City of Lakewood

Climate Hazard and Social Vulnerability Study

April 2025

Final Report

Image: Lakewood Civic Center. Source: City of Lakewood.

Prepared by

Sustainability Solutions Group

Prepared for

City of Lakewood

Lakewood
Sustainability
& Community Development

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Acronyms

BIPOC	Black, Indigenous, and People of Color
CERT	Community Emergency Response Team
CO_2e	Carbon dioxide equivalent
CVRA	Climate Vulnerability and Risk Assessment
CWG	Community Working Group
DEI	Diversity, Equity and Inclusion
DRCOG	Denver Regional Council of Governments
FEMA	Federal Emergency Management Agency
FG	Focus Group
GHG	Greenhouse Gas
HMP	Hazard Mitigation Plan
IPCC	Intergovernmental Panel on Climate Change
IWG	Internal Working Group
LEAP	Low-Income Energy Assistance Program
NDG	North Dry Gulch
PPE	Personal Protective Equipment
RCP	Representative Concentration Pathway
WUI	Wildland-Urban Interface

Glossary[1]

Term	Definition
Adaptation	In human systems, the process of adjusting to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities.
Adaptive Capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage in order to take advantage of opportunities or respond to consequences.
Consequence[2]	Consequences generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate change or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system.
Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.
Likelihood	The chance of a specific outcome occurring, where this might be estimated probabilistically. Likelihood is expressed in this report using a standard terminology.
Mitigation	A human intervention to reduce emissions or enhance the sinks of greenhouse gases (GHGs) .
Representative Concentration Pathway (RCP)	Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases and aerosols and chemically active gases, as well as land use/land cover. The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that the long-term concentration levels and the trajectory taken over time to reach that outcome are both of interest.

1 Unless otherwise noted, all definitions are taken from: "IPCC Glossary Search." n.d., https://apps.ipcc.ch/glossary/.

2 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment, ISO 14091:2021 (International Organization for Standardization, February 2021), https://www.iso.org/standard/68508.html.

Term	Definition
Risk	The potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change, as well as from human responses to climate change. Relevant adverse consequences include those that impact lives; livelihoods; health and well-being; economic, social and cultural assets and investments; infrastructure; services (including ecosystem services); ecosystems; and species.
Sensitivity	The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Extended Executive Summary

Introduction

The city of Lakewood, Colorado, is an incorporated home-rule municipality and a suburban community of 156,000 people. It is situated southwest of Denver and adjacent to the foothills of the Rocky Mountains. Lakewood is already experiencing significant impacts from climate change, including increasing drought, temperature extremes, flooding, wildfires and extreme weather events. Projections indicate these trends will intensify in the coming decades, with disproportionate effects on the city's populations experiencing the most social vulnerabilities. These shifts in climate will affect people's homes, health, and way of life, making it more important than ever to prepare for the challenges ahead. This Climate Hazard and Social Vulnerability Study builds upon the Jefferson County Hazard Mitigation Plan to further evaluate the risks climate hazards pose to people, infrastructure, and the economy, while identifying potential adaptation actions to enhance the city's resilience.

Image: Aerial view of the city of Lakewood, Colorado. Source: Adobe Stock under SSG's license.

A Changing Climate

Lakewood's climate is expected to become hotter, drier in summer, and more unpredictable over the coming decades. Rising temperatures will likely lead to more frequent and intense heat waves, making extreme heat a growing concern. Winters are projected to be milder overall, but occasional severe cold snaps may still occur due to shifting atmospheric patterns. Precipitation patterns are expected to change, with slightly more annual rainfall, particularly in the spring, but also more dry days throughout the year. These longer dry periods, combined with rising temperatures, could contribute to more frequent droughts and an increased risk of wildfires.

To better understand how these climate changes will affect the city, this study conducted a Climate Vulnerability and Risk Assessment, which evaluated risk based on three key factors: how likely a hazard is to occur, how vulnerable the community is to that hazard, and what the consequences would be if it happens. Ten hazards were evaluated in the process: hailstorms, extreme heat, extreme cold, flooding, wildfires, high winds and tornados, drought, biodiversity change, lightning and winter storms. Through the assessment process, five priority hazards were identified based on their levels of risk: hailstorms, extreme heat, extreme cold, flooding and wildfires. While hailstorms are expected to remain similar to historical trends and extreme cold events may become less frequent, climate change is projected to worsen the impacts of extreme heat, flooding, and wildfires. These findings highlight the need for targeted adaptation measures to protect the community from a changing climate.

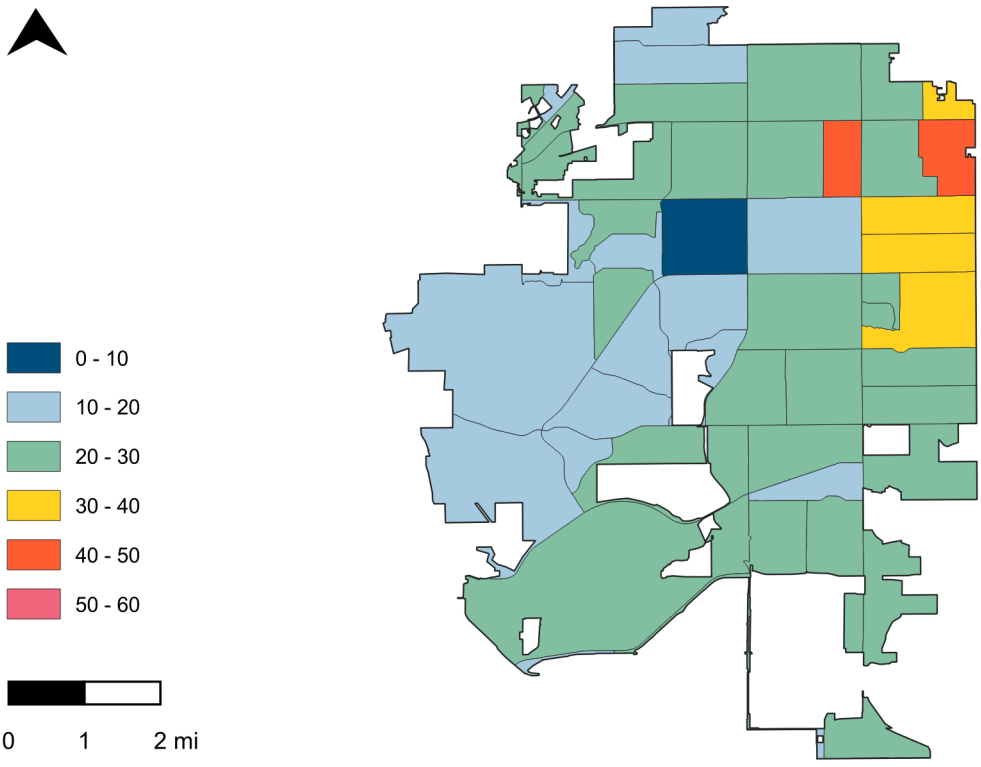
Image: Downed trees and traffic cuts due to heavy snowfall in Lakewood. Source: City of Lakewood.

Social Vulnerability

Social vulnerability was a key component of the study. The concept refers to the capacity of individuals or groups to anticipate, cope with and recover from hazards. Even though community members may experience the same physical hazards, those experiencing the most social vulnerabilities may be disproportionately impacted due to certain factors such as income, age, race, language and disability. The concept of social vulnerability emphasizes that certain groups — such as low-income households, aging adults, people with disabilities and marginalized racial groups — often face greater challenges in coping with and recovering from climate-related events.

To understand how climate change will impact residents experiencing higher levels of social vulnerability, the study incorporated an Equity Index developed by the Denver Regional Council of Governments (DRCOG). Based on 10 demographic indicators, the Index includes an equity score for each census tract in Lakewood, shown in **Figure 1**. In general, the eastern portion of the city has higher scores on the Equity Index, indicating higher levels of social vulnerability. This is due to economic and mobility challenges, as well the race and ethnicity of residents. Residents living on low incomes and facing cost burdens are particularly concentrated in the northeast corner of the city. This Equity Index was used throughout the study to inform the Climate Vulnerability and Risk Assessment.

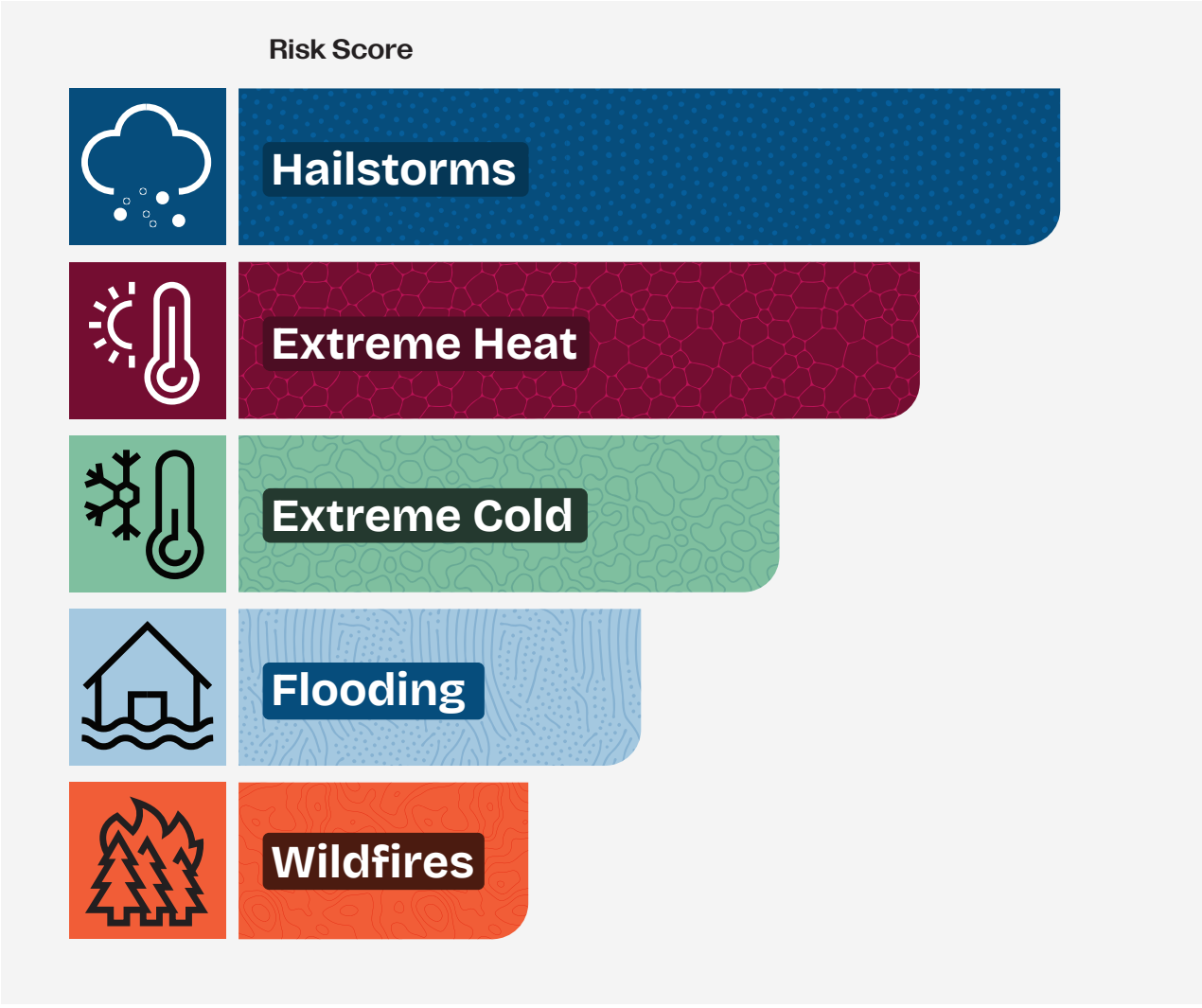
Figure 1. DRCOG Equity Index by census tract using ACS 2018-2022 data for the city of Lakewood.



Priority Hazards

Lakewood faces a range of climate-related hazards, but five have been identified as priority risks due to their likelihood, severity and potential impacts on people, infrastructure and the local environment. In order of their risk score, these top five hazards are hailstorms, extreme heat, extreme cold, flooding and wildfires. The following section highlights how each priority hazard is projected to change and who is most vulnerable, as well as the key adaptation actions.

Figure 2. Top five hazards for Lakewood based on risk score.



Climate-related hazard

Hailstorms

Hailstorms pose one of the most significant climate risks for Lakewood, and they have caused widespread property damage and rising insurance costs in recent years.

Some insurance providers have even reduced their presence in Colorado due to the increasing financial burden of severe hailstorms. However, projections for key climate indicators suggest that the frequency and severity of hailstorms are unlikely to increase significantly, though there is uncertainty in forecasting hailstorms, as complex interactions between several climate variables drive hail formation. While future storms may resemble historical events in intensity, the financial impact of hail damage could continue to rise due to expanding development and increasing repair costs.

Although hailstorms themselves may not worsen, many local systems remain highly vulnerable to their effects. Outdoor workers, residents without shelter, pedestrians, and cyclists face direct risks of injury, particularly during fast-moving storms. Homes without hail-resistant roofing, as well as farms, parks and recreational spaces, are also highly susceptible to damage. The aftermath of a severe hailstorm can disrupt local businesses, delay public services and strain emergency response resources. Given these risks, strengthening building resilience and increasing public awareness will be key strategies for reducing the impact of future hail events in Lakewood.

Potential adaptation actions related to hailstorms include:

- Provide building owners, homeowners and renters — especially in high-risk areas — with multilingual resources on how to strengthen their homes against extreme weather.
- Strengthen regional coordination on wildfire and extreme weather resilience and expand early warning systems for extreme weather events.
- Review and update municipal insurance policies to ensure city-owned assets and infrastructure are adequately covered for future climate risks.
- Establish an advisory service to help residents navigate insurance claims and understand financial recovery options.

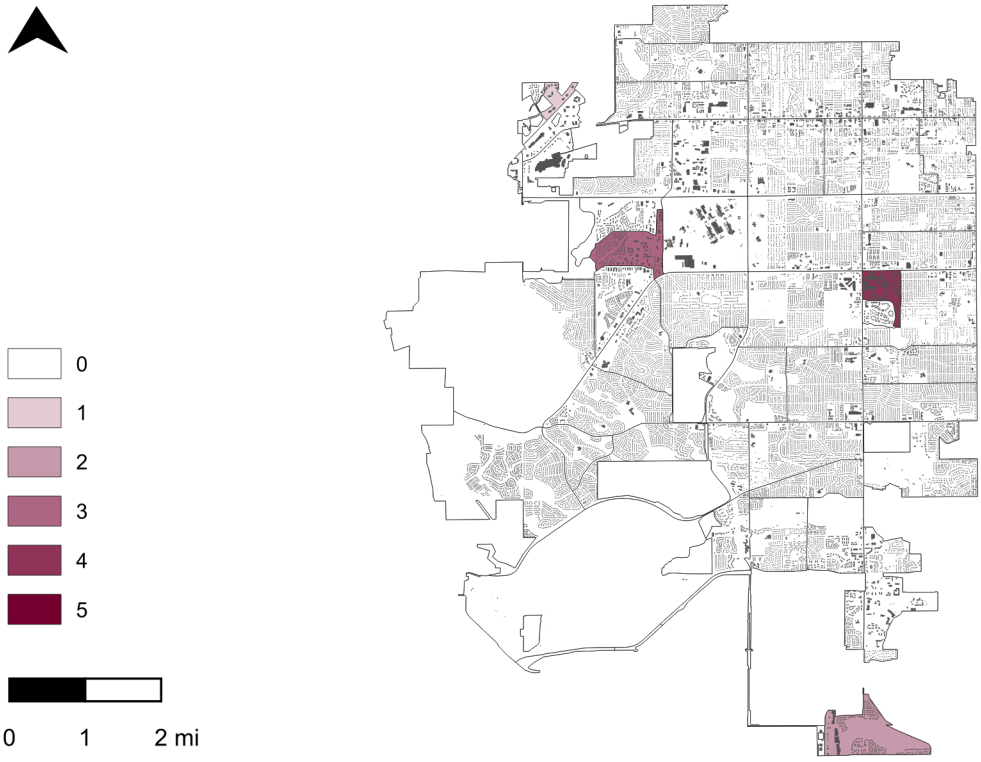
Climate-related hazard

Extreme Heat

Extreme heat is projected to become one of the most significant climate hazards for Lakewood, with longer, hotter summers and more frequent extreme heat days in the coming decades.

Rising nighttime temperatures will further intensify heat stress, particularly in areas most affected by the urban heat island effect, where paved surfaces and a lack of green space trap heat, making it harder for temperatures to cool down overnight. When nighttime cooling is limited, both people and infrastructure experience prolonged exposure to heat, increasing health risks and straining energy systems as air conditioning demand rises. **Figure 3** highlights heat risk priority areas based on a spatial analysis of the urban heat island effect and social vulnerability indicators.

Figure 3. Current heat risk priority areas.



Extreme heat events pose serious health risks, especially for older adults, young children, outdoor workers and individuals facing social isolation. Prolonged exposure to high temperatures can lead to heat exhaustion, heat stroke and other heat-related illnesses, which can become life threatening if not addressed quickly. People without access to air conditioning or stable housing face greater challenges, as they have limited ways to escape the heat. Extreme heat can also affect buildings and infrastructure, causing roofs and facades to crack, warp or curl, leading to costly damages to homes and businesses. With extreme heat becoming more frequent and intense, expanding cooling solutions, increasing urban tree cover and strengthening community support systems will be critical to protecting Lakewood's residents and infrastructure.

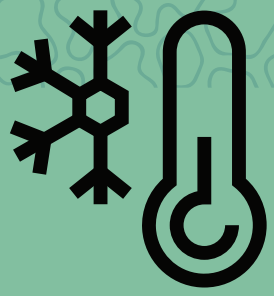
Potential adaptation actions related to extreme heat include:

- Develop a heat management plan for public spaces to ensure all city-hosted and permitted events provide adequate shade and cooling measures.
- Require a heat management plan for event organizers as part of the event application process.
- Set a minimum shading standard for public spaces by incorporating shade structures into city design guidelines.
- Expand emergency cooling zones by deploying temporary shade structures and promoting access to cooled indoor spaces.
- Build and expand splash pads in key locations using rainwater-fed and energy-efficient water features.
- Extend the season for water features by keeping splash pads and cooling facilities open longer.
- Expand community tree planting initiatives by adding shade trees along trails, sidewalks, creeks and outdoor sports fields.
- Set a tree canopy target to reduce the urban heat island effect.

Climate-related hazard

Extreme Cold

While extreme cold events are expected to become less frequent in Lakewood, they will still pose significant risks to vulnerable populations when they do occur.



Climate projections suggest a declining likelihood of extreme cold, along with lower wind speeds, which may reduce the impact of wind chill. However, the destabilization of the polar jet stream adds uncertainty to these trends. As the Arctic warms faster than other regions, the reduced temperature difference can weaken and disrupt the jet stream, leading to sudden, prolonged periods of extreme cold in mid-latitude areas like Lakewood.

Even as winters become milder overall, the potential for unexpected and intense cold snaps remains a concern. Certain groups, including outdoor workers, residents experiencing homelessness, children and older adults, are especially at risk when temperatures drop, particularly if they do not have access to adequate shelter. While most local buildings and infrastructure are designed to withstand cold conditions, severe cold events can still cause frozen and burst pipes, road hazards and increased demand on energy systems. Although Lakewood's winters are projected to warm over time, preparing for occasional extreme cold events remains essential to protecting public health, maintaining essential services and ensuring residents have access to safe and reliable heating when needed.

Potential adaptation actions related to extreme cold include:

- Adjust anti-idling policies during extreme weather to allow designated cooling or warming trucks for outdoor workers at job sites.
- Develop outdoor work recommendations for businesses to help reduce workers' exposure to extreme heat, cold and other hazardous conditions.
- Increase departmental funding for personal protective equipment (PPE) for extreme weather, including weather-resistant clothing, cooling vests and other protective gear.
- Create best practices for electric vehicle use during extreme weather by developing a user guide for city staff.
- Coordinate with non-profits to enhance snow removal services for older adults, individuals with disabilities and residents living on low incomes.

Climate-related hazard

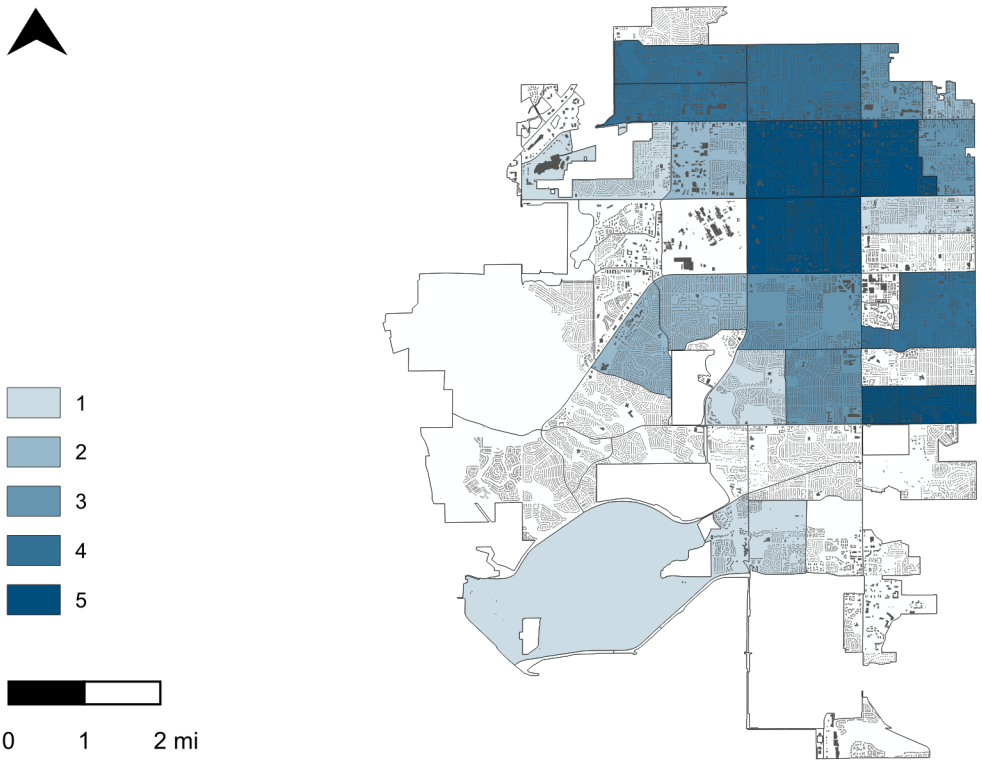
Flooding

Flooding is considered a moderate but growing risk for Lakewood, with climate change expected to bring slight increases in precipitation and runoff over the coming decades.

While overall annual precipitation is projected to rise slightly, spring rainfall is expected to increase more quickly than in other seasons. Additionally, the number of heavy rainfall days — when more than one inch of rain falls in a single day — is also projected to increase. This could lead to more frequent localized flooding, particularly in areas where stormwater drainage systems may struggle to keep up. Over time, annual runoff is expected to rise, which could place additional pressure on urban infrastructure, roads and waterways.

Certain populations are especially vulnerable to flooding, including residents with mobility challenges, individuals experiencing homelessness, outdoor workers, and residents experiencing social isolation, who may face greater challenges in evacuating or recovering from flood-related damage. Additionally, homes, businesses and critical infrastructure in flood-prone areas are at higher risk of water damage and disruption. Flood risks vary across Lakewood, with the northeastern part of the city facing higher potential risks from a rare flood event. **Figure 4** highlights flood risk priority areas based on a spatial analysis of potential flood impacts and social vulnerability indicators.

Figure 4. Current flood risk priority areas.



As flooding risks evolve, strengthening stormwater infrastructure, improving land-use planning and enhancing emergency preparedness efforts will be key to reducing future impacts on Lakewood's residents and infrastructure. The city is currently working on a project to reduce future flood risk called the North Dry Gulch improvement project. The purpose of the project is to update the city's storm sewer system in order to collect and convey a 100-year storm, effectively removing the floodplain from Dover Street to Newland Street. This project is expected to remove 19 residential and 67 commercial properties from the floodplain by 2070, saving approximately $20 million.

Potential adaptation actions related to flooding include:

- Offer rebate programs for flood- and fire-proofing upgrades to help homeowners make critical safety improvements in high-risk areas.
- Complete and implement a Culvert Replacement Study to identify and prioritize high-risk culvert replacements.
- Assess and improve high-risk roads prone to flooding.

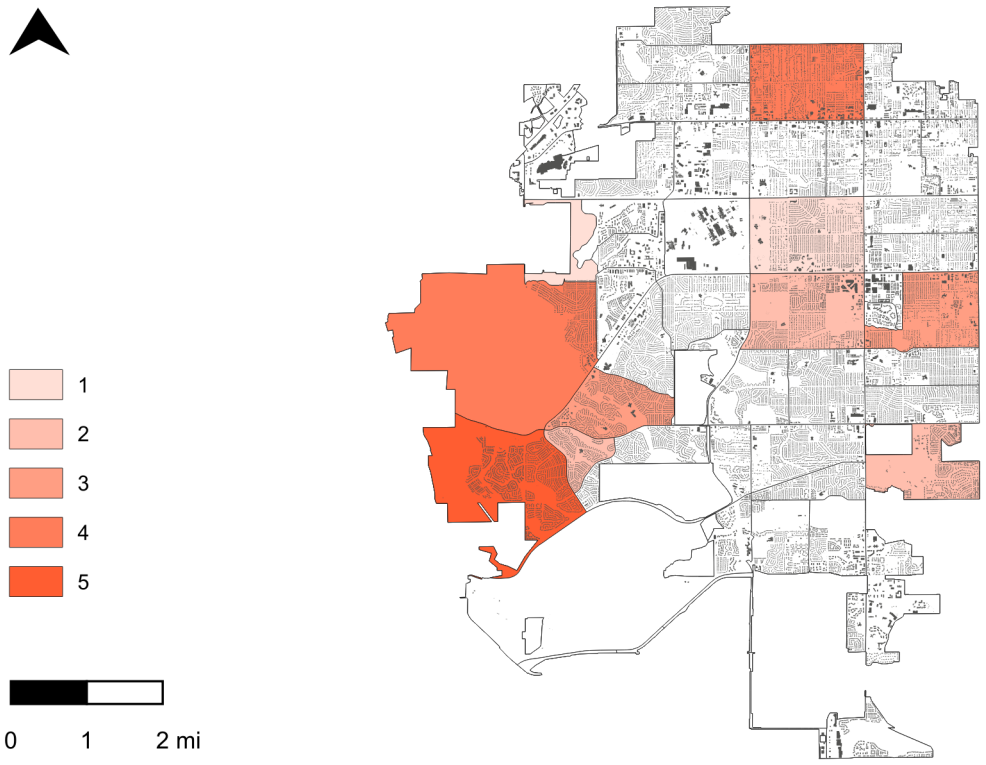
Climate-related hazard

Wildfires

Wildfires are considered a moderate but growing climate risk for Lakewood, as warmer and drier conditions are expected to increase the likelihood of fire activity in and around the city.

With more extremely hot days and a slight increase in the number of dry days each year, vegetation could become more prone to ignition, elevating wildfire risks. While fires have traditionally been more common in rural and forested areas, climate change is making urban and suburban communities more vulnerable, particularly those near parks, open spaces and the wildland-urban interface (WUI). **Figure 5** highlights current fire risk priority areas based on a spatial analysis of wildfire risks and social vulnerability indicators.

Figure 5. Current priority wildfire risk areas.



Certain areas and populations face greater wildfire risks than others. Residents living near Bear Creek, Green Mountain, Crown Hill Park and the Rooney Valley are especially vulnerable due to their proximity to fire-prone landscapes. Additionally, older adults, individuals with respiratory conditions and those sensitive to smoke exposure may experience health impacts from wildfire smoke, even if fires do not directly threaten their homes. Homes and businesses may also face power outages from utility shutdowns, a precaution sometimes taken during periods of extreme fire danger. Parks and natural areas are also at risk of damage from wildfires. As wildfire threats increase, improving emergency preparedness, strengthening fire prevention efforts and protecting vulnerable communities and infrastructure will be key to reducing risks and enhancing Lakewood's resilience to fire-related hazards.

Potential adaptation actions related to wildfires include:

- Review and update the Jefferson County Wildland Fire Evacuation Plan to ensure it meets the needs of residents.
- Strengthen regional coordination on wildfire and extreme weather resilience and expand early warning systems for extreme weather events.
- Offer rebate programs for flood- and fire-proofing upgrades to help homeowners make critical safety improvements in high-risk areas.
- Strengthen Sustainable Development Standards by requiring fire-proofing measures for new developments in wildfire-prone areas.

Community Engagement

The community engagement process ensured that the perspectives of Lakewood residents were reflected in the study recommendations. Engagement efforts included a mix of working groups and focus groups and a citywide survey targeting interested and affected parties, as well as the broader public. Activities included a Community Working Group with local leaders and organizations, as well as an Internal Working Group with city staff. Focus groups were held with representatives from business, development and utilities, as well as neighboring jurisdictions. The city also conducted a community survey, which received 228 responses, providing valuable data on residents' climate concerns, adaptation priorities and existing resilience initiatives. Through community discussions, surveys and workshops, six key themes emerged as top priorities, as highlighted in **Figure 6**. These key themes are summarized in the following section, along with potential actions to support each theme.

Figure 6. Emergent themes from community engagement.

Potential Actions

To help Lakewood prepare for a changing climate, this study identified **61 potential actions** to protect residents, strengthen infrastructure and make the city more resilient to extreme weather. These potential actions were developed based on climate risk assessments, community input and proven best practices in resilience planning. The potential actions are grouped into the six key themes that emerged during the community engagement process. The potential actions will inform the city's future policy analysis and planning efforts to ensure Lakewood remains a safe, sustainable and resilient community for years to come.

Image: Green Mountain fire in Lakewood. Source: City of Lakewood.

Key Theme

Public Engagement and Outreach

Community engagement emphasized the importance of greater public awareness of available programs, targeted outreach efforts for specific needs, and community-driven support systems and narratives to build trust.

Potential adaptation actions related to public engagement and outreach include:

1. Provide building owners, homeowners and renters — especially in high-risk areas — with multilingual resources on how to strengthen their homes against extreme weather.
2. Expand multilingual outreach in high-vulnerability neighborhoods and agricultural areas by increasing education on emergency preparedness, water conservation, energy efficiency and food security.
3. Establish a volunteer coordination platform that connects residents in need with available helpers during extreme weather events.
4. Create a voluntary registry for residents who may need assistance during extreme weather events.
5. Enhance communication about the Heat Repair Program and the Weatherization Assistance Program by developing and distributing multilingual outreach materials.
6. Assess and expand remote service options by reviewing which city services and programs can be offered remotely.
7. Integrate Indigenous knowledge into climate action efforts by partnering with Native American communities to incorporate traditional ecological knowledge, cultural practices and climate adaptation strategies into local resilience planning.
8. Establish a Climate Change Youth Committee to actively engage young people in climate policy discussions.
9. Work with the Diversity, Equity, and Inclusion (DEI) Advisory Committee to formally define people facing barriers and ensure that climate adaptation initiatives prioritize their needs.
10. Develop and apply an equity checklist for all climate adaptation and resilience projects.

Key Theme

Emergency Preparedness and Planning

Residents highlighted the need for enhanced emergency preparedness, including creating disaster plans for high-risk locations, improved hot and cold weather management strategies, and accessible emergency shelters with integrated support services.

Potential adaptation actions related to emergency preparedness and planning include:

11. Expand disaster outreach and recovery teams by working with police, fire departments and non-profits to provide support for residents.
12. Increase access to extreme weather shelters and resilience hubs by identifying indoor spaces for cooling, warming and clean air shelters.
13. Develop a policy for free transit during extreme weather to help residents safely reach cooling centers, shelters and essential services.
14. Enhance existing police initiatives to address trauma from extreme weather events by providing additional mental health support and crisis management for those affected by extreme weather and its aftermath.
15. Review and update the Jefferson County Wildland Fire Evacuation Plan to ensure it meets the needs of residents.
16. Strengthen emergency telecommunications systems by identifying gaps and investing in backup systems.
17. Create best practices for electric vehicle use during extreme weather by developing a user guide for city staff.
18. Develop a heat management plan for public spaces to ensure all city-hosted and permitted events provide adequate shade and cooling measures.
19. Require a heat management plan for event organizers as part of the event application process.
20. Set a minimum shading standard for public spaces by incorporating shade structures into city design guidelines.

Potential adaptation actions related to emergency preparedness and planning include:

21. Expand emergency cooling zones by deploying temporary shade structures and promoting access to cooled indoor spaces.
22. Build and expand splash pads in key locations using rainwater-fed and energy-efficient water features.
23. Extend the season for water features by keeping splash pads and cooling facilities open longer.
24. Support city departments in adapting to extreme weather by reviewing policies, identifying operational needs and ensuring staff are equipped with appropriate procedures and resources.
25. Adjust anti-idling policies during extreme weather to allow designated cooling or warming trucks for outdoor workers at job sites.
26. Develop outdoor work recommendations for businesses to help reduce workers' exposure to extreme heat, cold and other hazardous conditions.
27. Increase departmental funding for personal protective equipment for extreme weather, including weather-resistant clothing, cooling vests and other protective gear.

Key Theme

Climate-Resilient Infrastructure

Infrastructure resilience was a major theme in the engagement process. Residents emphasized the importance of improved stormwater and floodplain management, water conservation strategies, climate-adaptive building standards and support for homeowners to enhance property resilience.

Potential adaptation actions related to climate-resilient infrastructure include:

28. Develop and implement Community Climate Standards to improve the resilience of homes and farms.
29. Strengthen Sustainable Development Standards by requiring fire-proofing measures for new developments in wildfire-prone areas.
30. Expand the Sustainable Neighborhoods Program to include emergency planning and adaptation initiatives.
31. Offer rebate programs for flood- and fire-proofing upgrades to help homeowners make critical safety improvements in high-risk areas.
32. Complete and implement a Culvert Replacement Study to identify and prioritize high-risk culvert replacements.
33. Assess and improve high-risk roads prone to flooding.
34. Strengthen water and food security by expanding graywater systems, non-potable water use and rainwater harvesting, while also promoting drought-resilient agricultural techniques.

Key Theme

Energy Resilience

Participants emphasized the need for energy resilience through home weatherization education, community-scale renewable energy, expanded storage solutions and micro-grid development to ensure reliable power during extreme weather events.

Potential adaptation actions related to energy resilience include:

35. Develop an Energy Backup Supply Plan to ensure that multi-unit residential buildings have sufficient backup power.
36. Establish an Energy Emergency Supply Plan to require multi-unit residential buildings to maintain a minimum of 24 hours of emergency power.
37. Integrate energy storage in emergency heating and cooling centers.
38. Conduct a study on community-scale energy generation and storage to assess opportunities for renewable energy and battery storage solutions.
39. Conduct a study on micro-grid opportunities in existing developed areas.
40. Conduct a study on district energy systems for new developments.
41. Create a rebate program to support renewable energy and battery storage.
42. Expand utility cost assistance programs to provide financial relief for households who do not qualify for the Low-Income Energy Assistance Program (LEAP).

Key Theme

Natural Spaces and Green Infrastructure

Residents emphasized the importance of natural spaces in mitigating extreme heat, and advocated for an expanded tree canopy, shade structures and air quality protections. Residents also recognized the need to address threats to green infrastructure, such as invasive species.

Potential adaptation actions related to natural spaces and green infrastructure include:

43. Expand community tree planting initiatives by adding shade trees along trails, sidewalks, creeks and outdoor sports fields.
44. Set a tree canopy target to reduce the urban heat island effect.
45. Establish an Invasive Species Response Team by recruiting community volunteers.
46. Provide invasive species education for city staff through an internal training program.
47. Promote sustainable soil and land management by working with farmers and landowners to regenerative agriculture practices.
48. Update and expand the Natural Areas Plan to incorporate heat management strategies.
49. Create a voluntary wildlife and plant reporting platform by partnering with grassroots organizations and non-profits.

Key Theme

Governance and Collaboration

While not a major focus of public engagement, municipal governance and collaboration are key to addressing many of the actions that residents suggested. Governance and collaboration could include integrating climate adaptation into city policies and operations, enhancing staff training and strengthening regional collaboration to improve emergency preparedness, risk management and funding access.

Potential adaptation actions related to governance and collaboration include:

50. Integrate climate resilience into asset management practices.

51. Prioritize climate resilience in municipal budgeting to ensure funding aligns with long-term sustainability goals.

52. Strengthen procurement policies by requiring climate mitigation and adaptation considerations in all municipal purchasing and contracting decisions.

53. Require climate reporting in City Council decisions by including climate risk and adaptation strategies in staff and administrative reports.

54. Review and update municipal insurance policies to ensure city-owned assets and infrastructure are adequately covered for future climate risks.

55. Integrate climate adaptation into Diversity, Equity, and Inclusion (DEI) initiatives.

56. Support staff in incorporating climate resilience into project planning and decision-making.

57. Train city staff on climate adaptation strategies through regular workshops and capacity-building sessions.

58. Enhance cross-departmental coordination on climate risks.

59. Strengthen regional coordination on wildfire and extreme weather resilience and expand early warning systems for extreme weather events.

60. Establish an advisory service to help residents navigate insurance claims and understand financial recovery options.

61. Coordinate with non-profits to enhance snow removal services for older adults, individuals with disabilities and residents living on low-incomes.

Conclusion

This Climate Hazard and Social Vulnerability Study will inform future planning efforts across Lakewood and serve as a starting point for future policy and program ideas. The study builds upon the Jefferson County Hazard Mitigation Plan, assessing the risks that climate hazards pose to people, infrastructure and the economy. Potential adaptation actions have been identified through a climate vulnerability and risk assessment, spatial analysis and community engagement to improve the city's resilience to climate change. However, additional research, analysis and community input are necessary to evaluate the feasibility and benefits of these potential actions.

The rest of this report includes the complete Climate Hazard and Social Vulnerability Study for the city of Lakewood. The study consists of local contextual information, the detailed study approach, regional climate projections, the climate vulnerability and risk assessment results, an overview of key hazards and vulnerabilities and the community engagement results. It also includes a list of potential adaptation actions and a suggested implementation guide. This study serves as a foundation for ongoing climate resilience efforts in Lakewood, providing critical insights and possible strategies that will require continued collaboration, investment and community engagement to effectively address the challenges ahead.

Image: Bear Creek Lake Park at Lakewood, Colorado. Source: Adobe Stock under SSG's license.

1.

Introduction

Project Overview

The city of Lakewood, Colorado, is an incorporated home-rule municipality and a suburban community of 156,000 people. It is situated southwest of Denver and adjacent to the foothills of the Rocky Mountains. Lakewood has already experienced significant effects of climate change, with increasing drought, temperature extremes, flooding, wildfires and extreme weather events. Local and regional climate projections suggest that these trends will intensify in the coming decades.[3] These changes are likely to disproportionately affect Lakewood's populations facing the most social barriers, as they may struggle to adapt to climate change due to systemic inequities or limited resources. For example, during a heat wave, residents with limited access to air conditioning, transportation or healthcare are particularly vulnerable to the extreme temperatures.

Addressing these social vulnerabilities will require a comprehensive approach to climate adaptation. Climate adaptation involves preparing for and responding to the impacts of climate change in order to reduce risks and enhance resilience, especially for those most at risk. This includes preparing for wildfires, improving disaster preparedness, equipping communities to withstand extreme weather and restoring natural areas to limit the urban heat island effect and reduce stormwater runoff. Adaptation differs from mitigation, which focuses on reducing greenhouse gas emissions to limit future climate change, as illustrated in **Figure 7**. While mitigation addresses the root causes of climate change, adaptation ensures that communities can navigate its immediate and long-term effects.

The purpose of this Climate Hazard and Social Vulnerability Study was to assess the potential impacts of climate change on natural hazards that pose the greatest risks to the city's residents, infrastructure and economy, with particular focus on communities identified as socially vulnerable. The study was funded by the Federal Emergency Management Agency's (FEMA's) Hazard Mitigation Grant Program and builds on the Jefferson County Hazard Mitigation Plan (HMP) with a Lakewood-specific hazard vulnerability assessment and analysis of the anticipated impacts of climate change on these hazards.[4] The study involved data collection, community engagement and an analysis of potential climate risks in the city. It also included a preliminary review of potential strategies to mitigate hazards in Lakewood, which will assist the city in identifying and prioritizing future climate adaptation policies. This report summarizes the findings of the Climate Hazard and Social Vulnerability Study.

3 Local climate projections are highlighted in the Climate Projections section of this report.

4 Jefferson County. "Hazard Mitigation Plan." 2021. https://www.jeffco.us/488/Hazard-Mitigation-Plan.

Figure 7. Examples of climate change mitigation and adaptation actions.

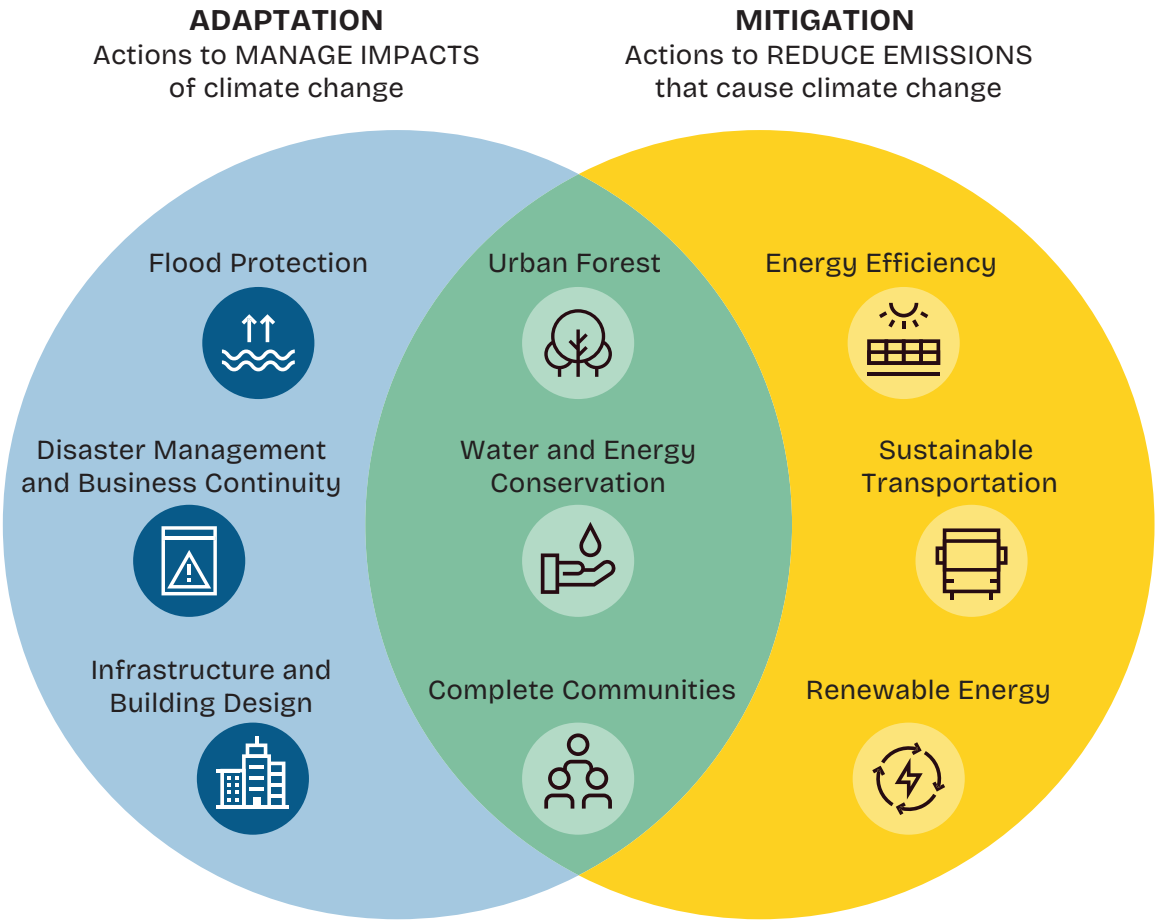


Image: Belmar Park, Lakewood. Source: Adobe Stock under SSG's license

2.

Local Context

Geography

The city of Lakewood, Colorado, is a suburban community located immediately west of Denver, bordered by Wheat Ridge to the north and Golden to the northwest. The city is positioned just east of the Front Range of the southern Rocky Mountains and includes Green Mountain, a 6,854-foot-tall mesa in the western part of the city. Lakewood is easily accessible via major highways, including Interstate 70, Colorado 470 and U.S. Highway 6, which connect the city to Denver, Boulder and the nearby mountain areas, as shown in **Figure 8**.

Ecoregions are geographic areas where the ecosystems are generally similar. The factors that determine ecoregions include include geology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology. Ecoregions are divided into 4 levels of increasingly specific details.[5] Due to Lakewood's location at the base of the foothills of the Rocky Mountains, the city is situated within multiple ecoregions, as shown in **Figure 9**. Most of the city is in ecoregion 25, known as High Plains. The High Plains are elevated, semi-arid plains that support native grama-buffalo grass vegetation. The specific ecoregions include 25d (Flat to Rolling Plains with generally silty soils) and 25l (Front Range Fans, with gravelly soils and a high shrink-swell potential.)

Land use in and around Denver has converted ecosystems from mostly cropland and rangeland to more extensive urban development. A small portion of Lakewood's western edge is located within ecoregion 21, known as the Southern Rockies, including 21d (Foothill Shrublands, a semiarid region with rolling to irregular terrain). The Foothill Shrublands is a transitionary ecoregion between the higher elevations and the plains. Typical vegetation includes sagebrush and mountain mahogany shrubland, pinyon-juniper woodland, and scattered oak shrublands with some interspersed grasslands of blue grama, Junegrass, and western wheatgrass.

The city is part of the South Platte River watershed and features several tributaries, including Lakewood Gulch, Weir Gulch, Sanderson Gulch, Bear Creek, Dry Gulch, McIntyre Gulch, Turkey Creek and Lena Gulch. Lakewood also has numerous lakes and reservoirs, such as the Soda Lakes, Bear Creek Lake, Main Reservoir, Kendrick Lake and Kountze Lake, which support both natural ecosystems and recreational activities.

Lakewood manages 114 parks covering over 7,400 acres of open space, with approximately 240 miles of multi-use trails. Key recreational areas include Hayden Green Mountain Park, Bear Creek Lake Park, Addenbrooke Park, Belmar Park and the Bear Creek Greenbelt. The city also operates four recreation centers: Green Mountain Recreation Center, Charles Whitlock Recreation Center, Lakewood Link Recreation Center, and Carmody Recreation Center.

5 US EPA. "Ecoregions," October 1, 2024. https://www.epa.gov/eco-research/ecoregions.

Figure 8. City of Lakewood in relation to other DRCOG municipalities.

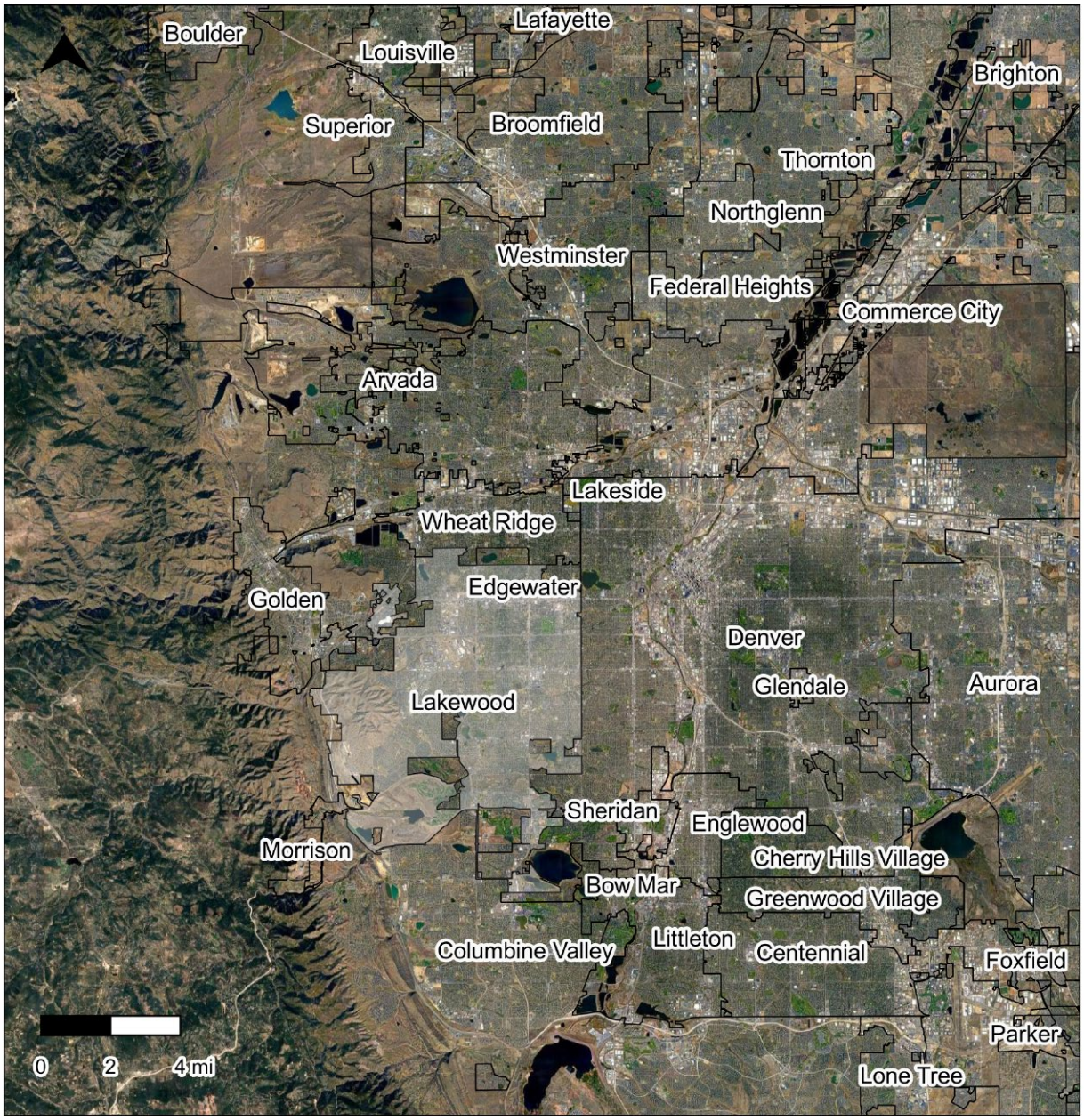
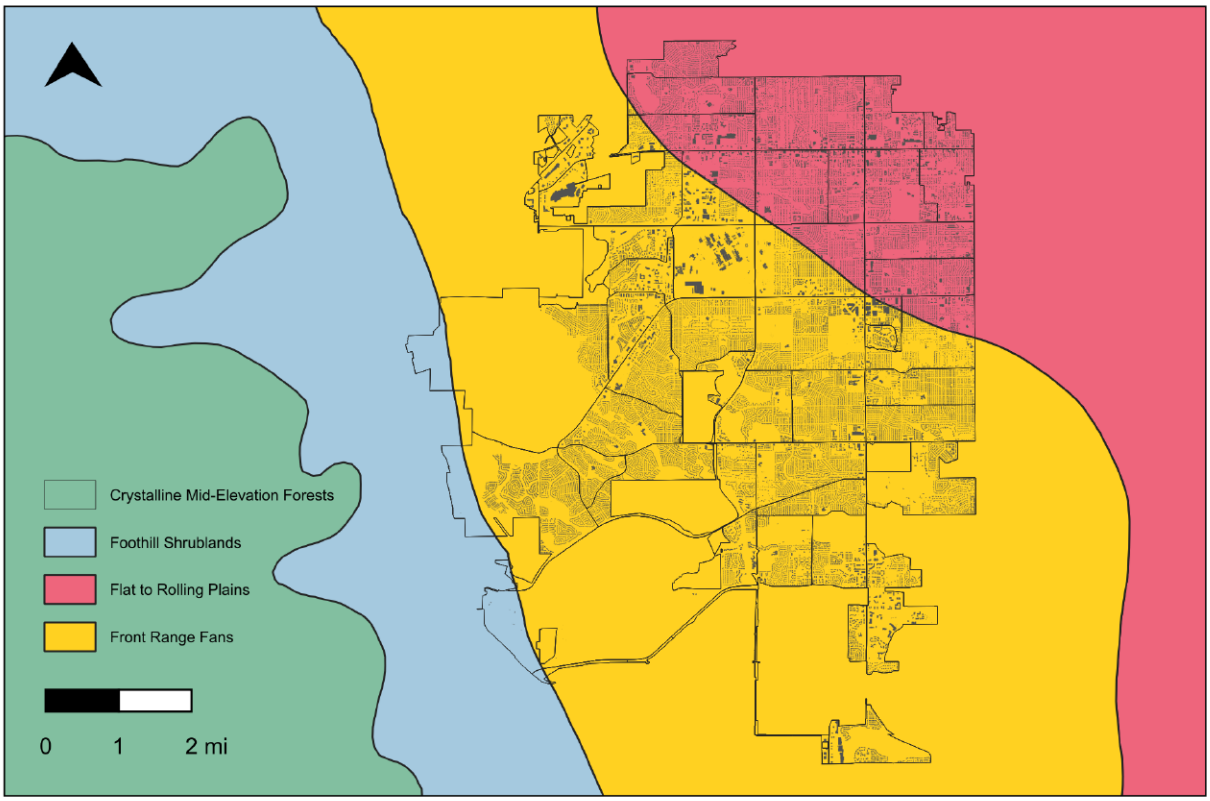


Figure 9. Level IV ecoregions of Lakewood.[6]



Demographics

The city of Lakewood is the third largest city in Metro Denver and the most populous city in Jefferson County. As of 2022, the city had a population of approximately 156,000 residents. The population was 68.2% White alone (not Hispanic or Latino), 22.4% Hispanic or Latino, 3.9% Asian, 3.3% two or more races, 1.5% Black or African American, 0.4% American Indian and Alaska Native, and 0.2% Native Hawaiian and other Pacific Islander.[7] The city had a median household income of $82,786 and a per capita income of $48,299.[8] Approximately 11% of residents were in poverty, though this varied significantly by race, as shown in **Figure 10**.[9]

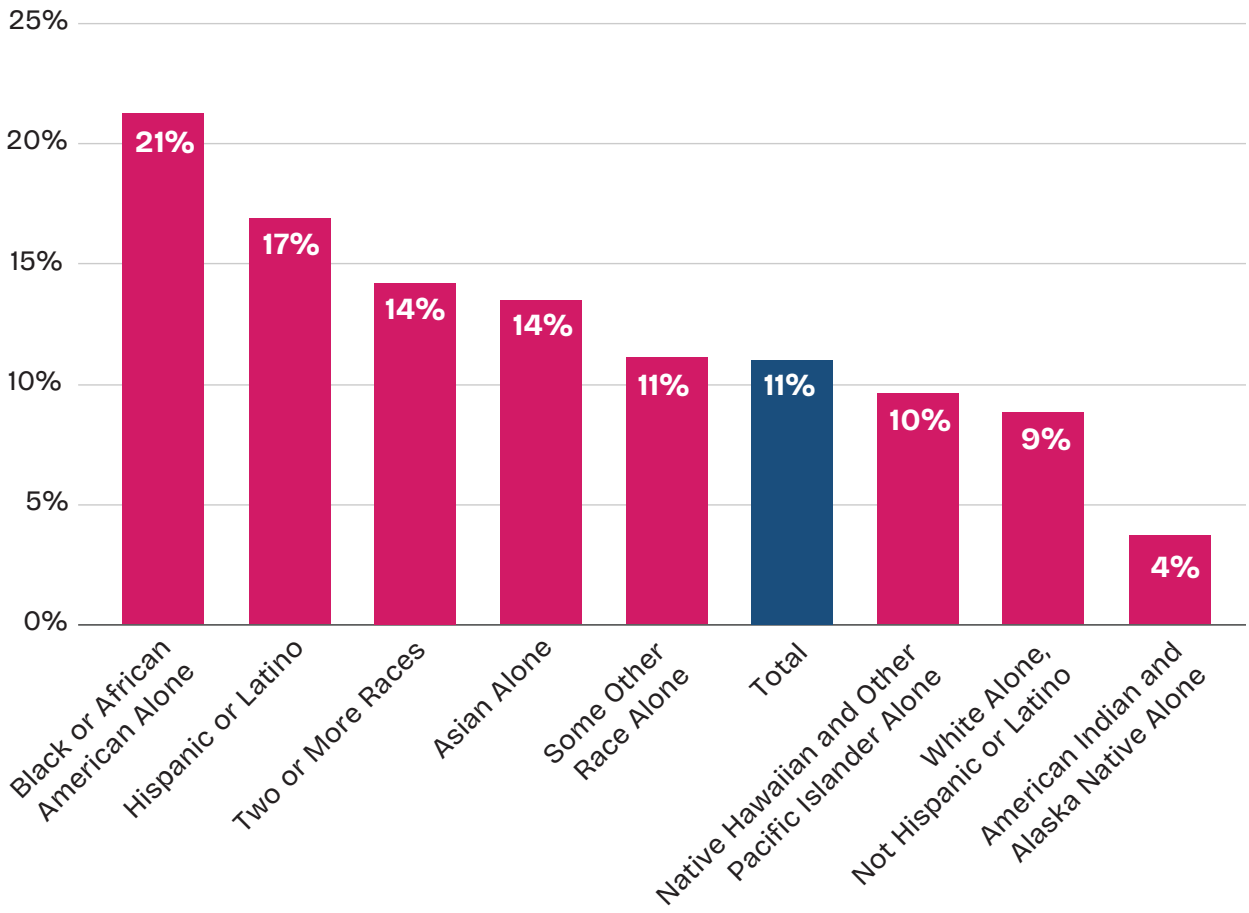
6 US EPA. "Ecoregion Download Files by State - Region 8 | US EPA," December 13, 2024. https://www.epa.gov/eco-research/ecoregion-download-files-state-region-8.

7 U.S. Census Bureau. "DP05: ACS Demographic and Housing Estimates - Census Bureau Table," 2022, https://data.census.gov/table/ACSDP5Y2022.DP05.

8 U.S. Census Bureau. "DP03: ACS Selected Economic Characteristics - Census Bureau Table," 2022, https://data.census.gov/table/ACSDP5Y2022.DP03.

9 U.S. Census Bureau. "B17020A-I: ACS Poverty Status in the Past 12 Months by Age - Census Bureau Tables", 2023, https://data.census.gov/table/ACSDT1Y2023.B17020?q=B17020.

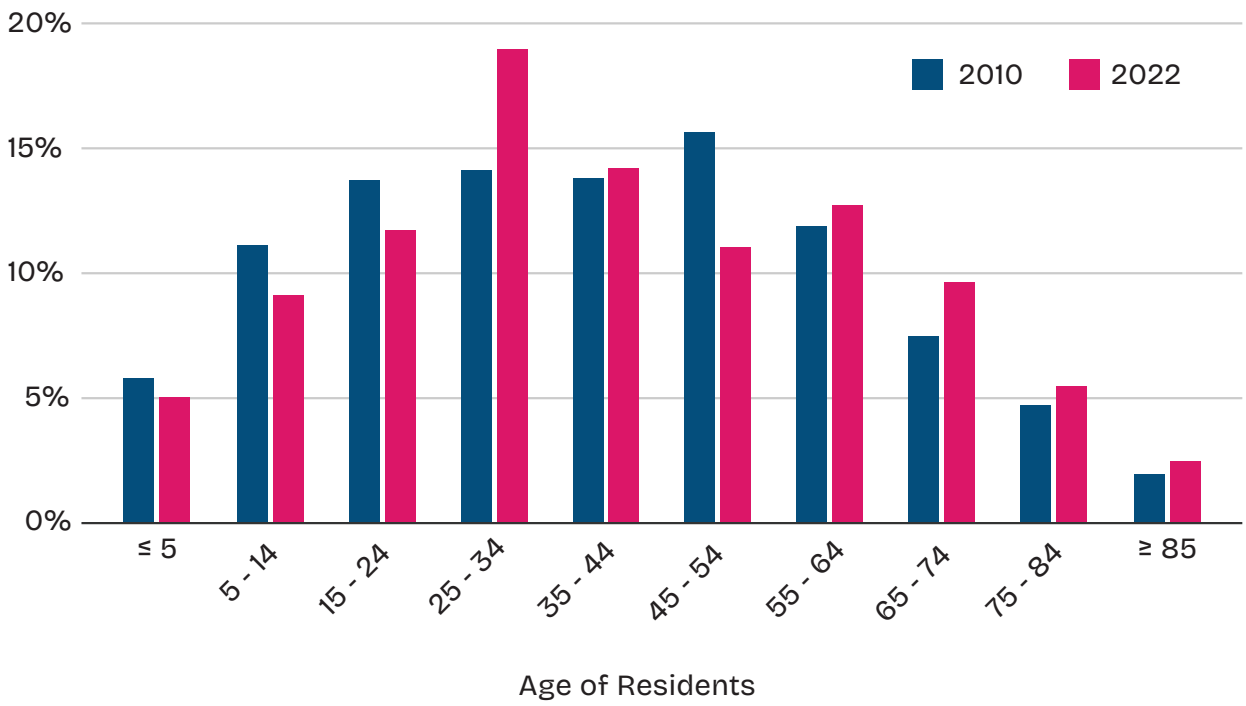
Figure 10. Poverty rate by race and Hispanic origin in Lakewood, 2023.



Over the last decade, Lakewood has experienced relatively slow population growth. Between 2010 and 2022, the population increased by about 10%, which is nearly half the statewide rate of 18% over the same period.[10] In recent years, the proportion of older adults in the city has also increased. As of 2022, more than 27,000 residents, or approximately 17.4% of the population, were aged 65 or older, compared to 14.8% statewide. This represents a notable increase from 2010, when just under 20,000 residents, or 14.0% of the population, were aged 65 or older. **Figure 11** highlights this trend. This trend is notable from a climate change perspective, as older residents are more vulnerable to climate hazards such as heatwaves and are more likely to face mobility challenges.

10 U.S. Census Bureau. "DP05: ACS Demographic and Housing Estimates - Census Bureau Table," 2010, https://data.census.gov/table/ACSDP1Y2010.DP05; U.S. Census Bureau. "DP05: ACS Demographic and Housing Estimates - Census Bureau Table," 2022, https://data.census.gov/table/ACSDP5Y2022.DP05.

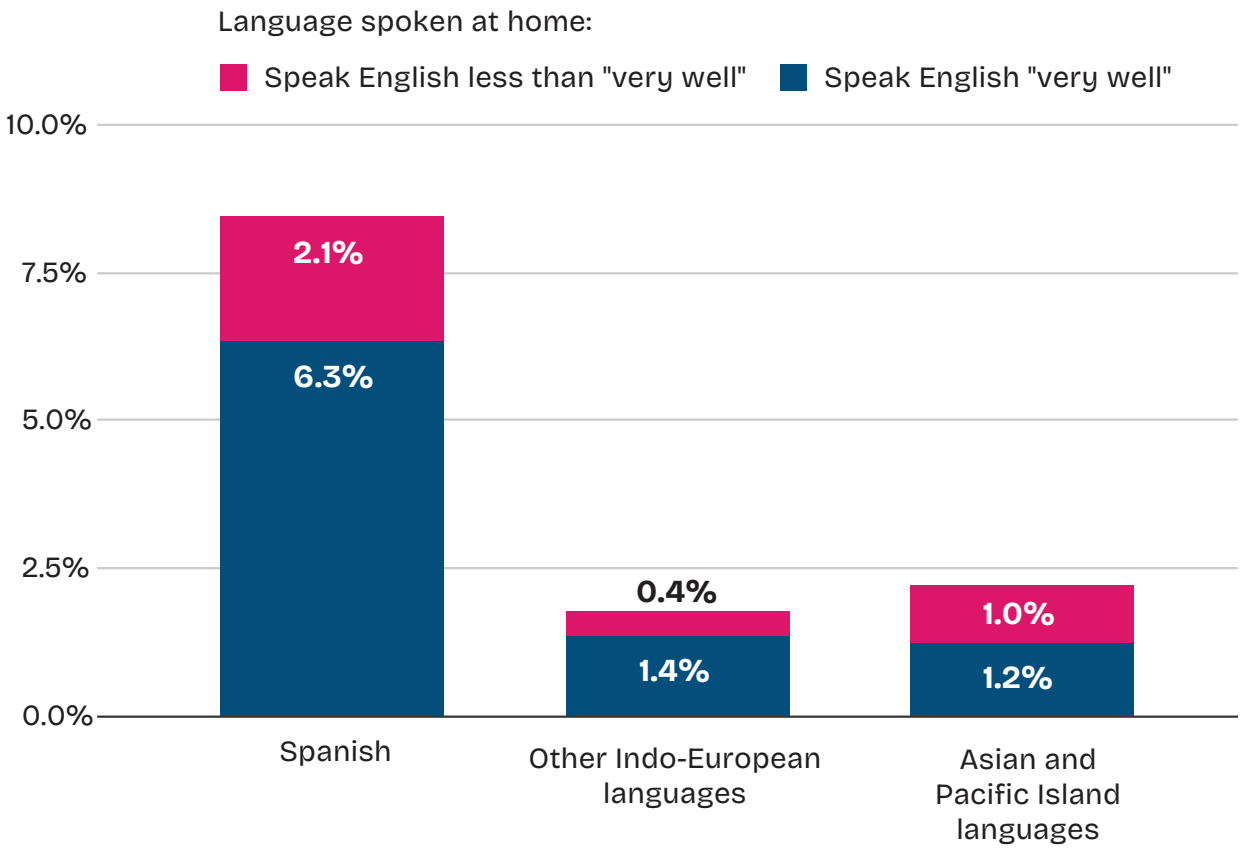
Figure 11. Proportion of Lakewood's population by age brackets, 2010 vs. 2022.



In 2022, roughly 87% of Lakewood's population only spoke English. Approximately 8% of the population spoke Spanish, while 2% spoke another Indo-European language, and another 2% spoke Asian and Pacific Island languages. The majority of residents who spoke another language also spoke English "very well," as shown in **Figure 12**. Only 3.5% of the population spoke English less than "very well," and roughly two-thirds of these residents spoke Spanish.[11] From a climate change perspective, it is important to consider language barriers that may make it difficult for residents to access important information and resources during climate-related events.

11 U.S. Census Bureau. "S1601: ACS Language Spoken at Home - Census Bureau Table," 2022, https://data.census.gov/table/ACSST1Y2022.S1601.

Figure 12. Percent of residents over 5 years old who speak a language other than English, 2022.

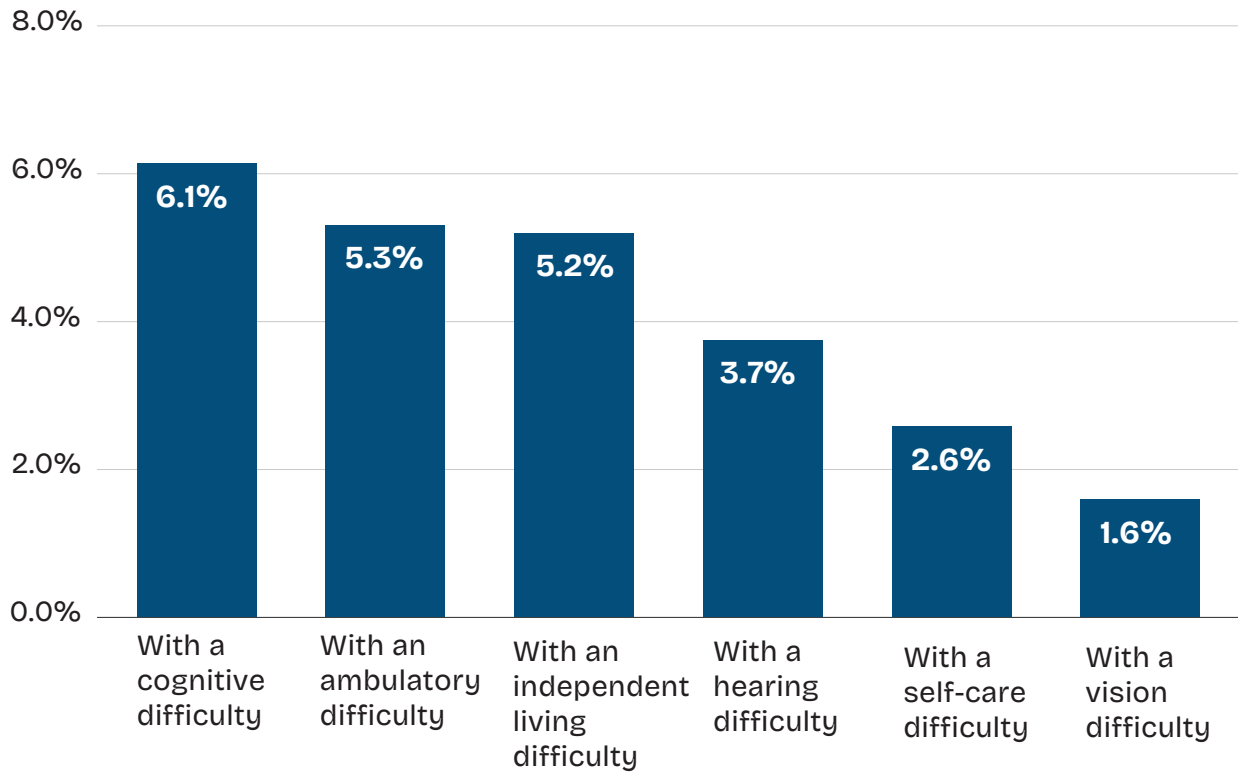


Roughly 12.5% of Lakewood's population had at least one disability in 2022, with 6.4% having two or more disabilities. This is higher than the state average of 11.5% of the population.[12] The most common type of disability in the city was cognitive difficulty, followed by ambulatory difficulty and difficulty with independent living, as shown in **Figure 13**.[13] These statistics are important to highlight, as individuals with disabilities may experience heightened risks in the face of climate-related hazards due to mobility limitations, reliance on assistive devices, and barriers to evacuation or accessing emergency services. They may also be more vulnerable to health complications and disruptions to essential care, making recovery efforts more challenging.

12 U.S. Census Bureau. "B18108: ACS Age by Number of Disabilities - Census Bureau Table," 2022, https://data.census.gov/table/ACSDT1Y2022.B18108.

13 U.S. Census Bureau. "K201803: ACS Types of Disabilities - Census Bureau Table," 2022, https://data.census.gov/table/ACSSE2022.K201803.

Figure 13. Percent of residents by disability type, 2022.



Housing

The city of Lakewood has approximately 72,000 housing units, with 47% being single-detached houses and another 11% consisting of single-attached units, which includes duplexes and row houses. The city's housing stock is relatively old compared to the average age of housing in the state, with 85% of homes in Lakewood built before 2000, compared to 71% statewide, as shown in **Figure 14**. Most housing development occurred during the 1960s, 1970s, and 1980s, reflecting the city's suburban expansion during that period.[14]

Most of the city is built-out, with the exception of the southwest area known as the Solterra development. This is the last planned greenfield development in the city, and most of the newest homes are located in this area, as highlighted in **Figure 15**, which shows the average age of residential buildings by census tract. Census tracts with no residential buildings, including the Denver Federal Center, appear white on the map.

14 U.S. Census Bureau. "DP04: ACS Selected Housing Characteristics - Census Bureau Table," 2022, https://data.census.gov/table/ACSDP5Y2022.DP04.

Outside of Solterra, much of the residential growth is infill development that has occurred in existing established urban renewal areas, such as along the Colfax corridor in the northeastern portion of the city. These established areas were developed before the city of Lakewood was incorporated in 1969, and some of the infrastructure is aging, which may elevate hazard risks in these neighborhoods.

Figure 14. Year of construction for the housing stock in Colorado and Lakewood, 2022.

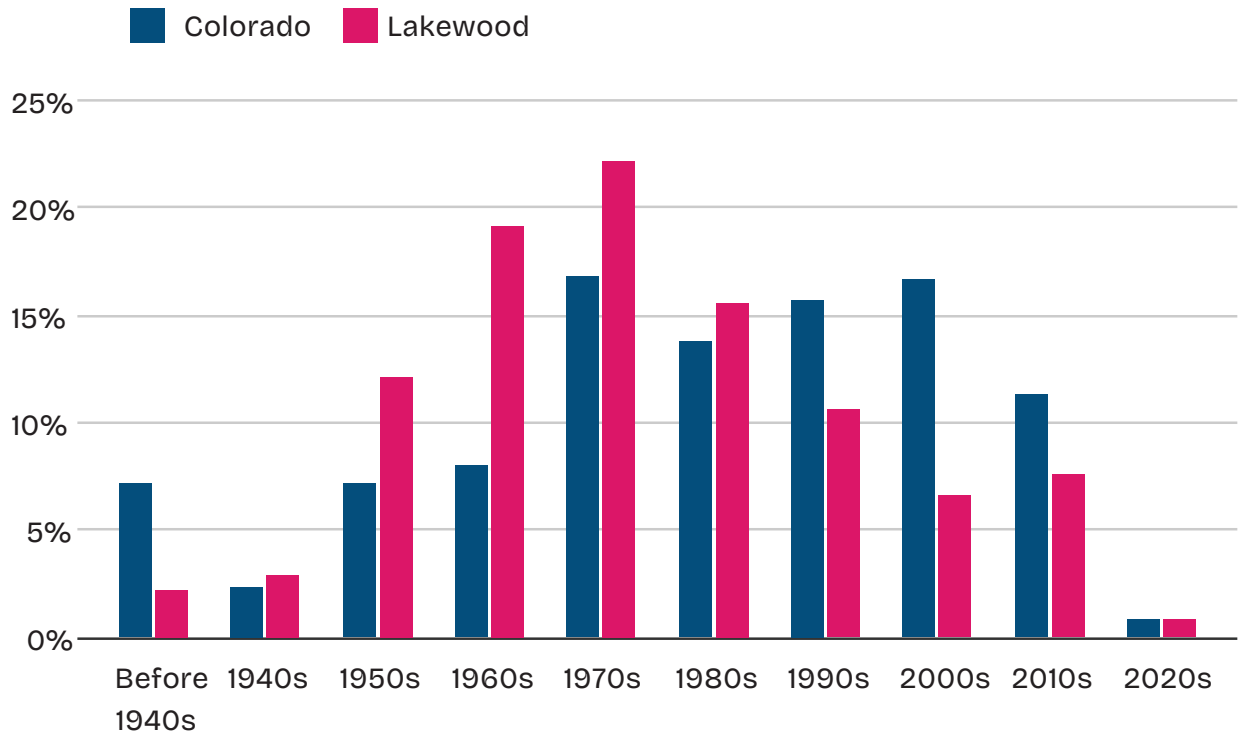
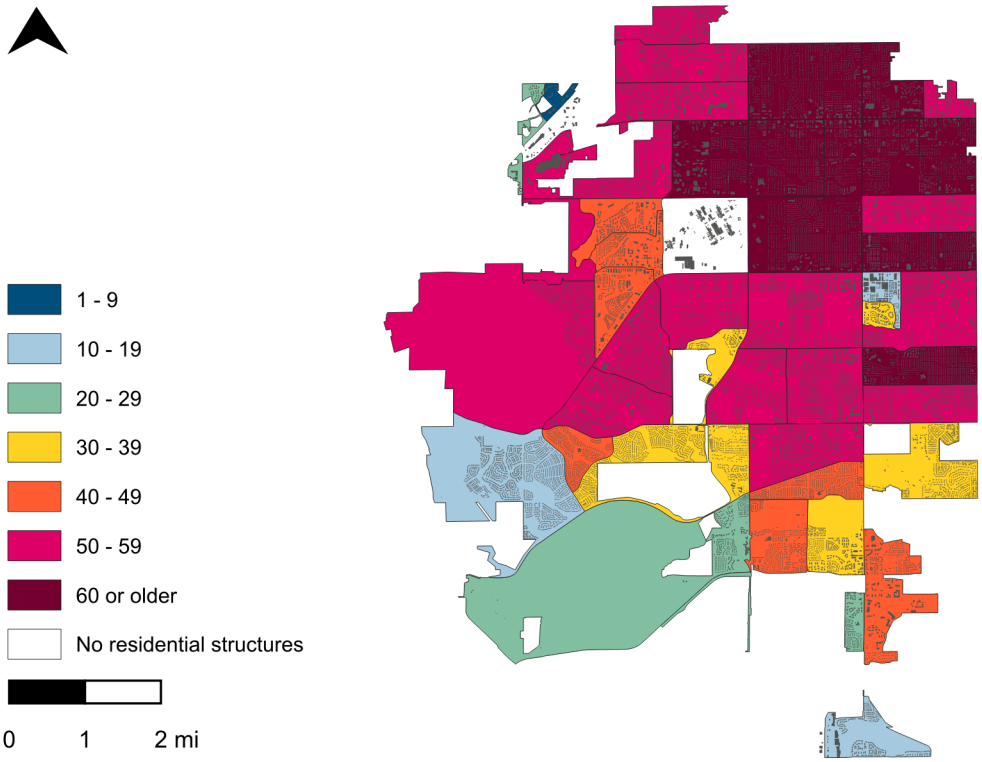


Figure 15. Average age (years) of residential buildings in Lakewood, 2023.[15]

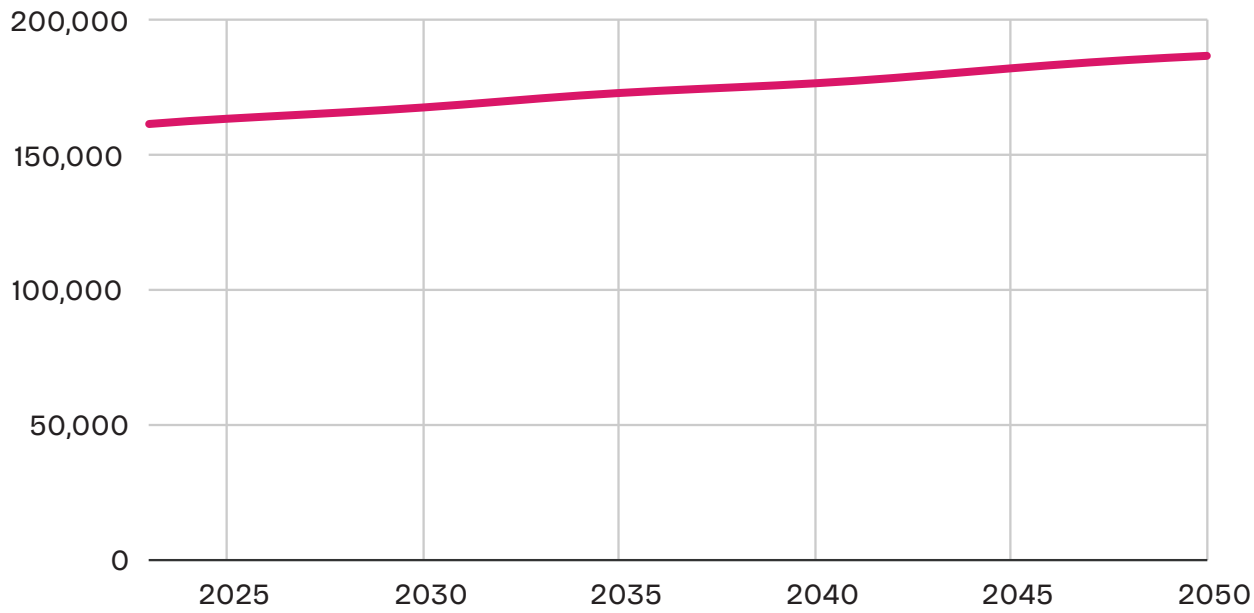


15 The age of commercial buildings is not included in this analysis.

Population Projections

Between 2023 and 2050, Lakewood's population is projected to grow by approximately 16%, with an average annual growth rate of 0.6%. The population is expected to reach roughly 168,000 residents by 2030; 177,000 by 2040; and 187,000 by 2050, as shown in **Figure 16.**[16] This population growth rate is less than that of the overall state, which is projected to increase by 27% by 2050.[17] The number of residential and non-residential buildings in Lakewood is also expected to increase from approximately 68,000 buildings to 79,000 buildings by 2050, as highlighted in **Figure 17**.[18] These projections are incorporated into this study.

Figure 16. Projected population growth for the city of Lakewood, 2023-2050.



16 This projection was calculated using a standard population cohort-survival method disaggregated by single year of age and gender, accounting for typical components of change including births, deaths, immigration and emigration. The population growth rate also extrapolated from housing projections in the city's Strategic Housing Plan: City of Lakewood. "Strategic Housing Plan," 2024, https://www.lakewoodtogether.org/housingstrategy.

17 Colorado Department of Local Affairs. "County Single Year of Age Lookup," n.d. https://demography.dola.colorado.gov/assets/lookups/county_sya_lookup.html.

18 Projections for residential buildings were developed based on the City's Strategic Housing Plan. Projections for non-residential buildings were developed based on employment projections for the City.

Figure 17. Projected total residential and non-residential buildings, 2025-2050.

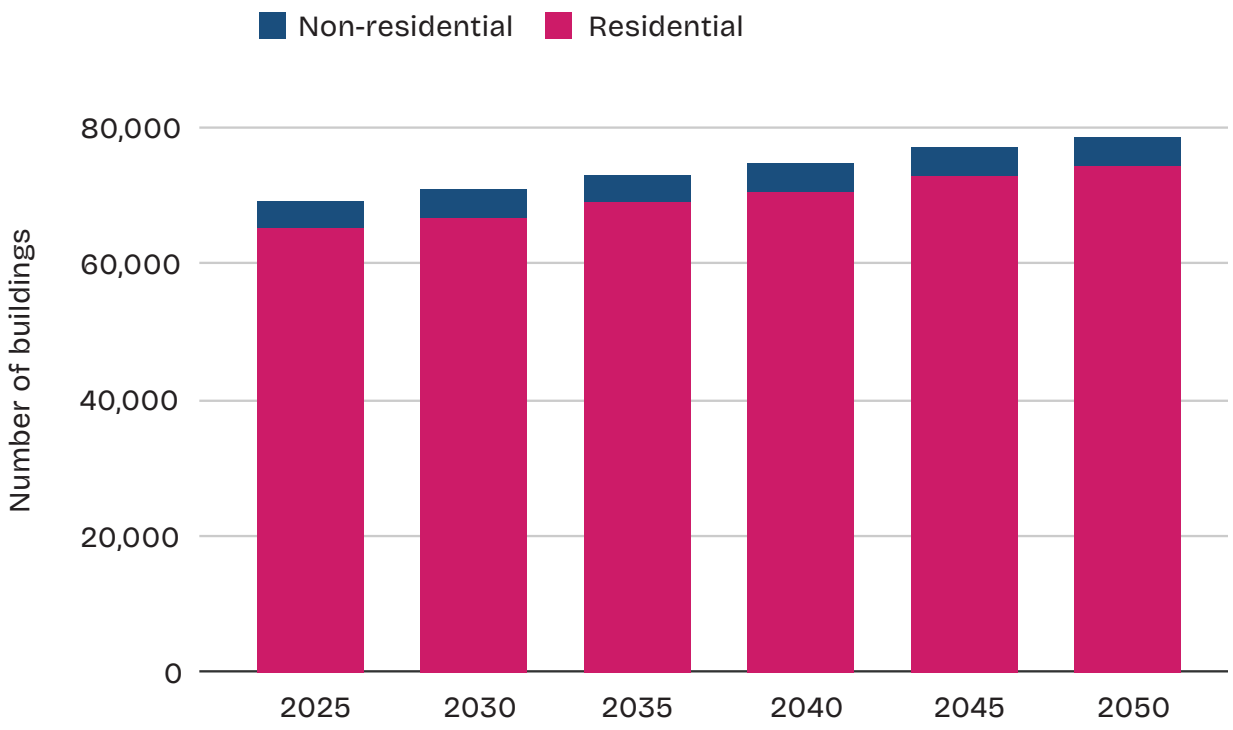


Image: Downtown Lakewood. Source: City of Lakewood.

3.

Study Approach

Project Scope

The following section defines the scope of Lakewood's Climate Hazard and Vulnerability Study. This includes the physical and temporal scope of the project and the climate scenarios used to analyze risks, as well as the hazards and systems included in the analysis.

Physical Scope

The risk assessment completed for this study was limited to the municipal boundary of the city of Lakewood. The city is roughly bounded by Sheridan Boulevard to the east, West 26th Avenue to the north, C-470 to the west, and CO-285 to the south. The City and County of Denver borders Lakewood to the east, while the cities of Wheat Ridge and Edgewater lie to the north. To the south and west, Lakewood primarily borders unincorporated Jefferson County, though small portions of the city boundary adjoin the Town of Morrison and the City of Golden.

Climate Scenarios

In this study, climate change is assessed using two climate scenarios known as Representative Concentration Pathways (RCPs) 4.5 and 8.5. The RCPs are a set of international scenarios developed through collaboration between climate modelers, emission inventory experts, terrestrial ecosystem modelers and integrated assessment modelers.[19] The Intergovernmental Panel on Climate Change (IPCC) used the RCP scenarios as part of its Fifth Assessment Report in 2014.[20] The RCP scenarios represent different levels of radiative forcing, which is a measure of how much extra heat is being trapped by the earth due to human activities. Each scenario involves different assumptions about future conditions, including population growth, economic activities, energy intensity, socio-economic development, land-use change and climate policy.

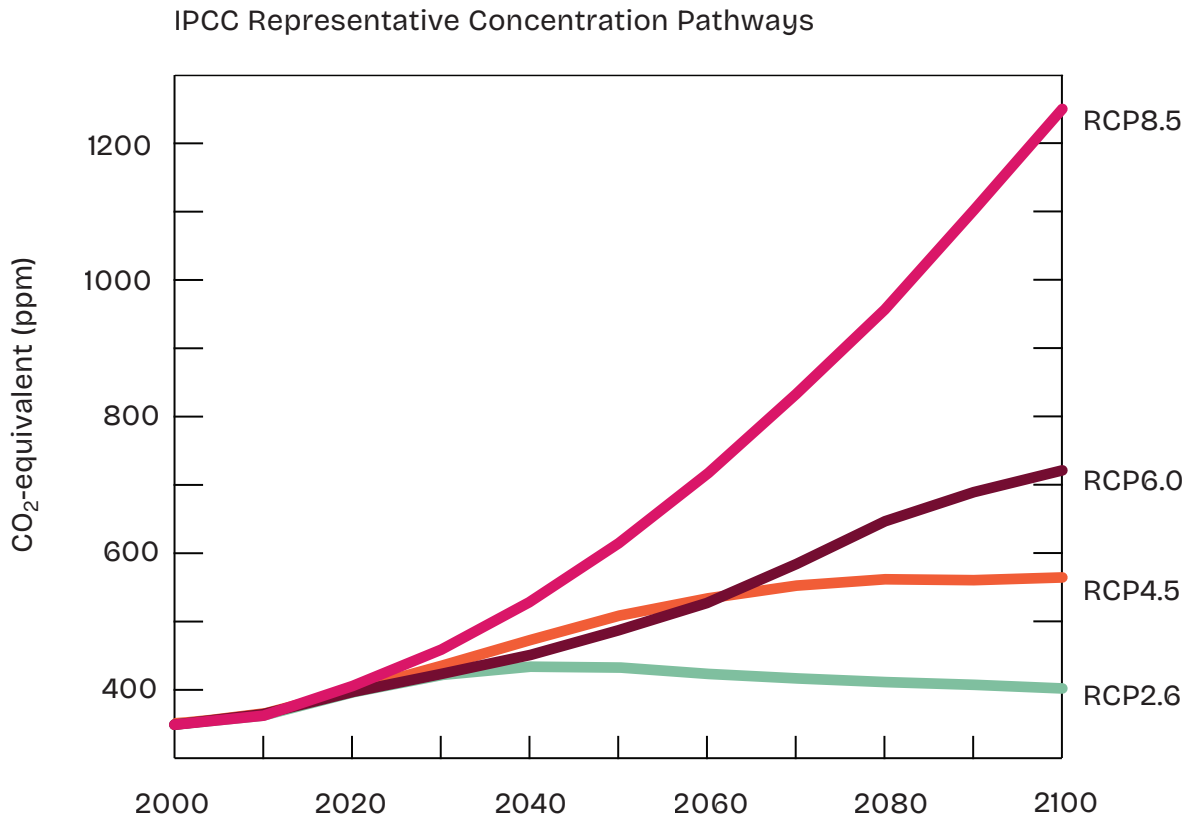
The RCP 4.5 and 8.5 scenarios were used to help Lakewood prepare for a range of futures. The scenarios represent two different sets of assumptions about future greenhouse gas emissions and concentrations of carbon dioxide equivaelent (CO_2e) in the atmosphere, as shown in **Figure 18**. The RCP 4.5 is an intermediate scenario where emissions continue to rise until around 2040, when they peak. After 2040, emissions gradually decrease due to a shift toward cleaner energy, improved efficiency and some new climate policies. In this scenario, concentrations of carbon dioxide equivalent (CO_2e) in the atmopshere begin to level off near the end of the century. This is often described as a "middle of the road" scenario that may be feasible based on the implementation of climate policies. In contrast, the RCP 8.5

19 Detlef P. Van Vuuren et al., "The Representative Concentration Pathways: An Overview," *Climatic Change* 109, no. 1–2 (August 4, 2011): 5–31, https://doi.org/10.1007/s10584-011-0148-z.

20 The AR5 also included RCP 2.6 and 6.0, which were not used in this assessment.

scenario represents a high-emissions pathway where greenhouse gas emissions and concentrations in the atmosphere continue to rise throughout the 21st century. This increase is due to low rates of technology development and climate policy compared to the other scenarios, as well as a high population growth rate. This is often described as a worst case scenario.[21]

Figure 18. Projected concentration of carbon dioxide equivalent (parts per million) in the atmosphere by representative concentration pathway.[22]



21 Detlef P. Van Vuuren et al., "The Representative Concentration Pathways: An Overview," *Climatic Change* 109, no. 1–2 (August 4, 2011): 5–31, https://doi.org/10.1007/s10584-011-0148-z.; USDA, "What are climate model phases and scenarios?" n.d.,https://www.climatehubs.usda.gov/hubs/northwest/topic/what-are-climate-model-phases-and-scenarios

22 Adapted from: IPCC. "AR5 Climate Change 2014: Mitigation of Climate Change — Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change." 2014. https://www.ipcc.ch/report/ar5/wg3/.

Temporal Scope

Climate projections are estimates of future climate conditions based on various scenarios of GHG emissions, land-use changes and other factors. In this study, climate projections for RCP 4.5 and 8.5 are assessed for three time periods between 2010 and 2100. Climate projections are typically based on 30-year periods to ensure that short-term variability, such as seasonal changes or extreme weather events, does not obscure long-term climate trends. These three time periods include the near-term, mid-term and long-term, as shown in **Table 1**.

Table 1. Time frames included in the study.

Name	Climatic Trends
Historical	1971-2000
Near-Term	2010-2039
Mid-Term	2040-2069
Long-Term	2070-2099

Systems

In this project, the climate risks were assessed for five key systems in Lakewood: parks, people, critical infrastructure and services, property, and economy. **Table 2** provides the descriptions of these five systems.

Table 2. Descriptions of key systems assessed in this study.

System	Description
Parks	All areas of the city designated or planned as open space and natural environment
People	Residents and people working, learning, traveling and visiting Lakewood
Critical Infrastructure & Services	All critical services or structures in the community, where the loss of the service delivery function causes cascading system-wide failures (e.g., roads, water and wastewater systems, stormwater system, utilities)

System	Description
Property	Residential, institutional, municipal, industrial and commercial property within Lakewood
Economy	Local businesses, commercial and industrial organizations

Hazards

Climate hazards are extreme weather events or long-term climate patterns that can impact a community. As part of this study, the city of Lakewood drew on Jefferson County's 2021 Hazard Mitigation Plan, which identified 18 potential hazards for the county.[23] Of these 18 hazards, nine were directly related to climate change and were incorporated into this study, as highlighted in **Table 3**. One of these hazards was Extreme Temperatures, which was divided into Extreme Heat and Extreme Cold in this study. The hazards High Winds and Tornados were combined into one hazard. Based on engagement with city staff, the hazard Biodiversity Change was also added to this study. In total, 10 climate hazards were included in this study.

Table 3. Hazards in Jefferson County's HMP that were included in this study.

Hazard	Included?	Hazard	Included?
Avalanche	No	Landslides	No
Dam Failure	No	Lightning	Yes ✓
Drought	Yes ✓	Severe Winter Storms	Yes ✓
Earthquake	No	Subsidence	No
Erosion	No	Tornado	Yes ✓
Expansive Soils	No	Wildfire	Yes ✓
Extreme Temperatures	Yes ✓	Windstorm	Yes ✓
Flood	Yes ✓	Cyber Attack	No
Hailstorms	Yes ✓	Pandemic	No

23 Jefferson County. "Hazard Mitigation Plan." 2021. https://www.jeffco.us/488/Hazard-Mitigation-Plan.

Community Engagement

Interested and Affected Parties

Community engagement was a key component of the Climate Hazard and Social Vulnerability Study. This included engagement with interested and affected parties, as well as the general public. Interested and affected parties included individuals or organizations interested in or affected by the proposed programs and policies resulting from the study, such as:

- City of Lakewood staff
- Environmental and/or climate change organizations
- Educational institutions
- ResidentsHousing authorities
- Social justice and assistance organizations
- Cultural organizations
- Local developers, businesses and industry associations
- Local utilities
- Faith-based organizations
- Public health experts
- Community-based and advocacy organizations

These interested and affected parties were engaged to ensure the study reflected realities of the Lakewood community and the concerns and needs of its residents.

Engagement Techniques

Interested and affected parties were engaged using several engagement techniques, including working groups, focus groups and a survey. These techniques are described in **Table 4**.

Table 4. Engagement techniques used in the study.

Technique	Description
Internal Working Group (IWG)	The IWG included representatives from the following city departments: ▪ Public Works — Capital Projects; ▪ Sustainability & Community Development — Comprehensive Planning; ▪ Sustainability & Community Development — Sustainability, Climate and Zero Waste; ▪ Police — Emergency Management; ▪ Community Resources — Forestry, Open Space, Facilities and Support Services. The goal was to consult with staff about Lakewood's vulnerability and capacity to respond to climate hazards. This was explored from an organizational perspective (e.g., impact on city resources, assets and employees) and a community perspective (e.g., impact on residents, businesses and other organizations). Engagement with this group also focused on supporting data collection and building connections. The IWG was engaged through six meetings, each designed to support key phases of the project. These meetings focused on introducing the project and its objectives, gathering input for the vulnerability assessment, reviewing and discussing spatial risk modeling, providing feedback on the development of proposed actions, and reviewing the draft report.
Community Working Group (CWG)	The CWG was composed of representatives who work with and/or advocate for members of the community, including those most vulnerable to climate change. A list of interested and affected parties was compiled to create this group. Contacts on the list were invited to be part of the CWG to ensure diverse perspectives were represented. The goal was to gather insights from the CWG about how the parties they represent are affected by climate change impacts and their priorities for adaptation actions (e.g., policies, programs, infrastructure upgrades). The CWG contributed their insights through two workshops held during the project. The first workshop provided an overview of the study, facilitated feedback to refine the vulnerability assessment and included data collection activities. The second workshop focused on reviewing vulnerability results and developing climate adaptation actions based on the findings. Representatives of the CWG also reviewed and offered feedback to the draft final report.

Technique	Description
Community Survey	A community survey for interested and affected parties was developed. The objectives were to gather information about participants' concerns about climate change impacts, to identify priority vulnerability and adaptation actions and to identify existing initiatives that could be scaled up to increase resiliency. The survey was published on the Lakewood Sustainability webpage and promoted through the city's newsletter, social media and posters at city facilities. While the survey was not designed to derive statistically significant results, the responses still offered valuable perspectives. A total of 228 people completed the survey. The survey respondents were fairly representative of Lakewood as a whole in terms of zip code, housing tenure, age, income, race/ethnicity, poverty status, and disability status.
Sector-Specific Focus Groups (FGs)	Two focus groups were conducted to supplement insight from the CWG. The objective was to gather insights from specific sectors and groups on how climate hazards impact their sector and determine potential actions to mitigate those impacts. The first focus group included representatives from the business, development and utility sectors, and the second included staff from neighboring jurisdictions. Representatives from both groups also reviewed and offered feedback to the draft final report.

Risk Assessment

Framework

A key component of Lakewood's Climate Hazard and Social Vulnerability Study was a Climate Vulnerability and Risk Assessment (CVRA). A CVRA was used to determine how climate change may affect Lakewood's residents, infrastructure and natural environment. The process involves identifying which populations, areas and systems are most at risk from hazards such as extreme heat, flooding, drought or severe storms, and assessing the potential consequences if these hazards become more frequent or intense.

In this process, risk is defined as the likelihood of an event having a negative outcome. Conceptually, risk is a function of three key components: the **threat likelihood** of a hazard, the **vulnerability** of a community or system to the hazard, and the **consequence** of the hazard on the community or system. This concept, as well as key questions associated with each of the three components, is highlighted in **Figure 19**. The Data, Methods, and Assumption Manual in **Appendix A** includes more details on this process.

Figure 19. The risk concept, including questions associated with each component.

In this conceptualization, the **threat likelihood** is the probability that an extreme weather event or climate hazard will occur. Many events can be assessed qualitatively or quantitatively based on the likelihood of it occurring in any given year, which is also known as the annual exceedance probability. For example, a flood with a 0.5% annual exceedance probability has a 0.5%, or 1-in-200, chance of occurring in any year. Climate change is increasing the likelihood of many extreme weather events and climate hazards, causing the annual exceedance probability of these events to increase.

Vulnerability is defined as the propensity of a system to be adversely affected by a hazard. Vulnerability can be further broken down into three components: adaptive capacity, sensitivity, and susceptibility. Adaptive capacity refers to the system's ability to respond to and adjust to impacts, while sensitivity refers to the system's ability to recover from the hazard. Susceptibility refers to the degree to which a system is vulnerable due to factors such as geographic location.

The third and final component of the formula is **consequence**, which refers to the effects on systems due to climate hazards and the vulnerability of an exposed system. The term can refer to either direct or indirect consequences. Direct consequences refer to tangible, measurable effects that result from a climate hazard, such as physical damage to buildings, infrastructure and the environment, as well as injuries or fatalities. These impacts are often immediately observable and can be quantified in terms of financial costs, environmental degradation and public health effects. For example, direct impacts might include the destruction of homes from flooding, the loss of crops due to drought, or injuries caused by extreme heat.

On the other hand, indirect consequences involve less immediately measurable, but still significant, effects. These are the secondary impacts, such as delays in transportation, loss of productivity, or strain on social services, that arise from disruptions to normal activities. Indirect impacts can be harder to quantify because they involve cascading effects that extend beyond the immediate aftermath of an event. For instance, an extended power outage may disrupt daily life and business operations, affecting not just those directly impacted by the outage but also the broader community. As they are more difficult to quantify, indirect impacts are scored qualitatively and rely on input from subject matter experts.

Social Vulnerability

Vulnerability is a qualitative assessment of how a hazard will impact a community or system. The concept of social vulnerability refers to the capacity of individuals or groups to anticipate, cope with and recover from hazards.[24] Even though community members may experience the same physical hazards, some community members may be disproportionately impacted due to social factors such as income, age, race, language and disability.[25] The concept emphasizes that certain groups — such as households living on low incomes, aging adults, people with disabilities and marginalized racial groups — often face greater challenges in preparing for, coping with and recovering from climate-related events.

Social vulnerability is a key component of this study, as it directly impacts an individual's capacity to respond to climate hazards, such as flooding, extreme heat and wildfires. Given this, an Equity Index developed by the Denver Regional Council of Governments (DRCOG) was incorporated into the analysis. The DRCOG's Equity Index includes 10 demographic indicators, three categorical domain scores and a final equity score for each census tract.[26] **Table 5** highlights the three categories and 10 indicators included in the Equity Index. The scores are reported on a scale of 1 to 100, where higher scores indicate higher levels of social vulnerability.

24 Jefferson County. "Hazard Mitigation Plan." 2021. https://www.jeffco.us/488/Hazard-Mitigation-Plan.

25 US EPA. "Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts," 2021, https://www.epa.gov/cira/social-vulnerability-report.

26 DRCOG. "Metro DNA DRCOG Equity Index Census Tract Clipped VIEW," 2023, https://www.arcgis.com/home/item.html?id=f292fb54eed44080b033d2b0c36db5ae.

Table 5. Categories and indicators included in the DRCOG's Equity Index.

Category	Indicator
Economic status	Percent of people with low income
	Percent of households burdened by housing costs
	Percent of single-parent households
Mobility barriers	Percent of people with a disability
	Percent of households without a vehicle
	Percent of older adults (60-plus)
	Percent of children and youth under 18
Race and ethnicity	Percent of people with limited English proficiency
	Percent of people of color
	Percent of people born outside the U.S.

Figure 20 highlights the overall DRCOG equity scores for Lakewood. In general, the eastern portion of the city has higher scores on the Equity Index, indicating higher levels of social vulnerability. This is due to economic and mobility challenges, as well the race and ethnicity of residents. Residents living on low incomes and facing cost burdens are particularly concentrated in the northeast corner of the city. The equity score varies across the region, as shown in **Figure 21**. Lakewood has the highest social vulnerability in Jefferson County, with the the highest scores concentrated in the northeast part of the city. Regionally, there may be opportunities for Lakewood to collaborate with and learn from other jurisdictions with high level of social vulnerability, such as Denver, Aurora, Commerce City, and Thornton.

Figure 20. DRCOG Equity Index by census tract using ACS 2018-2022 data for the city of Lakewood.

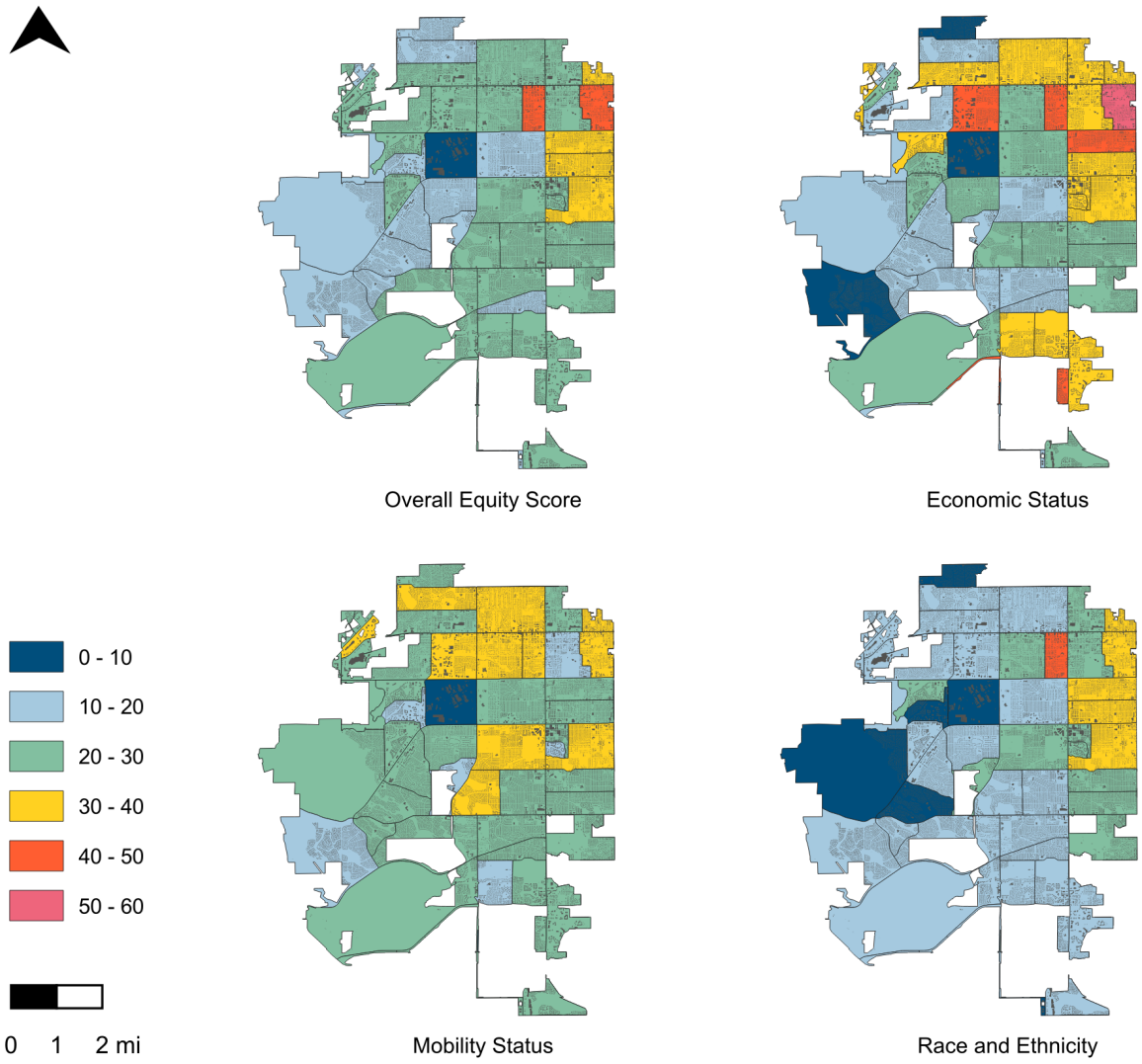
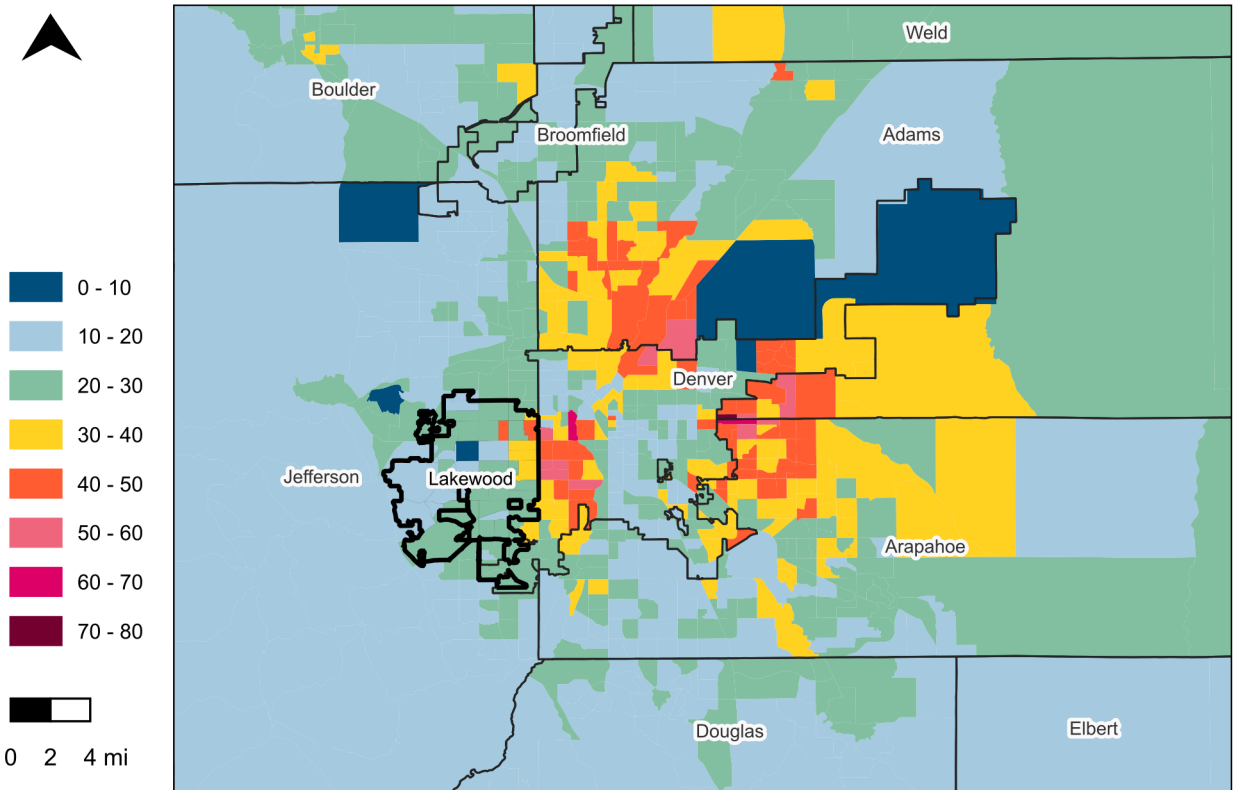


Figure 21. DRCOG Equity Index by census tract using ACS 2018-2022 data for the Denver region.

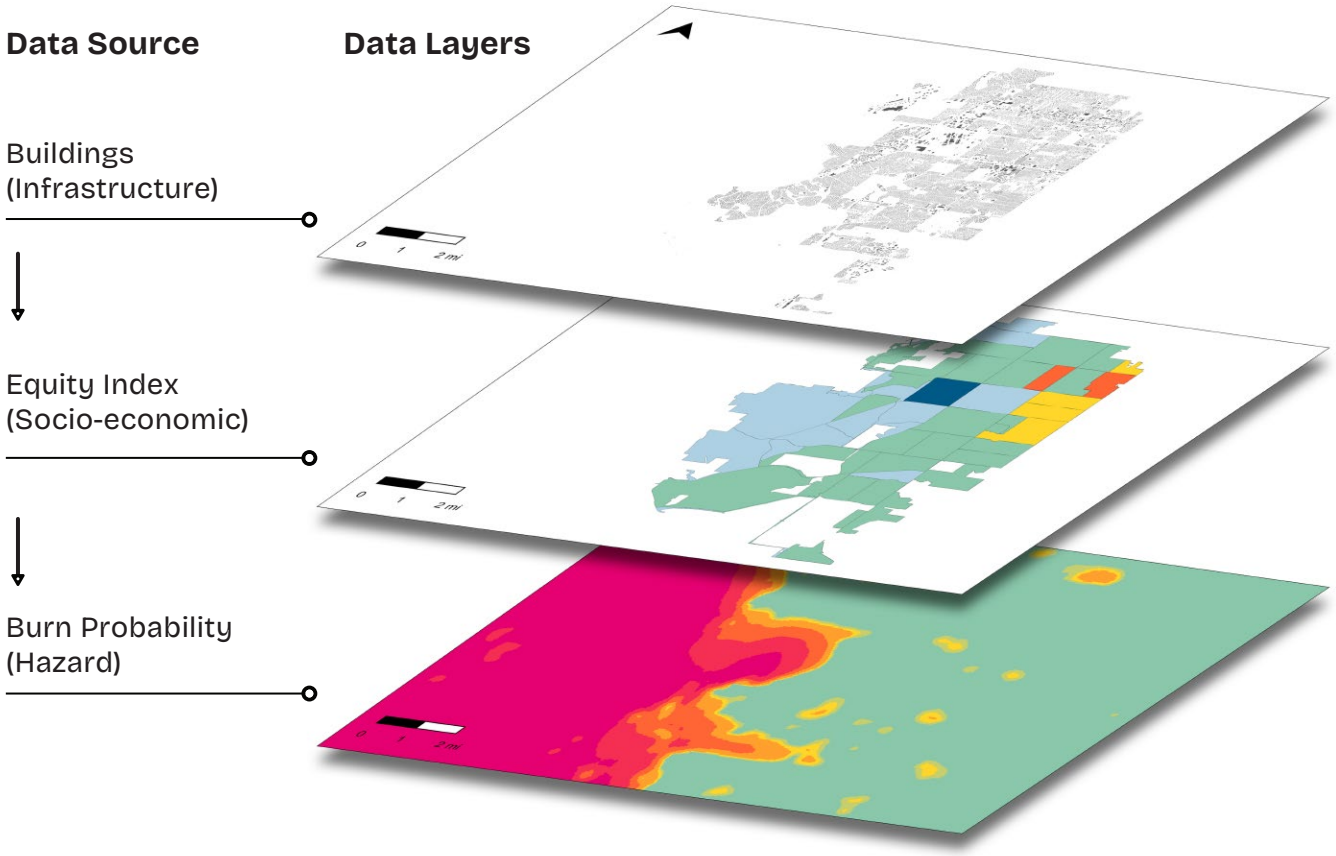


Spatial Risk Modeling

Framework

Following the Climate Vulnerability and Risk Assessment, a spatial risk analysis of three priority risks was completed using the GIS-enabled model ScenaAdaptation. The model simulated Lakewood's built and natural environment using environmental data such as buildings, land use and other infrastructure. Socio-economic data from DRCOG's Equity Index, described in the previous section, was also incorporated into the model. An assessment of Lakewood's climate hazards was then overlaid on the socio-economic and environmental data to understand the exposure of each asset to those hazards. **Figure 22** illustrates the main types of geographic data used in this spatial analysis.

Figure 22. Geographic data incorporated into the spatial risk modeling.



A spatial risk analysis was completed for three priority risks: wildfire, extreme heat and flooding. These three risks were selected because the environmental and socio-economic factors that contribute to them are highly localized. For example, temperatures on extremely hot days can vary significantly across the city because of the urban heat island effect, which is influenced by the presence or absence of vegetation, and concrete and asphalt surfaces. In contrast, the remaining two priority risks — extreme cold and hailstorms — are not highly localized risks that can be modeled with existing data. This is because extreme cold conditions are typically widespread and not significantly influenced by the built environment, while hailstorms are random and unpredictable in their occurrence. The following sections highlight the spatial analysis process used to model flooding, heat and wildfire risks in Lakewood. **Appendix A** includes more detailed information.

Flooding

Riverine flooding occurs when there is excessive rainfall over an extended period of time, causing rivers or creeks to overflow. Pluvial flooding occurs when precipitation events exceed the capacity of the stormwater drainage system. Due to data limitations, the spatial analysis and damage estimates were limited to riverine flooding.
.

Publicly available FEMA flood GIS data was overlaid with the location, type and value of existing and future buildings throughout Lakewood to determine the exposure of buildings to riverine flooding in different return periods. These return periods included a 0.2% annual chance of a flood (1-in-500-year flood) and a 1% annual chance of a flood (1-in-100-year flood). Frequent flooding was also represented by floodways. Based on the building characteristics and flood exposure in a parcel, the damages from flooding were calculated by return period by applying damage estimates presented in the Jefferson County Hazard Mitigation Plan, as shown in **Table 6**.

Table 6. Flood Vulnerability in Lakewood by Return Period.[27]

Return Period	Building Count	Total Value	Estimated Loss
1-in-100 year	269	$297,929,862	$74,482,466
1-in-500 year	309	$162,982,167	$40,745,542

The priority risk areas for riverine flooding were determined by the following formula:

> *Priority risk score = present day total structure and content flood damage for a rare (1-in-100) event for a census tract * social vulnerability index value (1-100)*

27 Copied directly from Table 4-38 and Table 4-39 in: Jefferson County. "Hazard Mitigation Plan." 2021. https://www.jeffco.us/488/Hazard-Mitigation-Plan.

The priority risk scores for each census tract were divided into quintiles and ranked from one to five, with five representing the highest-priority heat risk areas. The final maps developed through this spatial analysis are included in the Priority Risks section of this report.

The analysis also examined the impact of the North Dry Gulch Improvement Project, which the city is currently in the process of planning and designing. The purpose of the project is to update the City's storm sewer system in order to collect and convey a 100-year storm event. This would effectively remove the floodplain from Dover Street to Newland Street. In this study, the North Dry Gulch project was incorporated into the model by removing exposure to flood for properties in the designated project area.

Heat

Extreme heat was also spatially modeled in Lakewood. This analysis specifically explored the temperature difference between neighborhoods on a hot day in Lakewood. To complete the analysis, the spatial difference in temperature for high temperature days was estimated using NASA landsat data from September 17, 2016. This date was selected as it a clear day with low cloud coverage, allowing for clear imagery. The maximum temperature was 69°F and the minimum temperature was 45°F, with an average temperature of 57°F.[28] In order to obtain average temperature difference by census tract, surface temperature data at a 90 m pixel resolution was aggregated at the census tract level by taking the average value of all surface temperature readings within the census tract. To calculate future temperatures, projected hottest indicator data was used for two climate scenarios, RCP 4.5 and 8.5, and added to the estimated average temperature for each census tract.

To estimate the heat risk, the census tract temperature estimates and total population for each census tract were used. The number of people at high heat risk was determined by estimating the number of people exposed to nighttime temperature over a threshold of 70°F for each census tract. The nighttime temperature threshold used for this assessment was taken from the state of Colorado's HeatRisk system, which determines triggers for issuing public heat warnings. This threshold is significant because sustained high nighttime temperatures prevent the body from cooling down adequately, increasing the risk of heat-related illnesses.

Similarly, future heat risk was determined by combining future heat projections described in the previous section with the population projections by census tract for Lakewood.

28 NOAA. "NOWData - NOAA Online Weather Data." https://www.weather.gov/wrh/Climate?wfo=bou, September 17, 2016.

The priority risk areas for heat were determined by the following formula:

> *Priority risk score = present day number of people exposed to nighttime temperatures over 70°F * social vulnerability index value (1-100)*

The priority risk scores for each census tract were divided into quintiles and ranked from one to five, with five representing the highest-priority heat risk areas.

Wildfire

To assess wildfire risk, data on the value and location of all buildings within city boundaries were obtained from parcel information and building footprints via Jefferson County Open Data. The value of new buildings was estimated using the average building value of the census tract where they are projected to be constructed. Spatial wildfire risk categories from the Colorado State Forest Service website were overlaid with existing and future buildings to classify building values by risk level.

The priority risk areas for wildfire were determined by the following formula:

> *Priority risk score = total building value at high or extreme risk for a census tract * social vulnerability index value (1-100)*

The priority risk scores for each census tract were divided into quintiles and ranked from one to five, with five representing the highest-priority heat risk areas

Image: Green Mountain fire, Lakewood. Source: City of Lakewood.

4.

Climate Vulnerability and Risk Assessment

Climate Projections

Lakewood has already seen significant effects of climate change, with increasing drought, temperature extremes, flooding, wildfire and extreme weather events. Local and regional climate projections suggest that these trends will intensify in the coming decades. **Table 7** highlights projected weighted mean change across global climate models to select climate indicators in the city of Lakewood in the near-, mid-, and long-term for both RCP 4.5 and RCP 8.5 scenarios.

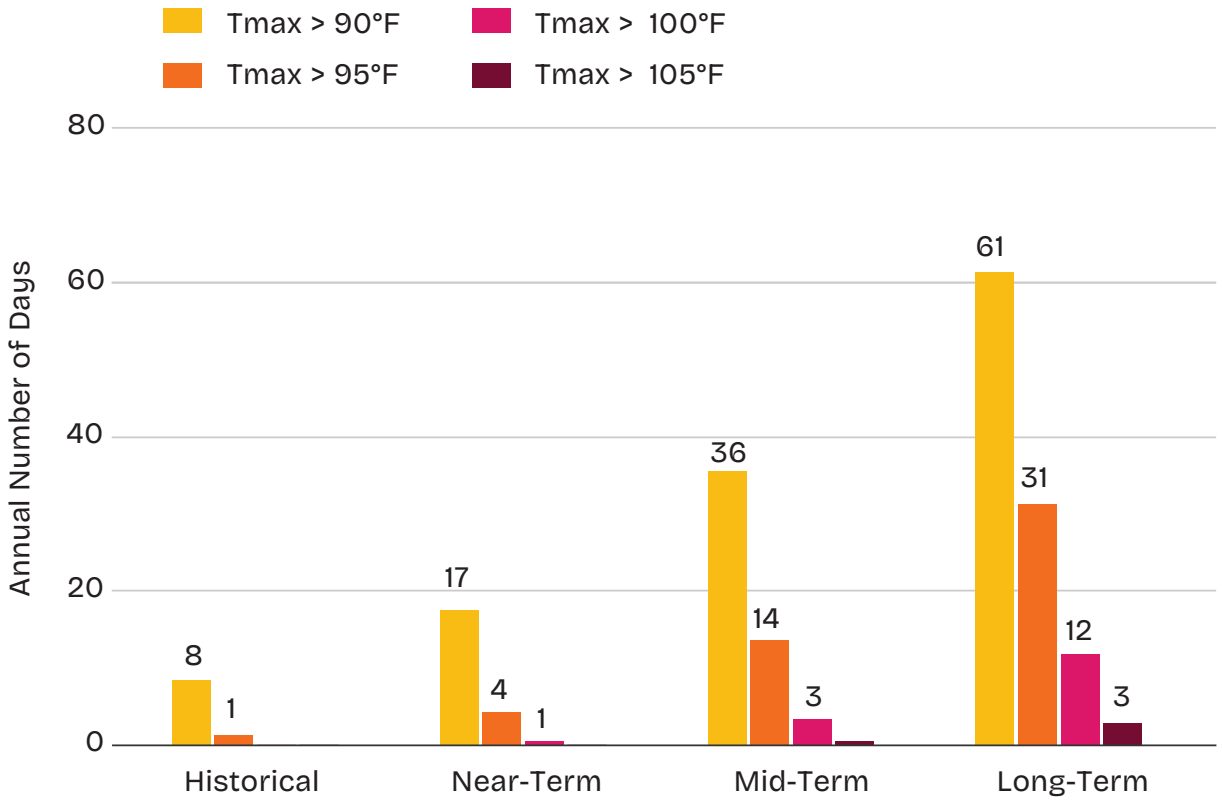
Table 7. Climate projections for select indicators in Lakewood for RCP 4.5 and 8.5 scenarios.

		RCP 4.5			RCP 8.5		
	Historical	Near-Term	Mid-Term	Long-Term	Near-Term	Mid-Term	Long-Term
Indicator	1971-2000	2010-2039	2040-2069	2070-2099	2010-2039	2040-2069	2070-2099
Mean Annual Temperature (°F)	51	53	55	56	53	56	60
Minimum Temperature (°F)	-6	-3	-1	0	-3	1	6
Maximum Temperature (°F)	96	99	101	102	99	102	107
Annual Days With Temperature Over 90°F	8	18	32	39	17	36	61
Annual Days With Heat Index Over 90°F[29]	12	27	44	52	19	45	77
Mean Annual Precipitation (Inches)	17.1	17.8	17.9	18.3	17.8	18.0	18.0
Annual Runoff (Inches)	0.9	1.0	1.0	1.0	1.0	0.9	0.9
Annual Days With More Than 1 Inch of Precipitation (Days)	1.0	1.1	1.2	1.3	1.1	1.3	1.3
Median Wind Speed (Miles/Hour)	8.1	7.9	7.7	7.7	7.9	7.7	7.5

29 The heat index is what the temperature feels like when the air temperature is combined with relative humidity.

The city of Lakewood is projected to experience more hot temperatures over the next several decades. The annual number of days with temperatures over 90°F is projected to increase from roughly eight days per year in the recent past to 61 days, or over two months, per year near the end of the century under the RCP 8.5 scenario, as shown in **Figure 23**. The maximum temperature is also projected to increase to up to 107°F in the long term. This rise in extreme heat will be amplified by the heat index, which is what the temperature feels like when the air temperature is combined with relative humidity.[30] This increase will make more days feel even hotter, especially in the near term. Meanwhile, wind speeds are projected to decrease over time, potentially influencing wildfire behavior by reducing their spread.

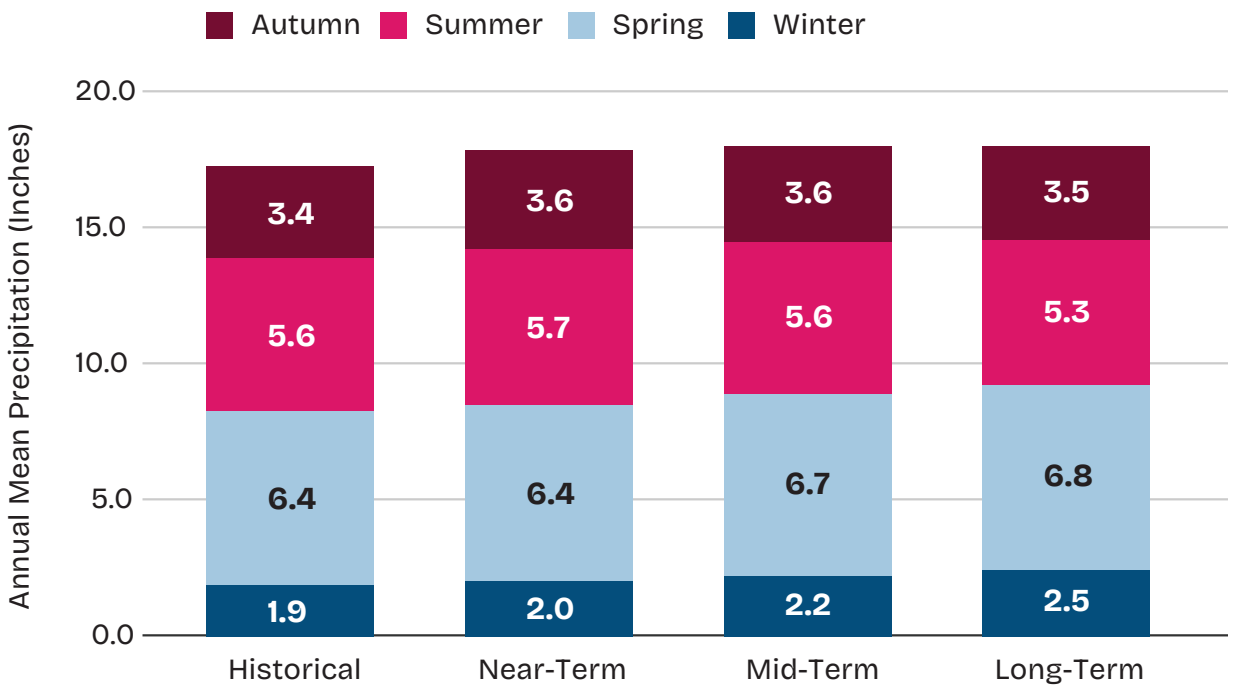
Figure 23. Projected changes in annual days with temperatures over 90°F, 95°F, 100°F and 105°F in Lakewood under RCP 8.5.



30 NOAA's National Weather Service. "What Is the Heat Index?," n.d. https://www.weather.gov/ama/heatindex.

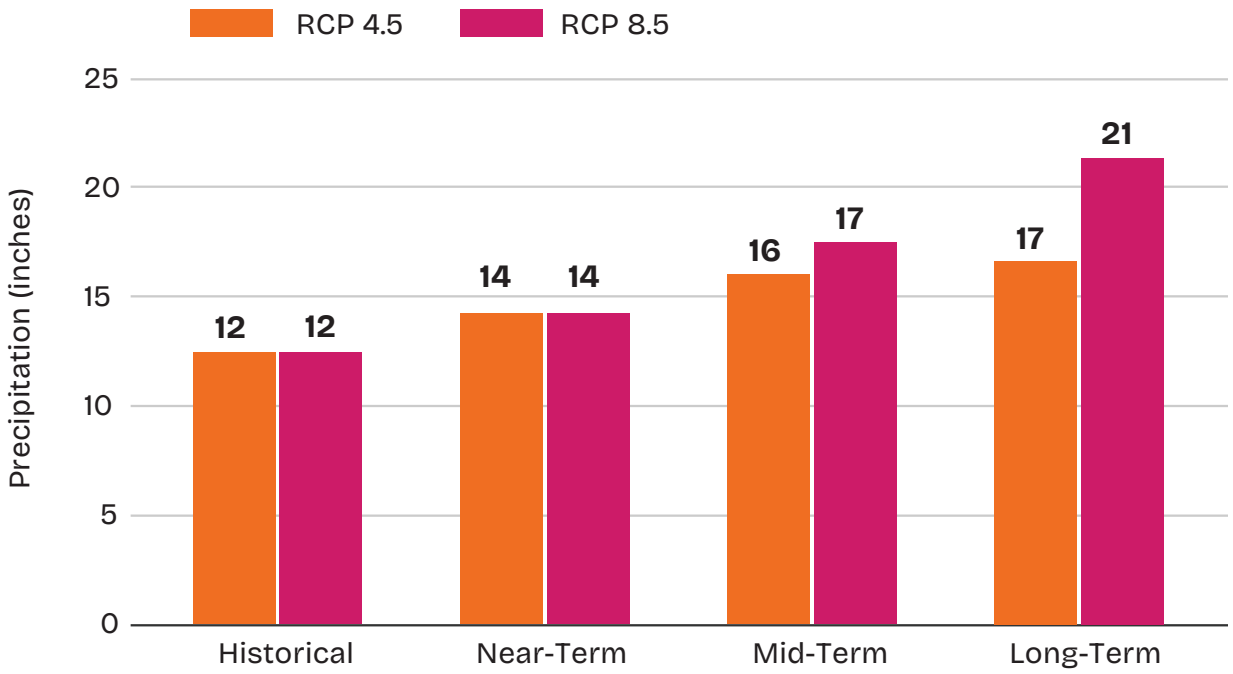
Precipitation patterns in Lakewood are projected to change subtly, with total annual precipitation increasing slightly and small seasonal shifts occurring, as highlighted in **Figure 24**. Spring and winter precipitation are expected to slightly increase, with warmer winters potentially leading to more rain instead of snow. At the same time, summer precipitation is projected to decrease, resulting in drier summers. Slight increases in annual heavy rainfall events and runoff are anticipated, with small rises in winter, spring and autumn runoff. These precipitation changes are likely to exacerbate flooding and extreme weather events.

Figure 24. Projected changes in seasonal precipitation in Lakewood under RCP 8.5.



Despite the projected slight increase in precipitation, the climatic water deficit is also projected to increase, likely due to the warmer temperatures. The climatic water deficit represents the amount of water that would have transpired or evaporated if it was present in the soil. It is used to estimate the drought stress on plants and soils. Climate projections suggest that the climatic water deficit will increase in both the RCP 4.5 and RCP 8.5 scenarios, as shown in **Figure 25**. This suggests that droughts will increase, which may also increase the risk of wildfires. This could also cause soils to become more hydrophobic, which can cause soils to repel water and may increase flood risks. Overall, the changing precipitation and temperature patterns are likely to exacerbate climate hazards in Lakewood, including extreme weather events, flooding, wildfires, droughts and heat waves.

Figure 25. Projected changes in the climatic water deficit in RCP 4.5 and RCP 8.5.



Threat Likelihood

The threat likelihood is the probability that a climate hazard will occur. As part of this study, projected changes to indicators related to each hazard were analyzed to understand how the frequency and severity of hazards will likely change over time. As noted in the Project Approach section, a standardized scale was used to quantify the significance of the projected changes across various indicator types, including temperature and precipitation. The scale ranges from “no change” (0.0) to “very high increase” (5.0), as highlighted in **Table 8**. These threat likelihood scores were divided by 10 and added to the original "overall significance" values from the Hazard Mitigation Plan to determine the new threat likelihood score.

Table 8. Overview of the hazard threat likelihood scale.

Definition	No Change	Minimal Increase	Low Increase	Moderate Increase	High Increase	Very High Increase
Score	0.0	0.1-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0

Using this process, 10 climate hazards were evaluated and ranked based on their likelihood of posing a threat in the near-, mid-, and long-term future. **Table 9** summarizes the scores for each hazard, while **Table 10** provides an explanation for each score. Six hazards — extreme heat, wildfire, drought, hailstorm, flooding and winter storms — received moderate scores ranging from 2.1 to 2.2. The remaining four hazards received low or minimal hazard threat likelihood scores.

Extreme heat, wildfire and drought received threat likelihood scores of 2.2 due to projected changes in climate conditions. Higher temperatures and increased humidity are expected to make extreme heat events more frequent and severe, with up to an additional month of days above 90°F in the long term. Warmer, drier conditions will also increase the risk of wildfire, with a slight rise in dry days and a decrease in fuel moisture, particularly in the mid- to long-term future. Although changes in precipitation are minimal, the increasing temperatures may also exacerbate drought conditions over time due to increased evaporation and transpiration.

Hailstorms, flooding and winter storms received hazard scores of 2.1 due to moderate changes in climate projections. Hailstorm severity is expected to remain stable or decrease, with no strong trends in precipitation and a slight decrease in wind speeds. Flooding risks will likely remain similar to historical conditions, with slight increases in annual precipitation, especially in spring and winter. For winter storms, fewer frost and ice days will likely reduce severe conditions. Despite rising winter temperatures, relatively stable precipitation patterns are expected to prevent significant increases in the intensity and frequency of winter storms.

Table 9. Near-, mid-, long-term and average hazard threat likelihood scores using RCP 8.5 for the 10 climate hazards included in the study.

Hazard	Near-Term	Mid-Term	Long-Term	Average
Extreme Heat	2.1	2.2	2.3	**2.2**
Wildfire	2.1	2.2	2.3	**2.2**
Drought	2.1	2.2	2.2	**2.2**
Hailstorm	2.1	2.1	2.1	**2.1**
Flooding	2.1	2.1	2.1	**2.1**
Winter Storms	2.1	2.1	2.1	**2.1**
Extreme Cold	2.0	2.0	2.0	**2.0**
Biodiversity Change	1.4	2.0	2.1	**1.8**
Lightning	1.0	1.0	1.0	**1.0**
High Winds/Tornado	1.0	1.0	1.0	**1.0**

Table 10. Explanation of the threat likelihood score for each hazard.

Hazard	Average Score	Explanation
Extreme Heat	2.2	Higher future temperatures and increased humidity will contribute to more frequent and severe extreme heat days, with a projected additional two weeks above 90°F in the near term and up to a full extra month in the long term. Summer average temperatures are expected to rise by 3°F in the near term and potentially reach average highs between 96°F and 102°F over the long term.
Wildfire	2.2	Warmer, drier conditions with more hot days will increase the likelihood of wildfire. In the near term, the projected increase in dry days increases slightly by one day per year, while the 100-hour fuel moisture decreases by 1%. There is no significant change in the potential for large fires in the near term, though the likelihood increases in the mid- and long-term future.
Drought	2.2	Annual dry days increase slightly in the long term, but changes in annual precipitation are minimal. Projected temperature rises could intensify drought conditions over time through incremental shifts. As droughts can occur on long time scales, ongoing monitoring will be required
Hailstorm	2.1	The frequency of heavy precipitation events remains stable, and wind speeds decrease modestly over time. With no strong trends in precipitation patterns and fewer frost days, hailstorm severity is projected to remain stable, although hailstorms are unpredictable by nature.
Flooding	2.1	Days with over 1 inch of rainfall increase from one day per year to 1.3 days. Total annual precipitation is projected to increase slightly, with notable precipitation increases in the spring and winter. The summer precipitation trend is undetermined, likely resulting in flood risks that resemble historical conditions. Annual runoff increases by 0.4 inches over all time horizons.
Winter Storms	2.1	Total annual frost days and ice days are projected to decrease, reducing the frequency of severe winter storm conditions. Days with precipitation events over 1 inch will likely remain relatively stable, meaning that while winter temperatures rise, storm intensity and frequency will not significantly increase.

Hazard	Average Score	Explanation
Extreme Cold	**2.0**	Fewer ice days and rising average winter temperatures in the near- and long-term future are projected to reduce the frequency and severity of extreme cold. The coldest winter temperatures will likely warm by several degrees, and lower wind speeds will likely decrease the chance of wind chill. Despite these warming trends, the destabilization of the polar jet stream may cause sporadic frigid temperatures.
Biodiversity Change	**1.8**	A shift in climatic patterns are projected to result in warmer conditions and an extended growing season. Slight increases in annual precipitation do not dramatically alter rainfall patterns, resulting in a warmer, slightly wetter environment that is still generally suitable for existing species.
High Winds/ Tornado	**1.0**	Median wind speeds are projected to decrease while maximum gusts remain stable, suggesting limited change in high wind or tornado risk. Uncertainties remain, as wind can influence other hazards like wildfires.
Lighting	**1.0**	There is currently no clear evidence on how climate change will alter the frequency or severity of lightning events.

Vulnerability

Vulnerability is a qualitative assessment of how a hazard will impact a community or system. Each system's vulnerability to the 10 climate hazards was evaluated based on the system's adaptive capacity, sensitivity and susceptibility. As noted in the Study Approach section, a standardized scale was applied to quantify the vulnerability score for each hazard to each system. The scale ranges from Very Low (0.00 to 0.20) to Very High (0.81 to 1.00), as shown in **Table 11**.

Table 11. Overview of the vulnerability scale.

Definition	Very Low	Low	Medium	High	Very High
Score	**0.00-0.20**	**0.21-0.40**	**0.41-0.60**	**0.61-0.80**	**0.81-1.00**

Based on this process, a vulnerability score was assigned to each hazard by system. The average score for each hazard across all systems was then calculated. **Table 12** highlights the vulnerability score for each hazard by system, while **Table 13** provides an explanation for each overall score. One hazard — hailstorms — received a high average vulnerability score, while eight hazards received a moderate vulnerability score. The remaining one hazard — winter storms — received a low vulnerability score.

Even though the frequency and severity of hailstorms are not projected to worsen as a result of climate change, the hazard received a high vulnerability score, as the impact is expected to be similar to historical events. There are several notable historic hailstorms that have caused extensive damage to buildings, vehicles and natural infrastructure in Lakewood. This includes major storms in July 2009, May 2017 and June 2023. Older buildings; outdoor equipment and vehicles, including farming equipment; and trees are particularly vulnerable to hailstorms. Outdoor workers, residents without housing, pedestrians and cyclists are also highly vulnerable to these events.

Wildfires, extreme heat, extreme cold and drought all received medium vulnerability scores between 0.52 and 0.60. For wildfires, coordinated evacuation plans and regional fire response are in place. In the case of extreme heat, health impacts can likely be managed without overwhelming local services. In terms of extreme cold, local resources can handle health impacts, and structures are generally resilient, despite recent severe cold snaps. Lastly, while drought is recognized as a threat, water conservation methods are in place to optimize water usage, though long-term trends need to be monitored.

Biodiversity change, high winds, flooding and lighting received medium vulnerability scores between 0.41 and 0.49. Biodiversity shifts are currently monitored, and the city's natural assets are in good shape, though invasive species and drought are concerns for the city's tree canopy. High winds are addressed through advisories and emergency plans, though building stock and tree health may need review. Flood risks are reduced by emergency protocols, floodplain regulations and stormwater fees. Lastly, lightning's impacts are generally manageable with local response capabilities.

Table 12. Vulnerability scores for each hazard by system.

Hazard	Parks	People	Critical Services & Infrastructure	Property	Economy	Average
Hailstorm	0.67	0.67	0.53	0.73	0.73	0.67
Wildfire	0.60	0.60	0.60	0.60	0.60	0.60
Extreme Heat	0.53	0.67	0.53	0.60	0.47	0.56
Extreme Cold	0.53	0.60	0.53	0.53	0.53	0.55
Drought	0.40	0.53	0.67	0.47	0.53	0.52

Hazard	Parks	People	Critical Services & Infrastructure	Property	Economy	Average
Biodiversity Change	0.60	0.47	0.40	0.53	0.47	0.49
High Winds	0.47	0.47	0.47	0.47	0.47	0.47
Flooding	0.40	0.47	0.40	0.47	0.40	0.43
Lightning	0.47	0.33	0.47	0.40	0.40	0.41
Winter Storms	0.33	0.40	0.40	0.40	0.40	0.39

Table 13. Explanation of the vulnerability score for each hazard.

Hazard	Average Score	Explanation
Hailstorm	**0.67**	The jurisdiction has an emergency response plan in place and can handle related health impacts without straining existing medical resources. Some buildings need to be reviewed to understand the structural stresses related to future events. Impacts are expected to mirror past events, such as the major hailstorm in June 2023.
Wildfire	**0.60**	Coordinated evacuation plans and regional fire response are in place. Grasslands are vulnerable to wildfire spread, and past events have occurred regularly over the last decade. Future risk may increase due to factors like high winds and lightning, with risks to Green Mountain and Bear Creek Lake Park.
Extreme Heat	**0.56**	Health impacts can be managed without overwhelming local services. Nighttime temperatures usually cool down due to Lakewood's latitude and semi-arid climate, helping limit stress to structures. Energy demand during heat events may need further study. Events are likely to increase in frequency and severity, affecting the entire community.

Hazard	Average Score	Explanation
Extreme Cold	0.55	Local resources can handle health impacts from cold spells without major strain. Structures are generally resilient, and no permanent damage is expected from most events. This past winter saw one of the worst cold snaps in a decade, and such events impact the entire community.
Drought	0.52	Dry conditions are recognized as a threat, but adaptive strategies need further exploration. Water is supplied by major providers with conservation methods in place to optimize water usage. No historical droughts are on record, but dry weather may contribute to other hazards, such as wildfires.
Biodiversity Change	0.49	Early identification of public health concerns is underway, though more research on vector-borne diseases, invasive species and common pests is needed. Natural assets are currently in good condition. Changes in temperature and precipitation may increase the frequency and severity of biodiversity shifts.
High Winds	0.47	Wind advisories, emergency plans and some infrastructure preparedness measures are already in place. Building stock and tree health need further review. No major climate-change-driven shifts are expected, though high-wind events can spread wildfire and intensify hail impacts.
Flooding	0.43	Flooding is addressed in emergency plans and supported by higher jurisdictional capacities, plus regulations and a stormwater fee. Ongoing floodplain management helps reduce sensitivity. Historical floods have been site specific and not community-wide.
Lightning	0.41	While it can ignite home fires, lightning's health impacts are generally manageable with basic first aid or local response capabilities. Homes have historically been sensitive to lightning strikes, but future impacts are anticipated to remain low. Lightning could contribute to the risk of wildfires.
Winter Storms	0.39	Snow clearing and standard winter protocols are well established. Structures and natural assets are generally resilient to snow accumulation. Future winter storms are expected to resemble past events, and their overall threat likelihood will decrease over time.

Consequence

The third and final component of the risk formula is consequence. This can refer to direct consequences or indirect consequences, as described earlier in this report. As part of the risk assessment, the direct and indirect consequences of each hazard on the five systems were evaluated. A standardized scale was applied to quantify the consequence score for each hazard to each system. The scale ranges from Insignificant (0.0-1.0) to Severe (4.1-5.0), as shown in **Table 14**.

Table 14. Overview of the consequence scale.

Definition	Insignificant	Minor	Moderate	Major	Severe
Score	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0

Using this consequence scale, a score was assigned to each hazard overall and by system. **Table 15** documents the consequence score for each hazard by system and overall, while **Table 16** provides an explanation of each consequence score. Four hazards — hailstorms, flooding, extreme heat and extreme cold — received moderate consequence scores, while five hazards received a minor consequence score. The remaining one hazard received an insignificant consequence score.

Hailstorms, flooding, extreme heat and extreme cold received moderate scores, as these events would likely have moderate physical impacts on property in Lakewood. It is estimated that 10% to 25% of properties may experience severe damage during these events, leading to disruptions in facilities and services that could last from one to seven days. Wildfire, high winds, drought, lightning and biodiversity changes were assigned minor consequence scores, as their physical and financial impacts are expected to be limited. Less than 10% of properties in the city are likely to suffer severe damage from these hazards, with disruptions to facilities and services anticipated to last less than 24 hours.

Table 15. Consequence scores for each hazard by system.

Hazard	Parks	People	Critical Services & Infrastructure	Property	Economy	Overall
Hailstorm	3.5	3.0	3.0	3.0	3.0	3.0
Flooding	2.0	3.0	3.0	3.0	2.5	3.0
Extreme Heat	2.0	3.0	2.5	3.0	1.5	3.0

Hazard	Parks	People	Critical Services & Infrastructure	Property	Economy	Overall
Extreme Cold	2.5	2.0	2.5	2.0	2.0	3.0
Wildfire	3.0	2.5	2.0	2.5	2.0	2.0
High Winds	3.0	1.0	2.0	1.0	2.0	2.0
Drought	3.0	3.0	2.0	2.0	1.5	1.5
Lightning	2.0	2.5	2.0	1.5	1.5	1.5
Biodiversity Change	2.5	1.5	1.5	1.5	1.5	1.5
Winter Storms	2.5	1.0	2.0	1.0	1.0	1.0

Table 16. Explanation of the consequence score for each hazard.

Hazard	Overall Score	Explanation
Hailstorm	**3.0**	About 10%-25% of property may be severely damaged. Facilities and services may be disrupted for one to seven days.
Flooding	**3.0**	About 10%-25% of property may be severely damaged. Facilities and services may be disrupted for one to seven days.
Extreme Heat	**3.0**	About 10%-25% of property may be severely damaged. Facilities and services may be disrupted for one to seven days.
Extreme Cold	**3.0**	About 10%-25% of property may be severely damaged. Facilities and services may be disrupted for one to seven days.
Wildfire	**2.0**	Less than 10% of property may be severely damaged. Facilities and services may be disrupted for less than 24 hours, not including the actual burn area.
High Winds	**2.0**	Less than 10% of property may be severely damaged. Facilities and services may be disrupted for less than 24 hours.

Hazard	Overall Score	Explanation
Drought	**1.5**	Water shortages may raise costs, as supply depends on external sources. Facilities and services may be disrupted for less than 24 hours.
Lightning	**1.5**	Occasional single-home damages have been reported. Facilities and services may be disrupted for less than 24 hours.
Biodiversity Change	**1.5**	Less than 10% of property may be severely damaged. Minor infrastructure impacts and delays may last less than 24 hours.
Winter Storms	**1.0**	Less than 10% of property may be severely damaged. Facilities and services may be disrupted for less than 24 hours.

Risk

The risk assessment is a function of the threat likelihood, vulnerability and consequence scores. The final risk scale ranges from Minor (0.20-0.59) to Very High (4.00-5.00), as shown in **Table 17**. **Table 18** shows the final risk scores for each hazard. None of the city's hazards are ranked as very high risks. One hazard — hailstorms — is ranked as a high risk and four hazards are ranked as moderate risks for Lakewood. These high and moderate risks represent impacts that are beyond Lakewood's current capacity to prepare for, respond to and recover from. Given the potential impact of these five risks, they were identified as priority hazards for the city of Lakewood to further study in this project. The following section provides more information about these priority risks.

Table 17. Overview of the risk scale.

Definition	Minor	Limited	Moderate	High	Very High
Score	0.20-0.59	0.60-0.99	1.00-1.99	2.00-3.99	4.00-5.00

Table 18. Vulnerability, consequence and risk scores for each hazard.

Hazard	Vulnerability	Consequence	Risk
Hailstorm	0.67	3.0	2.0
Extreme Heat	0.56	3.0	1.7
Extreme Cold	0.55	3.0	1.7
Flooding	0.43	3.0	1.3
Wildfire	0.60	2.0	1.2
High Winds/ Tornado	0.47	2.0	0.9
Drought	0.52	1.5	0.8
Biodiversity Change	0.49	1.5	0.7
Lightning	0.41	1.5	0.6
Winter Storms	0.39	1.0	0.4

Image: Lakewood hailstorm. Source: City of Lakewood.

5.

Hazards

The Climate Vulnerability and Risk Assessment completed as part of this study analyzed 10 hazards for the city of Lakewood. Based on this assessment, five priority hazards were identified: hailstorms, extreme heat, extreme cold, flooding and wildfire. The following section provides a detailed description of these five priority hazards. It also includes a summary of the other five hazards that were not identified as priorities for Lakewood. These five non-priority hazards include high winds and tornados, drought, biodiversity change, lighting and winter storms. The hazards are presented in order based on their final risk scores.

Climate-related hazard

Hailstorms

Overview

In this study, hailstorms were ranked as the most significant climate risk for the city of Lakewood. **Table 19** highlights the results of the analysis, including the vulnerability, consequence and risk scores. While hailstorms are not expected to get notably worse in the city, many local systems are highly vulnerable to them and they can cause significant direct and indirect consequences. They are also highly unpredictable, can form anywhere and have very localized impacts. Recent hailstorms have caused significant damages to property and caused insurance rates to increase substantially, with some insurance companies even leaving the Colorado market.[31] For these reasons, hailstorms are considered a high risk for the city of Lakewood.

Table 19. Overview of the risk assessment for hailstorms.

System	Vulnerability	Consequence	Risk
Parks	0.67	3.5	2.3
People	0.67	3.0	2.0
Critical Infrastructure & Services	0.53	3.0	1.6
Property	0.73	3.0	2.2
Economy	0.73	3.0	2.2
Total	0.67	3.0	2.0

31 Chuang, Tamara and Olivia Prentzel. "Nonrenewals Are Fueling Colorado's Growing Homeowners Insurance Crisis." The Colorado Sun, January 24, 2025. https://coloradosun.com/2025/01/19/colorado-home-insurance-nonrenewals-crisis/.

Threat Likelihood

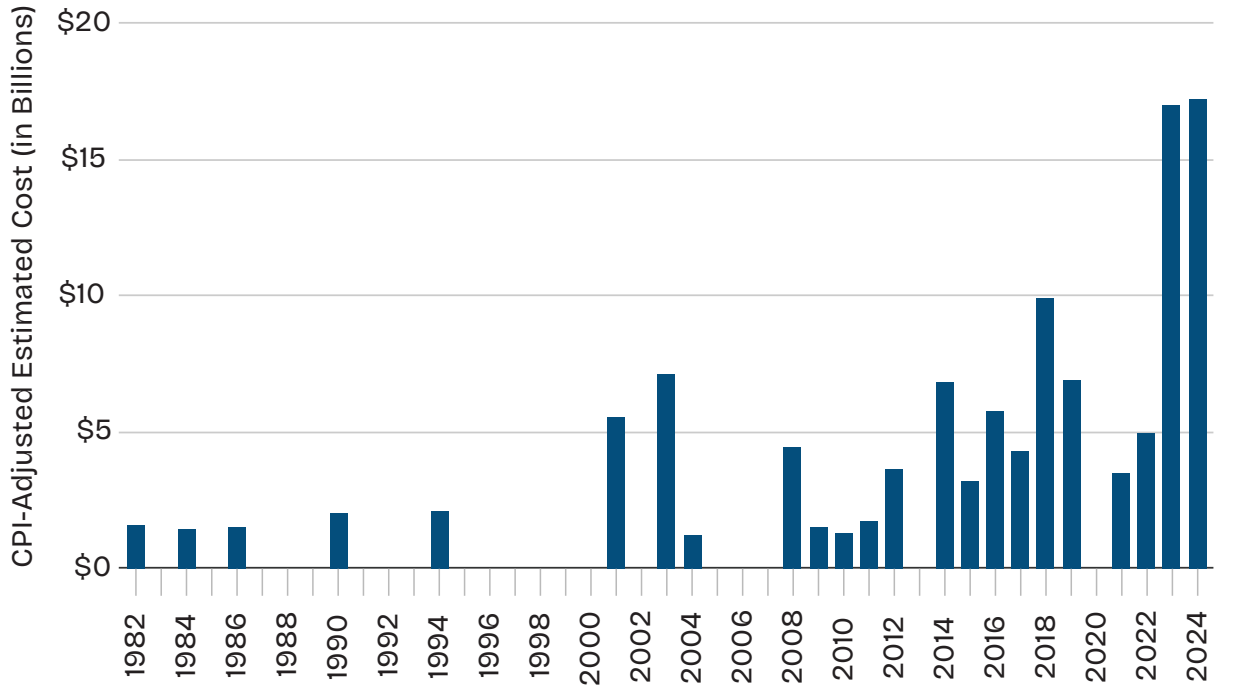
Lakewood has experienced several significant hailstorms over the years, causing extensive damage to property and infrastructure. In June 2004, golf-ball-sized hail hit the area, contributing to statewide insurance damages of $146.5 million. A July 2009 hailstorm caused widespread destruction in Jefferson County, with preliminary insurance claims across the Denver metro area totaling $350 million. The severe May 2017 hailstorm led to substantial damage in Lakewood, including extensive destruction at Colorado Mills Mall and local mobile home parks. According to the Jefferson County Hazard Mitigation Plan, the total damage cost of the event was approximately $2.3 billion.[32] Most recently, in June 2023, another storm brought large hail, strong winds and a probable tornado, resulting in personal injuries and significant damage across the area.[33]

Damages from severe storms have risen significantly in recent years across the state, as illustrated in **Figure 26**. Between 1980 and 1999, Colorado experienced five severe storms that each caused over a billion dollars in damage, resulting in approximately $8.6 billion in total damages. In contrast, there were 24 severe storms causing over a billion dollars in damage from 2000 to 2019, leading to costs of around $63.1 billion. In the first half of the 2020s, there have already been 13 storms causing over a billion dollars in damage, amounting to $42.6 billion in damages across the state. While this increase is substantial, the National Centers for Environmental Information states that not all of it can be attributed to climate change. Instead, part of the increase is likely due to greater material wealth and development, particularly in areas that are vulnerable to extreme weather events.

32 Jefferson County. "Hazard Mitigation Plan." 2021. https://www.jeffco.us/488/Hazard-Mitigation-Plan.

33 Harris, Kyle. "Red Rocks Ampitheatre's Big June Hail Storm: A Timeline of How the Chaotic Night Unfolded." Denverite, August 8, 2023. https://denverite.com/2023/08/07/red-rocks-ampitheatre-hail-storm-louis-tomlinson/.

Figure 26. CPI-adjusted cost (in billions) of storms causing over a billion dollars in damage in Colorado, 1982-2024.[34]



Hailstorms are expected to continue occurring in Lakewood. An analysis of four key indicators — median wind speed, days of precipitation exceeding one inch, frost days (with minimum temperatures below 32°F) and total summer precipitation — indicates that the frequency and severity of hailstorms may not worsen significantly. Wind speed is projected to decrease by about 2.5% in the near term and by 5% in the long term, while little change is expected in the frequency of heavy precipitation events. Frost days are anticipated to decline over time, and no clear trend in total summer precipitation is observable. This suggests that the severity of future hailstorms may be similar to historical events, though costs may increase due to new developments.

Climate Risk

Hailstorms pose a significant climate risk to Lakewood, driven by the area's high susceptibility to such events. With four major hailstorms documented between 2000 and 2024, the region remains vulnerable to future events of similar magnitude. **Table 20** highlights vulnerabilities and potential consequences identified through the engagement process.

Populations facing barriers include outdoor workers, residents without housing, pedestrians and cyclists. These people face elevated risks of injury during hailstorms.

34 NOAA National Centers for Environmental Information. "Billion-Dollar Weather and Climate Disasters - Colorado Summary," 2025, https://www.ncei.noaa.gov/access/billions/state-summary/CO.

Additionally, parks are affected by hailstorms, as hail damages fully leafed-out trees, making them more susceptible to insect infestations and disease. Older homes lacking hail-resistant roofing are also vulnerable, as are farms, which may experience both crop damage and equipment losses during a hailstorm. Overall, hailstorms can cause significant damage in Lakewood and can cause facilities and services to be disrupted for up to a week.

Table 20. The consequences of and Lakewood's vulnerabilities to hailstorms, identified through the engagement activities of the IWG, CWG and FGs

System	Vulnerabilities	Consequences
Parks	▪ Trees and vegetation ▪ Infrastructure and recreational areas (shelters, signage, benches and playground equipment)	▪ Freezing or cracking of tree trunks ▪ Tree death
People	▪ Populations without housing ▪ Outdoor workers ▪ Children ▪ Older adults ▪ Pedestrians and cyclists ▪ People without adequate housing	▪ Risk of injury during hailstorms ▪ Mobility challenges and transfer trauma ▪ Financial and mental stress caused by home repairs ▪ Mental health/psychological impacts of hailstorms
Critical Infrastructure & Services	▪ Fleet vehicles ▪ Water system ▪ Heating utility	▪ Physical damage to vehicles ▪ Potable water main breaks ▪ Increased demand for heating
Property	▪ Homes without impact-resistant roofing ▪ Farm equipment and facilities ▪ Vehicles	▪ Physical damage ▪ Cost of repairs
Economy	▪ Agricultural crops ▪ Food supply ▪ Buildings ▪ Other activities relying on performance of outdoor workers	▪ Depleted crop yields ▪ Food supply disruptions ▪ Financial costs of repairs ▪ Decreased workers productivity

Climate-related hazard

Extreme Heat

Overview

In this risk assessment, extreme heat was ranked as the second most significant climate risk for the city of Lakewood. **Table 21** highlights the results of the analysis, including the vulnerability, consequence and risk scores. Over the next several decades, the frequency and severity of extreme heat events are projected to worsen. These events can lead to heat-related illnesses, such as heat exhaustion and heat stroke, which can be life-threatening if not addressed promptly. Certain populations in Lakewood are particularly vulnerable to extreme heat due to various factors, including age, occupation, housing status and geographic location. For these reasons, extreme heat is considered a priority risk for the city of Lakewood.

Table 21. Overview of the risk assessment for extreme heat.

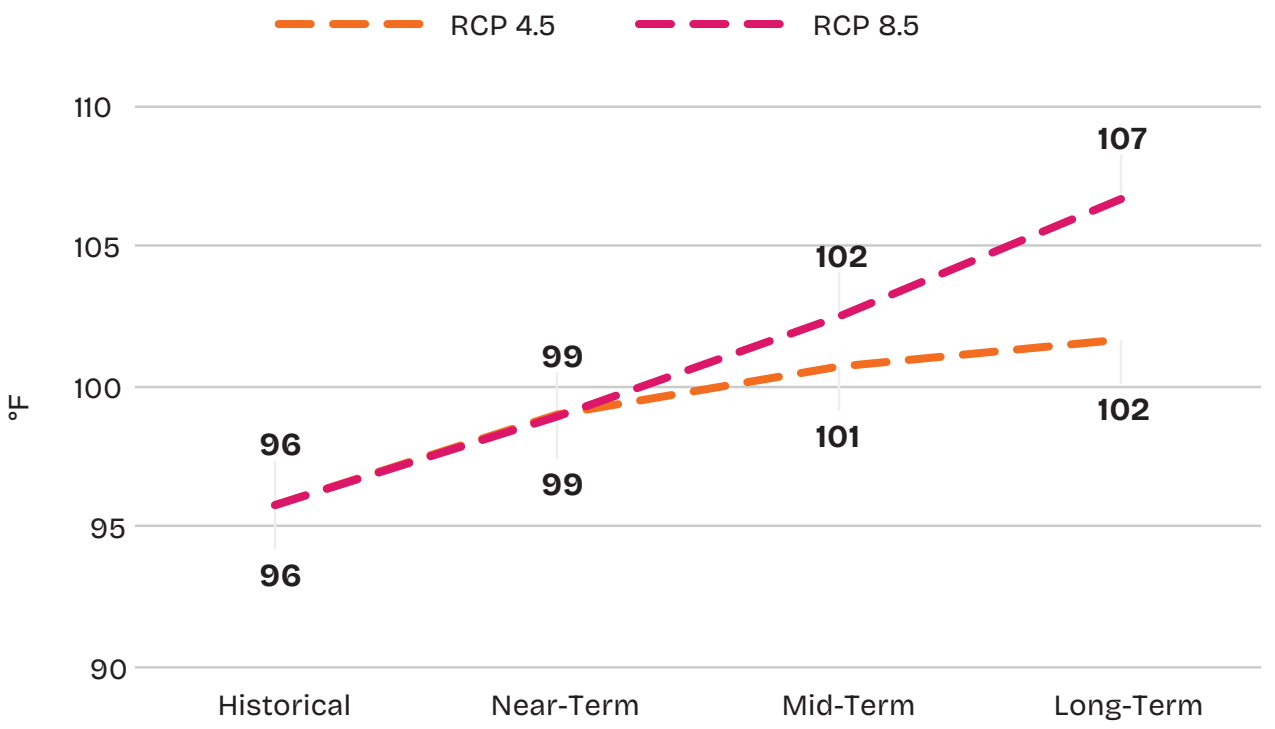
System	Vulnerability	Consequence	Risk
Parks	0.53	2.0	1.1
People	0.67	3.0	2.0
Critical Infrastructure & Services	0.53	2.5	1.3
Property	0.60	3.0	1.8
Economy	0.47	1.5	0.7
Total	**0.56**	**3.0**	**1.7**

Threat Likelihood

The frequency and severity of extreme heat events in Lakewood are projected to increase significantly in the coming decades. Climate projections for key indicators, such as mean summer temperature, maximum temperature and the number of days over 90°F, show an upward trend. Historically, the city's annual maximum temperature has been about 96°F, with the maximum temperature

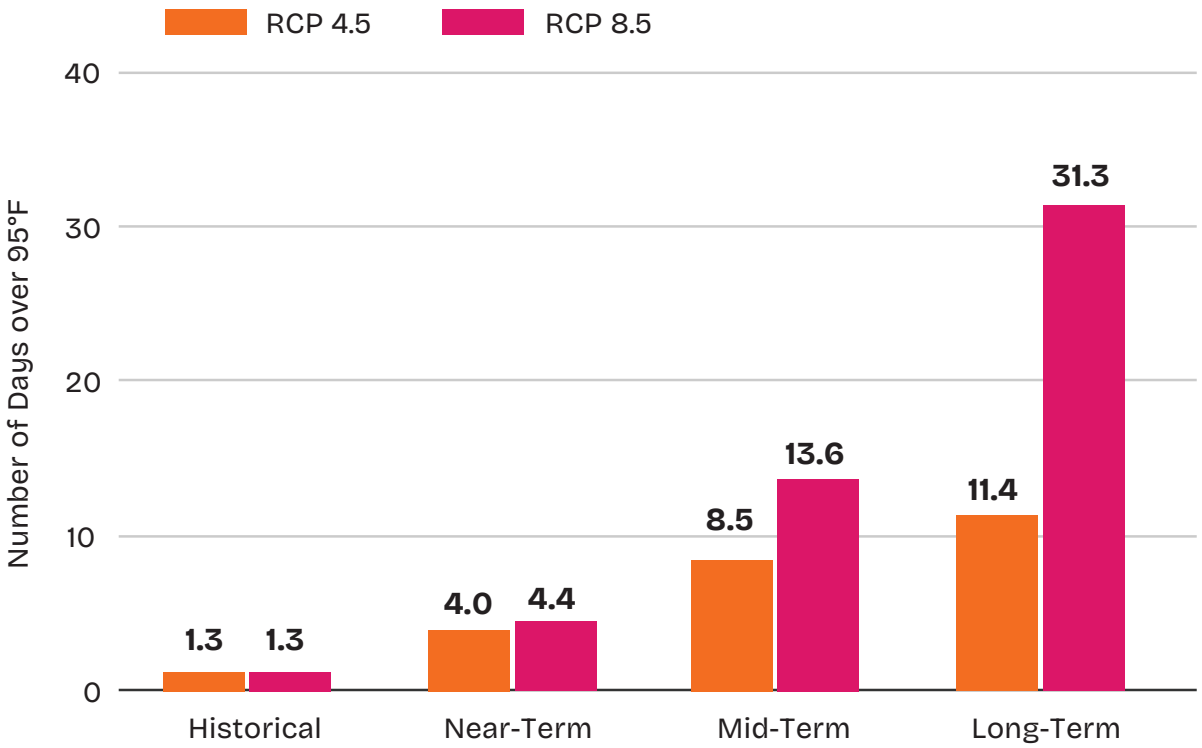
ever recorded in Denver being 105°F.[35] By the 2080s, the maximum temperature is expected to rise to 102°F under RCP 4.5 and 107°F under RCP 8.5, as highlighted in **Figure 27**. The number of days exceeding 95°F will also increase substantially from about one day per year historically, to 11 days under RCP 4.5 and 31 days under RCP 8.5 by the 2080s, as highlighted in **Figure 28**. These projections suggest that Lakewood will experience more frequent and intense heat events in the future.

Figure 27. Annual maximum temperature for Lakewood under different climate scenarios.



35 NOAA's National Weather Service. "NWS Boulder Denver Daily Normals and Records August," n.d. https://www.weather.gov/bou/Climate_Record_August.

Figure 28. Number of days over 95°F under different climate scenarios.



Climate Risk

The climate risk analysis revealed that certain populations in Lakewood are particularly vulnerable to these events due to various factors, including age, occupation, housing status and geographic location. **Table 22** highlights vulnerabilities and potential consequences identified through the engagement process.

Older adults, youth, outdoor workers and individuals facing social isolation are especially at risk during hot temperatures. Additionally, people without access to adequate housing or air conditioning are more vulnerable to extreme heat, as they have limited means to escape high temperatures. For these populations, these events can lead to heat-related illnesses, such as heat exhaustion and heat stroke, which can be life-threatening if not addressed promptly.

Table 22. Consequences of and Lakewood's vulnerabilities to extreme heat, identified through the engagement activities of the IWG, CWG and FGs.

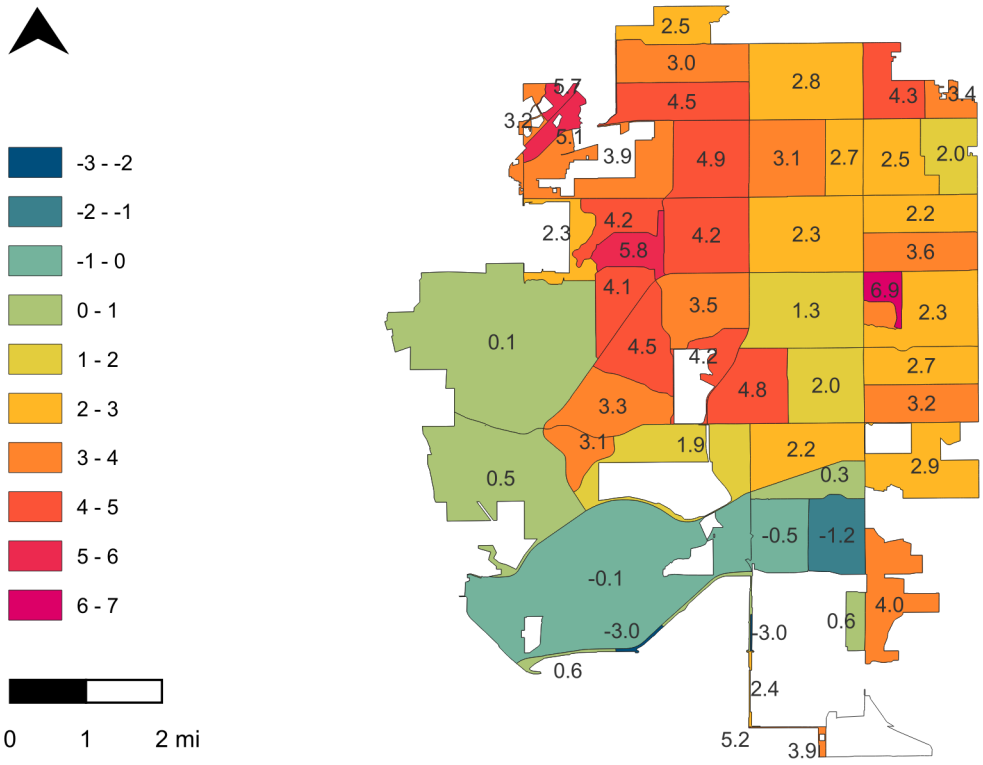
System	Vulnerabilities	Consequences
Parks	▪ Vegetation	▪ Risks for trees and plants to become more stressed and vulnerable to disease or even die due to water deficits, and/or impossibility for workers to do proper park maintenance during extreme heat events.
People	▪ Populations without housing ▪ Outdoor workers (laborers, farmers, food access workers, park maintenance staff) ▪ Children ▪ Older adults ▪ Populations experiencing isolation ▪ Pedestrians and cyclists ▪ People without air conditioning	▪ Risk of heat stress or heat stroke ▪ Mobility challenges and transfer trauma ▪ Financial stress caused by high energy costs ▪ Mental health/psychological impacts of extreme heat ▪ Mental health/psychological impacts due to the inability to access essential services
Critical Infrastructure & Services	▪ Power utilities ▪ Water utilities	▪ Increased demand on utilities for cooling and risk of outages ▪ Increased likelihood of overloaded grids sparking wildfires ▪ Increased demand of water on utilities and higher water loss in reservoirs they rely on, due to accelerated evaporation ▪ Increased algal bloom likelihood and/or concentration of contaminants and pathogen levels in reservoirs and other water bodies used by water utilities due to warmer temperatures

System	Vulnerabilities	Consequences
Property	▪ Older homes and HVAC systems ▪ Headstart buildings (Childcare facilities) ▪ Roof and building facade	▪ Physical damage from heat to roof — cracks, warping or curling — and building facades — stucco, wood and vinyl siding may warp, crack or peel ▪ Poorer indoor air quality (older HVAC systems may not work properly, evaporative coolers more common on older homes, risk of mold and leaks)
Economy	▪ Household finances ▪ Businesses ▪ Agriculture production ▪ Other activities relying on performance of outdoor workers	▪ High energy and repairs to property damage costs impacting household budgets and small businesses ▪ Higher water use costs due to irrigation needs to cope with higher evapotranspiration from vegetation ▪ Lower agriculture production due to dehydration and wilting, heat stress, flower abortion., pollination failure, sunburn on fruits and other impacts related to extreme heat. ▪ Decreased outdoor workers productivity

The urban heat island effect further exacerbates vulnerability to extreme heat. This effect is caused by factors such as reduced vegetation, limited green spaces, and increased concrete and asphalt surfaces, as well as by roof materials that trap heat and increase urban temperatures. **Figure 29** highlights the urban heat island effect across Lakewood, showing the average nighttime temperature difference among the city's census tracts, which can vary by up to 10°F between neighborhoods.

Census tracts with the strongest urban heat island effect tend to have more buildings, parking lots and roads, along with fewer green spaces than cooler areas. In Lakewood, the census tract with the hottest temperature is Belmar, the city's downtown area. The tract was 6.9°F warmer than the average temperature across the city in the spatial analysis. Belmar is the site of a former mall that was redeveloped as a walkable, mixed-use neighborhood. While Belmar is currently the warmest area in the city, dense, mixed-use walkable neighborhoods can be cooled by investing in green infrastructure, shading structures and reflective surfaces.

Figure 29. Average nighttime temperature difference (°F) in census tracts across the city of Lakewood.



When nighttime temperatures remain above 70°F, it limits the ability of people and infrastructure to cool down after a hot day.[36] This lack of nighttime relief increases the risk of heat stress and heat-related illnesses, especially for populations facing barriers. **Figure 30** illustrates the projected number of residents who will likely be exposed to overnight temperatures over 70°F under the RCP 4.5 and 8.5 scenarios, compared to the present population for the yearly hottest day. By 2030, the majority of Lakewood's population will experience overnight temperatures greater than 70°F under the RCP 8.5 scenario for the yearly hottest day. While the increase is less drastic in the RCP 4.5 scenario, it still signifies a noteworthy change regarding heat risk. **Figure 31** visually represents this change across different census tracts in Lakewood.

36 The nighttime temperature threshold used for this assessment was taken from the state of Colorado's HeatRisk system, which determines triggers for issuing public heat warnings. For more information, see: NOAA's National Weather Service. "Heat Forecast Tools," n.d. https://www.weather.gov/safety/heat-tools.

Figure 30. Population exposed to nighttime temperatures above 70°F for the yearly hottest day, from the present day to 2070.

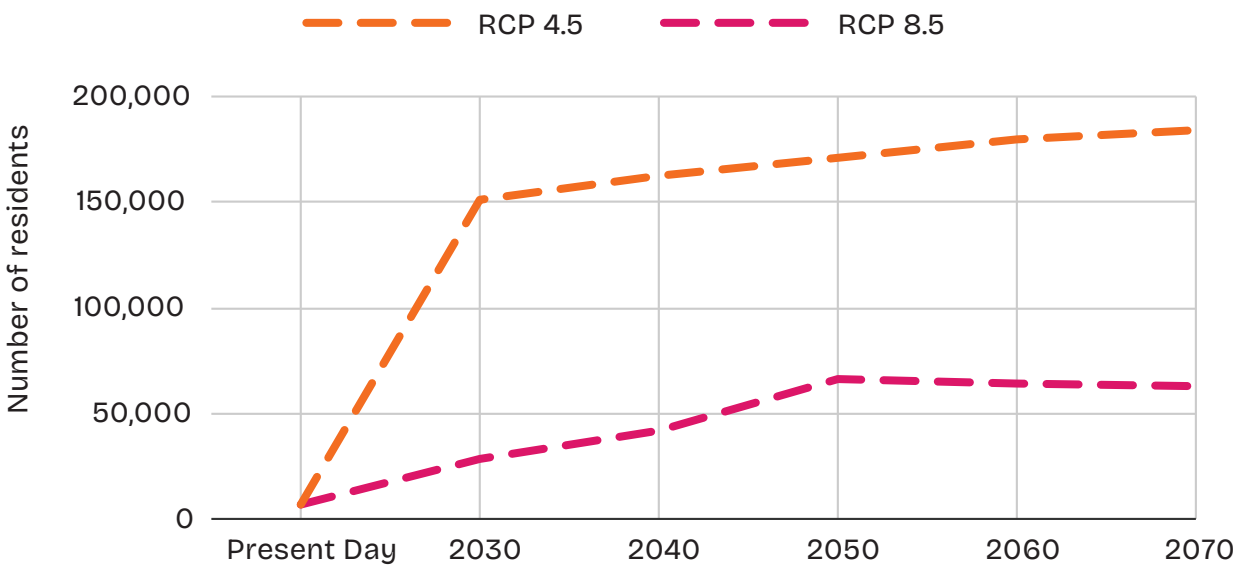
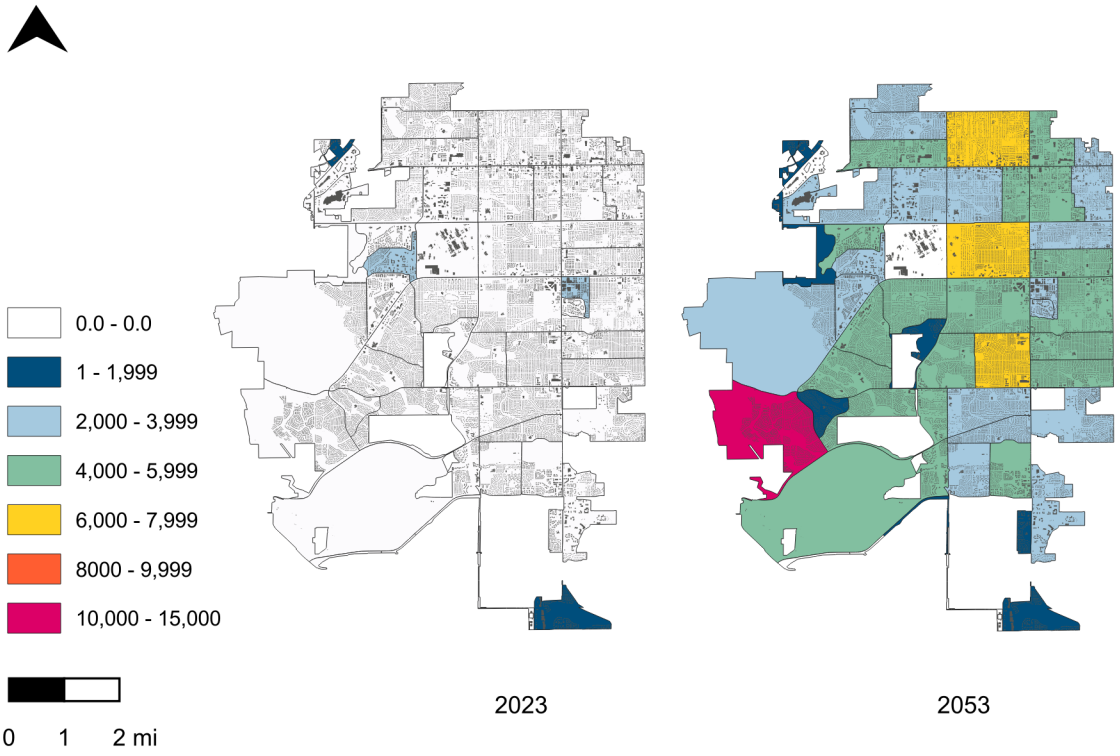
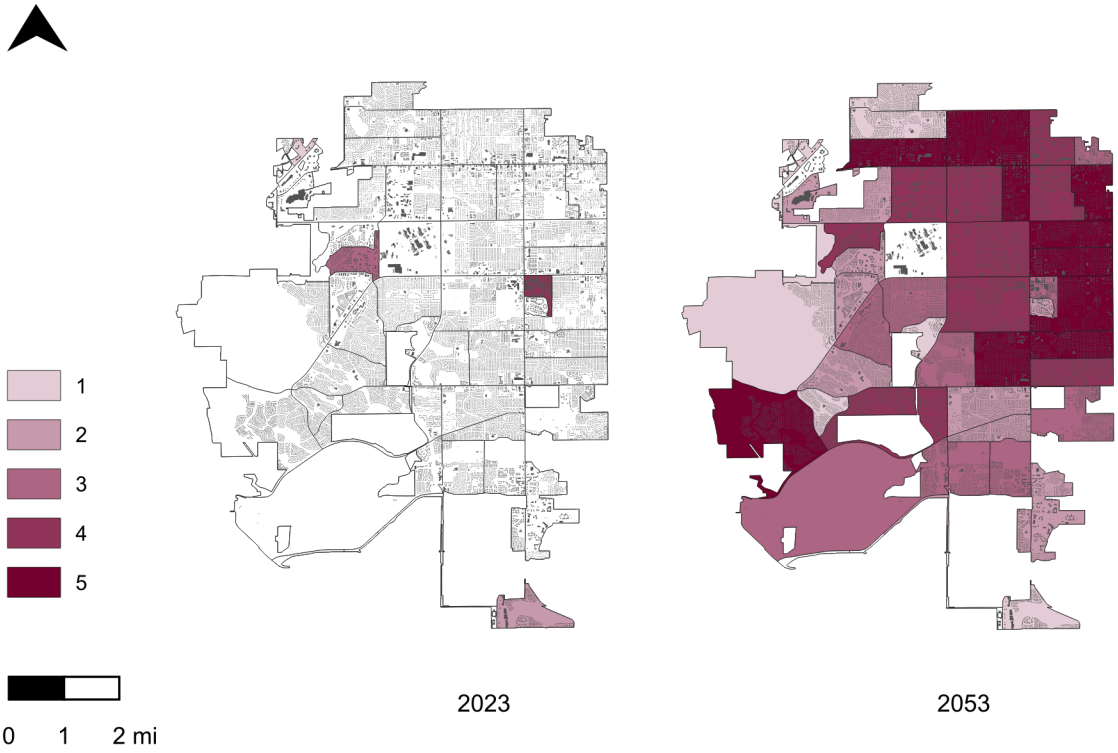


Figure 31. Left: Population exposed to nighttime temperatures over 70°F in 2023. Right: Population exposed to nighttime temperatures over 70°F in 2053 under RCP 8.5.



The risk assessment included a spatial analysis that integrated the population exposed to overnight temperatures exceeding 70°F with social vulnerability indicators. Based on this analysis, priority areas for intervention were determined, as illustrated in **Figure 32.** Risk levels ranging from one to five were assigned to each census tract, with five indicating the highest risk. The future heat risk priority areas are predominantly located on the eastern border of the city. These are areas with higher vulnerability index scores and a significant urban heat island effect.

Figure 32. Current and future heat risk priority areas based on population and DRCOG Equity Index.



Climate-related hazard

Extreme Cold

Overview

In this study, extreme cold events were ranked as a moderate climate risk for Lakewood. **Table 23** highlights the analysis results, including the vulnerability, consequence and risk scores. Overall, extreme cold events are projected to occur less frequently due to warming trends. However, the destabilization of the polar jet stream introduces uncertainty to these projections. As the Arctic warms faster than other regions, the reduced temperature difference can weaken and disrupt the jet stream, leading to sudden, prolonged periods of extreme cold in mid-latitude areas like Lakewood. Local populations and infrastructure are vulnerable to extreme cold snaps. For this reason, extreme cold events are considered a moderate risk for the city of Lakewood.

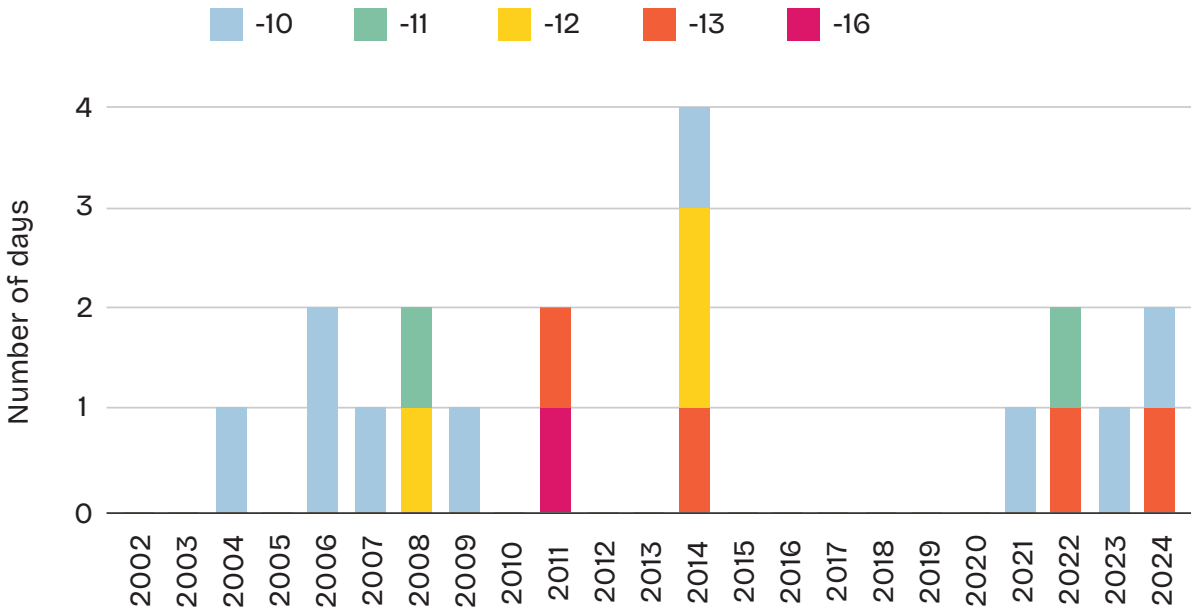
Table 23. Overview of the risk assessment for extreme cold.

System	Vulnerability	Consequence	Risk
Parks	0.53	2.5	1.3
People	0.60	2.0	1.2
Critical Infrastructure & Services	0.53	2.5	1.3
Property	0.53	2.0	1.1
Economy	0.53	2.0	1.1
Total	**0.55**	**3.0**	**1.7**

Threat Likelihood

In recent years, Lakewood has experienced several notable extreme cold events, as shown in **Figure 33**. The coldest temperature recorded in recent decades was -16 °F in February 2011, which caused pipes to freeze and burst in many buildings. Several school districts had to close due to the damage. In 2014, there were four days recorded with temperatures below -10 °F. Between 2021 and 2024, there were one to two days each year with temperatures between -10 °F and -13 °F. During the most recent cold snaps, local shelters were set up for residents to access. These events highlight the impact of cold temperatures on local community members and infrastructure.

Figure 33. Number of days when the minimum temperature was less than -10 °F between 2002 and 2024.[37]



Unlike its effect on the other priority hazards, climate change is projected to decrease the likelihood of extreme cold events in Lakewood. Key indicators, such as the minimum annual temperature and the average winter temperature, suggest that extremely cold weather will likely become less frequent in the future. For instance, the coldest annual temperature is projected to increase from -6 °F to 6°F by the 2080s in the RCP 8.5 scenario, as highlighted in **Figure 34**. **Figure 35** shows that the average winter temperature is projected to increase from 33 °F to 42°F by the 2080s.[38] During this time, wind speeds are also projected to decrease, reducing the likelihood of wind chill.

Despite the overall trend of warming winters and the decreasing likelihood of extreme cold events, the destabilization of the polar jet stream introduces uncertainty to these projections. As the Arctic warms at a faster rate than lower latitudes, the reduced temperature gradient can weaken and destabilize the jet stream, causing it to meander. This phenomenon can lead to prolonged periods of unusually cold weather in mid-latitude regions like Colorado, even as average temperatures rise. Although extreme cold events are expected to become less frequent overall, there remains the potential for unpredictable and intense cold spells in Lakewood.

37 Data for local weather station USC00054762 retrieved from: National Centers for Environmental Information (NCEI). "Search - Climate Data Online (CDO)." n.d. https://www.ncdc.noaa.gov/cdo-web/search.

38 The average winter temperature is the average of the daily maximum temperature (Tmax) and the daily minimum temperature (Tmin) for the winter season.

Figure 34. Minimum temperature under different climate scenarios.

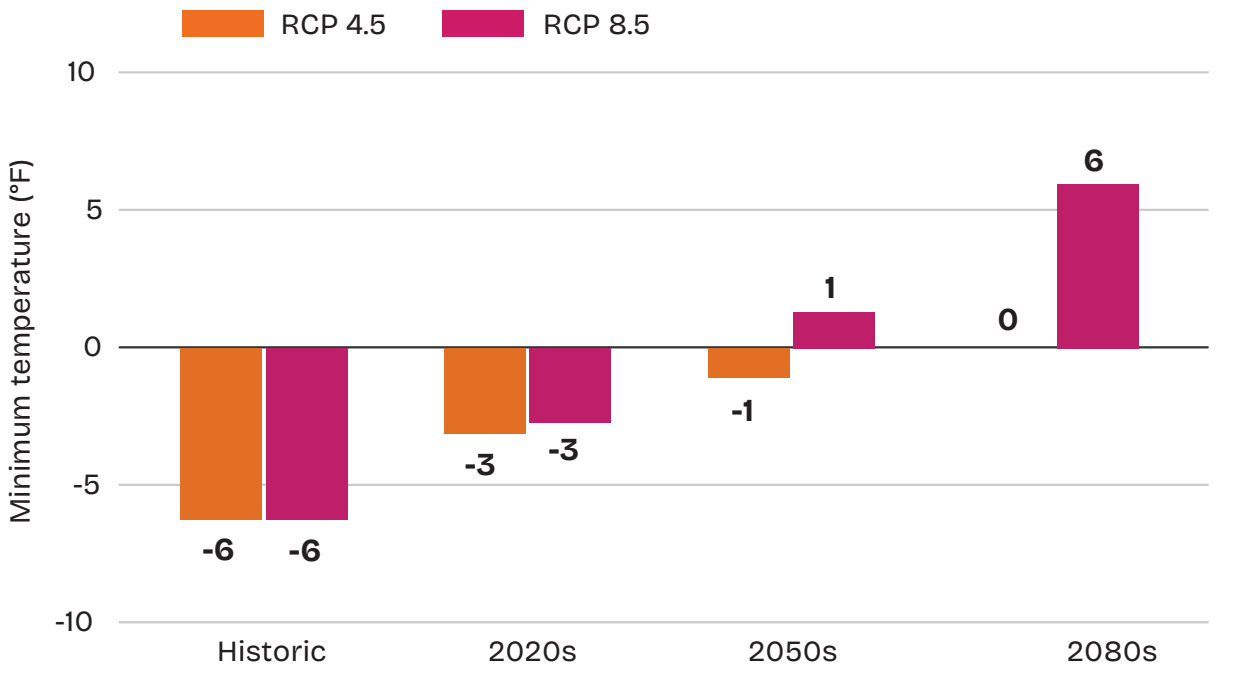
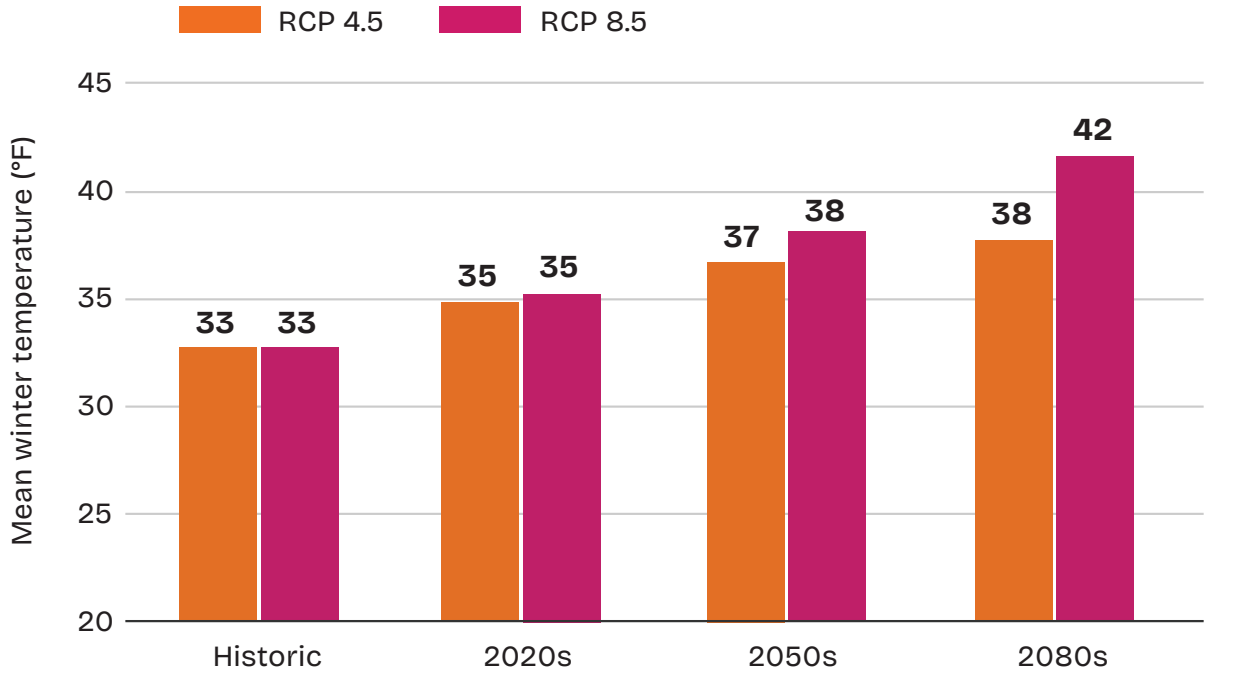


Figure 35. Mean winter temperature under different climate scenarios.



Climate Risk

Extreme cold events present a moderate climate risk for Lakewood. **Table 24** highlights vulnerabilities and potential consequences identified through the engagement process. Generally, the city's health services can adequately address the health impacts associated with extreme cold. However, certain groups are particularly vulnerable during severe cold weather, including outdoor workers, residents without housing, children and older adults. Local buildings and infrastructure can usually withstand cold conditions, but severe cold snaps can lead to frozen and broken pipes, as well as increased energy demand and costs for heating. Although winter temperatures are expected to rise over time, it is still important for the city to prepare for unpredictable extreme cold events.

Table 24. Consequences of and Lakewood's vulnerabilities to extreme cold, identified through the engagement activities of the IWG, CWG and FGs.

System	Vulnerabilities	Consequences
Parks	▪ Trees and other vegetation	▪ Freezing or cracking of tree trunks ▪ Tree and vegetation death
People	▪ Populations without housing ▪ Outdoor workers ▪ Children ▪ Older adults ▪ Pedestrians and cyclists	▪ Risk of injury during hailstorms ▪ Mobility challenges ▪ Transfer trauma[39] ▪ Financial and mental stress caused by home repairs ▪ Mental health/psychological impacts of extreme cold ▪ Wages lost if unable to work

39 Transfer trauma refers to the psychological and physiological distress experienced by individuals — particularly populations facing barriers — when they are moved from one environment to another. This can occur in response to relocation due to extreme weather events, such as winter storms, heat waves, or cold waves, when at-risk individuals (e.g., older adults, medically fragile individuals, people with disabilities and those experiencing homelessness) are transferred to shelters, hospitals or safer locations. For more information, see: Melrose, Sherri. "Reducing Relocation Stress Syndrome in Long-Term Care Facilities." Journal of Practical Nursing 54, no. 4 (2004): 15-17.

System	Vulnerabilities	Consequences
Critical Infrastructure & Services	▪ Fleet vehicles ▪ Water system ▪ Gas utility	▪ Physical damage to vehicles ▪ Potable water main breaks ▪ Increased demand for heating
Property	▪ Homes and other buildings, including frozen pipes and bursts, heating systems — being overworked, mold and moisture issues, fire — due to increased use of heaters and electrical systems ▪ Farm equipment and facilities (battery failure of tractors and trucks), cracked metal components, frozen irrigation systems, frozen water lines for livestock) ▪ Vehicles (battery and engine problems, diesel fuel gelling, cracked rubber tires, accidents due to reduced traction)	▪ Physical damage ▪ Cost of repairs
Economy	▪ Agricultural crops ▪ Food supply ▪ Businesses ▪ Other activities relying on performance of outdoor workers	▪ Depleted crop yields ▪ Food supply disruptions ▪ Businesses closure ▪ Financial costs of repairs ▪ Decreased outdoor workers productivity

Climate-related hazard

Flooding

Overview

In this risk assessment, flooding was considered a moderate risk for Lakewood. **Table 25** highlights the results of the analysis, including the vulnerability, consequence and risk scores. Over the next several decades, flooding may modestly increase in Lakewood as a result of climate change. Certain populations, buildings and infrastructure are particularly vulnerable to flooding. Much of this flood risk is associated with existing buildings and infrastructure rather than anticipated new construction. Additional future damages to existing buildings and infrastructure could be reduced or avoided through strategic investments, such as the North Dry Gulch project.

Table 25. Overview of the risk assessment for flooding.

System	Vulnerability	Consequence	Risk
Parks	0.40	2.0	0.8
People	0.47	3.0	1.4
Critical Infrastructure & Services	0.40	3.0	1.2
Property	0.47	3.0	1.4
Economy	0.40	2.5	1.0
Total	**0.43**	**3.0**	**1.3**

Threat Likelihood

Historically, Lakewood has experienced several significant flood events. In August 1998, more than 3 inches of rain fell within an hour, leading to extensive urban flooding. Many homes had flooded basements, and vehicles were seen floating in the Walmart parking lot. In May 2007, a flash flood occurred in Lakewood Gulch, tragically resulting in the loss of a child, who was swept away and later found deceased. In September 2013, heavy rainfall caused flash floods and sent torrents of water rushing through Bear Creek. This event damaged park amenities and altered the creek's course. Most recently, in July 2019, a thunderstorm triggered a flash flood in Lakewood Gulch, where another individual was swept away by the rushing water and was later found dead.

Key climate indicators related to flooding suggest that climate change may modestly increase future flood risks in Lakewood. These key indicators include total mean precipitation, seasonal precipitation, precipitation days and annual runoff. Historically, the city has received an average of 17.1 inches of precipitation per year. In both climate scenarios, this value is projected to increase slightly, as shown in **Figure 36**. Precipitation is expected to increase slightly faster in spring than in other seasons, while the summer precipitation trend is undetermined. The number of days per year when the total precipitation exceeds 1 inch is also projected to increase slightly, as shown in **Figure 37**. Annual runoff is expected to increase by 0.4 inches over time. These indicators suggest that flooding will likely resemble historical conditions in Lakewood.

Figure 36. Projected mean annual precipitation, RCP 4.5 and RCP 8.5.

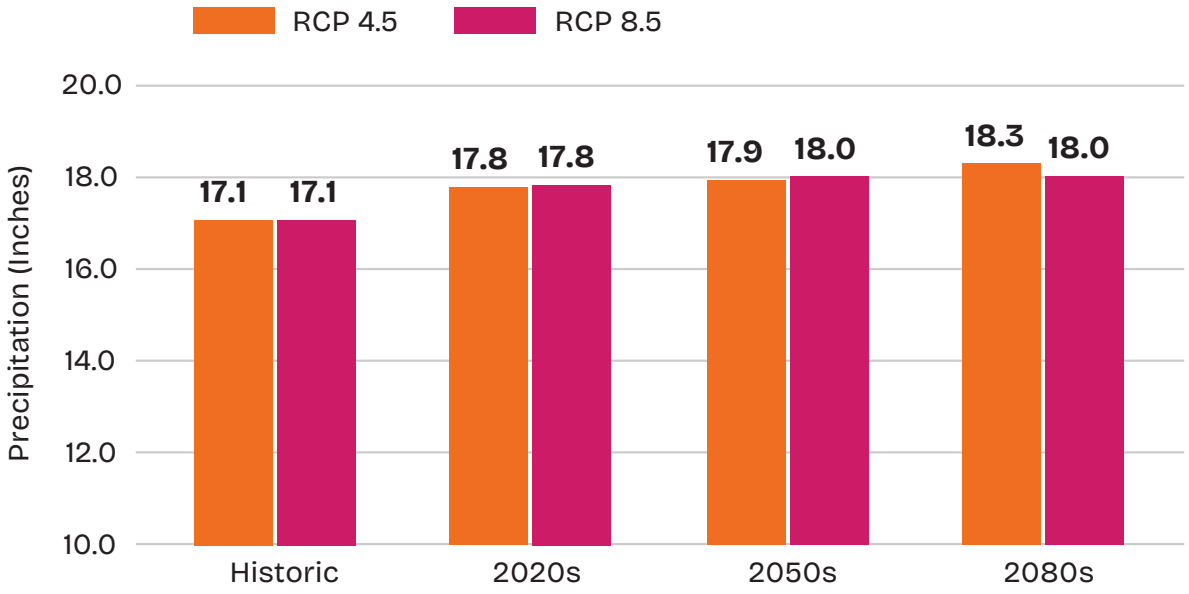
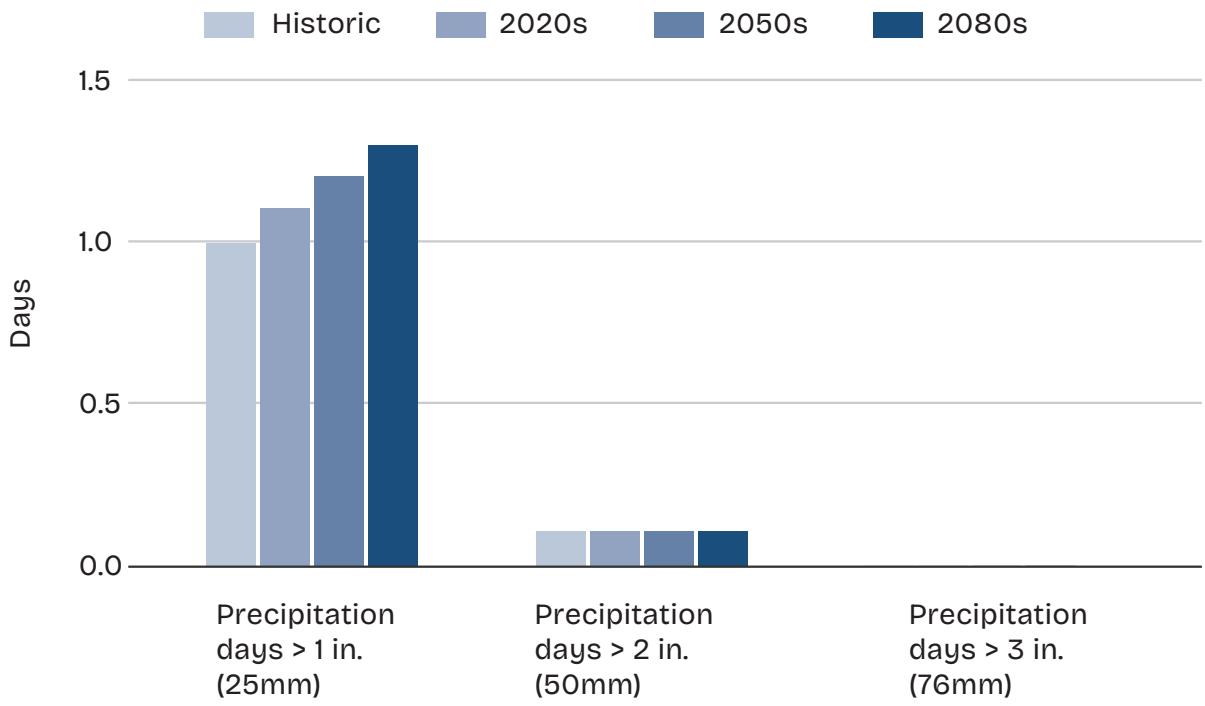


Figure 37. Projected number of days with precipitation exceeding 1 inch for RCP 4.5.



Climate Risks

The climate risk assessment revealed that certain populations, buildings and infrastructure are vulnerable to flooding. **Table 26** highlights vulnerabilities and potential consequences identified through the engagement process. Groups facing barriers include older adults, outdoor workers, those who are socially isolated, and individuals who are unhoused. Some of the city's encampments are located along drainageways, as they are more secluded and less visible from adjacent streets, which could pose risks to life during flash floods. Additionally, buildings and infrastructure located in flood-prone areas are at risk.

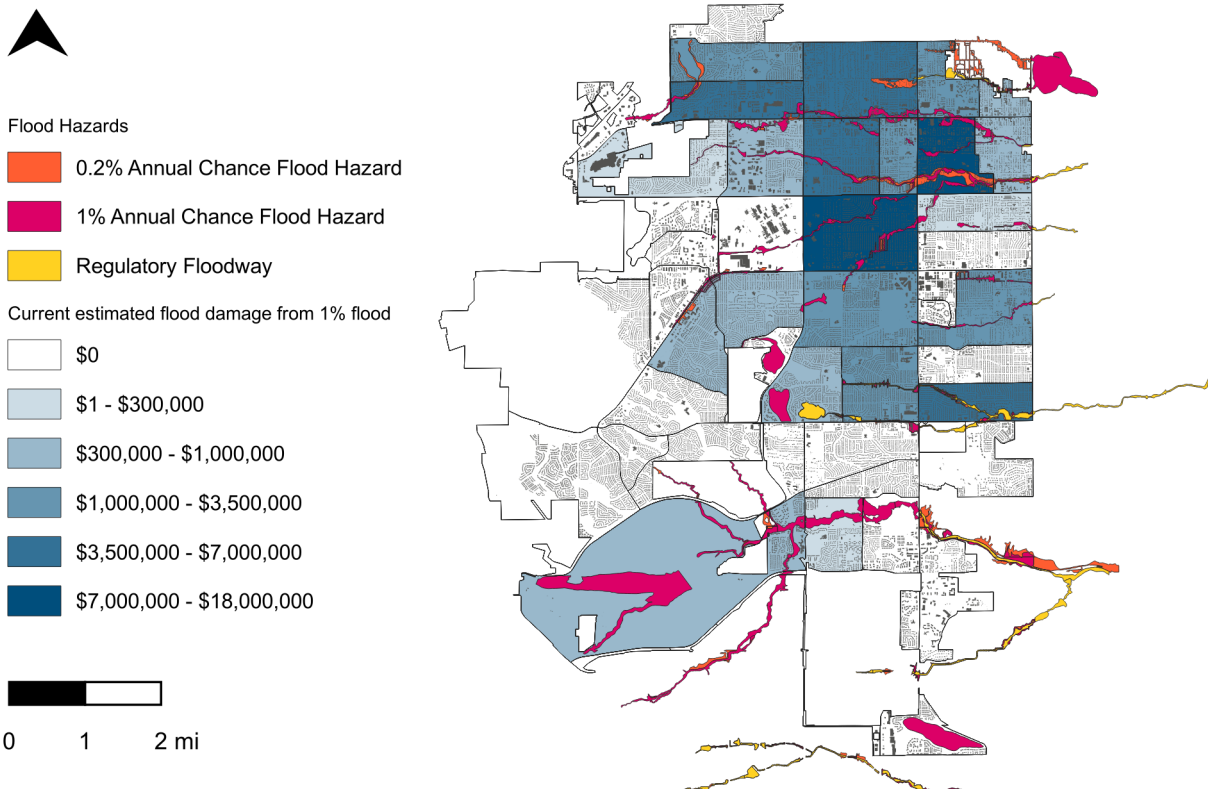
Table 26. Consequences of and Lakewood's vulnerabilities to flooding, identified through the engagement activities of the IWG, CWG and FGs.

System	Vulnerabilities	Consequences
Parks	▪ Vegetation along creeks ▪ Trees	▪ Vegetation eroded or washed away ▪ Tree failures due to root slippage
People	▪ Populations without housing, especially in flood-prone areas ▪ Property owners ▪ Tenants ▪ Pedestrians and cyclists	▪ Risk of injury ▪ Mobility challenges ▪ Transfer trauma ▪ Health impacts due to mold and poor air quality ▪ Mental health/psychological impacts of flooding
Critical Infrastructure & Services	▪ Road network ▪ Storm sewer	▪ Flooded roads disrupting travel ▪ Affected sewer systems due to overwhelming storm sewer systems capacity, blockages and clogs, infrastructure damage and combined sewer overflows
Property	▪ Buildings in general, including homes and businesses ▪ Vehicles	▪ Physical damage ▪ Mold and moisture issues
Economy	▪ Local businesses ▪ Residents ▪ Other activities relying on performance of outdoor workers	▪ Damage to businesses ▪ Short-term closures ▪ Rising flood insurance costs ▪ Costs of infrastructure repairs ▪ Decreased outdoor workers productivity

This study included a spatial analysis of projected damages from a hypothetical rare riverine flood event, defined as a flood with a 1% annual chance of occurring. Riverine flooding occurs when rivers and creeks overflow their banks, inundating the surrounding areas. As illustrated in **Figure 38**, the projected damage from such a rare flood event varies geographically, ranging from under $300,000 to up to $18 million across different census tracts and potentially impacting around 60,000 residents. The estimated total citywide damage from this scenario is projected to be $79 million, with much of this damage concentrated in the northeastern part of the city.

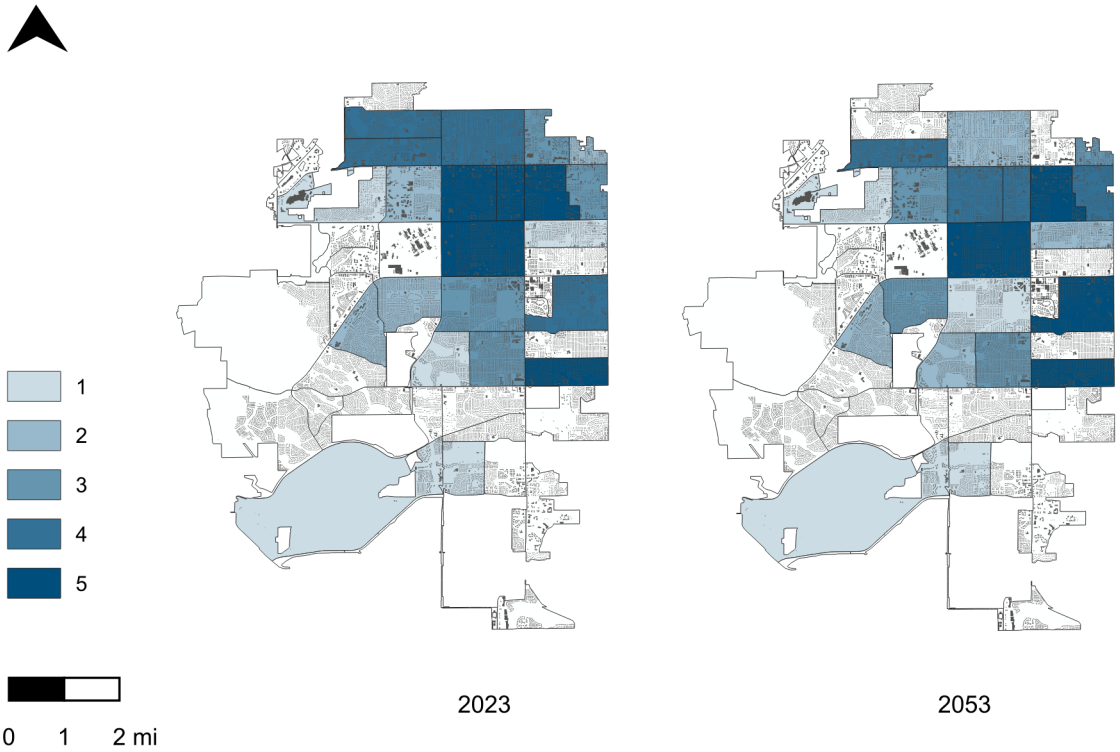
New construction in flood-prone areas is predicted to increase the total damage to $84.5 million in current dollars. If this development occurs as projected, an estimated 3,400 individuals living in 275 residential buildings and 101 commercial buildings could be at risk of being impacted by a rare flood event by the year 2070. This would include both existing and projected developments. This analysis suggests that while much of the flood risk is associated with existing buildings, additional future damages could be limited by continuing to require flood-proofing measures in flood-prone areas and investing in infrastructure to mitigate the risks.

Figure 38. Current estimated damage from a flood event with a 1% annual likelihood of occurring and FEMA flood hazards.



As part of the spatial risk analysis, priority flood risk areas were determined by combining social vulnerability indicators with modeling estimates for current and future flood damage, as shown in **Figure 39**. Priority flood risk areas are concentrated in the northeastern part of the city, primarily around the intersection between 6th Avenue and Wadsworth. While some of these priority areas do not have particularly high levels of social vulnerability, they are at high risk of flooding during a rare flood event.

Figure 39. Current and future flood risk priority areas, not including mitigation from the North Dry Gulch project.



The city of Lakewood is currently in the planning and design phase of the North Dry Gulch (NDG) Improvement Project. The purpose of the project is to update the City's storm sewer system in order to collect and convey a 100-year storm event. This would effectively remove the floodplain from Dover Street to Newland Street, as shown in **Figure 40**. In this study, the North Dry Gulch (NDG) project was incorporated into the model by removing exposure to flood for properties in the designated project area. **Table 27** shows the reduction in content and structure damages anticipated when the project is complete. It is anticipated that this project will remove 19 residential and 67 commercial properties from the floodplain by 2070, resulting in a savings of approximately $20 million.

Figure 40. Approximate area to be removed from the floodplain as a result of the planned North Dry Gulch Improvement Project.[40]

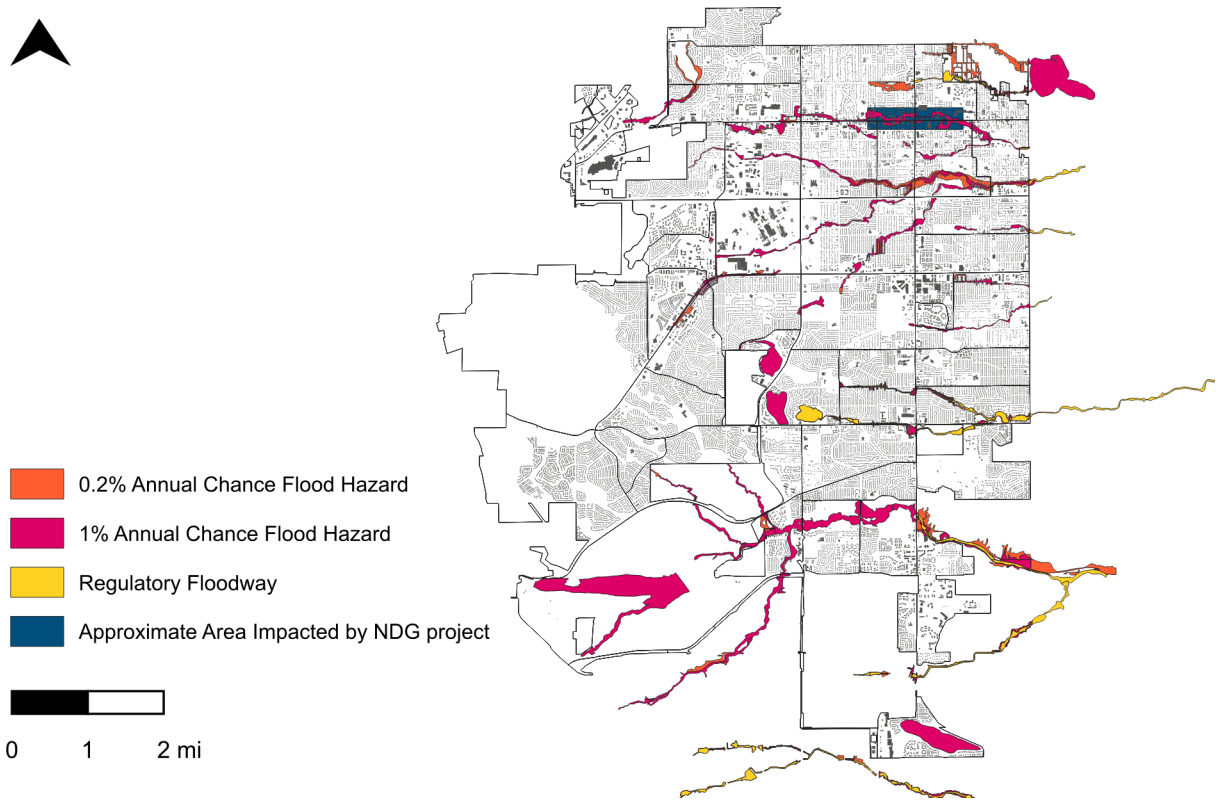


Table 27. Estimated structure and contents damages in a rare flood event.

Category	2030	2070
Damages Before NDG Project	$78,800,000	$84,500,000
Damages After NDG Project	$59,300,000	$64,100,000
Anticipated Savings	$19,500,000	$20,400,000

40 Some permanent water bodies are included in the 1-in-100 year floodplain.

Climate-related hazard

Wildfires

Overview

In this study, wildfires were ranked as a moderate climate risk for Lakewood. **Table 28** highlights the analysis results, including the vulnerability, consequence and risk scores. Overall, warmer, drier conditions are projected to increase the likelihood of wildfires in Lakewood. Certain areas of the city are more vulnerable to wildfires than others due to the presence of the Wildland-Urban Interface (WUI). Over the next several decades, new development is expected to occur in areas with high wildfire risk. Wildfires from across North America may also cause indirect consequences in Lakewood, including air quality issues from smoke.

Table 28. Overview of the risk assessment for wildfires.

System	Vulnerability	Consequence	Risk
Parks	0.6	3.0	1.8
People	0.6	2.5	1.5
Critical Infrastructure & Services	0.6	2.0	1.2
Property	0.6	2.5	1.5
Economy	0.6	2.0	1.2
Total	**0.6**	**2.0**	**1.2**

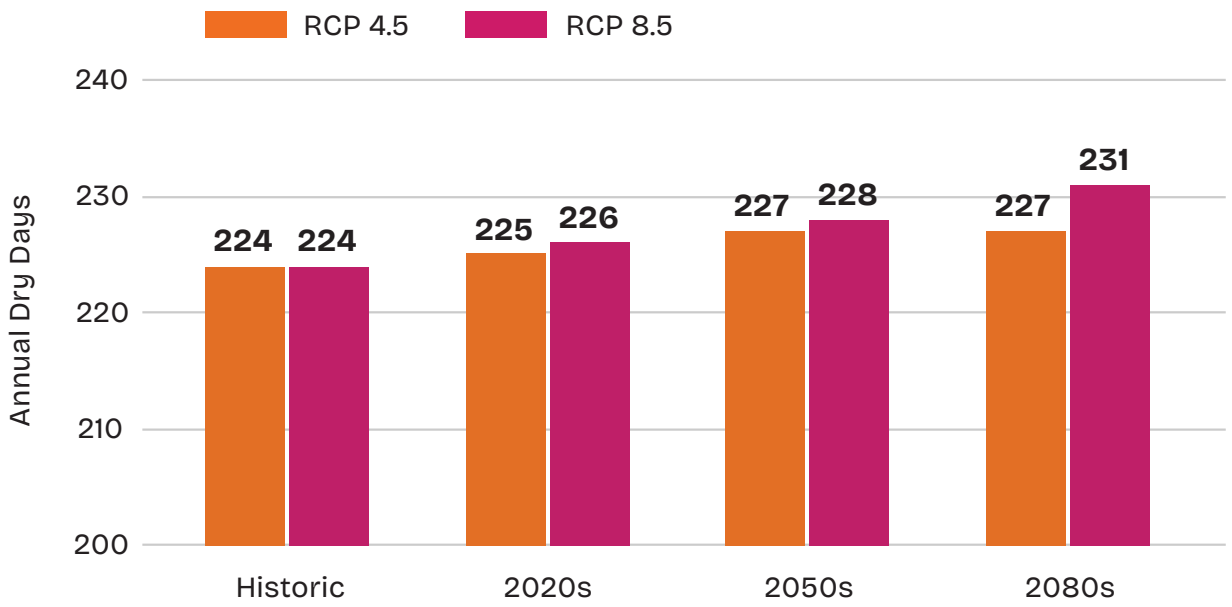
Threat Likelihood

Lakewood has seen four significant fires in recent years. In August 2008, a grassland fire on Green Mountain burned 388 acres. Another fire there in November 2016 consumed about 300 acres, leading to the evacuation of a dozen homes and another 3,000 being placed on standby. In February 2021, a grass fire near Bear Creek Lake Park and Fox Hollow Golf Course burned 446 acres. No buildings were damaged, but evacuation orders were issued for residents east of the fire. More recently, in March 2023, a downed power line sparked a fire near Matthews Winters Park just west of Lakewood.

One notable fire outside of Lakewood was the Marshall Fire, which impacted homes in the Boulder County communities of Louisville and Superior in 2021. The fire quickly evolved from a grassfire to a suburban fire, destroying 1,083 homes and seven commercial buildings.[41] This was the first fire in Colorado to primarily impact denser suburban areas rather than more rural neighborhoods. Due to its proximity to the Denver metro area, most local discussions about wildfires focus on how to prevent a similar incident from occurring in Lakewood.

Lakewood is located in a semi-arid climate where fire is an important part of the local ecosystem.[42] Warmer, drier conditions are projected to increase the likelihood of wildfires in Lakewood. Climate projections for key indicators, such as maximum temperature, the number of days over 90°F and the total number of dry days, were analyzed as part of the climate vulnerability and risk assessment. The number of dry days — defined as the number of days in a year where the precipitation is less than 0.01 inches — is only expected to increase modestly in both climate scenarios, as shown in **Figure 41**. However, other projections, such as the increase in the number of hot days and annual maximum temperatures, included in the extreme heat section could increase the likelihood of wildfires.

Figure 41. Total annual dry days for RCP 4.5 and RCP 8.5.



41 Kiest, Kristina. "Looking Back at Colorado's Marshall Fire." NOAA Research, January 8, 2024. https://research.noaa.gov/looking-back-at-colorados-marshall-fire/.

42 Colorado State Forest Service. "Grassland Wildfire - Colorado State Forest Service," February 10, 2025. https://csfs.colostate.edu/wildfire-mitigation/grasslands/

Climate Risk

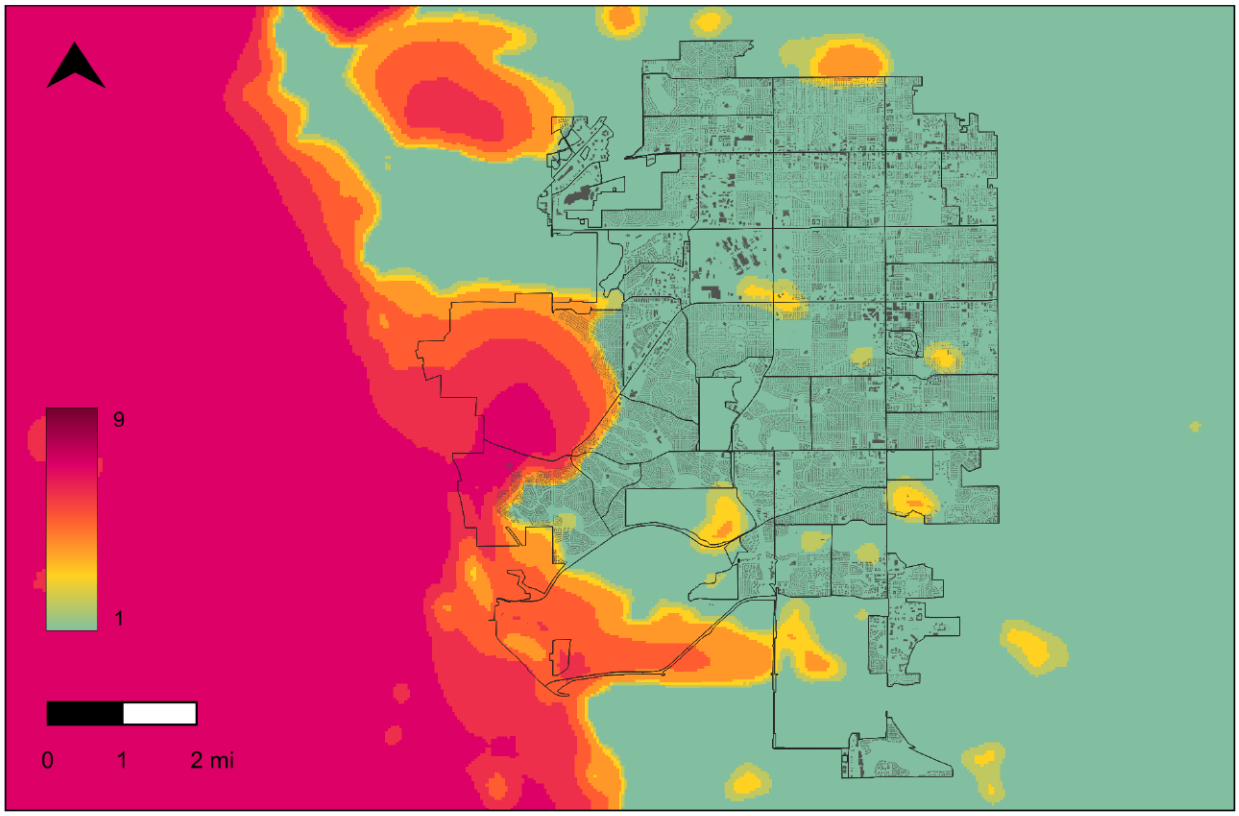
Certain populations and geographic areas are more vulnerable to wildfires than others. **Table 29** highlights vulnerabilities and potential consequences identified through the engagement process. Populations that are more vulnerable include residents who are sensitive to smoke. Residents without stable housing or living in encampments, particularly those along drainageways, may also be vulnerable to wildfires. Homes near Wildland-Urban Interface areas such as Bear Creek or Green Mountain are also vulnerable to wildfires, as are homes that may lose power due to utility shutdowns. Parks and natural areas may also be affected by wildfires.

Table 29. Consequences of and Lakewood's vulnerabilities to wildfires, identified through the engagement activities of the IWG, CWG and FGs.

System	Vulnerabilities	Consequences
Parks	▪ Natural areas	▪ Risk of burning
People	▪ Populations without housing, especially in fire-prone areas ▪ Populations exposed to smoke pollution ▪ Older adults ▪ Residents near Wildland-Urban Interface	▪ Risk of injury or death ▪ Mobility challenges and transfer trauma ▪ Smoke pollution causing health issues ▪ Mental health/psychological impacts of fire
Critical Infrastructure & Services	▪ Power utilities	▪ Physical damage of infrastructure ▪ Risk of outage during wildfires
Property	▪ Homes and neighborhoods near Wildland-Urban Interface ▪ Homes impacted by utility shutdowns	▪ Physical damage to buildings ▪ Loss of electricity during wildfires
Economy	▪ Residents and local businesses ▪ Activities relying on performance of outdoor workers	▪ Rising insurance rates due to wildfires ▪ Decreased outdoor workers productivity

This study included a spatial analysis of the wildfire risk in Lakewood, as shown in **Figures 42 and 43**. **Figure 42** highlights the burn probability near Lakewood, with one representing the lowest probability and nine representing the highest probability, while **Figure 43** highlights the total value of residential buildings at moderate, high and extreme levels of risk from wildfires. Most of this risk is concentrated in the southwestern part of the city due to the Wildland-Urban Interface. Over the next several decades, new development in the Solterra development is expected to occur in areas that currently have moderate, high and extreme levels of wildfire risk, as shown in **Figure 44**. While risk levels may decrease as the Wildland-Urban Interface recedes, these areas would still be at risk of wildfire as embers can be carried miles downwind from a wildfire.[43] This development would increase the number of residential buildings at risk of wildfires. This suggests that additional future damages caused by wildfires could be avoided by limiting development in areas with high and extreme wildfire risk.

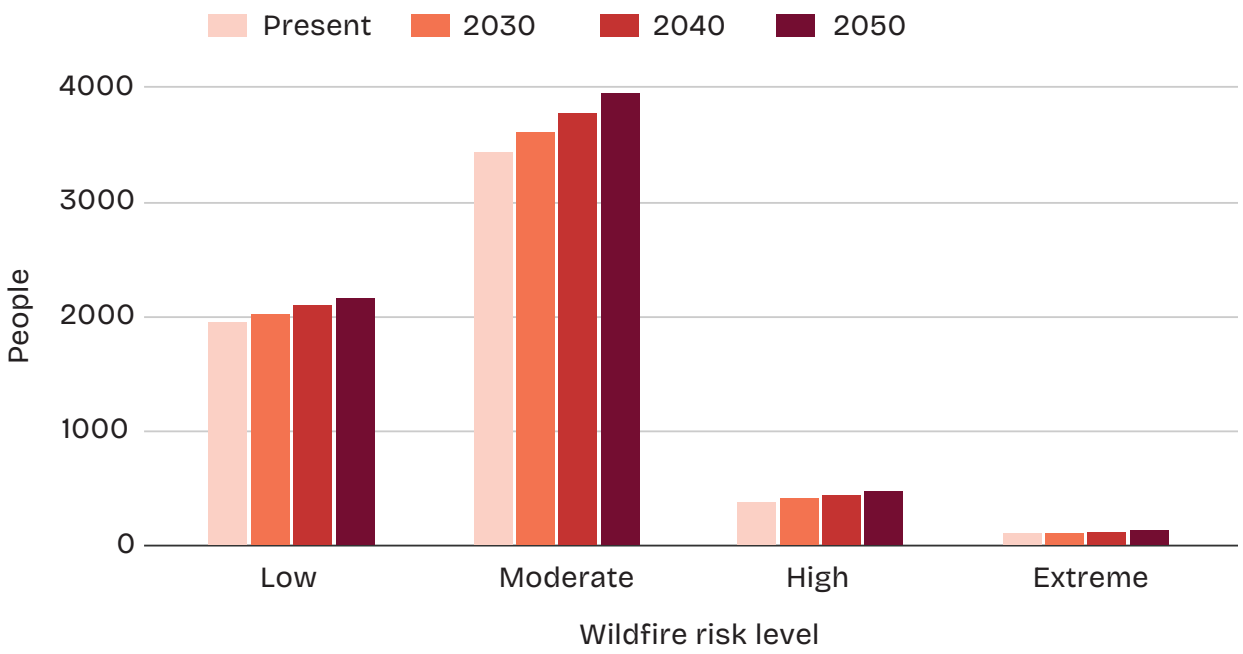
Figure 42. Burn probability near Lakewood, with one representing the lowest probability and nine representing the highest probability.



43 National Institute of Standards and Technology (NIST), "NIST Technical Note 2135: A Case Study of the Camp Fire - Fire Progression Timeline." (U.S. Department of Commerce, 2021), https://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.2135.pdf.

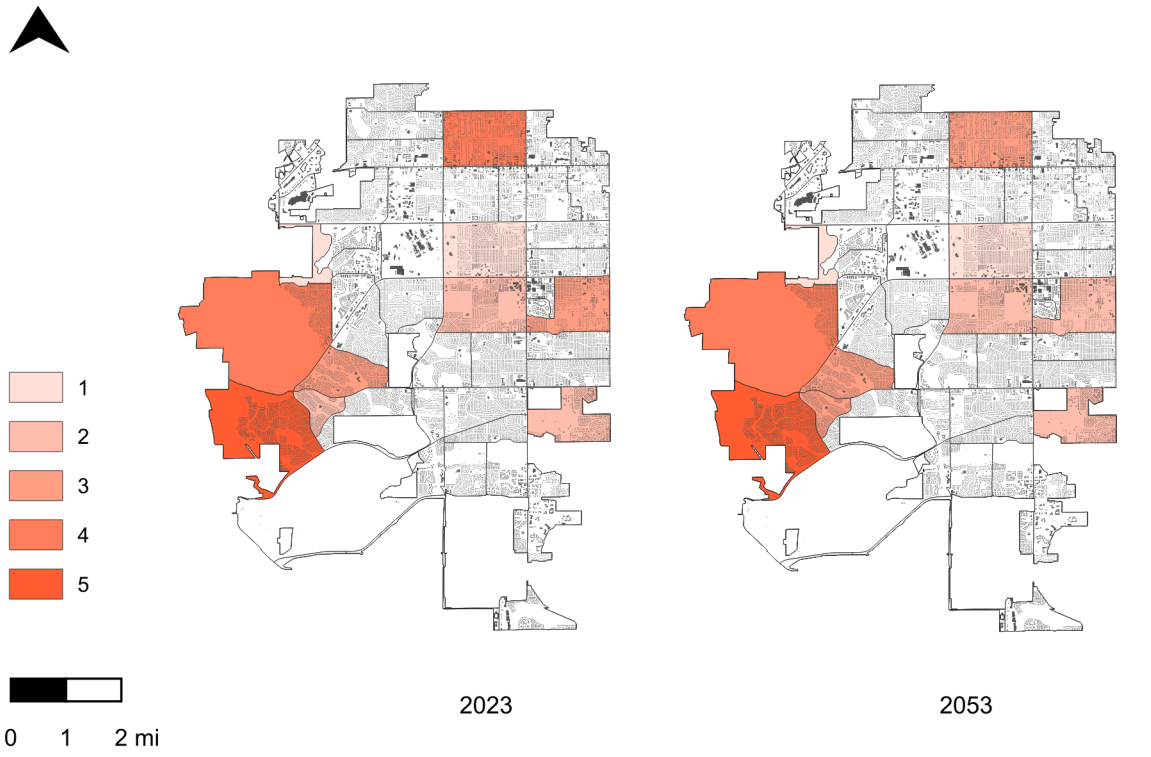
Figure 43. Current total residential building values at moderate, high and extreme levels of risk from wildfires.

Figure 44. Number of people living in areas with different levels of wildfire risk based on their burn probability.



As part of the spatial risk analysis, current and future priority areas were determined by combining building value at risk and social vulnerability index, as shown in **Figure 45**. Even though the southwest area of Lakewood is not as socially vulnerable as other areas, it is still a priority, given the heightened wildfire risk it faces due to the presence of the Wildland-Urban Interface near this portion of the city.

Figure 45. Current and future priority wildfire risk areas.



Climate-related hazard

High Winds and Tornados

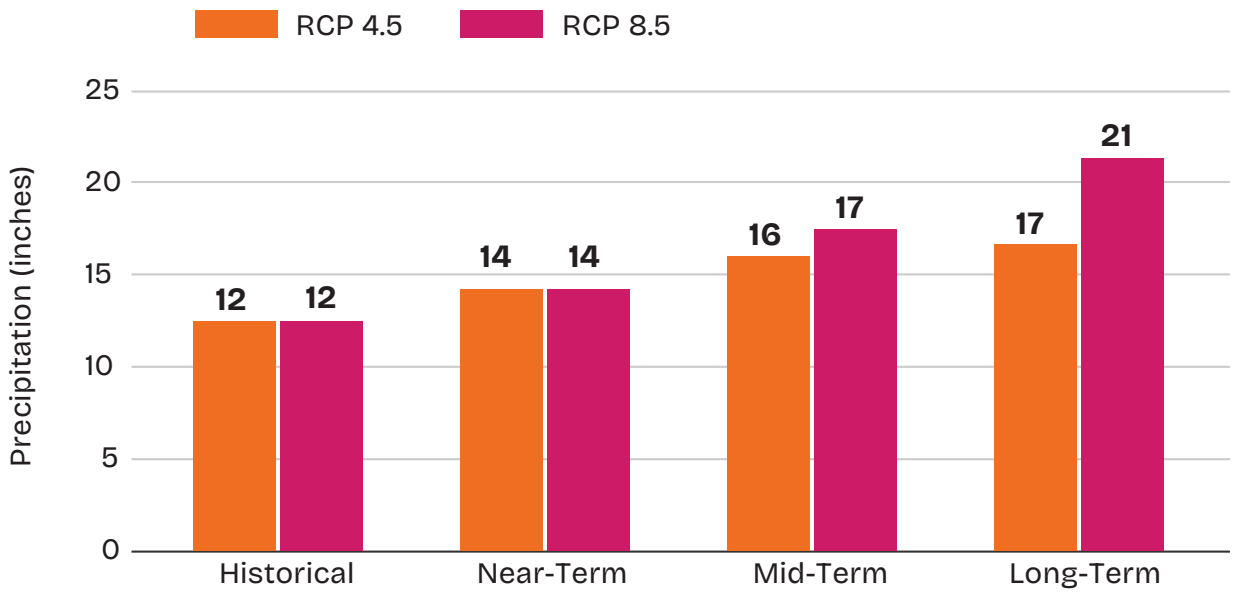
High winds and tornados pose a low overall risk to Lakewood, with limited changes anticipated due to climate influence. Median wind speeds are projected to decrease by up to 5% in the long term. As a result, future events will likely reflect historical wind storms and tornados. Outdoor workers, individuals experiencing isolation and those in older or less structurally sound buildings may be vulnerable to high winds and tornados. Damage from storms is expected to be limited. However, fallen trees, power outages and temporary disruptions to critical services could pose challenges, especially for populations experiencing vulnerabilities.

Climate-related hazard

Drought

Drought poses a limited risk to Lakewood in the short term based on the climate indicator data used for the analysis as well as the limited historical impact of drought on the city. However,, though the overall impact of climate change on drought is gradual and unfolds over long time scales. The number of dry days is projected to increase slightly, while summer precipitation decreases slightly in the RCP 8.5 scenario. Summer temperatures are expected to rise by up to 10°F in the long term in the RCP 8.5 scenario. The climatic water deficit, which represents the amount of water that would have transpired or evaporated if it was present in the soil, is also projected to increase, as shown in **Figure 46**. The overall influence of climate change on drought will likely remain gradual.

Figure 46. Projected changes in the climatic water deficit in RCP 4.5 and RCP 8.5.



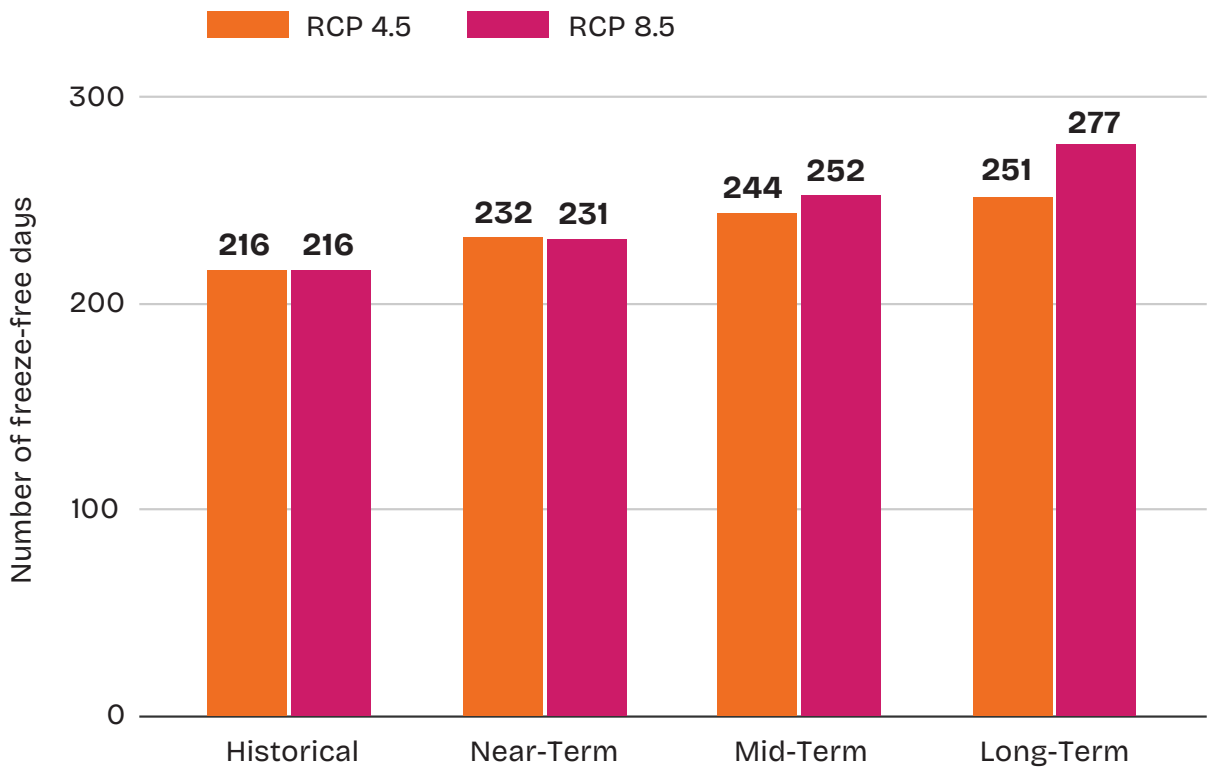
While water conservation measures are already in place, there are concerns about rising water costs due to scarcity and potential supply disruptions if drought conditions occur. Extended dry periods can reduce soil's ability to absorb water, as prolonged drought can lead to soil compaction and decreased organic matter. As a result, drought could also contribute to other hazards such as flooding and decreased biodiversity. Populations experiencing social vulnerabilities include residents living on low incomes and facing higher water costs and local farmers managing crop yields. Parks and green spaces may also be vulnerable, as prolonged dry conditions may weaken vegetation, making it more susceptible to pests and disease.

Climate-related hazard

Biodiversity Change

Biodiversity in Lakewood is expected to shift as a result of increasing temperatures and a longer growing season. As shown in **Figure 47**, the number of freeze-free days is projected to extend by one to two months in the long term, resulting in a longer growing period. As noted earlier in the Climate Projects section of the report, spring and winter precipitation are projected to increase. Warmer, wetter winters and springs may influence local ecosystems, potentially affecting plant and animal species. There is uncertainty about the extent of changes to native flora, insect populations and soil health. Potential risks may include disruptions to local food production, damage to plants from early spring freezes, increased invasive species or pests, and emerging public health concerns, such as vector-borne diseases. Vulnerable elements include populations relying on local food supplies and local farmers facing shifting crop yields. Continued research is needed to understand the long-term impacts of these biodiversity changes, particularly for food security, pest management and ecosystem resilience.

Figure 47. Projected number of freeze-free days in the RCP 4.5 and 8.5 scenarios.



Climate-related hazard

Lightning

Lightning presents a low overall risk to Lakewood, with no discernible influence from climate change and historical trends expected to continue. While lighting can occur in both dry and wet conditions, its primary impacts are site specific, typically resulting in single-home damages or localized fires. Trees in parks and open spaces, particularly in elevated areas like Green Mountain and Bear Creek, are common lightning targets, posing a risk of fire ignition, which could contribute to future wildfires. Some residents may be more vulnerable to lighting, including outdoor workers, individuals facing isolation and populations without housing, who may be more exposed during storms. While power outages due to lightning strikes are uncommon, they could disrupt essential services without backup power. Overall, the risk from lightning remains low, with minimal direct damage and only short-term service disruptions anticipated.

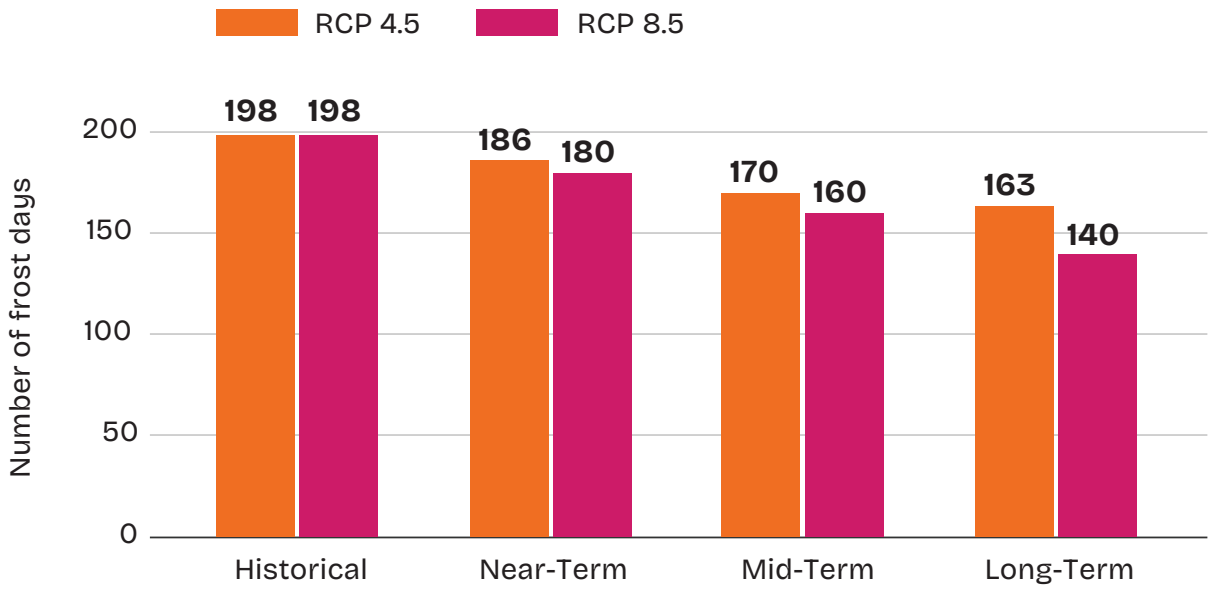
Climate-related hazard

Winter Storms

Winter storms in Lakewood are expected to become less frequent and severe over time as temperatures rise. The number of frost and ice days are both projected to decrease, with frost days decreasing by nearly two months in the long-term RCP 8.5 scenario, as shown in **Figure 48**.[44] Over the next several decades, average winter temperatures are expected to rise above freezing, and winter precipitation may increase slightly. Snowstorms are anticipated to have similar impacts to historical events in the near future, with overall risks diminishing over time. The city is capable of responding to winter storms and has established snow clearing procedures and protocols in place.

However, certain populations, such as outdoor workers, pedestrians and individuals without access to personal vehicles, may be vulnerable to winter weather conditions. Additionally, early season storms may pose risks to leafed trees, evergreens, and some food crops like fruit trees that can accumulate heavy snow. Power outages remain a potential concern due to the vulnerability of overhead lines, which could disrupt heating, refrigeration and medical devices. Despite these factors, the overall risk from winter storms is considered low, with limited direct damage and only short-term service disruptions expected.

Figure 48. Projected number of frost days where the minimum temperature is less than 32 °F in the RCP 4.5 and 8.5 scenarios.



44 Frost days occur when the minimum temperature is less than 32 °F, while ice days occur when the maximum temperature is less than 32 °F.

Image: Lakewood frost days. Source: City of Lakewood.

6.

Community Engagement

As part of the engagement process for this project, key affected and interested parties provided valuable insights on climate vulnerabilities and potential climate actions that could enhance community resilience and preparedness. These insights reflect a wide range of priorities, from infrastructure improvements and regulatory updates to community engagement, education and disaster preparedness strategies. These represent the range of options that came up through the engagement process and study of best practices.

Internal Working Group, Community Working Group and Focus Groups

During the Internal Working Group (IWG), Community Working Group (CWG) and Focus Group (FG) engagement activities, participants shared many ideas about actions that would help the community adapt to climate change. Participants emphasized proactive planning, resilience-building and community-centered solutions to address climate risks. Key priorities included updating zoning and building codes to enhance fire resistance, reduce flood risks and promote energy efficiency, as well as considering infrastructure improvements such as stormwater management systems, graywater systems and localized storage for critical utilities. Participants highlighted the need for expanded financial assistance to support populations facing barriers with home weatherization, energy credits and heating/cooling solutions.

Emergency preparedness and disaster response emerged as crucial themes, with calls for community-driven initiatives like Community Emergency Response Team (CERT) training, wildfire awareness programs and snow removal support, particularly for older adults and people with disabilities. Respondents emphasized transportation access to shelters, pet-friendly evacuation options, and better coordination of food and resource distribution. Expanding communication strategies, including multilingual outreach, awareness of early warning systems, and using local media outlets, was identified as critical for ensuring equitable access to emergency services.

Finally, nature-based solutions and green infrastructure were widely supported to mitigate flooding, improve urban cooling and restore local ecosystems, with a focus on converting bluegrass areas, managing invasive species, and integrating resilient tree species. Collaboration across local governments, businesses and Black, Indigenous, and People of Color (BIPOC) communities was seen as essential to ensuring equitable and effective climate adaptation efforts.

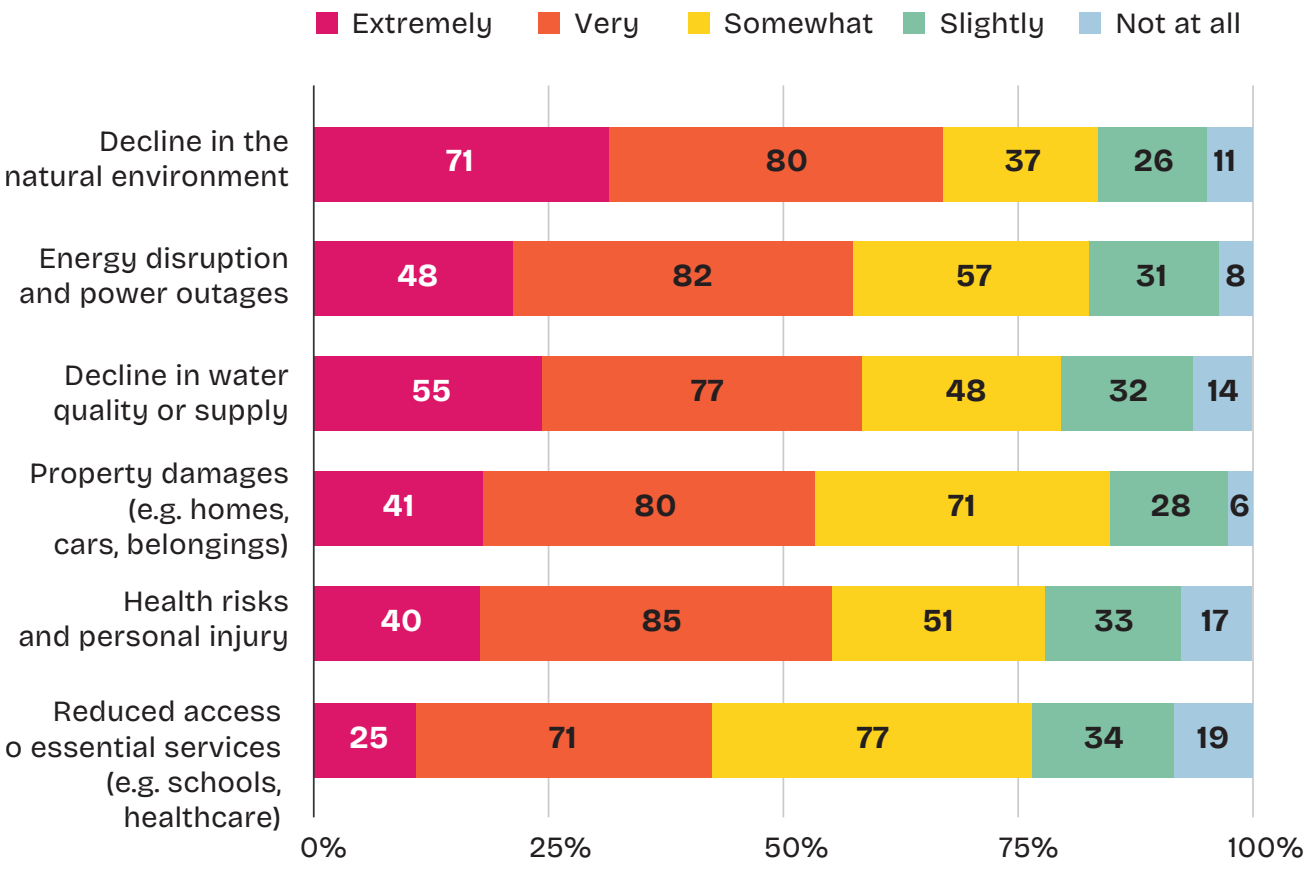
Community Survey

In addition to the working group and focus groups, an online community survey was used to explore awareness and perception of existing programs and resources within the broader community, as well as interest in potential new climate actions. The following subsection summarizes key findings from the survey.

Key Vulnerabilities

Based on the results of the risk assessment for each priority hazard, key vulnerabilities were identified for the city of Lakewood. These include property damage, personal injury, water disruption, energy disruption, reduced access to essential services and biodiversity risks. One of the survey questions was designed to evaluate how concerned residents were about these key vulnerabilities. **Figure 49** highlights the survey results for this question.

Figure 49. Survey results (226 responses) for the question, "Please indicate how concerned you are for yourself or close friends and family about the vulnerabilities listed below."



Below are the key takeaways based on the responses to this specific question:

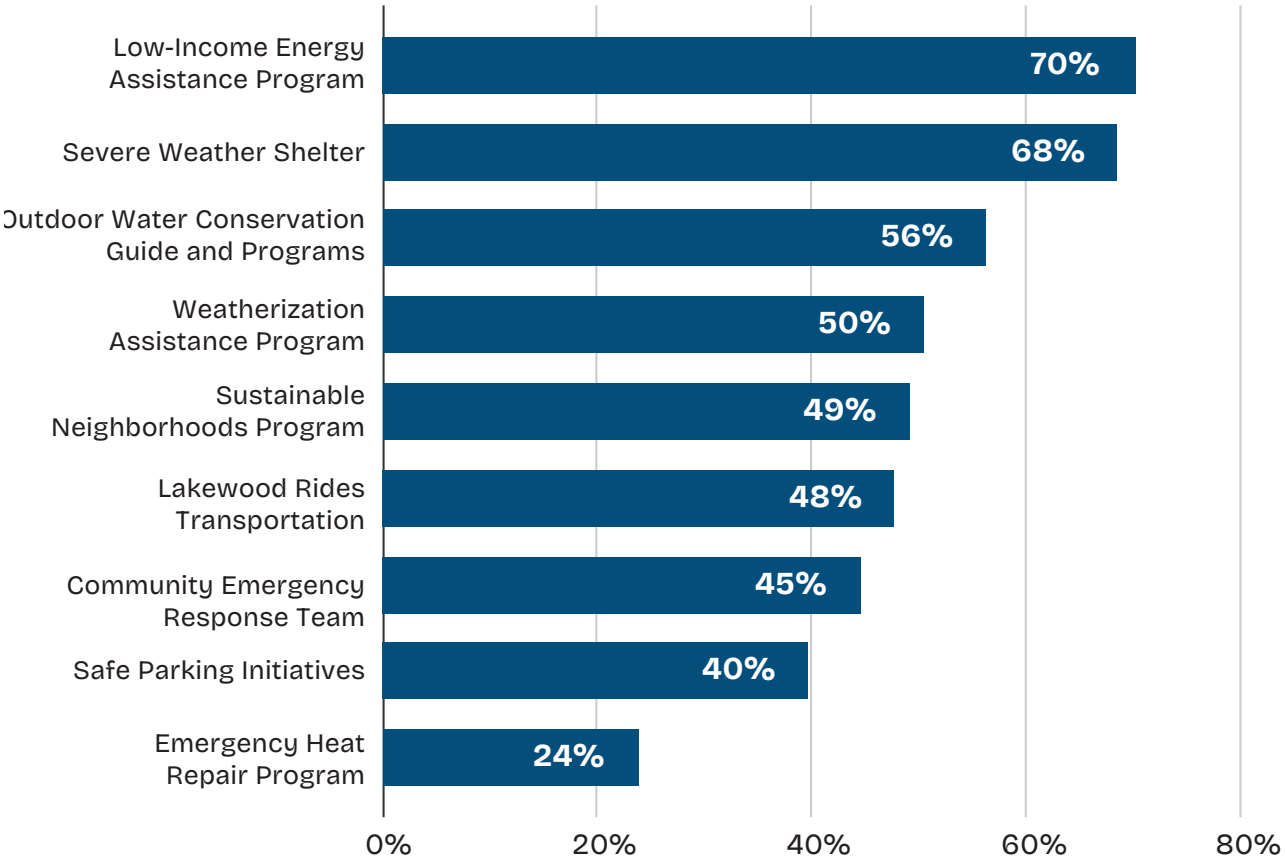
- Overall, the survey results indicate that respondents are highly engaged and concerned about the potential impacts of climate change. The majority of respondents said they were "Extremely" or "Very" concerned about all of the vulnerabilities, with the exception of reduced access to essential services. In contrast, less than a quarter of respondents said they were "Slightly" or "Not at all" concerned about the vulnerabilities. This suggests that climate change and its effects are broadly acknowledged as relevant issues.

- High priorities: The natural environment, energy disruption and water quality show the strongest overall concern. These areas might benefit from targeted initiatives or educational campaigns to address specific anxieties.
- Health-related vulnerabilities also rank high, likely reflecting the public's increasing awareness of climate impacts on well-being (e.g., heat, air quality, disasters).
- While still a concern, reduced access to essential services is comparatively lower in urgency. This could suggest the need to explore why and whether it is perceived as less impactful or pressing.

Level of Awareness of Programs and Resources

The survey asked participants whether they were aware of existing programs and resources to reduce vulnerability in Lakewood. **Figure 50** highlights the survey results, with the percentages indicating the number of respondents who were aware of each option.

Figure 50. Survey responses to the question, "The following programs and resources that aim to reduce vulnerability are available in Lakewood. Please mark those programs and resources that you are aware of (select all that apply)."



Programs with the highest awareness (above 66%) include the Low-Income Energy Assistance Program (LEAP) at 70.3%, followed by the Severe Weather Shelter at 68.5%. These programs likely have better outreach, visibility or direct engagement with residents.

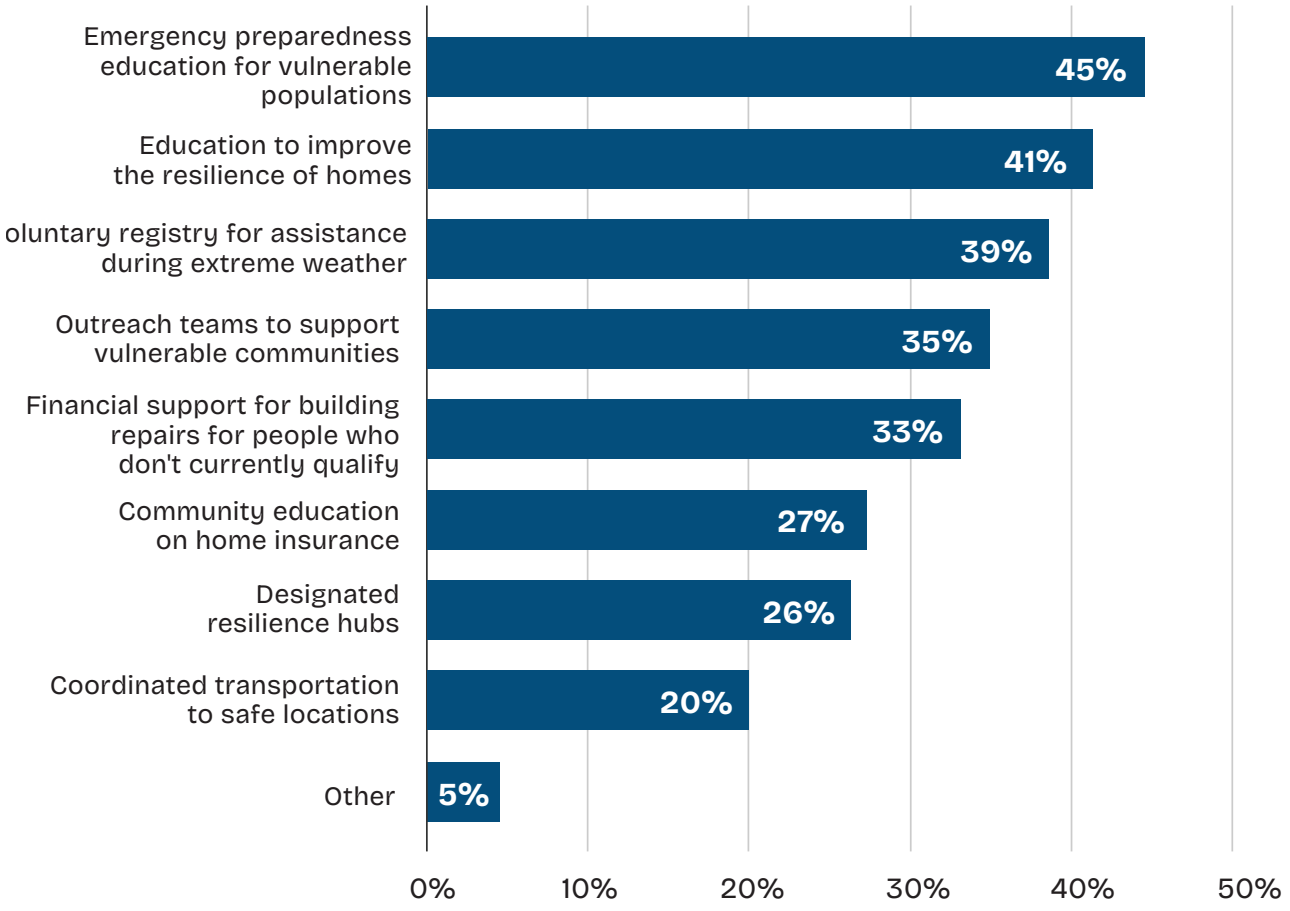
Programs with moderate awareness, ranging between 33% and 66%, include the Outdoor Water Conservation Guide and Programs (56.3%), Weatherization Assistance Program (50.5%), Sustainable Neighborhoods Program (49.1%), Lakewood Rides Transportation (47.7%), Community Emergency Response Team (44.6%) and the Safe Parking Initiatives at 39.6%. While these programs are known within certain segments of the population, they could benefit from broader outreach efforts to improve overall awareness.

The Emergency Heat Repair Program Programs had the lowest awareness (23.9%). This suggests that this program may require stronger communication efforts. Overall, these findings show that programs providing direct financial relief and emergency sheltering services tend to be the most widely recognized. In contrast, more proactive initiatives like sustainability programs and housing-related support services have more moderate awareness. Strengthening communication efforts — especially for less-recognized programs — could help ensure that more residents benefit from the available resources.

Interest in New Actions

In addition to awareness of existing programs, the survey was also used to explore participants' interests and priorities related to potential new actions that Lakewood could implement to support community resilience. The survey asked participants to review a list of potential actions and select up to three that would be the most helpful and interesting. **Figure 51** highlights the survey results.

Figure 51. Survey responses to the question, "Potential New Actions —The following list includes potential actions beyond what is already available. Please identify the potential actions that would be most helpful and interesting for you. Select up to three."



The most supported potential action (selected by 44.5% of respondents) was emergency preparedness education programs tailored for neighborhoods and populations facing barriers. This highlights a strong community demand for targeted education on household readiness, emergency planning and resources for at-risk groups.

Educational guidelines to improve the resilience of existing homes to extreme weather followed closely at 41.4%, suggesting a widespread interest in practical strategies to enhance home safety and efficiency.

The voluntary registry for individuals needing assistance during extreme weather events was also highly favored, with 38.6% of respondents selecting it, underscoring the need for proactive identification and support of residents facing barriers.

Among the least supported options was coordinated transportation services for moving at-risk individuals during severe weather events. This option was selected by only 20% of respondents, indicating relatively lower perceived urgency or existing alternatives.

The designation of resilience hubs also received moderate interest (26.4%), suggesting that while community gathering spaces for resilience and emergency support are valued, they may not be a top priority compared to direct assistance measures. The lowest response rate came from the "Other" category, with just 4.5% interest, indicating that most respondents found the listed options comprehensive.

The results suggest that the community prioritizes education, home resilience and direct support for vulnerable individuals over broader infrastructure investments or logistical coordination. These findings can help guide resource allocation toward the most impactful initiatives.

Community Support and Type of Assistance Needed

Survey results suggest that the community has a strong willingness to support one another during extreme events but that barriers to coordination and communication may limit participation. When asked about their role in supporting others during extreme events, approximately 75% of 57 respondents said they had provided assistance to others. Among those who did not offer help, the vast majority (86%) indicated that this was due to a lack of awareness — either not knowing who needed assistance or how to provide it. Only 8.8% of respondents cited personal circumstances as the reason they were unable to help, while approximately 5% explicitly stated that they chose not to assist others.

Participants were also asked what type of support they provided and what help they lacked during extreme weather events. Results are shown in **Figure 52** and **Figure 53**, respectively.

Figure 52. Survey responses to the question, “What kind of help did you provide? Select all that apply. I provided help with...”

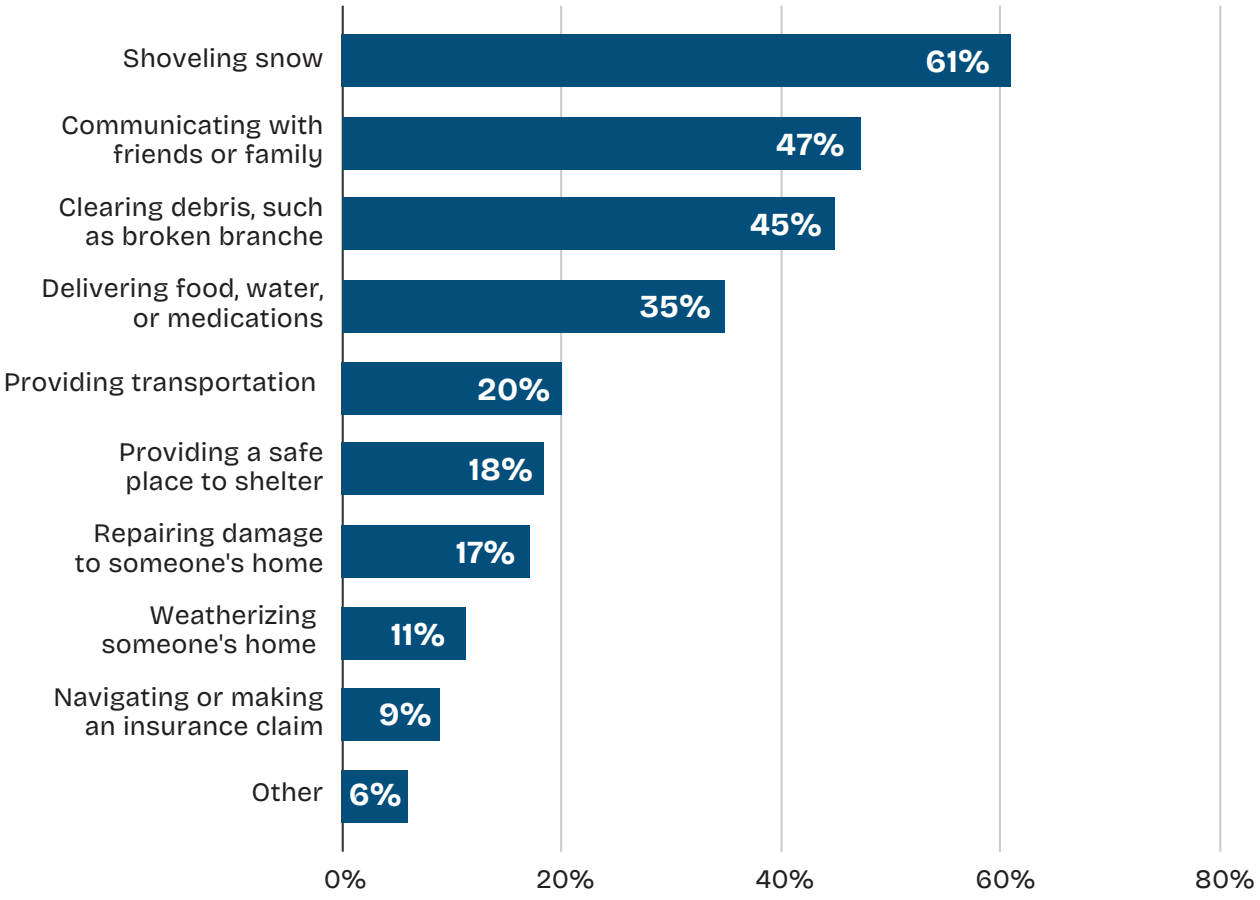
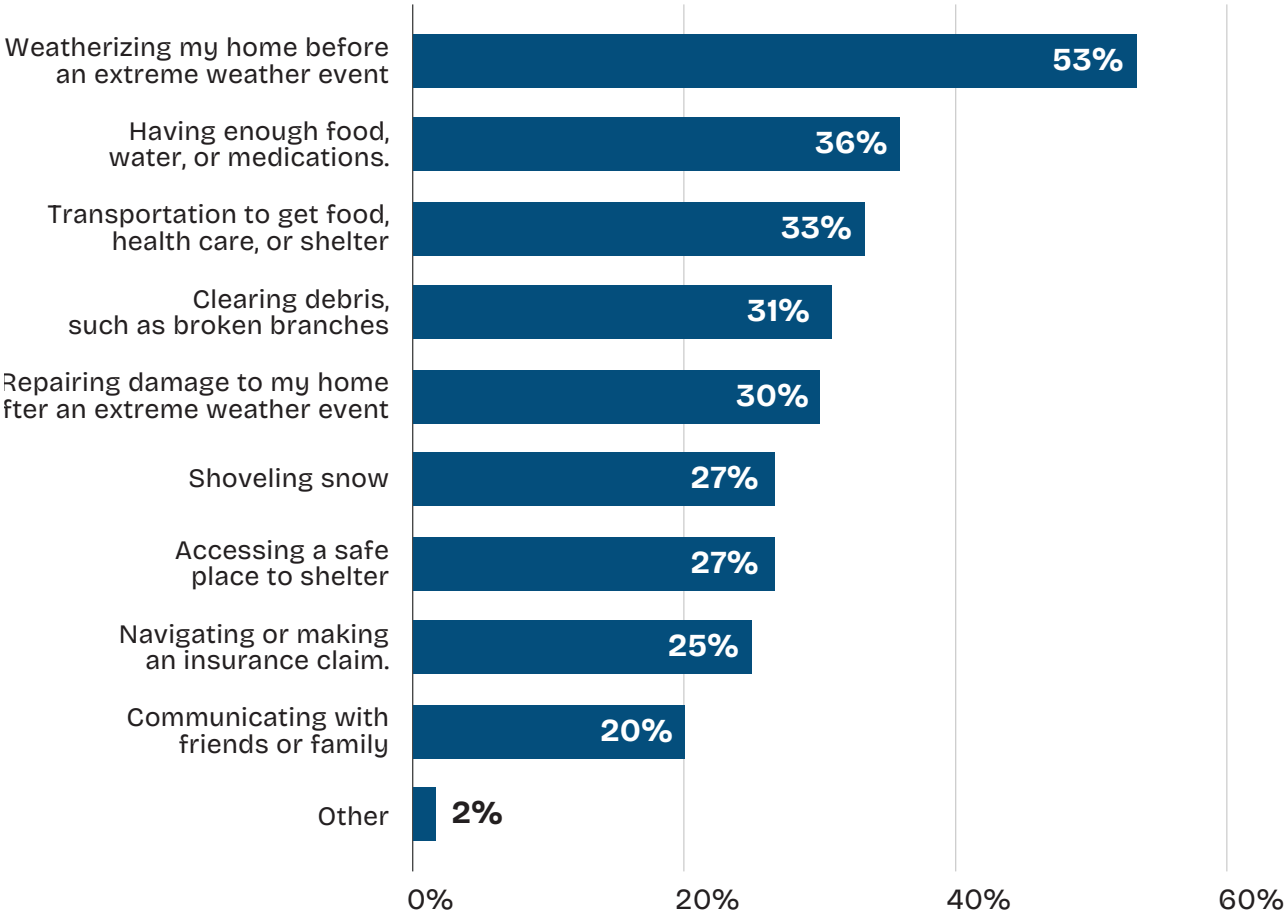


Figure 53. Survey responses to the question, "What kind of help did you wish you had received? Select all that apply. I wish I had help with..."



The survey results revealed key patterns in the assistance community members provided and the support they wished they had received during extreme weather events.

The most common form of assistance provided was shoveling snow, with 61% of respondents reporting that they helped in this way, emphasizing the strong role of community support in managing winter weather impacts. Other frequently provided forms of aid included communicating with friends or family (47%) and clearing debris, such as broken branches (45.0%), reflecting a strong focus on immediate, practical responses to weather-related challenges. In contrast, more technical or resource-intensive support, such as navigating insurance claims (9%) and repairing damage to someone else's home (17%), was provided by fewer individuals, likely due to the specialized knowledge or financial resources required for such assistance. These findings suggest that community support is primarily focused on direct, hands-on aid during and after extreme weather events, while post-event recovery assistance is less commonly available.

On the other hand, when asked what kind of help they wished they had received, respondents most frequently cited weatherizing their homes to make them safer before an extreme weather event, with 53% identifying this as a need. This highlights a strong demand for proactive resilience measures, suggesting that many residents recognize the benefits of home improvements but may lack the financial or technical resources to implement them. Other major unmet needs included having enough food, water, or medications (35.8%) and receiving transportation to access essential services (33%), pointing to significant barriers in securing basic necessities and mobility during extreme weather.

Comparing provided and desired assistance, a clear gap in long-term resilience and recovery support emerges. While many residents engaged in immediate response actions, such as snow removal and debris clearing, fewer were able to help with home repairs, insurance navigation or weatherization — even though these were among the most commonly reported unmet needs. Navigating insurance or making a claim, for example, were two of the least provided forms of help (8.9%) but remained a moderate unmet need (25.0%), reinforcing the complexity of post-event recovery.

Overall, the results suggest that communities are highly engaged in immediate weather response efforts but may lack the resources, expertise or programs needed for long-term resilience and recovery. Expanding initiatives that provide financial assistance for home improvements, education on insurance processes and increased access to essential supplies and transportation could help address these gaps, ensuring that residents are better prepared and supported before, during and after extreme weather events.

Respondents also suggested ways in which the city could strengthen the community cooperation that already happens during extreme weather events. The following are the key takeaways:

- Better communication is a top priority, with calls for improved emergency alerts, centralized information and community engagement.
- Stronger neighborhood-level networks could enhance cooperation, with suggestions for volunteer programs and mutual aid initiatives.
- Infrastructure improvements and resource access are seen as critical to making communities more resilient.
- More education on climate risks and preparedness would help ensure residents are informed and proactive.
- Some residents feel frustrated with existing city policies and want more action rather than planning.

Image: Lakewood Arbor Day 2024. Source: City of Lakewood.

7.

Adaptation Actions

Overview

This section highlights potential adaptation actions that the city of Lakewood can take to enhance its resilience to climate change. These actions were developed through multiple steps. First, current actions were identified and reviewed to understand what Lakewood is already doing or is planning to do in the near future to reduce climate risks. These actions were then mapped against key vulnerabilities identified in this study to highlight gaps.

These key vulnerabilities were developed based on the results of the risk assessment, and they represent critical areas where the impacts of climate-related events or trends could cause significant disruption or damage to people, ecosystems or infrastructure. **Table 30** highlights the key vulnerabilities. These six key vulnerabilities differ from the five key systems included in this study. While the five key systems were used to assess potential risks to Lakewood, the six vulnerabilities represent the main areas of vulnerability Lakewood faces as a result of climate change.

Table 30. Descriptions of key vulnerabilities in the city of Lakewood.

	Key Vulnerability	Description
	Property Damage	Damage to local buildings and infrastructure caused by either community-wide or site-specific events.
	Personal Injury	Personal injuries to local populations caused by both community-wide and site-specific events.
	Water Disruption	Disruptions to local water supplies due to increased demand for water to cope with heat stress, as well as water main breaks during shifts in temperatures.
	Energy Disruption	Disruptions to local energy supplies due to increased energy demand during extreme temperature events and power outages due to extreme weather events.
	Reduced Access to Essential Services	Reduced access to essential services for residents as a result of travel delays caused by road closures and road blocks due to extreme weather events, as well as increased demand for public resources such as emergency and medical services, emergency shelters and debris removal due to extreme weather events.
	Biodiversity Risk	Changes to ecosystems requiring increased parks maintenance, as well as vector-borne diseases requiring public health resources.

After the current actions were mapped against key vulnerabilities, engagement was conducted to collect feedback on new potential actions that Lakewood could take. The previous section summarized this engagement. The actions that residents identified were organized into six key emergent themes, highlighted in **Figure 54** and **Table 31.** Finally, the proposed actions were compared to the consultant's database of adaptation actions to identify remaining gaps. The proposed actions are organized by key themes in the following section. Icons next to each proposed action indicate which of the six key vulnerabilities the action addresses.

Figure 54. Emergent themes from community engagement.

Table 31. Key action themes that emerged from community engagement.

Key Action Theme	Description
Public Engagement and Outreach 	This key theme includes actions oriented to enhance public awareness and accessibility of climate programs by expanding multilingual outreach, using local media and partnering with community organizations. Actions to improve volunteer coordination to connect residents in need with available support and foster trust through storytelling and community resilience narratives are also included in this key theme.
Emergency Preparedness and Planning 	This key theme includes actions oriented to strengthen disaster planning for high-risk facilities; expand cooling and warming shelters; improve access to emergency food, water, and transportation; enhance snow removal programs; ensure accessible sidewalks; establish resilience hubs; and integrate behavioral health support into emergency shelters.
Climate-Resilient Infrastructure 	This key theme includes actions oriented to improve infrastructure in stormwater and flood management, upgrade building codes for fire and flood resistance, expand financial assistance for home retrofits, and promote water conservation through graywater systems, non-potable water use, and rainwater harvesting.
Energy Resilience 	This key theme includes actions oriented to support energy efficiency and affordability by expanding weatherization programs, financial assistance and community-based renewable energy projects. This key theme also includes actions around the development of microgrids, battery storage solutions and district energy systems to enhance resilience during extreme weather events.
Natural Spaces and Green Infrastructure 	This key theme includes actions to expand the urban tree canopy, install shade structures, promote nature-based solutions like green infrastructure and wetland restoration, address risks from invasive species, and improve air quality protections, particularly during wildfire season.
Governance and Collaboration 	This key theme includes actions to integrate climate adaptation into city operations, asset management, and budgeting. This key theme also includes actions to strengthen regional partnerships for wildfire and flood risk management, emergency preparedness and climate finance, as well as actions to seek funding opportunities for infrastructure resilience and renewable energy investments.

Options to Build Resilience

To address the six key vulnerabilities in Lakewood, the study identifies 61 potential adaptation actions that could be implemented to help safeguard people and structures, protect critical infrastructure, and preserve the natural environment. As noted above, these actions were developed through multiple steps of staff and community engagement, and they represent a range of suggested ideas to be developed further in future planning processes. The potential actions are organized below by the key themes that emerged from the engagement process, as described in the previous section. Each action includes a description and an indication of which of the six key vulnerabilities it addresses. A guide of considerations for future implementation is included in the following section.

Key Theme

Public Engagement and Outreach

Table 32. Public engagement and outreach actions.

PD = Property Damage

PI = Personal Injury

WD = Water Disruption

ED = Energy Disruption

AES = Access to Essential Service

BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
1. **Education for Building Owners, Homeowners and Renters**: Consider developing multilingual education programs specifically for building owners, homeowners and renters to take action to make their homes more resilient and improve preparedness.	Yes	No	Yes	Yes	No	No

PD = Property Damage | **PI** = Personal Injury

WD = Water Disruption | **ED** = Energy Disruption

AES = Access to Essential Service | **BR** = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
2. **Education for High-Risk Neighborhoods and Farms**: Prioritize multilingual engagement in high vulnerability neighborhoods and agricultural areas, including expanding communication efforts about the CERT program; developing a multilingual community navigator program; offering emergency preparedness programs and resources, including water conservation, energy efficiency, and support for food security; and enhancing community awareness about priority climate risks (e.g., wildfire, extreme heat and cold, hailstorms and flooding). Consider notifying high-risk facilities of wildfire vulnerabilities and offering customized activities for older adults and individuals without housing.	Yes	Yes	Yes	Yes	Yes	Yes
3. **Provide a Platform to Connect Those in Need With Helpers**: Establishing a volunteer coordination platform or an alert system that connects those in need with available helpers to improve mutual aid efforts.	No	Yes	No	No	No	No
4. **Provide a Voluntary Register for Assistance During Extreme Weather**: Provide a voluntary register for citizens, including seniors and individuals living with a disability, that may require assistance or support during extreme weather events.	No	Yes	No	No	Yes	No

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PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
5. **Enhanced Communication Efforts for Heat Repair Program and Weatherization Assistance Program**: Define, design and implement multilingual communication activities about these programs through targeted outreach, social media campaigns and community workshops to ensure that more residents benefit from them.	No	Yes	Yes	Yes	Yes	No
6. **Offer Remote Services**: Conduct an internal review of essential programs and services that can be offered remotely and conduct multilingual public engagement to prioritize remote service offerings.	No	No	No	No	Yes	No
7. **Incorporate Indigenous Knowledge in Climate Action Initiatives**: Collaborate with Native American communities to integrate their traditional ecological knowledge, cultural practices and perspectives into climate strategies.	Yes	Yes	Yes	Yes	Yes	Yes
8. **Create a Climate Change Youth Committee**: Involve youth by creating a Climate Change Youth Committee.	Yes	Yes	Yes	Yes	Yes	Yes
9. **Define Vulnerable Population With Diversity, Equity and Inclusion Committee**: Define vulnerable populations, working with a Diversity, Equity and Inclusion (DEI) Advisory Committee.	Yes	Yes	Yes	Yes	Yes	Yes
10. **Develop an Equity Checklist in Climate Adaptation Plan**: Apply an equity checklist to climate adaptation and resilience projects and programs.	Yes	Yes	Yes	Yes	Yes	Yes

Key Theme

Emergency Preparedness and Planning

Table 33. Emergency preparedness and planning actions.

PD = Property Damage

PI = Personal Injury

WD = Water Disruption

ED = Energy Disruption

AES = Access to Essential Service

BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
11. Support Disaster Outreach and Recovery Teams: Collaborate with police, the fire department and nonprofits to develop multilingual outreach teams that focus on connecting with individuals facing barriers or experiencing homelessness or inadequate housing prior to, during or after extreme weather events. Collaborate to hand out water, food and medications; provide information about extreme events warnings; and offer advice about services (such as cooling stations, businesses and facilities that welcome people to stay longer on hot days, and any free transit initiatives during extreme weather events). These teams could also coordinate community-led cleanup days, volunteer repair programs or partnerships with local businesses, and nonprofits could provide much-needed support for residents recovering from extreme weather events.	No	Yes	No	No	Yes	No

PD = Property Damage
PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
12. **Consider expanding the Services of the Extreme Weather Shelter and Resilience Hubs**: Identify and provide indoor spaces for clean air shelters, cooling shelters and temporary shelters during extreme weather events, making them be pet friendly. Include a strategy for deploying temporary shade structures in public spaces. Consider providing behavioral and mental health support and recreational activities at shelters and using naturally occurring cooling/warming resources (e.g., libraries, recreation centers). Explore the implementation of resilience hubs to serve as multipurpose centers offering multilingual education, emergency supplies and social services before and during extreme weather events.	No	Yes	Yes	Yes	Yes	No
13. **Explore Free Transportation Services During Extreme Weather**: Improve accessible transportation during extreme weather for essential services such as free passes and defined routes.	No	Yes	No	No	Yes	Yes
14. **Continue to Address Trauma from Extreme Weather Events:** Explore opportunities to increase availability and capacity of initiatives to address trauma from extreme weather events by providing additional mental health support and crisis management for those affected by extreme weather and its aftermath.	No	Yes	No	No	No	No

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ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
15. **Review the Jefferson County Wildland Fire Evacuation Plan:** Review and update the Jefferson County Wildland Fire Evacuation. Plan to account for the needs of individuals in nursing homes and assisted living facilities during emergencies.	No	Yes	No	No	Yes	No
16. **Review Emergency Telecommunications:** Review internal communications during extreme weather events to identify gaps and coordinate investments in backup systems for telecommunications outages (e.g., internet, phone lines).	No	No	No	No	Yes	No
17. **Create an Electric Vehicle Best Practices Guide for Users:** Create a user guide for city staff with electric fleet vehicles, ensuring vehicle maintenance and readiness for extreme weather scenarios (e.g., power outages, relocation, property damage prevention).	Yes	No	No	No	Yes	No
18. **Develop a Heat Management Plan for Public Spaces:** Create a policy to ensure shaded spaces and a heat management plan at all public events and events hosted on city-owned lands.	No	Yes	No	No	No	No
19. **Require a Heat Management Plan for Event Applications:** Ensure that all individuals and groups hosting events on public lands are aware of the shaded spaces and heat management plan policy and require that they submit a heat management plan with their event application. Multilingual education on an appropriate heat management plan should be provided.	No	Yes	No	No	No	No

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PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
20. **Develop a Minimum Shading Standard for Public Spaces**: Create a policy or design guideline for public spaces to incorporate shade structures and set a minimum shaded area standard for public spaces.	No	Yes	No	No	No	No
21. **Explore Emergency Cooling Zones**: Consider developing a strategy for when, where and how to deploy temporary structures, such as event tents, in public spaces to be used as temporary shade structures and promote these to the public. Identify cooled indoor spaces that can be used as clean air shelters during times with poor air quality due to wildfire smoke.	No	Yes	Yes	Yes	Yes	No
22. **Build Splash Pads**: Create an implementation schedule and construct splash pads in key locations previously identified by the city. Fountain features should be 100% recirculating and fed from harvested rainwater using treatment systems that comply with CSA B805-18/ICC 805-2018, with prioritization of energy efficiency and chlorine-free treatment.	No	Yes	No	No	No	No
23. **Extend the Water Feature Season**: Extend the season of water fountains, splash pads and cooling facilities so they are open to the public to coincide with weather and climate trends.	No	Yes	No	No	No	No
24. **Support Department Needs and Policy Changes During Extreme Weather**: Consult individual departments on operational needs and policy changes during inclement weather and extreme weather conditions.	Yes	Yes	Yes	Yes	Yes	No

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AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
25. **Adjust Anti-Idle Policy During Extreme Weather**: Support the exception in anti-idling policies — do not preclude outdoor staff from staying warm, dry or cool in inclement weather or on extreme heat days. For example, designate one "cooling" truck on a work site that workers can access as an air-conditioned space.	No	Yes	No	No	Yes	No
26. **Develop Outdoor Work Recommendations**: Inform private businesses/employers about the city''s strategy and tips for reducing outdoor workers' exposure to extreme weather conditions.	No	Yes	No	No	Yes	No
27. **Consider Budgets for Personal Protective Equipment (PPE) for Extreme Weather**: Ensure adequate budget for personal protective equipment and clothing to decrease weather-related exposure and risk and inform departments about their ability to have such budget requests considered.	No	Yes	No	No	Yes	No

Key Theme

Climate-Resilient Infrastructure

Table 34. Climate-resilient infrastructure actions.

PD = Property Damage
PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
28. **Create Community Climate Standards**: Create and implement guidelines to increase the resilience of homes and farms to extreme weather by installing cool roofs, fire-smart retrofits, energy efficiency upgrades, and waterproofing.	Yes	Yes	Yes	Yes	Yes	Yes
29. **Expand Sustainable Development Standards**: Expand development standards to include fire-proofing measures, such as spark arrestors and fire-resistant materials, for new constructions in wildfire-prone areas, as well as requirements to reduce or avoid the use of impervious surfaces.	Yes	Yes	Yes	Yes	Yes	Yes
30. **Expand the Sustainable Neighborhoods Program**: Expanding the program will include establishing projects and events geared to improving the resilience of the neighborhood. These additional activities may include neighborhood workshops for emergency planning, setting up an emergency checklist, Neighborhood Buddy Program to assist neighbors with snow/ice clearing, implementing an invasive species watch, and performing tree planting.	Yes	Yes	No	No	No	Yes

PD = Property Damage
PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
31. **Explore the Development of Rebate Programs for Flood- and Fire- Proofing Upgrades in High-Risk Neighborhoods**: Implement rebate programs to promote upgrades to existing households.	Yes	Yes	Yes	Yes	Yes	No
32. **Complete a Storm Sewer Replacement Study**: Assess storm sewer replacement studies with a climate lens to determine high-priority culvert replacements and needs for over-sizing. Define right-sized culvert replacement, based on the city's design standards, and integrate into asset management planning and budgeting, as opposed to one-for-one replacements.	Yes	No	Yes	No	No	No
33. **Review High-Risk Roads Prone to Flooding**: Assess high-risk roads that are prone to flooding to prioritize them for flood mitigation measures and integrate findings into the city's Asset Management Plan. Consider developing drainage master plans at the local level.	Yes	No	Yes	No	Yes	No
34. **Strengthen Water and Food Security**: Improve water security and efficiency in agricultural areas by expanding graywater systems, non-potable water use and rainwater harvesting. Implement advanced irrigation techniques, such as drip irrigation, and promote soil moisture retention strategies like mulching to increase drought resilience. Strengthen local food security efforts and enhance energy efficiency programs to ensure that both urban and rural communities are better prepared for climate-related disruptions.	No	No	No	No	Yes	No

Key Theme

Energy Resilience

Table 35. Energy resilience actions.

PD = Property Damage | **PI** = Personal Injury

WD = Water Disruption | **ED** = Energy Disruption

AES = Access to Essential Service | **BR** = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
35. Establish Guidelines for 24-Hour Energy Emergency Supply Plans: Collaborate with the development community to establish minimum targets for multi-unit residential buildings to ensure that emergency energy supply is provided to meet minimum life safety requirements, which specify 24 hours of power supply to facilitate occupant evacuation and firefighter access. During sustained area-wide power outages, emergency power is not designed to keep residents in their buildings with any degree of comfort, even if there is no particular problem with the building.	No	Yes	No	Yes	Yes	No
36. Establish Guidelines for 72-hour Energy Backup Supply Plans: Collaborate with the development community to establish minimum targets for multi-unit residential buildings to ensure that the backup energy supply sufficiently allows residents to remain safely and with a degree of comfort in their dwelling for at least 72 hours.	No	Yes	No	Yes	Yes	No

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PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
37. **Integrate Energy Storage During Extreme Weather**: Integrate energy storage into emergency heating and cooling centers to enable continued operation during partial disruptions.	No	Yes	No	Yes	Yes	No
38. **Study Community-Scale Energy Generation and Storage Opportunities**: Conduct a study to assess opportunities for community-scale renewable energy and energy storage.	No	No	No	Yes	No	No
39. **Study Community-Scale Microgrid Opportunities**: Conduct a study to explore microgrids in existing developed areas.	No	No	No	Yes	No	No
40. **Study District Energy in New Developments**: Conduct a study to explore ambient district energy systems in new development areas with higher building intensities.	No	No	No	Yes	No	No
41. **Explore Creating a Rebate Program to Support Renewable Energy Initiatives and Battery Implementation**: Consider developing a rebate program to incentivize the adoption of renewable energy systems and battery storage for households, businesses and community facilities. Offer financial incentives for solar panel installations, battery backup systems and other clean energy technologies to enhance energy resilience and prioritize support for households living on low and middle incomes to ensure equitable access to renewable energy benefits.	No	No	No	Yes	No	No

PD = Property Damage

PI = Personal Injury

WD = Water Disruption

ED = Energy Disruption

AES = Access to Essential Service

BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
42. **Explore Creating a Utility Cost Assistance Program for Families Not Qualifying for LEAP:** Explore opportunities to provide targeted financial relief for households struggling with heating and cooling expenses who do not qualify for the Low-Income Energy Assistance Program, particularly during extreme weather events, and ensure accessibility by streamlining the application process.	No	No	No	Yes	No	No

Key Theme

Natural Spaces and Green Infrastructure

Table 36. Natural spaces and green infrastructure actions.

PD = Property Damage
PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
43. Community Tree Planting: Implement planting of shade trees alongside trails, sidewalks, creeks and outdoor sports fields/facilities and encourage residents to plant trees by hosting community tree planting events.	No	Yes	No	No	No	Yes
44. Develop a Tree Canopy Target: Implement a target to increase the tree canopy coverage with native and climate-resilient species, with a particular focus on locations above 68°F by 2070.	No	Yes	No	No	No	Yes
45. Develop an Invasive Species Response Team: Put out an open call and assemble interested parties who wish to distribute and monitor invasive species traps and report back to the city.	No	No	No	No	No	Yes
46. Educate Staff on Invasive Species: Inform staff about invasive species through an internal education program with a focus on the Early Detection and Distribution Mapping System.	No	No	No	No	No	Yes

PD = Property Damage

PI = Personal Injury

WD = Water Disruption

ED = Energy Disruption

AES = Access to Essential Service

BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
47. Promote Sustainable Soil and Land Management: Target farmers to promote soil conservation techniques such as no-till farming, composting and rotational grazing to enhance carbon sequestration and water retention. Promote crop diversification and regenerative agriculture to maintain and improve yields under changing climate conditions.	No	No	Yes	No	No	Yes
48. Update and Expand the Natural Areas Plan: Integrate heat management planning as a key topic in the city's natural areas plan to address climate impacts on local ecosystems.	No	No	No	No	No	Yes
49. Voluntary Reporting of Animal and Plant Sightings: Partner with grassroots organizations and nonprofits to improve residents' knowledge and create a platform for reporting unusual animal sightings, while sharing information about animal behavior changes.	No	No	No	No	No	Yes

Key Theme

Governance and Collaboration

Table 37. Governance and collaboration actions.

PD = Property Damage | **PI** = Personal Injury | **WD** = Water Disruption | **ED** = Energy Disruption | **AES** = Access to Essential Service | **BR** = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
50. Incorporate Climate Lens in Asset Management: Incorporate climate risk within the asset management policy and ensure its incorporation is compatible with the activity occurring at levels of jurisdiction.	Yes	No	Yes	Yes	Yes	No
51. Incorporate Climate Lens in Budgeting: Integrate climate resilience into the priority-based budgeting mechanism and reflect the findings from the asset management plan renewal.	Yes	No	Yes	Yes	Yes	Yes
52. Incorporate Climate Lens in Procurement: Integrate climate change mitigation and adaptation in a sustainable procurement policy. The policy is fully integrated when results are reflected in the asset management plan renewal.	Yes	No	Yes	Yes	Yes	No
53. Report on Climate Impacts: Consider opportunities to share analysis of climate impacts, risks, and adaptation strategies with decision makers and the community.	Yes	Yes	Yes	Yes	Yes	Yes
54. Review of Insurance for Municipal Assets: Review the city's insurance policies to ensure coverage for extreme weather events affecting municipal assets.	Yes	No	Yes	Yes	Yes	No

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PI = Personal Injury
WD = Water Disruption
ED = Energy Disruption
AES = Access to Essential Service
BR = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
55. Integrate Climate Change into DEI Initiatives: Integrate climate change and emergency preparedness in the city's Diversity, Equity and Inclusion initiatives to better identify how to deliver services that are reflective of the community.	Yes	Yes	Yes	Yes	Yes	Yes
56. Support Staff Analyzing Project Climate Risk: Empower staff to analyze climate risk in their projects through knowledge exchange activities (peer-to-peer, learning sessions, workshops, etc.)	Yes	Yes	Yes	Yes	Yes	Yes
57. Train Staff on Climate Adaptation: Involve city staff in climate change adaptation and resilience through training and workshops.	Yes	Yes	Yes	Yes	Yes	Yes
58. Encourage Cross-Department Climate Risks Coordination: Coordinate across internal departments to ensure clear communication strategies for cross-departmental responsibilities.	Yes	Yes	Yes	Yes	Yes	Yes

PD = Property Damage | **PI** = Personal Injury

WD = Water Disruption | **ED** = Energy Disruption

AES = Access to Essential Service | **BR** = Biodiversity Risk

Potential Action	PD	PI	WD	ED	AES	BR
59. Enhance Regional Coordination for Wildfire and Extreme Weather Resilience: Establish joint wildfire risk assessments, share real-time fire and air quality data and align emergency response protocols to enhance preparedness across municipal boundaries. Expand early-warning systems for floods, hailstorms and heatwaves to protect urban and agricultural areas from extreme weather impacts and promote fire-resistant practices such as firebreaks and controlled burns, reducing fuel loads and preventing uncontrolled wildfires. Partner on fuel reduction projects, fire-adapted land management strategies and climate resilience funding initiatives to help ensure a more unified and effective response to growing wildfire threats.	Yes	Yes	Yes	Yes	Yes	Yes
60. Explore Establishing a Community-Based Advisory Service for Financial Recovery: Consider establishing this service to support residents in navigating insurance claims after extreme weather events, understanding their coverage and improving their ability to recover financially after disasters.	Yes	No	No	No	No	No
61. Identify Nonprofits Supporting Snow-Removal Services: Coordinate with nonprofits providing snow-removal services to offer support for populations facing barriers during winter weather events.	No	Yes	No	No	Yes	No

Considerations for Future Implementation

This Climate Hazard and Social Vulnerability Study identified 61 options for potential adaptation actions that could be used to enhance Lakewood's resilience to current and future climate risks. The following section outlines preliminary considerations for developing future implementation strategies for the actions. Each action is accompanied by a description of the action type, a key metric to measure the implementation of the action and a high-level cost estimate for the action.

These cost estimates only reflect the cost of completing the specific action itself, excluding any follow-up actions. For example, the estimate for the action "Study Community-Scale Energy Generation and Storage Opportunities" only covers the cost of completing the study and not of developing community-scale renewable energy projects. For ongoing program costs, the estimate reflects the annual expected cost of the action. The estimates are preliminary and should not be relied upon without verification. **Table 38** describes these components in more detail.

Table 38. Description of columns in the implementation table.

Indicator	Description
Potential Action	Name of the action.
Action Types	**Project**: A time-limited, specific effort aimed at achieving a particular outcome or deliverable.
	Program: An ongoing organized initiative or effort that aims to achieve specific long-term goals. Cost estimates reflect annual program costs.
	Policy: A formal set of rules, regulations or guidelines to establish standards or direct behavior.
	Partnership: A collaboration with an organization, business or another government.
	Study: A research process focused on gathering data, assessing risks or evaluating solutions to inform decision-making or future actions.
Key Metric	A measurable indicator that tracks progress, effectiveness or success toward achieving a specific goal or objective.
Cost Estimate	**Low ($)**: Less than $80,000 USD
	Medium ($$): $80,000 to $500,000 USD
	High ($$$): More than $500,000 USD

Key Theme:

Public Engagement and Outreach

Table 39. Considerations for future implementation related to Public Engagement and Outreach.

Action	Action Type	Possible Metric	Cost Estimate
1. Education for Building Owners, Homeowners and Renters	Program	# of owners and renters engaged	$
2. Education for High-Risk Neighborhoods and Farms	Program	# of community members engaged	$
3. Provide a Platform to Connect Those in Need With Helpers	Program	# of community members connected	$
4. Provide a Voluntary Register for Assistance During Extreme Weather	Program	# of registrants	$
5. Enhanced Communication Efforts for Heat Repair Program and Weatherization Assistance Program	Partnership	% increase in program applications	$
6. Offer Remote Services	Program	# of remote service days per service	$
7. Incorporate Indigenous Knowledge in Climate Action Initiatives	Partnership	% of Indigenous Knowledge holders engaged with	$$
8. Create a Climate Change Youth Committee	Program	Committee created and meeting regularly	$
9. Define Vulnerable Population With Diversity, Equity and Inclusion Committee	Project	Definition developed	$
10. Develop an Equity Checklist in Climate Adaptation Plan	Project	% of projects equity checklist is applied to	$

Key Theme:

Emergency Preparedness and Planning

Table 40. Considerations for future implementation related to Emergency Preparedness and Planning.

Action	Action Type	Possible Metric	Cost Estimate
11. Support Disaster Outreach and Recovery Teams	Program	# of vulnerable persons contacted during each event	$$
12. Consider Expanding the Services of the Extreme Weather Shelter and Resilience Hubs	Program	# of shelter spaces provided	$$$
13. Explore Free Transportation Services During Extreme Weather	Program	# of transit routes offered	$$
14. Continue to Address Trauma from Extreme Weather Events	Project	# of initiatives updated	$$
15. Review the Jefferson County Wildland Fire Evacuation Plan	Project	Plan updated	$$
16. Review Emergency Telecommunications	Project	# of backup systems developed	$
17. Create an Electric Vehicle Best Practices for Users	Project	Guide developed and and distributed	$
18. Develop a Heat Management Plan for Public Spaces	Project	Policy status	$$
19. Require a Heat Management Plan for Event Applications	Policy	% of applications with a heat management plan	$
20. Develop a Minimum Shading Standard for Public Space	Policy	% of 'shade canopy' in public spaces, # of public spaces with shade facilities	$

Action	Action Type	Possible Metric	Cost Estimate
21. Explore Emergency Cooling Zones	Program	# of temporary shelters, anticipated schedule of operation	$$
22. Build Splash Pads	Project	# of planned splash parks constructed	$$$
23. Extend the Water Feature Season	Program	# days in water feature season	$$
24. Support Department Needs and Policy Changes During Extreme Weather	Program	# of departments consulted	$
25. Adjust Anti-Idle Policy During Extreme Weather	Policy	Policy exception made in all relevant climate hazard scenarios	$
26. Develop Outdoor Work Recommendations	Project	Recommendations developed and shared	$
27. Consider Budgets for PPE for Extreme Weather	Program	Budget allocated for PPE	$

Key Theme:

Climate-Resilient Infrastructure

Table 41. Considerations for future implementation related to Climate-Resilient Infrastructure.

Action	Action Type	Possible Metric	Cost Estimate
28. Create Community Climate Standards	Policy	Standards developed and implemented	$$
29. Expand Sustainable Development Standards	Policy	Standards updated and implemented	$$
30. Expand the Sustainable Neighborhoods Program	Program	# of community members engaged	$$$
31. Explore the Development of Rebate Programs for Flood- and Fire-Proofing Upgrades in High-Risk Neighborhoods	Project	# of upgrades completed, $ allocated, estimated ROI	$$$
32. Complete a Storm Sewer Replacement Study	Study	Completion of study	$$$
33. Review High-Risk Roads Prone to Flooding	Study	# of miles of road, type of road	$$
34. Strengthen Water and Food Security	Program	% of households experiencing food insecurity	$$$

Key Theme:

Energy Resilience

Table 42. Considerations for future implementation related to Energy Resilience.

Action	Action Type	Possible Metric	Cost Estimate
35. Establish Guidelines for 24-Hour Energy Emergency Supply Plans	Project	Plan completed	$
36. Establish Guidelines for 72-hour Energy Backup Supply Plans	Project	Plan completed	$
37. Integrate Energy Storage During Extreme Weather	Project	% of emergency centers with energy storage	$$$
38. Study Community-Scale Energy Generation and Storage Opportunities	Study	Study completed	$
39. Study Community-Scale Microgrid Opportunities	Study	Study completed	$
40. Study District Energy in New Developments	Partnership	Study completed	$
41. Explore Creating a Rebate Program to Support Renewable Energy Initiatives and Battery Implementation	Program	# of rebates provided	$$$
42. Explore Creating a Utility Cost Assistance Program for Families Not Qualifying for LEAP	Program	# of residents registered	$$$

Key Theme:

Natural Spaces and Green Infrastructure

Table 43. Considerations for future implementation related to Natural Spaces and Green Infrastructure.

Action	Action Type	Possible Metric	Cost Estimate
43. Community Tree Planting	Program	# of trees planted, projected tree canopy increase	$$
44. Develop a Tree Canopy Target	Policy	Target developed	$
45. Develop an Invasive Species Response Team	Program	# of trees treated, geographic spread of sightings	$
46. Educate Staff on Invasive Species	Program	# of targeted staff trained	$
47. Promote Sustainable Soil and Land Management	Project	# of acres converted to regenerative practices	$$
48. Update and Expand the Natural Areas Plan	Project	Plan updated	$$
49. Voluntary Reporting of Animal and Animal Sightings	Program	# of reported sightings, # unique participants	$

Key Theme:

Governance and Collaboration

Table 44. Considerations for future implementation related to Governance and Collaboration.

Action	Action Type	Possible Metric	Cost Estimate
50. Incorporate Climate Lens in Asset Management	Policy	% of assets assessed with climate risk lens	$
51. Incorporate Climate Lens in Budgeting	Policy	Impacts of climate change included in the official budget	$
52. Incorporate Climate Lens in Procurement	Policy	Policy developed and implemented	$
53. Report on Climate Impacts	Policy	% of reports with assessment of climate risk	$
54. Review of Insurance for Municipal Assets	Project	Review completed	$
55. Integrate Climate Change into DEI Initiatives	Program	% of initiatives climate change is incorporated into	$
56. Support Staff Analyzing Project Climate Risk	Program	% of priorities/ projects being supported by trained staff	$
57. Train Staff on Climate Adaptation	Program	% of staff completed training	$
58. Encourage Cross-Department Climate Risks Coordination	Program	# of departments consulted	$
59. Enhance Regional Coordination for Wildfire and Extreme Weather Resilience	Partnership	# of regional partnerships developed	$$

Action		Action Type	Possible Metric	Cost Estimate
60.	Explore Establishing a Community-Based Advisory Service for Financial Recovery	Partnership	# of residents advised, satisfaction of advisees	$$
61.	Identify Nonprofits Supporting Snow-Removal Services	Project	# of services identified	$

Image: Lakewood Civic Center Plaza. Source: City of Lakewood.

Appendix A: Data, Methods and Assumptions Manual

(External document)