Sacramento Transportation Infrastructure Vulnerability Assessment

June 2025

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Introduction

This vulnerability assessment will inform the priorities and focus areas of the SacAdapt Sacramento Transportation Infrastructure Adaptation Plan. Some key terms used throughout the vulnerability assessment are defined in Figure 1.

Climate Vulnerability	The extent to which individuals, communities, or infrastructure are exposed to, susceptible to, and/or unable to cope with or adapt to the effects of climate change
Climate Resilience	The ability of a system, community, structure, or individual to withstand and recover from a climate hazard while maintaining its core functions
Adaptive Capacity	The ability to respond to climate change impacts
Hazard Likelihood	The probability of being adversely affected by a hazard
Hazard Risk	The overall impact of a hazard based on a combination of likelihood and severity

Figure 1. Relevant definitions to the assessment, adapted from the 2024 City of Sacramento Climate Action and Adaptation Plan Vulnerability Assessment

A literature review compiling relevant plans, strategies, and data was conducted to document the analysis that has already occurred in the region and the relevant strategies and plans for this assessment. One of the more critical documents reviewed, the 2024 City of Sacramento Climate Action & Adaptation Plan (CAAP), includes a Climate Change Vulnerability Assessment (VA); this assessment draws from the CAAP VA where possible.[1] However, this assessment differs from the CAAP VA in two key ways: 1) this assessment has a direct focus on transportation, and 2) this assessment incorporates the most recent generation of climate projections as of January 2025.

Table 1 was adapted from the CAAP VA, detailing the assessment of climate hazards most likely to affect Sacramento and qualifying the impact of each on the city.

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[1] https://www.cityofsacramento.gov/content/dam/portal/cdd/Planning/Long-Range/Climate-Action-Plan/18-06051_Sac CAAP_Digital - Final Adopted FEB272024.pdf

Table 1. Primary and secondary climate change impacts in Sacramento. Adapted from Table 2-1 in the 2024 City of Sacramento Climate Action and Adaptation Plan Vulnerability Assessment

Impacts	Temporal Extent	Spatial Extent	Permanence	Level of Disruption	Level of Uncertainty
Temperature Increase • Increased Heat waves • Increased Urban heat island effects • Warmer average temperatures	**Moderate**. Effects will be most extreme in July and August, but may be felt anytime between May and October	**High**. Effects will be felt throughout the City, but will be most extreme in and around urban heat islands	**High**. The most extreme effects will be seasonal, but average ambient temperatures will increase steadily over the century	**High**. Increased strain and potential physical damage to energy, utility, and transportation infrastructure from extreme heat; risk of blackouts; and heat-related illness/death. Higher source water temperature create need for additional water treatment technologies	**Low**.
Precipitation Changes • Extreme Storms • Flooding • Snowpack reduction • Drought • Reduced groundwater recharge • Increased water temperature • Deteriorated water quality	**High**. Increased likelihood of riverine flooding in winter/early spring. Reduced surface water supply in summer due to reductions in winter snowpack	**High**. Nearly all of the city is low-lying and dependent on levee protection and a system of pumping stations, pipes, ditches, and channels, but areas already susceptible to localized, riverine, and flash flooding and/or that have limited stormwater infrastructure will be most affected by increased winter rain and flows. Drought will affect most areas and increase demand for groundwater use	**High**. The most extreme effects will be seasonal, with continued changes expected over the century	**High**. A large storm could cause significant health and infrastructure impacts over potentially large portions of the city. Increased water temperature is harmful to water treatment, reservoir and hydroelectric operation, and ecological health	**Moderate**. While impacts vary year to year, climate change is increasing the likelihood of a storm event capable of significant flooding; drought frequency is projected to increase in California
Wildfire • Declines in air quality	**Moderate**. Projected wildfire extent/severity is highly variable but will generally increase over the century. Future fire seasons may become longer	**High**. A wildfire is unlikely to break out within City limits, but wildfire smoke will affect the entire city	**Moderate**. Wildfire intensity is expected to gradually increase, with significant year-to-year variability	**Moderate**. The wildfire impact most likely to have a significant impact on the city is reduced air quality from wildfire smoke	**Moderate**.
Sea Level Rise • Higher river levels during major storm events	**Low**. Sea level rise is projected to occur gradually over the course of the century	**Low**. Areas within or near the Delta are most at risk	**High**. In the longer term, sea level rise may exacerbate flood risk associated with major storm events	**Low**. Effects may be significant when coinciding with riverine or flash flooding. Increasing salinity of water may increase burden on upper watershed resources	**Moderate**.

Additional relevant studies provided useful data, like the 2020 NASA Extreme Heat and Social Vulnerability Study that developed extremely high-resolution data showing areas where extreme heat impacts the city most strongly;[2] and the 2022 Central Valley Flood Protection Plan which includes a detailed assessment of flood risk for the Sacramento and American Rivers.[3]

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[2] https://storymaps.arcgis.com/stories/ff71072724c14084a7e674df9847708b

[3] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan/Files/CVFPP-Updates/2022/Central_Valley_Flood_Protection_Plan_Update_2022_ADOPTED.pdf

1. Climate Science & Projections

To analyze future climate impacts in Sacramento, the following datasets and tools were used:

- **Localized Constructed Analogs Version 2 (LOCA2) Hybrid**:[4] recently developed high-resolution downscaled climate projections for temperature, precipitation, and humidity across California utilizing the most recent generation of climate models from the sixth Coupled Model Intercomparison Project (CMIP6). This robust dataset is specific to California and incorporates a strong combination of techniques including different types of downscaling that provide more accurate projections for localized conditions. This data was used for the analysis of heat index and heavy precipitation. The following parameters were used for the analysis based on this data:
    - Time Periods:[5]
        - Historical Baseline: 1985-2014
        - Mid-Century/2050s: 2035-2064
        - End-of-Century/2080s: 2070-2099
    - Emissions Scenarios:
        - SSP 2-4.5 (Moderate Emissions): some mitigation and adaptation measures are taken globally, there is some level of cross-country collaboration, and global population growth levels off in the second half of the century
        - SSP 3-7.0 (High Emissions): greater levels of coal use, social inequality, population growth, nationalism, and regional conflicts and security concerns with decreasing investments in technological development, leading to drastic environmental damage
        - SSP 5-8.5 (Very High Emissions): continual and increasing use of fossil fuels continuing throughout the coming century, reaching levels of around double the current consumption level by the end of the century – this is now considered a worst-case outcome
- **California Heat Assessment Tool (CHAT)**:[6] tool developed by the state of California to estimate future heat health events, or periods of extreme heat where public health impacts become more likely. While CHAT relies on CMIP5 data, rather

[4] https://loca.ucsd.edu/loca-version-2-for-california-ca-may-2023/

[5] The future time periods are the same as those used in the CAAP, but the historical period differs because the baseline data used by LOCA have since been updated. The CAAP used data from CMIP5 LOCA projections.

[6] https://www.cal-heat.org/

than the current CMIP6 data, it remains a valuable resource for assessing the risks of extreme heat on public health for transit riders. This data is based on LOCA, the previous generation of projections, using the localized constructed analogs statistical downscaling method. The emissions scenarios are slightly less refined than the SSPs and do not include consideration of social dynamics and inequalities but are comparable to two of the SSPs used. The following parameters were used for the analysis based on this data:

   - Time Periods (year-round; and June, July, and August):
     - Historical: 1984-2013 (weather data); 2005-2013 (health data)
     - Mid-Century/2050s: 2041-2060
     - End-of-Century/2080s: 2071-2090
   - Emissions Scenarios – Representative Concentration Pathways (RCPs):
     - RCP 4.5 (Moderate Emissions): fossil fuel dependence peaks in 2040 and declines for the remainder of the century – comparable to SSP 2-4.5
     - RCP 8.5 (Very High Emissions): fossil fuel dependence increases and continues growing higher through the end of the century – comparable to SSP 5-8.5
- **NASA Extreme Heat and Social Vulnerability Study**:[7] 2020 study from NASA DEVELOP that produced an urban heat island index based on historical remote sensing data at a very high resolution.
- **Central Valley Flood Protection Plan (CVFPP)**:[8] 2022 report from California Department of Water Resources (DWR) with projected future flows and water surface elevations for large rivers, including the American and Sacramento Rivers.

All these datasets use the statistical downscaling method of localized constructed analogs, which refines coarse global climate model (GCM) outputs to more fine-grained data to better represent local conditions. LOCA2 improves upon the previous iteration by better simulating extreme events, particularly for precipitation, based on improved spatial pattern analysis and updated baseline data upon which the projections are trained. This data underpins the National Climate Assessments, and the California-specific LOCA2 data was used in the most recent California Climate Assessment. The following sections contain the results of the analyses.

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[7] As of April 2025, due to ongoing changes in the federal administration, this dataset is no longer publicly available and was not able to be used in its entirety.

[8] https://water.ca.gov/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan

1.1 Extreme Heat

The LOCA2 Hybrid data was used to project future conditions for extreme heat for dry bulb temperature thresholds (those that only consider air temperature) and heat index (which considers both air temperature and humidity). The prior generation of data was used in conjunction with the CHAT tool to project heat health events.

Under all emissions scenarios and for every future time period, the frequency and intensity of extreme heat events is projected to increase. The sensitivities discussed in the previous section related to heat will all be exacerbated to some degree in the future. As the effects of extreme heat grow more frequent and intense, vulnerable populations, those with underlying health conditions, households without cars, and people without access to regular cooling will be at the greatest risk.

From waiting at the bus stop in warmer temperatures to missing work due to transit delays because of malfunctioning equipment, impacts on transit riders will vary. A study published in 2024 by researchers from Arizona State University and the University of Texas at Austin found that extreme heat, particularly when combined with humidity (heat index), makes people more likely to stay indoors, avoid non-essential travel, and travel in early morning or late evening rather than mid-day.[9] The study also found that public transit trips decrease by nearly 50% on extremely hot days and car trips (with reliable air conditioning in personal vehicles) increase, presenting significant challenges for public transit. This impact could make it more challenging for the region to achieve its goals for mode shift toward more public transit and active transportation.

1.1.1 Temperature Thresholds

Five different temperature thresholds were selected for analysis in this assessment based on a combination of the feedback received in interviews and high impact thresholds for transportation infrastructure. The thresholds were selected with the following reasoning:

- **80°F** – Occupational Safety and Health Administration (OSHA) standards for outdoor worker safety measures implemented[10]
- **90°F** – General infrastructural impacts to roads, rails, bridges, and vehicles[11]

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[9] https://www.sciencedirect.com/science/article/abs/pii/S1361920924003882
[10] https://www.dir.ca.gov/title8/3395.html
[11] https://nca2009.globalchange.gov/transportation/index.html#:~:text=and%20safety.2-,Extreme%20Temperatures%20and%20Drought,snow%20and%20ice%20removal%20costs.&text=Increases%20in%20very%20hot%20days,rail%20closures%20in%20affected%20areas

- **95°F** – OSHA standards for outdoor worker safety measures implemented;[12] minor City contractor work restrictions[13]
- **100°F** – SacRT overhead catenary system (OCS) speed restrictions;[14] general infrastructural impacts to equipment;[15] DPW worker health concern threshold noted in staff interview; SacRT Facilities CNG compressor malfunction threshold noted in staff interview
- **104°F** – SacRT warping of light rail tracks threshold noted in staff interview; threshold of extreme heat as defined by the CAAP VA (103.8°F)

The results of this analysis are shown in Table 2. As expected, the number of average annual days above each threshold increases over the coming century for each scenario, with greater intensity under the higher emissions scenarios. For example, there has been a historical average of six days with temperatures at or above 104°F. This is projected to increase to 27 days per year, by the 2080s under the 'high' emissions scenario, or 39 days under the 'very high' emissions scenario. The thresholds were calculated individually, not categorically, meaning that a day of 92°F will count as both a day over 80°F and a day over 90°F. Maps are available in the appendix.

Table 2. Average annual number of days over thresholds ranging from 80°F to 104°F. Values shown are the 50th percentile, and the 10th and 90th percentiles are italicized in parentheses to provide uncertainty bounds[16]

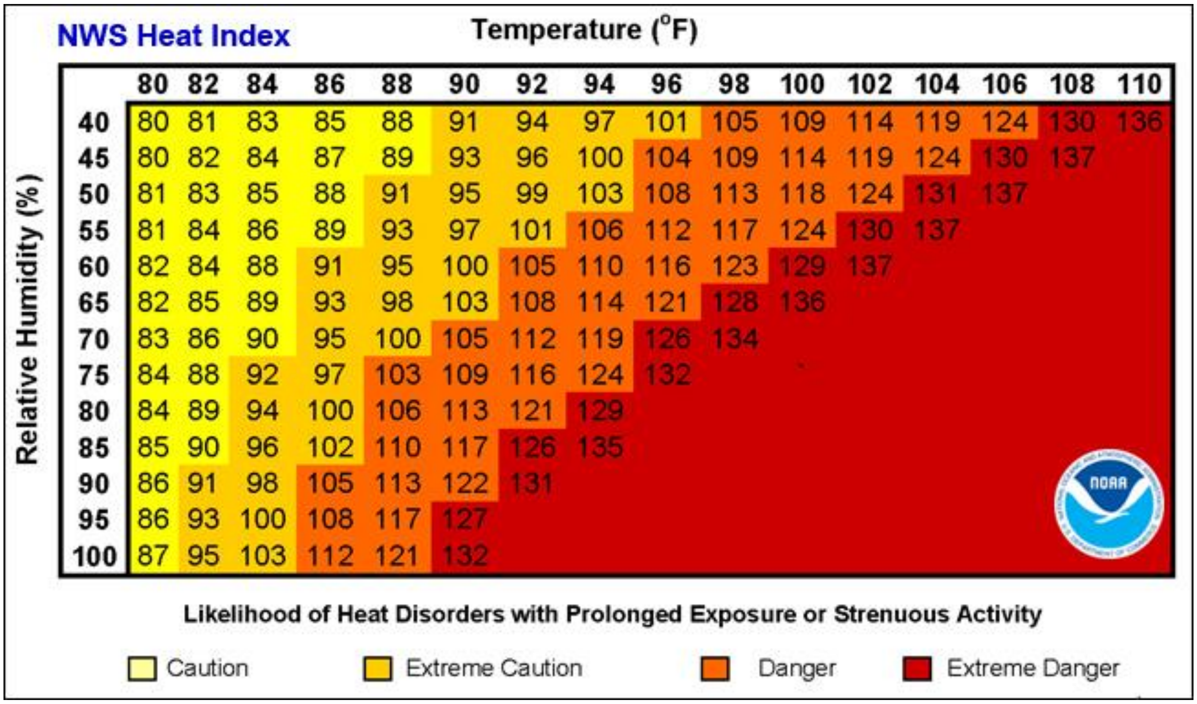
Annual Average Days Over	Historical	2050s			2080s		
		SSP 2-4.5	SSP 3-7.0	SSP 5-8.5	SSP 2-4.5	SSP 3-7.0	SSP 5-8.5
80°F	148 days	167 days *(161-175)*	168 days *(147-175)*	174 days *(164-177)*	177 days *(165-180)*	182 days *(132-193)*	192 days *(177-199)*
90°F	80 days	104 days *(97-110)*	105 days *(93-111)*	111 days *(102-117)*	116 days *(104-123)*	121 days *(92-138)*	135 days *(127-147)*
95°F	44 days	67 days *(61-74)*	69 days *(60-74)*	74 days *(67-81)*	78 days *(67-89)*	85 days *(68-103)*	101 days *(92-117)*
100°F	17 days	33 days *(28-40)*	34 days *(29-39)*	40 days (31-44)	42 days *(32-53)*	50 days *(40-64)*	66 days *(49-78)*
104°F	6 days	14 days *(11-20)*	15 days *(11-19)*	19 days *(12-22)*	20 days *(14-28)*	27 days *(19-37)*	39 days *(23-49)*

[12] https://www.dir.ca.gov/title8/3395.html
[13] https://www.cityofsacramento.gov/content/dam/portal/dou/Specifications_FINAL2020.pdf
[14] https://www.sacrt.com/light-rail-service-disruption-faqs/
[15] https://nca2009.globalchange.gov/transportation/index.html#:~:text=and%20safety.2-,Extreme%20Temperatures%20and%20Drought,snow%20and%20ice%20removal%20costs.&text=Increases%20in%20very%20hot%20days,rail%20closures%20in%20affected%20areas
[16] For a more visual summary of extreme heat projections, the CAAP VA Figures 2-2, 2-3, 2-4, and 2-5 visually show extreme heat projections for a single climate model for RCP 8.5.

1.1.2 Extreme Heat & Humidity (Heat Index)

Heat index, a measure combining air temperature and relative humidity, is particularly useful for measuring public health impacts of extreme heat. The National Weather Service (NWS) categorizes public health impacts of heat index temperatures in four classifications based on the relationship between relative humidity and air temperature (Figure 2), each with different impacts on physical health (Figure 3).[17]

Vulnerable populations are particularly susceptible to high heat index temperatures.



NWS Heat Index — Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution — Extreme Caution — Danger — Extreme Danger

Figure 2. National Weather Service heat index chart

Classification	Heat Index	Effect on the body
Caution	80°F - 90°F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90°F - 103°F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103°F - 124°F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125°F or higher	Heat stroke highly likely

Figure 3. Heat index classifications and the impacts on human health

[17] The heat index was calculated using the National Weather Service's methodology for heat index calculation utilizing the Rothfusz and Steadman equations and adjustments https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml

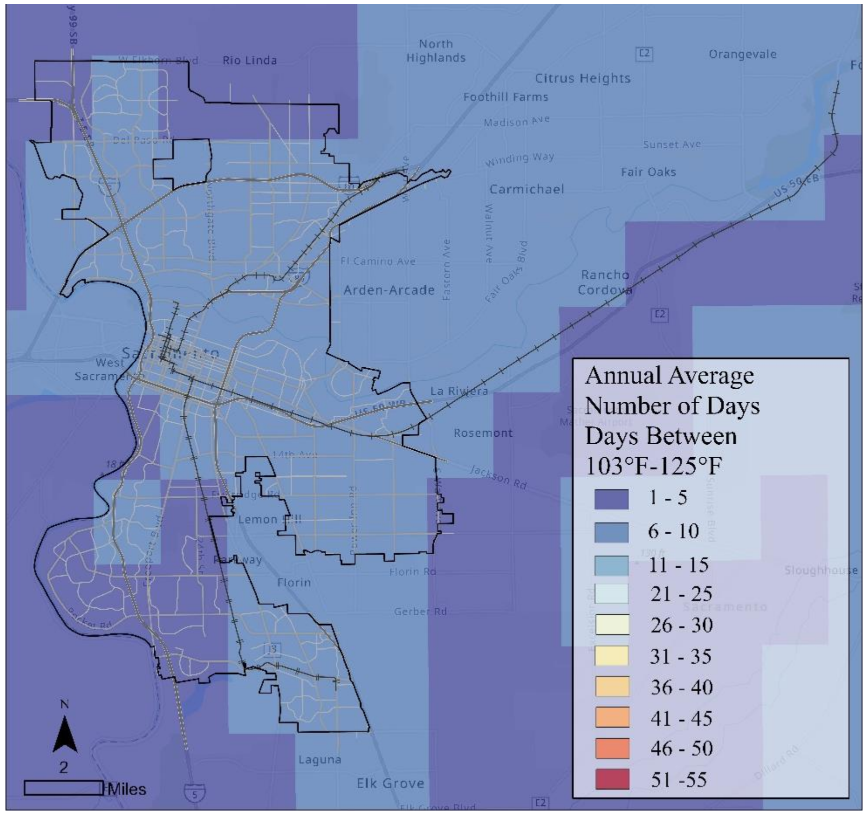
Table 3 indicates the projected number of days within each of the four NWS heat index classifications. Days are categorized by health classification and are not counted cumulatively as in the previous section of air temperature thresholds. The projected number of days in the 'Caution (80°F – 90°F)' classification decreases into the future; however, this occurs as warmer temperatures shift 'Caution' days into the 'Extreme Caution' or 'Danger' classifications. For example, a day that would previously have been 85°F but now reaches 95°F is classified in the 'Extreme Caution (90°F – 103°F)' category instead. Days in the last category, 'Extreme Danger (> 125°F),' are rare on average even by the 2080s in the extremely high emissions scenario.

It is important to note that these projections estimate average conditions. Due to weather variability, most years will fall either below or above the thresholds presented.

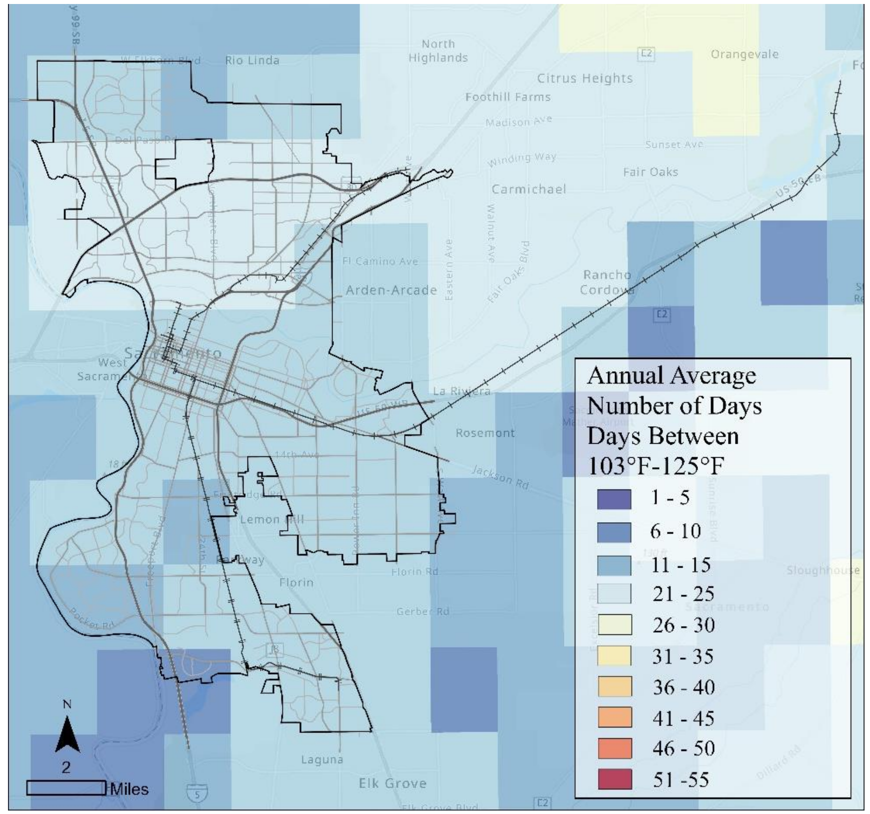
Table 3. Average annual number of days within each of the four National Weather Service heat index classifications. Total days in all categories combined are calculated in the bottom row to show the upward trend even though categorizations of days may vary. Values shown are the 50th percentile, and the 10th and 90th percentiles are italicized in parentheses.

Classification	Historical	2050s			2080s		
		SSP 2-4.5	SSP 3-7.0	SSP 5-8.5	SSP 2-4.5	SSP 3-7.0	SSP 5-8.5
Caution (80°F-90°F)	81 days	74 days *(70-77)*	73 days *(59-78)*	70 days *(66-75)*	70 days *(66-74)*	65 days *(39-70)*	61 days *(55-68)*
Extreme Caution (90°F-103°F)	54 days	69 days *(62-76)*	66 days *(60-76)*	75 days *(65-83)*	72 days *(66-83)*	69 days *(48-83)*	73 days *(66-84)*
Danger (103°F-125°F)	4 days	17 days *(11-28)*	16 days *(12-30)*	21 days *(14-33)*	24 days *(17-37)*	35 days *(23-46)*	52 days *(29-65)*
Extreme Danger (> 125°)	0 days	0 days *(0-3)*	0 days *(0-2)*	0 days *(0-3)*	0 days *(0-3)*	0 days *(0-6)*	1 day *(0-10)*
Total (Days Above 80°F)	**139 days**	**160 days *(143-184)***	**155 days *(131-186)***	**166 days *(145-194)***	**166 days *(149-197)***	**169 days *(110-205)***	**187 days *(150-227)***

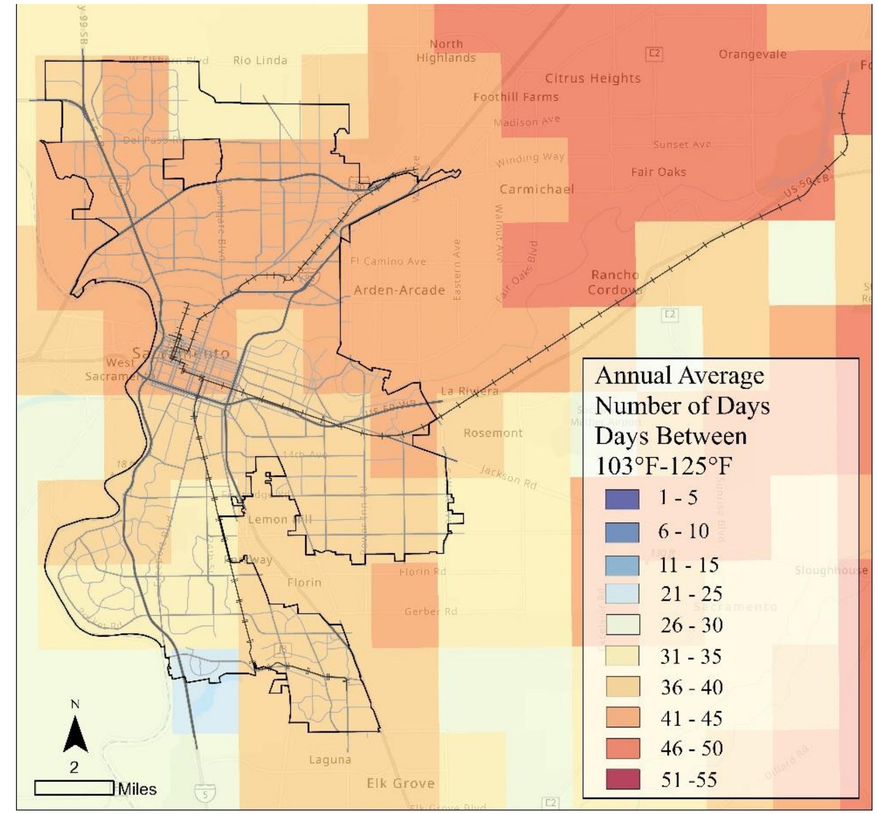
The following maps depict the historical conditions and projections for the 2050s and 2080s based on SSP 3-7.0 for the average annual number of days in category 'Danger (103°F-125°F)'.



Map 1. Historical annual average number of days with a heat index between 103-125°F



Map 2. 2050s high emissions scenario (SSP 3-7.0) projected annual average number of days with a heat index between 103-125°F



Map 3. 2080s high emissions scenario (SSP 3-7.0) projected annual average number of days with a heat index between 103-125°F

1.1.3 Heat Health

Extreme heat events have significant implications for public health, particularly among vulnerable populations with limited access to indoor cooling resources. Increased emergency room visits and hospitalizations associated with extreme heat, or heat health events, were analyzed using the CHAT tool.

Heat health events are warm weather periods lasting two or more days associated with significant negative public health impacts. Table 4 shows projections of the annual number of days with heat health events.[18] Major increases in the number of days with heat health events in Sacramento are expected as the century progresses.

Table 4. Number of days with heat health events for the general population. Projected values shown are the minimum and maximum of the 5 model results presented by CHAT. Table shows averages across Sacramento census tracts.

Heat Health Events	Historical	2050s		2080s	
		RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Average Days per Year	5 days	19 – 48 days	24 - 91 days	25 - 96 days	56 - 113 days

1.1.4 Urban Heat Island (UHI) Index

Urban areas often experience higher ambient temperatures than surrounding regions due to the concentration of buildings, pavement, and limited vegetation—an effect known as the urban heat island (UHI). To assess this phenomenon, the 2020 NASA DEVELOP *Extreme Heat and Social Vulnerability* study[19] produced a fine-scale daytime Urban Heat Island Index using historical remote sensing data. This index quantifies relative differences in surface temperature, in degrees Fahrenheit, across the urban landscape, to identify localized hotspots of elevated heat exposure.

Map 4 shows cooler areas are generally found where there is greater vegetation and nearby water features, such as the American River Parkway and the Sacramento River corridor. Parks, golf courses, and cemeteries often serve as localized cool spots within the urban landscape. In contrast, the hottest zones are concentrated along major transportation corridors and densely built urban areas, including Franklin Boulevard, Stockton Boulevard, Freeport Boulevard, and Del Paso Boulevard. Notably, the light rail line and Sacramento Executive Airport are among the most heat-intense locations. The highest temperatures

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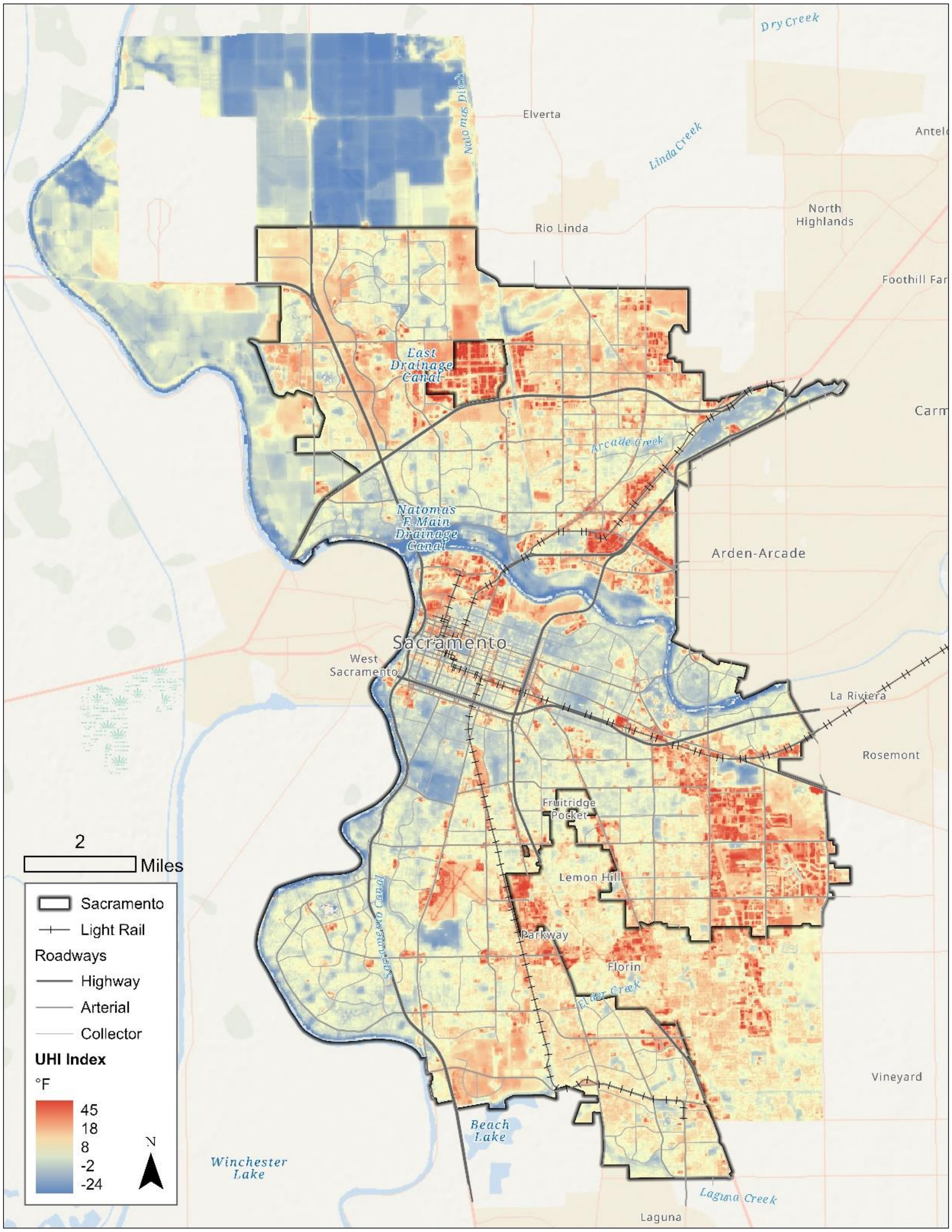
[18] The number of days of heat health events was calculated by taking the product of the average annual heat health events and average annual duration of heat health events for each percentile model.
[19] https://ntrs.nasa.gov/api/citations/20210013844/downloads/2020Fall_LaRC_Sacramento UrbanDevelopment_TechPaper_FD-final.docx.pdf

within the study area are found in industrial zones such as Florin Fruitridge Industrial Park, Erikson Industrial Park, and Pell-Main Industrial Park.



Map 4. UHI index for Sacramento in degrees Fahrenheit

1.2 Wind

Wind speed data was gathered from the American Society of Civil Engineers (ASCE) 7-22 Hazard Tool, which provides location-specific hazard data based on commonly used design standards for buildings.[20,21] Table 5 shows wind speeds for gusts lasting for 3 seconds by return period (i.e. the average period of time between wind speeds of that magnitude occurring).

Table 5. ASCE 7-22 3-second wind gusts in wind speed miles per hour (Vmph) by return period for Sacramento

Return Period	Wind Speed (3-Second Gust)
10-Year	65 Vmph
25-Year	71 Vmph
50-Year	75 Vmph
100-Year	80 Vmph
300-Year	88 Vmph
700-Year	94 Vmph

Future changes in extreme wind are not assessed in this VA. Projections were not readily available, and accurately assessing how future climate conditions affect extremely strong short bursts of wind (e.g., 3-second gusts) is difficult given the high temporal and spatial resolution of modeling needed.

1.3 Heavy Precipitation

Historical data for precipitation return periods (i.e., a 100-year storm), or annual exceedance probabilities (i.e., a 1% chance annual storm – an alternative way of referring to return periods), was obtained from a historical extreme precipitation dataset from the National Oceanic and Atmospheric Administration (NOAA) Atlas-14.[22]

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[20] The ASCE risk delineations, from 1 to 4, provide a scale of criticality of infrastructure. A risk level of 4, the highest, was assumed in the generation of the wind data. https://ascehazardtool.org/

[21] The City's design standards require that residential buildings must withstand up to 110 mph winds. The City's design standards for commercial buildings vary from 90 mph to 105 mph winds, depending on risk category. See: https://www.cityofsacramento.gov/community-development/building/plan-review/design-criteria. For traffic signals and utility poles, standards typically align with Caltrans Standard Plans, which require design for 3-second gusts up to 100 mph or more, depending on location and configuration. See: https://dot.ca.gov/-/media/dot-media/programs/engineering/documents/standardplanuserguides/signsohstructures/201901ugspsectesele ctricalsystemspolespostsstandardsa11y.pdf.

[22] Given the robust nature of the LOCA2 Hybrid projections, additional bias correction was not conducted on any of the metrics calculated except for heavy precipitation. It was completed for this metric because the calculation of return period storms incorporates extreme value analysis, so additional processing to correct potential biases in the model is warranted. The distribution of the historical data in the LOCA2 dataset was

The projected increases in extreme precipitation events indicate a greater likelihood of severe flooding that can damage infrastructure and cause service delays relative to historical conditions. These disruptions have direct consequences for vulnerable populations with limited mobility and no alternative transportation options, who are more likely to rely on active or public transit and have fewer resources to adapt. The results are shown in Table 6. Maps are available in the appendix.

Table 6. Precipitation depth for various return periods of a 24-hour storm. Values shown are the 50th percentile, and the 10th and 90th percentiles are italicized in parentheses to provide uncertainty bounds.

Return Period	Historical	2050s			2080s		
		SSP 2-4.5	SSP 3-7.0	SSP 5-8.5	SSP 2-4.5	SSP 3-7.0	SSP 5-8.5
2-Year	2.1 in *(1.9-2.3)*	2.1 in *(1.9-2.6)*	2.1 in *(1.9-2.5)*	2.1 in *(1.9-2.4)*	2.3 in *(1.9-2.7)*	2.3 in *(2.0-2.6)*	2.2 in *(1.9-2.8)*
5-Year	2.7 in *(2.4-3.0)*	2.8 in *(2.4-3.5)*	2.7 in *(2.4-3.3)*	2.7 in *(2.3-3.3)*	2.9 in *(2.4-3.6)*	3.0 in *(2.5-3.5)*	2.9 in *(2.4-3.7)*
10-Year	3.1 in *(2.8-3.6)*	3.3 in *(2.8-4.4)*	3.3 in *(2.9-4.0)*	3.2 in *(2.7-4.0)*	3.5 in *(2.8-4.4)*	3.6 in *(3.0-4.3)*	3.5 in *(2.9-4.6)*
25-Year	3.8 in *(3.3-4.4)*	4.1 in *(3.3-5.8)*	4.0 in *(3.3-5.1)*	4.0 in *(3.2-5.2)*	4.3 in *(3.3-5.6)*	4.4 in *(3.6-5.6)*	4.3 in *(3.4-5.9)*
50-Year	4.3 in *(3.6-5.1)*	4.8 in *(3.7-6.9)*	4.6 in *(3.7-6.0)*	4.6 in *(3.6-6.1)*	4.9 in *(3.7-6.6)*	5.2 in *(4.0-6.7)*	5.0 in *(3.8-7.0)*
100-Year	4.8 in *(4.0-5.9)*	5.5 in *(4.1-8.3)*	5.3 in *(4.1-7.0)*	5.3 in *(4.0-7.3)*	5.6 in *(4.2-7.9)*	6.0 in *(4.5-8.1)*	5.7 in *(4.3-8.3)*

compared to the NOAA Atlas-14 data; although the difference was not very large, it was significant enough to justify its use, even with the 1.13 ratio adjustment recommended by NOAA to transform daily data into 24-hour data. A delta bias correction method was employed, applying the modeled difference between historical and future modeled data to the NOAA Atlas-14 data.

1.4 Large River Flows

The city faces significant flood risks from the American and Sacramento Rivers, and these risks are expected to increase as the climate changes and the region continues to develop. Major flooding resulting from a levee failure or similar event would lead to widespread damage and likely loss of life and injury. Much of the system would become impassable, disrupting regular travel patterns and potentially hindering evacuation and emergency response efforts.

The California Department of Water Resources (DWR) Central Valley Flood Protection Plan (CVFPP) 2022 Update performed extensive analysis of current and future flood risks in the Central Valley, including in the Sacramento area.[23] The next several figures summarize information about current and projected future flows and flood depths on the American and Sacramento Rivers, as well as projections of flood damage and loss of life associated with levee failure along these rivers. The figures in this section are from the CVFPP Technical Analyses Summary Report and Appendices.[24]

The climate projections used in the CVFPP leverage LOCA CMIP5 projections for a number of climate models for both RCP 4.5 (moderate emissions) and RCP 8.5 (very high emissions).[25, 26] Low, medium, and high climate scenarios were created based on these downscaled projections. The analysis focused on a 2022 baseline and a 2072 horizon year, encompassing a 50-year time period.

These projections were used in hydrologic modeling that accounts for changes in atmospheric variables such as precipitation and temperature, and hydrologic variables such as runoff and snowpack, across the large drainage basins that feed the major rivers in the Central Valley, including the Sacramento and American Rivers. This modeling was used to develop climate change ratios that represent the proportion of future flows (with climate change) to current flows. Larger ratios represent larger expected increases in flows. For example, a ratio of 1.0 indicates no change, and a ratio of 1.5 indicates a 50% increase.

The next two figures show climate change ratios for unregulated flows (i.e., flows uninterrupted by dams). These were then converted into regulated flow projections for use in the risk analysis. The figures depict ratios for 3-day duration flow events for different

[23] https://water.ca.gov/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan
[24] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-Planning-and-Studies/Central-Valley-Flood-Protection-Plan/Files/CVFPP-Updates/2022/FINAL-2022-CVFPP-Technical-Analysis-Summary-Report.pdf
[25] CVFPP 2022 Update Technical Appendix A. Climate Change Analysis
[26] The LOCA CMIP5 projections are the same utilized in the CHAT tool.

exceedance intervals. The different colors correspond with the three different climate scenarios. Figure 4 shows ratios for the American River below Folsom Dam, and Figure 5 shows ratios for the Sacramento River below Sacramento Weir. Both curves show high ratios for more frequent events (e.g., a 2-year exceedance interval), with a relatively wide spread between the three scenarios. The ratios decrease and converge for lower probability events (e.g., a 100-year exceedance interval) but remain above one, implying that, for a 3-day flow duration, future extreme flows (e.g., in 2072) will be higher than current extreme flows of the same exceedance interval.

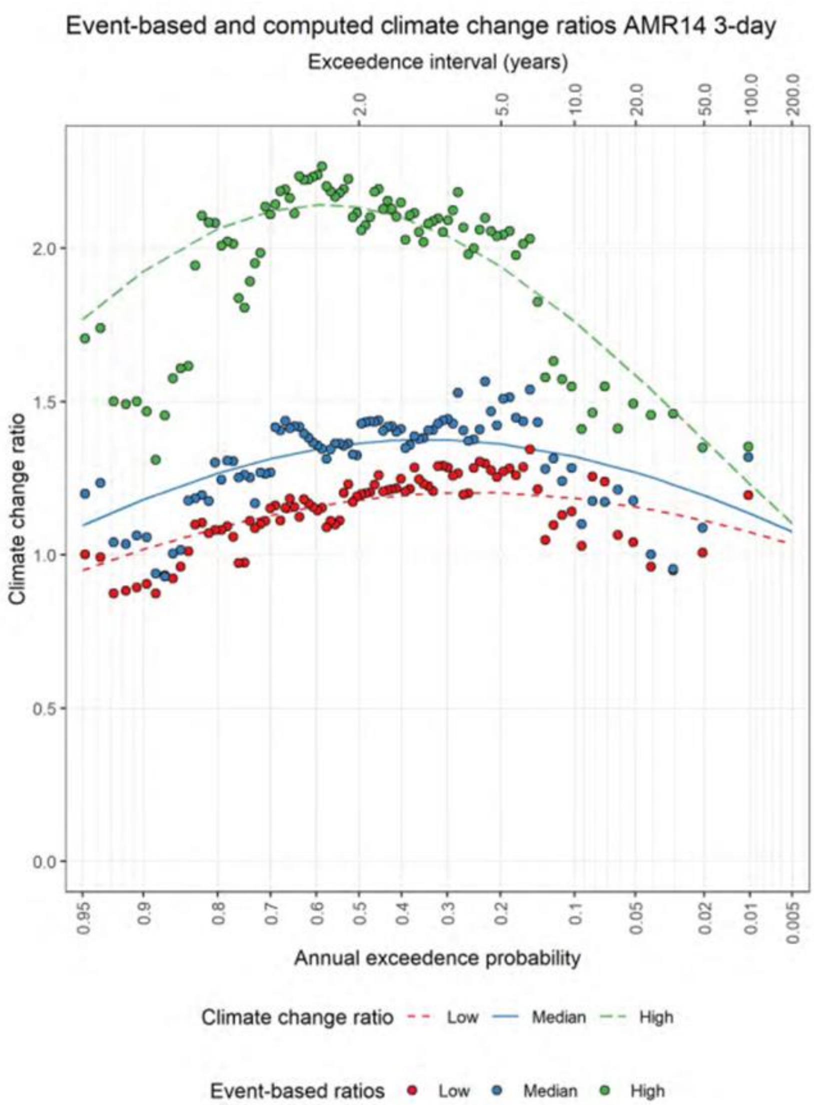

Figure 4.Climate Change Ratios of unregulated flows by Exceedance Interval and Climate Scenario, 3-Day Duration, American River below Folsom Dam (CVFPP Technical Appendix B)

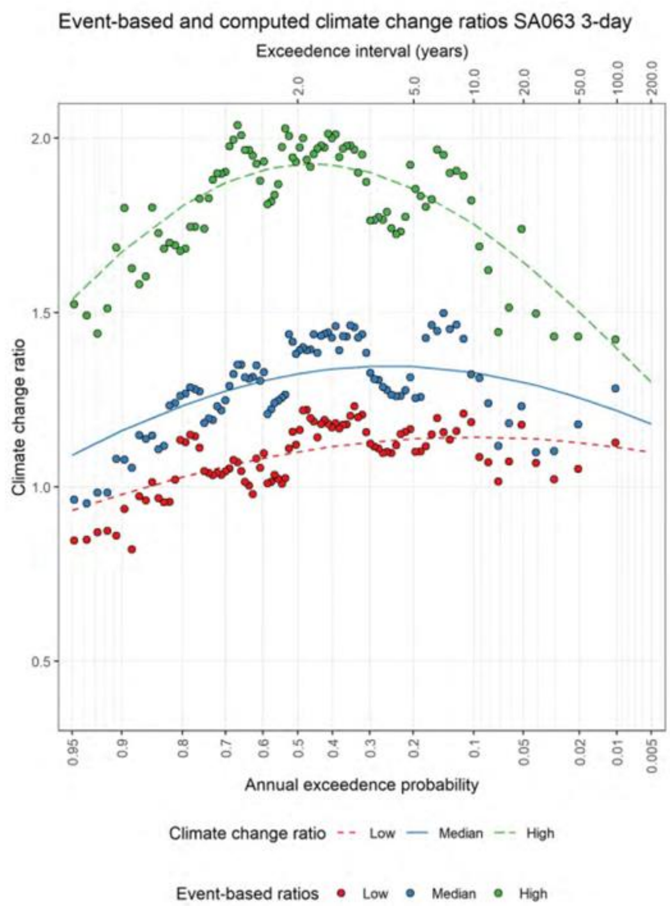

Figure 5. Climate Change Ratios of unregulated flows by Exceedance Interval and Climate Scenario, 3-Day Duration, American River below Folsom Dam (CVFPP Technical Appendix B)

The next several figures show results from risk modeling for different areas that include the city. The analysis incorporates current and future flows and flood elevations, potential for levee failure, and other data to model expected annualized loss of life and damages due to flood events. The results include both with and without the State Systemwide Investment Approach (SSIA), a collection of investments and management strategies to mitigate flood risk in the Central Valley. These results are referred to as “with” or “without project.”[27]

Map 5 shows the three geographies, or impact areas, from the CVFPP that are summarized in this Vulnerability Assessment (Natomas, Sacramento North, and Sacramento South). The CVFPP assesses flood risk for each impact area associated with levee failure at one or two locations called index points. For the purposes of this Vulnerability Assessment, if

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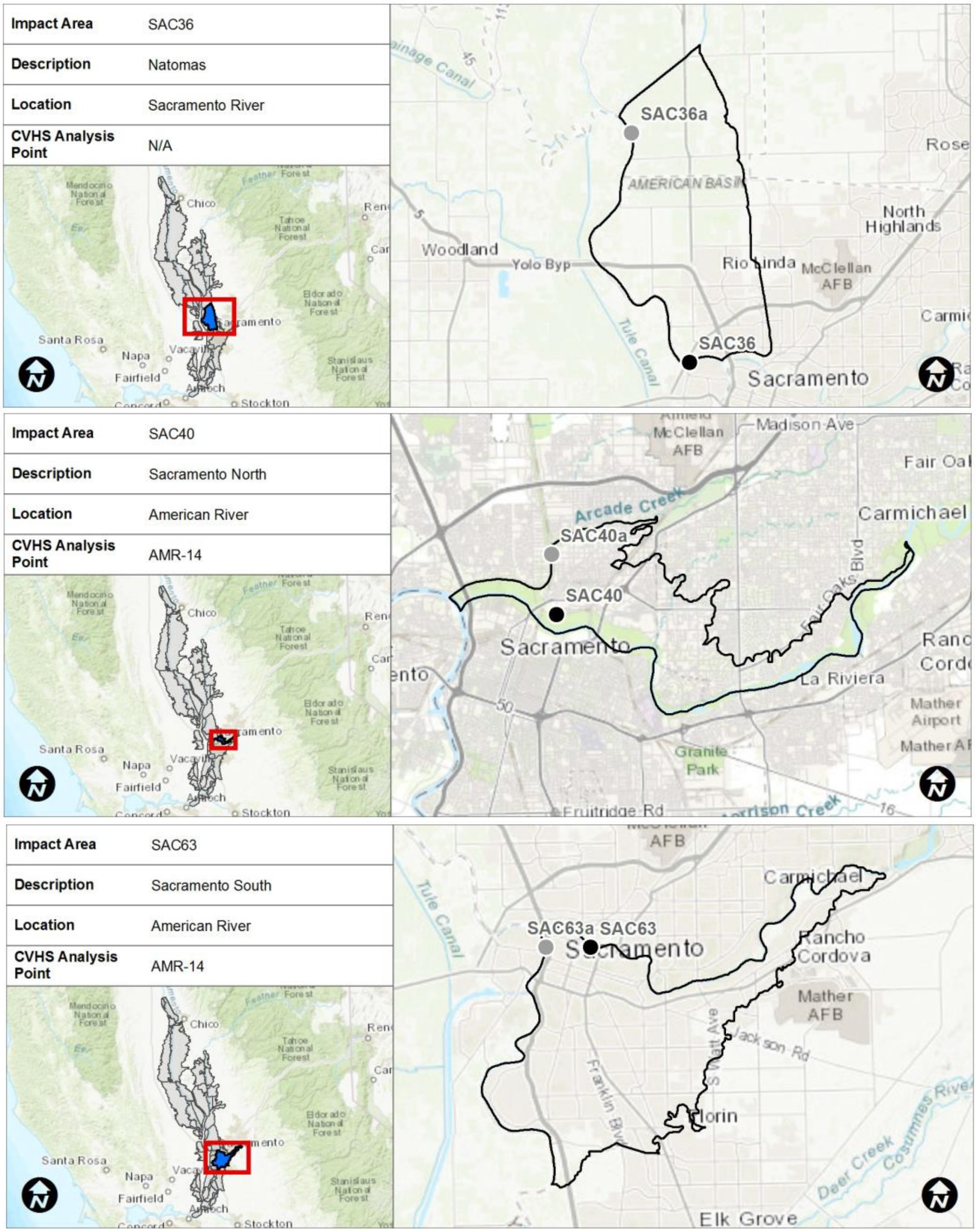
[27] Chapter 3 of the CVFPP delves further into the SSIA and how flood risk may evolve with and without it. More information on ongoing investments can be found on the California Natural Resources Agency website: https://bondaccountability.resources.ca.gov/Program/ProgramDetail/57?PropositionPK=5

there are two index points associated with a given impact area, the highest-impact index point was selected.



Impact Area	SAC36
Description	Natomas
Location	Sacramento River
CVHS Analysis Point	N/A

Impact Area	SAC40
Description	Sacramento North
Location	American River
CVHS Analysis Point	AMR-14

Impact Area	SAC63
Description	Sacramento South
Location	American River
CVHS Analysis Point	AMR-14

Map 5. CVFPP impact areas most relevant for SacAdapt (CVFPP Technical Appendix D)

The next several tables show the relationship between annual exceedance probability (AEP),[28] flows in cubic feet per second (cfs), water surface elevations (WSE) in feet,[29] and levee failure probabilities.

Table 7 focuses on Natomas and shows different WSEs associated with different AEPs and then different levee failure probabilities associated with different WSEs.

Table 7. Natomas (SAC36) AEPs, WSEs and levee failure probabilities at higher impact index point (SAC36) (CVFPP Technical Appendix D)

WSE (ft)								
AEP	2022 without-project	2072 without-project, low	2072 without-project, median	2072 without-project, high	2022 with-project	2072 with-project, low	2072 with-project, median	2072 with-project, high
0.100	32.1	32.7	33.3	34.1	32.1	31.4	31.5	31.8
0.040	33.3	33.7	34.1	34.9	33.3	31.6	31.8	32.5
0.020	34.0	34.1	34.5	35.2	34.0	31.8	32.1	33.3
0.010	34.3	34.5	35.2	35.4	34.3	32.2	33.2	33.7
0.005	35.2	35.2	35.4	36.7	35.2	33.4	33.7	34.5
0.002	37.4	37.4	37.4	37.5	37.4	35.3	35.3	35.6

Probability of failure				
WSE (ft)	2022 without-project	2072 without-project	2022 with-project	2072 with-project
23.3	0.0%	0.0%	0.0%	0.0%
25.9	0.0%	0.0%	0.0%	0.0%
29.3	0.0%	0.0%	0.0%	0.0%
32.8	0.1%	0.1%	0.1%	0.1%
36.2	0.6%	0.6%	0.6%	0.6%
40.5	100.0%	100.0%	100.0%	100.0%

Table 8 focuses on South Sacramento and shows different flows associated with different AEPs, then different flows associated with different WSEs, and finally different levee failure probabilities associated with different WSEs. Table 9 shows the same information for North Sacramento.

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[28] AEPs are another way of describing return periods. For example, a 100-year return period event has an AEP of 0.01, or a 1% chance of occurring annually; a 50-year return period event has an AEP of 0.02, or a 2% chance of occurring annually.
[29] Given in North American Vertical Datum of 1988

Table 8. South Sacramento (SAC40) AEPs, Flows, WSEs and levee failure probabilities at higher impact index point (SAC40) (CVFPP Technical Appendix D)

Flow (cfs)								
AEP	**2022 without-project**	**2072 without-project, low**	**2072 without-project, median**	**2072 without-project, high**	**2022 with-project**	**2072 with-project, low**	**2072 with-project, median**	**2072 with-project, high**
0.100	69,400	89,300	97,900	114,200	69,400	89,500	98,000	113,600
0.040	110,300	114,800	115,000	115,700	110,300	113,900	114,200	115,100
0.020	115,400	115,800	115,900	116,400	115,400	115,300	115,700	116,800
0.010	116,300	117,400	123,600	140,000	116,300	119,300	124,300	137,500
0.005	152,000	152,100	152,500	152,600	152,000	153,000	153,400	153,500
0.002	203,300	203,300	205,200	203,800	203,300	206,100	209,000	207,100

Flow (cfs)								
WSE (ft)	**2022 without-project**	**2072 without-project, low**	**2072 without-project, median**	**2072 without-project, high**	**2022 with-project**	**2072 with-project, low**	**2072 with-project, median**	**2072 with-project, high**
26.9	13,300	13,300	13,300	13,300	13,300	N/A	N/A	N/A
35.1	101,900	101,900	101,900	101,900	101,900	115,000	115,000	115,000
36.6	115,200	115,200	115,200	115,200	115,200	138,000	138,000	138,000
39.4	157,300	157,300	157,300	157,300	157,300	162,400	162,400	162,400
44.2	193,800	193,800	193,800	193,800	193,800	216,400	216,400	216,400
46.4	257,100	257,100	257,100	257,100	257,100	N/A	N/A	N/A

Probability of failure				
WSE (ft)	**2022 without-project**	**2072 without-project**	**2022 with-project**	**2072 with-project**
27.6	0.0%	0.0%	0.0%	0.0%
30.1	0.0%	0.0%	0.0%	0.0%
33.4	0.1%	0.1%	0.1%	0.1%
36.7	0.4%	0.4%	0.4%	0.4%
40.1	1.6%	1.6%	1.6%	1.6%
44.2	4.1%	4.1%	4.1%	4.1%

Table 9. North Sacramento (SAC63) AEPs, Flows, WSEs and levee failure probabilities at higher impact index point (SAC63) (CVFPP Technical Appendix D)

	Flow (cfs)							
AEP	2022 without-project	2072 without-project, low	2072 without-project, median	2072 without-project, high	2022 with-project	2072 with-project, low	2072 with-project, median	2072 with-project, high
0.100	69,400	89,300	97,900	114,200	69,400	89,500	98,000	113,600
0.040	110,300	114,800	115,000	115,700	110,300	113,900	114,200	115,100
0.020	115,400	115,800	115,900	116,400	115,400	115,300	115,700	116,800
0.010	116,300	117,400	123,600	140,000	116,300	119,300	124,300	137,500
0.005	152,000	152,100	152,500	152,600	152,000	153,000	153,400	153,500
0.002	203,300	203,300	205,200	203,800	203,300	206,100	209,000	207,100

	Flow (cfs)							
WSE (ft)	2022 without-project	2072 without-project, low	2072 without-project, median	2072 without-project, high	2022 with-project	2072 with-project, low	2072 with-project, median	2072 with-project, high
26.9	13,300	13,300	13,300	13,300	13,300	N/A	N/A	N/A
35.1	101,900	101,900	101,900	101,900	101,900	115,000	115,000	115,000
36.6	115,200	115,200	115,200	115,200	115,200	138,000	138,000	138,000
39.4	157,300	157,300	157,300	157,300	157,300	162,400	162,400	162,400
44.2	193,800	193,800	193,800	193,800	193,800	216,400	216,400	216,400
46.4	257,100	257,100	257,100	257,100	257,100	N/A	N/A	N/A

	Probability of failure			
WSE (ft)	2022 without-project	2072 without-project	2022 with-project	2072 with-project
29.7	0.0%	0.0%	0.0%	0.0%
31.9	0.3%	0.3%	0.3%	0.3%
35.0	0.7%	0.7%	0.7%	0.7%
38.0	1.3%	1.3%	1.3%	1.3%
41.0	8.3%	8.3%	8.3%	8.3%
44.8	35.0%	35.0%	35.0%	35.0%

Table 10 summarizes the expected annual damage (EAD) for 2022 and 2072, with and without project, for the three climate scenarios. It is organized by impact area and contains results for the higher impact index point at each of these areas. The expected annual damage reflects both the very low probability of levee failure and the high consequences when failure does occur.

Table 10. Expected Annual Damage in thousands of January 2021 dollars by Impact Area and higher impact Index Point (CVFPP Technical Appendix C)

Impact Area (and Index Point)	2022 Without-Project (WoP)	2072 WoP Climate Change-Low	2072 WoP Climate Change-Medium	2072 WoP Climate Change-High	2022 With-Project (WP)	2072 WP Climate Change-Low	2072 WP Climate Change-Medium	2072 WP Climate Change-High
Natomas (SAC36)	3,720	5,567	6,761	11,069	3,520	3,250	3,618	4,676
North Sacramento (SAC40)	5,809	7,916	8,546	9,332	5,809	6,589	7,051	7,373
South Sacramento (SAC63)	45,994	93,447	99,093	142,194	43,282	71,396	73,606	111,280

Focusing on the 'without-project' alternative, with current climate conditions, annualized damages are $3.7 million for Natomas, $5.8 million for North Sacramento, and $46.0 million for South Sacramento (in 2021 dollars). Depending on the climate scenario, these annualized damages are expected to increase from 2022 to 2072 by 50-198% for Natomas, 36-61% for North Sacramento, and 103-209% for South Sacramento. With the SSIA project in 2072, damages are generally expected to increase less compared to the 2022 without-project baseline. Percent changes from 2022 without-project to 2072 with-project are 13-26% for Natomas, 13-27% for North Sacramento, and 55-142% for South Sacramento.

Table 11 shows the breakdown of damages by type for the 2022 without-project baseline. Streets and highways make up a comparatively small proportion of damages according to the CVFPP modeling.

Table 11. 2022 Without Project Expected Annual Damage by Damage Category in thousands of January 2021 dollars (CVFPP Technical Appendix C)

Damage Category	Natomas (SAC36)	North Sacramento (SAC40)	South Sacramento (SAC63)
Business Loss	7	14	93
Commercial Structures	404	999	7,137
Crops	8	0	1
Emergency Costs	60	98	887
Highways	9	6	98
Industrial Structures	611	396	4,639
Public Structures	178	585	2,496
Residential Structures	2,215	3,347	27,184
Streets	22	38	293
Vehicles	206	327	3,165
Total	**3,720**	**5,809**	**45,994**

Table 12 summarizes the expected annual loss of life (EALL)[30] for 2022 and 2072, with and without project, for the three climate scenarios. It is organized by impact area and contains results for the higher impact index point at each of these areas.

Table 12. Expected Annual Loss of Life in number of persons by Impact Area and higher impact Index Point (CVFPP Technical Appendix C)

Impact Area (and Index Point)	2022 Without-Project (WoP)	2072 WoP Climate Change-High	2072 WoP Climate Change-Low	2072 WoP Climate Change-Medium	2022 With-Project (WP)	2072 WP Climate Change-Low	2072 WP Climate Change-Medium	2072 WP Climate Change-High
Natomas (SAC36)	1.1	3.2	1.7	2.0	1.1	1.2	1.4	1.7
North Sacramento (SAC40)	2.6	4.4	3.7	4.0	2.6	3.3	3.6	3.8
South Sacramento (SAC63)	12.7	34.4	23.1	25.0	12.7	19.2	20.3	28.8

Focusing on the without-project alternative, with current climate conditions, annualized losses of life are 1.1 persons for Natomas, 2.6 persons for North Sacramento, and 12.7 persons for South Sacramento. Depending on the climate scenario, these annualized losses are expected to increase from 2022 to 2072 by 55-191% for Natomas, 42-69% for North Sacramento, and 82-171% for South Sacramento. With the SSIA project in 2072, losses of life are generally expected to increase less compared to the 2022 without-project baseline. Percent changes from 2022 without-project to 2072 with-project are 9-55% for Natomas, 27-46% for North Sacramento, and 51-127% for South Sacramento.

1.5 Wildfire

Although wildfires are relatively unlikely to ignite within Sacramento City limits, they can have far-reaching impacts from elsewhere in the state and cause public health concerns with high levels of air pollution from wildfire smoke. Exposure to wildfire smoke is associated with a range of health impacts, particularly for vulnerable populations, including exacerbation of existing respiratory diseases like asthma, adverse birth outcomes, and cardiovascular health events.[31] Active transportation users and people who

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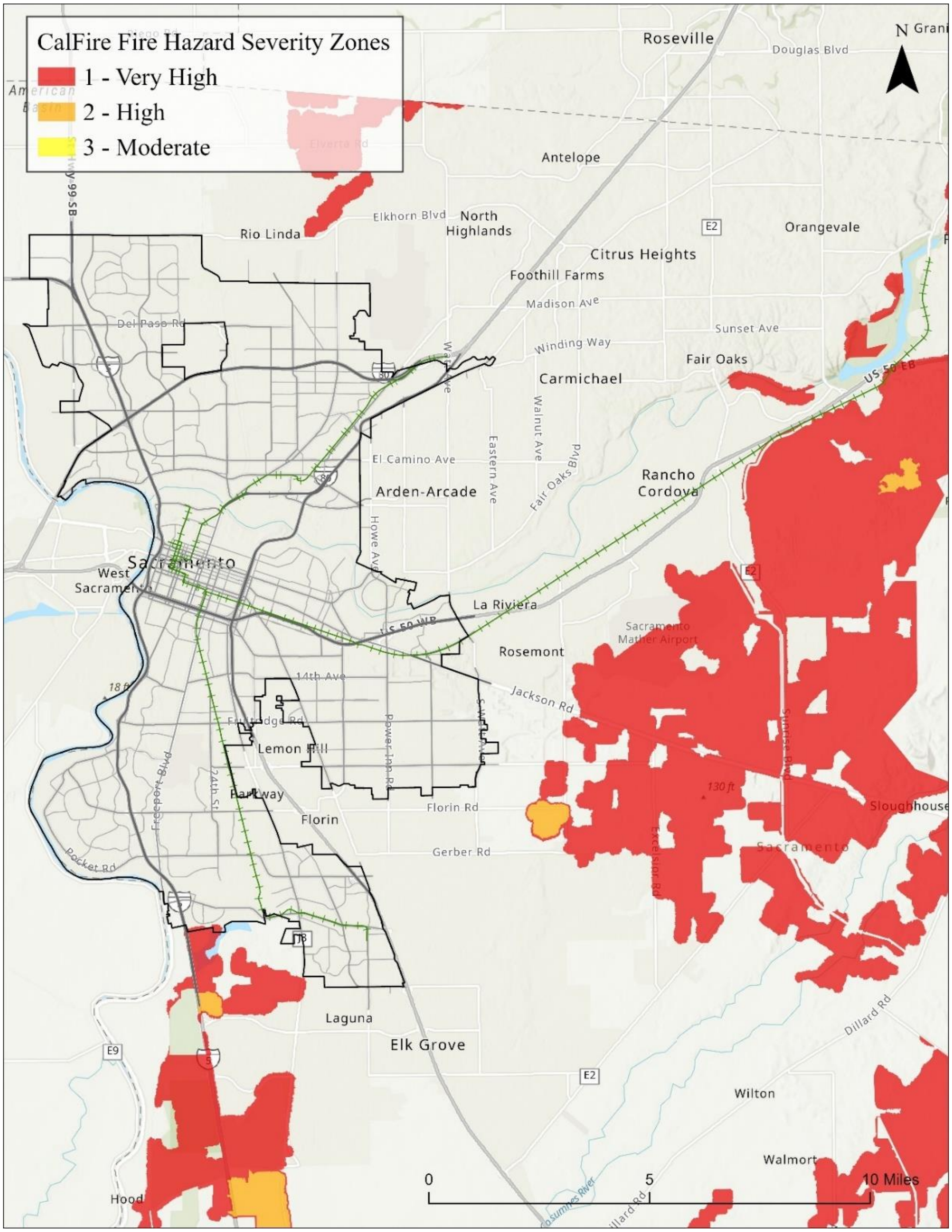
[30] EALL is the average loss of life experienced in a given year. It accounts for both the probability of a loss event occurring and the magnitude of the loss when it occurs. Because EALL is an average, it can include decimals.

[31] https://pmc.ncbi.nlm.nih.gov/articles/PMC9076366/#:~:text=Exposure%20to%20wildfire%20smoke%20is,birth%20outcomes%2C%20and%20cardiovascular%20events.

use public transit as their primary or only method of transportation are more likely to experience negative outcomes as they will have more exposure to smoke.



Map 6. CalFire Fire Severity Zones[32]

32 CalFire Fire Hazard Severity Zones

2. Potential Transportation Damage Types

To understand agency concerns regarding extreme weather impacts to transportation assets, key staff from various City of Sacramento departments and offices – including the Public Works Department, Office of Emergency Management (OEM), and Department of Utilities (DOU) – and the Sacramento Regional Transit District (SacRT) provided feedback through interviews and a Technical Advisory Committee (TAC). In both the TAC meetings and staff interviews, the primary extreme weather concerns were extreme heat, heavy precipitation and flooding, and wind. Indirect impacts from wildfire were also discussed but, given the relatively lower wildfire risk in the city, it was not covered heavily in this section.[33]

TAC members were polled on level of concern for each hazard. Results are shown in Figure 6. The most concerning hazard was extreme heat by a significant margin, though nearly half of the TAC members were either 'very concerned' or 'extremely concerned' with all four hazards discussed: flooding, extreme heat, wind, and fire.

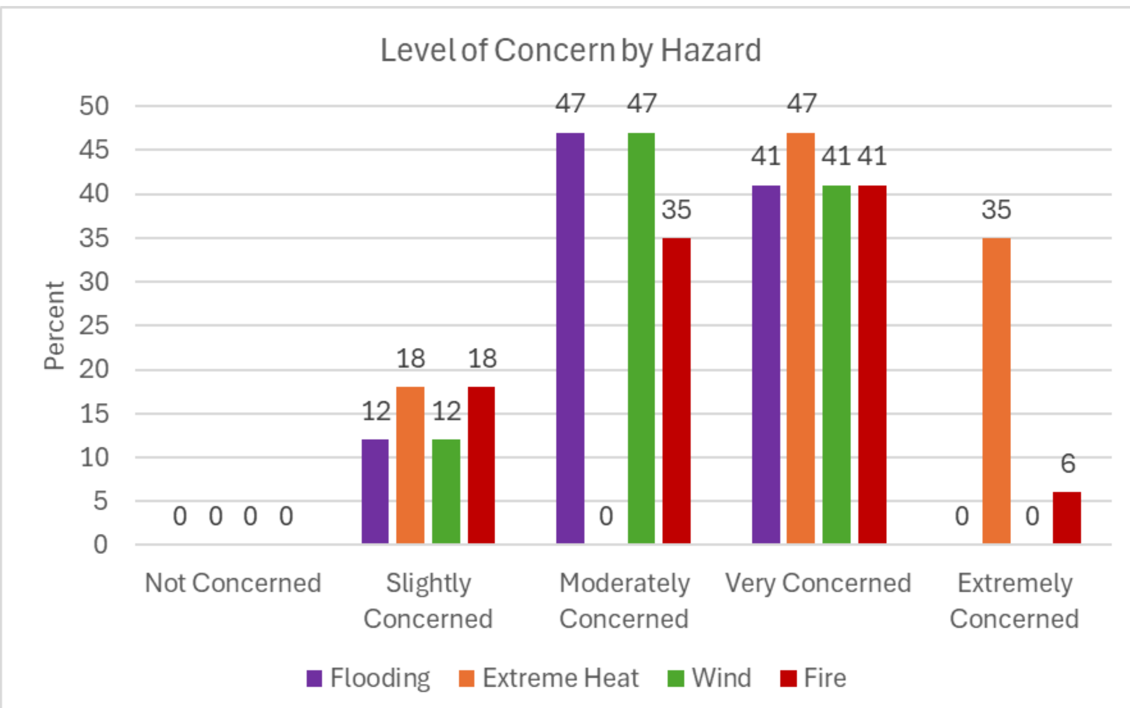


Figure 6. TAC member level of concern by hazard (percent). Hazards were ranked individually, not relatively

[33] That said, some staff identified concerns about trees with decorative lighting catching on fire.

Specific concerns for the City and SacRT are described in the sections below. While some of the issues discussed affect many aspects of the city, the descriptions focus primarily on the transportation system in the study area (i.e., all transportation assets within City boundaries, and SacRT light rail and key transit facilities outside City boundaries).

Emergency management issues are considered throughout, as transportation infrastructure is a critical conduit for emergency response for evacuation route accessibility, emergency vehicle mobility, and coordination of multi-agency response during extreme weather and climate-related incidents. The public health impacts to travelers are another important consideration.

Table 13 provides a qualitative summary of the level of concern for each damage type based on staff feedback. The "Agency Ability to Adapt" column is a qualitative summary of the feasibility of the City or SacRT to directly address the damage type and mitigate risk, and does not reflect the current availability of funding to implement recommended adaptation measures. For damage types with relatively low Agency Ability to Adapt, either the City or SacRT do not have many options to reduce the risk, even if funding was available (e.g., neither the City nor SacRT directly manage the power grid). That said, funding will be a key constraint and consideration with all strategies (unless the strategy has no upfront cost and immediate savings).

Table 13. Summary of transportation damage types, level of concern, and ability to adapt, classified as low, medium, or high

Damage Type	Level of Concern	Agency Ability to Adapt
Extreme Heat		
Outdoor Traveler Comfort and Health	High	Low-Moderate
Outdoor Workers Health	High	High
Pavement	Moderate	High
SacRT Light Rail Tracks	Low	High
Power Distribution System for SacRT	High	High
Overhead Catenary System (OCS) for SacRT	High	High
SacRT Compressed Natural Gas (CNG) Plant	Low	High
HVAC Systems	Moderate	Moderate
Signage	Moderate-High	Moderate
Extreme Wind		
Crossing Gate Arms and other SacRT Infrastructure	Low	High
Traffic Signals, Streetlights, and Other City Infrastructure	Moderate	Moderate-High
Flooding and Heavy Precipitation		
Levee Failure	High	Moderate
Roadways, Railways, and Shared Use Paths	Moderate	Low-Moderate
Underground/At-Grade Telecommunications and Electrical Infrastructure	Low	Moderate
Transit Facility Damage	Moderate-High	Moderate
Bridge Damage	Moderate	High
Wildfire		
Smoke Impacts to Travelers	High	Low
Multiple Hazards		
Power Grid Failure	High	Low-Moderate

2.1 Extreme Heat

2.1.1 Heat and Outdoor Traveler Comfort and Health

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Traveler Health	Extreme Heat	☒ City of Sacramento ☒ SacRT	Level of Concern = High Agency Ability to Manage = Low-Moderate

- **Brief Description**: Heat, particularly when combined with humidity, can affect the health of travelers, particularly those that are walking, bicycling, scooting, or riding transit. It can cause heat-related illness, such as heat exhaustion and heat stroke, respiratory problems, and exacerbation of pre-existing medical conditions including, but not limited to, diabetes, autoimmune conditions, cardiovascular disease, and respiratory disease.
- **Assets/System Components/Users Affected**: People riding transit, walking, or biking, particularly vulnerable populations. Populations at high risk, as identified in the CAAP VA, include children (14 and younger), older adults (65 and older), people with disabilities, low-income households, outdoor workers, cost-burdened households, households living in substandard housing conditions, linguistically isolated households, and communities of color.[34]
- **Locations Affected**: Throughout the study area. Some areas of the city are more affected than others by extreme heat due to the urban heat island effect, which refers to the increased temperatures that urban areas with high amounts of impervious surfaces, like pavement and roadways, experience compared to rural areas. Sidewalks, roads, and bicycle facilities that are not shaded by trees or other structures are more heavily impacted. Similarly, bus stops without shelters or canopy coverage are similarly impacted. Light rail stations have larger shade structures and are less severely impacted, although ambient air temperatures will still impact transit users.
- **Qualitative Level of Concern and Rationale**: High.
  - The majority of bus routes operate at 30-minute headways, so people may be waiting for 30 minutes at a bus stop, and possibly longer for routes with

[34] https://www.cityofsacramento.gov/content/dam/portal/cdd/Planning/General-Plan/07Redlined-Version-of-the-revised-Draft-Climate-Action--Adaptation-Plan.pdf

poor on-time performance. As a result, transit riders are exposed to the heat for prolonged periods, with possible direct sun exposure.
    - Approximately 30% of sidewalks citywide are shaded by existing overhead tree canopy. Coverage is highest in neighborhoods such as Downtown Sacramento, East Sacramento, and Land Park, and lowest in North Sacramento, South Sacramento, and the Fruitridge/Broadway corridor. Shared-use bike paths have about 19% canopy coverage. On-street bike lanes 12% canopy coverage.[35]
    - Discomfort and potential health risks as a result of extreme heat exposure will decrease mode shift to active and public transportation. This reduced mode shift will impact the ability to reach local and regional greenhouse gas emission goals, as identified in the CAAP.
- **Agency Ability/Opportunities to Manage**: Low to moderate.
    - Bus shelters can provide a limited amount of shade coverage at a transit stop. At crowded stops, a single shelter may not be sufficient. Additionally, bus shelters do not shade transit riders while traveling to and from the stop. Bus shelters can be very costly to install due to material costs, as well as costs to redesign infrastructure to maintain ADA accessibility at and around bus stops.
    - Trees can provide shade at bus stops and along sidewalks and bicycle facilities. Consideration must be given to the type of tree, maintenance impacts, planting area (including sufficient soil space to allow trees to establish without damaging streets and sidewalks), irrigation infrastructure, and planting location (e.g., preferably to the west or south of the asset).
    - Hydration and misting stations can mitigate heat stress on active and public transportation users. Hydration and misting stations can be costly to install as the result of needed water and power connections.
    - Strategies that speed up bus and light rail service (e.g., transit signal priority, bus rapid transit), thus decreasing waiting times at transit stations, can mitigate the heat exposure to transit users.
- **Ongoing Actions:**
    - SacRT was recently awarded a grant to procure and install heat-resilient bus shelters at up to 20 shelter-ready[36] bus stop locations that were identified in

[35] https://www.cityofsacramento.gov/content/dam/portal/pw/Transportation/Public%20Draft%20Tree%20Opportunity%20Analysis%20Results.pdf

[36] A shelter ready bus stop has an existing concrete pad that is large enough to support a shelter.

a previous study. The grant will fund the study of heat-resilient shelter options and designs, in addition to the installation of these new bus shelters.
  - The City of Sacramento has an approved street tree list. The Urban Forest Plan includes a recommendation to update the tree list with more climate resilient trees.
  - The City's Street Design Standards are undergoing an update, which will include new requirements around street trees.
  - The City is launching a heat mitigation project to develop minimum tree planting requirements for new development and update design guidelines to incorporate heat-resilient strategies for private development.

2.1.2 Heat and Outdoor Worker Health

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Worker Health	**Extreme Heat**	**☒ City of Sacramento** **☒ SacRT**	**Level of Concern = High** **Agency Ability to Manage = High**

- **Brief Description**: Heat can significantly impact the health of the workforce, particularly for maintenance workers or emergency response crews who must be outdoors in inclement conditions.
- **Assets/System Components/Users Affected**: Workforce. Outdoor workers from vulnerable communities are at greater risk.
- **Locations Affected**: Throughout the study area.
- **Qualitative Level of Concern and Rationale**: High.
  - Several agency officials interviewed noted heat as a significant threat to outdoor worker health but have implemented strategies and Occupational Safety and Health Administration (OSHA) regulations that mitigate much of the impact.
- **Agency Ability/Opportunities to Manage**: High.
  - Training is conducted regularly to ensure that there are adequate supplies (e.g., ice machines, sunscreen, Gatorade, canopies, etc.) and understanding of the signs of heat illness. Workers themselves are encouraged to self-monitor for signs of heat illness. Extra breaks are provided when temperatures reach certain levels.

    - OSHA regulations in California require access to shade starting at 80°F, in addition to other procedures regarding rest, acclimatization, and availability of cold water.
    - Maintenance can re-schedule some work to night shifts or early morning shifts to minimize work during times of high heat.

2.1.3 Heat and Asphalt

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Roadways	Extreme Heat	☒ City of Sacramento ☐ SacRT	**Level of Concern = Moderate** **Agency Ability to Manage = High**

- **Brief Description**: Heat can soften asphalt, making it more susceptible to deterioration and shortening its lifespan. At some intersections, traffic signal loops – systems embedded in asphalt that detect vehicles and/or bicycles – can be destroyed when pavement softens.
- **Assets/System Components/Users Affected**: Roadway asphalt and shared-use path asphalt.
- **Locations Affected**: Throughout the city. Chronic rather than acute issue. Deterioration more likely in areas with heavy truck and bus traffic. Traffic signal loops at older intersections are more susceptible.
- **Qualitative Level of Concern and Rationale**: Moderate.
    - Both engineering and maintenance staff noted that heat does not seem to be a major contributor to decreasing pavement quality, but it may become a future issue as temperatures continue to increase.
- **Agency Ability/Opportunities to Manage**: High.
    - Maintenance efforts can shave down asphalt to address deformation.
    - Streets in poor condition can be fully reconstructed; however, this is estimated to be 26 times more expensive than maintaining a good street.[37]
    - Traffic signal loops can be replaced with traffic cameras.
- **Other notes**:

[37] https://www.cityofsacramento.gov/content/dam/portal/pw/Maintenance-Services/Sacramento-2022-Pavement-Update-FINAL.pdf

- The City's asphalt pavement design specifications require a similar asphalt binder performance grade as Caltrans.[38]
- If ambient temperatures are too high, or too low, pavement cannot be placed.
- Increasing temperatures may shorten the season for preventative maintenance.

2.1.4 Heat and SacRT Light Rail Tracks

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Rail	Extreme Heat	☐ City of Sacramento ☒ SacRT	Level of Concern = Low Agency Ability to Manage = High

- **Brief Description**: Heat can cause tracks to expand. If not properly managed, this can cause warping or buckling of the tracks, which can lead to train derailment.
- **Assets/System Components/Users Affected**: Light rail tracks.
- **Locations Affected**: Typically, the places where the tracks meet bridges can be trouble spots, though issues can occur throughout the system. Some of these locations are identified in the Exposure Analysis section.
- **Qualitative Level of Concern and Rationale**: Low.
  - Light rail maintenance staff noted that buckling and derailment due to high heat are highly unlikely on SacRT systems, but not impossible, as a result of current preventative maintenance practices. Track-buckling has not happened previously on the SacRT system.
- **Agency Ability/Opportunities to Manage**: High.
  - Inspections can proactively identify potential issue areas.
  - Preventative maintenance, e.g., addressing profile issues (tracks not straight and level), and hardening are the preferred methods to mitigate impacts from high temperatures.
  - Concerns about warping tracks from extreme heat arise around 104°F-105°F. These concerns can be managed operationally through slow orders, particularly in certain spots where there is a higher likelihood of issues.

[38] Chapter 630 of the Caltrans Highway Design Manual provides detailed information on pavement selection. See: https://dot.ca.gov/-/media/dot-media/programs/design/documents/chp0630-032020.pdf. Sacramento is in the Inland Valley region for purposes of asphalt binder grade selection.

However, slow orders result in slower service and impact schedule adherence and service reliability. This creates longer wait times for passengers and increases the amount of time spent outdoors in high heat. Slow orders can usually be lifted in the evening (e.g., 7pm), but if temperatures do not drop below 70°F at night, slow orders must be implemented for longer periods.

- **Other Notes**:
  - Buckling and derailment is a bigger risk on Class 1 railroads[39] where the tonnage is higher. Heavy rail lines utilize heat patrols to mitigate issues.
  - Rails can break at or under 34°F. Proper maintenance and ultrasonic flaw testing minimize risk. However, this weather hazard is likely to decrease in frequency with warmer temperatures on average.

2.1.5 Heat and Power Distribution System (Substations) for SacRT

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Substations	**Extreme Heat**	☐ **City of Sacramento** ☒ **SacRT**	**Level of Concern = High** **Agency Ability to Manage = High**

- **Brief Description**: SacRT's all-electric light rail system is powered by multiple substation locations. Extreme heat can cause substations to shut off when in-unit cooling capacity is exceeded in hot conditions. Substations can also go offline if the power grid fails due to extreme heat.
- **Assets/System Components/Users Affected**: Light rail substations.
- **Locations Affected**: Can occur throughout light rail system.
- **Qualitative Level of Concern and Rationale**: High.
  - During the summer months, substation outages occur regularly. Light rail maintenance staff estimated about one substation outage per week.
  - Equipment can be damaged from high temperatures, with failure most common during hotter months.
- **Agency Ability/Opportunities to Manage**: High, when outage is caused by SacRT equipment failures due to extreme heat. Low, when the result of grid outage.

[39] Class 1 railroads are generally the largest in rail networks with high operating revenues. Class 1 railroads are defined as "heavy rail"; SacRT is classified as "light rail".

- Operational impacts range from slower train speeds that run behind schedule (i.e., to minimize the electrical load the trains pull from the substations), to smaller train sets (e.g., fewer train cars, again minimizing electrical load required to accelerate), to bus bridges (buses operating between the stations when the light rail cannot).
    - Existing equipment redundancies mitigate impacts (e.g., each substation has two air handlers for substation cooling; if there are three substations in a row and the middle substation fails, the outside two can often carry the light rail load). However, when equipment fails, the load requirements increase for the operating equipment, which can lead to subsequent equipment failures.
- **Ongoing Actions:**
    - There is a proposed heat management study to better understand how high temperatures affect the power distribution system and develop improved cooling solutions. Most air conditioning systems procured by SacRT are designed based on American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) standards for the Sacramento area.
- **Other Notes**:
    - Crossing cabinets and signal enclosures have air conditioning as well. These are also susceptible to failure, although with a smaller relative impact as compared to substation failure.
    - In addition to direct heat impacts on substations, increased energy demand from light rail vehicles requiring more air conditioning can also strain equipment during hot conditions.

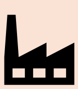
2.1.6 Heat and Overhead Catenary System (OCS) for SacRT

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
OCS 	**Extreme Heat** 	☐ **City of Sacramento** ☒ **SacRT**	**Level of Concern = High** **Agency Ability to Manage = High**

- **Brief Description**: The OCS, a system of overhead electrical cables that are used to transmit electricity to power trains via electric propulsion, is metal and therefore expands and contracts due to heat. There are two types of OCS: fixed tension, where lines are tied off at the poles, and constant tension, where tension is kept by weighted blocks at the end of lines. Constant tension encounters issues more frequently.

- **Assets/System Components/Users Affected**: Light rail OCS.
- **Locations Affected**: Can occur throughout light rail system.
- **Qualitative Level of Concern and Rationale**: High.
    - High level of concern, but operational and maintenance strategies mitigate most risk.
- **Agency Ability/Opportunities to Manage**: High, in most cases.
    - SacRT performs inspections often (every section is checked at least once a quarter) and addresses issues to prevent breaks due to heat. Gauges are placed on the contact wire during inspection to measure the level of contact wire wear; when these reach a certain threshold, the contact wire is replaced or other preventative measures are taken.
    - For constant tension systems, weighted blocks prevent the contact wire from sagging as temperatures change; but sometimes these assemblies hit the ground if the copper expands too much, at which point not much can be done.
    - Slow orders during high heat reduce the stress on the OCS to avoid damage.
- **Other Notes**:
    - Ambient temperatures used in design standards are selected by consultants and are based on ASHRAE.
    - None of SacRT's OCS systems have been replaced, or needed to be replaced as of 2025, since installation in the 1980s.

2.1.7 Heat and SacRT Compressed Natural Gas (CNG) Plant

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
CNG Plant 	Extreme Heat 	☐ City of Sacramento ☒ SacRT	**Level of Concern = Low** **Agency Ability to Manage = High**

- **Brief Description**: Heat can disrupt SacRT's CNG plant in midtown, which is currently the main fueling location for much of its fleet. During hot conditions, compressors can overheat, and the plant may need to shut down or trigger pressure release valves.

- **Assets/System Components/Users Affected**: SacRT CNG plant and CNG-fueled buses.
- **Locations Affected**: SacRT CNG plant in midtown.
- **Qualitative Level of Concern and Rationale**: Low.
    - Compressors overheat each summer about 3-4 times per month. They get back in service relatively quickly, but it is not healthy for the system or the lifespan of the compressors. Temperatures over 100°F are usually where issues start to occur; refueling typically begins at 5pm, so high nighttime temperatures can lead to service delays.
- **Agency Ability/Opportunities to Manage**: High.
    - Old infrastructure can be replaced. SacRT does not currently have designated funding for this.
    - Staff are assigned to monitor the issue.
    - Different refueling schedules could be explored, working around high temperature times.

2.1.8 Heat and Transit-Related HVAC Systems

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
HVAC 	Extreme Heat 	☐ City of Sacramento[40] ☒ SacRT	Level of Concern = Moderate Agency Ability to Manage = Moderate

- **Brief Description**: Extreme heat can exacerbate the load on HVAC systems and lead to equipment malfunction.
- **Assets/System Components/Users Affected**: Facilities, buses, light rail vehicles.
- **Locations Affected**: There are many aging systems throughout SacRT facilities, e.g., the bus maintenance facility at 29th Street.
- **Qualitative Level of Concern and Rationale**: Moderate.
    - OSHA regulations in California include an indoor heat standard, requiring functioning HVAC systems during extreme summer heat.
- **Agency Ability/Opportunities to Manage**: Moderate.

[40] Hotter conditions will also affect City-owned buildings, but these were not a major focus of this assessment as they are not transportation-specific.

- Old rooftop units can be replaced with new, more energy efficient systems that can withstand higher temperatures.

2.1.9 Heat and Signage

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Signage	Extreme Heat	☒ City of Sacramento[41] ☒ SacRT	Level of Concern = Moderate-High Agency Ability to Manage = Moderate

- **Brief Description**: Exposure to extreme heat, high temperatures, and direct sunlight damages signage (including traffic control and wayfinding signage); worn and fading signage can make navigation for active transportation users difficult. Illegible wayfinding signage prevents transit riders from being able to navigate the system resulting in missed trips and unnecessary detours, and faded traffic control signage can pose a direct traffic safety risk.
- **Locations affected**: Citywide, concentrated around light rail stations and transit centers. Streets and major roadways provide wayfinding to the nearest station/transit center; however, if those are faded and not legible, travelers are not able to determine the direction to transit facilities and services.
- **Qualitative Level of Concern and Rationale**: Moderate to High.
- **Agency Ability/Opportunities to Manage**: Moderate.

2.2 Extreme Wind

2.2.1 Wind Impacts to Crossing Gates and other SacRT Infrastructure

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Infrastructure	Wind	☐ City of Sacramento ☒ SacRT	Level of Concern = Low Agency Ability to Manage = High

[41] Hotter conditions will also affect City-owned buildings, but these were not a major focus of this assessment as they are not transportation-specific.

- **Brief Description**: The primary direct impact of wind on SacRT's infrastructure is on crossing gates, which wind can bend or break. Wind can also knock down trees or branches, which can block light rail tracks, damage OCS wires, and indirectly result in substations losing power through grid outages.
- **Assets/System Components/Users Affected**: Light rail crossing gates, OCS.
- **Locations Affected**: Crossing gates in east/west aligned portions of the system are more prone to damage given strong north/south winds, which utilize crossing gates to control north/south traffic. The TAC identified 24 specific locations where crossings have experienced wind damage, the majority of which are on the Gold Line.[42]
- **Qualitative Level of Concern and Rationale**: Low.
    - Crossing arm damage often results in a slow down or a stop at the crossing. The level of damage varies in a given year. In January 2023, when winter storms with heavy winds occurred, an estimated 74 gates were broken or damaged.
- **Agency Ability/Opportunities to Manage**: High.
    - Branches that can reach OCS wires are trimmed year-round.
    - Each maintenance person usually carries tools and materials in their trucks for the common equipment that breaks, especially for gates. When grade crossings are damaged by wind, staff prioritize the busiest crossings and key routes for emergency responders. Gate repairs can take place quickly, although some repairs may be postponed after wind events to minimize the potential need for multiple repairs.
    - Light rail trains can continue operations using "stop and protect" rules and procedures or with flaggers managing control of the intersection crossings.
- **Other Notes**:
    - Clearing downed trees/limbs can take priority over a grade crossing failure if vegetation is on a high voltage conductor.

[42] The locations are: Blue Ravine Crossing, Bradshaw Crossing, Butterfield Crossing, Center Parkway Crossing, Florin Perkins, Franklin Crossing, Glenn Crossing, Horn Crossing, Jackson Crossing, Kilgore Crossing, Marketplace Crossing, Mather Crossing, Mayhew Grade Crossing, Mercantile Crossing, Nimbus Crossing, Olsen Crossing, Parkshore Crossing, Richards Crossing, Routier Crossing, S. Watt Crossing, Starfire Crossing, Sunrise Crossing, and Zinfandel Crossing.

2.2.2 Wind Impacts to Traffic Signals, Streetlights, and Other City Infrastructure

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Traffic Infrastructure	Wind	☒ City of Sacramento ☐ SacRT	**Level of Concern = Moderate** **Agency Ability to Manage = Moderate-High**

- **Brief Description**: Wind can bring down large branches or trees, which in turn can damage or destroy traffic signals, streetlights, overhead wires, and other city infrastructure and block vehicle, bicycle, and pedestrian traffic. Wind can also crush the hoists used to pull up floodgates and clean their screens. Wind-driven power outages can lead to traffic signal outages and can disrupt pumping stations, leading to flooding in low-lying areas.
- **Assets/System Components/Users Affected**: Light rail tracks, roadways, sidewalks, shared-use paths, traffic signal infrastructure, pumps.
- **Locations Affected**: Trees weakened by disease, decay, drought or previous damage are particularly vulnerable to limb drop and tree failure, but all infrastructure adjacent to trees may be impacted. Areas with aging signal infrastructure.
- **Qualitative Level of Concern and Rationale**: Moderate.
    - One of the top staff concerns was widespread damage from downed trees as a result of an extreme wind or storm event.
    - High consequence impacts from wind events include major roads being blocked by downed trees and power outages that impact pumping stations or traffic signals at major intersections.
    - Moderate consequence impacts from wind events can extend for days, or weeks depending on the scale of the event, with tree debris blocking minor roads, bicycle facilities, sidewalks, or shared-use paths.
    - In 2023, heavy storms with severe winds led to the loss of 3,000 trees in the city, and 99 of 150 pumping stations lost power at some point. Due to the extent of regional damage, some stations were without power for up to three days.
- **Agency Ability/Opportunities to Manage**: Moderate to high.
    - Regular, proactive tree maintenance/trimming and watering is the main way to manage the risk for both city-maintained and private trees.

    - Design standards on vertical infrastructure, like signals and streetlights, can be increased.
    - Undergrounding wires can mitigate impacts from downed trees, although these projects are expensive and require partnership with SMUD.
    - Increased staffing can speed up storm clean-up.
    - Battery back-up can be used at traffic signals to make sure they do not "go dark" in a power outage; however, these systems require regular maintenance to ensure reliability in an emergency.
    - Back-up generators can power critical pumping stations during outages.
- **Ongoing Actions:**
    - City tree crews meet industry recommended maintenance standards, although increased maintenance may help mitigate impacts.
    - Caltrans sets the signal foundation depth and size standards based on wind loads, and the City chooses to follow these guidelines. Caltrans standards have become more conservative over the years, resulting in a larger base. Going deeper and wider than current standards would increase costs, require larger sidewalks to maintain ADA compliance around signal poles in sidewalks, and present additional challenges (e.g., with other underground utilities or maintaining Americans with Disabilities Act (ADA) accessibility design standards).
    - 311 is currently used by community members to inform the City of downed branches or trees.
    - Currently, not every key pumping site has a dedicated generator, so portable diesel generators are rotated between smaller facilities to maintain levels in the wet wells and avoid flooding/property damage.
    - DOU recently completed a study on how to prioritize spending in terms of pumping stations and power outages.
- **Other Notes**:
    - Private trees are the responsibility of private property owners. Trees on private property can fall and block roadways and damage infrastructure, but city crews cannot enter and perform proactive maintenance on trees on private property. This limits the level of control the city has on mitigating incidents of tree conflicts with transportation infrastructure.
    - Ongoing staffing challenges can also hinder preventative tree maintenance, beyond required industry standards.
    - Drought followed by storms can lead to tree failure because roots that are weakened from drought struggle to anchor trees in saturated soils, making them prone to toppling in strong winds.

2.3 Flooding and Heavy Precipitation

Note: The first subsection briefly describes widespread flood events resulting from levee failure and general strategies for managing that risk that are relevant to SacAdapt. The following subsections discuss impacts to specific parts of the transportation system in more detail. The strategies described in the first subsection can help manage risks to these specific parts of the system but are not repeated in each subsection for the sake of brevity.

2.3.1 Levee Failure and Widespread Flooding

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Levees	Flooding & Heavy Precip	☒ City of Sacramento ☒ SacRT	Level of Concern = High Agency Ability to Manage = Moderate

- **Brief Description**: Flooding
- **Assets/System Components/Users Affected**: All
- **Locations Affected**: The majority of the city faces risks from a large-scale flood event (discussed in Section 3.1.1). Significant portions of the city are protected from flooding by the primary and secondary levees; should these levees fail, they would be heavily affected. Other areas, such as portions of Natomas, are in the 100-year floodplain.[43]
- **Qualitative Level of Concern and Rationale**: High.
  - While it has a small annual probability, a levee failure along the American or Sacramento Rivers or a nearby canal could be catastrophic and inundate large portions of the city and its transportation infrastructure, making it impassable in many cases. Death and injury to travelers can also occur due to high water.
- **Agency Ability/Opportunities to Manage**: Moderate. There are many ways the City and others can, and already do, manage flood risk. However, much of the risk is difficult to mitigate – both because of the potential catastrophic impact from levee failure and due to Sacramento's flat terrain, which is challenging to drain even

[43] Per FEMA, a 100-year floodplain is the boundary of a flood that has at least a 1% chance of occurring in any given year.

under frequent local flooding events. Some flood management considerations relevant to transportation are:

- Flood monitoring
    - For larger riverine flooding, the I Street gauge and telemetry monitors Sacramento River levels. The H Street gauge for the American River is less active because of upstream Folsom Dam control, although high Sacramento River levels can backflow to the American River.
    - The State Water Resources Control Board (WRCB) website also monitors river levels.
    - Staff coordinate and deploy based on water levels, e.g., for closer monitoring, levee patrol, floodgate deployment. When the I Street gauge gets to 25 ft., the City begins 24/7 monitoring of all levees/streams.
- Evacuation
    - Major events like levee overtopping would likely happen after a heavy precipitation winter and heavy rain-on-snow in the Sierras. Weather forecasts would serve as a critical tool for providing the advance warning needed to evacuate.
    - Evacuation routes depend on the hazard and level of advance notice. Finding the easiest way out of town if a levee breaks is critical. Signal disruptions and/or road inundation will make evacuations more difficult to manage.
    - Signal timing is one of the main tools to use during evacuations or other events when rerouting traffic is needed. The Traffic Operation Center (TOC) monitors busy intersections in real-time. Most major intersection signals can be managed remotely from the TOC.
    - The City has an emergency evacuation plan involving multiple agencies, such as OEM, PD, FD, DPW, DOU, SacRT, etc. DPW is involved with closing the roads (with barricades, cones, etc.).
    - If flooding affects the secondary floodgate system, the City is partnered with SacRT buses to help with evacuation.
    - Other potential challenges for evacuation include lane reductions (i.e., road diets) and self-driving cars.
- Floodgates
    - The flood protection system in the Sacramento Region is made up of levees, floodgates, and other components. The City maintains and operates 18 floodgates, which are a critical part of this system.

- **Ongoing Actions:**

- The DOU Comprehensive Flood Management Plan discusses the City's strategies to manage flooding in greater detail.
- The Floodgate Modernization and Resilience Project is currently repairing and modernizing ten of the 18 City-operated floodgates. Additional funding will be needed to continue implementing the recommendations identified from the Floodgate Assessment.

2.3.2 Flooding and Roadways, Railways, and Shared Use Paths

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Roads & Paths	Flooding & Heavy Precip	☒ City of Sacramento ☒ SacRT	Level of Concern = Moderate Agency Ability to Manage = Moderate

- **Brief Description**: Flooding can inundate, disrupt, and damage linear transportation infrastructure. The magnitude of impacts varies widely in the Sacramento region and includes localized flooding, smaller riverine flooding, and major riverine flooding resulting from levee failure.
- **Assets/System Components/Users Affected**: Roads, railways, bicycle facilities, sidewalks, shared-use paths, and travelers.
- **Locations Affected**: The majority of the city.
  - In addition to system-wide flood risks, there are specific concerns with localized flooding in low-lying areas because of overloaded, blocked, or inadequate stormwater drainage. These locations are noted in the Exposure Analysis section of this report.
  - Although most of Sacramento's linear infrastructure is not on earthen embankments (including levees), this infrastructure (e.g., certain roadways, many shared-use paths) is susceptible to acute erosion damage from riverine flooding with relatively high velocities.
  - Inundation of Discovery Park during significant storm events, or during subsequent dam releases, poses a major barrier to North-South active transportation connections by flooding a shared-use path connection without a nearby alternative route.
  - Roadways with high traffic from heavy vehicles— e.g., solid waste trucks, commercial truck traffic, buses, light rail tracks embedded in streets—are more susceptible to pavement deterioration. Areas above hollow sidewalks or other tunnels can also be more susceptible.

    - Flooding can further exacerbate the formation of sinkholes in areas where groundwater levels fluctuate.
- **Qualitative Level of Concern and Rationale**: Moderate.
    - While it has a small annual probability, a levee failure along the American or Sacramento Rivers would be catastrophic and inundate large portions of the city, including transportation infrastructure, making them impassable in many cases and critically disrupting evacuation travel.
    - Flooding can delaminate pavement acutely when water velocities are higher or, more commonly, accelerate deterioration. Deterioration occurs when water seeps through cracks and gets into the base layer, and is exacerbated by heavy vehicles.
    - Most recurring flood issue locations along roadways have shallow and lower velocity water. This can lead to traffic delays due to slower speeds or rerouted traffic. Unlike motorists, bicyclists and pedestrians can be highly impacted even by shallow water depths, particularly in bicycle facilities, curb ramps, and crosswalks.
    - Wind can exacerbate impacts during heavy rainstorms if pump station power is disrupted, thus worsening or prolonging localized flooding.
    - Impacts of regular flooding events include increased maintenance costs and shorter asset lifecycles. This accelerated pavement deterioration impacts year-round travel through slower traffic through areas with lower quality pavement and potential physical barriers to people walking and biking. For light rail, impacts can result in service disruption.
- **Agency Ability/Opportunities to Manage**: Moderate. There are many ways the City and others can, and already do, manage flood risk. However, much of the risk is difficult to mitigate – both because of the potential catastrophic impact from levee failure and due to Sacramento's flat terrain, which is challenging to drain even under frequent local flooding events. Some flood management considerations relevant to transportation are:
    - Flood monitoring
        - For local rainfall/urban runoff, flooding is mostly identified by feedback from O&M staff, 311 calls from community members, or sometimes, through stormwater modeling.
        - For new infrastructure, the City can check dewatering wells to make sure they are properly managed.
    - Evacuation
        - See previous subsection.
    - Internal drainage improvements

        - Increasing drainage pipe size of the combined sewer system (CSS) can be helpful.
        - DOU requires new development projects to submit drainage studies and implement drainage mitigation methods to ensure they do not negatively impact the City's storm drain system.
        - Drain inlets can cause localized flooding when leaves and debris block grates. Certain drain inlet styles are more prone to this than others.
        - Culverts are cleaned out by DPW maintenance staff September to November before the rainy season. More maintenance capacity is needed during this season.
    - Land use development
        - Local flooding can also be caused by homeowners installing non-compliant driveways over drainage ditches.
    - Transportation system maintenance
        - For pavement degradation, maintenance is prioritized where the pavement condition index (PCI) is the worst.
        - For light rail in areas that get compacted, sometimes SacRT needs to raise the tracks.
- **Ongoing Action:**
    - The DOU Comprehensive Flood Management Plan discusses the City's strategies to manage flooding in greater detail.
    - DOU is required to maintain a level of service for all services including drainage:
        - Under a 10-year design storm event, streets should be clear of flooding.
        - For anything above a 10-year design storm event, ponding is expected on streets. Six inches of flooding – which poses barriers to people walking, biking, and driving – is the maximum allowed for a 10-year design storm event. DOU uses a 10-year design storm for its standard pipe design.
        - For a 100-year design storm event, damage to structures should be prevented.
    - The County of Sacramento is updating its design storms to include a future climate hydrology scenario. Once the county adopts these design storms, the City plans to adopt the same ones.

- Hydraulic modeling has been completed for about half of the basins in the city. The areas where modeling has been completed have generally been those that are at higher risk.
- Implementation of the Streets for People Active Transportation Plan and Transportation Priorities Plan would create greater redundancy in the active transportation network.

2.3.3 Flooding and Underground/At-Grade Telecommunications and Electrical Infrastructure

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Electrical Infrastructure 	**Flooding & Heavy Precip** 	☒ **City of Sacramento** ☐ **SacRT**	**Level of Concern = Low** **Agency Ability to Manage = Low-Moderate**

- **Brief Description**: Localized or riverine flooding can inundate and destroy underground or at-grade electrical and telecommunications infrastructure. This includes interconnections with the police department and other emergency responders, IT infrastructure, traffic signals, and railway infrastructure.
- **Assets/System Components/Users Affected**: Affected transportation-specific infrastructure includes traffic signals and underground or at-grade SacRT electrical or communications infrastructure, but the issue affects a broader set of assets as described above.
- **Locations Affected**: More likely to occur in denser urban areas where more infrastructure is underground and in areas susceptible to inundation. Along Freeport Boulevard there is infrastructure that was undergrounded and serves the Police Department; they have lost communication during a flood event for a brief period in the past.
- **Qualitative Level of Concern and Rationale**: Low.
    - Flooding typically only causes temporary outages, rather than permanent damage to signal equipment.
    - Damage could be widespread during a levee breach, though annual probability is very low.
    - In cases where signals are disrupted, evacuations can be more difficult to manage. That said, for major widespread flood events, roads being

inundated may be a larger issue than the signals on those roads not functioning properly.

- **Agency Ability/Opportunities to Manage**: Relatively low for a widespread flood event. Moderate for more localized or smaller riverine flooding; can be managed somewhat operationally.
    - Some of the infrastructure in the downtown area is in hollow sidewalks which can fill with water in certain areas and is difficult to detect given its age and the fact that it is are underground. After initial flooding, it can be difficult and time-consuming to pinpoint what is still flooded and causing things to shut down.
- **Other Notes**:
    - Traffic signals (and signal boxes) are not designed to account for flooding. However, short-term inundation with stormwater has not created permanent damage in the past, rather just temporary outages. Waterproofing signal boxes is a possibility, though it may not be cost effective; making them tamper-proof is more of a concern.
    - Traffic signal elevation and design is not based on climate hazards (for example, a 100-year storm) as there is usually enough time to prepare for storms, close intersections, and implement certain traffic patterns.
    - Fiber optic cable connects many traffic signals to the TOC, enabling remote signal pattern changing. This signal connection would facilitate an evacuation. Signals that are not connected to fiber, or where signal connection has been lost, can only be changed at the traffic control box at the signal itself. The goal is for every signal to be connected to the TOC. More than half are currently connected. For new developments that will induce traffic, there are usually development fees that fund signal(s).

2.3.4 Flooding and Transit Facility Damage

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Facilities	**Flooding & Heavy Precip**	**☐ City of Sacramento** **☒ SacRT**	**Level of Concern = Moderate-High** **Agency Ability to Manage = Moderate**

- **Brief Description**: Flooding can damage buildings and their contents, including transit facilities.
- **Assets/System Components/Users Affected**: SacRT facilities and other transit facilities.
- **Locations Affected**: Specific locations mentioned by TAC members or other key agency staff include:
    - The SacRT bus maintenance facility in midtown has a large amount of underground storage and pathways for stormwater to drain into the facility. The main building with dispatch has drainage issues. In 2024, a pump in the basement died during one of the heaviest rain events, and stormwater drained into the basement, causing electrical issues.
    - Other SacRT facilities, e.g., bus stops, stations, transit centers.
    - Sacramento Valley Station.
- **Qualitative Level of Concern and Rationale**: Moderate to high.
    - With a levee breach, all SacRT facilities in the downtown area would likely flood.
    - Even in a localized flooding event, if the main dispatch building is flooded, it can heavily impact service.
- **Agency Ability/Opportunities to Manage**: Moderate.
    - SacRT has a second bus maintenance facility in McClellan where buses can be relocated in case of a levee breach. This would allow SacRT to move its vehicles away from downtown flooding and still provide transit service (including emergency service) to the city.
    - The majority of the equipment downtown is fixed in place so it would be difficult to move it up above flood levels.
    - Emergency drills can improve agency ability to manage these disruptions.

2.3.5 Flooding and Bridge Damage

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Bridges	**Flooding & Heavy Precip**	**☒ City of Sacramento** **☒ SacRT**	**Level of Concern = Moderate** **Agency Ability to Manage = High**

- **Brief Description**: Flooding can damage road and rail bridges, particularly through scour of abutments or piers.
- **Assets/System Components/Users Affected**: City and SacRT bridges.
- **Locations Affected**: City bridge inspection data has information on bridges with issues that could make them more susceptible to flooding. The Exposure Analysis section discusses some bridge crossings where flooding occurs.
- **Qualitative Level of Concern and Rationale**: Moderate.
    - Bridges can be at risk if they are not well maintained. For instance, one City engineer noted that if channels are not clear of debris, particularly at piers, it can essentially dam water and put more pressure on the structure.
    - Neither City nor SacRT engineering staff noted recent major flood damage at bridges.
- **Agency Ability/Opportunities to Manage**: High.
    - Caltrans performs bridge inspections every other year and sends them to the City. The City divides them into maintenance activities for minor repairs, and capital improvement projects for major repairs.
    - Existing channel clean-up and trash capture initiatives exist. Opportunity to focus efforts around key bridge infrastructure.
- **Other Notes**:
    - For the city, many bridges were built to have a 50-year life cycle but some last for twice that long. A few older bridges were built under different standards. As those bridges come up for needed repairs or reach the end of their life cycles, they are rebuilt to current standards (i.e., at least 2 feet above the 200-year storm depth).
    - SacRT does not have a standardized process for bridge design. They hire consultants who suggest design standards (usually based on Caltrans).

2.4 Wildfire

2.4.1 Wildfire and Smoke Impacts to Travelers

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Traveler Health	Wildfire	☒ City of Sacramento ☒ SacRT	Level of Concern = High Agency Ability to Manage = Low

- **Brief Description**: Wildfires, while unlikely to break out within Sacramento city limits, can cause significant public health impacts due to wildfire smoke. Wildfire smoke also encourages travel in personal vehicles rather than by active or public transportation.
- **Assets/System Components/Users Affected**: City-wide. Vulnerable populations are at greater risk, particularly households that do not own a vehicle.
- **Locations Affected**: City-wide.
- **Qualitative Level of Concern and Rationale**: High.
  - Exposure to wildfire smoke is associated with a range of health impacts, particularly for vulnerable populations. People walking, biking, driving, or riding transit that breathe in the fine particulate matter in wildfire smoke can experience respiratory problems, especially those at higher risk or with underlying health conditions.
  - Wildfire can also impact the ability of first responders to respond in emergencies.
- **Agency Ability/Opportunities to Manage**: Low.
  - Masks can be distributed to people walking and biking to mitigate the impacts of wildfire smoke, but there is not much that can be done - particularly for outdoor areas where any sort of air filtration is impossible.
  - With more sophisticated HVAC technology, some indoor transit facilities could be turned into clean air centers.
  - Air filtration systems are already in place on transit vehicles. The benefits of improved filtration would be minimal due to regular opening of doors on these vehicles.
  - Outdoor air quality sensors can help residents make informed decisions about time spent outdoors.

2.5 Multiple Hazards

2.5.1 Power Grid Failure

Damage Focus	Hazard	Agency	Level of Concern and Agency Ability to Manage
Power Grid	**Multiple**	☒ **City of Sacramento** ☒ **SacRT**	**Level of Concern = High** **Agency Ability to Manage = Low-Moderate**

- **Brief Description**: Power grid failure can be weather-driven, including by heat, wildfire, wind, or flooding.
- **Assets/System Components/Users Affected**: All. Grid failure can significantly disrupt traffic signals, light rail substations, pumping stations, electric bus chargers, agency maintenance and public safety vehicles, chargers for personal EVs, and active transportation (e.g., via e-scooters and e-bikes). Bridges, roadways, walking/biking facilities, traffic flow, and evacuation are all impacted.
- **Locations Affected**: Entire study area.
- **Qualitative Level of Concern and Rationale**: High.
  - Extreme heat can cause power outages by overloading electrical infrastructure, precipitating failures. Overloaded infrastructure during extreme heat can be caused by increased air conditioning usage throughout the entire day, higher equipment operating temperatures forcing shutoffs to avoid overloads, or a combination of these events.
  - Power outages can significantly disrupt many parts of the City and SacRT transportation systems, including but not limited to traffic signals, pump stations used to reduce flooding, the light rail system, critical facilities, and electric buses and vehicles. Larger scale and longer outages present a higher level of concern.
  - As described in Section 2.2.2, in 2023, a storm caused power outages at over 99 pumping stations (out of 150 that require power). Due to the extent of regional damage, some stations were without power for up to three days. DOU has standby power at critical sites to continue operations, but the smaller facilities share 23 portable diesel generators that are deployed and require staff to make rotations.
  - There are also concerns of fleet electrification and its impacts during power outages if EVs are used during emergencies.
- **Agency Ability/Opportunities to Manage**: Low to moderate.
  - The City and SacRT do not manage the grid directly so are dependent on SMUD for resolving issues. That said, there are ways both agencies can add more backup power capabilities to mitigate power outages. Battery storage capacity may provide additional backup power
  - EVs and electric buses can serve as mobile generators during power outages. When equipped with vehicle-to-grid (V2G) or vehicle-to-building (V2B) technology, they can store additional power in their batteries that can be returned to the grid during peak times of use or, in emergencies, as

backup generators.[44] Additionally, critical and emergency facilities that must run or must have an operating fleet to provide mobile services can install stationary storage or behind the meter energy storage to power their electric fleets or vehicles during a grid outage. Building microgrids on critical facilities can further mitigate outage impacts to electrified fleet operations.

- DOU conducted an in-house study to prioritize spending on back-up generators based on areas that would flood during power outages. The study identified the need for more permanent generators at key locations.
- Back-up power systems at traffic signals can prevent them from "going dark" if they lose grid power but are still operable.

3. Exposure Analysis

This section describes the results of a GIS-based exposure analysis which involved querying hazard data at asset locations and summarizing information across the system.

3.1 Hazard Analysis

The hazard analysis includes a range of transportation assets, including roadways, bridges, sidewalks, bikeways, traffic signals, pump stations, light rail tracks and stations, bus stops, transit facilities, and zero emissions bus (ZEB) charging stations. Map 7 and Map 8 show the locations of City-owned assets and SacRT assets considered in this analysis. Overall, 181 bridges, 78 pump stations, over 725 miles of bicycle facilities, over 1,921 centerline miles of road, 927 traffic signals, 2,843 bus stops, 54 light rail stations, 10 transit facilities (see Table 14), 16 ZEB charging stations, and approximately 44 miles of light rail tracks[45] were analyzed across multiple hazards to assess exposure. Table 15 summarizes the percentage of assets located within the official boundaries of the City of Sacramento, excluding unincorporated areas such as Florin, Rio Linda, and other nearby communities. Although these areas are not strictly within the City boundaries, City-owned assets located there were still included in the analysis.

[44] https://www.epa.gov/greenvehicles/what-if-electric-school-buses-could-be-used-supply-power-when-duty

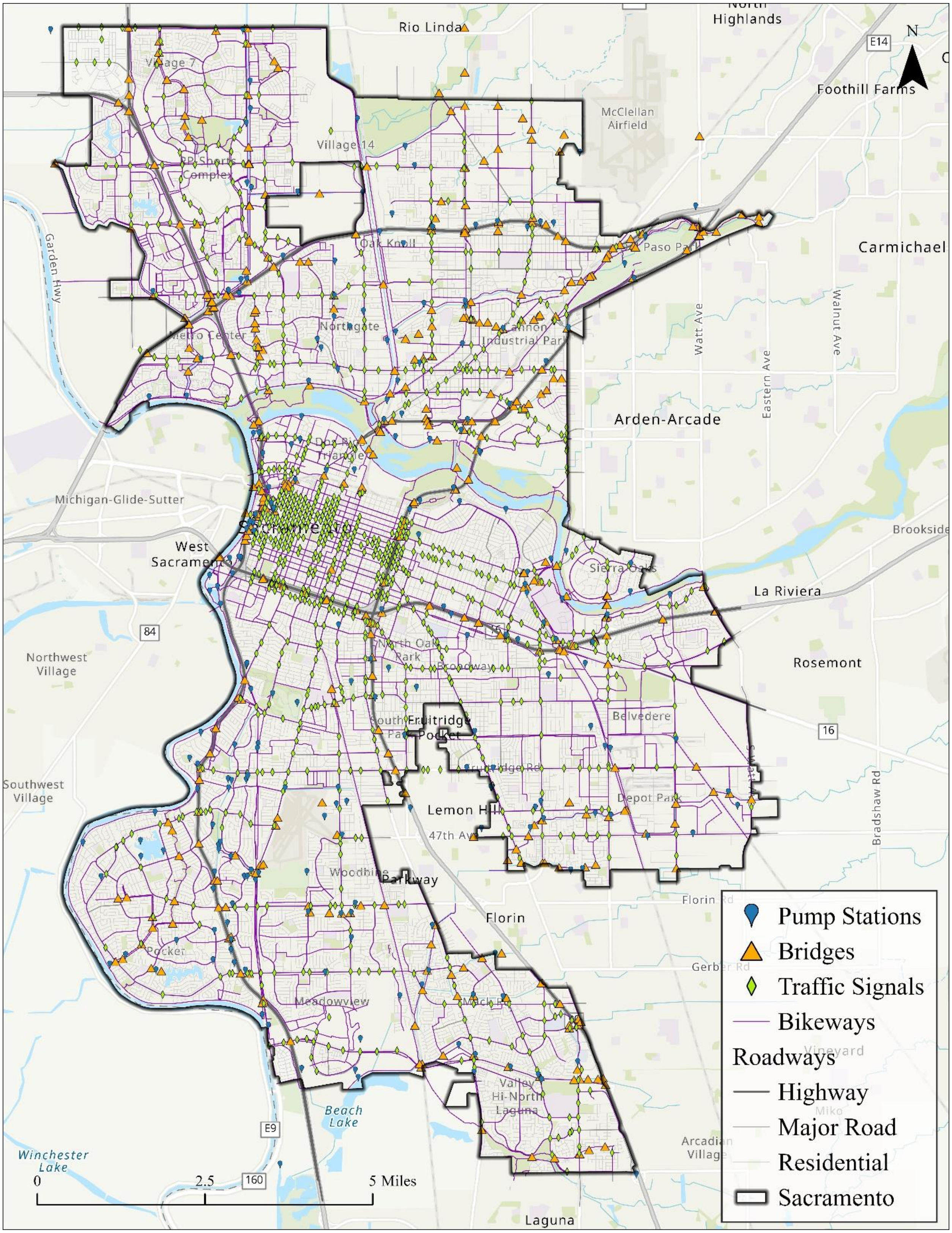
[45] There are roughly 88 miles of actual track (since the system is double track in most areas). But this 44 number is used for consistency with roads (which are summarized in terms of centerline miles).

Table 14. Transit Facility Information

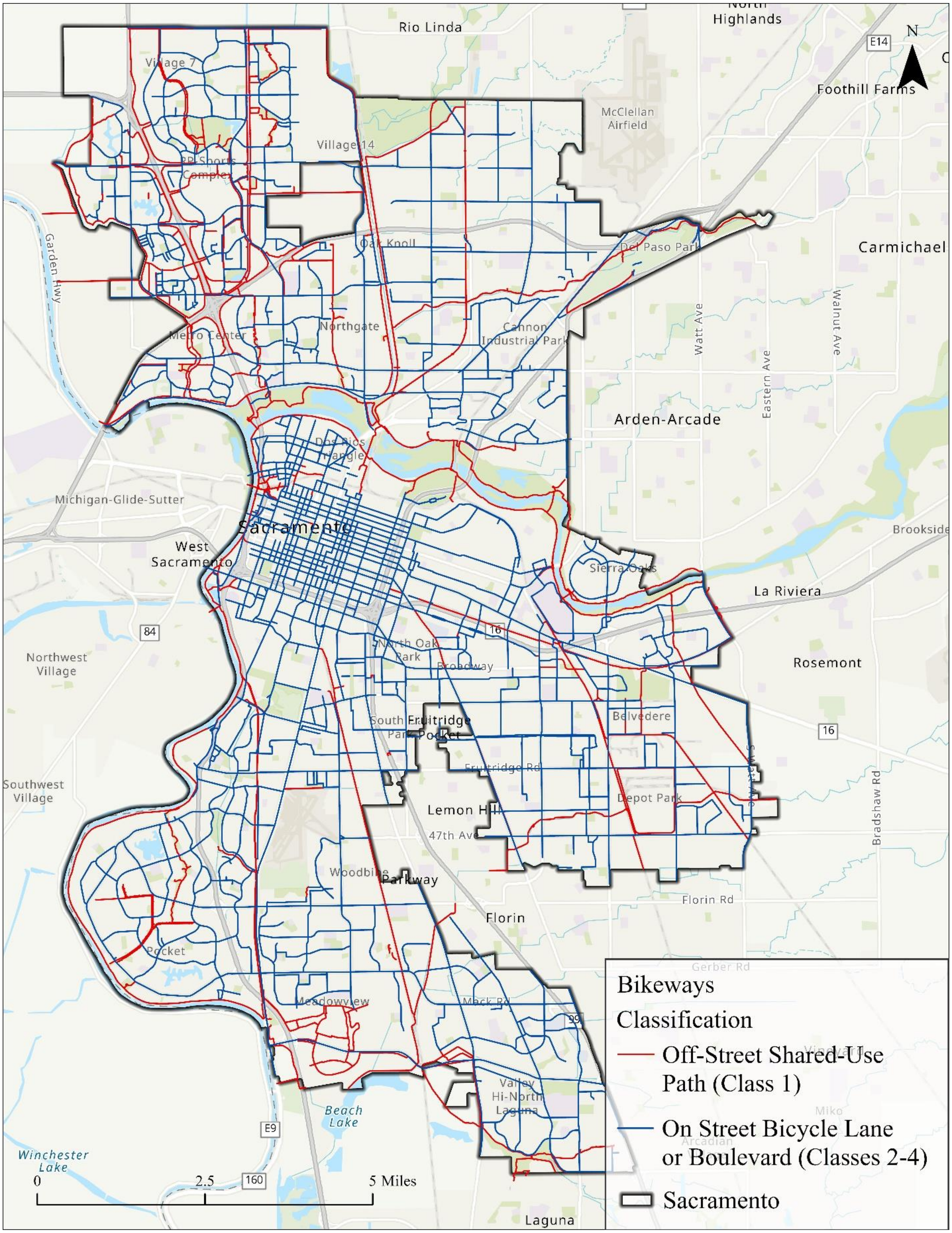
Name	Type
Louis Orlando Transit Center	Operations (transit) Center
Florin Towne Centre Transit Center	Operations (transit) Center
Pocket Transit Center	Operations (transit) Center
Sunrise Transit Center	Operations (transit) Center
Bus maintenance facility 1 (BMF1)	Maintenance buildings
Bus maintenance facility 2 (BMF2)	Maintenance buildings
Light Rail maintenance facility	Maintenance buildings
Downtown bus lot	Bus lot
Elk Grove yard	Bus lot
Security Operations Center (SOC)	Other

Table 15. Asset breakdown by percentage inside versus outside the City of Sacramento

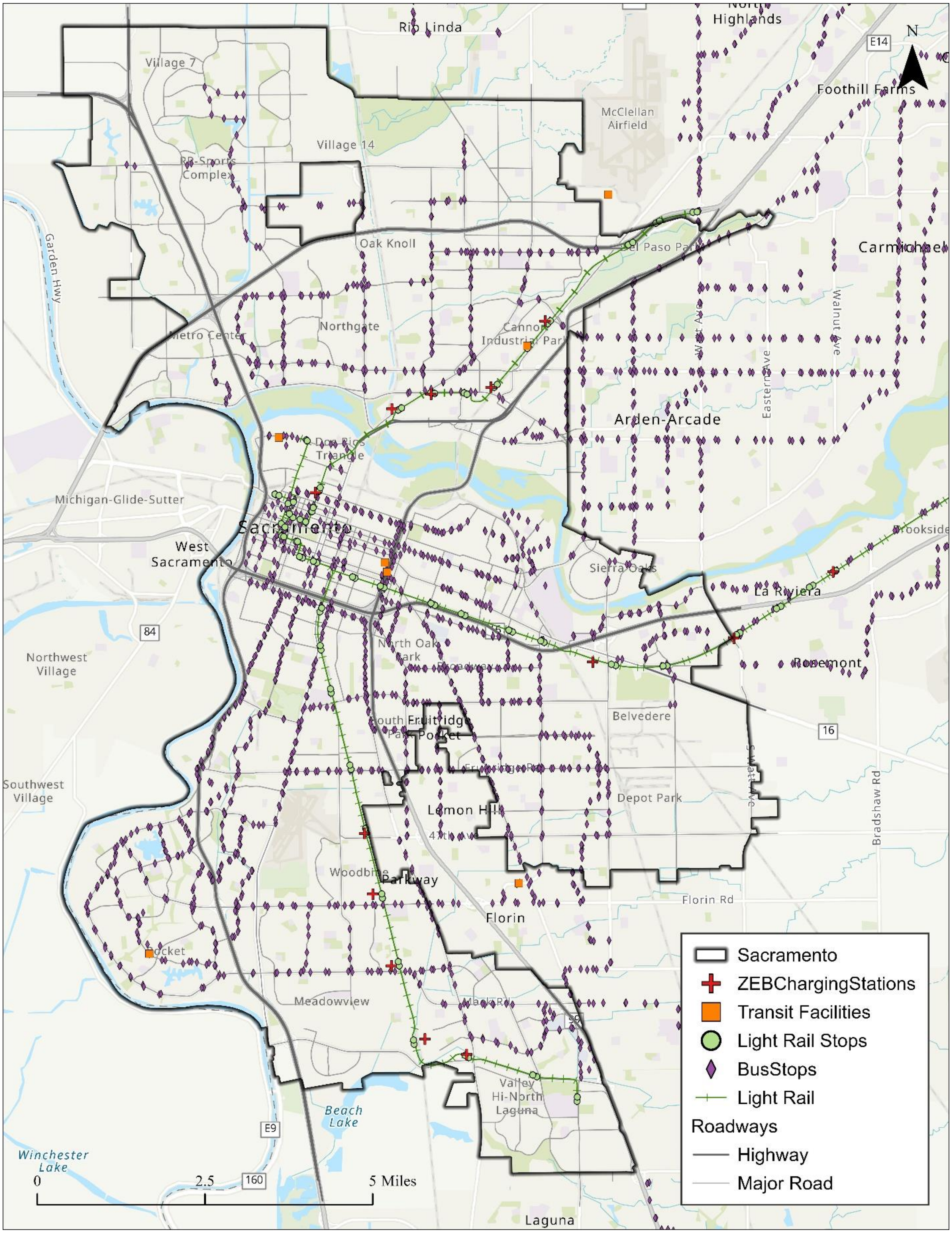
	Asset Class	Total Asset Count/ Total Linear Miles	Percentage Within City	Percentage Outside City
City Assets	**Pump Stations**	**235**	**94%**	**6%**
	Traffic Signals	**927**	**98%**	**2%**
	Bicycle Facilities	**725.2**	**96%**	**4%**
	Roadways	**1,921.34**	**97%**	**3%**
	Curbs and Sidewalks	**2,899**	**100%**	**0%**
	Bridges	**452**	**93%**	**7%**
SacRT Assets	**Light Rail Stations**	**54**	**73%**	**27%**
	Bus Stops	**2,843**	**54%**	**46%**
	Transit Facilities	**10**	**38%**	**62%**
	ZEB Charging Stations	**16**	**69%**	**31%**
	Light Rail Tracks	**44**	**65%**	**35%**



Map 7. City owned assets included in exposure analysis



Map 8. Bikeway classification



Map 9. SacRT Assets included in exposure analysis

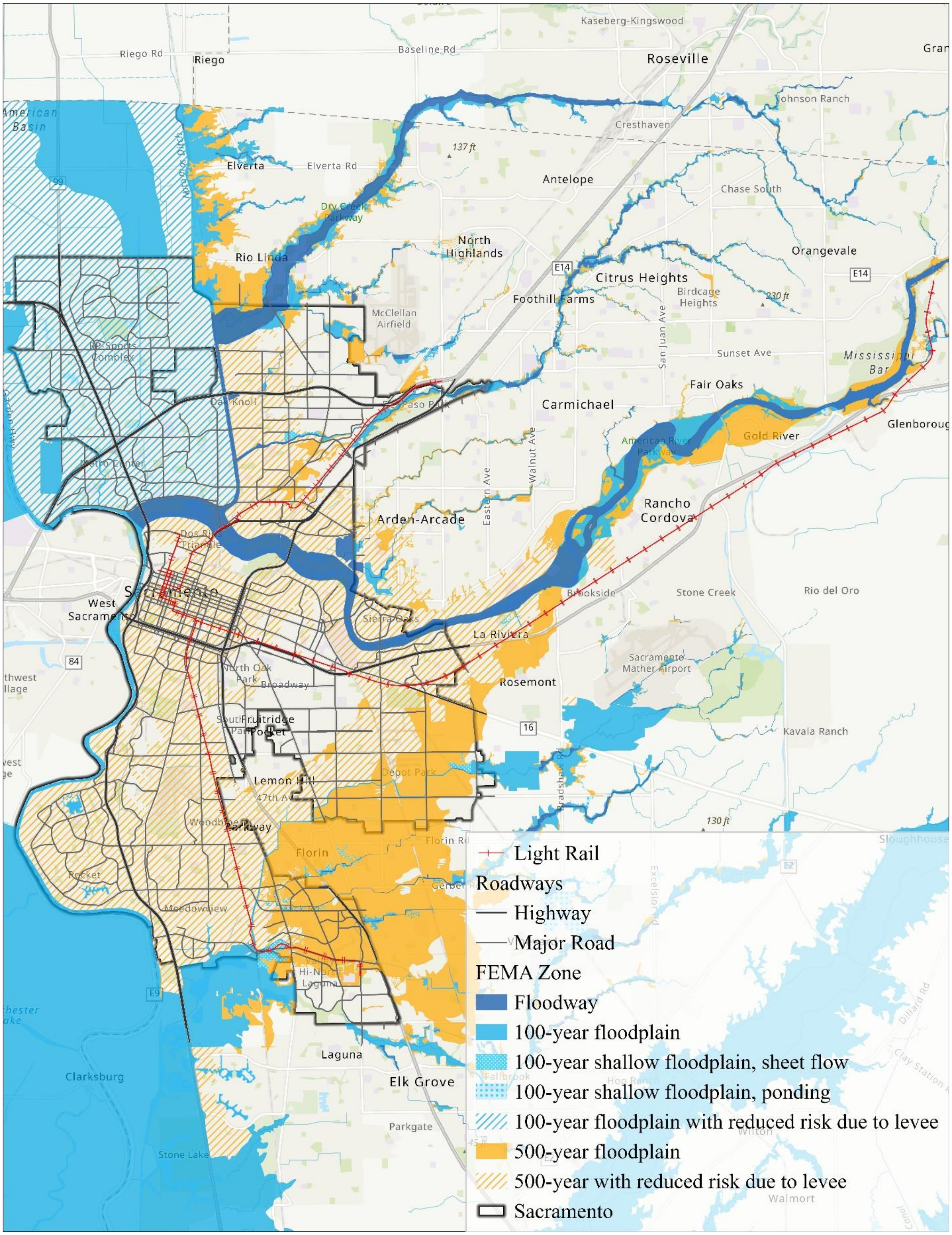
3.1.1 Flooding

Transportation assets were analyzed for exposure to the Federal Emergency Management Agency (FEMA) 100-year and 500-year floodplains, as well as the 200-year floodplain defined by the Sacramento Area Flood Control Agency (SAFCA). SAFCA is a regional agency responsible for managing flood protection infrastructure and modeling residual flood risk, particularly in levee-protected areas such as the Natomas Basin and portions of South Sacramento. Overlays were performed to determine where assets intersect these floodplains. Linear assets such as roadways were summarized by total mileage, while point and area assets were summarized by count.

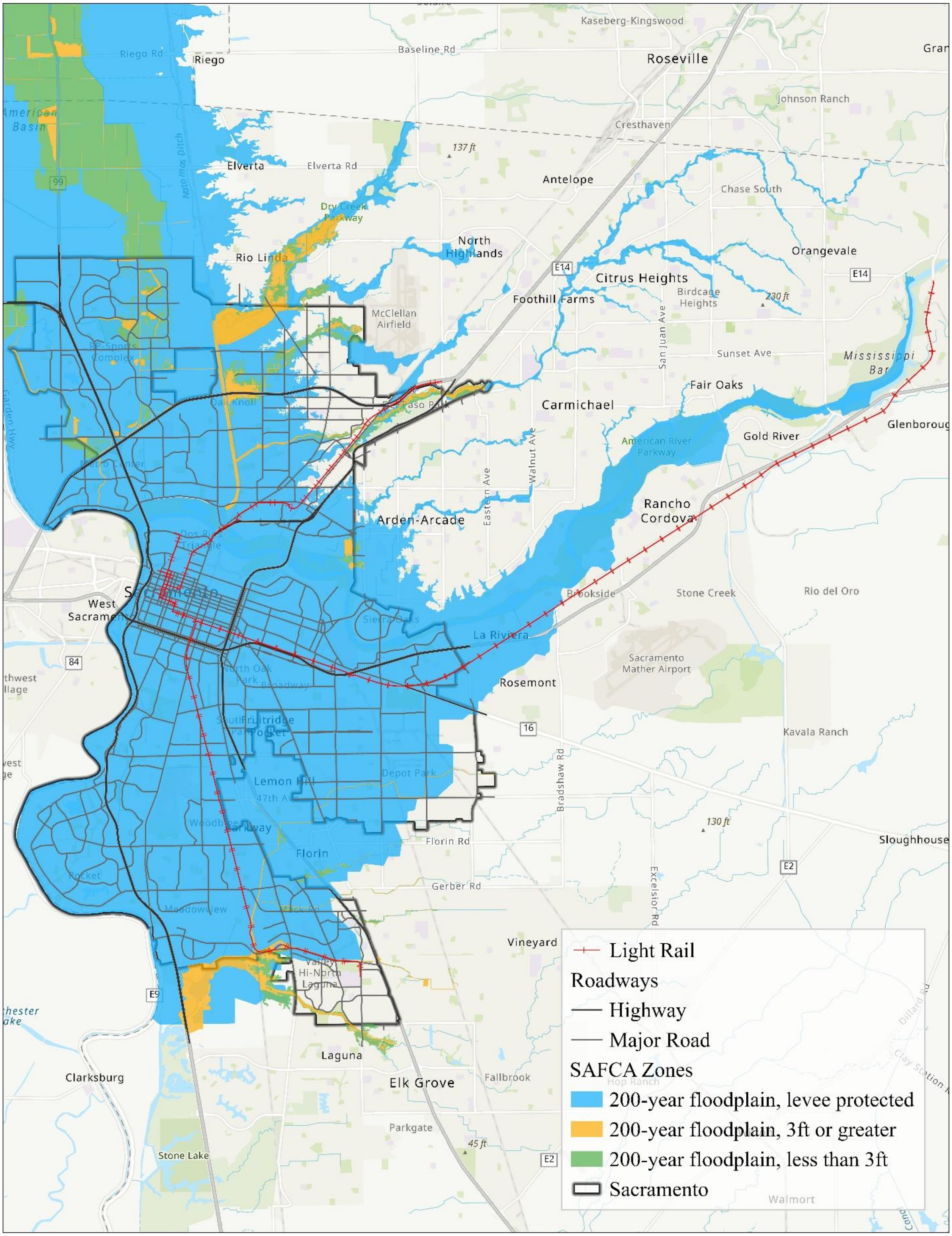
Map 10 and Map 11 show the spatial extent of the FEMA and SAFCA floodplains across the Sacramento area. The SAFCA floodplain modeling is distinct from the FEMA modeling. Some assets can be seen in both the SAFCA and FEMA floodplains.

Most of the City lies within a FEMA-designated floodplain. Old north Sacramento, central neighborhoods—including Downtown, Midtown, and Land Park—the Pocket and large portions of South Sacramento are generally located within the 500-year floodplain. Many of these areas are protected by levees, which reduce the likelihood of flooding, though they still carry residual risk.

Much of the Natomas area falls within the FEMA 100-year floodplain but is also protected by levees and subject to ongoing SAFCA mitigation efforts. The SAFCA 200-year floodplain includes areas where extreme flood events could cause inundation, including those behind levees. This modeling accounts for potential levee failure scenarios and assigns estimated flood depths. Areas shown within the SAFCA 200-year floodplain may include zones with water depths of “less than 3 feet” or “3 feet or greater”, which indicate increasing levels of potential hazard. In some cases, depth values are provided outside the 200-year floodplain due to localized risks, while some areas inside the boundary may show no depth where flooding is not expected or below the reporting threshold.



Map 10. FEMA floodplains



Map 11. SAFCA 200-year floodplains.

Table 16 shows the results of the overlay for exposure to the FEMA 100-year floodplain. Table 17 shows the roadway results further broken down by functional class, and Table 18 shows bikeways by simplified class.

Table 16. FEMA 100-year floodplain exposure results by asset type

	Asset Class	Total Asset Count or Total Linear Miles	FEMA Floodplain Exposure							
			Floodway		100-year floodplain		100-year shallow floodplain, ponding		100-year floodplain with reduced risk due to levee	
			Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent
City Assets	Pump Stations	235	2	1%	10	4%	2	1%	27	12%
	Traffic Signals	927	6	1%	4	0.4%	0	0%	127	14%
	Bicycle Facilities	725	29	4%	32	4%	24	3%	159	22%
	Roadways	1,921	19	1%	13	1%	4	0.2%	387	20%
	Sidewalks	2,899	8	0.2%	4	0.1%	3	0.1%	48	2%
SacRT Assets	Bus Stops	2,843	5	0.2%	19	0.7%	7	0.2%	14	5%
	Light Rail Stations	54	0	0%	0	0%	2	2%	0	0%
	Transit Facilities	10	0	0%	0	0%	0	0%	0	0%
	ZEB Charging Stations	16	0	0%	0	0%	0	0%	0	0%
	Light Rail Tracks	44	1	1%	1	1%	2	2%	0	0%

Table 17. FEMA 100-year floodplain exposure results for roadways by functional classification

FEMA Floodplain Exposure for Roadways by Functional Classification									
		Floodway		100-year floodplain		100-year shallow floodplain, ponding		100-year floodplain with reduced risk due to levee	
Class	**Total Mileage**	**Mileage**	**Percent**	**Mileage**	**Percent**	**Mileage**	**Percent**	**Mileage**	**Percent**
Highway	**104**	3	3%	1	1%	0	0%	22	22%
Collector	**168**	1	0.5%	1	0.3%	0.3	0.2%	25	15%
Arterial	**195**	3	2%	4	2%	1	0.3%	33	17%
Local	**1,233**	2	0.2%	6	0.5%	3	0.3%	273	23%

Table 18. FEMA 100- year floodplain bikeway exposure by classification.

FEMA Floodplain Exposure for Bikeways by Classification									
		Floodway		100-year floodplain		100-year shallow floodplain, ponding		100-year floodplain with reduced risk due to levee	
Class	**Total Mileage**	**Mileage**	**Percent**	**Mileage**	**Percent**	**Mileage**	**Percent**	**Mileage**	**Percent**
Class 1: Shared-Use Path (Off-Street)	**218**	41	19%	79	36%	9	4%	73	33%
Class 2 - 4: Bike Lane (On-Street)	**507**	23	5%	28	6%	4	0.8%	94	19%

Notable highways and arterials overlapping the standard 100-year floodplains (aside from elevated portions over major river crossings) include:

- Highways:
  - I-80 just west of I-5
  - I-80 between Northgate Boulevard and Norwood Avenue
  - SR-99 north of Mack Road
- Arterials (grouped mainly by water feature)
  - Garden Highway, Arden-Garden Connector, and Northgate Boulevard near northern banks of Sacramento and American Rivers
  - Arena Boulevard, Truxel Road, Del Paso Road in North Natomas, and Elkhorn Boulevard near or over the East Drainage Canal
  - Auburn Boulevard, Watt Avenue, Roseville Road, Marysville Boulevard, and Norwood Avenue near or over the Arcade Creek
  - Bell Avenue between Norwood Avenue and Rio Linda Boulevard
  - Stockton Boulevard, Center Parkway, Franklin Boulevard, and Cosumnes River Boulevard near or over Strawberry Creek (portions sometimes referred to as Union House Creek)
  - Watt Avenue, Florin Perkins Road, 65th Street Expressway, Elder Creek Road, Stockton Boulevard, Franklin Boulevard, Mack Road, and Cosumnes River Boulevard near or over Morrison Creek
  - Center Parkway and Franklin Boulevard over Elder Creek
  - Del Paso Boulevard in North Sacramento near or over Steelhead Creek
  - Del Paso Road, El Centro Road, and El Camino Avenue near or over West Drainage Canal
  - El Centro Road north of I-80
  - East Stocketon Boulevard over Union House Creek
  - Ethan Way south of Exposition Boulevard
  - Raley Boulevard near or over Magpie Creek
  - West Elkorn Boulevard, Del Paso Road, and El Camino Avenue near or over Steelhead Creek

Of the 12 pump stations in the standard 100-year floodplains:

- Four are located near the Sacramento Marina along the Sacramento River
- Four are located near the southern edge of the City in the Beach Lake and Morrison Creek area
- One is located where the West Drainage Canal meets the Sacramento River
- One is located where Verano Creek meets Steelhead Creek

- One is located near where Dry Creek meets Steelhead Creek
- One is located along Arcade Creek near Longview Drive

Notable areas where the light rail is at or near grade in the standard 100-year floodplain include:

- Blue line near Arcade Creek in the Del Paso Park area
- Gold line near Willow Creek in the Natoma Station area

In terms of percentages of assets in the standard 100-year floodplain (i.e., not protected by levee or not shallow flooding only), over 8% of bicycle facility mileage and over 5% of pump stations are exposed.

For flood impacts on roads, paths, or light rail, specific locations mentioned during interviews or TAC meetings include:

- SacRT Gold Line over Alder Creek near the southwestern part of Folsom.
- SacRT Gold Line over Folsom South Canal in northeastern Rancho Cordova.
- Raley Boulevard north of I-80 – in a floodplain and a known area of concern that floods every year and must be shut down every time there is a storm. The City has an alert station here when water exceeds roadway elevation.
- Arcade Creek has regular flooding issues. These often impact the Verano Street at the bridge. Some bus stops near the Creek are impacted; damage is not common, but service has to be suspended. This happens roughly every other year and lingers for a day or two when it happens.
- There is a line on the CSS that runs along I-5 north of Sutterville Road to Front Street at the Pioneer Reservoir to discharge to the river on Front Street; this is a potential issue area.
- Because of flooding from the Natomas East Main Drain Canal (NEMDC), sometimes the parallel Union Pacific (UP) railroad needs to be closed. Alerts are sent when water is 3 and 2 feet below the top of tie. When it is 1 foot below, the floodgates are deployed, and the rail is closed. This affects freight traffic.
- Del Paso floodgate gets closed every year (sometimes up to 5-6 times per year). It was recently retrofitted to make it easier to close. Freight railroad closes frequently too. UP notifies the City as soon as water recedes so gates can open. If gates are not opened within 30 minutes, the City gets fined.
- Flooding of rail at Arcade South floodgate, where water comes from Arcade Creek. Usually there is not much damage to the rail, just temporary closures until the water recedes.

- Roads and shared-use paths in Discovery Park along northern edge of American River are fully inundated when major storm events prompt dam releases. This flooding (and flooding on the connecting ARP/Sacramento Northern trail) limits bike access to downtown for people living north of the American River.
- Roadways in low-lying areas are a concern, particularly in underpasses.
- 7th Street downtown near D Street is a low-lying area that has a pump station to avoid road flooding.

The DOU Comprehensive Flood Management Plan's Repetitive Loss Area Analysis appendix documents flood issues at groups of properties in 20 specific locations in the City. It includes potential mitigation strategies, many of which involve the drainage system and streets.

Table 19 shows the results of the exposure hazard analysis for the FEMA 500-year floodplain. The categories are mutually exclusive; for example, the 500-year floodplain results refer to assets that are only in the 500-year floodplain category and do not include assets already counted in the 100-year floodplain categories. Table 20 and Table 21 further break this data down for roadway functional classes and bikeway classes.

Table 19. FEMA 500-year floodplain exposure results by asset type (excludes assets in FEMA 100-year floodplains)

	Asset Class	Total Asset Count or Total Linear Miles	FEMA Floodplain Exposure			
			500-year floodplain		500-year floodplain with reduced risk due to levee	
			Count/ Mileage	Percent	Count/ Mileage	Percent
City Assets	Pump Stations	235	17	7%	133	57%
	Traffic Signals	927	59	6%	523	56%
	Bicycle Facilities	725	52	7%	327	45%
	Roadways	1,921	146	8%	942	49%
	Sidewalks/Curbs	2,899	215	7%	1,466	51%
SacRT Assets	Bus Stops	2,843	217	8%	1,038	37%
	Light Rail Stations	54	3	5%	28	52%
	Transit Facilities	10	1	10%	3	30%
	ZEB Charging Stations	16	0	0%	11	69%
	Light Rail Tracks	44	3	6%	0	0%

Table 20. FEMA 500-year floodplain exposure results for roadways by functional class (excludes assets in FEMA 100-year floodplains)

		500-year floodplain		500-year floodplain with reduced risk due to levee	
Class	Total Mileage	Mileage	Percent	Mileage	Percent
Highway	**104**	5	4 %	44	42%
Collector	**168**	10	6%	90	53%
Arterial	**195**	25	13%	86	44%
Local	**1,233**	97	8%	616	50%

Table 21. FEMA 500-year floodplain bikeway exposure by classification.

		500-year floodplain		500-year floodplain with reduced risk due to levee	
Class	Total Mileage	Mileage	Percent	Mileage	Percent
Class 1: Shared-Use Path (Off-Street)	**218**	37	17%	113	52&
Class 2 - 4: Bike Lane (On-Street)	**507**	66	13%	301	59%

Table 22, Table 23, and Table 24 show the results of the analysis for the 200-year floodplain. A large majority of the assets analyzed fall within the 200-year floodplain, with most protected by levee.

Table 22. SAFCA 200-year floodplain exposure results by asset type

			Within 200-year floodplain Levee Protected		Within 200-year floodplain Depth >=3ft		Within 200-year floodplain Depth <3ft	
	Asset Class	**Total Asset Count/ Total Linear Miles**	**Count/ Mileage**	**Percent**	**Count/ Mileage**	**Percent**	**Count/ Mileage**	**Percent**
City Assets	**Pump Stations**	**235**	215	91%	2	0.8%	5	2%
	Traffic Signals	**927**	853	92%	2	0.2%	12	1%
	Bicycle Facilities	**725**	107	15%	1	0.1%	0.2	0%
	Roadways	**1,921**	1,479	77%	9	0.5%	50	3%
	Sidewalks	**2,899**	2,521	87%	15	0.5%	86	3%
SacRT Assets	**Bus Stops**	**2,843**	1,592	56%	18	0.6%	2	0%
	Light Rail Stations	**54**	37	69%	1	2%	0	0%
	Transit Facilities	**10**	5	50%	0	0%	0	0%
	ZEB Charging Stations	**16**	11	69%	1	6%	0	0%
	Light Rail Tracks	**44**	28	64%	1	2%	0.5	1%

Table 23. SAFCA 200-year floodplain roadway exposure by functional classification.

		Within 200-year floodplain Levee Protected		Within 200-year floodplain Depth >=3ft		Within 200-year floodplain Depth <3ft	
Class	**Total Mileage**	**Mileage**	**Percent**	**Mileage**	**Percent**	**Mileage**	**Percent**
Highway	**103**	89.5	87%	1.6	2%	0.1	0.1%
Collector	**168**	143.8	86%	0.5	0.5%	3.9	4%
Arterial	**195**	162.4	83%	1.4	1%	2.8	3%
Local	**1,233**	1083.6	88%	5.4	5%	42.8	42%

Table 24. SAFCA 200-year floodplain bikeway exposure by classification.

		Within 200-year floodplain Levee Protected		Within 200-year floodplain Depth >=3ft		Within 200-year floodplain Depth <3ft	
Class	**Total Mileage**	**Mileage**	**Percent**	**Mileage**	**Percent**	**Mileage**	**Percent**
Class 1: Shared-Use Path (Off-Street)	**218**	80	16%	0.5	0.1%	0.2	0%
Class 2- 4: Bike Lane (On-Street)	**508**	27	12%	0.2	0%	0	0%

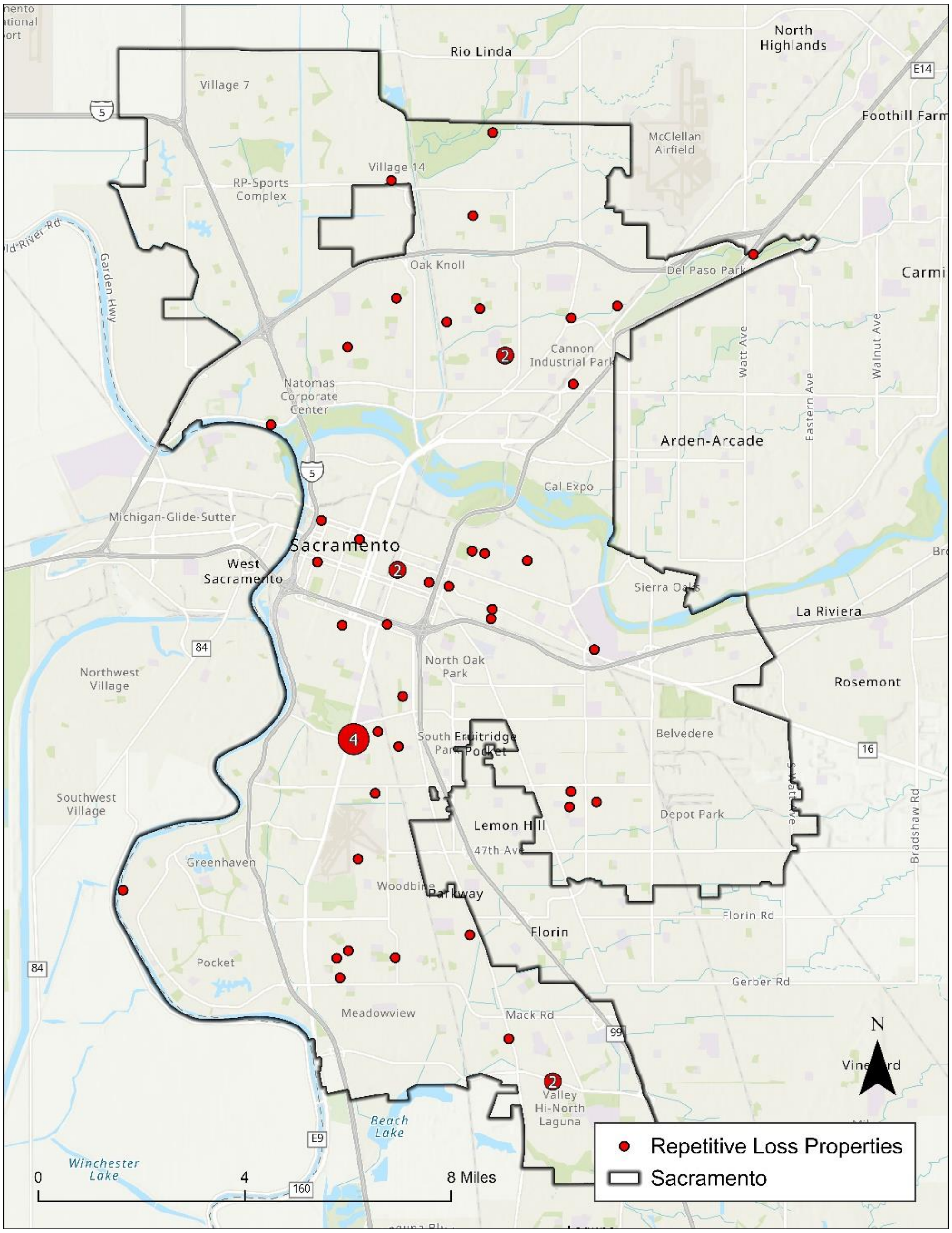
Assessing city bridges and exposure to flooding is a special case as many bridges are designed to carry facilities across floodways or floodplains. Therefore, GIS overlays were not performed with the bridges. Table 25 shows bridge inspection comments and work recommendations that are potentially relevant for flood damage prevention to bridges. The list was filtered based on a larger set of inspection comments and work recommendations to include recommendations for addressing scour issues, drainage issues, erosion issues, and miscellaneous substructure issues. It does not include the full list of recommendations involving debris clearing and similar preventative maintenance, though those activities are important for addressing flood risk as well.

Table 25. Selected City Bridge Inspection Comments and Work Recommendations

Bridge Number	Work Recommendation	Field Inspection Comments	Bridge Location	Facility Carried
24C0133	Drainage Issue	Install slope protection and mitigate the drainage at Abutment 7. This should be done currently with the joint seal rehabilitation, as the damaged joint seal likely contributes significantly to the drainage.	Between Northgate & Norwood	W Silver Eagle Rd
24C0538	Drainage-Erosion Issue	Unclog the drains on both ends of the structure. Repair the erosion holes on both sides of Abutment 1.	0.1 MI E of Northgate Blvd.	Main Avenue
24C0532	Drainage-Erosion Issue	Clean out the deck drains which are filled with debris.	0.7 MI W/O FRANKLIN BLVD.	Cosumnes River Blvd.
24C0424R	Scour-Place Countermeasures	Mitigate the undermining of the RC diaphragm at abutment 5. See inspection report for additional comments.	1.2 MI S/O Del Paso Rd	Truxel Rd
24C0424L	Scour-Place Countermeasures	Mitigate the undermining of the RC diaphragm at abutment 5. For guidance in choosing and installing appropriate scour countermeasures, refer to HEC-23, "Bridge Scour and Stream instability Countermeasures: Experience, Selection, and Design Guidance.	1.2 MI S/O Del Paso Rd	Truxel Rd
24C0598	Scour-Place Countermeasures	Mitigate the undermining of the RD diaphragms at both abutments. For guidance and installing appropriate countermeasures refer to HEC-23. See additional comments in inspection report.	E OF Natomas Blvd	Gateway Park Blvd.
24C0105	Scour-Place Countermeasures	Remediate the bank deterioration under the bridge and upstream of Abutment 1.	1.75 MI E/O RTE 99	Elkhorn Blvd
24C0521	Scour-Place Countermeasures	Backfill and patch three holes (2 at Column 13 Pier 1 and 1 at Column 13 of Pier 3) in the concrete lined slope protection located along the right (upstream) side of the bridge.	N/O Cosumnes River Blvd	Franklin Blvd
24C0113	Scour-Place Countermeasures	Mitigate the scour vulnerability (across the channel and at the base of the existing concrete slope protection under the original bridge foundations). SEE INSPECTION REPORT.	0.3 MI S/O Florin Rd	Franklin Blvd
24C0293	Sub-Fix Scour Crit.	Mitigate the undermining below the Abutment 4 spread footing. Additionally, protect the Abutment 4 slope with scour countermeasures placed in accordance with HEC-23.	0.1 MI N/O Mack Rd	Tangerine Ave
24C0133	Sub-Misc	Repair the run-off water erosion areas at Abutment 7	Between Northgate & Norwood	W Silver Eagle Rd

Bridge Number	Work Recommendation	Field Inspection Comments	Bridge Location	Facility Carried
24C0177	Sub-Misc	Fill and stabilize the loss of fill and deterioration of the slope protection, most notably at Abutment 1. Refer to photos Nos. 4 and 5 dated 01/26/2016.	0.3 MI N Auburn Blvd	Watt Ave
24C0107L	Sub-Misc	Remove the debris (soil and gravel) from the abutment seat and around the bearings at both Abutments 1 and 12.	0.4 MI N/O SR 50	Howe Ave
24C0107L	Sub-Misc	Remove loose concrete, clean exposed steel, and patch or paint spall in left wingwall of Abutment 12.	0.4 MI N/O SR 50	Howe Ave
24C0225	Sub-Rehab	Repair the broken channel lining at the east (upstream) end of the culvert.	N/O Interstate 80	Norwood Ave
24C0209	Sub-Rehab	Mitigate the section loss within the steel pipes (such as with a protective sleeve or placement of a concrete invert).	100 W/O 21st St	Florin Rd
24C0302	Sub-Rehab	Mitigate the section loss within the steel pipes (such as with protective sleeve or placement of a concrete invert).	0.1 MI S of Florin Rd.	21st Street
24C0304	Sub-Rehab	Mitigate the section loss with the steel pipes (such as a protective sleeve or placement of a concrete invert).	0.21 MI S of Florin Rd	24th St
24C0303	Sub-Rehab	Mitigate the effectiveness of the galvanized coating with Barrels 3 to 5 (such as with the use of a protective sleeve or placement of a concrete invert).	0.1 MI S/O Florin Rd	Tamoshanter Way

In addition, the City's Comprehensive Flood Management Plan identified six large Repetitive Loss Area Analysis (RLAA) regions throughout Sacramento, each organized into several smaller areas (ranging from one to six areas per region) based on properties that have experienced significant flood damage repeatedly within the past several decades. These properties are shown in Map 12. These areas include South Natomas, Downtown Sacramento, Southeast Sacramento, and Sutterville/Meadowview.



Map 12. Repetitive Loss Properties

3.1.2 Heat

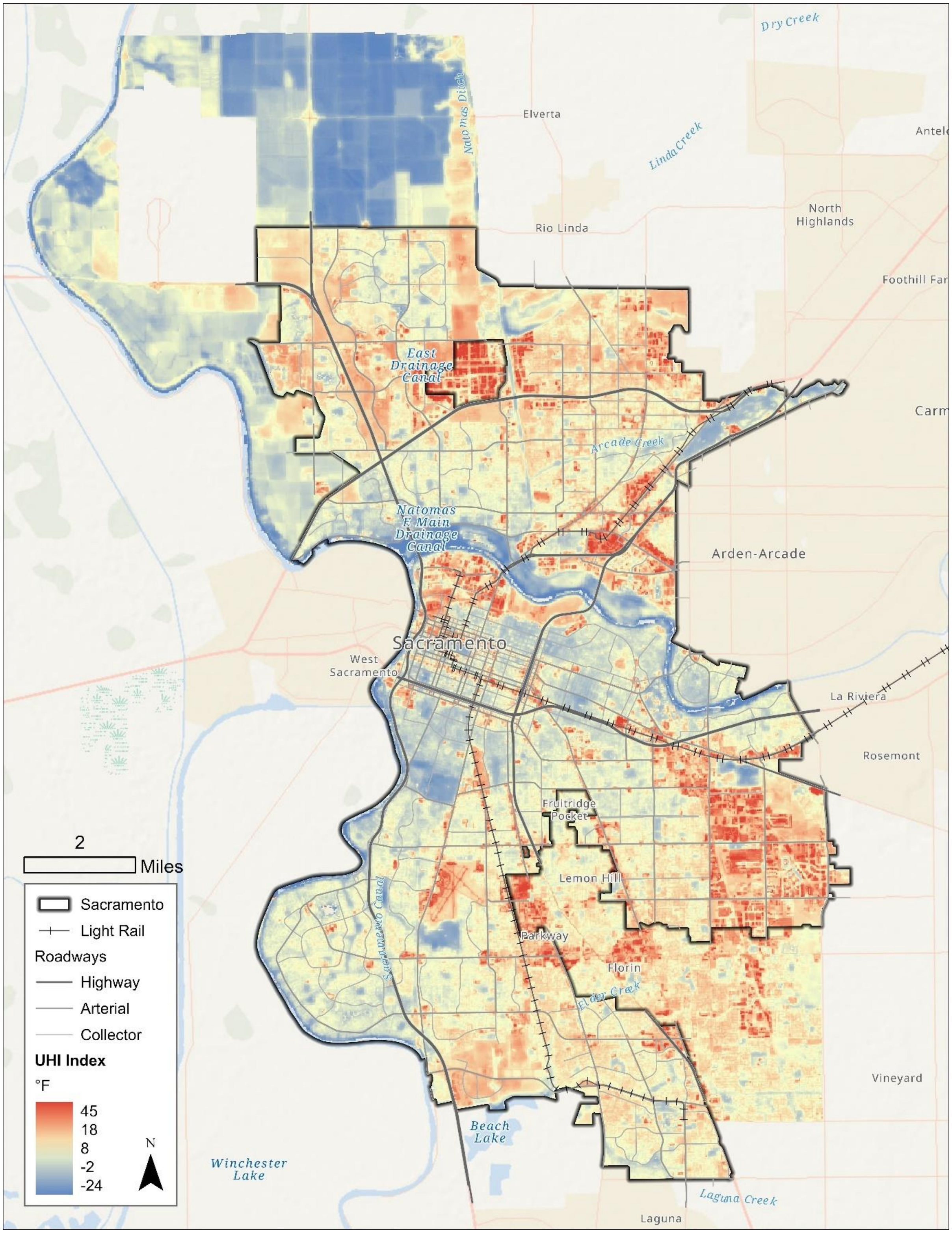
Transportation assets were overlaid with the UHI Index to quantify the extent of exposure across different heat intensity levels. Linear features such as roadways were summarized by total mileage within each UHI category, while point and area assets - including bus stops, bridges, and traffic signals - were counted within zones of elevated surface temperature. This approach allows for comparison across asset types and geographic areas.

Map 13 shows the spatial distribution of UHI intensity in Sacramento, with surface temperatures ranging from -24°F to 45°F above regional baselines. Cooler areas are found near vegetation and water - such as the Natomas Basin, American River Parkway, and South Sacramento - while the hottest zones are concentrated in dense urban cores, major roads, and industrial areas like Florin Fruitridge and Lemon Hill. Notable hotspots also include the central grid, key corridors, and the Sacramento Executive Airport.

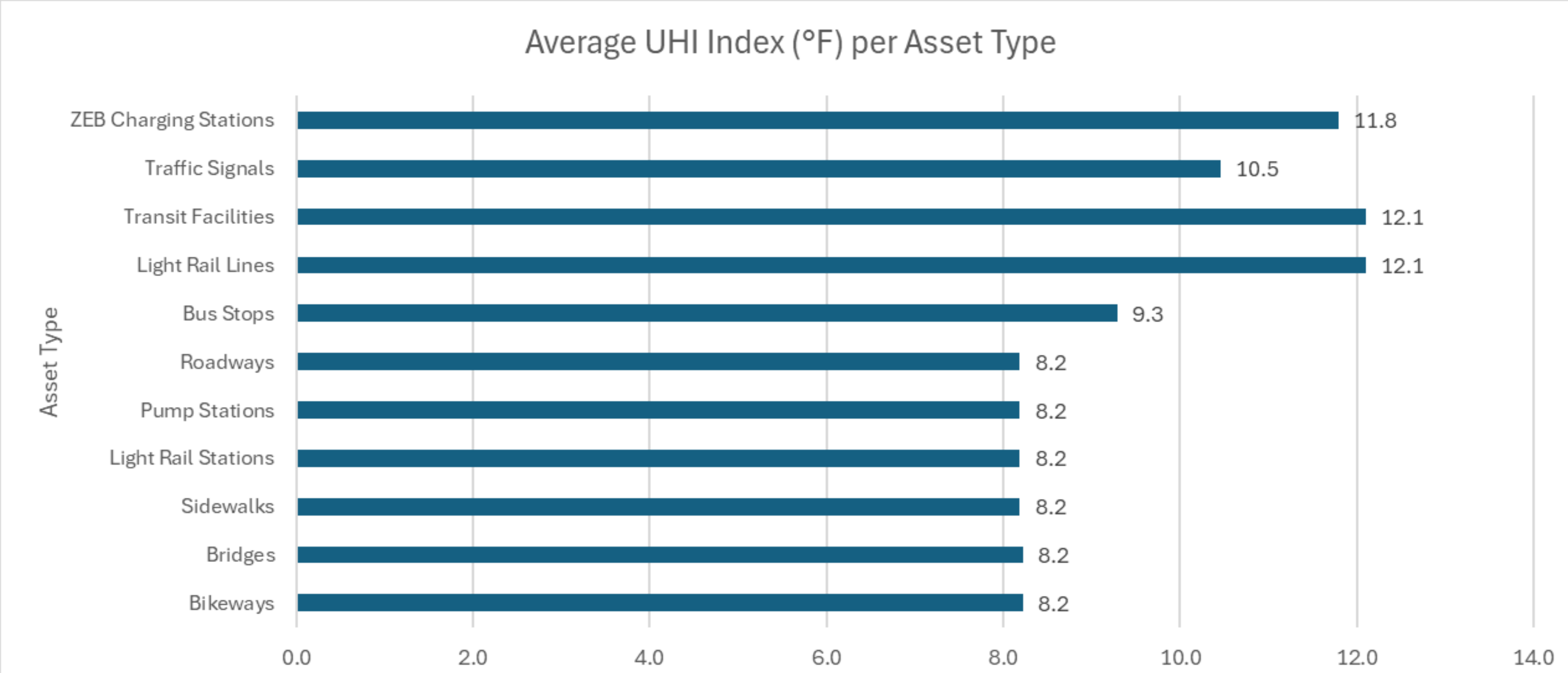
Figure 7 shows that Transit Facilities and Light Rail Lines experience the highest UHI index, each with an average index of 12.1°F. ZEB Charging Stations and Traffic Signals also show elevated UHI levels at 11.8°F and 10.5°F, respectively. In contrast, assets like Roadways, Sidewalks, Bridges, and Bikeways have the lowest UHI index, all averaging around 8.2°F, indicating relatively lower heat exposure.

In addition to the analysis, TAC members noted particular locations where there have been past issues with heat affecting the SacRT rail:

- Bee Bridge on both inbound and outbound sides
- Near Grand Avenue on the Blue Line
- Between Arden Del Paso and Globe stations on the Blue Line
- North B to C Street on the Blue Line
- 8th and K Street
- 7th and H Street
- Between Glenn and Historic Folsom stations on the Gold Line



Map 13. UHI index for current conditions in °F from Sacramento 2020 NASA UHI study



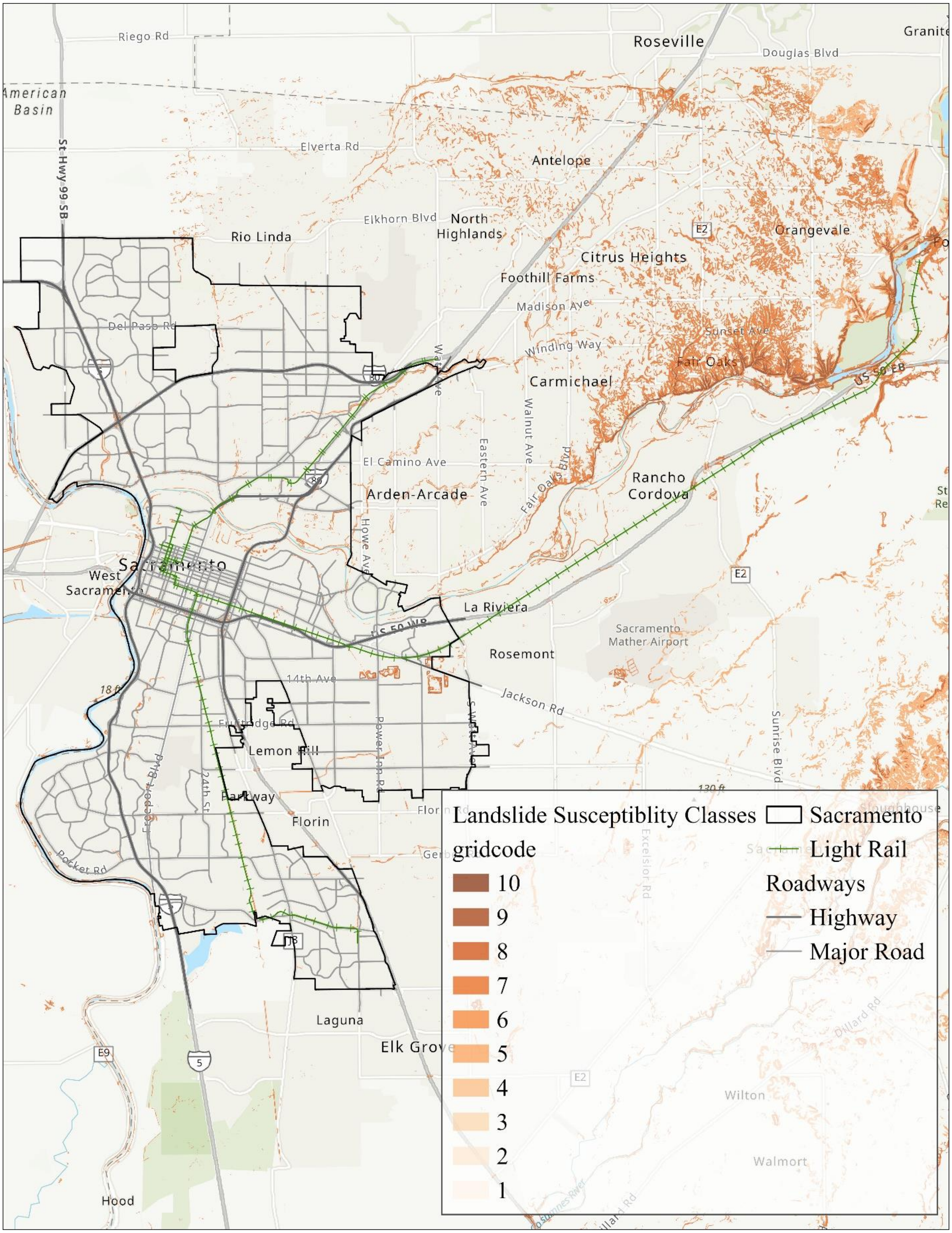
	Bikeways	Bridges	Sidewalks	Light Rail Stations	Pump Stations	Roadways	Bus Stops	Light Rail Lines	Transit Facilities	Traffic Signals	ZEB Charging Stations
UHI Mean	8.2	8.2	8.2	8.2	8.2	8.2	9.3	12.1	12.1	10.5	11.8

Figure 7. Average UHI index per asset type.

3.1.3 Landslide

CGS Landslide Susceptibility Ratings were overlaid with transportation assets to assess potential exposure to landslides.[46] Landslide susceptibility, as classified by the California Geological Survey, represents locations with relatively high potential for landslides due to slope steepness and rock strength. A susceptibility score of 10 is the highest and 0 is the lowest. While landslides are not a major threat in the City given its flat terrain, this analysis was included mainly to understand potential threats to light rail assets in more variable terrain areas to the east of the City. This consideration is particularly important for light rail since impacts in one location can have systemwide implications for travelers and people riding transit.

46 https://catalog.data.gov/dataset/cgs-map-sheet-58-deep-seated-landslide-susceptibility-7b33a



Map 14. CGS Landslide Susceptibility ratings

Map 14 shows landslide susceptibility around Sacramento. The highest concentration of high susceptibility scores is along the American River by Folsom. Only isolated spots within the City received relatively high scores.

Table 26 and Table 27 show asset counts and mileages for the highest susceptibility scores. The majority of assets for all asset types have low scores and are thus not captured in the table. For bridges, 15.0% received a susceptibility score of 7, though only one received a higher landslide susceptibility score than 7. Pump stations and traffic signals have relatively low exposure, with 6.1% and 2.9% respectively in category 7, but no assets in the highest-risk scores. For bicycle facilities, 3.22% are in category 7 and 0.2% are in higher categories. For roads, 1.73% received a score of 7 and 0.11% received higher scores. Among SacRT assets, bus stops have minimal exposure, with 1.2% in category 7, while light rail stations, transit facilities, and light rail tracks have minor susceptibility, with a small fraction falling into category 7 but none in higher-risk zones. For light rail, a small portion toward the eastern end of the Gold Line received high scores, including near the terminus in the City of Folsom and in the Natoma Station area.

Table 26. CGS landslide susceptibility score exposure results

	Asset Class	Total Asset Count or Total Linear Miles	Landslide Susceptibility Score							
			7		8		9		10	
			Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent
City Assets	Bridges	452	68	15%	0	0%	1	0.2%	0	0%
	Pump Stations	212	13	6%	0	0%	0	0%	0	0%
	Traffic Signals	927	27	3%	0	0%	0	0%	0	0%
	Bicycle Facilities	725.19	23	3%	0	0%	1	0.2%	0.3	0.03%
	Roadways	1,921	33	2%	0	0%	2	0.1%	0.3	0.02%
SacRT Assets	Bus Stops	2843	33	1%	0	0%	0	0%	0	0%
	Light Rail Stations	54	1	1%	0	0%	0	0%	0	0%
	Transit Facilities	10	1	10%	0	0%	0	0%	0	0%
	ZEB Charging Stations	16	0	0%	0	0%	0	0%	0	0%
	Light Rail Tracks	44	2	5%	0	0%	0.1	0.1%	0	0%

Table 27. Landslide susceptibility score exposure results for roadways by functional class

		Landslide Susceptibility Score							
		7		8		9		10	
Class	Total Mileage	Mileage	Percent	Mileage	Percent	Mileage	Percent	Mileage	Percent
Highway	103	6	6%	0	0%	0.3	0.2%	0.09	0.09%
Collector	168	2	1%	0	0%	0.1	0.05%	0	0%
Arterial	195	6	3%	0	0%	0.3	0.2%	0.001	0.0005%
Local	1,233	6	0.5%	0	0%	0.1	0.007%	0.06	0.004%

3.1.4 Disadvantaged Communities

CalEnviroScreen from CalEPA evaluates California communities' pollution burden and vulnerability based on environmental, health, and socioeconomic data. A higher score indicates that a census tract experiences a higher burden than other tracts in California. The state designates census tracts with CalEnviroScreen scores at or above the 75th percentile as disadvantaged communities (DACs).

A geospatial overlay was performed with the CalEnviroScreen data[47] and transportation assets to identify the CalEnviroScreen Score associated with each transportation asset. For linear assets that intersect multiple census tracts, and thus multiple CalEnviroScreen scores, the maximum score was taken.

Map 15 shows a map of census tracts with CalEnviroScreen scores greater than or equal to the 75th percentile.

A significant portion of communities, and transportation infrastructure serving them, are located in areas with high CalEnviroScreen scores. Approximately 28% of Sacramento's area is in a DAC, and approximately 30% of Sacramento's population lives in a DAC.

Roadways (29%), bus stops (23%), bicycle facilities (37%), and bridges (40%) represent substantial portions of infrastructure serving these highly burdened communities. Additionally, SacRT assets, including light rail (100%) and ZEB charging stations (44%), have a strong presence in areas with higher environmental burdens.

Table 28, Table 29, Table 30, Table 31, and Table 32 show hazard results per asset type for only those assets that serve census tracts with CalEnviroScreen scores greater than or equal to the 75th percentile.

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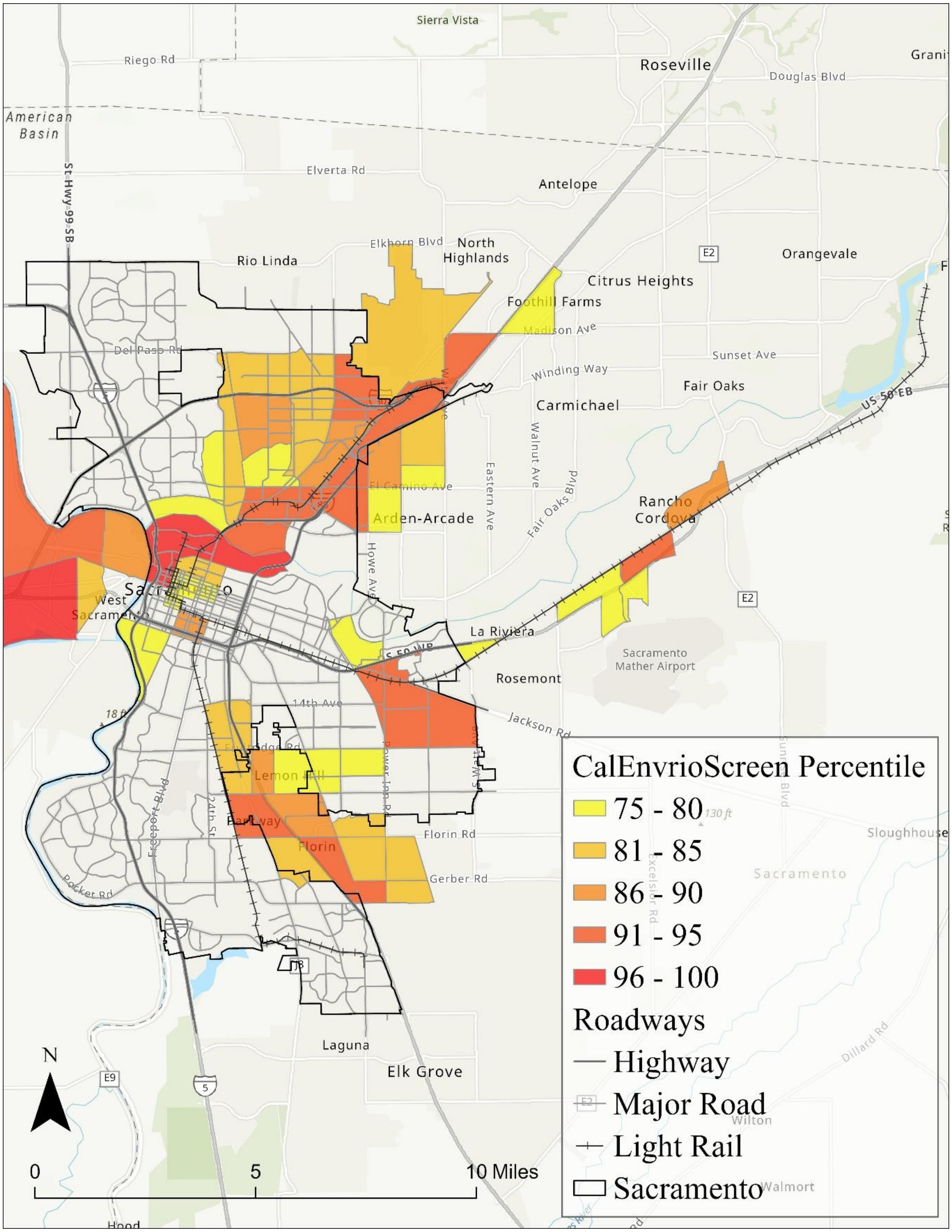
[47] CalEnviroScreen 4.0 released October 2021



Map 15. CalEnviroScreenScores greater than or equal to the 75th percentile

Table 28. Assets that serve census tracts with CalEnviroScreen Score greater than or equal to 75th percentile

			Maximum CalEnviroScreen Score is greater than or equal to the 75th percentile	
	Asset Class	**Total Asset Count or Total Linear Miles**	**Count/ Mileage**	**Percent**
City Assets	**Pump Stations**	**235**	78	33%
	Traffic Signals	**927**	325	35%
	Bridges	**452**	181	40%
	On Street Bicycle Lane or Boulevard	**349**	89	26%
	Off-Street Shared-Use Path	**92**	29	31%
	Sidewalks	**2,899**	761	26%
	Roadways	**1,921**	561	29%
SacRT Assets	**Bus Stops**	**2843**	655	23%
	Light Rail Stations	**54**	23	42%
	Transit Facilities	**10**	4	40%
	ZEB Charging Stations	**16**	7	44%
	Light Rail Tracks	**44**	449	100%

Table 29. FEMA 100-year floodplain exposure results by asset type for CalEnviroScreen Scores greater than or equal to the 75th percentile

	Asset Class	Total Asset Count or Total Linear Miles	FEMA Floodplain Exposure for CalEnviroScreen Score >=75th Percentile							
			Floodway		100-year floodplain		100-year shallow floodplain, ponding		100-year floodplain with reduced risk due to levee	
			Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent
City Assets	Pump Stations	235	1	0.4%	5	2%	1	0.4%	5	2%
	Traffic Signals	927	2	0.2%	2	0.2%	0	0%	13	1%
	On Street Bicycle Lane or Boulevard	349	1	0.2%	0	0%	0	0%	2	0.7%
	Off-Street Shared-Use Path	92	3	3%	1	0.2%	0	0%	2	0.5%
	Sidewalks	2,899	8	0.2%	4	0.1%	3	0.1%	48	2%
	Roadways	1,921	34	2%	108	0.5%	2	0%	34	2%
SacRT Assets	Bus Stops	2,843	2	0.07%	1	0.03%	2	0.07%	28	1%
	Light Rail Stations	54	0	0%	0	0%	0	0%	0	0%
	Transit Facilities	10	0	0%	0	0%	0	0%	0	0%
	ZEB Charging Stations	16	0	0%	0	0%	0	0%	0	0%
	Light Rail Tracks	44	1	1%	1	2%	1	2%	0	0%

Table 30. FEMA 500-year floodplain exposure results by asset type for CalEnviroScreen Scores greater than or equal to the 75th percentile

	Asset Class	Total Asset Count or Total Linear Miles	FEMA Floodplain Exposure for CalEnviroScreen Score >=75th Percentile			
			500-year floodplain		500-year floodplain with reduced risk due to levee	
			Count/ Mileage	Percent	Count/ Mileage	Percent
City Assets	Pump Stations	235	4	2%	41	17%
	Traffic Signals	927	13	1%	208	22%
	On Street Bicycle Lane or Boulevard	349	4	1%	21	6%
	Off-Street Shared-Use Path	92	0	0%	4	1%
	Sidewalk	2,899	50	2%	418	14%
	Roadways	1,921	41	2%	305	16%
SacRT Assets	Bus Stops	2,843	79	3%	285	10%
	Light Rail Stations	54	1	1%	11	21%
	Transit Facilities	10	1	10%	1	10%
	ZEB Charging Stations	16	0	0%	5	31%
	Light Rail Tracks	44	3	6%	0	0%

Table 31. SAFCA 200-year floodplain exposure results by asset type for CalEnviroScreen Scores greater than or equal to the 75th percentile

Within 200-year floodplain for CalEnviroScreen Score >=75th Percentile				
	Asset Class	**Total Asset Count/ Total Linear Miles**	**Count/ Mileage**	**Percent**
City Assets	**Pump Stations**	**235**	70	30%
	Traffic Signals	**927**	300	32%
	On Street Bicycle Lane or Boulevard	**349**	81	23%
	Off-Street Shared-Use Path	**92**	27	30%
	Sidewalks	**2,899**	623	22%
	Roadways	**1,921**	462	24%
SacRT Assets	**Bus Stops**	**2,843**	454	16%
	Light Rail Stations	**54**	16	29%
	Transit Facilities	**10**	2	20%
	ZEB Charging Stations	**16**	5	31%
	Light Rail Tracks	**44**	28	34%

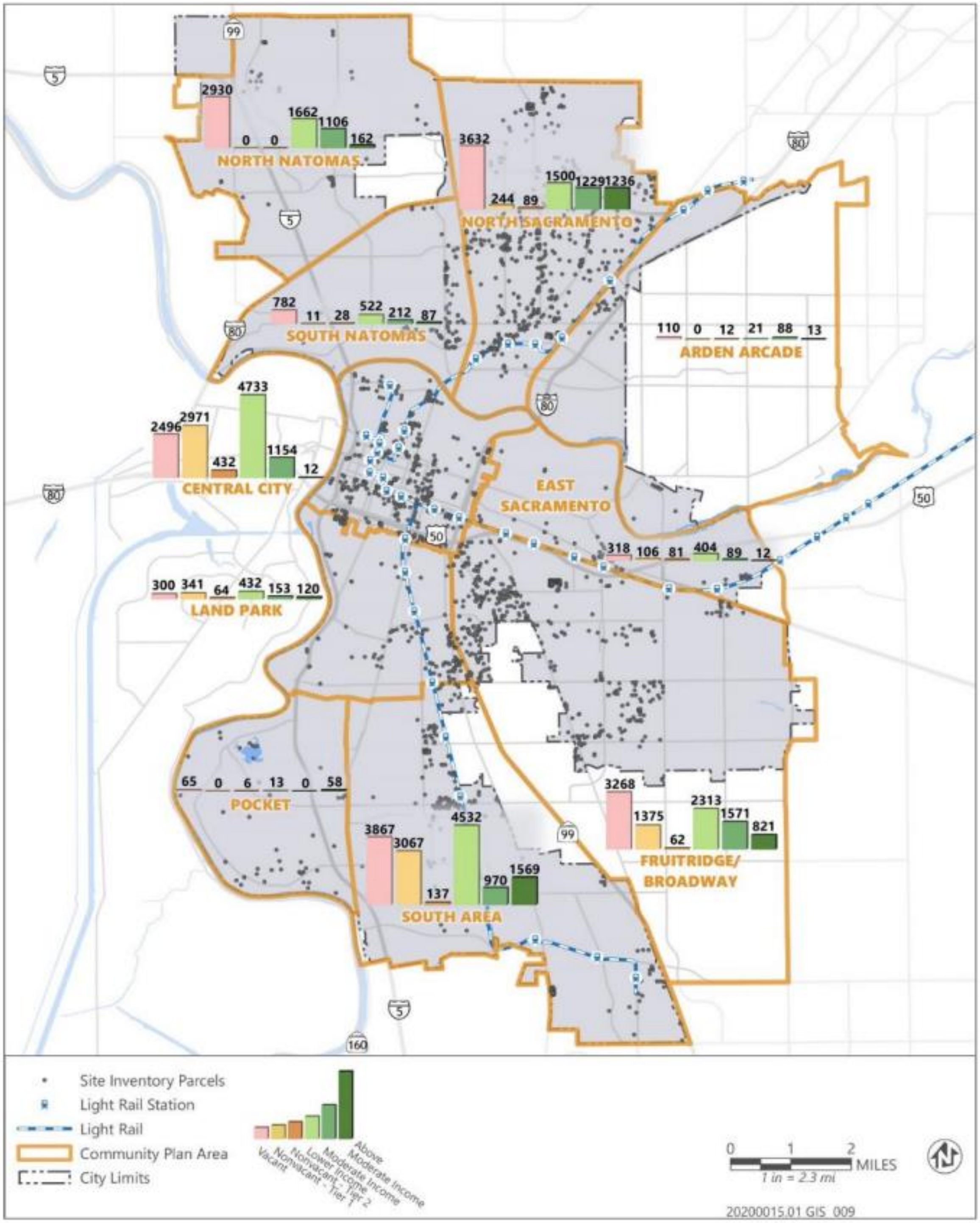
Table 32. CGS landslide susceptibility score for assets with CalEnviroScreen scores greater than or equal to the 75th percentile

Asset Class		Total Asset Count or Total Linear Miles	Landslide Susceptibility Score for CalEnviroScreen Score >=75th Percentile							
			7		8		9		10	
			Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent	Count/ Mileage	Percent
City Assets	Bridges	452	27	6%	0	0%	0	0%	0	0%
	Pump Stations	212	3	1%	0	0%	0	0%	0	0%
	Traffic Signals	927	8	1%	0	0%	0	0%	0	0%
	On Street Bicycle Lane or Boulevard	349	0	0%	0	0%	0	0%	0	0%
	Off-Street Shared-Use Path	92	1	1%	0	0%	0	0%	0	0%
	Sidewalks	2,899	4	0.1%	0	0%	0.2	0%	0	0%
	Roadways	1,921	14	1%	0	0%	1	0.03%	0.1	0.01%
SacRT Assets	Bus Stops	2,843	1	0.04%	0	0%	0	0%	0	0%
	Light Rail Stations	54	0	0%	0	0%	0	0%	0	0%
	Transit Facilities	10	1	10%	0	0%	0	0%	0	0%
	ZEB Charging Stations	16	0	0%	0	0%	0	0%	0	0%
	Light Rail Tracks	44	2	4.5%	0	0%	0.04	0.1%	0	0%

3.1.5 Power Grid Vulnerabilities

Power grid failure can occur as a result of extreme weather including extreme heat, wildfire, extreme wind, or flooding. Analyzing the exposure and risk to power grid vulnerabilities requires substantial input from partner agencies like SMUD, which manages the power distribution and preventative maintenance and mitigation efforts. This input can help to determine the geographic vulnerabilities of various power infrastructure. The ability of the City and SacRT to address power grid vulnerabilities is limited, although investment in back-up power solutions can mitigate certain risks.

3.1.6 Anticipated Future Growth



Source: Ascent, 2021; City of Sacramento, 2021.

Map 16. Summary of capacity on vacant and underutilized sites by community plan area from the City of Sacramento Housing Element 2021-2029.

Map 16 shows potential future housing development based on underutilized and vacant sites. Areas like North Natomas, North Sacramento, Central City, Fruitridge/Broadway, and South Sacramento have relatively higher opportunities for growth. Some of these areas, particularly North Natomas, have high flood risks.

Large parts of North Natomas, North Sacramento, Central City, and Fruitridge/Broadway are at higher relative risk to extreme heat due to the urban heat island effect. A large portion of North Sacramento is also in the SAFCA 200-year floodplain (3 feet or greater). Additional analyses and areas of population growth with anticipated climate impacts will be further analyzed in upcoming tasks within this analysis that focus on risk.

4. Public Outreach Findings

SacAdapt's Phase 1 public survey focused on measuring the level and frequency of weather-related impacts to travel. From past outreach efforts, the City has clearly heard that the following are barriers to walking and biking:

- Lack of infrastructure (e.g., sidewalks, bicycle facilities, bike parking) or outdated/poorly maintained infrastructure
- Gaps in connectivity
- Sidewalks or bicycle facilities that feel unsafe
- Sidewalks or bicycle facilities that are uncomfortable, with heat and lack of shade being recurring themes
- Lack of shade at transit stops has also been mentioned frequently.

Other City planning documents are geared toward addressing new and improved pedestrian and bicycle facilities. SacAdapt is primarily focused on existing infrastructure, and what upgrades and investments are needed to increase resilience to extreme weather.

421 people responded to the SacAdapt survey. Out of these, 386 people completed the weather event related questions. The following results summaries are based on those 386 responses.

Per Figure 8, the majority of respondents reported using personal vehicles as their primary mode of travel on a daily basis, while walking and using public transit (bus or light rail) showed more varied patterns of frequency. Modes such as bicycling, scooters, and carpooling or ridesharing were reportedly less frequently used on a daily basis, with a significant portion of respondents indicating they never used them.

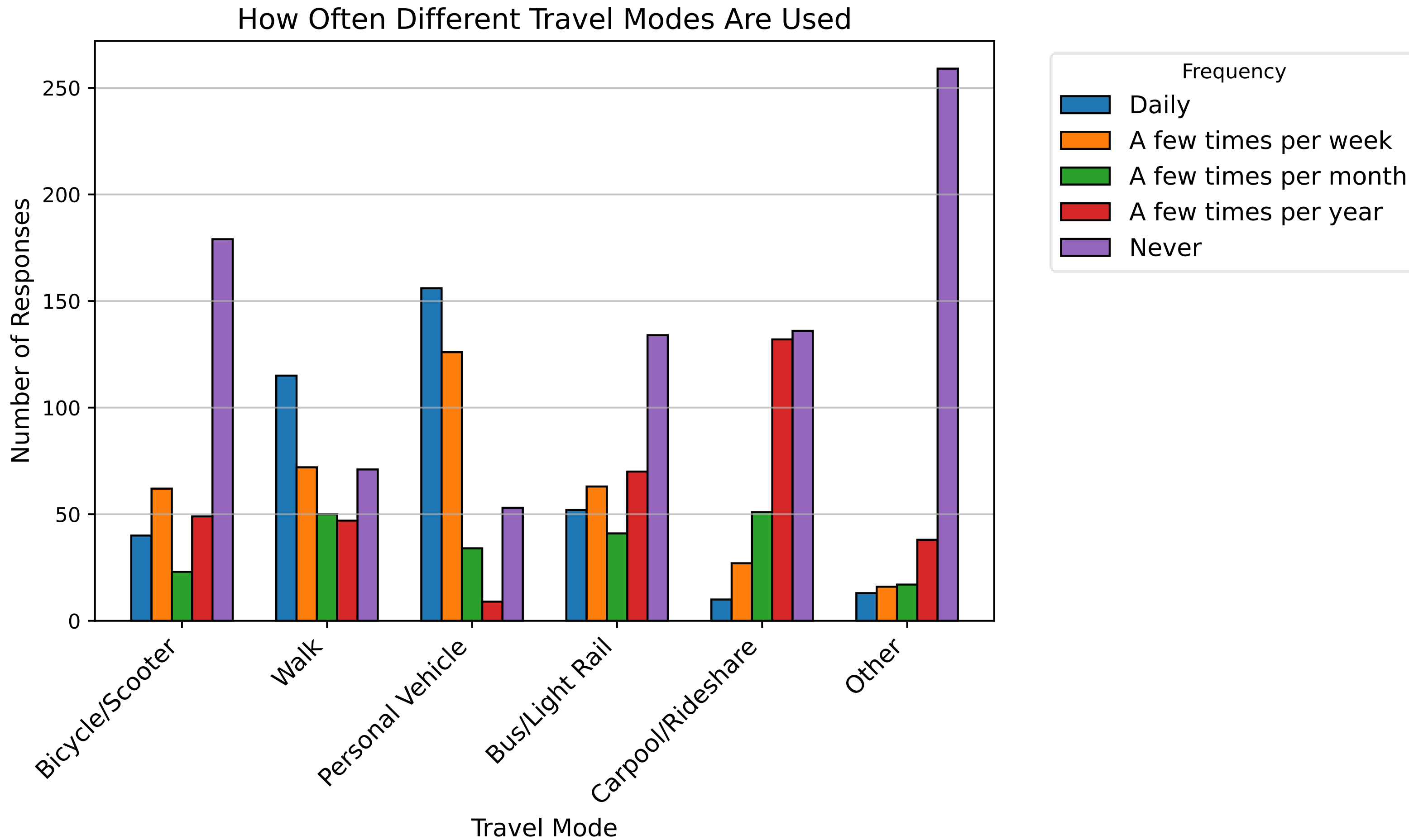


Figure 8. Frequency of travel by different transportation modes among respondents. 85 respondents reported using an "Other" travel mode not listed in the options provided, at varying frequencies

When asked about the types of extreme weather events that have disrupted or delayed their travel in the past five years, respondents most frequently cited flooding or heavy rain and extreme heat. These two events were consistently reported as having the most significant impact, while events such as extreme cold had fewer mentions. In terms of the frequency of disruption, delays caused by flooding or rain and extreme heat were commonly reported as occurring sometimes or rarely, with a smaller number of respondents indicating frequent delays due to these events. These results are summarized in Figure 9 and Figure 10.

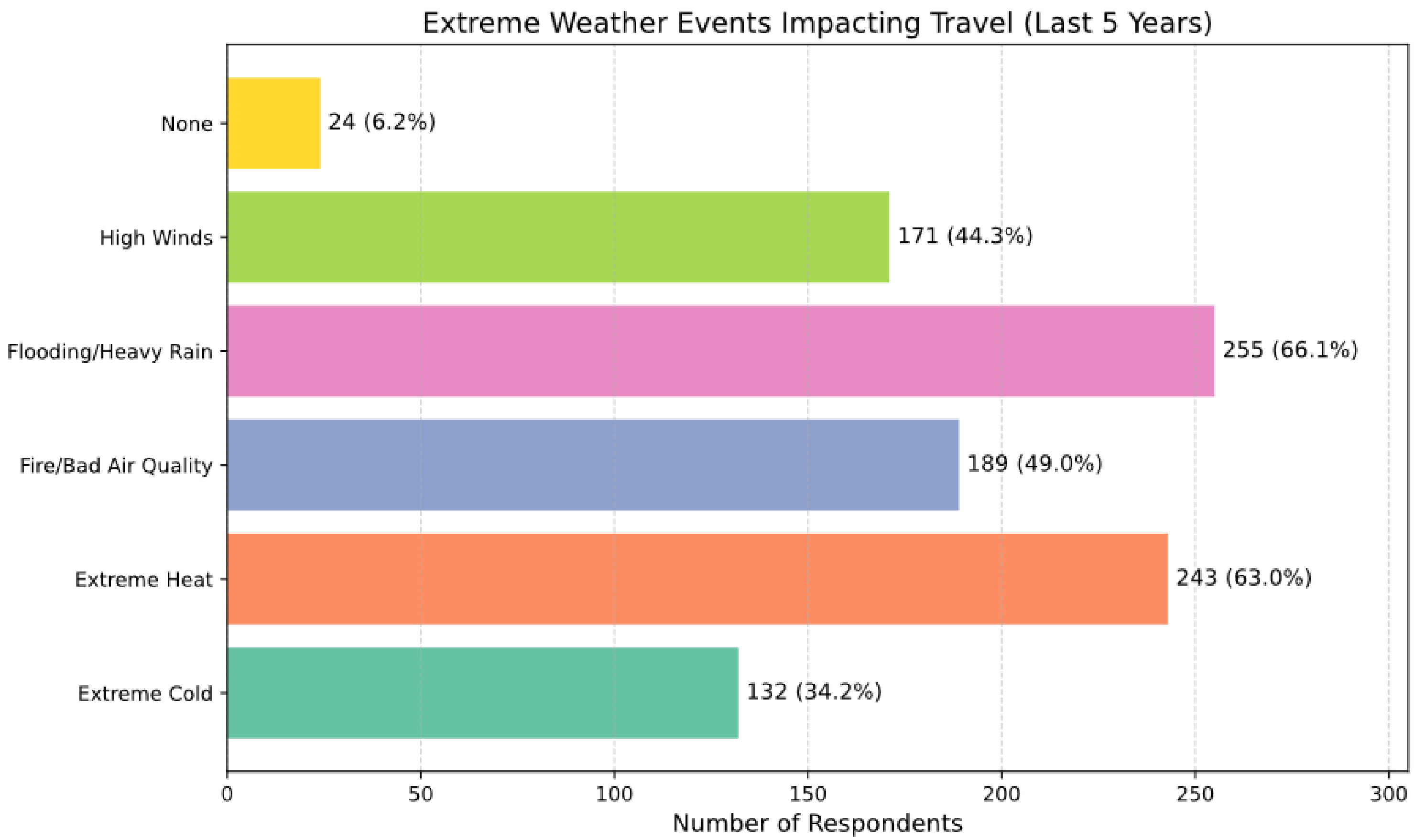


Figure 9. Extreme weather events reported to have impacted travel in the past five years.

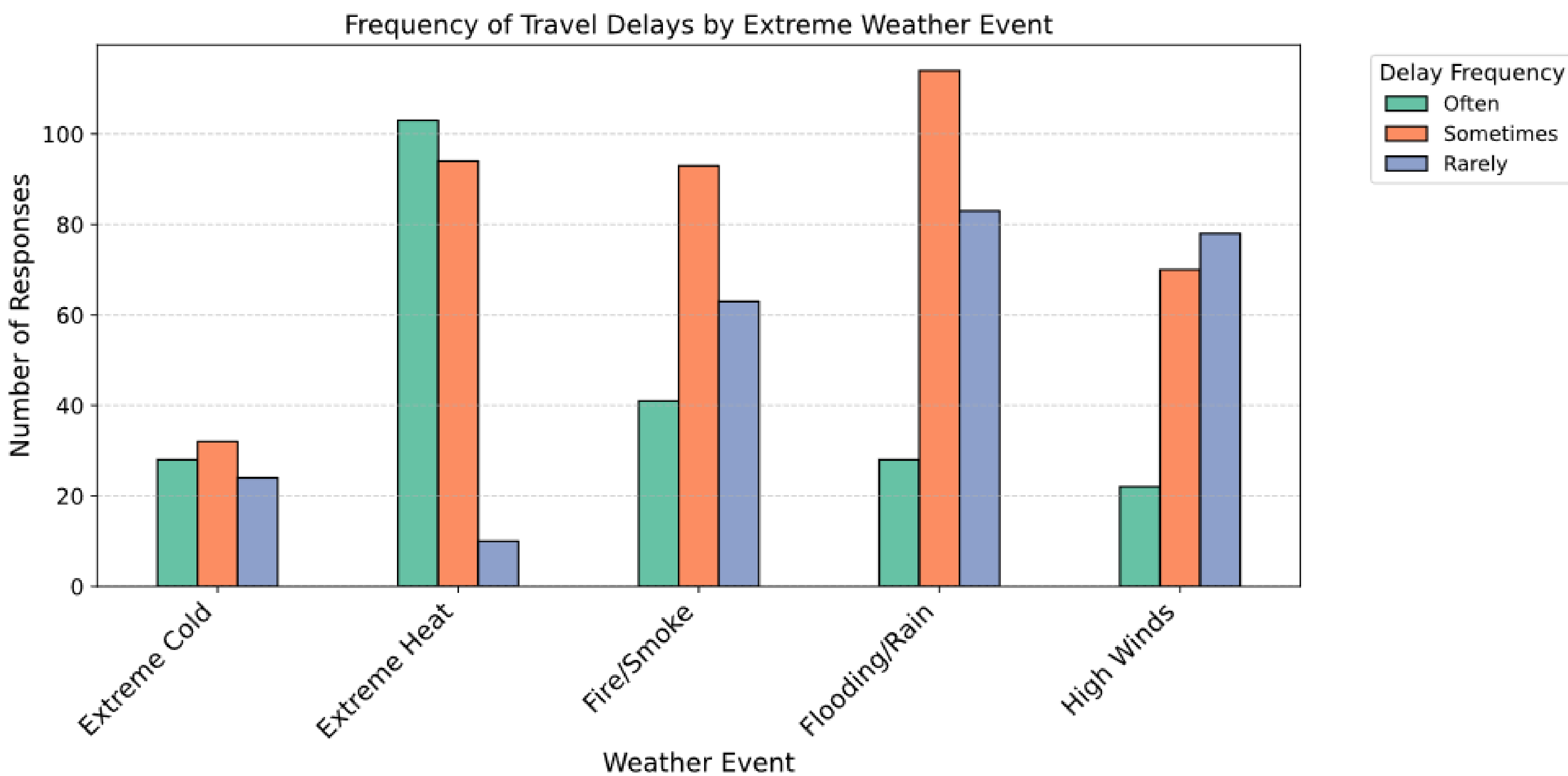


Figure 10. Frequency of travel delays caused by specific extreme weather events

Figure 11 shows the duration of travel delays varied by hazard, with extreme heat and flooding or heavy rain more often associated with longer disruptions, including instances where travel was delayed for more than a day. In contrast, events such as high winds and extreme cold were generally linked to shorter disruptions, most commonly under four hours.

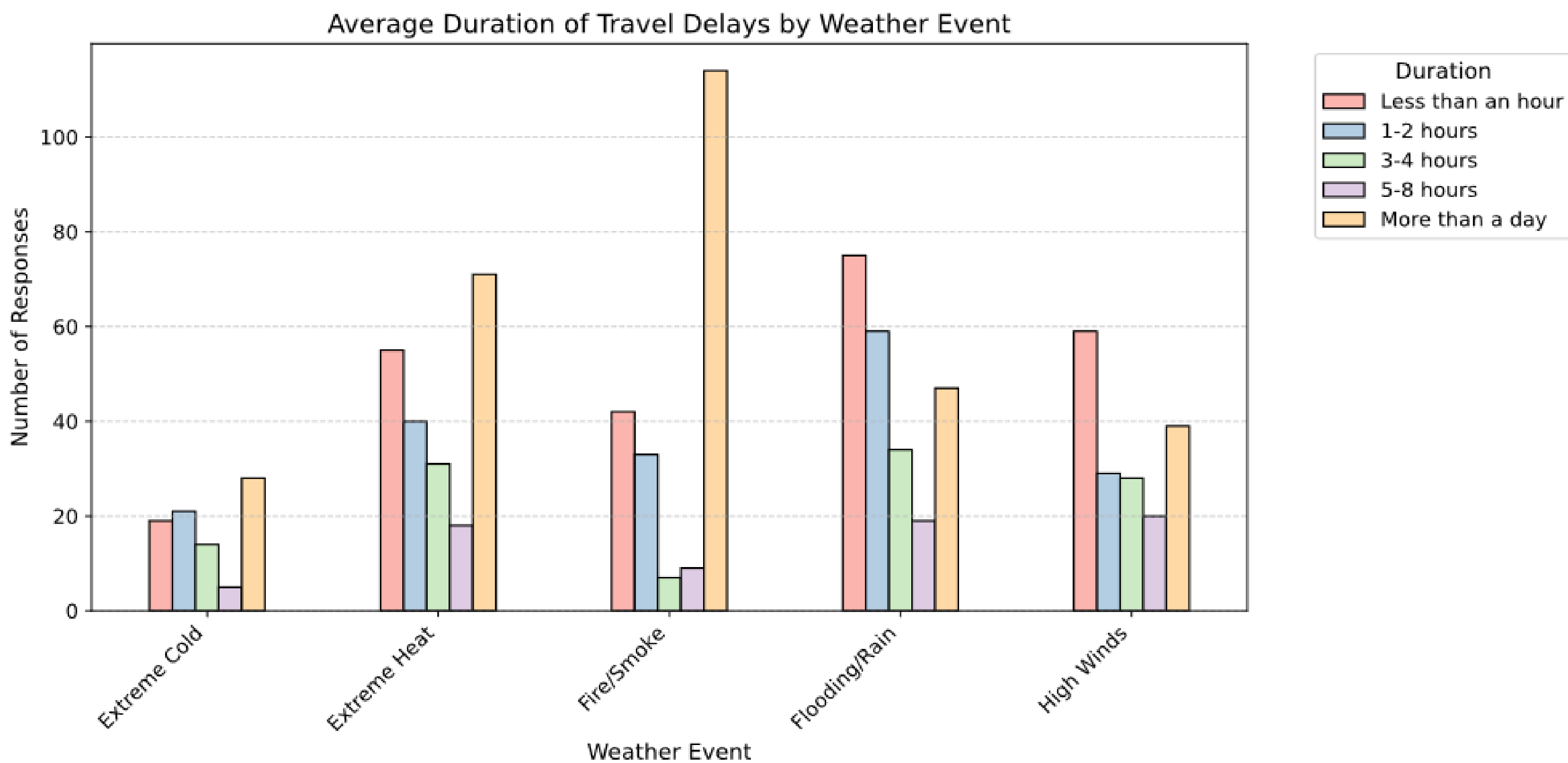


Figure 11. Average duration of travel delays by weather events

The location of impacts followed an identifiable pattern. For most weather events, respondents reported that the disruption was citywide. This was especially true for events like heatwaves and major flood events, though there were also notable mentions of specific streets, highways, and neighborhoods that experienced repeated disruptions.

The survey also captured how these disruptions affected daily life. These results are shown in

Figure 12. Respondents most frequently reported increased travel times or transportation costs, along with disrupted access to schools and essential services such as groceries or healthcare. Some participants noted they chose to stay home or were unable to travel during an emergency. This included 73 respondents during extreme cold, 188 during extreme heat, 185 during

fire/smoke, 173 during flooding/heavy rain, and 129 during high winds. Among daily users of public transit (bus or light rail), 20 respondents reported staying home during flooding or heavy rain and 17 during extreme heat. Table 33 shows the number of daily users across all travel modes who reported staying home due to different weather events. A smaller number indicated that travel disruptions led to lost wages or job-related consequences.

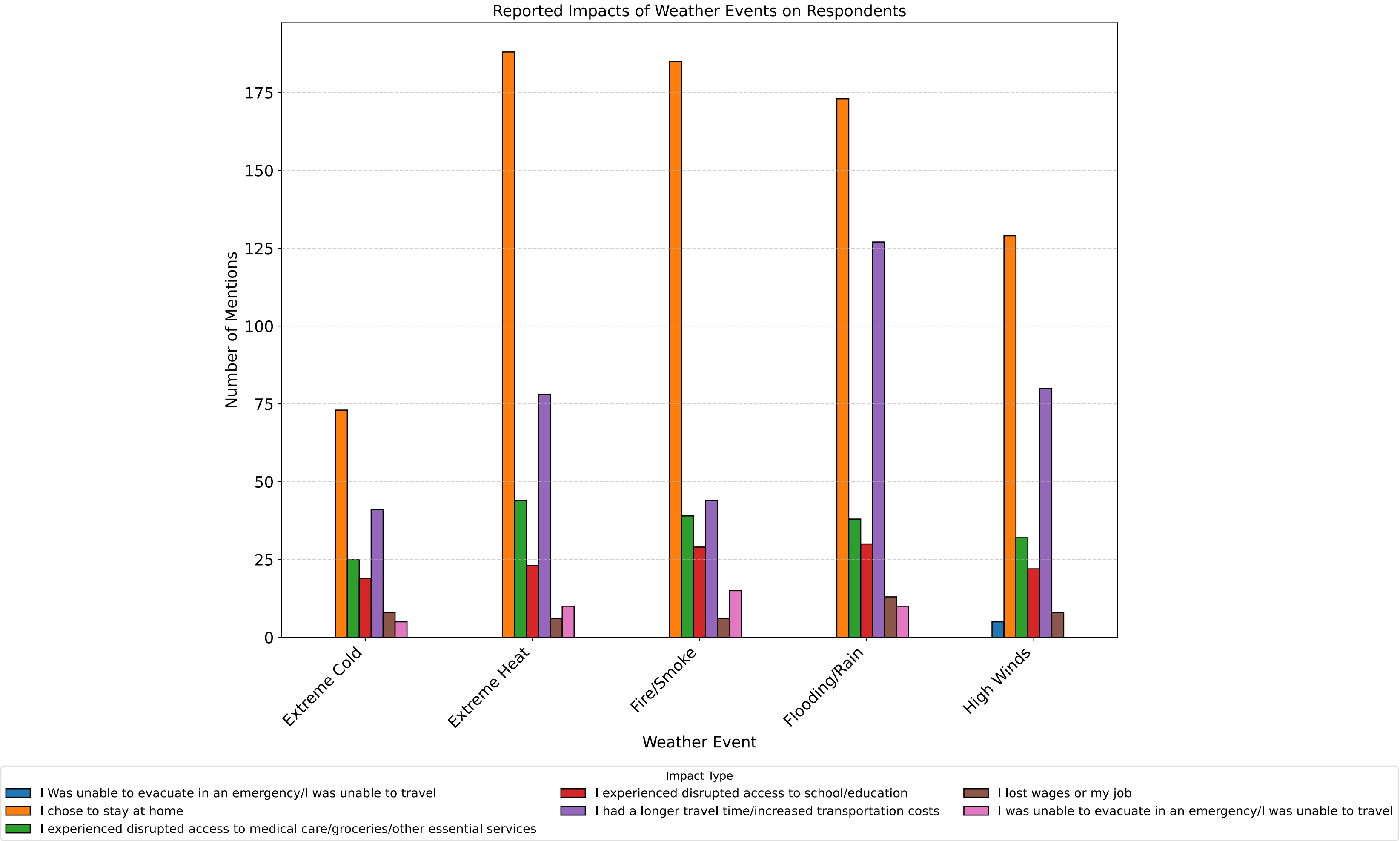


Figure 12. Types of impacts experienced by respondents during weather events

Table 33. Number of respondents who reported using a mode of transport daily and indicated they chose to stay home during specific weather events.

Mode of Transport	Weather Event					
	Extreme cold	Extreme heat	Fire, smoke, or ad air quality		Flooding or heavy rain	High winds
Bicycle or Scooter	12	26	20	24	15	
Walk	24	57	50	53	35	
Personal Vehicle (car, truck, motorcycle)	24	63	67	63	51	
Bus or Light Rail	15	17	15	20	12	
Carpool or Rideshare (Uber, Lyft)	3	4	3	2	2	
Other	2	3	3	5	2	

A further breakdown of the data comparing daily users of different travel modes and their exposure to weather events revealed that people who walk or bike daily experienced a higher incidence of travel disruption from extreme heat and flooding. Daily transit riders also reported diverse impacts from multiple hazards, while those who primarily drive personal vehicles reported fewer disruptions overall but were still affected by flooding in particular. These results can be seen in Figure 13 and Figure 14.

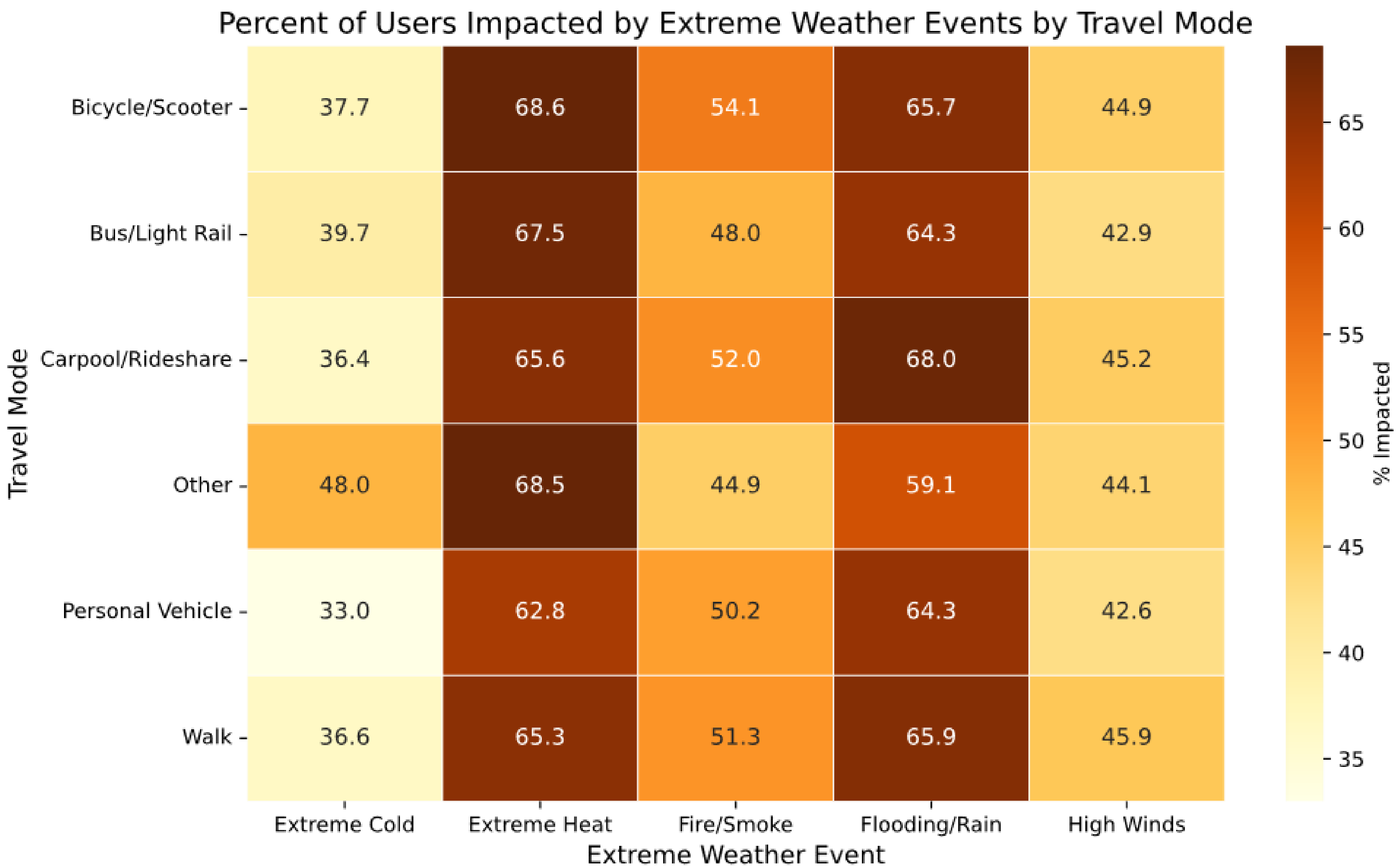


Figure 13. Heatmap showing which travel modes are most affected by specific weather events

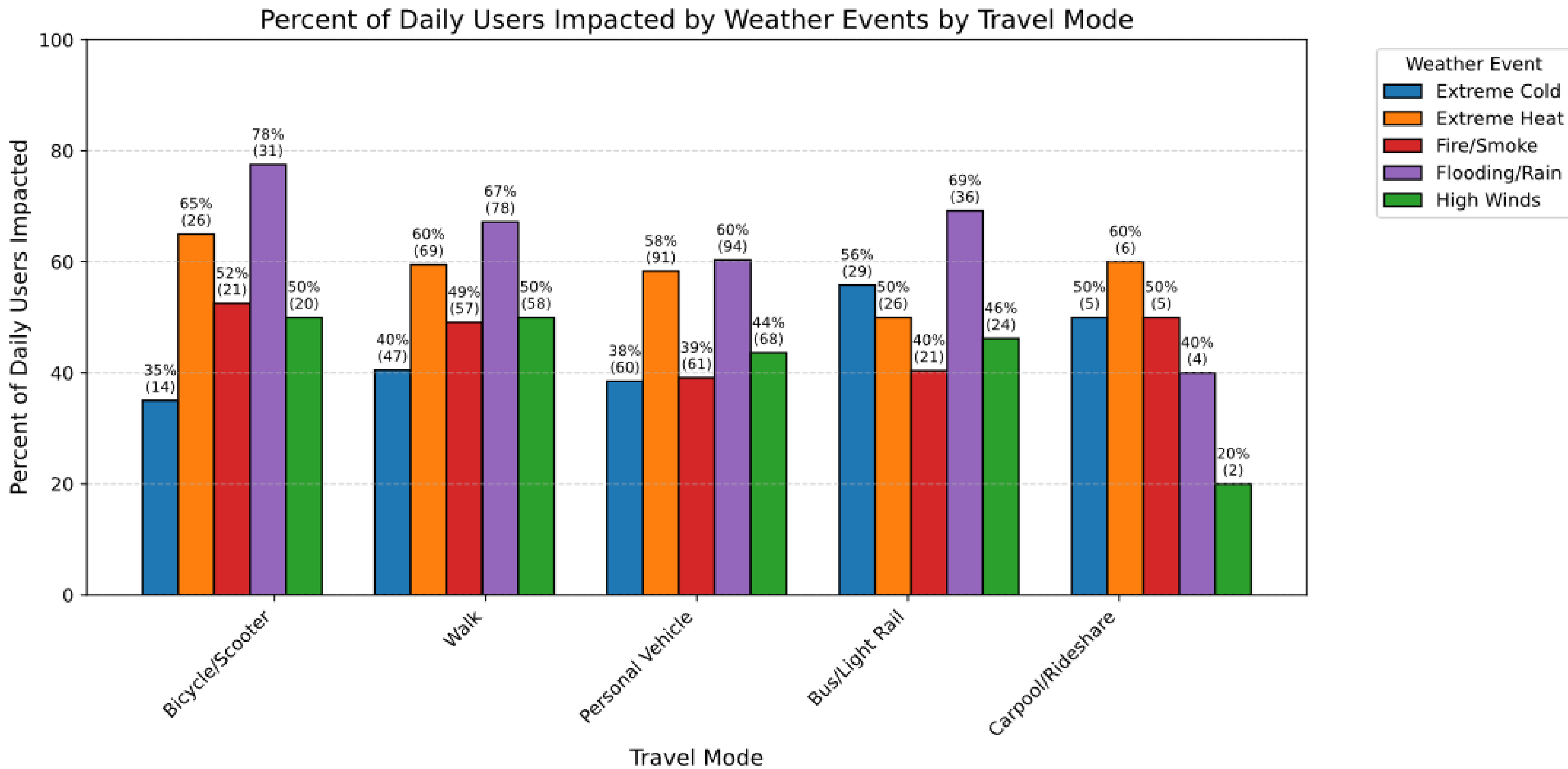


Figure 14. Travel disruption by weather events among daily users of different travel methods. Number of daily users of each travel mode impacted by weather events shown in parentheses

Additionally, when weather-related impacts were analyzed by income level, respondents across all income categories reported experiencing a range of impacts. The prevalence of certain impacts—such as choosing to stay home, longer travel times, and loss of wages or jobs—varied by income groups. To summarize the findings of the survey, residents reported experiencing a range of transportation disruptions due to extreme weather, with flooding and extreme heat cited most frequently. Active travelers such as those who walk, bike, or use public transit daily, were more likely to report impacts, including longer delays and inability to travel. While those driving personal vehicles reported fewer disruptions, flooding still posed a significant challenge. Across all income levels, respondents noted impacts like staying home, increased travel times or costs, and lost wages, illustrating how weather events broadly affected mobility and access to essential services in Sacramento. Together, these findings underscore how both the type of travel and the nature of weather events shape how residents experience transportation disruptions in Sacramento. More information on the impacts of income are shown in Figure 15 and Figure 16.

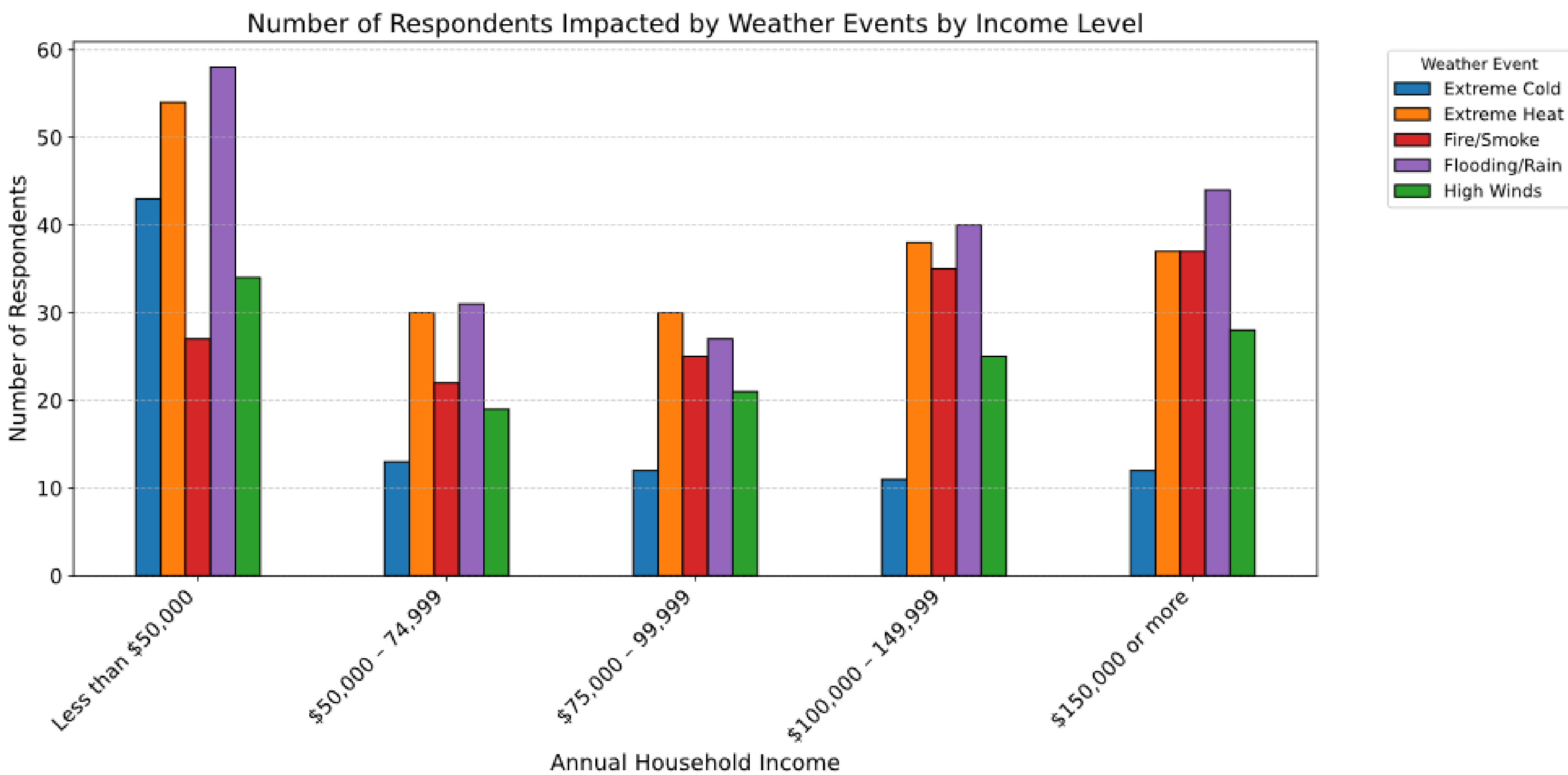


Figure 15. Weather events most frequently encountered by income groups

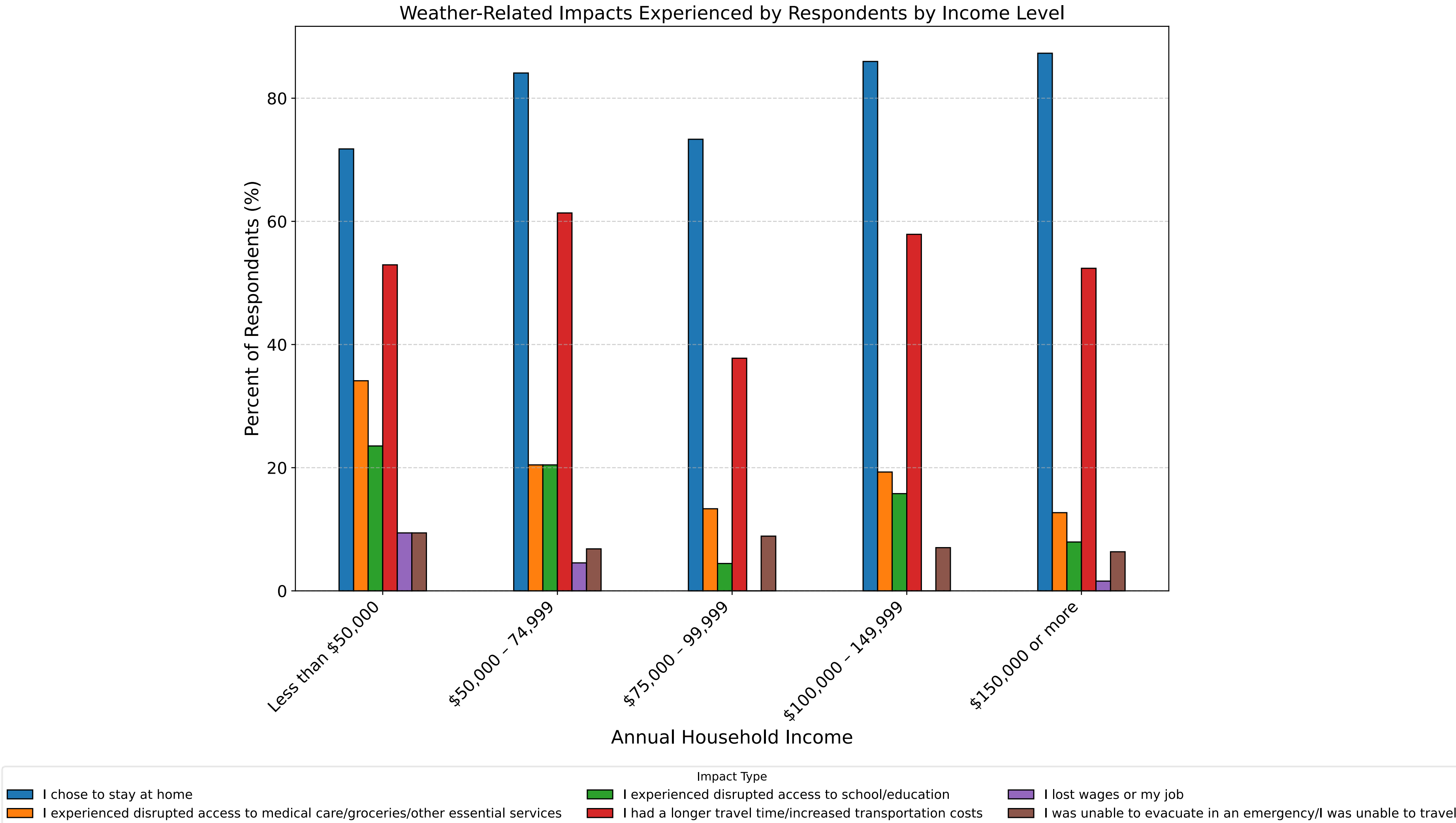


Figure 16. Percent of respondents within each income group reporting specific weather-related impacts. Each percentage represents the share of respondents in that income category who reported experiencing the corresponding impact type at least once across all weather events.

The following figures and tables provide a demographic profile of the survey respondents. For comparison, pie charts representing the same demographic categories for the City of Sacramento are provided after each respective survey figure. In the case of age distribution, two accompanying tables are also provided due to the differing age groupings used in the survey and the city's census. These charts and table regarding the City of Sacramento demography are based on the U.S. Census Bureau's 2023 ACS 5-Year Estimates[48].

Characteristics of survey respondents and the City writ large are shown for annual household income (Figure 17, Figure 18), age (Figure 19, Figure 20, Table 34, Table 35), gender identity (Figure 21, Figure 22), racial/ethnic identity (Figure 23, Figure 24), and language (Figure 25, Figure 26).

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[48] Source: U.S. Census Bureau, American Community Survey 2023 5-Year Estimates for the City of Sacramento. Tables:

- DP05: *Demographic and Housing Estimates* (Age, Race, Gender)
- S1901: *Income in the Past 12 Months (in 2023 Inflation-Adjusted Dollars)*
- S1601: *Language Spoken at Home*
  Accessed June 27, 2025, from https://data.census.gov.

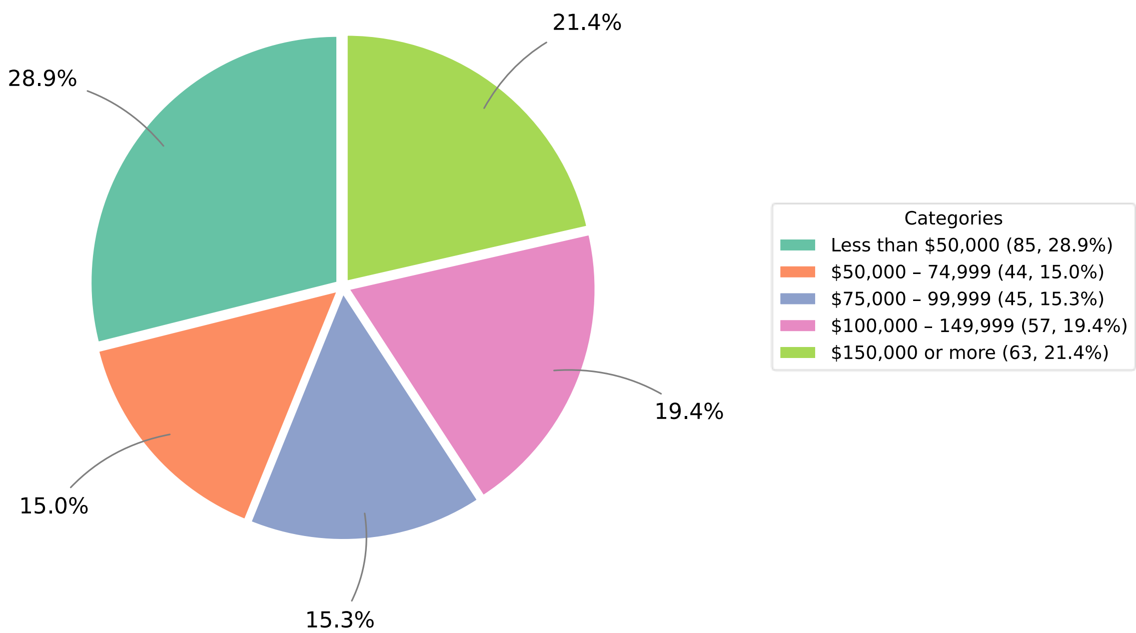


Figure 17. Annual household income of respondents.

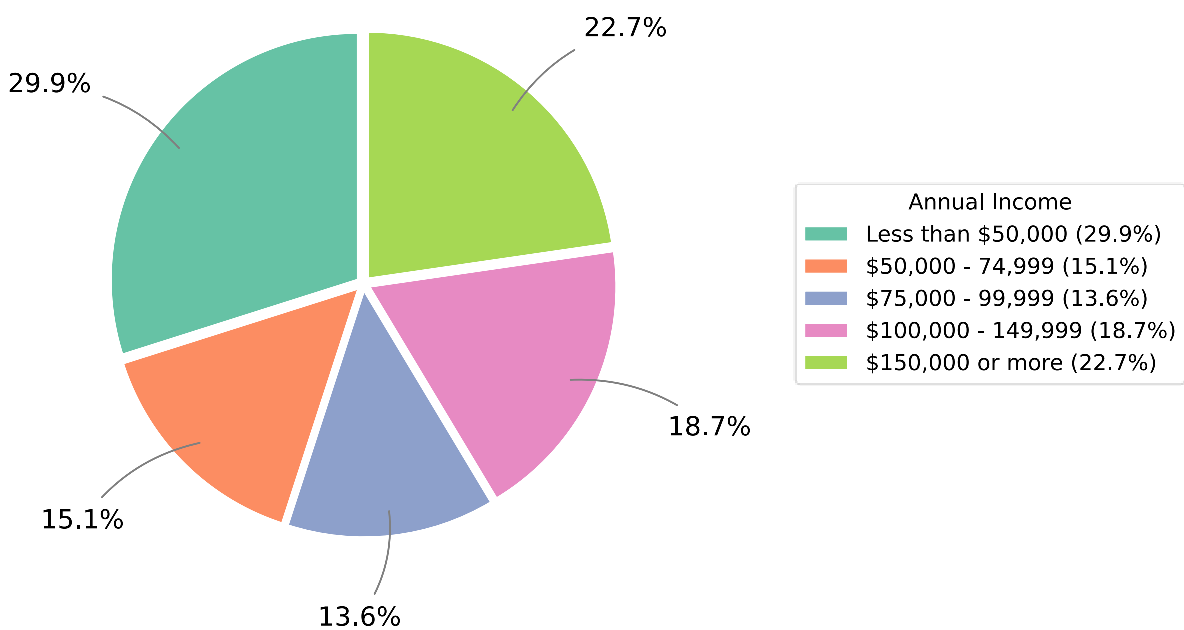


Figure 18. Distribution of annual household income among residents of the City of Sacramento, based on ACS 5-Year Estimates

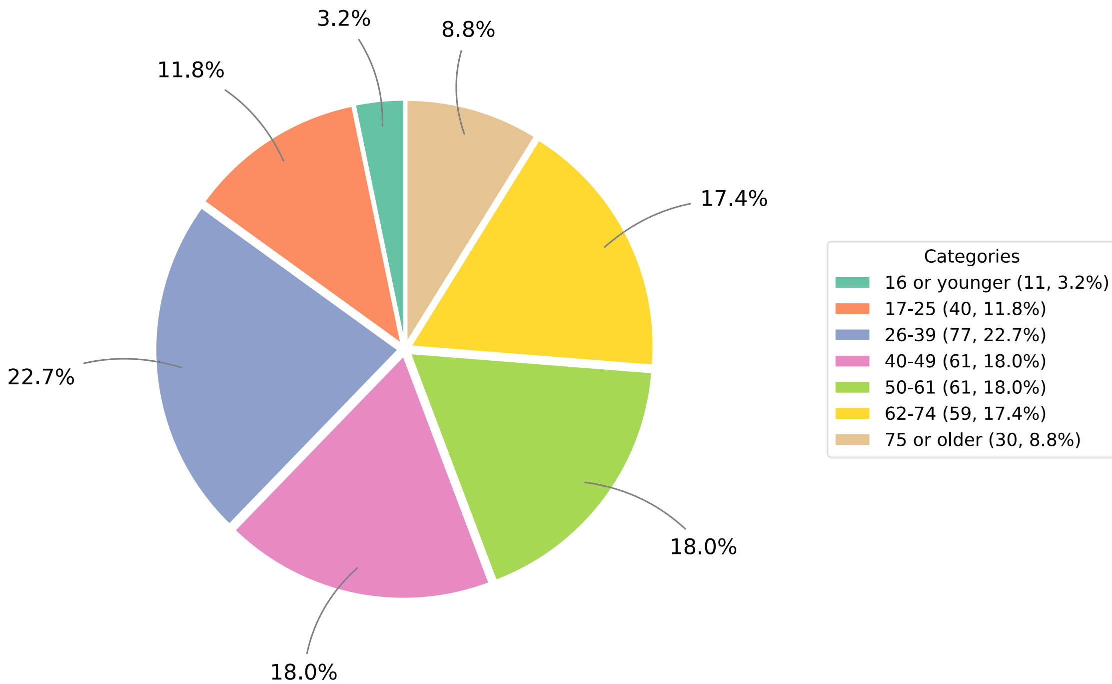


Figure 19. Age distribution of respondents

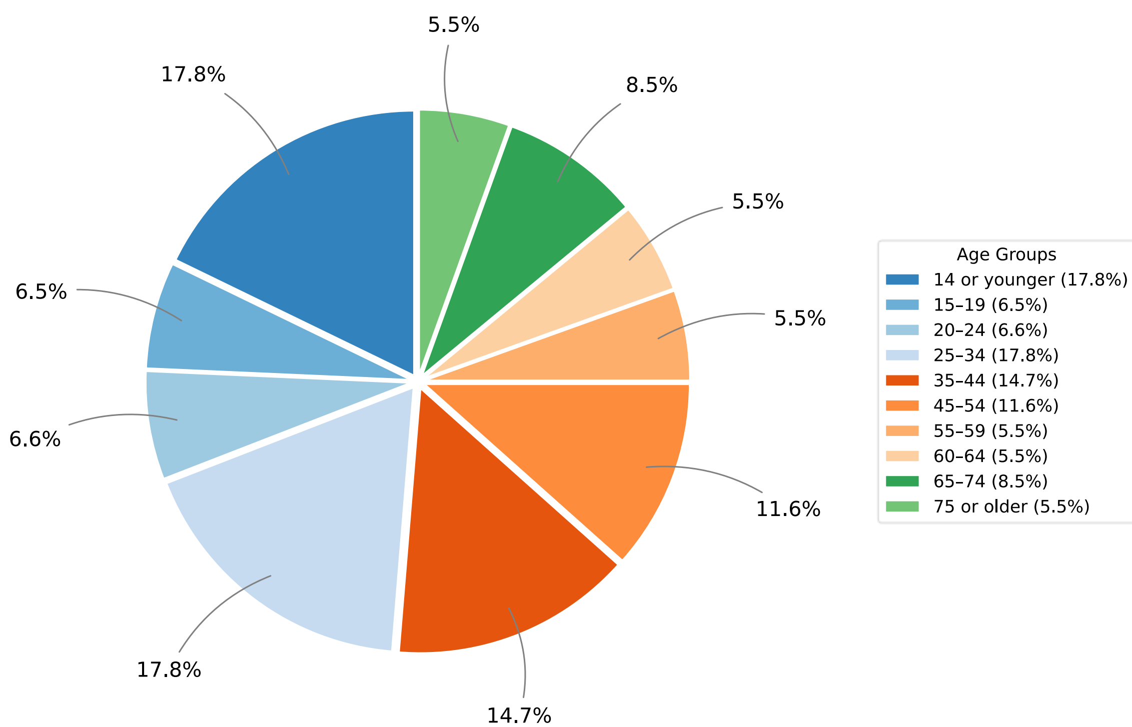


Figure 20. Age distribution of residents in the City of Sacramento, according to the 2023 ACS 5-Year Estimates

Table 34. Age Distribution of Survey Respondents

Age Group	Percentage (%)
16 or younger	3.2%
17–25	11.8%
26–39	22.7%
40–49	18.0%
50–61	18.0%
62–74	17.4%
75 or older	8.8%

Table 35. Age distribution of residents in the City of Sacramento, according to the 2023 ACS 5-Year Estimates

Age Group	Percentage (%)
14 or younger	17.8%
15-19	6.5%
20-24	6.6%
25-34	17.8%
35-44	14.7%
45-54	11.6%
55-59	5.5%
60-64	5.5%
65-74	8.5%
75 or older	5.5%

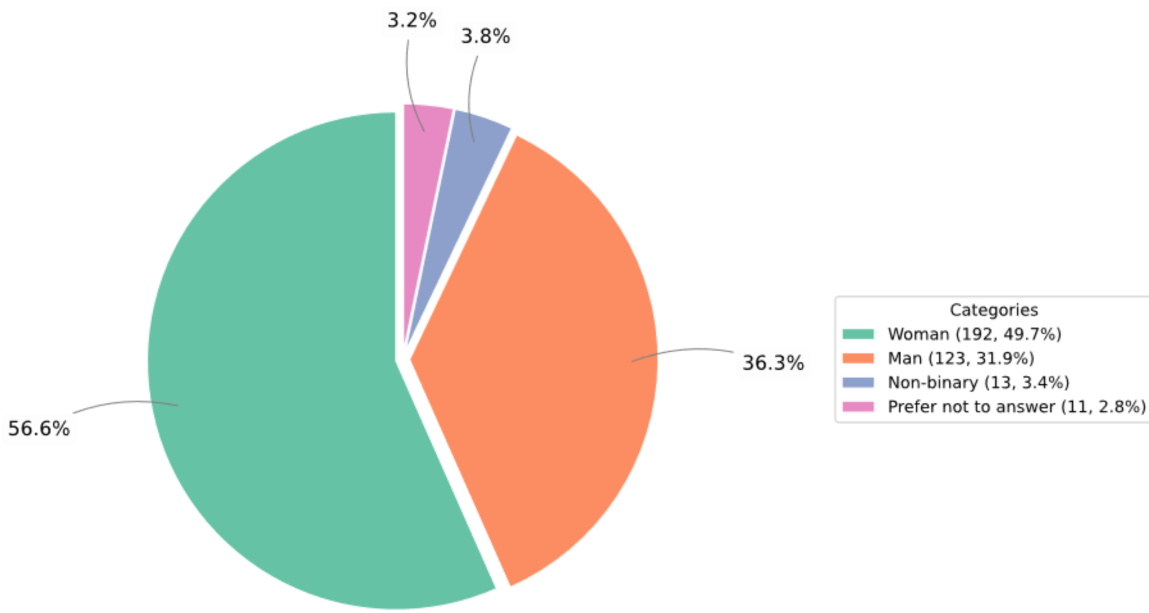


Figure 21. Gender identity of survey respondents

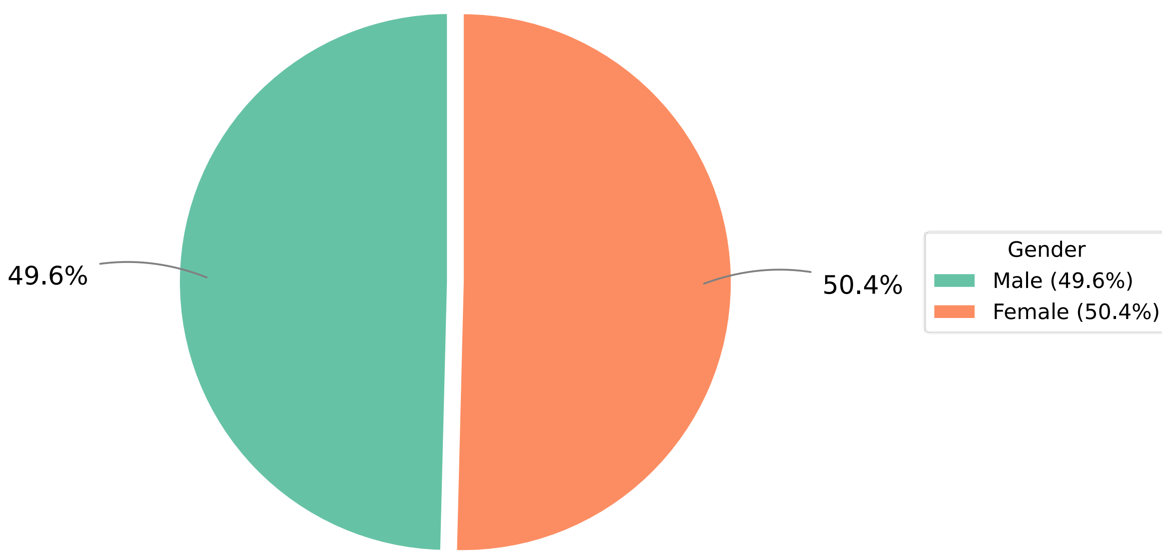


Figure 22. Gender identity of residents in the City of Sacramento, according to the 2023 ACS 5-Year Estimates

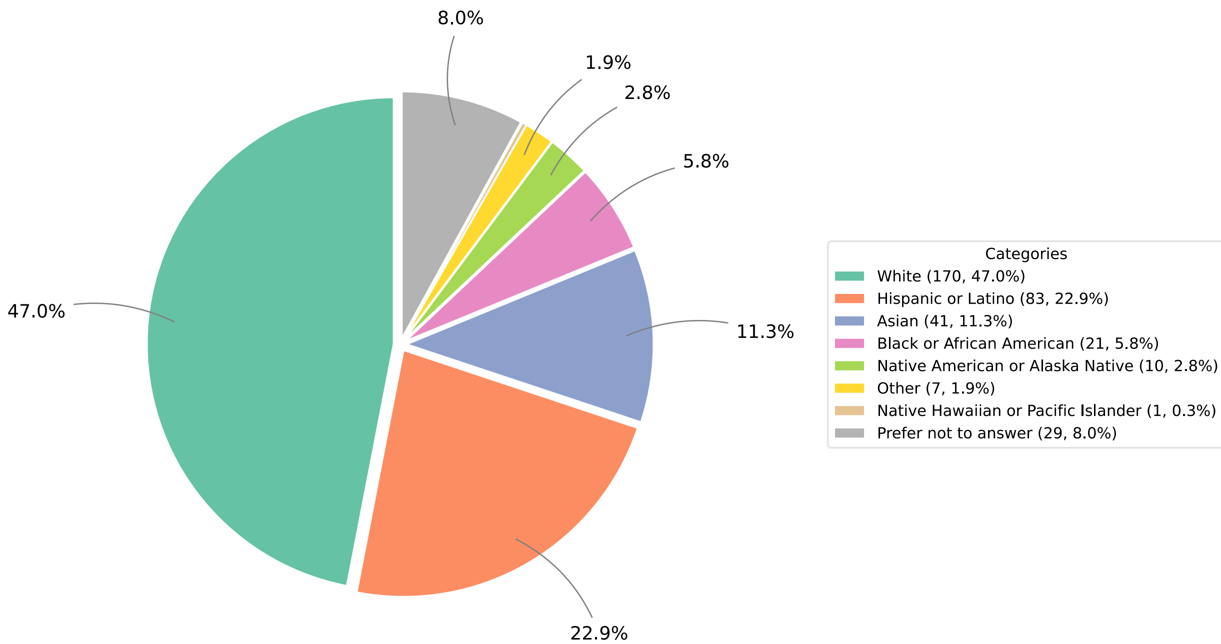


Figure 23. Race/Ethnicity of respondents

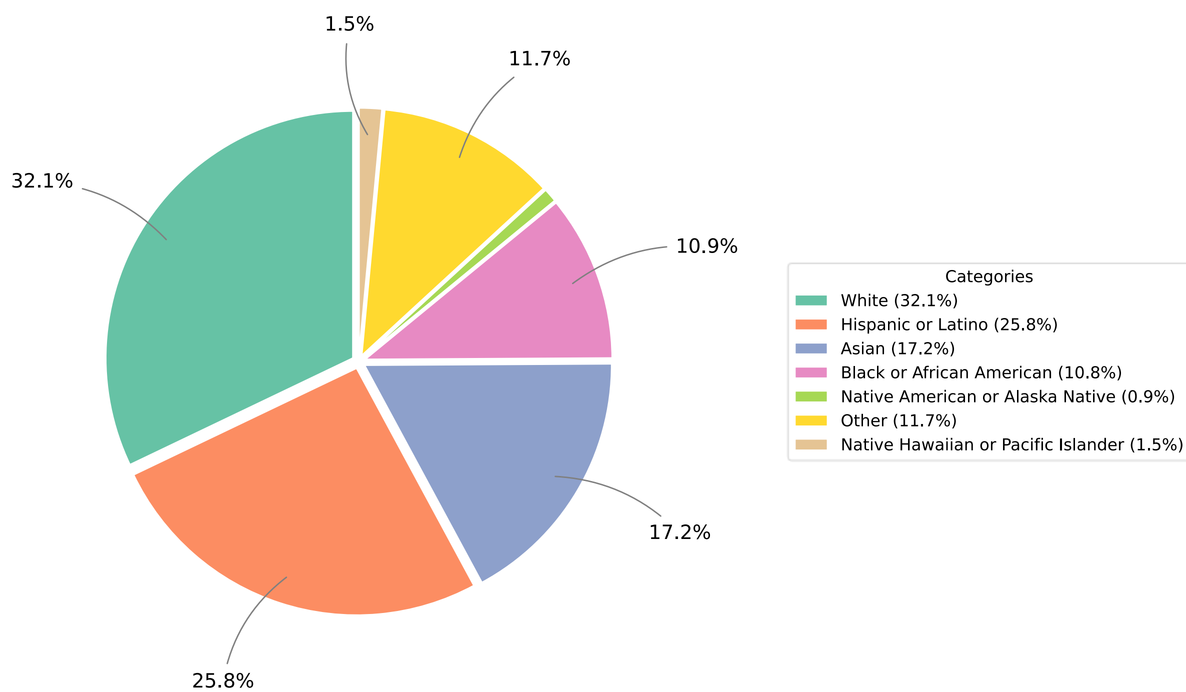


Figure 24. Race and ethnicity of residents in the City of Sacramento, according to the 2023 ACS 5-Year Estimates

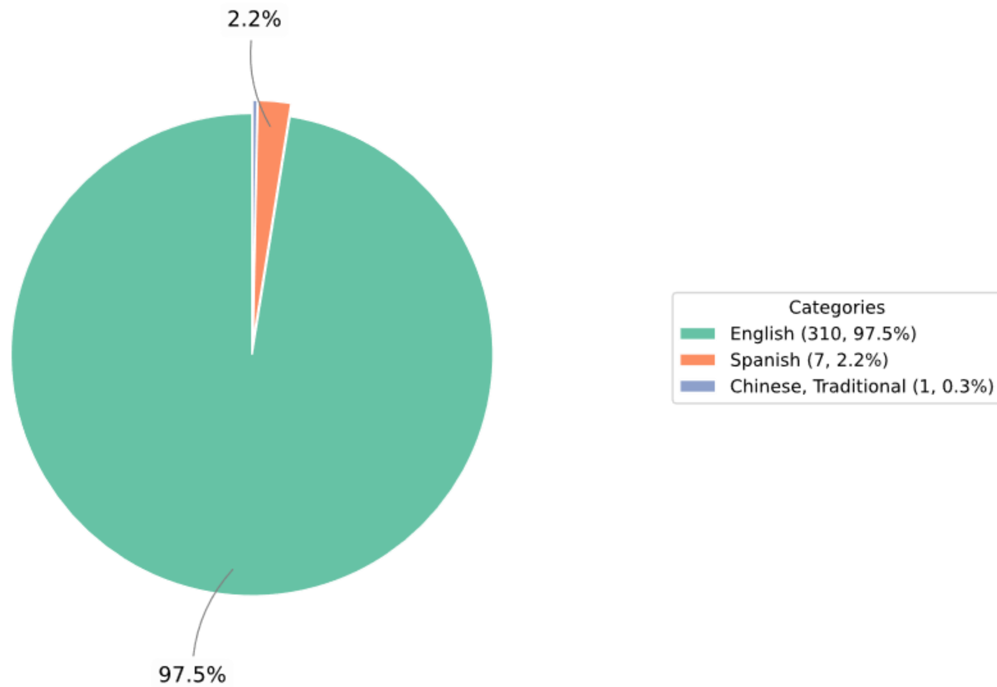


Figure 25. Language in which respondents completed the survey

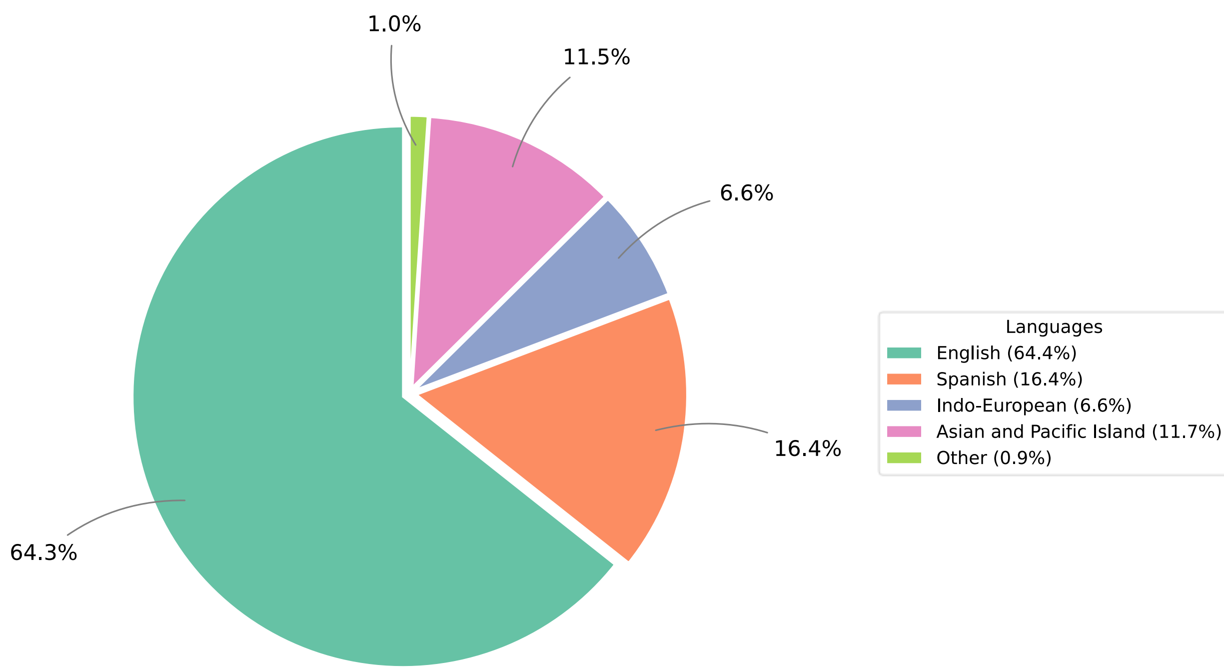


Figure 26. Most spoken languages at home for residents in the City of Sacramento, according to the ACS 2023 5-Year Estimates

The following three figures document whether respondents are enrolled in relevant alert systems (Figure 27, Figure 28), and how they completed the survey (Figure 29).

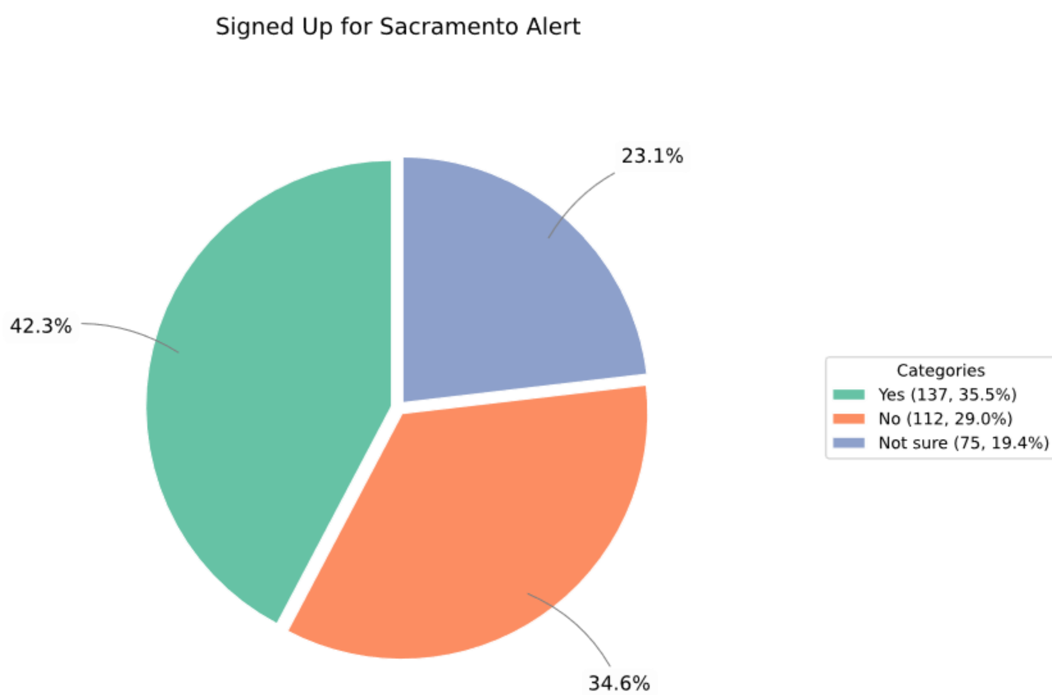


Figure 27. Respondents' enrollment in Sacramento Alert

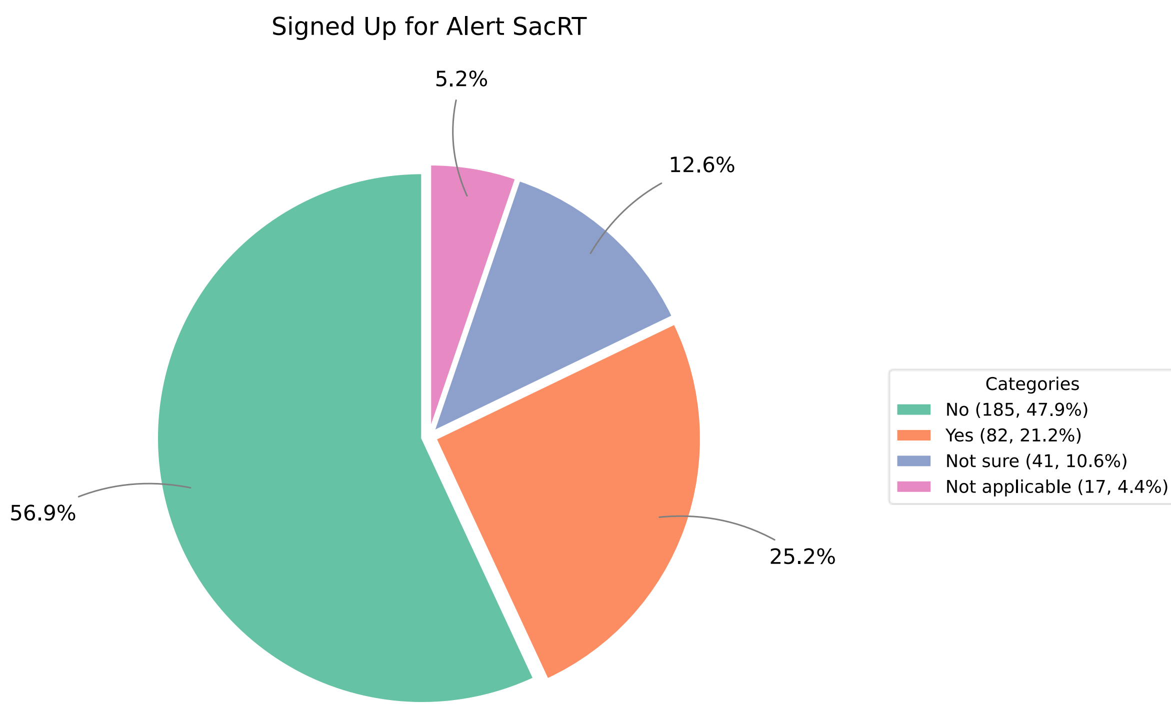


Figure 28. Respondents' enrollment in SacRT transit disruption alerts

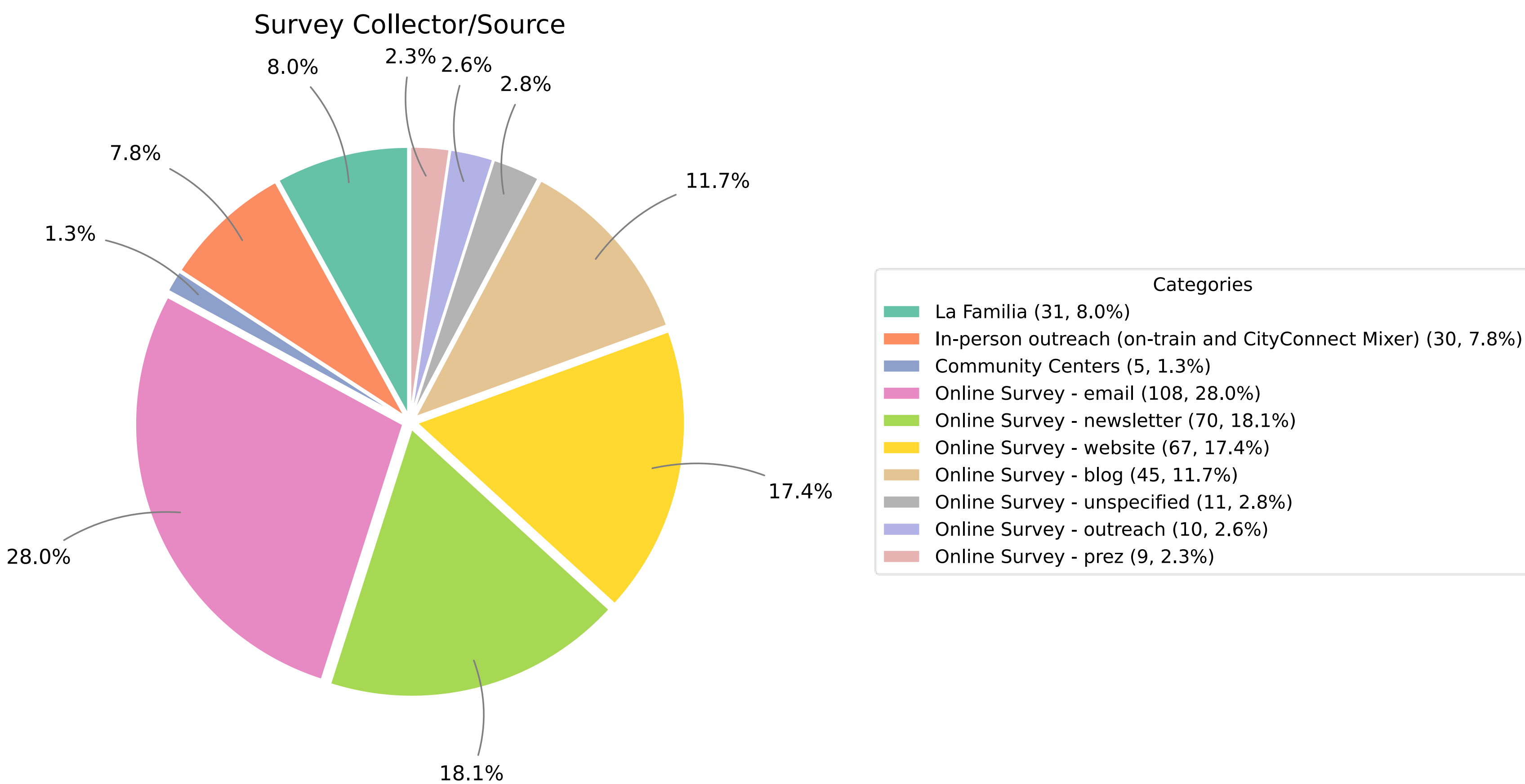
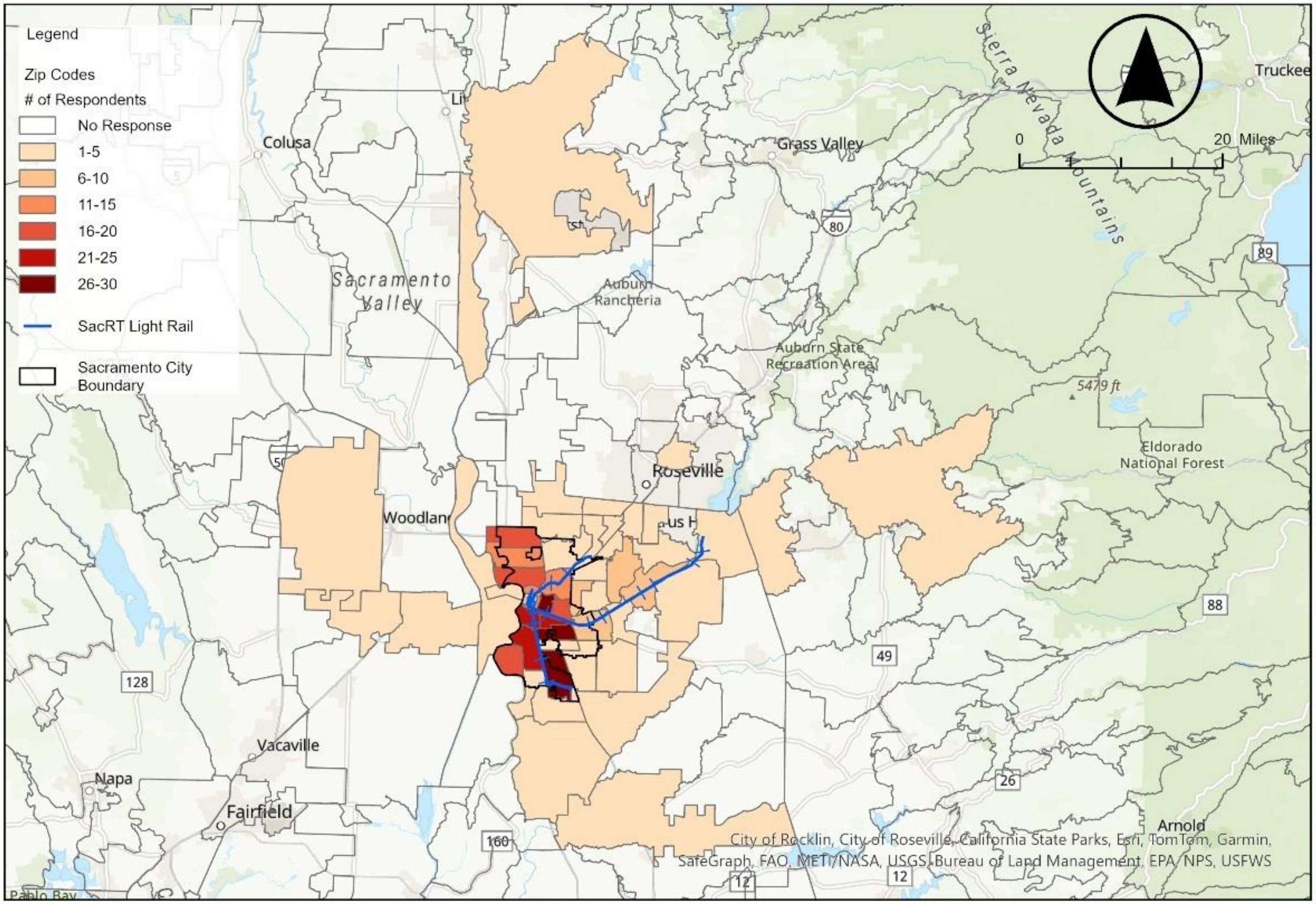


Figure 29. Distribution of respondents by survey collector or source

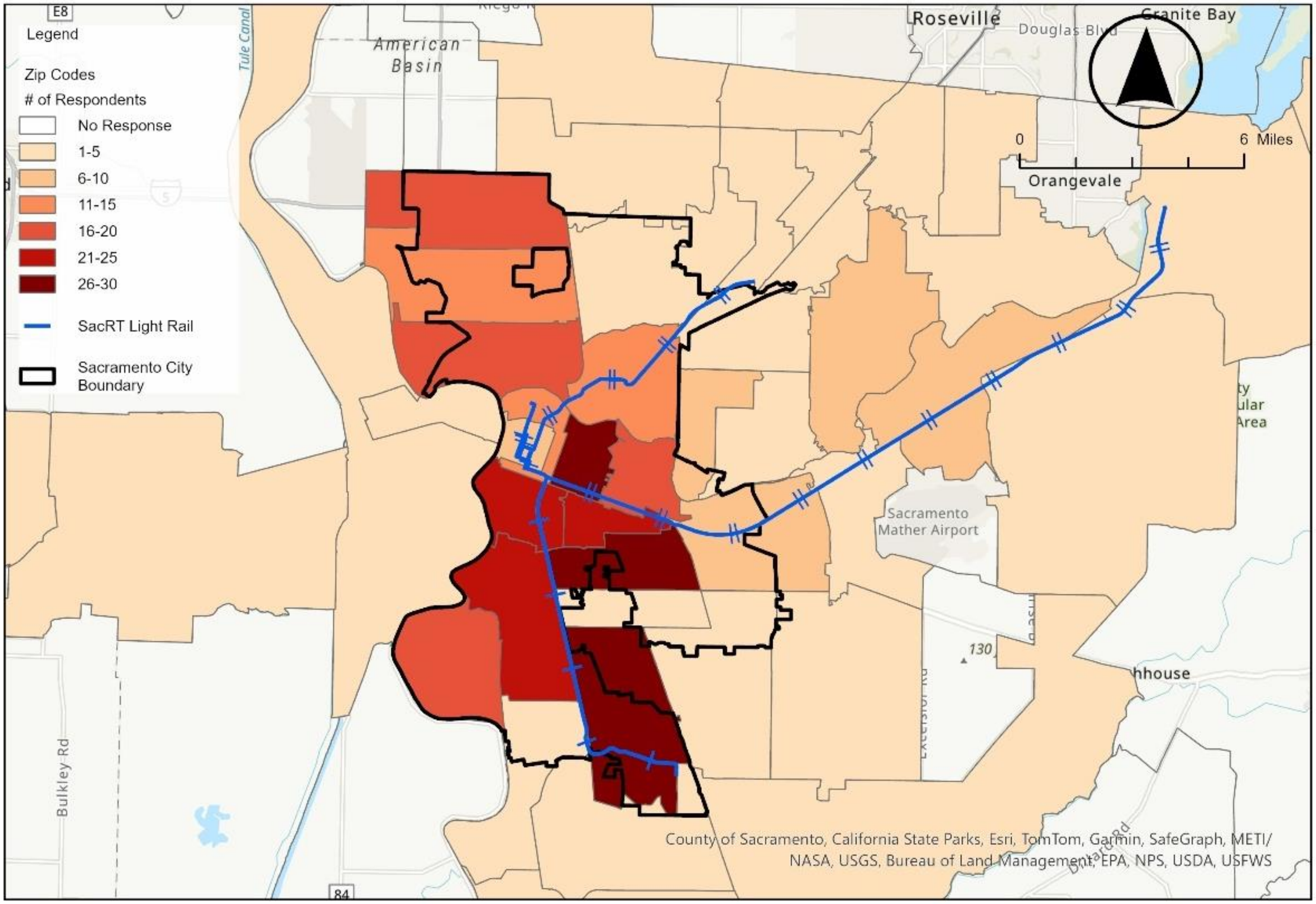
Most responses came through online sources: email (28%), newsletter (18.1%), website (17.4%), and blog (11.7%). Community partners and in-person outreach contributed a smaller share: La Familia (8%), on-train/CityConnect Mixer (7.8%), and community centers (1.3%). Map 17 through Map 20 show the reported home and work zip codes of participants across the Sacramento region.

Home Zip Codes of Survey Respondents



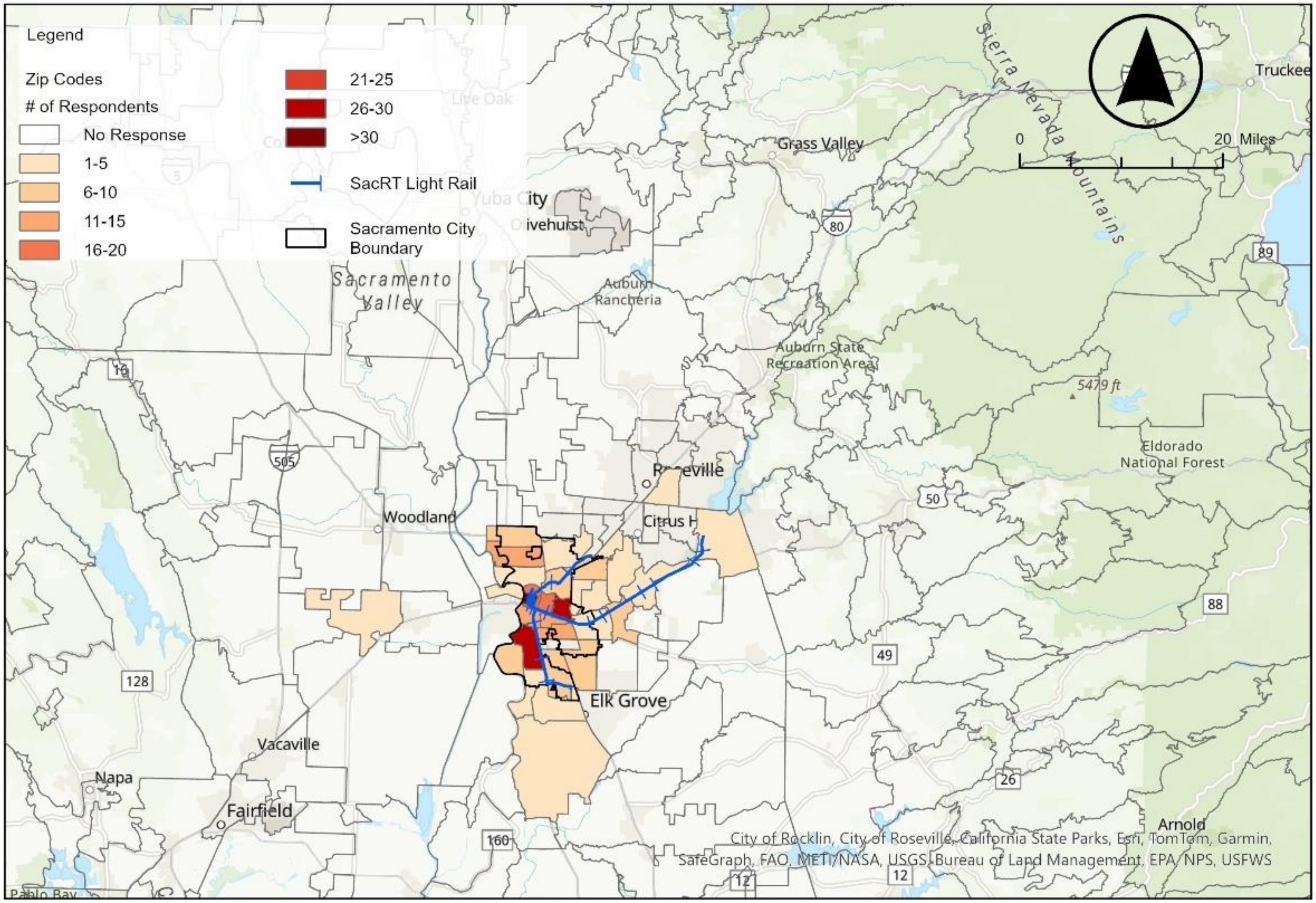
Map 17. Home zip codes of survey respondents (small-scale)

Home Zip Codes of Survey Respondents



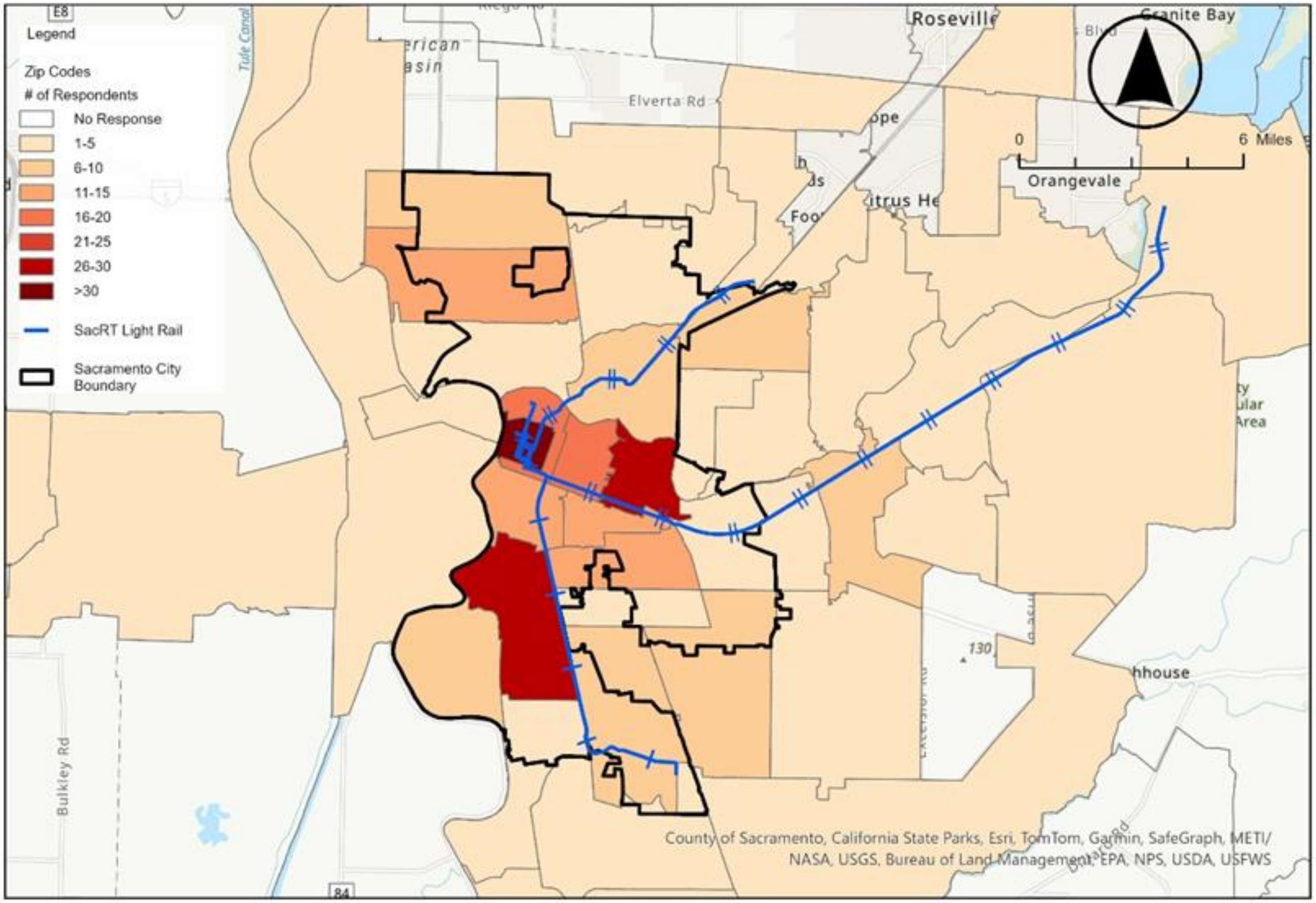
Map 18. Home zip codes of survey respondents (large-scale)

Work Zip Codes of Survey Respondents



Map 19. Work zip codes of survey respondents (small-scale)

Work Zip Codes of Survey Respondents



Map 20. Work zip codes of survey respondents (small-scale)

5. Key Takeaways

Damage types with a high level of concern were:

- Levee Failure and Widespread Flooding
- Heat and Outdoor Traveler Comfort & Health
- Heat and Outdoor Worker Health
- Heat and Power Distribution System for SacRT
- Heat and OCS
- Wildfire and Smoke Impacts to Travelers
- Power Grid Failure

Many of these are complex issues that are not fully under the City's and SacRT's jurisdiction. However, there are still many opportunities to manage risk, particularly around flooding.

Moderate impacts with high ability to manage include:

- Heat and Asphalt
- Flooding and Bridge Damage

Moderate impacts with moderate ability to manage include:

- Heat and HVAC systems
- Wind damage to Traffic Signals, Streetlights, and Other City Infrastructure
- Flooding and Disruption to Roadways, Railways, and Shared-Use Paths
- Flooding and Transit Facility Damage

The vulnerability assessment additionally identified potential or planned projects that can enhance resilience of the transportation system. These include:

- The specific areas mentioned by agency partners and documented under the "Locations Affected" portions of the "Potential Transportation Damage Types" section
- Drainage and other improvements described in the DOU Comprehensive Flood Management Plan's Repetitive Loss Area Analysis appendix
- Maintenance and rehabilitation recommendations from the City's bridge inspection list
- Connecting every traffic signal to the City's Traffic Operations Center (TOC)
- Improving tree pruning efforts
- Including dedicated maintenance funding as part of capital project budget

- Remaining floodgate improvements, after Floodgate Modernization and Resilience Project is completed
- More maintenance capacity for DOU to collect and clear debris from drains, especially during leaf-fall season
- Projects from DOU's study on how to prioritize spending for pump stations, particularly in portions of system most susceptible to power outages
- Joint operations center for emergency management
- Regular schedule for evacuation planning, training, and exercises
- SacRT's proposed study on heat management for light rail substations
- Recommendations stemming from SacRT's current heat-resilient bus shelters pilot
- Replacement of aging CNG infrastructure at the SacRT CNG plant
- Specific assets flagged as exposed in "Exposure Analysis" section

The Sacramento-specific climate projections summarized in the "Climate Science & Projections" section will be incorporated into the risk analysis and project prioritization.