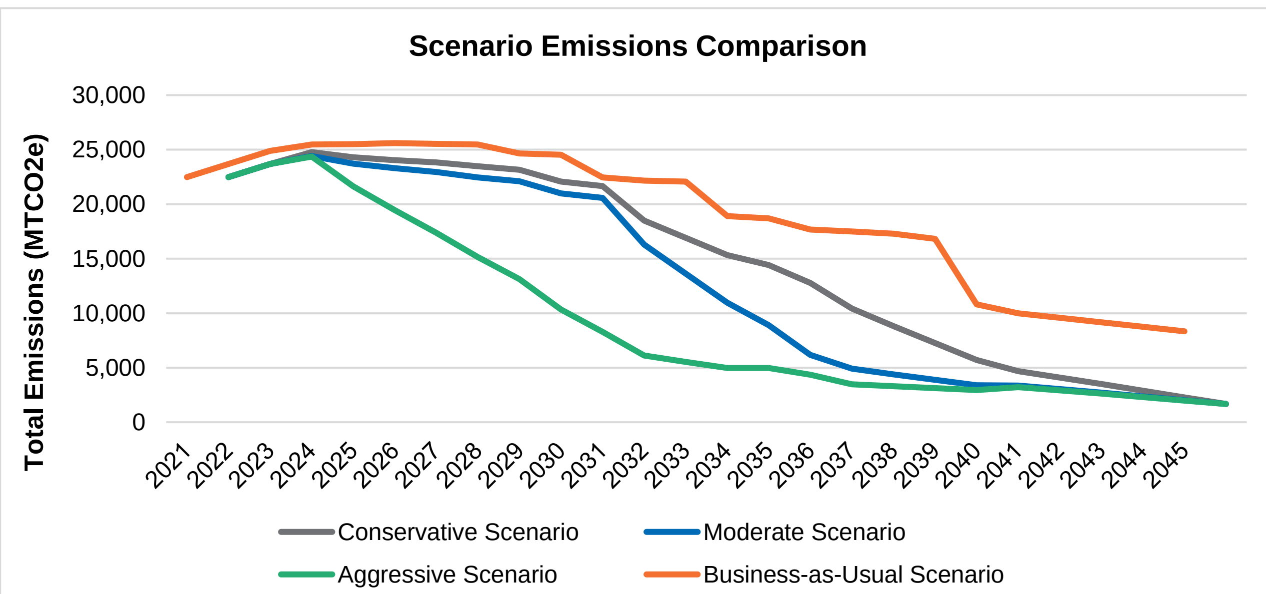
Table 5-16. *Total Forecasted Emissions*

Total Forecasted Emissions ($MTCO_2e$)				
Year	Business-as-Usual Scenario	Conservative Scenario	Moderate Scenario	Aggressive Scenario
2021	22,494	22,494	22,494	22,494
2035	18,702	12,767	6,164	4,358
2040	10,817	4,676	3,365	3,228
2045	8,339	1,674	1,674	1,674

Table 5-17. *Percentage Reduction Compared to BAU*

% Reduction Compared to BAU				
Year	Business-as-Usual Scenario	Conservative Scenario	Moderate Scenario	Aggressive Scenario
2021				
2035	N/A	32%	67%	77%
2040	N/A	57%	69%	70%
2045	N/A	80%	80%	80%

Figure 5-5. *Sustainability Scenario Emission Comparison*



6 RECOMMENDATIONS & NEXT STEPS

The *Climate Adaptation and Sustainability Plan* serves multiple purposes: it is an inventory of existing efforts, an assessment of the current state with respect to sustainability and climate adaptation, and above all, it is an exploratory framework to support decision-making on behalf of the agency. This section offers a set of proposed next steps for OCTA to consider in moving the agency toward adopting sustainability and climate adaptation targets, selecting strategies, developing projects and programs for implementation, instituting tools to monitor and report the agency's progress, and advancing partnerships to achieve agency-wide and regional goals.

6.1 IMPLEMENTATION FRAMEWORK

As an exploratory framework, the CASP outlines potential climate adaptation and sustainability targets and strategies that OCTA could consider as part of the next phase in its sustainability journey. While robust assessments were completed in developing the CASP to verify baseline conditions and identify a menu of potential strategies, this plan is intended to serve as a tool for further investigation, planning, and decision-making. Additionally, at the time of the development of this CASP, OCTA is an Entry-Level signatory to the American Public Transportation Association (APTA) Sustainability Commitment. As part of the next phases of its sustainability journey, OCTA intends to leverage this CASP to further advance its APTA commitments.

As a next step, it is recommended that OCTA adopt a holistic, four-step implementation framework (Figure 6-1) to guide its next phase of work, including considering setting targets for adaptation and sustainability efforts, establishing milestone years for achieving these goals, prioritizing projects for implementation, and monitoring and reporting on progress over time.

1. ESTABLISH TARGETS

As a first step, it is recommended that OCTA evaluate the feasibility of considering either quantitative or qualitative targets for both the agency's climate adaptation and sustainability efforts. As the appropriate measures are considered, these targets could help inform the selection and prioritization of strategies and actions to advance climate adaptation and sustainability.

2. ASSESS & PRIORITIZE ACTIONS

While the CASP explored numerous, high-impact strategies, OCTA should further investigate the feasibility and cost-effectiveness of each strategy identified in the CASP before selecting and prioritizing actions and projects to be implemented moving forward. This stage may include the exploration of additional strategies not selected for inclusion in the CASP. As part of the project identification phase, specific actions should be evaluated and selected based on considerations, including but not limited to:

1) Feasibility
2) Costs
3) Timeline
4) Funding Opportunities
5) Alignment with key OCTA policies, programs, and procedures, such as the Transit Asset Management Plan
6) Effectiveness of the strategy in meeting program objectives and performance targets
7) To the extent feasible, consistency with regional and stakeholder priorities
8) Maturity of potential strategies and technological advancements

Projects should be evaluated for upfront costs, costs of inaction, impact, financial savings, and feasibility. This may include formal onsite assessments, as well as associated data analysis and modeling.

It is recommended that OCTA seek to prioritize those actions that have the greatest benefit at the lowest cost, as well as actions that have co-benefits to meet compliance requirements,

Figure 6-1. *Recommended Implementation Framework*

reduce operating costs, and foster equitable communities.

As a result, OCTA may choose to pursue the strategies for each measure as presented in this plan, or it may determine that alternate strategies are more appropriate based on additional evaluation.

This process should happen in close coordination with OCTA's Internal Advisory Group and External Stakeholder Groups, which were integral in the development of the CASP.

Following project selection, OCTA should identify and pursue funding (both through internal budgeting processes as well as through external grant funding sources) to support implementation of those actions. The identification of funding will likely be a primary factor in determining the feasibility and implementation timeline for selected strategies.

3. IMPLEMENT PROJECTS & PROGRAMS

A critical consideration for OCTA as it plans to implement selected climate adaptation and sustainability measures is developing a realistic implementation timeline. Adaptation strategies are intended to be proactive and preemptive to help reduce the vulnerability to future climate related impacts. If implemented too early, strategies may not be cost effective, or take full advantage of emerging technologies or collaborative planning efforts that develop over time. If strategies are implemented too late, intense effects may already be experienced, and desirable adaptation pathways may be "out of reach" due to decisions made without consideration of the full range of vulnerabilities. These situations are often referred to as "maladaptation". To avoid maladaptation, OCTA will take a flexible approach, relying on Adaptation Pathways Framework which looks to review, update, expand, or develop feasible strategies in response to future trigger points. As such, the adaptation measures may be implemented across a longer timeframe than the sustainability measures, which are generally designed to address current baseline conditions in the shorter term.

When considering an implementation approach for the CASP, it is helpful to categorize measures for implementation across the three different timeframes of short, medium, and long term. The following definitions are being used for these timeframes:

- **Short-Term** refers to the timeframe from 2023 – 2035
- **Medium-Term** refers to the timeframe within 2035 – 2070
- **Long-Term** refers to the timeframe from 2070-2100

Using these timeframes, Table 6-1 below presents a hypothetical implementation timeline for each CASP measure (as identified in Section 4.4, Table 4-20 and Section 5.3, Table 5-7), reflecting OCTA's existing plans, current climate change projections, and other factors that would influence the timing and sequence of strategy implementation.

Some adaptation measures span the course of multiple implementation horizons due to long implementation timelines, uncertain timing of climate trigger points, or because they are designed to be iterative and performed routinely over time. Conversely, it is estimated that all sustainability measures in the CASP could be accomplished in the short to early medium term, should OCTA elect to pursue the aggressive or moderate scenarios. However, some of the conservative scenarios extend into the medium-term implementation timeline.

In taking an Adaptation Pathways approach to resiliency, it is not necessary for OCTA to commit to implementing specific adaptation strategies by a certain date. While exact implementation timelines will depend on evolving climate conditions and the logistical considerations discussed above, this table can serve as a refence for OCTA on which strategies could be planned for implementation across each timeframe.

Table 6-1. *Measure Implementation Timeframe*

CASP Measures	Potential Implementation Timeframe		
	Short -Term (2023 – 2035)	***Medium-Term (2035 – 2070)***	***Long-Term (2070-2100)***
Adaptation Measures			
AQ-1: Outdoor Exposure & Emissions Reduction *(e.g., reduce vehicle idling)*	→	→	→
AQ-2: Indoor Air Quality *(e.g., install high performance air filtration systems)*	→	→	
D-1: Facilities *(e.g., minimize bus washing water use)*	→	→	→
D-2: Routes & Roads *(e.g., work with agencies for subsidence protection)*		→	→
D-3: Vegetation *(e.g., select drought-tolerant, native plant palettes)*		→	→
EW-1: Emergency Operations *(e.g., implement redundancy for swift emergency response)*		→	→
HH-1: Employee Cooling *(e.g., train employees to manage heat stress; offer cooling stations)*	→	→	
HH-2: Ventilation *(e.g., explore active/passive methods for better heat mitigation)*	→	→	→
HH-3: Shading *(e.g., active/passive methods to minimize direct sunlight exposure)*		→	
HH-4: Shade Trees *(e.g., plant shade trees and native, low maintenance plants)*	→	→	
HH-5: Urban Heat Island Effect Reduction *(e.g., explore building/surface improvements to reduce heat)*		→	→
HH-6: Maintenance *(e.g., coordinate with providers to enhance infrastructure protection)*		→	→
HH-7: Power *(e.g., assess on-site fuel and battery energy storage feasibility)*		→	→
HH-8: Weatherizing *(e.g., weatherproof signal/communication system electronics)*	→	→	
FL-1: Facilities *(e.g., increase on-site permeable surface area)*	→	→	→
FL-2: Routes & Roads *(e.g., avoid new routes and assets in flood prone zones)*		→	→
FL-3: Infrastructure *(e.g., partner with local public works to reduce nearby flood risks)*		→	→
SS-1: Warning System *(e.g., explore storm surge forecasting and early warning systems)*		→	→
SS-2: Routes & Roads *(e.g., protective measures along coastal routes and transit stops)*	→	→	→
WF-1: Vegetation Management *(e.g., control vegetation in wildfire-prone right-of-way areas)*		→	
WF-2: Power *(e.g., consider on-site renewable energy and storage options)*		→	→

CASP Measures	Potential Implementation Timeframe		
	Short -Term (2023 – 2035)	*Medium-Term (2035 – 2070)*	*Long-Term (2070-2100)*
Sustainability Measures			
Zero Emission Bus Fleet *(e.g., transition to hydrogen/electric buses)*	→	→	
Cleaner Non-Revenue Fuel *(e.g., transition to renewable natural gas/diesel and electric vehicles)*	→	→	
Energy Efficiency *(e.g., upgrade to LED lighting and install lighting controls)*	→		
Facility Electrification *(e.g., replace gas-powered systems with electric alternatives)*	→	→	
Onsite Renewables *(e.g., install onsite solar PV and other renewable energy systems)*	→	→	
Purchase of Renewable Energy *(e.g., purchase electricity demand through Clean Power from SCE)*	→	→	
Purchase of RECs *(e.g., offset finite amounts of electricity through RECs)*	→	→	

4. MONITOR & REPORT

The last step in the recommended implementation framework is monitoring and reporting performance over time. As part of the development of the CASP, OCTA is developing a reporting framework for consideration to help the agency monitor its performance against relevant adaptation and sustainability categories on an ongoing basis. OCTA will evaluate the feasibility of monitoring and reporting its progress on a routine schedule, as determined through the adoption of targets or other agency-wide commitments, including considerations for implementation of APTA sustainability reporting.

6.2 PROGRAMMATIC SUPPORT FOR THE CASP

In addition to the measures described in the CASP, it is recommended that OCTA consider implementing/expanding several supporting programs to promote behavioral change and facilitate processes that lead to enhanced resiliency outcomes and emissions reductions. These include, but are not limited to:

Employee Training to increase awareness on sustainability best practices (e.g., opting for reusables over single-use plastics and decreasing food waste to landfill) and empower OCTA employees to champion climate adaptation and mitigation.

Community Engagement and Partnerships for staff to connect with OCTA customers to promote sustainability in the community and leverage collaboration opportunities around specific climate adaptation and emissions reduction measures.

Design Standard Updates to ensure future OCTA expansion and capital projects prioritize climate adaptation considerations in siting and design of new facilities, as well as zero- or low-emission technologies, such as heat pumps and solar PV.

Policy & Program Updates to ensure that strategies identified in this plan are carried forward through planning, operations, and construction. Specific programs/policies may include an agency adaptation working group and sustainable procurement program.

Finally, while not directly in OCTA's control, the agency may consider expanding its current climate mitigation efforts in the future to include Scope 3 emissions to further understand the broader impacts of the agency and set a baseline that would assist in identifying opportunities for minimizing indirect emissions. However, this would require additional assessments and planning. Some programs to help mitigate these emissions include water conservation measures (e.g., installation of low-flow fixtures or using recycled water where feasible), sustainable procurement to minimize emissions from OCTA's supply chain, and increased rideshare and active transportation opportunities.

Furthermore, OCTA will continue to engage and coordinate with stakeholders and keep them apprised of any future follow-on activities and relevant studies and/or projects. Additionally, where appropriate, OCTA will work with local jurisdictions on any response or preventative measure to ensure consistency with local, regional, and state climate goals and plans, such as the South Orange County Regional Coastal Resilience Strategic Plan, currently underway to build coastal resiliency and restore public beaches in South Orange County.

7 APPENDICES

APPENDIX A: DEFINITIONS

- **Adaptation:** Adjustment or preparation of natural or human systems to a new or changing environment which moderates harm or exploits beneficial opportunities.[50]
- **Adaptative Capacity:** The ability of a system to adjust to climate change, including climate variability and extremes, to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. [50]
- **Anthropogenic Emissions:** Made by people or resulting from human activities. Usually used in the context of emissions that are produced as a result of human activities.[50]
- **Business-As-Usual Scenario (BAU):** A projection of future environmental and social conditions based on the assumption that current trends and practices will continue without significant change.
- **Carbon Dioxide Equivalent:** A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents ($MMTCO_2Eq$)." The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. $MMTCO_2Eq$ = (million metric tons of a gas) * (GWP of the gas) See greenhouse gas, global warming potential, metric ton.[50]
- **Carbon Neutrality:** The state in which an organization has a net-zero carbon footprint, meaning that their overall greenhouse gas emissions are balanced by removing an equivalent amount of carbon dioxide from the atmosphere, or by offsetting emissions through investments in renewable energy or other carbon-reducing projects.
- **Carbon Offset:** The practice of compensating for an organization's carbon dioxide emissions by funding a project or program that reduces or removes an equivalent amount of carbon dioxide from the atmosphere. Carbon offsets are a tool for mitigating the negative impact of greenhouse gas emissions on the environment and climate.
- **Climate Change:** Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer.[50]
- **Climate Hazards:** Risks posed to human societies, ecosystems, and economies by extreme weather events and other environmental changes resulting from global climate change.
- **Climate Mitigation:** A human intervention to reduce the human impact on the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.
- **Climate Stressors:** Environmental and ecological changes caused by climate change that can lead to negative impacts on natural systems and human societies.

[50] United States Environmental Protection Agency. 2013. <https://sor.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do>.

- **Displaced Emissions:** GHG emissions that are avoided due to mode shift and land use benefits associated with transit.
- **GHG Inventory:** A systematic record of the total amount of greenhouse gases emitted by a company, organization, or country over a specified period. It includes all major greenhouse gases such as carbon dioxide, methane, nitrous oxide, as well as other gases with high global warming potential.
- **Greenhouse Gas (GHG):** Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.[50]
- **Land Use Benefit:** Positive outcomes that result from the use of land in a sustainable and responsible way. This can include a wide range of benefits, such as improved soil health, enhanced biodiversity, reduced greenhouse gas emissions, increased food and fiber production, and improved quality of life for local communities.
- **Mode Shift:** A change in the way people travel between different modes of transportation, such as from driving a car to using public transit, biking, or walking. It typically involves a shift from single-occupancy vehicles, which are associated with traffic congestion, air pollution, and greenhouse gas emissions, towards more sustainable and efficient modes of transportation.
- **Renewable Energy Credit (REC):** A type of tradeable certificate that represents the environmental attributes of renewable energy generation. When renewable energy is produced, RECs are created and can be sold separately from the physical energy generated. RECs can be bought and sold by entities to offset greenhouse gases or support the development of renewable energy.
- **Risk:** The likelihood or probability of negative impacts on the environment, society, or economy.
- **Sustainability:** Create and maintain conditions under which humans and nature can exist in productive harmony to support present and future generations.[50] Within the CASP, sustainability specifically indicates actions to reduce contributions to climate change.
- **Vehicle Miles Traveled (VMT):** A measure of the total distance traveled by all vehicles within a given geographic area or period of time.[50]

APPENDIX B: ACRONYMS

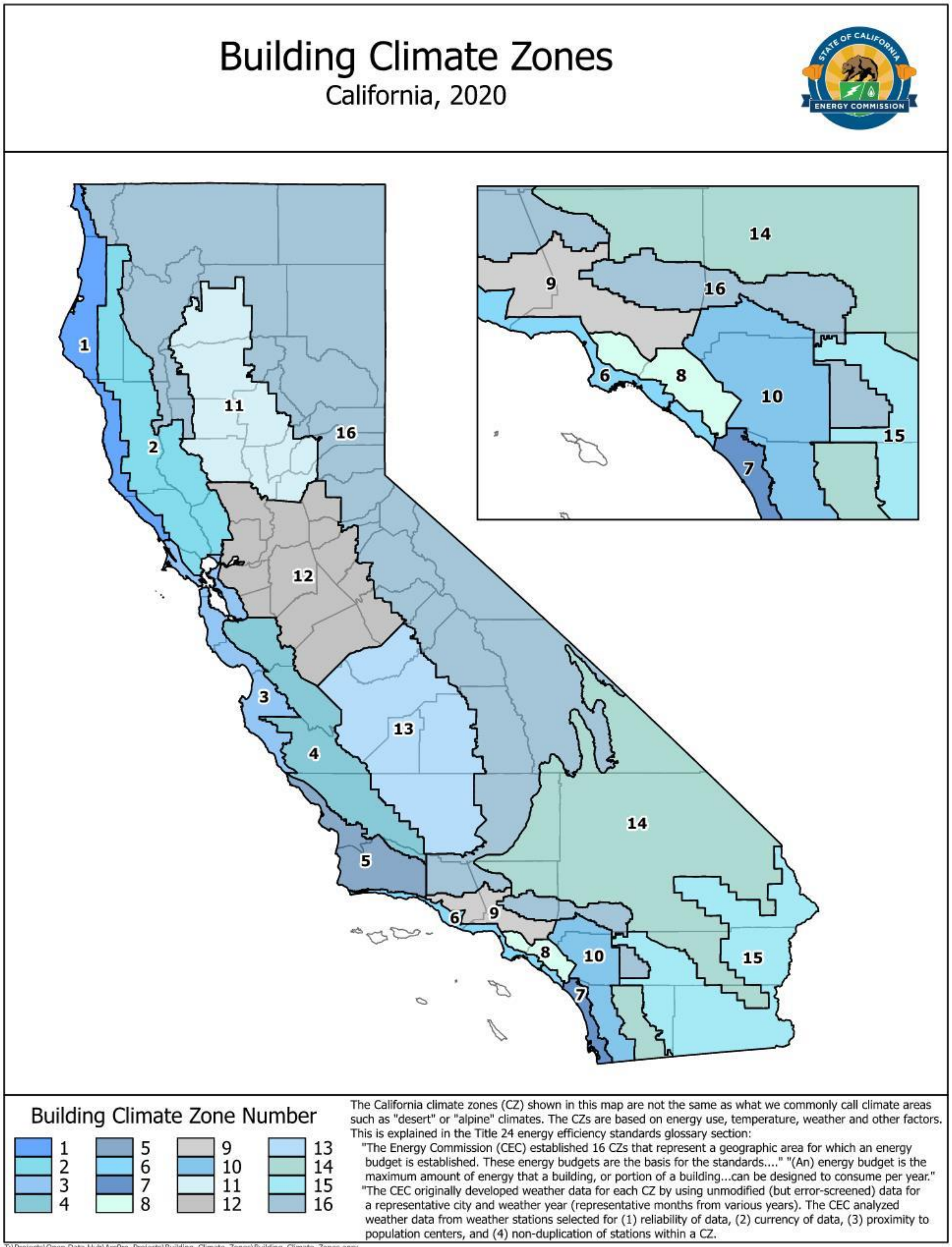
- **AB:** Assembly Bill
- **APG:** California Adaptation Planning Guide
- **APTA:** American Public Transportation Association
- **APU:** Anaheim Public Utilities
- **AQ:** Air Quality
- **AQI:** Air Quality Index
- **ARTIC:** Anaheim Regional Transportation Intermodal Center
- **BAU:** Business-As-Usual
- **CAAQS:** California Ambient Air Quality Standards
- **CalOES:** California Governor's Office of Emergency Services
- **Caltrans:** State of California Department of Transportation
- **CARB:** California Air Resources Board
- **CASP:** Climate Adaptation and Sustainability Plan
- **CEC:** California Energy Commission
- **CFR:** Contracted Fixed-Route
- **CNG:** Compressed Natural Gas
- **CoSMoS:** Coastal Storm Modeling System
- **CVA:** Climate Vulnerability Assessment
- **DAC:** Disadvantaged Community
- **DOFR:** Directly Operated Fixed-Route
- **ECP:** Environmental Cleanup Program
- **EGD:** Electrical Grid and Distribution
- **EL:** Express Lane
- **EMP:** Environmental Mitigation Program
- **EMS:** Energy Management System
- **FEMA:** Federal Emergency Management Agency
- **FHWA:** Federal Highway Administration
  FTA: Federal Transit Administration
- **GG:** Garden Grove
- **GHG:** Greenhouse Gas
- **HH:** High Heat
- **HMP:** Hazard Mitigation Plan
- **HVAC:** Heating, Ventilation, and Air Conditioning
- **IPCC:** The Intergovernmental Panel on Climate Change
- **KPI:** Key Performance Indicator
- **LDV:** Light Duty Vehicles
- **LED:** Light Emitting Diode
- **LCTOP:** Low Carbon Transit Operations Program
- **LRTP:** Long Range Transportation Plan
- **$MTCO_2e$:** Metric Tons Carbon Dioxide Equivalent
- **NOAA:** National Oceanic and Atmospheric Administration
- **NTC:** Newport Transportation Center
- **OCTA:** Orange County Transportation Authority
- **OC:** Orange County
- **OPR:** Office of Planning and Research
- **P&R:** Park-and-Ride
- **PEC:** Pacific Energy Center
- **PM:** Particulate Matter
- **PV:** Photovoltaic
- **RCP:** Representative Concentration Pathways
- **RCTC:** Riverside County Transportation Commission
- **RCx:** Retro-Commissioning
- **REC:** Renewable Energy Credit
- **RMP:** Resource Management Plan
- **RNG:** Renewable Natural Gas
- **ROM:** Rough Order of Magnitude
- **RPS:** Renewable Portfolio Standard
- **RTP/SCS:** Regional Transportation Plan and Sustainable Communities Strategy
- **SB:** Senate Bill
- **SC:** San Clemente
- **SCAG:** Southern California Association of Governments
- **SCAQMD:** South Coast Air Quality Management District
- **SCE:** Southern California Edison
- **SDS:** Storm Drain Systems
- **SoCAB:** South Coast Air Basin
- **SLR:** Sea Level Rise
- **SOV:** Single-Occupancy Vehicles
- **TAM:** Transit Asset Management
- **TCR:** The Climate Registry

- **U.S. EPA:** U.S. Environmental Protection Agency
- **USGS:** U.S. Geological Survey
- **VMT:** Vehicle Miles Traveled
- **WUI:** Wildland-Urban Interface
- **ZEB:** Zero-Emission Bus

APPENDIX C: LIST OF TABLES

APPENDIX D: LIST OF FIGURES

APPENDIX E: DETAILED CALIFORNIA BUILDING CLIMATE ZONES MAP



APPENDIX F: GHG EMISSIONS INVENTORY & 2045 FORECAST METHODOLOGY

The 2021 greenhouse gas emissions (GHG) baseline inventory, and the accompanying 2045 emissions forecast, were developed in alignment with industry-standard methodology and guidance from the U.S. EPA,[51] the Greenhouse Gas Protocol and World Resources Institute,[52] the APTA,[53] and CARB.[54] This appendix to the plan details the methodology, including assumptions, estimates, and exclusions, that underlie the baseline inventory and emissions forecast.

BASELINE EMISSIONS INVENTORY

As described in Chapter 5, the baseline emissions inventory reports on Scope 1 and Scope 2 emissions, as is industry standard. Scope 1 emissions include direct emissions from stationary combustion (i.e., OCTA facilities), mobile combustion (i.e., vehicle and equipment fuel), and fugitive emissions (i.e., refrigerants). Scope 2 emissions include indirect emissions from purchased electricity (i.e., for facilities and rail). Scope 3 emissions, which would include indirect emissions that are tied to OCTA's value chain, are not included in the baseline inventory. OCTA's baseline inventory also does not include any insets or offsets, and only includes actual, generated emissions from agency operations.

All emissions are reported in metric tons of carbon dioxide equivalent ($MTCO_2e$). Emissions as accounted in this inventory include carbon dioxide (CO_2) emissions, methane (CH_4) emissions, and nitrous oxide (N_2O) emissions. Each of these greenhouse gases have an associated global warming potential (GWP) as assigned by the United Nations Intergovernmental Panel on Climate Change (IPCC) in its Assessment Reports, which refers to the energy or heat that a ton of that gas will observe over a given period (which, for these analyses, is 100 years). In the case of refrigerants (fugitive emissions under Scope 1), these have their own GWPs as assigned by the IPCC. For these calculations, the GWPs applied were drawn from the IPCC's Fifth Assessment Report (AR5), released in 2014, based on current best practice.[55]

Scope 1 Emissions

In the baseline inventory, Scope 1 emissions include natural gas used at OCTA facilities, as well as fuel used by vehicles and equipment, which included unleaded gasoline, renewable compressed natural gas (RNG), diesel fuel, propane fuel, and hydrogen fuel.

To calculate Scope 1 emissions, total fuel consumption in 2021 for each fuel type was aggregated in its native unit and converted into metric tons using the fuel's assigned emission factors and appropriate unit conversion constants (provided by the U.S. EPA and compiled by The Climate Registry).[56,57] Metric tons are then multiplied by GWPs of CO_2, CH_4, and N_2O in three distinct

[51] U.S. Environmental Protection Agency. "GHG Inventory Development Process and Guidance." <https://www.epa.gov/climateleadership/ghg-inventory-development-process-and-guidance>.
[52] Greenhouse Gas Protocol. <https://ghgprotocol.org/>.
[53] APTA Standards Development Program. "APTA SUDS CC-RP-001-09, Rev 1. "Quantifying Greenhouse Gas Emissions from Transit." 10 September 2018. <https://www.apta.com/wp-content/uploads/Standards_Documents/APTA-SUDS-CC-RP-001-09_Rev-1.pdf>.
[54] California Air Resources Board. "Mandatory GHG Reporting – Guidance Documents." <https://ww2.arb.ca.gov/mrr-guidance>.
[55] Intergovernmental Panel on Climate Change. "Fifth Assessment Report." October 2014. <https://www.ipcc.ch/assessment-report/ar5/>.
[56] U.S. Environmental Protection Agency. "GHG Emission Factors Hub." April 2023. <https://www.epa.gov/climateleadership/ghg-emission-factors-hub>.
[57] The Climate Registry. "2022 Default Emission Factors." May 2022. <https://theclimateregistry.org/wp-content/uploads/2022/11/2022-Default-Emission-Factors-Final.pdf>.

calculations, resulting in GHG emission totals for each. These emissions are aggregated into a single $MTCO_2e$ figure to represent total emissions from that fuel source. In the case of select fuels, specific assumptions were applied. These are detailed below:

Assumptions:

- In the case of RNG, tailpipe carbon dioxide emissions are excluded from the inventory because they are considered biogenic (or naturally occurring). However, guidance from CARB suggests that entities include emissions from the production and distribution of RNG, as its production sources (e.g., dairy farms, landfills) have vastly different emissions outputs.[58] OCTA thus opted to calculate and include those lifecycle emissions in this inventory.

- In the case of hydrogen, tailpipe emissions were assumed to be zero. However, lifecycle emissions are also likely to vary based on production source. At the time of drafting, regulatory guidance is not yet available on lifecycle emissions from hydrogen production. Consequently, only tailpipe emissions are included in this baseline inventory.

Scope 2 Emissions

Scope 2 emissions, or indirect emissions from purchased electricity, included emissions from electricity used for both facilities and rail propulsion. Scope 2 emissions are calculated twice: first, to reflect market-based emissions (i.e., emissions reflecting the carbon intensity of the utility (or utilities) from which electricity is actually procured), and second, to reflect location-based emissions (i.e., emissions reflecting the average carbon intensity of the regional grid). For the baseline inventory, market-based emissions were calculated using an emissions factor provided by Southern California Edison (SCE), which reflects the carbon intensity of the utility's electric grid and is derived from the power content or sourcing of that electricity.[59] Location-based emissions are calculated using the California regional grid average ("CAMX" sub-region) carbon intensity provided by the U.S. EPA's Emissions & Generated Resource Integrated Database (eGRID).[60]

To calculate market-based Scope 2 emissions, electricity use data, collected in kilowatt-hours (kWh), was aggregated, and then multiplied by the SCE emissions factor and converted into metric tons. Similar to Scope 1 emissions, metrics tons were multiplied by the respective GWPs and aggregated to produce total emissions from electricity. Location-based emissions were calculated in a similar fashion, substituting the SCE emissions factor for the CAMX sub-region average emissions factor provided by eGRID.

The Scope 2 emissions used in the baseline inventory and scenario modeling reflect market-based emissions totals, rather than location-based emissions, as market-based emissions are considered to be the most accurate emissions total.

[58] California Air Resources Board. "Low Carbon Fuel Standard (LCFS) Guidance 19-05: Reporting and Recordkeeping for Natural Gas and Book-and-Claim Accounting for Biomethane." October 2019. <https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/guidance/lcfsguidance_19-05.pdf>.
[59] California Energy Commission. "2021 Power Content Label: Southern California Edison." <https://www.energy.ca.gov/filebrowser/download/4676>.
[60] U.S. Environmental Protection Agency. "Emissions & Generation Resource Integrated Database (eGRID)." 31 January 2023. <https://www.epa.gov/egrid>.

2045 EMISSIONS FORECAST

The 2045 emissions forecast was developed to show how OCTA's operational emissions are projected to change over time in a business-as-usual (BAU) scenario. A BAU scenario is a projection of future environmental and social conditions based on the assumption that current trends and practices will continue without significant change. The BAU scenario is intended to provide a rough-order-of-magnitude estimate of OCTA emissions over time, and to provide a baseline from which to model the impacts of emissions mitigation strategies. The BAU scenario represents a snapshot in time and is not expected to reflect reality over time as operational changes, population/ridership trends, and technological improvements emerge that cannot be predicted at present.

For the 2045 BAU scenario, OCTA applied certain assumptions to better estimate how emissions across scope and operational areas would shift over time.

Scope 1 Emissions

Stationary Combustion: In the case of emissions from stationary combustion (i.e., OCTA facilities natural gas), the baseline emissions scenario assumes no change to natural gas consumption at existing facilities. However, it incorporates estimated natural gas consumption (and resulting emissions) from OCTA's forthcoming Transit Security and Operations Center (TSOC), which is expected to come online in 2026.[61]

Mobile Combustion: The BAU scenario for mobile combustion incorporates a handful of expected regulatory mandates that will shift the composition of OCTA's vehicle fleets and thus change emissions from mobile combustion over time.

- OCTA Bus Fuel: The BAU scenario reflects the agency's *Zero-Emission Bus (ZEB) Draft Rollout Plan* as submitted to CARB under the Innovative Clean Transit (ICT) Regulation,[62] which reflects a steady shift from internal-combustion-engine (ICE) buses using RNG to a mix of zero-emission buses that are battery-electric or hydrogen fuel cell electric. Since specific fuel sources are not designated in the rollout plan, a split of 60% fuel cell electric buses and 40% battery-electric buses is assumed to be achieved by 2040. Consequently, emissions reductions through 2045 correlate with the decrease in RNG-fueled buses and the uptake in hydrogen fuel cell electric and battery-electric buses. Increased emissions from electricity to charge new battery-electric buses are folded in under Scope 2 emissions projections.

- OCTA Bus Mileage: In addition to shifts in fuel composition, bus mileage is assumed to increase over time. This increase in mileage is correlated to an increase in vehicle revenue hours (VRH), which is derived from agency-wide goal to increase from 1,579,914 VRH in 2021 to 1,926,000 VRH in 2045.

- Diesel and Propane Fuel: It is assumed that all diesel vehicles in OCTA's non-revenue fleet will be retired as of 2024, wiping out nearly 95% of diesel emissions. Residual (5%) diesel emissions remain after 2024 reflecting fuel use for generator sets. Propane used for generators does not change through 2045.

[61] Orange County Transportation Authority. "Transit Security and Operations Center." <https://www.octa.net/programs-projects/projects/transit-facility-projects/transit-security-and-operations-center/>.
[62] California Air Resources Board. "Orange County Transportation Authority's Zero-Emission Bus Rollout Plan." 30 June 2020. <https://ww2.arb.ca.gov/sites/default/files/2020-09/OCTA%20ZEB%20Rollout%20Plan_ADA08122020.pdf>.

- Unleaded Gasoline: Unleaded gasoline consumption and associated emissions from revenue fleets are expected to decline as zero-emission vehicles are incorporated into the fleet and replace gas-powered vehicles. The phase-out of gas-powered revenue vehicles, as reflected in the BAU scenario, is derived from the aforementioned *Zero-Emission Bus (ZEB) Draft Rollout Plan*. Nearly all gas-powered revenue vehicles are expected to be phased out by 2040. Unleaded gasoline consumption and associated emissions from non-revenue are not expected to change out through 2045.

Fugitive Emissions: Refrigerant use is assumed to increase proportionally with expected increases in vehicle miles traveled, as refrigerants included in this inventory are used for buses and other vehicles.

Scope 2 Emissions

In the case of scope 2 emissions, only market-based emissions are modeled out through 2045 in the BAU scenario. A couple of assumptions are applied to estimate emissions from purchased electricity out through 2045:

- Grid Carbon Intensity: It is assumed that the carbon intensity of the electric grid will decline steadily to zero by 2045 due to state regulations.[63] Improving grid carbon intensity is reflected in all emissions calculations for purchased electricity out through 2045.

- Facilities Electricity: It is assumed that electricity consumption for existing facilities will not change out through 2045. However, the BAU incorporates estimated electricity consumption (and resulting emissions) from OCTA's forthcoming Transit Security and Operations Center (TSOC), which is expected to come online in 2026.

- Rail Electricity: It is assumed that electricity consumption for existing rail will not change out through 2045.

- However, it incorporates estimated electricity consumptions (and resulting emissions) from the new OC Streetcar, which is expected to come online in 2024.[64]

- OCTA Battery-Electric Buses: As mentioned under Scope 1, anticipated increase in electricity use (and associated emissions) from bus charging as new battery-electric buses are folded into the fleet are folded into the BAU scenario under Scope 2 emissions.

[63] California Energy Commission. "SB 100 Joint Agency Report." <https://www.energy.ca.gov/sb100>.
[64] Orange County Transportation Authority. "OC Streetcar." <https://www.octa.net/programs-projects/projects/rail-projects/oc-streetcar/overview/ >.

Orange County Transportation Authority

2024 Climate Adaptation & Sustainability Plan

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