



San Joaquin Council  
of Governments  
Climate  
Adaptation &  
Resiliency Study

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Climate Adaptation  
Report

APRIL 2, 2020

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- Altamont Corridor Express
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- City of Lodi
- City of Manteca
- City of Ripon
- City of Stockton
- City of Tracy
- Delta Stewardship Council
- Port of Stockton
- Reinvent South Stockton
- San Joaquin County Community Development
- San Joaquin Regional Transit District
- Stockton Metropolitan Airport
- Third City Coalition

## Executive Summary

The San Joaquin Council of Governments (SJCOG) is committed to improving the resiliency of the county's transportation system in the face of climate impacts. This Climate Adaptation and Resiliency Report assesses the vulnerability of the San Joaquin County transportation system to sea level rise and riverine flooding, extreme precipitation, wildfire, extreme heat and drought. The study considered these vulnerabilities within the context of existing hazards and climate impact planning efforts in order to identify and prioritize additional adaptation planning and actions. Given SJCOG's responsibility for producing the Regional Transportation Plan (RTP), the study team also identified opportunities to further integrate resiliency into RTP transportation project prioritization and design.

The project began with a criticality assessment to identify crucial assets for a resilient transportation system that supports multimodal transport, redundant routes, and emergency response. Based on input from the working group, the assessment focused on transportation assets falling into the following categories:

- Bus routes
- Key supporting services: bus and train maintenance centers and intermodal railyards
- Goods movement connectors: connectivity between major trucking routes and businesses
- Access points for transportation-disadvantaged, rural populations
- Access to transit for transportation-disadvantaged, urban populations
- Evacuation routes operating at low level of service
- Air and deep-water transport: Stockton Airport and Port of Stockton

The study team investigated how these assets are projected to be impacted by each climate stressor. This included an assessment of which assets will be exposed to the impact, sensitivity of assets to the impact, how easily assets can adapt, and the consequences of a disruption to the community. The working group identified the following assets as priorities for adaptation planning:

Top Priorities	Additional Priorities
<ul style="list-style-type: none"> <li>• SR-99 through Lodi</li> <li>• South Stockton Neighborhood</li> <li>• Stockton Airport</li> <li>• Stockton Wye</li> <li>• SR-4 from Stockton west to Contra Costa</li> <li>• BNSF Intermodal Railyard</li> </ul>	<ul style="list-style-type: none"> <li>• Port of Stockton</li> <li>• I-5 between Tracy &amp; Lathrop</li> <li>• Waterloo Rd/CA-88</li> <li>• Bus stops in downtown Stockton, Hammer Triangle, Harrell Park</li> </ul>

After investigating these vulnerabilities as well as existing hazards and transportation planning, the study team identified the following system-wide adaptation needs:

- Strategies for a resilient transit system
- Requirements to integrate resilient designs into road and infrastructure upgrade projects
- Plans to adapt to Public Safety Power Shutoffs (as a precaution to avoid wildfires)

Findings and recommendations from this study will drive development of tools and actions to support local and regional adaptation efforts.

## Introduction

The San Joaquin Council of Governments (SJCOG) Climate Adaptation and Resiliency Study is a year-long effort, launched in March of 2019, to consider how to improve the resiliency and increase the reliability of the transportation system in the face of climate impacts. Serving as the drainage basin for the San Joaquin River and its many tributaries, San Joaquin County is projected to face increased flood risk over time. The frequency and size of extreme precipitation events are expected to increase, and rising sea levels are predicted to move up into the delta. The intensity and frequency of droughts and heat waves are also anticipated to increase. While climate projections indicate that extreme fire events may remain steady or decline slightly in San Joaquin County through the mid-century, wildfire projections continue to evolve, and fire risk remains an important issue.<sup>1</sup>

Recognizing that climate hazards may cause far-reaching impacts to the communities, economy, and environment of San Joaquin County, SJCOG undertook a study to assess climate impacts. The purpose of this study is to examine how climate will impact a highly networked component of the county's infrastructure—the transportation system. Some examples of the types of impacts that the study team evaluated across the system are provided in Table 1.

This study considers existing climate impact planning efforts in order to identify where additional adaptation planning and actions are needed. Given SJCOG's responsibility for producing the Regional Transportation Plan (RTP) for the region every four years, the study team also looked for opportunities to further integrate resiliency into transportation project prioritization and design.

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<sup>1</sup> Westerling, Anthony Leroy. (University of California, Merced). 2018. Wildfire Simulations for California's Fourth Climate Change Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CCCA4-CEC-2018- 014.

Table 1. Impacts of climate stressors on transportation assets.<sup>2</sup>

	 Flooding (riverine, Extreme precipitation, sea level rise)	 Extreme Temperature	 Wildfire	 Drought
<b>Roads</b>	Asphalt stripping, washouts, subbase erosion, route closures, delays	Asphalt-concrete cracking	Rutting/softening, closures, need for safe evacuation routes	Shrinking of ground below asphalt can cause pavement to crack
<b>Rail</b>	Substructure erosion, inundation, forced delays	Track buckling, forced slower speeds and delays, derailments	Blocked routes, forced delays	Runoff, leaching, slope instability, decreased load bearing capacity, reduced track stability and visibility
<b>Buses</b>	Delays and route changes	Transit vehicles overheating, decreased comfort for passengers	Route closures, delays	--
<b>Airports</b>	Damage to runways, delays	Flight delays—planes cannot take off in extreme heat	Damage to infrastructure, delays due to poor visibility and worker safety concerns	Stress on water supply for cooling towers, irrigation, & pavement power washing
<b>Port</b>	Flooding of electrical equipment and bottom of cranes	Deterioration of pavement for storage cargo	Worker safety concerns	Challenges accessing fixed docks with water level fluctuation

<sup>2</sup> U.S. Department of Transportation & ICF International. "Transportation Climate Change Sensitivity Matrix." June 2014.

[https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation\\_framework/modules/sensitivity\\_matrix.xlsx](https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/modules/sensitivity_matrix.xlsx)

## Methodology

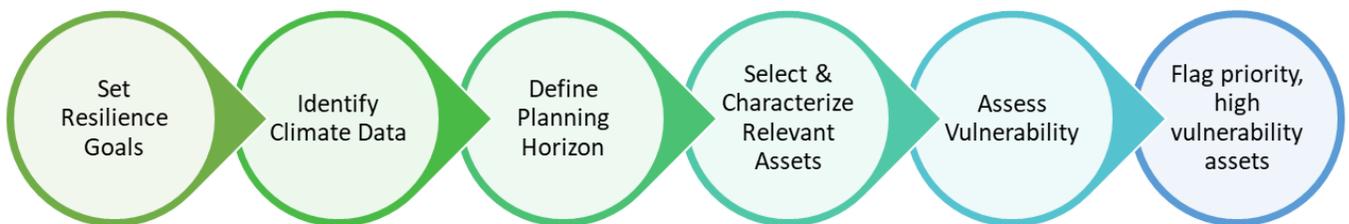
This study was carried out by a “study team” referenced throughout this report: SJCOG Planning Staff, ERG, and a working group of cross-sector stakeholders. The first step of this project focused on collaborating with the working group, which consisted of individuals from city and county government, transportation providers, environmental groups, non-profit organizations, flood managers, and other key organizations. The study team developed project resiliency goals, which helped to define the study scope, focus on tangible outcomes, and prioritize top vulnerabilities. These goals (see text box right) focused the vulnerability assessment on issues and assets related to transit, goods movement, and emergency evacuation.

**Project Resilience Goals:**

- Maintain a **multi-modal transportation** network to deliver people, goods, and emergency services throughout the county, with a focus on vulnerable populations in floodplains and low-income communities with limited bus service.
- Create and maintain **redundancy** in the transportation system to allow for rerouting during disruptions.
- Ensure operation of routes supporting **evacuation**, staging areas, and emergency response

Once project goals were established, the study team embarked on the vulnerability assessment by identifying best available greenhouse gas emissions projections and climate stressor data, establishing the planning horizon, and selecting relevant transportation assets. The team next examined projected impacts of each climate stressor on the region and its critical transportation assets. After investigating vulnerabilities related to each climate stressor, key vulnerabilities were flagged for further investigation. This process is outlined in Figure 1.

**Figure 1. Process for assessing San Joaquin County transportation system vulnerability to climate impacts**



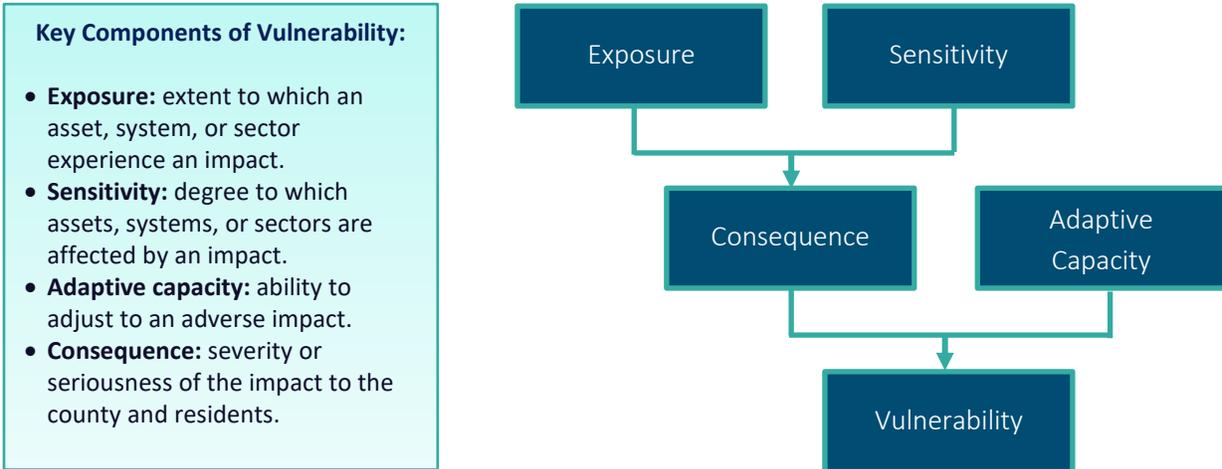
The best available climate projection data (and metrics for measuring impacts and change) identified by the project team for California and the San Joaquin County region is summarized in Table 2 below.

**Table 2. Climate impact data (by stressor) applied in this study and key metric for each dataset.**

Climate stressor	Data source	Metric	Metric explained
<b>Sea level rise</b>	Preliminary outputs of Delta Stewardship Council, Climate Change Vulnerability Assessment (CCVA) and Adaptation Strategy (DSM2 model)	<b>Inundation (yes or no)</b> due to 12 inches and 36 inches of sea level rise from San Francisco Bay (plus a riverine flood event).	Sea level rise exposure maps show how rising water in San Francisco Bay will impact the San Joaquin Delta. The sea level rise maps show land and assets that may be covered by flood waters (though specific depth of flooding is not indicated). The addition of a riverine flood event (from rain or snow melt upstream) shows us combined (riverine-sea level rise) risk.
<b>Fluvial/riverine inflows</b>	FEMA Flood Insurance Rate Maps  Note: This data does not estimate inflows under future climate conditions. It looks at current flood risk and represents best available data at the time of the study.	<b>Located in or out of 100-year and 500-year floodplains</b>	<b>100-year floodplain</b> boundaries have a 1% annual chance of being equaled or exceeded any given year. <b>500-year floodplain</b> boundaries have a .2% annual chance of being equaled or exceeded any given year. A 500-year flood inundates much larger area than a 100-year flood. Though unlikely, either flood category can happen two years in a row.
<b>Extreme precipitation events</b>	EPA's Climate Resilience Evaluation and Awareness Tool (CREAT)	<b>Percent change in rainstorm intensity</b> during a 5-, 10-, 15-, 30-, 50- and 100-year storm	Intensity refers to the amount of rain (measured in depth) that occurs over a period of time (in this case 24 hours).
<b>Wildfire</b>	Westerling, Anthony Leroy. (University of California, Merced). 2018. Applied in California Fourth Climate Assessment.	<b>Annual mean hectares burned by wildfires</b>	In any given year, how many hectares of land are burned by wildfire (on average)?
<b>Extreme Heat</b>	LOCA Downscaled CMIP5 Climate Projection from Scripps <sup>3</sup> . Applied in California Fourth Climate Assessment.	<b>Change in annual extreme heat days</b>	In any given year, how many days is the temperature expected to exceed 101.5°F?

<sup>3</sup> LOCA stands for Localized Constructed Analogs. It is a technique for downscaling climate model projections of the future climate, enabling us to look at finer spatial scales. CMIP5 is the Coupled Model Intercomparison Project 5. It is a collaborative, experimental framework for studying the output of coupled atmosphere-ocean general circulation models.

The working group met three times to provide feedback on the characterization of vulnerable assets and insights on asset function and operations. Armed with this information, the study team investigated asset vulnerability according to key components of vulnerability, defined in the text box below and according to the process, represented in the diagram below:



The working group reviewed the vulnerability assessment in the context of the resilience goals for the project (see Appendix A for detailed methodology and detailed findings). In doing so, the working group identified transportation assets considered the highest priority for adaptation action given their exposure and sensitivity to climate impacts, adaptive capacity, and the consequences of disruption.

The study team reviewed the list of most vulnerable assets and evaluated whether plans and strategies are in place to address some of these vulnerabilities in the future. Opportunities for transportation resilience planning were evaluated within the context of city and county general plans, hazard mitigation plans, and climate action plans (see Appendix B for a complete list). The study team specifically focused on adaptation actions that could be integrated into the RTP and met with SCJOG planning staff to discuss opportunities for integration of this assessment into the next plan.

Draft study findings, recommendations for RTP integration, and next steps for regional resilience planning were reviewed and discussed by a broad range of stakeholders (city, county, and state government, local non-profit organizations, environmental groups, transportation managers, and flood managers) at the Regional Climate Summit in February. The Regional Climate Summit agenda and summary notes can be found in Appendix E. The project team integrated stakeholder feedback into this final document, particularly in the “Next Steps” section.

## Vulnerability Assessment: Key Findings

Based on the process outlined above, the vulnerability assessment focused on the following components of the transportation system:

- Bus routes
- Key supporting services: bus and train maintenance centers and intermodal railyards
- Goods movement connectors: key roads providing first and last-mile connectivity between major trucking routes and businesses
- Access points for transportation-disadvantaged, rural populations
- Access to transit for transportation-disadvantaged, urban populations
- Evacuation routes operating at low level of service: Evacuation routes identified by the Regional Congestion Management Plan Monitoring Report as having traffic level of service (LOS) rating of “deficient”
- Air and deep-water transport: Stockton Airport and Port of Stockton

In assessing the impacts of each climate stressor to these transportation assets, the study team found that several stressors had impacts across a large geographic scale, making it hard to differentiate and pinpoint impacts to individual assets. As a result, vulnerabilities to these stressors are discussed at a system-wide scale for categories of assets. For example, the study discusses the projected 21-25% increase in 100-year storm intensity at mid-century across the entire county and the damage such rain events can cause to pavements, including roadways and runways.<sup>4</sup> Similarly, extreme heat projections indicate that annual extreme heat days (over 101.5°F) in the county may increase from the historical average of 5 days to between 22 and 26 days at mid-century and the assessment discusses the challenges such heat poses to the entire bus system.

There is spatial variation in future wildfire (Figure 2) and sea level rise and riverine flood impacts (Figure 3), and this allowed the study team and working group to identify and prioritize key vulnerabilities in the county. Additional maps for wildfire and flooding can be found in Appendices A and C.

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<sup>4</sup> EPA. (2016). *CREAT 3.0 Methodology Guide*. Available online at [https://www.epa.gov/sites/production/files/2016-05/documents/creat\\_3\\_0\\_methodology\\_guide\\_may\\_2016.pdf](https://www.epa.gov/sites/production/files/2016-05/documents/creat_3_0_methodology_guide_may_2016.pdf).

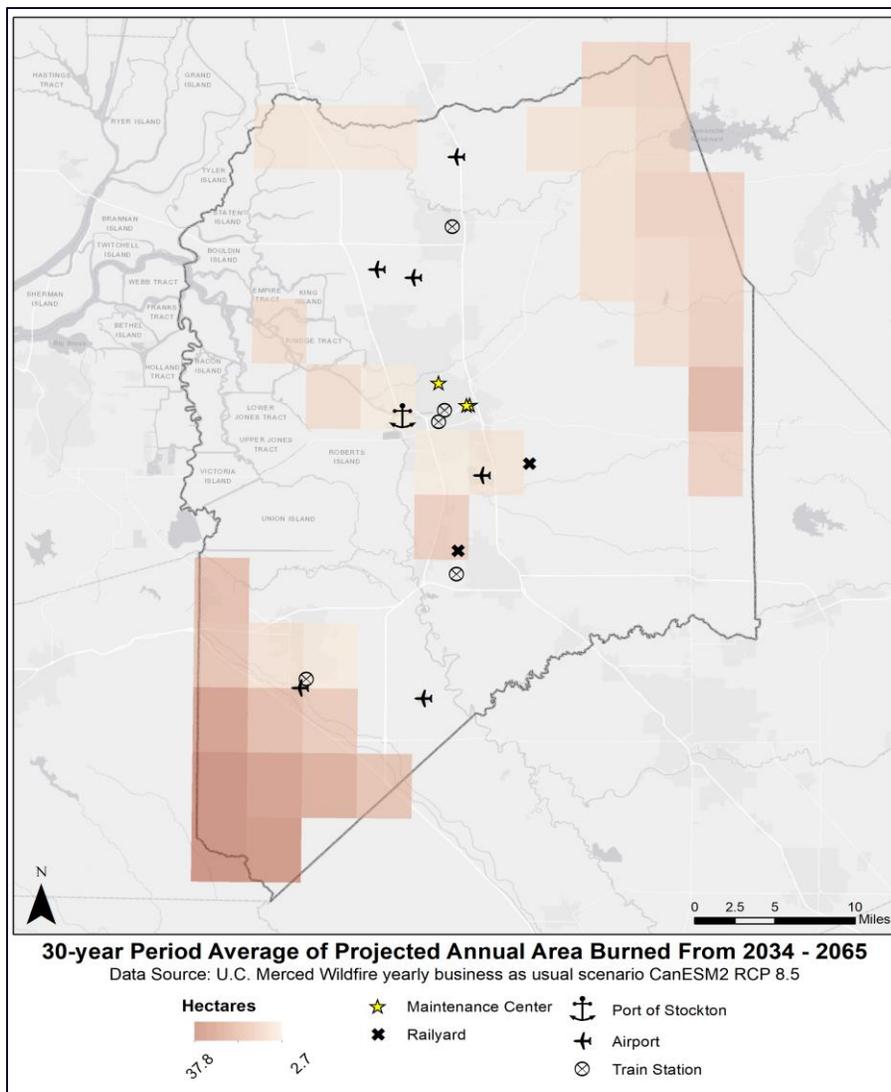


Figure 2. Average annual area burned over a 30-year period (2034-2065). A 30-year period was selected to reflect the time frame selected in Westerling et al. Each of the grid cells mapped below is six by six kilometers.

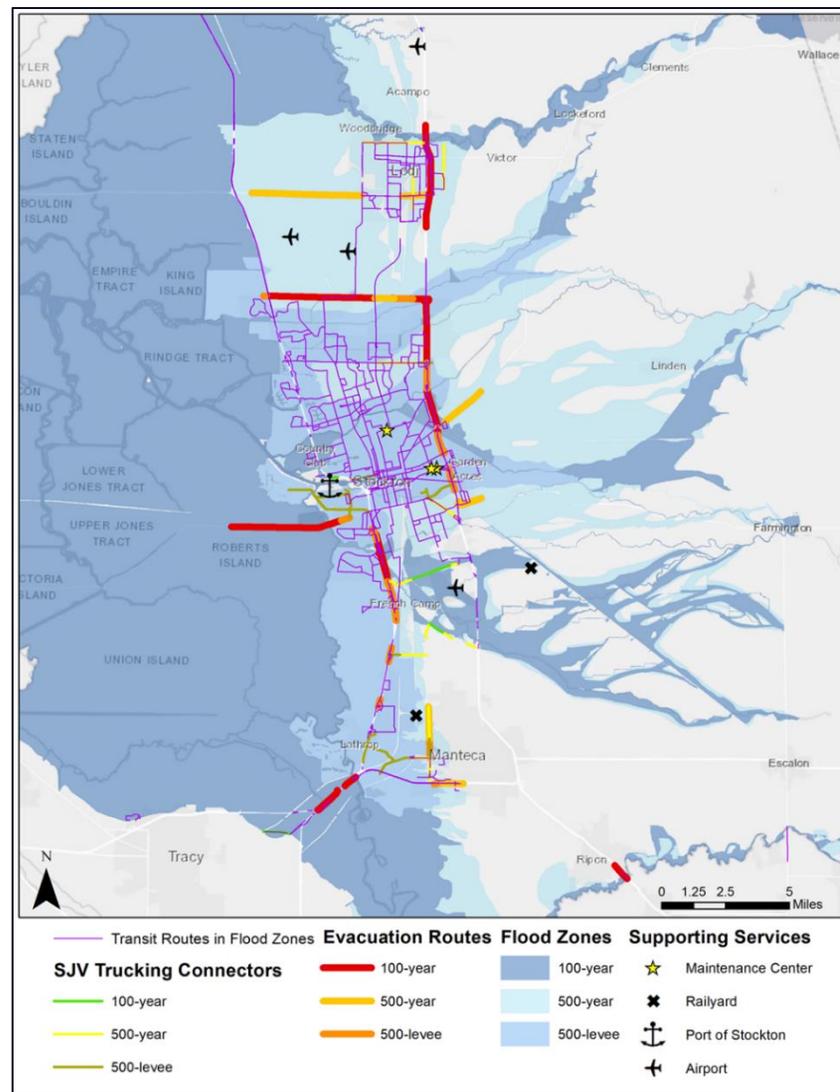


Figure 3. Deficient level of service evacuation routes, first- and last-mile trucking connectors, and main transit routes located in the 100-year and 500-year floodplains. Areas labeled “500-levee” are within the 500-year floodplain and may have some flood protection from levees that are not accredited.

The following assets were flagged as highly vulnerable and in need of priority action:

- **SR-99 through Lodi:** This segment of SR-99 was identified as a priority vulnerability by the working group because it is within the 500-year floodplain and serves key functions for the local community and the region. Flood risk originates from the Mokelumne River, with berms west of SR-99 providing protection from flows slightly greater than the 100-year event.<sup>5</sup> SR-99 includes a bridge that crosses the Mokelumne River (and the 100-year floodplain) in Lodi. This section of the freeway is a bus corridor (connecting Lodi and Stockton) and an evacuation corridor that is already operating at a deficient level of service. The route is already congested during rush hour, so it has the potential to be overwhelmed during an evacuation.

SR-99 is a key connection between Lodi and the Sacramento Region, and Lodi has many residents who commute to the Sacramento Region.<sup>6</sup> Significant disruptions would occur should the route face flooding and/or become overly congested during an evacuation. Although there are alternative (and slightly longer) routes between Lodi and the Sacramento Region (via I-5) and between Lodi and Stockton (via West Lane), effective communication procedures and adequate infrastructure is needed to inform the public of the need to reroute during a flood and/or evacuation.

- **South Stockton Neighborhood:** Major roadways running through the South Stockton neighborhood include S. El Dorado Street, S. Airport Way, and S. Wilson Way, all of which run North-South. SR-99 forms the eastern edge of the neighborhood, with I-5 forming the western edge of the neighborhood. East Charter Way and SR-4 run East-West through the neighborhood with SR-4 forming the northern boundary.<sup>7</sup>

Impacts to the transit system are a major concern for this neighborhood, which has a disproportionately high percentage of transportation-disadvantaged communities compared to the county as a whole. Several bus stops are within the 100-year floodplain and dozens are in the 500-year floodplain. While bus rerouting is likely an option in the event of an interruption, all changes must be effectively communicated to passengers. Bus and train stops in these transit-dependent neighborhoods also need to accommodate passengers' needs for protection from heat and rain as weather events become more extreme.

The Union Pacific Railroad Stockton Railyard is a support facility for railroad operations located within the neighborhood. Although the railyard is an area of "undetermined flood hazard" according to FEMA, it is immediately surrounded by 500-year floodplain. The railyard includes a locomotive service track, a locomotive maintenance shop, a freight car repair shop, a wastewater treatment plant, maintenance buildings and storage areas, and facilities supporting railroad operations. The Altamont Commuter

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<sup>5</sup> City of Lodi. General Plan (2010): Safety Element. <https://www.lodi.gov/DocumentCenter/View/196/Chapter-8---Safety-PDF>

<sup>6</sup> SJCOG. RTP/SCS (2018): Appendix M1 Plan Performance <https://www.sjocog.org/DocumentCenter/View/3803/Final-2018-RTPSCS-Technical-Appendix-M---Plan-Performance-and-Regional-Progress-Report?bidId=>

<sup>7</sup> City of Stockton. General Plan Update (2014). <http://www.stocktongov.com/files/StocktonNeighborhoodsMap.pdf>

Express (ACE) commuter rail uses a portion of the yard to service its trains.<sup>8</sup> Flooding of tracks and maintenance facilities could have broader system-wide impacts and create access issues for workers. In addition, any flooding of the area raises concerns about movement of any hazardous materials used or stored at the facilities.

- **Stockton Metropolitan Airport:** The Stockton Airport is playing an increasingly important role in the region, due to growth in passenger flights, new airlines and flights and growth in cargo transport. Total cargo weight jumped more than 80% in 2017 and then fell by 19% in 2018 (these values are not yet available for 2019).<sup>9</sup> Growth in cargo transport is driven in part by growth of warehouse and logistics jobs in the County, with an Amazon fulfillment center located at the airport. Amazon is now one of the major employers in the County.<sup>10</sup> Airport runways are located within the 100-year floodplain. Since timely delivery is important to logistics and Amazon's business, interruptions due to flooding pose a serious economic risk. Wildfire and extreme heat could also impact business operations and perhaps limit future employment opportunities. Wildfire and smoke-related visibility impacts are of concern given that the airport lies in a location projected to have a minor increase in average annual area burned at mid-century. Increased flood protection infrastructure will likely be needed to address flood risk as well as contingency plans (e.g. shifting flights to cooler hours during a heat wave) to address extreme heat impacts.

The 2018 RTP includes over a dozen airport projects, including runway rehabilitation, taxiway reconstruction, and terminal expansion and modernization.<sup>11</sup> The latter project is included on the list of projects under SJCOG's One Voice Program, a legislative advocacy program for the County that promotes issues of regional significance to federal legislators and agencies in Washington, D.C.<sup>12</sup> As federal, state, and private funds are invested in these projects, there will be opportunities to integrate resilient designs to support the longevity of the projects, regional economy, and surrounding communities and ecosystems under a changing climate.

The Stockton Airport also provides military and emergency service functions, including hosting ground and aviation activities of the California Army National Guard.<sup>13</sup> Given that the National Guard provides important services domestically and abroad, interruption of their activities is problematic. Additional research is needed to determine how easily they can adapt their facility or relocate to meet their needs.

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<sup>8</sup> California Air Resources Board. "Health Risk Assessment of the Union Pacific Railroad Stockton Railyard." 2007. [https://ww3.arb.ca.gov/railyard/hra/up\\_stockton\\_hra.pdf?\\_ga=2.259367374.574678899.1579126071-599391694.1537899981](https://ww3.arb.ca.gov/railyard/hra/up_stockton_hra.pdf?_ga=2.259367374.574678899.1579126071-599391694.1537899981)

<sup>9</sup> Federal Aviation Administration. "CY 2018 Final All-Cargo Landed Weights" [https://www.faa.gov/airports/planning\\_capacity/passenger\\_allcargo\\_stats/passenger/media/cy18-cargo-airports.pdf](https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy18-cargo-airports.pdf)

<sup>10</sup> California Employment Development Department. "Major Employers in San Joaquin County." 2020. <https://www.labormarketinfo.edd.ca.gov/majorer/countymajorer.asp?CountyCode=000077>

<sup>11</sup> SJCOG. RTP/SCS (2018): Appendix F: Plan Project List <https://www.sjcog.org/DocumentCenter/View/3716/Final-2018-RTPSCS-Technical-Appendix-F---Plan-Project-List?bidId=>

<sup>12</sup> SJCOG. "2019 One Voice Project List" <https://www.sjcog.org/DocumentCenter/View/4728/2019-Project-Summary-List>

<sup>13</sup> SJCOG. "Stockton Metropolitan Airport Master Plan (2009)" <https://www.sigov.org/WorkArea/DownloadAsset.aspx?id=10378>

- **Stockton Wye:** Stockton Wye is where tracks cross between the North-South Union Pacific Fresno Subdivision and the East-West BNSF Stockton Subdivision. New projects are moving forward to extend Northwest Wye tracks to allow direct movement of Union Pacific (UP) freight trains to and from the Port of Stockton without crossing the BNSF diamond to avoid delays and congestion for freight trains and grade crossings. This will support lower operating costs for trains serving the Port of Stockton. The Wye is currently mapped in the 500- year floodplain in an area with levees that may offer some level of flood protection, although the levees are not accredited for 500-year protection. Any disruption to this key intersection in the rail system would have significant impacts to goods movement from the port and across the system.<sup>14</sup> The planned changes to the Wye may limit disruptions by creating additional connectivity and potentially prevent a single failure from delaying both UP and BNSF trains. It is important for train operators and the port to have repair and backup systems in place in the event of any disruption across their system and to prioritize repairs and protection action at critical points, such as the Wye.

Train operators can help the Wye and train system adapt to heat impacts by implementing a range of practices such as monitoring for extreme heat, slowing trains, and adjusting outdoor work schedules.

- **SR-4 from Stockton west to Contra Costa County.** Carrying approximately 10,000 vehicles per day (11 percent of which are trucks as of 2017), the route plays an important role in economic development; commuter, agriculture, and goods movement; and recreation access to the San Joaquin Delta. This road also plays an important role in evacuation from the San Joaquin Delta in the event of flooding, such as the breach of the Upper Jones Tract that occurred in 2004.<sup>15</sup>

This evacuation route is operating at a deficient level of service and runs through the 100-year floodplain. In addition, it transects tracts that are projected to be flooded under one foot of sea level rise (plus storm) scenario. It is important to reduce flood risk along this roadway because it serves a rural area with few alternative access points. The rural tract it connects to at the western edge of the county has a relatively low population (less than 1,500 people). The tract has eight access points in total, seven of which are in the 100-year floodplain.

SJCOG is promoting the SR-4 Corridor Improvement Project to expand lanes and safety of SR-4, which is the major road traversing the County.<sup>16</sup> Flood adaptation measures could be further integrated into the project.

- **BNSF Intermodal Railyard, Stockton.** The facility lifts approximately 300,000 container units annually and serves as a major network hub between Northern California and the Midwest. Interruptions to the facility would have major economic consequences. There are additional plans to expand the capacity of

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<sup>14</sup> SJCOG. "2017 One Voice Project: Stockton Freight & Passenger Rail Mobility Enhancement" <https://sjcog.org/DocumentCenter/View/612/San-Joaquin-Regional-Rail-Commission?bidId=>

<sup>15</sup> SJCOG. "2017 One Voice Project: SR 4 Corridor Improvements" <https://www.sjcog.org/DocumentCenter/View/580/San-Joaquin-County-?bidId=>

<sup>16</sup> Ibid.

the facility. Future expansion and investment could provide opportunities to address flooding from its location in the 100-year floodplain.

The working group and study team also identified an additional set of vulnerable assets for adaptation action:

- **Port of Stockton.** The Port is a key center of multi-modal logistics in the county and includes warehouse space, serves 130 tenants, has 700 acres for development, and represents over 5,000 jobs.<sup>17</sup> While the Port generally has 100-year flood protection, some of its access roads do not. In addition, it does not have accredited 500-year flood protection.
- **I-5 between Tracy and Lathrop.** This route operates at a deficient level of service but plays a key evacuation function and is heavily used by the bus system, serving more than five bus lines. This segment of I-5 is located within the 100-year floodplain.
- **Waterloo Road/CA-88.** This evacuation route originates in the 100-year floodplain and then moves east into the 500-year floodplain that serves the City of Stockton as well as residents of the Waterloo area. The rural and large elderly demographics in the Waterloo area must be accounted for in evacuation planning for this area. The Waterloo community consists of over 25% individuals aged 65 and above.<sup>18</sup>
- **Bus stops serving transit-dependent census tracts in downtown Stockton, the Hammer Triangle area, and the Harrell Park area.** Approximately two dozen of these bus stops are in the 100-year floodplain, with several dozen located in the 500-year floodplain. Since the City of Stockton has the highest percentage of households without cars of all cities and census designated places in the county (10%), the protection of the bus system is essential. This is especially important as the region seeks to improve transit and reduce single passenger car trips.

The list of assets above are priority vulnerabilities identified by the working group and study team to provide a starting point to direct adaptation planning in the region. Some of the vulnerabilities can be addressed through asset-specific infrastructure investments (often requiring a combination of local, state, and federal investment and collaboration) and others can be addressed through major levee improvements by municipalities and reclamation districts. Other assets may require cities or the county to revisit their evacuation procedures. Specific adaptation actions to address these vulnerabilities will be developed in a follow-up study led by SJCOG.

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<sup>17</sup> San Joaquin County 2019 – 2024 Comprehensive Economic Development Strategy  
[http://www.sjworknet.org/eda\\_docs/images/CEDS%20Cover\\_2019-2024\\_Web.pdf](http://www.sjworknet.org/eda_docs/images/CEDS%20Cover_2019-2024_Web.pdf)

<sup>18</sup> 2018 Regional Transportation Plan/ Sustainable Communities Strategy. Draft EIR.  
<https://www.sicog.org/DocumentCenter/View/3878/2018-RTP-SCS-PDEIR---Full?bidId=>

## Gaps and Recommendations

The study team reviewed the complete vulnerability assessment (Appendix A) within the context of existing adaptation planning efforts in the county (Appendix D) to identify key planning gaps and recommendations for filling them. The key gaps and recommendations are as follows:

- **Focus on climate impacts to the transit system.** The city climate action plans (CAPs) and general plans across the county include strong commitments to expand and improve the quality of transit to get people out of cars and reduce transportation-related greenhouse gas (GHG) emissions. While most city and county hazard mitigation plans, CAPs, and related planning documents discuss climate hazards, they do not address concerns specific to the transit system. Such transit concerns include, steps to keep passengers comfortable and safe while waiting for the bus during extreme heat, major rain or during a wildfire smoke event, or keeping them informed of delays/rerouting due to roads flooding. These issues are especially important in the City of Stockton where the highest percentage of the population does not have a car (10%)<sup>19</sup> and much of the city is located within the 500-year floodplain.<sup>20</sup> San Joaquin County Office of Emergency Services already has a memorandum of understanding with San Joaquin Regional Transit District and other transportation providers to assist with evacuation during an emergency.

This coordination between the county, SJCOG, cities and transit providers can expand to address these gaps and integrate other aspects of resiliency into the transit system.

- **Integrate climate resilience into all road improvement projects.** Cities, the county, and regional government have identified priority road improvement projects, such as improving interchanges and increasing the number of lanes to relieve congestion. These projects will be subjected to changing climate conditions in the course of their lifespan. Some of those routes have been identified in this assessment. For example, SJCOG and its partners have identified a project to expand traffic capacity of the SR-4 corridor linking San Joaquin and Contra Costa counties as a priority funding request.<sup>21</sup> The main focus of the project is expanding the roadway from two to four lanes for increased capacity and safety, however, climate adaptation measures could be considered, such as pavement type to address temperature swings and permeability, or future flood adaptation since this road crosses the San Joaquin Delta.
- **Plan for Public Safety Power Shut Offs (PSPSs).** PSPSs are not currently well integrated into hazard and emergency planning procedures in California, including within San Joaquin County. Review of wildfire projections indicate that wildfire, and thus PSPS risk, is not expected to grow in San Joaquin

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<sup>19</sup> 2018 Regional Transportation Plan/ Sustainable Communities Strategy. Draft EIR.

<https://www.sjocog.org/DocumentCenter/View/3878/2018-RTP-SCS-PDEIR---Full?bidId=>

<sup>20</sup> With potential protection from unaccredited levees—see maps in Appendix A.

<sup>21</sup> SJCOG. “2017 One Voice Project: SR 4 Corridor Improvements.” <https://www.sjocog.org/DocumentCenter/View/580/San-Joaquin-County-?bidId=>

County as it is in many parts of the state. However, San Joaquin County is not immune to wildfire risk, as evidenced in Vernalis in October 2019.<sup>22</sup>

From the perspective of transportation, planning for PSPSs must focus on public safety (e.g. backup power for traffic lights and railroad crossings) and maintaining cellular service. Many jurisdictions' plans for communication with residents about emergency response and evacuation rely on cellular service, which can fail without backup power supply. In the event of an extended PSPS, there must also be plans in place to address the challenge of charging the region's growing fleet of electric buses.

## Integrating Transportation Resilience into the Regional Transportation Plan (RTP)

Transportation resilience requires the work of many: cities, the county, transportation providers, flood managers who implement major levee improvements, and SJCOG. The RTP is a key tool for collaborative planning. The study team and a broader group of SJCOG staff collaborated to develop a range of options for integrating transportation resilience into the RTP.

- 1) **Use climate projections to define future scenarios in the RTP.** The RTP process is designed to evaluate issues of equity, economy, and environment based on projections of future housing development, population change, and commuting patterns (among other factors). Climate impacts could be integrated into some of these projections of future change, potentially altering how all proposals for major transportation investments are evaluated.
- 2) **Use indicators of criticality and vulnerability to assess all projects.** SJCOG can develop a simplified set of indicators and a basic project ranking system by drawing on the criticality criteria (see Appendix A "Conduct Criticality Assessment") and exposure to flood or wildfire risk from this study. The indicators can be applied following similar methods to the SCS Implementation Health Indicators Project to ensure consistency across SJCOG projects. This indicator-based system ensures that all projects going through the RTP process are evaluated in terms of their climate vulnerability and includes this variable when developing the final project list.
- 3) **Review priority assets from the vulnerability assessment and add them to the RTP project list.** This approach simply joins the vulnerability assessment findings directly into the RTP process by ensuring that adaptation strategies are developed for priority assets and then added to the RTP list.

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<sup>22</sup> CBS Local. "Stockton, Tracy, West Sacramento Listed On PG&E Shutoff Map By Mistake." October 9, 2019. <https://sacramento.cbslocal.com/2019/10/09/stockton-tracy-west-sacramento-farmington-pge-outage-mistake/>

## Next Steps

SJCOG is preparing to launch the next phase of its resilience work through a project called “Regional Resiliency Implementation Plan and Adaptation Guidance” project. This next phase will provide specific solutions to the risks and vulnerabilities identified in this study. Objectives of this next phase of work include:

- Carry forward the data, vulnerability assessment, and implementation recommendations of phase one study (captured in this report) to create a shared understanding between local, regional, and state agencies of adaptation planning needs in San Joaquin County
- Provide a focus on disadvantaged communities to ensure their needs are met and prioritized
- Provide a variety of tools for local and regional adaptation efforts to both ensure consistent approaches and methods for project development, but also recognize that communities will have different needs and capacity
- Strengthen existing collaboration and partnerships around climate impacts – and bring in new state and community partners as appropriate
- Expand SJCOG’s role as a source of technical assistance and up-to-date information, guidance, and leadership for county-wide integration of resilience for member agencies, stakeholders, and the public
- Ensure local jurisdictions and other partners are equipped with the technical tools needed to consider expected climate impacts on transportation infrastructure

Participants at the February 2020 Regional Climate Summit provided key input that will enable SJCOG to launch the next phase of work. For example, participants provided suggestions for what kinds of tools and technical assistance local governments, member agencies, and stakeholders need to support their resilience planning efforts. SJCOG can design their next program of work to address some of the needs expressed, which included the following:

- **Geospatial data from climate vulnerabilities assessments in an easy-to-use format.** Local governments and other stakeholders who do not have resources to carry out their own vulnerability assessments need to work with the data produced by partners.
- **Data and metrics sharing.** Stakeholders need help understanding what information is already available and how to access it.
- **Framework for identifying regional resilience priorities.** The Regional Shoreline Assessment Strategy Project (in process) being led by the San Francisco Bay Conservation and Development Commission (BCDC) to identify principles and priorities for Bay shoreline adaptation was identified as a potential model to follow.
- **New outreach and education methods.** There is a significant learning curve for everyone to understand climate projections and impacts. Different stakeholders will require different communication methods to engage in regional and community planning. Targeted outreach and education efforts and tools require resources, and SJCOG can provide support. As a starting point, SJCOG can look to the recently finalized “Caltrans Climate Change Communication Guide” which provides suggestions for reaching different audiences, especially on issues related to transportation.

Participants also provided valuable recommendations on addressing the needs of disadvantaged communities. Recommendations included:

- Conduct outreach and capacity building in disadvantaged communities through community-based organizations.
- Build trust and relationships through strategic engagements, while being mindful of planning fatigue.
- Hold in-person outreach and events during non-working hours and when possible, meet people where they are.
- Focus on improved transit and on-demand transit.
- Settle on a common language for resilience planning that everyone can understand.

As SJCOG works to integrate these recommendations into its resilience work moving forward, it is important that the staff continue to stay abreast of important concurrent resilience studies and efforts by partner agencies. For example, Caltrans District 10 has just released its Climate Change Vulnerability Assessment and is in midst of drafting an adaptation plan that will establish priority adaptation projects. Similarly, the Delta Stewardship Council is in the midst of a robust Climate Vulnerability Assessment and Adaptation Planning process. SJCOG will continue to be involved in establishing adaptation priorities with the Caltrans and Delta Stewardship Council processes and will integrate this work into its own regional priority setting moving forward.

# Appendix A: Detailed Vulnerability Assessment Report

## Introduction

The San Joaquin Council of Governments (SJCOG) Climate Adaptation and Resiliency Study is a year-long effort that began in March of 2019 to improve the resiliency and increase the reliability of our transportation system in accordance with RTP (Regional Transportation Plan) guidelines. A key component of the study is a climate vulnerability assessment of the transportation system. The vulnerability assessment considers impacts of changing precipitation patterns, flooding, extreme heat, drought, and wildfires. This assessment focuses on climate impacts to county and local roads, the Port of Stockton, airports, trains, and buses. The assessment and study were carried out by a “study team” referenced throughout this report: SJCOG Planning Staff, Eastern Research Group, Inc. (ERG), and a working group of cross-sector stakeholders.

Serving as the drainage basin for the San Joaquin River and its many tributaries, San Joaquin County faces increasing flood risk due to climate impacts. The frequency and size of extreme precipitation events are expected to increase, and rising sea levels are predicted to continue moving up into the San Joaquin Delta. More intense and frequent heat waves and drought are also predicted. Although climate projections indicate that the area burned by extreme fire events may remain steady or decline slightly in San Joaquin County to mid-century, wildfire risk continues to be an issue and our understanding of wildfire projections continues to evolve.<sup>23</sup>

The following table provides a summary of climate stressors, including extreme weather conditions, and their impacts on transportation assets:<sup>24 25</sup>

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<sup>23</sup> Westerling, Anthony Leroy. (University of California, Merced). 2018. Wildfire Simulations for California’s Fourth Climate Change Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate. California’s Fourth Climate Change Assessment, California Energy Commission. Publication Number: CCCA4-CEC-2018- 014.

<sup>24</sup> U.S. Department of Transportation & ICF International. “Transportation Climate Change Sensitivity Matrix.” June 2014. [https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation\\_framework/modules/sensitivity\\_matrix.xlsm](https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/modules/sensitivity_matrix.xlsm)

<sup>25</sup> McGuirk, M., Shuford, S., Peterson, T.C., and Pisano, P. (World Meteorological Organization). 2009. “Weather and Climate Change Implications for Surface Transportation in the USA.” <https://public.wmo.int/en/bulletin/weather-and-climate-change-implications-surface-transportation-usa>

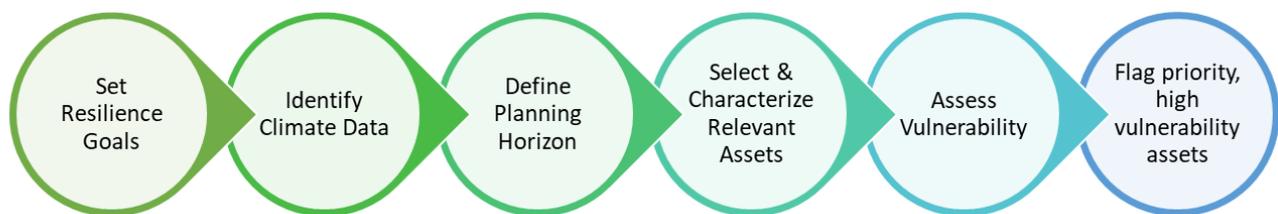
**Appendix A, Table 1. Impacts of climate stressors on transportation assets.**

	<b>Flooding (riverine, Extreme precipitation, sea level rise)</b>	<b>Extreme Temperature</b>	<b>Wildfire</b>	<b>Drought</b>
<b>Roads</b>	Asphalt stripping, washouts, subbase erosion, route closures, delays	Asphalt-concrete cracking	Rutting/softening, closures, need for safe evacuation routes	Shrinking of ground below asphalt can cause pavement to crack
<b>Rail</b>	Substructure erosion, inundation, forced delays	Track buckling, forced slower speeds and delays, derailments	Blocked routes, forced delays	Runoff, leaching, slope instability, load bearing capacity, track stability and visibility
<b>Buses</b>	Delays and route changes	Transit vehicles overheating, decreased comfort for passengers	Route closures, delays	--
<b>Airports</b>	Damage to runways, delays	Flight delays—planes cannot take off in extreme heat	Damage to infrastructure, delays due to poor visibility and worker safety (wildfire smoke)	Stress on water supply for cooling energy powers, irrigation, pavement power washing
<b>Port</b>	Flooding of electrical equipment and bottom of cranes	Deterioration of pavement for storage cargo	Worker safety (wildfire smoke)	Challenges accessing fixed docks with water level fluctuation

## Methods

The first step of this project focused on scoping project goals. Once project goals were established, the study team identified the best available greenhouse gas (GHG) emissions projections and climate stressor data, established the planning horizon, and selected relevant transportation assets. The team next examined projected impacts of each climate stressor on the county’s transportation assets. After investigating vulnerabilities related to each climate stressor, key vulnerabilities were flagged for further investigation. This process is outlined in Appendix A, Figure 1.

**Appendix A, Figure 1. Process for assessing San Joaquin County transportation system vulnerability to climate impacts**



Each step of this process is discussed in the following pages.

## A. Set Resilience Goals

SJCOG collaborated with the working group to develop a set of resilience goals. The resilience goals helped to define a manageable study scope, focus on tangible outcomes, and develop prioritized adaptation actions. The working group defined goals for a resilient regional transportation system as follows:

- Maintain a multi-modal transportation network to deliver people, goods, and emergency services throughout the county, with a focus on vulnerable populations in floodplains and low-income communities with limited bus service.
- Create and maintain redundancy in the transportation system to allow for rerouting during disruptions.
- Ensure operation of routes supporting evacuation, staging areas, and emergency response.

These goals were used to define criteria to identify a subset of critical assets to be the focus of this study. The criteria are described further below.

## B. Identify Climate Data and Emission Scenarios

This SJCOG study draws primarily on climate data sets developed and applied in California's Fourth Climate Change Assessment. The Fourth Assessment is designed to directly inform state policies, plans, programs, and guidance to promote climate resiliency. The assessment was led by the California Energy Commission and supported by the Department of Water Resource, Natural Resources Agency, academic research institutions such as Scripps Institution of Oceanography, and many other collaborators.

In order to understand future climate impacts in California, researchers downscaled global climate models to the regional scale for several climate stressors through a technique called Localized Constructed Analogs (LOCA). LOCA is a statistical technique that uses historical data to add fine-scale detail to global climate models. State agencies helped select downscaled models that are most relevant to California. Where Fourth Assessment data could not be readily processed and applied to the county scale, alternative data sources were applied (at a consistent temporal and spatial scale).

Running the global climate models showing how the environment will respond to a warmer climate (and then downscaling the models) requires a set of assumptions about greenhouse gas (GHG) emissions scenarios into the future. The range of paths the global community may take to change future GHG emissions and their atmospheric concentrations is standardized by the Intergovernmental Panel on Climate Change (IPCC) and known as representative concentration pathways (RCPs). In accordance with Fourth California Climate Change Assessment, this SJCOG study will consider two of the four RCPs:

- RCP 4.5 assumes that GHG emissions peak around 2040 and then begin to decline. It is considered a moderate rate of emissions reductions and is insufficient to achieve Paris Agreement targets.
- RCP 8.5 assumes a business as usual scenario of high emissions to end of century.<sup>26</sup>

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<sup>26</sup> Intergovernmental Panel on Climate Change (IPCC). Fifth Assessment Report. Summary for Policy Makers. 2014. [https://ar5-syr.ipcc.ch/topic\\_summary.php](https://ar5-syr.ipcc.ch/topic_summary.php)

These two RCPs are being commonly applied by a range of state natural resources and planning agencies (e.g. Ocean Protection Council, Governor’s Office of Planning and Research) to acknowledge the uncertainty involved in predicting how rapidly the global community will cut GHG emissions. While this study will consider these two RCPs, it should be noted that adaptation planning guidance from the California Governor’s Office of Research and Planning recommends that assessments evaluating climate impacts before the year 2050 should apply RCP 8.5 since the difference between RCPs is limited for the first half of the century and current emissions are trending with RCP 8.5.<sup>27</sup> As this assessment is focused on a planning horizon of 2050, it will identify any divergence between RCPs 4.5 and 8.5 (where data is available) but focuses more heavily on RCP 8.5 per this guidance from the Office of Planning and Research.

### C. Determine Planning Horizon

This assessment focuses on projected climate impacts to the year 2050 in order to approximately align with the timeline for SJCOG’s next Regional Transportation Plan (RTP) Update. The next RTP update is expected in 2022 and will commit the region to a set of transportation improvements over the next 25 years (to approximately 2047). Our study team rounded up from 2047 to 2050 for ease of analysis and data availability. Assessing risks that climate stressors pose to transportation assets along a parallel timeline allows SJCOG, county, and local leadership and stakeholders the opportunity to shape resilience planning and RTP investment plans.

### D. Select Relevant Assets

Identifying a subset of transportation assets specific to the resilience goals keeps the scope of the assessment manageable and ensures that there is adequate time and resources available to investigate key assets. This study applies the following factors to select assets:

- a. *Geography*: San Joaquin County.
- b. *Jurisdiction*: This study is focused on assets that are owned and maintained by cities and the county, primarily entities other than Caltrans. The study team made this choice because Caltrans is concurrently conducting a climate vulnerability assessment of its own assets across the county and there was no need to repeat the analysis. In the maps that follow, Caltrans assets are displayed when necessary for clarity or when Caltrans assets have been designated by the county, cities, and others to serve some of the critical services described below (e.g. evacuation and bus routes).
- c. *Criticality*: The most critical elements of the transportation system were identified in collaboration with the working group by flagging a set of characteristics that reflect the project resilience goals and accordingly, the defining characteristics of a resilient transportation system. The criteria applied are as follows:
  - i. Bus route density
  - ii. Key supporting services
  - iii. Goods movement connectors
  - iv. Access points for transportation-disadvantaged, rural populations
  - v. Access to transit for transportation-disadvantaged, urban populations

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<sup>27</sup> Governor’s Office of Research and Planning. “Planning and Investing for a Resilient California: A Guidebook for State Agencies.” 2018. [http://opr.ca.gov/docs/20180313-Building\\_a\\_Resilient\\_CA.pdf](http://opr.ca.gov/docs/20180313-Building_a_Resilient_CA.pdf)

- vi. Evacuation routes operating at low level of service
- vii. Air and deep-water transport

Identification of key transportation elements based on these characteristics necessitated a criticality assessment, which is explained below.

## E. Conduct Criticality Assessment

A criticality assessment provides a structured way to focus on assets most important to the functioning of a resilient transportation system, as defined by our project resilient goals. The criticality criteria were shaped by best-available, county-scale qualitative and quantitative data. GIS data used in this analysis are listed in Appendix B. A description and rationale for each criterion are presented here (with accompanying figures below):

*Bus route density.* This criterion is defined by roads that are heavily used by several bus lines, as mapped below. Specifically, the study team overlaid the routes within the Regional Transit District, Ripon Blossom Express, Tracy, Escalon, Manteca, and Lodi bus systems to identify roads that are utilized by several lines. Bus routes were considered whether they use local or Caltrans-managed roads. These high-density bus lines are highlighted because there could be systems-wide impacts should a hazard, such as flooding, directly impact those roads. These roads are mapped on Appendix A, Figure 2 below.

*Key supporting services.* This criterion is defined by bus and train maintenance centers and intermodal railyards, which provide supporting services without which the bus and train systems in the county cannot function. The following supporting sites are mapped on Appendix A, Figure 3 below:

1. Altamont Corridor Express Service Facility
2. Regional Transportation Center (Maintenance and Operations)
3. County Transportation Center (Maintenance and Operations)
4. BNSF Railyard, Stockton
5. Union Pacific (UP) Intermodal Terminal, Lathrop

*Goods movement connectors.* This criterion focuses on key roads providing first and last-mile connectivity between major trucking routes and businesses. Businesses are defined as freight generators and receivers, such as warehousing and manufacturing land uses; wholesale or retail clusters; and industrial, logging, mining, and other resources extraction and processing. These connectors are identified in the San Joaquin Valley Goods Movement Sustainable Implementation Plan.<sup>28</sup> Goods movement connectors are mapped on Appendix A, Figure 4 and clearly highlight connectors surrounding urban areas of the county.

*Access points for transportation-disadvantaged, rural populations.* This criterion identifies rural tracts in the county with transportation-disadvantaged residents. It then flags those tracts with a limited number of access

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<sup>28</sup> The San Joaquin Valley Goods Movement Sustainable Implementation Plan. 2017. [http://sjvcogs.org/wp-content/uploads/2017/10/ExSumm\\_SJV\\_GoodsMovement\\_AUG17.pdf](http://sjvcogs.org/wp-content/uploads/2017/10/ExSumm_SJV_GoodsMovement_AUG17.pdf)

points, since those limited access points must be available in the event of a hazard. Transportation disadvantaged communities are defined according to the Regional Transportation Plan definition of block groups with higher than the county average of the following characteristics: Senior population; limited English; zero-vehicle household; and single-parent household. This data was applied to the tract level; road access points were assessed to identify tracts with limited access points (as visualized in Appendix A, Figure 5-6). Access points were considered whether they use local or Caltrans managed roads.

*Access to transit for transportation-disadvantaged, urban populations.* This criterion identifies urban tracts in the county with transportation-disadvantaged residents, following the same method as above. The study team identified those transportation disadvantaged tracts (with higher than the county average of the four criteria) as well as a limited number of transit points (bus and train stops within a half mile of the tract). In these tracts, the existing transportation access must be usable in the event of a hazard (See Appendix A, Figure 7).

*Evacuation routes operating at low level of service.* This criterion draws on a combined set of neighborhood-level evacuation maps developed by San Joaquin County Community Development Department. The maps indicate routes the public should use to leave the area in the event of an evacuation. The study team overlaid these maps with traffic level of service (LOS) ratings from Regional Congestion Management Plan Monitoring Report which provides the traffic LOS rating from A to F.<sup>29</sup> E or F ratings are classified as “deficient” meaning the roadway is at or exceeding its designed capacity. PM (afternoon) LOS is mapped per the industry practice as afternoon commutes tend to be more congested. Evacuation routes with E or F ratings were identified (see Appendix A, Figure 8) as they are likely to be heavily used during an evacuation if they are already heavily used on a day to day basis. The routes must be resilient to climate impacts in order to maintain an effective evacuation system.

*Transport via deep-water port and air.* The Port of Stockton and Stockton Airport are critical to movement of goods and people within and in and out of the county. These two assets are included on all maps of the county throughout this report given that they are important landmarks. The Port of Stockton is critical a major inland deep-water port in the San Joaquin Delta and the only water port in the county. In 2018, the port handled 4.7 million metric tons of cargo.<sup>30</sup> The Stockton Airport also has an important role in goods movement, with approximately 270 million pounds of landed cargo weight last year, in addition to nearly 100,000 passengers.<sup>31</sup> Though there are five additional public access airports in the county, they move a fraction of the volume of cargo and number of people each year.<sup>32</sup>

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<sup>29</sup> SJCOG. Regional Congestion Management Program. 2019 Monitoring and Conformance Report.

[http://www.sjog.org/DocumentCenter/View/4817/FINAL\\_WEBSITE\\_SJCOG\\_2019\\_RCMP\\_Monitoring\\_Report](http://www.sjog.org/DocumentCenter/View/4817/FINAL_WEBSITE_SJCOG_2019_RCMP_Monitoring_Report)

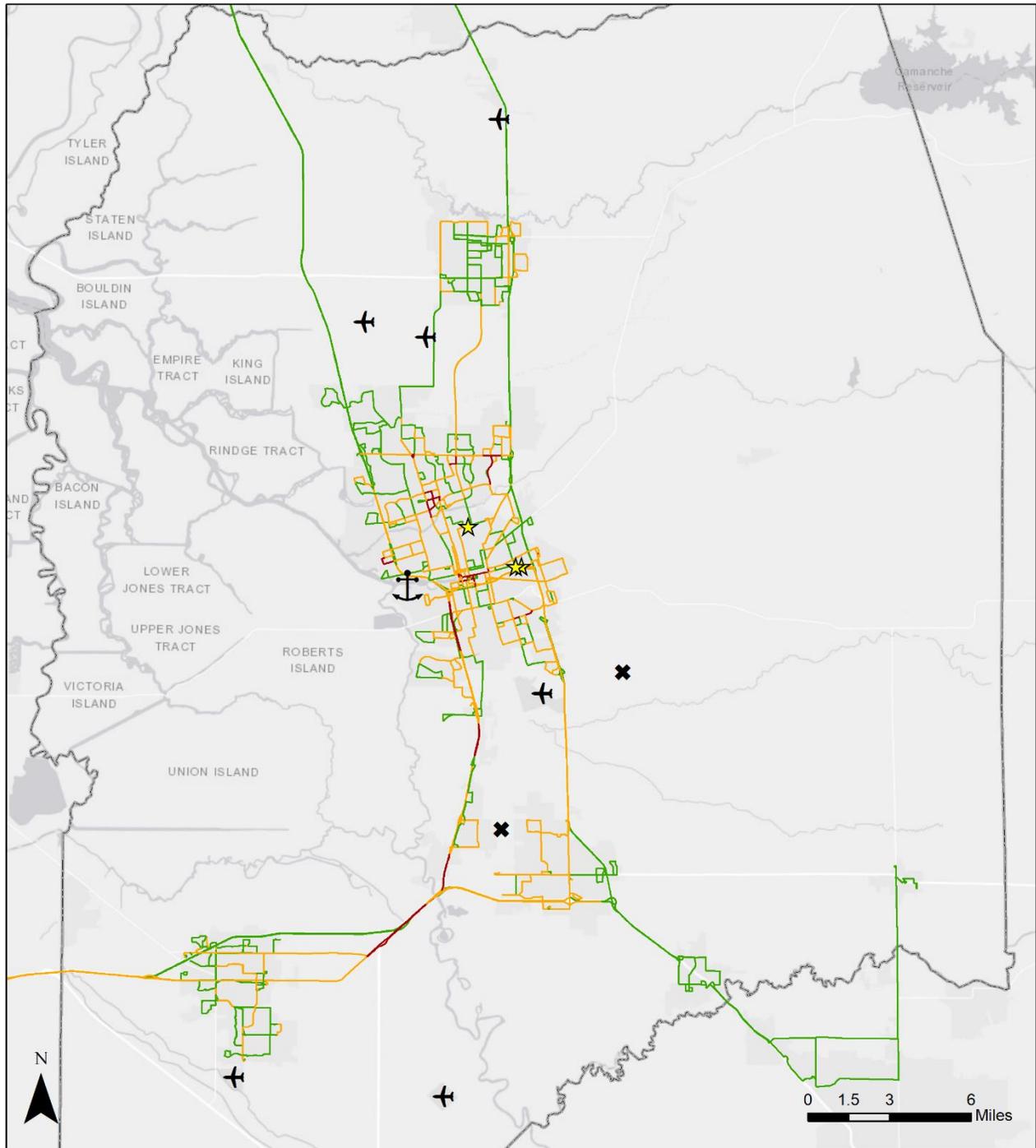
<sup>30</sup> Port of Stockton. 2018 Annual Report. <https://www.portofstockton.com/annual-report>

<sup>31</sup> FAA, provided by SJCOG.

<sup>32</sup> SJCOG. Airport Land Use Compatibility Land. Amended 2018. Figure 1: Map of Bus Route Density.

<https://www.sjog.org/DocumentCenter/View/17/2009-San-Joaquin-County-ALUCP---Amended-January-2018?bidid=>

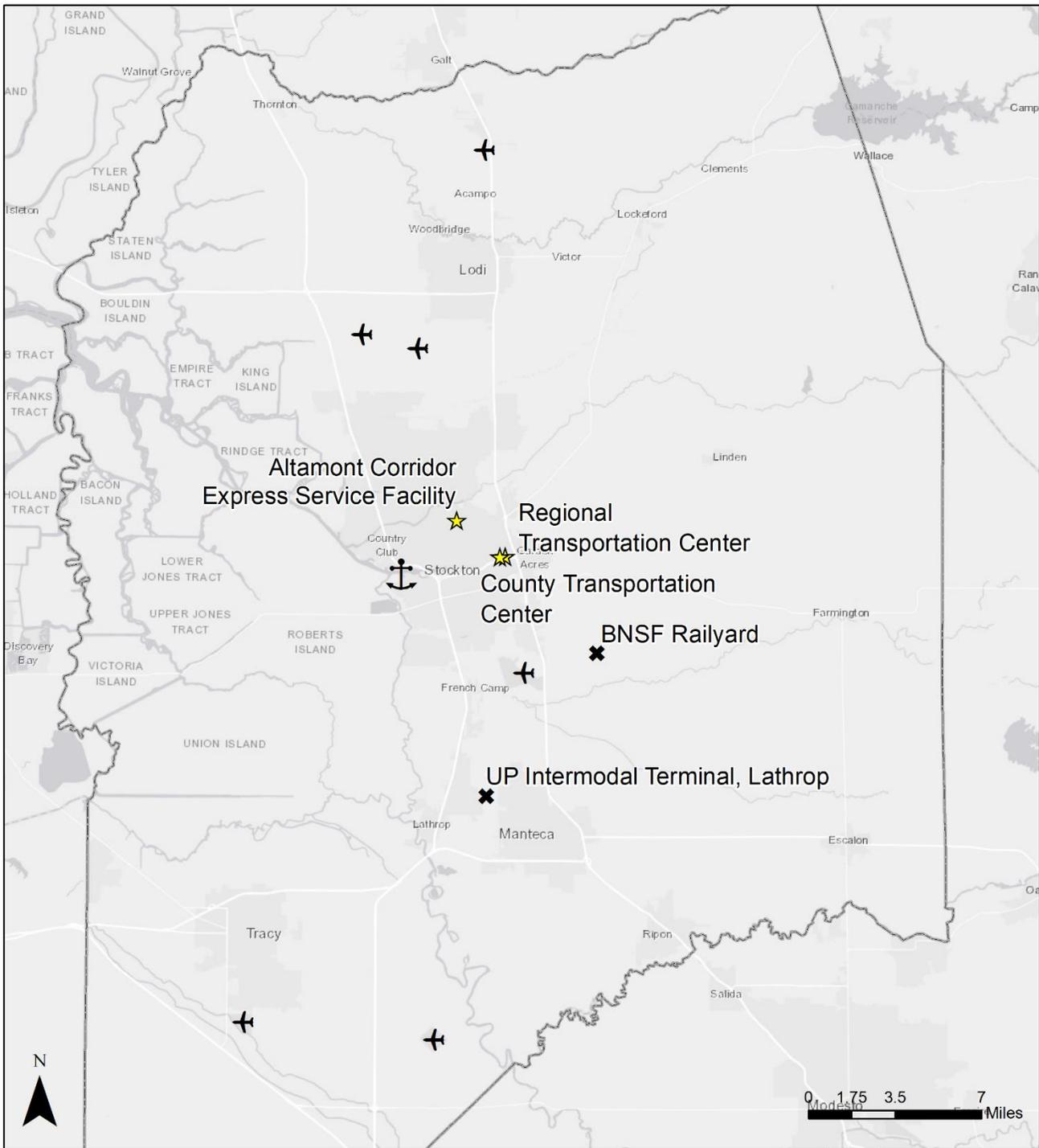
Appendix A, Figure 2. Map of Bus Route Density



**Density of Bus Routes**

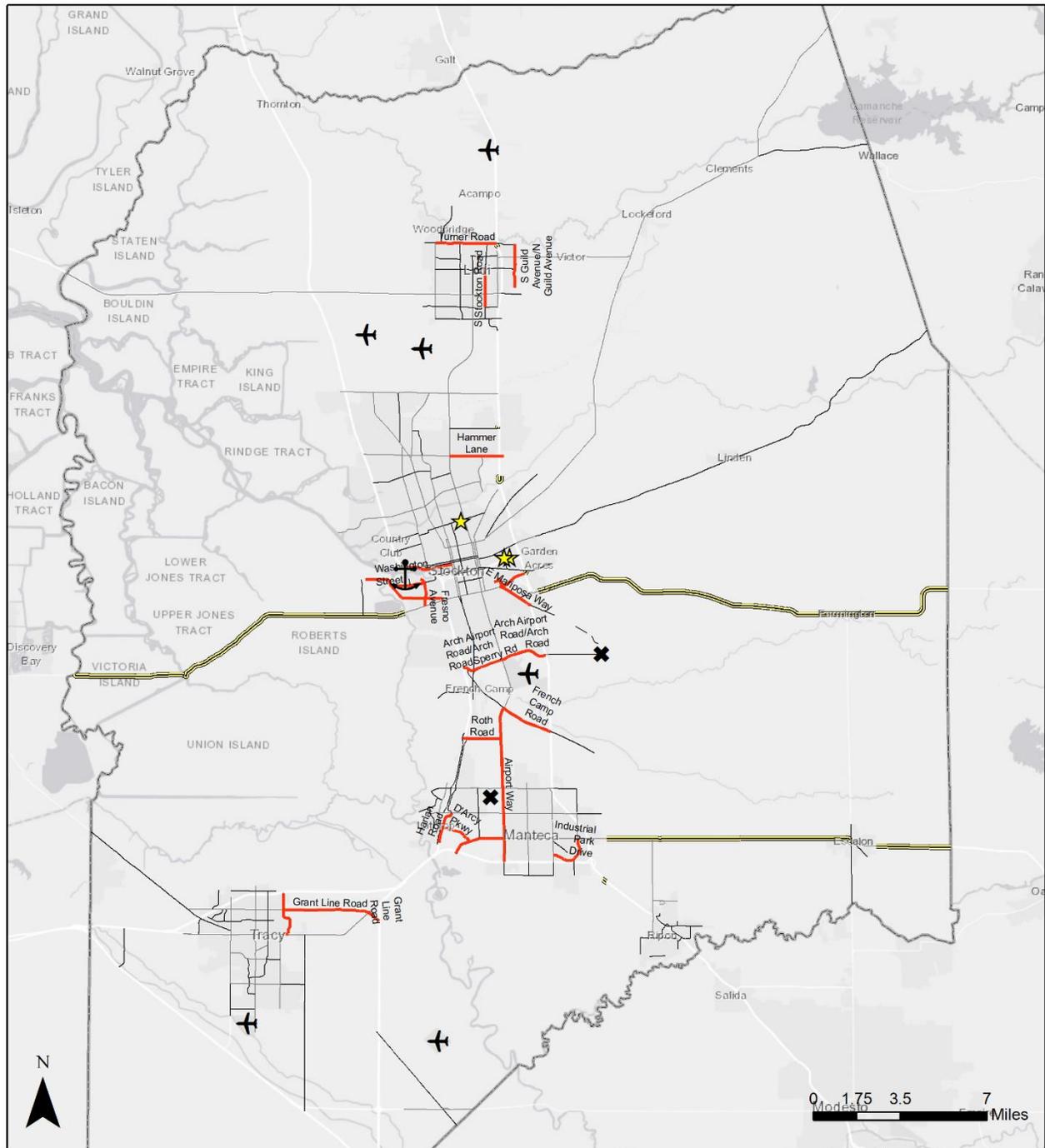
- |                         |         |                    |                      |
|-------------------------|---------|--------------------|----------------------|
| <b>Number of Routes</b> | — 2 - 5 | ⚓ Port of Stockton | ★ Maintenance Center |
| — 1                     | — > 5   | ✈ Airport          | ✕ Railyard           |

Appendix A, Figure 3. Map of Supporting Services



- |  |  |
|--|--|
|  Port of Stockton | <b>Supporting Services</b>   |
|  Airport          |  Maintenance Center |
|  |  Railyard           |

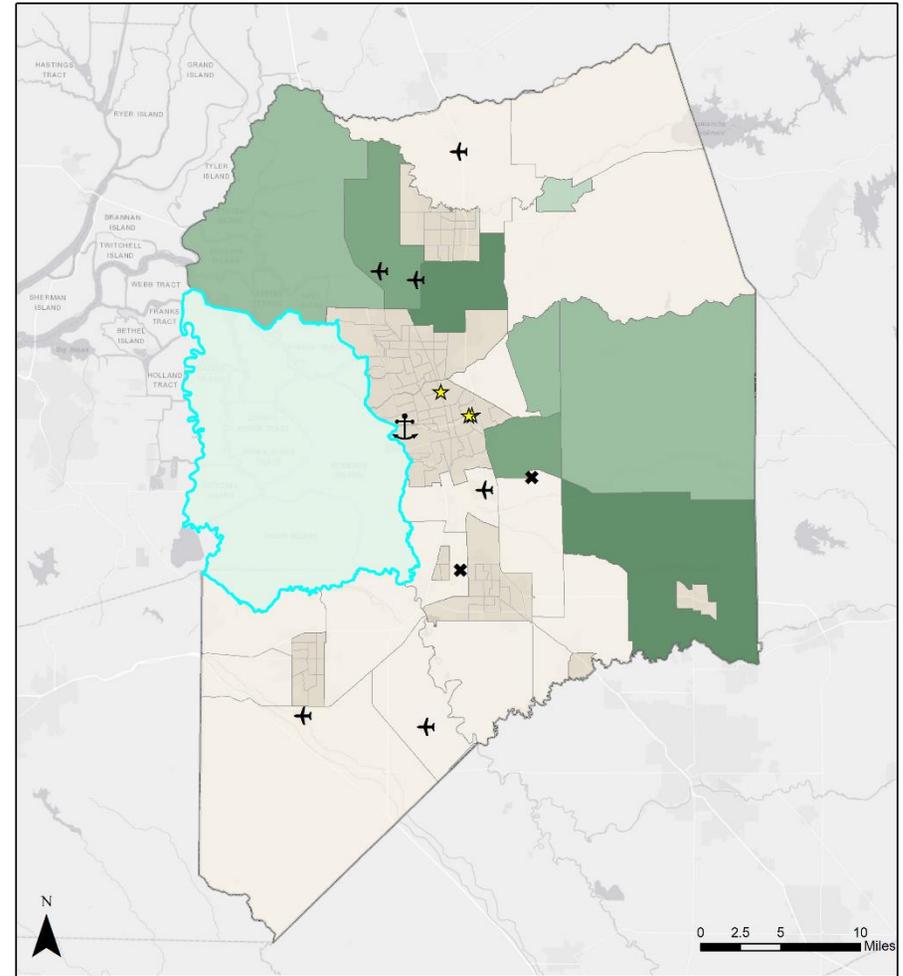
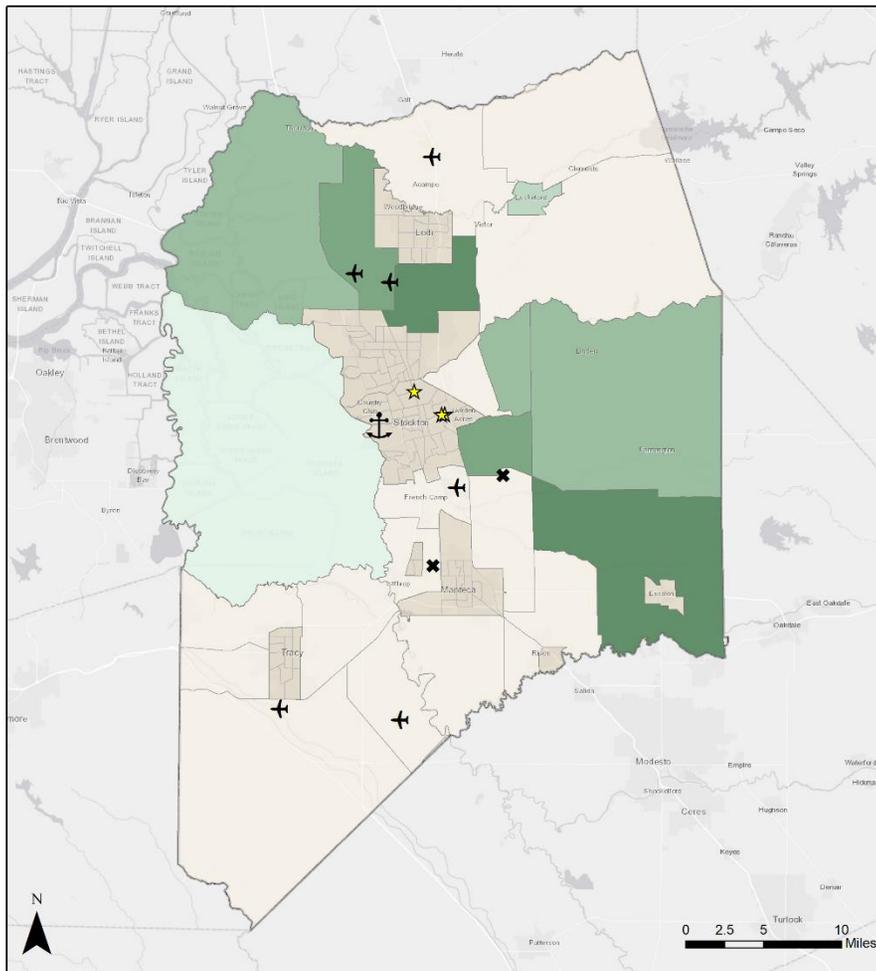
Appendix A, Figure 4. Goods Movement Connectors



## Goods Movement

- |                     |                             |                  |                    |
|---------------------|-----------------------------|------------------|--------------------|
| Expressways         | Minor arterials             | Port of Stockton | Maintenance Center |
| Principal arterials | SJV Trucking Key Connectors | Airport          | Railyard           |

**Appendix A, Figure 5-6. Access points for transportation-disadvantaged, rural populations. The tracts in green have higher than the county average of two or three (out of four) characteristics of transportation disadvantaged communities. The census tract circled in blue highlighting has higher than the county average of two characteristics of transportation-disadvantaged communities and less than fifteen access roads. While this tract has a low population (less than 1,500 people), access is a concern.**



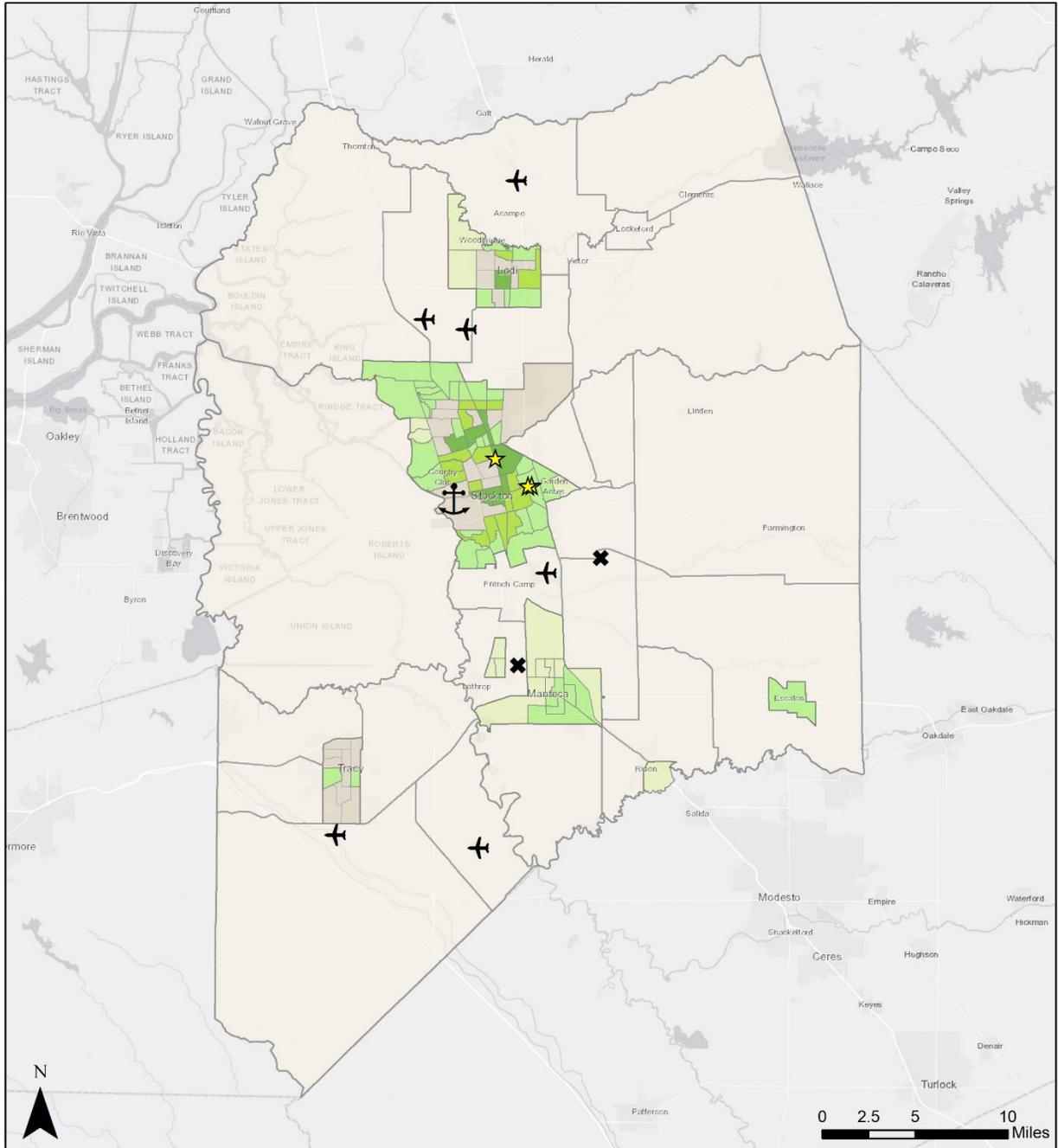
**Road Access Points for Transportation-Disadvantaged, Rural Populations**

- |                   |         |              |                      |                    |
|-------------------|---------|--------------|----------------------|--------------------|
| Number of Streets | 26 - 50 | Rural Tracts | ★ Maintenance Center | ⚓ Port of Stockton |
| ≤ 15              | 51 - 75 | Urban Tracts | ✖ Railyard           | ✈ Airport          |
| 16 - 25           | > 75    |              |                      |                    |

**Road Access Points for Transportation-Disadvantaged, Rural Populations**

- |                   |         |              |                      |                    |
|-------------------|---------|--------------|----------------------|--------------------|
| Number of Streets | 26 - 50 | Rural Tracts | ★ Maintenance Center | ⚓ Port of Stockton |
| ≤ 15              | 51 - 75 | Urban Tracts | ✖ Railyard           | ✈ Airport          |
| 16 - 25           | > 75    |              |                      |                    |

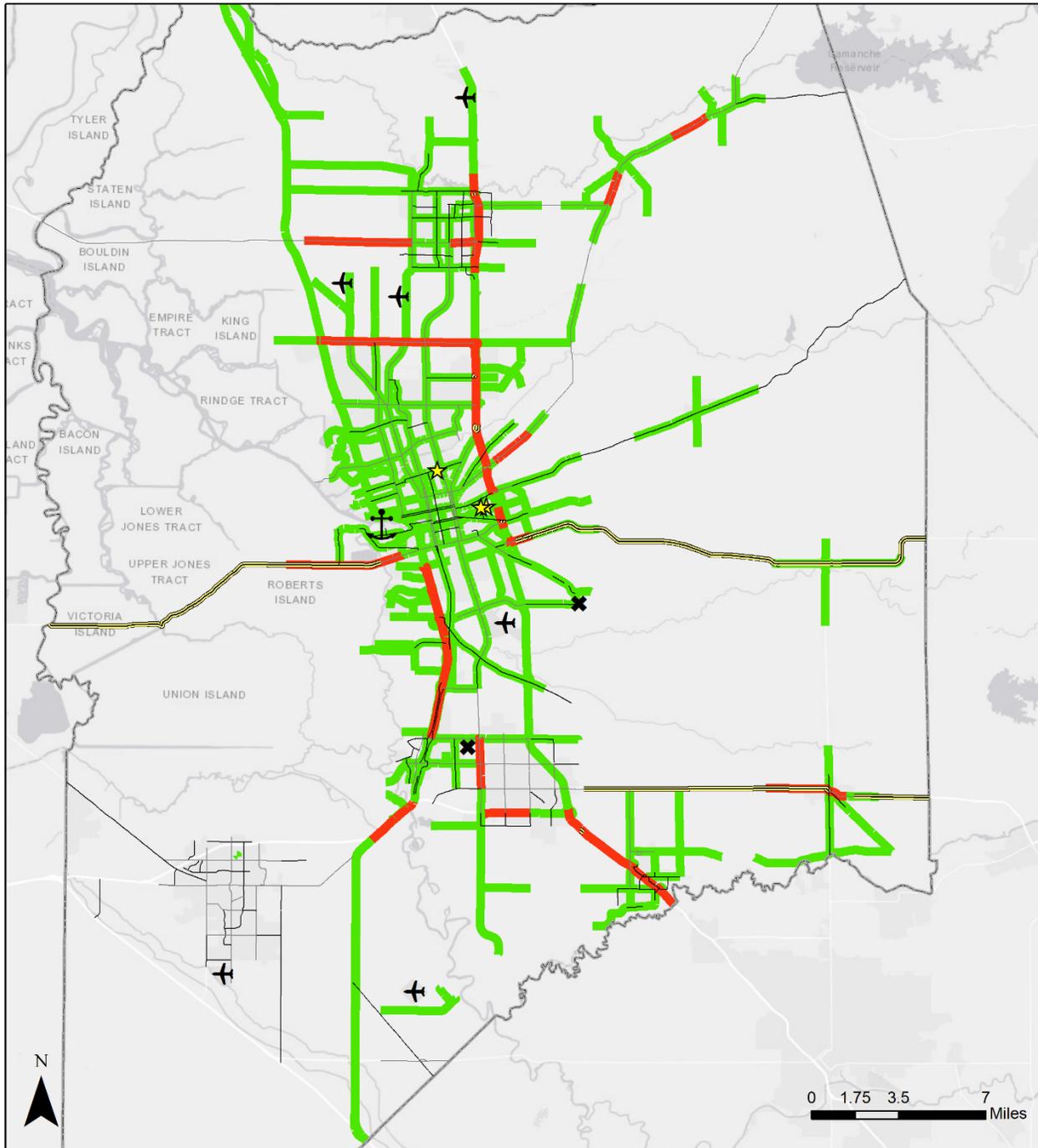
**Appendix A, Figure 7. Access to transit (bus, train) for transportation-disadvantaged, urban populations. The tracts in green have higher than the county average of three or four (out of four) characteristics of transportation disadvantaged communities.**



**Number of Transit Stops Serving Urban Census Tracts with a High Number of Transportation-Disadvantaged Characteristics**

- < 25 stops
- 25 - 50
- 50 - 75
- > 75 stops
- Urban Tracts
- Rural Tracts
- ★ Maintenance Center
- ✕ Rail yard
- ✈ Airport
- ⚓ Port of Stockton

**Appendix A, Figure 8. Evacuation Routes operating at low level of services (PM). Evacuation routes in red are those designated along routes that are rated as “deficient”, meaning that the roadway is at or is exceeding its designed capacity. In locations where evacuation routes overlap with a black line for principal or minor arterials or expressways, these routes are managed by cities or the county.**



### Evacuation Routes with PM Travel LOS Rating E/F

- |                     |                                |                    |
|---------------------|--------------------------------|--------------------|
| Expressways         | Evacuation Routes PM LOS (E/F) | Maintenance Center |
| Principal arterials | Evacuation Routes              | Railyard           |
| Minor arterials     | Airport                        | Port of Stockton   |

## F. Assess exposure and vulnerability to climate stressors

Having identified critical transportation assets, the study team investigated how these assets are projected to be impacted by a range of climate stressors into the future. We considered the extent to which assets will be exposed to the impact, how sensitive different assets are to the impact, how easily they can adapt, and how severe the consequence of impacts to the asset or transportation system are expected to be.

### Key Components of Vulnerability:

- **Exposure:** extent to which an asset experiences an impact
- **Sensitivity:** degree to which assets are affected by the impact
- **Adaptive capacity:** ability to adjust to an adverse impact
- **Consequence:** severity or seriousness of the impact to the county

## Vulnerability Assessment

Each climate stressor, its projected impacts in the county, and an assessment of vulnerability of the transportation system to the stressor are described below.

### A. Sea level rise and riverine flooding

#### *Description of Stressor:*

There are a range of factors that impact water levels in the San Joaquin Delta, including fluvial inflows (from local and upstream precipitation), San Joaquin Delta exports, astronomical tide, atmospheric effects (pressure and wind), and flow control operations. All these factors are expected to be impacted by climate change and there is extensive research in progress to model these impacts. SJCOG is currently part of the working group to support work by the Delta Stewardship Council to specifically understand the combined effects of sea level rise and changing inflows on local water levels within the San Joaquin Delta. Past studies show that sea level rise at the Golden Gate bridge and across San Francisco Bay apply strong influence on water levels in the central San Joaquin Delta. In addition, the latest climate science indicates that at the headwaters of the San Joaquin River, more precipitation is expected to arrive as rain rather than snow, causing greater surface water flows over shorter periods. As such, water years may be characterized as having less water and more flooding.<sup>33</sup>

It is important to understand how sea level rise will interact with greater inflows into the delta to anticipate the need for upgrading flood control systems to protect communities and essential infrastructure.<sup>34</sup> This is critical because some levees have already been identified as potentially at risk for failure, and the U.S. Army Corps of Engineers, California Department of Water Resources, U.S. Bureau of Reclamation Districts, and others already working hard to upgrade levees to address this risk.<sup>35</sup>

<sup>33</sup> CA Office of Planning and Research, CA Energy Commission, CA Natural Resources. California's Fourth Climate Assessment: San Joaquin Valley Region Report (Preview). 2018.

<sup>34</sup> Bay Conservation and Development Commission, Anchor QEA and AECOM. Eastern Contra Costa and Solano Counties Adapting to Rising Tides Modeling and Mapping. 2018. <http://www.adaptingtorisingtides.org/wp-content/uploads/2018/06/ECCARTModelingAndMappingExplainer06.05.2018.pdf>

<sup>35</sup> California Department of Water Resources. Basin-Wade Feasibility Study San Joaquin Basin March 2017 <https://water.ca.gov/LegacyFiles/cvfm/docs/2017/BWFS-SJR-Rpt-March2017.pdf>

## Overview of Projections:

### Sea level rise

The State of California has developed Sea Level Rise Guidance, adopted by the Ocean Protection Council in March 2018.<sup>36</sup> This guidance document provides probabilistic projections for the height of sea-level rise over time for several RCPs (Representative Concentration Pathways). In addition, it includes an extreme, stand-alone scenario, called H++ (which refers to a scenario of ice loss from the West Antarctic Ice Sheet which is not assigned a probability of occurrence). The projections applied in the study are shown in Appendix A, Table 2 below. High emissions (RCP 8.5) are assumed to mid-century with the range of emissions scenarios possible in the latter half of the century. The guidance presents a range of projections and encourages decision-makers to determine their level of risk aversion for climate planning.

The state guidance does not currently have guidance and projection specific to the San Joaquin Delta. The closest and most appropriate projections are those for San Francisco Bay (Appendix A, Table 2).

### **Appendix A, Table 2. California OPC Sea Level Rise Projections (inches) for San Francisco Bay (Adapted)**

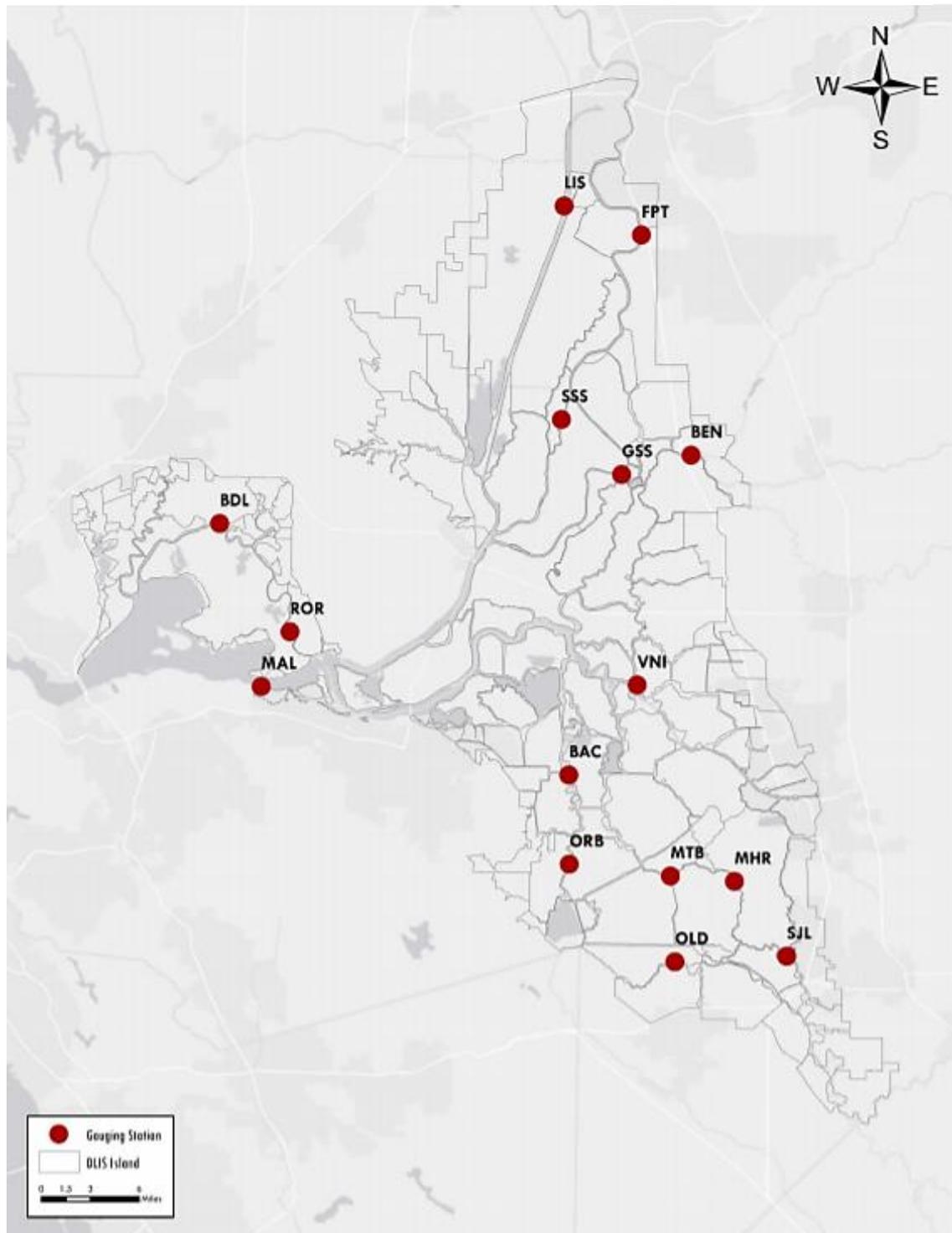
Year	Likely Range (66% Chance)	1-in-20 Chance Sea Level Rise Exceeds	1-in-200 Chance Sea Level Rise Exceeds	H++ Single Scenario
	High end of this range (underlined)= low risk aversion		Medium-risk aversion	Extreme risk aversion
2030	4" – <u>6"</u>	7"	10"	12"
2050	7" – <u>13"</u>	17"	23"	32"

Early work (Delta Risk Management Strategy Phase 1, Topical Area: Flood Hazard, 2009) provides insights into how we can expect effects of sea level rise at the Golden Gate bridge to vary spatially across the San Joaquin Delta.<sup>37</sup> DWR's 2009 study calculated tide factors, defining the effect of tide level at the Golden Gate Bridge on water level at gauging stations throughout the delta. For example, a tide level of 12 feet at Golden Gate Bridge would contribute 9.72 feet (12 feet x a tide factor of 0.81) to the water level on the Old River near the Tracy gauging station (identified as "OLD" on the Gauging Station Map in Appendix A, Figure 9). This spatial variation in tide factors is shown in Appendix A, Figure 10.

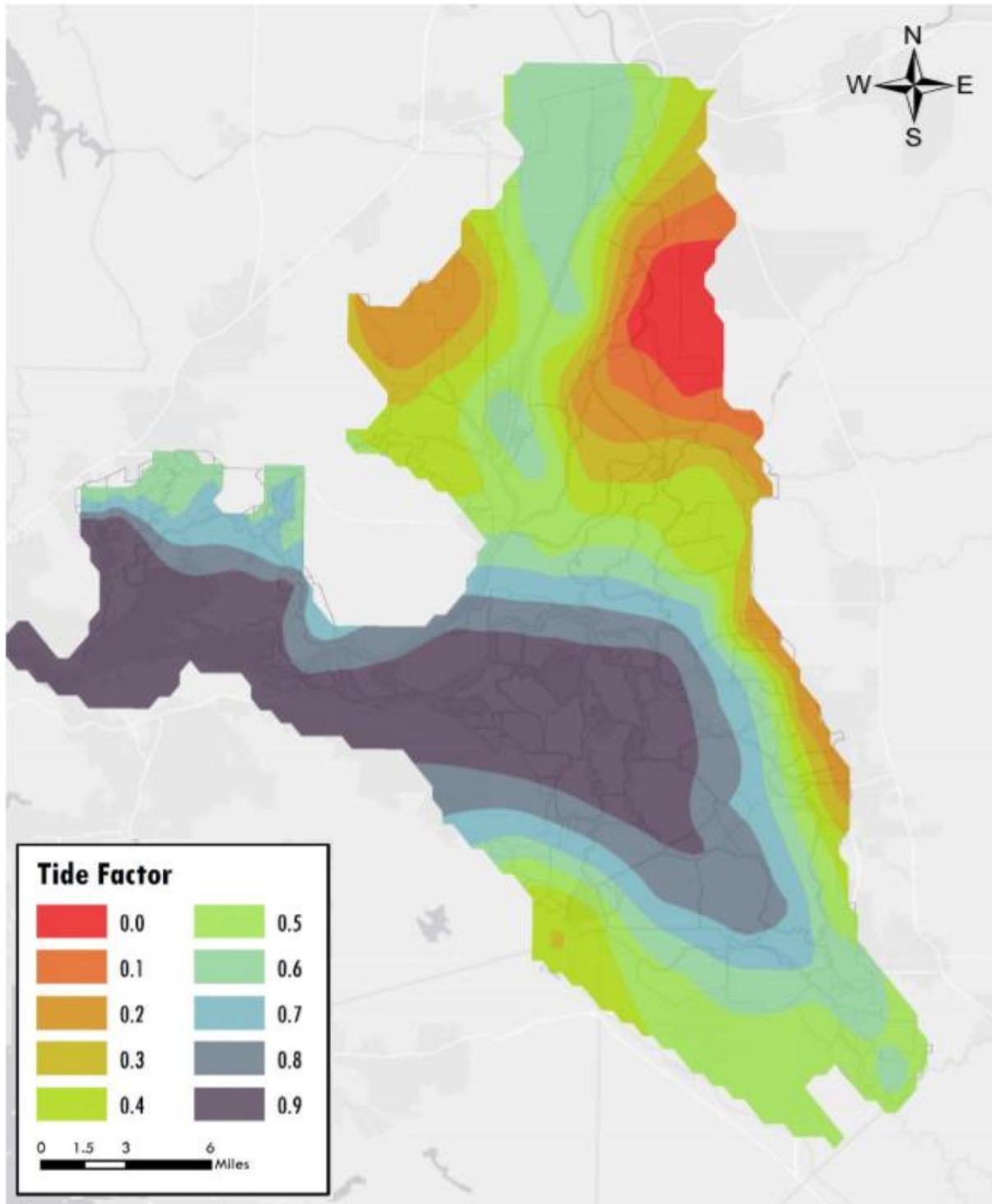
<sup>36</sup> California Natural Resources Agency and California Ocean Protection Council. State of California Sea-Level Rise Guidance: 2018 Update.

<sup>37</sup> California Department of Water Resources. 2009. "Delta Risk Management Strategy (DRMS) Phase 1, Topical Area: Flood Hazard Report"

**Appendix A, Figure 9. Location of Gauging Stations throughout the San Joaquin Delta (credit: DWR, 2009)**



**Appendix A, Figure 10. Tide factor contours, defining the effect of tide level at the Golden Gate on water level at gauging stations throughout the delta (credit: DWR, 2009)**



The Delta Stewardship Council (DSC) is working on an analysis<sup>38</sup> of the combined effects of sea level rise and changing inflows to the delta as part their Climate Change Vulnerability Assessment (CCVA) and Adaptation Strategy (AS) for the Sacramento-San Joaquin River Delta and Suisun Marsh. As the supporting analysis on sea level rise and changing inflows was not available at the time of this SJCOG work, instead, our study team has drawn on the best available interim work in order to understand potential flood risk to transportation assets. In order to consider sea level rise impacts, our study team has applied two preliminary maps of sea level rise flooding in the county:

- Mean sea level plus **12 inches** of sea level rise plus the modeled 1997 flood<sup>39</sup>
- Mean sea level plus **36 inches** of sea level rise plus the modeled 1997 flood

These sea level rise maps approximately align with “low risk aversion” planning (12 inches) or “extreme risk aversion” planning (36 inches) for 2050 with the largest historically recorded flood event on top of those levels of sea level rise. DSC produced these preliminary flood scenario maps by running the Delta Simulation Model II (DSM2) model with a sea level boundary condition applied (12 and 36 inches of sea level rise) and an inflow event representing the 1997 flood conditions. DSM2 is a model developed and applied by the California Department of Water Resources to calculate flood stage, flows, and velocity for river and estuary systems. In this analysis, DSM2 outputs are considered in combination with levee elevation data to identify where water surface elevation exceeds levee elevation, potentially flooding islands (quality control and assurance of this aspect of the analysis is ongoing).<sup>40</sup> While this work is in process, these interim draft outputs provide an important view into sea level rise impacts in low-lying islands (often called tracts) in the western county.

The consideration of additional extreme events (the 1997 flood) is in line with recommendations in the State Sea Level Rise Guidance which calls on jurisdictions to consider potential storm impacts on top of sea level rise (though a specific recurrence interval is not specifically indicated). It is important to note that this modeling technique is best at capturing flood impacts on islands and less effective at identifying flood risk east of the eastern-most delta levees. For levees protecting islands, this technique assumes that if the water elevation exceeds the levee elevation, the island will flood. However, inundation of low-lying area adjacent to overtopped levees is not specifically modeled.

### Fluvial inflows

The SJCOG study team applied FEMA 100-year and 500-year flood maps in order to account for fluvial flood risk. While the 100-year and 500-year floodplain do not capture climate impacts (and are not applied additively on top of the sea level rise maps), they are an important indicator of current flood risk. In addition, events of this magnitude can be expected to occur with increased frequency as our climate becomes stormier. The floodplain represents statistical modeling of many potential floods (as opposed to showing impacts of the single 1997 flood

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<sup>38</sup> This work is through Delta Stewardship Council’s project: Climate Change Vulnerability Assessment and Adaptation Strategy for the Sacramento-San Joaquin Delta and Suisun Marsh.

<sup>39</sup> The 1997 led to failure of many levees. The state declared a state of disaster in 43 counties. This flood was approximately equivalent to a 100-year flood.

<sup>40</sup> DSM2 assumes infinite vertical levees. If a levee overtops in our analysis, DSM2 still treats that water as within the channel.

included with the sea level rise mapping). The mapping methods applied by FEMA are more effective (than the sea level rise analysis above) at capturing surface flooding caused by overtopping of river and creek banks into the central and eastern parts of the county.

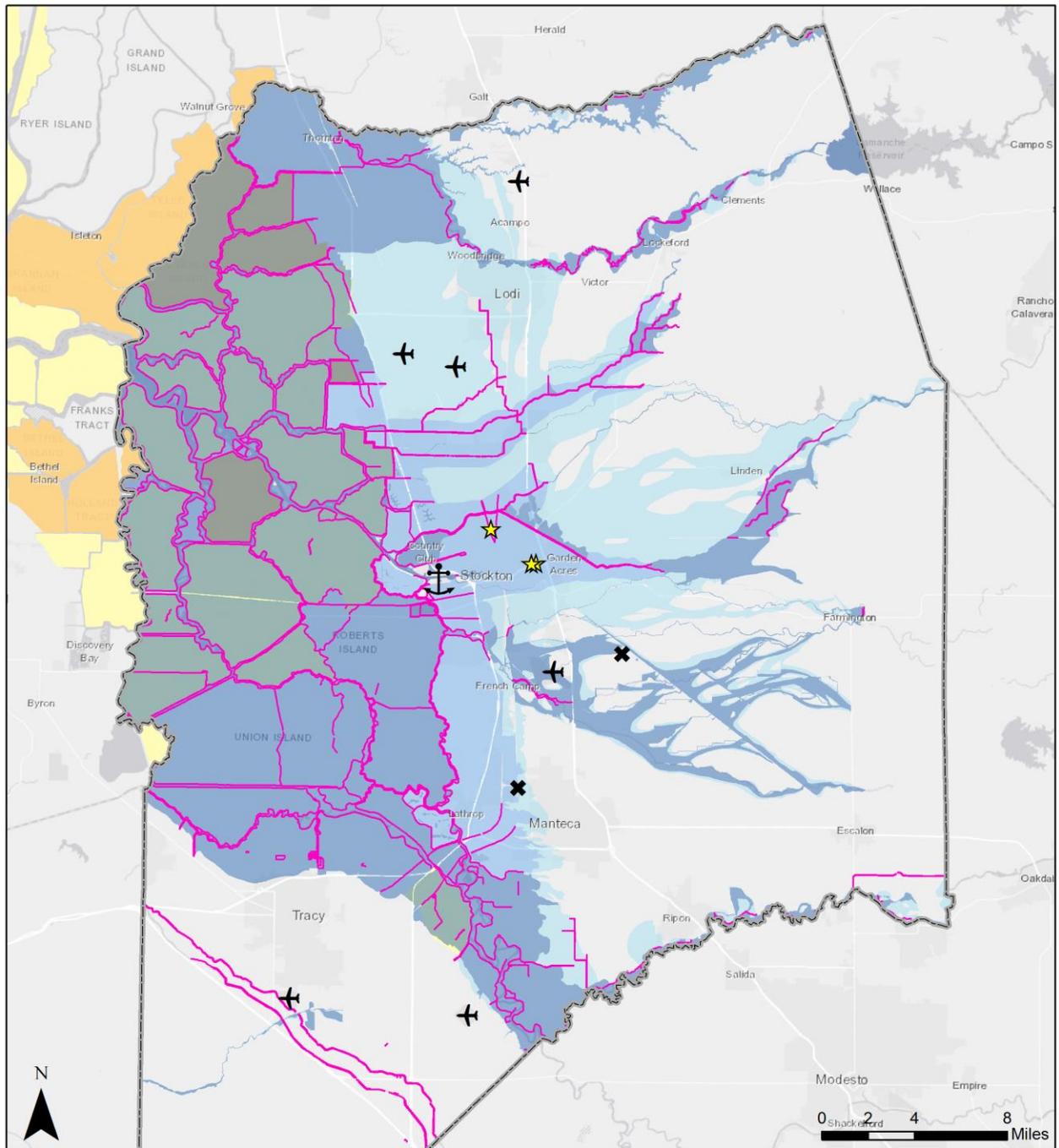
Reclamation districts and municipalities in the delta are working hard to achieve the 200-year level of flood protection required for urban areas required under SB5. This 200-year standard is driving investment and prioritization of flood protection projects by cities. As a county-wide map of the 200-year floodplain does not exist, the readily available 500-year floodplain applied in this study is a useful indicator of risk. As the climate changes, it is possible that the 200-year floodplain is increasingly similar to the 500-year floodplain (originally produced in 2009) mapped in this study.

### *Spatial Distribution of Impacts:*

Appendix A, Figure 11 shows the spatial distribution of flood risk across San Joaquin County. It clearly shows that the greatest flood risk (or the 100-year floodplain or “special flood hazard area” in FEMA terminology) is primarily located on the western side of the county. The 500-year floodplain (identified by FEMA as “moderate flood hazard areas” stretches east across the county, following tributaries of the San Joaquin River. Figure 11 and subsequent flood maps throughout this report distinguish between portions of the 500-year floodplain that may and those that may not have reduced flood risk due to the presence of levees (those that may have some protection due to levees are labeled “500-year with levee” or “500-levee” on maps and included populated portions of Stockton and Lathrop. The levees are not accredited for 500-year flood protection, so the extent of the protection is unknown.

A series of maps are included in Appendix C below that show flood impacts to individual groups of assets in the county (organized by criticality criteria). As several assets appear in the 100-year and 500-year floodplains, Appendix A, Figure 12 displays the at-risk linear assets together to assist in prioritizing assets and areas for adaptation and protection. For example, a strong case may be made on the need to protect an at-risk roadway if it is both an evacuation route and a key bus route (serving transit disadvantaged communities).

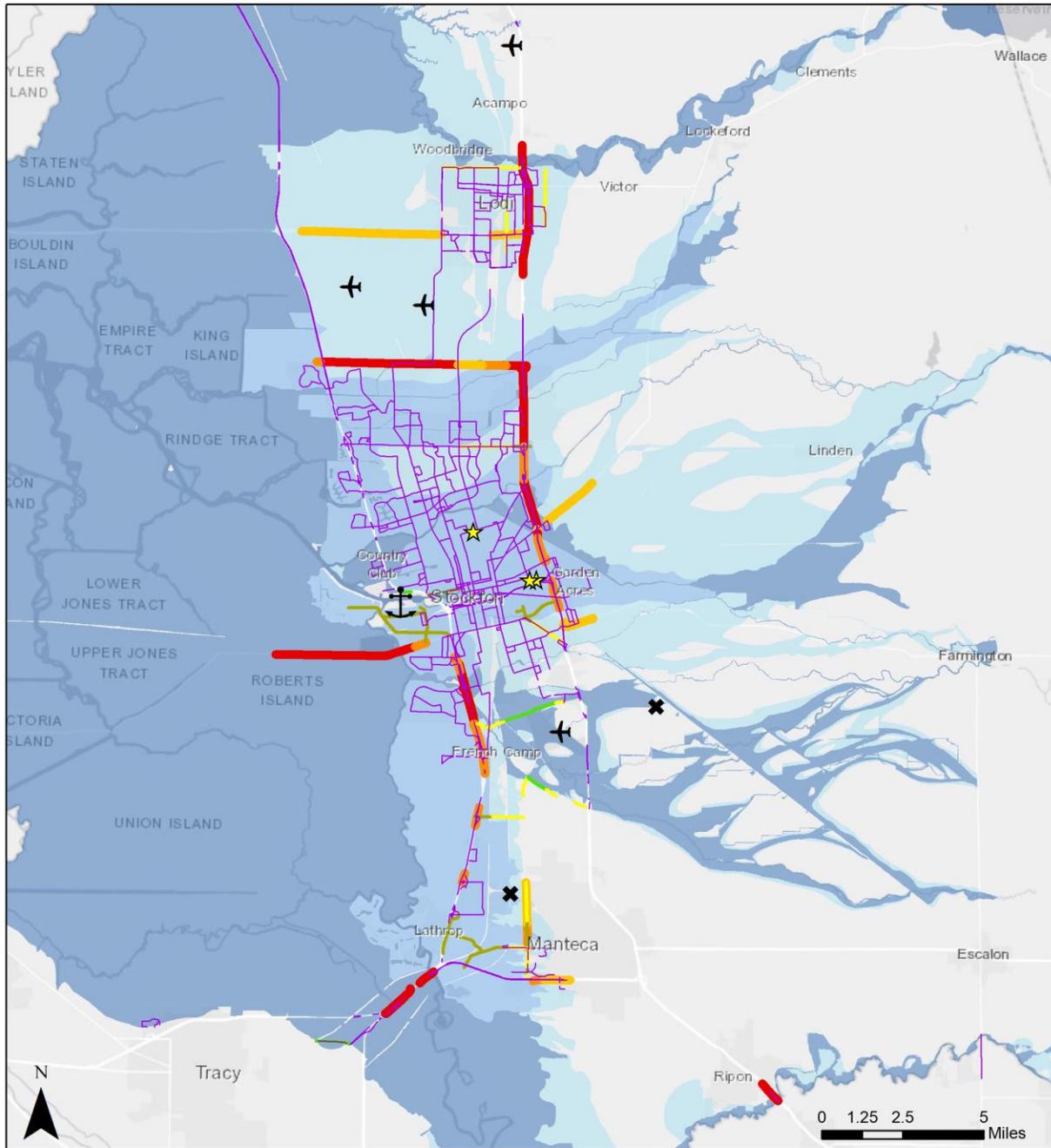
**Appendix A, Figure 11. Sea level rise (1 and 3 ft plus modeled 1997 storm) and 100-year and 500-year floodplain.**



**Flood Zone Designations and Levee Centerlines**

<b>Flood zones</b>	1-ft Sea Level Rise	County Border	<b>Supporting Services</b>
100-year	3-ft Sea Level Rise	Port of Stockton	Maintenance Center
500-year	Levee Centerlines	Airport	Railyard
500-year with levees			

**Appendix A, Figure 12. Overlapping Vulnerabilities: Low level of service evacuation routes, first- and last-mile trucking connectors, and main transit routes located in the 100-year and 500-year floodplains.**



SJV Trucking Connectors		Evacuation Routes		Flood Zones		Supporting Services	
	Transit Routes in Flood Zones		100-year		100-year		Maintenance Center
	100-year		500-year		500-year		Railyard
	500-year		500-levee		500-levee		Port of Stockton
	500-levee						Airport

Critical assets at flood risk can be identified by their location relative to the FEMA 100-year and 500-year floodplains. Key risks include the Stockton Airport, which is located within the FEMA 100-year floodplain, as well as Arch Airport Road and French Camp Road, which serve as trucking connector routes around the airport. The Kingdon Airport and Lodi Air Park are in the 500-year floodplain.

While the Port of Stockton has at least 100-year flood protection from its levees, its levees are not accredited to provide protection in the event of a 500-year event. In addition, segments of the first- and last-mile trucking connectors that link the Port to trucking routes are within the 100-year floodplain (segments of W. Fremont St.) and the 500-year floodplain with non-accredited levees (segments of Navy Drive, W. Washington St., and S. Fresno Ave) which can impact goods movement if flooded. Another risk to goods movement is flooding of the BNSF Intermodal Railyard in Stockton, parts of which are within the 100-year floodplain. Several trucking connector routes in the Lodi area also fall in the 500-year floodplain.

In terms of risks to transit access in urban areas, this study has highlighted flood risks to station stops serving transit-dependent communities (tracts with higher than the county average of all four characteristics of transit dependence). All census tracts meeting this definition are located in the City of Stockton. Several bus stops in downtown Stockton are within the 100-year floodplain and the vast majority of bus stops surrounding transit-dependent census tracts in the Hammer Triangle area and the Harrell Park area are within the 500-year floodplain (Appendix C, Figure 4).

This analysis also highlights evacuation routes (operating at deficient level- of service) within flood zones, including major routes among the county's major cities. Segments of the following lie within the 100-year floodplain: I-5/205 between Tracy and Lathrop; I-5 between French Camp and Stockton; SR-99 between Garden Acres and Valley Oak; Eight Mile Road between Morada and King Island; and SR-4 across Roberts Island.

A few critical assets are specifically exposed to sea level rise flooding (as well a 100-year event) according to the data applied in this study (see Appendix C, Figure 3):

- 1) Kasson Road and I-5/205 in the Tracy area are adjacent to an area projected to be flooded with a foot of sea level rise (and a storm event).
- 2) SR-4 evacuation route (already operating at a low level of service) heading west out of Stockton toward Discovery Bay. This tract was flagged because the community has some of the indicators of transportation-disadvantaged population. It has a total of eight road access points, of which, seven are exposed to 100-year flooding and two face flood risk under a scenario of 3ft of sea level rise (plus a storm). Naturally, it will be important to maintain access in the event of flooding.

### *Impacts to Transportation System:*

Sea level rise and riverine floods can decrease clearance under bridges creating issues with boat clearance. In addition, bridge design criteria for erosion and scour will need to be amended as water levels rise. Additional data collection on bridge clearance and condition data as well as additional analysis will be required in the future in order to identify whether individual bridges are at risk. In terms of impacts to roads adjacent to the delta river banks, some drainage systems may begin to become less effective as delta water levels rise.



***Appendix A, Figure 13. Elk Grove Train Derailment, likely due to a nearby levee break (2017).***

Sea level rise and riverine flooding create a range of risks for rail located in the floodplain. Bridges that support rail systems may be damaged as the earth supporting those systems erodes. If train, bus or maintenance stations flood, they will have to be temporarily closed for repairs. Rail service can be disrupted during and following a flood event due to direct damage to rail and debris on rails. This is clearly a risk at the BNSF Intermodal railyard given its location in the 100-year floodplain. The facility lifts approximately 300,000 container units annually and serves as a major network hub between Northern California and the Midwest. There are additional plans to expand the capacity of the facility.<sup>41</sup> Interruptions to the facility would have major economic consequences.

Railroad owners and operators have emergency protocols to manage risks related to damaged lines. These protocols are generally publicly available for publicly held transit lines. This information is not generally available for privately held freight railroads, potentially representing an informational vulnerability.<sup>42</sup>

Roadways are relatively resilient to temporary flooding events, often returning to normal after the event. However, erosion and scour are possible, and even temporary flooding of evacuation routes such as SR-4 is a major public safety concern. Roadways that are permanently inundated as sea level rises will simply become unusable unless the road is raised or the road rerouted.

The Port of Stockton is reliant on a highly networked transportation system and flood impacts to nearby first- and last-mile connectors would be significantly impact operations. Over 3,000 cars and trucks enter the port's West Complex every day, so rerouting and delays could cause backups.<sup>43</sup>

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<sup>41</sup> SJCOG. Regional Transportation Plan/ Sustainable Community Strategy 2014.

<https://www.sicog.org/DocumentCenter/View/486/2014-RTPSCS-Chapter-6---Economic-Vitality?bidId=>

<sup>42</sup> U.S. Department of Transportation & ICF International. 2014.

<sup>43</sup> Port of Stockton 2018 Annual Report

Flood risk at Stockton Airport is a significant concern as a large portion of the facility and runways are within the 100-year floodplain. Flooding would lead to flight cancelations and significant economic impacts given the Stockton airport's approximately annual 270 million pounds of landed cargo weight and nearly 100,000 passengers (based on 2019 data). Submersion in water can destroy electronic equipment and damage landing gear.

In San Joaquin County, which is protected by a winding series of levees, it is not possible to adapt the transportation system without considering broader flood protection improvements. Flood impacts in the county can be sudden. The levees hold back water until they do not—at which point levees overtop or potentially fail, flooding some of the critical transportation assets described here, as well as surrounding neighborhoods and other community assets. A levee vulnerability assessment was beyond the scope of this study but should be undertaken because some of the transportation vulnerabilities to future sea level rise and flood impacts identified here may best be resolved with broader community-level flood improvements. Some of the priorities for levee improvements can be found in the Delta Levee Investment Strategy (2018); other evaluations of levee vulnerability and investment priorities are ongoing. SJCOG may wish to revisit study findings as new assessments of levee vulnerability and investment are developed under future climate scenarios.

#### *Specific Areas of Concern:*

- 1) Stockton Airport
- 2) First and last mile trucking connectors around the Port of Stockton
- 3) BNSF Intermodal Railroad
- 4) SR-4 from Stockton heading west
- 5) At risk road segments serving several key functions in the county:
  - a. Interstate 205/5 between Tracy and Lathrop (between SR-120 and S. Bird Rd) serves as key transit route and an evacuation route (operating at deficient LOS)
  - b. Interstate 5 south of Stockton (near Taft Mosswood) serves as key transit route and an evacuation route (operating at deficient LOS) Turner Road in Lodi serves as a key transit route and a first- and last-mile trucking connector
  - c. State Route 99 through Lodi serves as key transit route and an evacuation route (operating at deficient LOS). Additional areas of overlapping critical (and at risk) functions are indicated on Figure Appendix A, 12.
- 6) Bus stops serving transit-dependent census tracts in downtown Stockton, the Hammer Triangle area, and the Harrell Park area (Appendix C, Figure 4).
- 7) Interstate-5 in the Thornton area and SR 12 running east-west across the County. Caltrans District 10 identified these road segments as significant flood risk in their district-wide vulnerability assessment.<sup>44</sup>

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<sup>44</sup> Though these Caltrans assets were not a primary focus of this SJCOG study, these roads are in the flood zone. The Caltrans study was completed at the same time as the SJCOG vulnerability assessment and further integration priority setting will be needed moving forward.

Interstate 5 in the Thornton area serves as a Greyhound bus route connecting Sacramento and Stockton. State Route 12 runs across the Delta islands. Closer to Lodi, it serves as a transit and evacuation route.

## B. Extreme precipitation events

### *Description of Stressor:*

The definition of an “extreme precipitation event” changes depending on the context, forecast models, length of historical record, analytical decisions, and many other factors. In general, an “extreme” or “heavy” precipitation event is in the top 1% of events in terms of intensity measured in precipitation over a defined period (e.g., inches per hour or inches in 24 hours) and is defined based on records of storm intensity and duration.<sup>45</sup> Thus, “extreme” precipitation differs based on local conditions.

The PRISM dataset<sup>46</sup> includes observed precipitation records from thousands of monitoring stations across the country. Using these data, EPA determined the intensity of an “extreme” event for each station for multiple storm recurrence intervals (5-year up to 100-year) to help water utilities and other decision makers understand climate risks facing their infrastructure. The data are transferable to other contexts as well. The projections used in EPA’s Climate Resilience Evaluation and Awareness Tool (CREAT) are derived from the Coupled Model Inter-comparison Project, Phase 5 (CMIP5) and rely on historical observations from PRISM. All model simulations employed RCP 8.5 to conform with an overall focus on higher risk futures. A subset of the models used to project temperature and precipitation also have “storm scalars” (22 of the 38 models) that define changes in precipitation per degree of warming for storm events with defined return intervals (i.e., 5-year, 10-year, 100-year). The results of the 22 model runs were plotted and those at the high and low end of projected changes were split into two scenarios – “Stormy” and “Not Stormy” Future Conditions.<sup>47</sup> The EPA projections are binned into two time periods – 2035 and 2060 – that correspond to projection data for a range of 2025-2045 and 2050-2070 respectively. EPA recommends that users of CREAT select the timeframe that is closest to the planning horizon of interest. For the purposes of this assessment, that would be the “2060” projection, which is a reasonable planning target for an analysis to 2050.

Extreme precipitation events are likely to contribute to riverine flooding (described above) but can also lead to flash flooding and street flooding if the intensity of an event overwhelms a stormwater system or runoff contributes to flash flooding in otherwise dry locations.<sup>48</sup>

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<sup>45</sup> U.S. Global Change Research Program (USGCRP). National Climate Assessment. *USGCRP Indicators – Heavy Precipitation*. Available online at <https://www.globalchange.gov/browse/indicators/heavy-precipitation>.

<sup>46</sup> Parameter-elevation Relationships on Independent Slopes Model (PRISM)

<sup>47</sup> EPA. (2016). *CREAT 3.0 Methodology Guide*. Available online at [https://www.epa.gov/sites/production/files/2016-05/documents/creat\\_3\\_0\\_methodology\\_guide\\_may\\_2016.pdf](https://www.epa.gov/sites/production/files/2016-05/documents/creat_3_0_methodology_guide_may_2016.pdf).

<sup>48</sup> SJOCG. Regional Transportation Plan EIR. 2018. <https://www.sjocg.org/DocumentCenter/View/3860/2018-RTP-SCS-PDEIR-411-Hydrology-and-Water-Quality>

### Overview of Projections:

The EPA projections of extreme precipitation produced for CREAT for the 2050-2070 timeframe are displayed in Table 3 below. The actual projections are given in a percent change in intensity – for example, the 5-year storm in the area around San Joaquin County is expected to be 3.7% more intense under the “Not Stormy” scenario, and 19.9% more intense under the “Stormy” scenario. The values were converted to inches in the table to relate them to historical events.

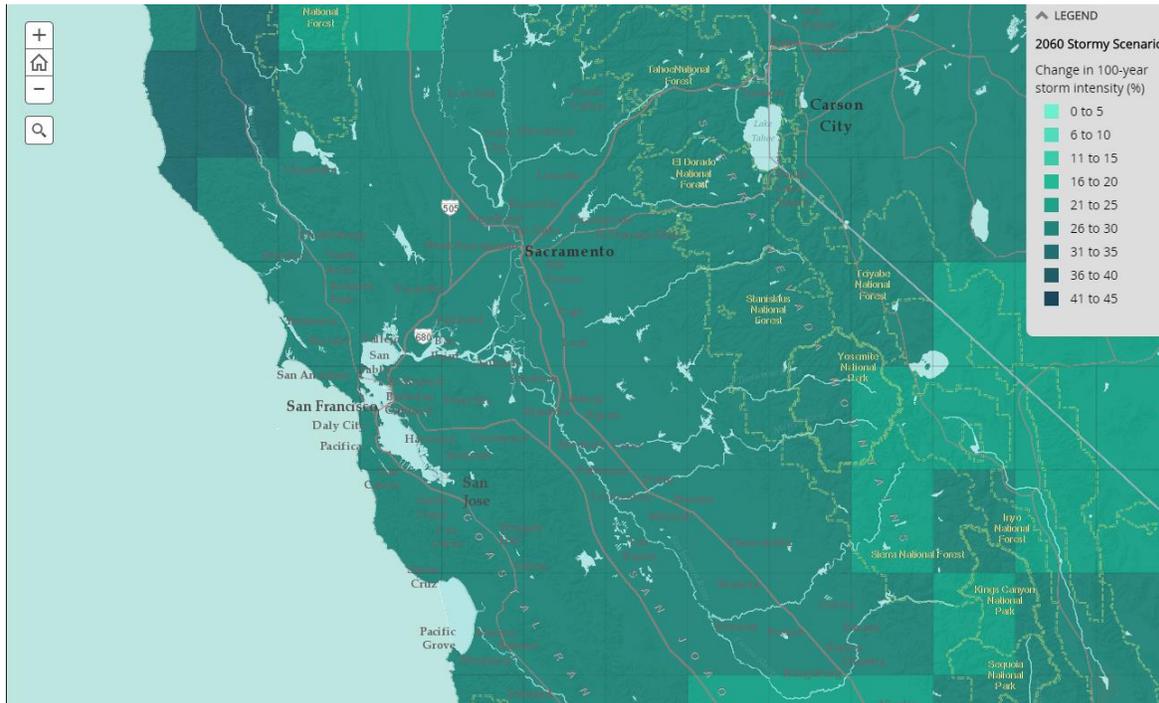
**Appendix A, Table 3. EPA CREAT projections for extreme precipitation events (5-year to 100-year events) for the period 2050 to 2070 for the San Joaquin County area.**

*All values in inches	Historical 24-Hour	24-Hour (Stormy)	24-Hour (Not Stormy)			Historical 72-Hour	72-Hour (Stormy)	72-Hour (Not Stormy)
5-year	1.77	2.12	1.87			2.8	3.36	2.90
10-year	2.05	2.49	2.22			3.26	3.95	3.43
15-year	2.21		2.70	2.42	3.52	4.30	3.73	
30-year	2.49		3.09	2.79	3.96	4.91	4.26	
50-year	2.69		3.38	3.07	4.26	5.35	4.64	
100-year	2.96		3.79	3.46	4.68	5.99	5.18	

### Spatial Distribution of Impacts:

Downscaling projections of extreme precipitation is difficult, and the spatial resolution of the projections is often limited. Projections are available in the San Joaquin area in grids of roughly 30 miles by 30 miles. There is relatively limited variation in adjacent grid cells in this part of California. The map below shows the spatial variability at a regional scale. Due to the limited resolution of climate projections for extreme precipitation, the best analysis focuses on the sensitivity and adaptive capacity of affected assets and systems, assuming that all are exposed to extreme precipitation events to the same degree. Topographic and hydrologic features like dry creek beds or other depressions can increase the risk of flash flooding during extreme events. In addition, areas of San Joaquin County that have low soil permeability are likely to saturate quickly, increasing the risk of flash flooding. Ensuring effective drainage for transportation assets will increase resilience to extreme precipitation.

**Appendix A, Figure 14. Screenshot of CREAT Climate Scenarios Projection Map showing projections for extreme precipitation in the region surrounding San Joaquin County. The values displayed here are for the 2060 “Stormy” Scenario for a 100-year event.**



#### *Impacts to Transportation System:*

Extreme rain events can lead to flash flooding and washouts, as well as structural damage to transportation assets including, roads, culverts, bridges, railways, runways, and port infrastructure (e.g. docks). Rainstorms can cause damage to roads and other paved surfaces through stripping, whereby the aggregates that hold pavement together begin to separate. Rail faces damage through erosion of the ballast or subgrade materials that can destabilize the rails.<sup>49</sup> Additional impacts include delays to all modes of transportation and the need to reroute vehicles.<sup>50</sup> Such damage, delays and interruptions could lead to major disruptions to commuter and goods movements and impact the regional economy. It is important to note that disrupted commuter movement is likely to be felt region-wide and into the Bay Area: between 85,000 and 120,000 workers travel outside of the County for work each day, with a majority commuting to Alameda County and the broader Bay Area.<sup>51</sup> Damages to bridges or roads that are part of evacuation routes could threaten public safety. Interruptions to public transit, creating concerns for transportation-disadvantaged populations in particular.

<sup>49</sup> Sacramento Area Council of Governments & Civic Spark. Sacramento Region Transportation Climate Adaptation Plan. 2015.

<sup>50</sup> Federal Highway Administration. Vulnerability Assessment and Adaptation Framework, 3<sup>rd</sup> edition. 2017. [https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation\\_framework/climate\\_adaptation.pdf](https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/climate_adaptation.pdf)

<sup>51</sup> SJCOG. 2018 Regional Transportation Plan/Sustainable Communities Strategy. <https://www.sicog.org/DocumentCenter/View/4156/Final-Compiled-RTPSCS-2018>

Flood damage from major rain events are not new to the county. Airport staff suspect that damage to one of the runways at the Stockton Airport was likely caused by a combination of large winter rains over the past few years as well as increased use from Amazon cargo service. The runway (which is still in use despite damages) is currently undergoing an engineering study to determine what repairs are needed and the cost of repairs. Local roadways are also already impacted by winter rains. When a late season rain and hailstorm hit North Stockton in May of 2019 with 1.44 inches in an hour, several roads were flooded. Police reported closing a section East Hammer Lane, which is a designated evacuation route.<sup>52</sup> This is just one of many examples of roadways in the region being flooded during major winter storms.<sup>53</sup>



**Appendix A, Figure 15. Stripping of asphalt pavement caused by water damage (State of Minnesota Department of Transportation, 2010)**

Existing stormwater and culvert drainage deficiencies will worsen in the future as rain events become more extreme. Drainage issues could also grow as the county continues to urbanize, reducing permeability of the ground surface and increasing runoff unless strict stormwater runoff volume and peak flow controls are imposed. Informational vulnerability is a significant issue associated with drainage issues and flood risk. Even though it is not unusual for certain streets and neighborhoods to flood during major rainstorms, there is no systematic tracking of impacts (unless major damages and repairs occur), especially at a county-wide scale. Tracking of nuisance flooding provides an important way of identifying problem areas that may get worse in the future. Although stormwater and drainage upgrades are likely to be expensive, there are many innovative designs that provide co-benefits and will become increasingly necessary as an adaptation strategy that can reduce flooding of transportation assets (and communities) without the need to redesign transportation systems. Existing plans by cities to implement green infrastructure requirements provide a positive step in this direction.

Fortunately, the Port of Stockton facility is already designed to adapt to rain events since the facility is sloped towards a drainage ditch (that ultimately drains into the San Joaquin River).<sup>54</sup> While this design prevents pooling of water, it may not be adequate to prevent flooding of the immediate area adjacent to the ditch should it overtop its banks.

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<sup>52</sup> Henterly, Emma Franklin. "Thunderstorms bring hail, heavy rain to north Stockton." The Record. May 19, 2019. <https://www.recordnet.com/news/20190519/thunderstorm-brings-hail-heavy-rain-to-north-stockton>

<sup>53</sup> Comment during Working group Meeting 2 and conversation between SJO CG and Airport Deputy Director (October 23, 2019)

<sup>54</sup> Phone call with Port of Stockton, Oct 2019 (ERG to add more detail)

It should be noted that extreme precipitation events can coincide with elevated delta water levels (a phenomenon known as “coastal coupling”). This is unlikely as major rainfall and snowmelt from higher elevations of the southern watershed are generally delayed by days to weeks and associated flood events do not occur at the same time as localized rain events. However, should precipitation-based flooding coincide with elevated delta water levels driven by tidal inflows as seas rise, some of the riverine flooding adaptation strategies will also apply to impacts and strategies connected to sea level rise.

### *Specific Areas of Concern:*

As discussed above, it is challenging to downscale projections of extreme rain events and identify those specific transportation assets that are most vulnerable to extreme precipitation events. In addition, risk of overland flooding from these events is impacted by on-the-ground conditions, such as soil type, soil moisture and stormwater system capacity. However, as the county considers upgrades to transportation assets and associated storm water systems, managers will need to account for a 21-25% increase in 100-year storm intensity at mid-century. Prioritizing effective drainage for the “most critical” assets identified above will support resilience of the transportation system since these transportation assets are highly networked and/or have far reaching impacts for evacuation, transit, and goods movement.

## **C. Wildfire**

### *Description of Stressor:*

The frequency and intensity of wildfire is expected to increase across much of California over the next several decades due to frequent intervals of floods (which create fuel from vegetation growth) and drought, increased temperature, and changing land-use patterns. However, the latest climate projections indicate that San Joaquin County impacts from extreme fires (average area burned) are expected to remain relatively consistent, with a slight decline into the future.

### *Overview of Projections:*

Future wildfire risk is projected in the California Fourth Climate Assessment (from University of California Merced).<sup>55</sup> The University of California Merced model analyzes conditions of past large fires and uses those patterns to predict future fires. In addition, the model draws on downscaled climate models for key inputs of future precipitation, temperature, and population change. Specifically, the model applies gridded downscaled climate simulations from four global climate models with each global climate model making slightly different future climate conditions as follows:

- HadGEWM2-ES: A warmer/drier simulation
- CNRM-CM5: A cooler/wetter simulation
- CanESM2: An average simulation

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<sup>55</sup> Westerling, Anthony Leroy. (University of California, Merced). 2018.

- MIROC5: A simulation unlike the first three to best cover potential outcomes

In considering this range of climate models in San Joaquin County, projections for annual averages of area burned in the county remain relatively unchanged or decline slightly when comparing modeled projections for today (average for the period 2004 to 2036) and the 2050 planning horizon (average for the period 2034 to 2065). For example, Appendix A, Table 4 below presents annual averages of area burned for two of the simulations, considering RCPs 4.5 and 8.5:

**Appendix A, Table 4. Annual mean hectares burned by wildfire in San Joaquin County 2004 to 2036 and 2034 to 2065 based on two of the climate models.**

Climate Model	RCP Scenario	Annual Mean Hectares Burned 2004 to 2036	Annual Mean Hectares Burned 2034 to 2065
<b>HadGEWM2-ES</b>	RCP 4.5	1,050 ha	985 ha
	RCP 8.5	1,015 ha	934 ha
<b>CanESM2 model</b>	RCP 4.5	1,000	920 ha
	RCP 8.5	945 ha	845 ha

These models do not show a trend of increase annual average area burned for San Joaquin County towards mid or end of century. While risk of extreme fire events will persist, fire risk is not on a clear upward trajectory like in many parts of the state.

It should be noted that there are limitations to current fire simulations. For example, more work is needed to incorporate downscaled winds and relative humidity. Thus, wildfire projections for the county could change with advances in future research.

While it will be essential for utilities, cities, counties, emergency managers, and others to monitor high winds under wildfire risk conditions in the immediate term, in terms of predicting long-term wildfire risk, higher velocity, more frequent wind events are not currently seen as climate stressors. Rather, it is simply drier winds (caused by climate change) that is the culprit. Initial climate projections for large wind events across the state are inconclusive but indicate that climate change may suppress Santa Ana winds in Southern California.<sup>56</sup> Much more research is needed to project climate impacts on the frequency and intensity of major wind events in the Central Valley and Northern California.

<sup>56</sup> Guzman-Morales, J., & Gershunov, A. (2019). Climate change suppresses Santa Ana winds of Southern California and sharpens their seasonality. *Geophysical Research Letters*, 46, 2772– 2780. <https://doi.org/10.1029/2018GL080261>

### Spatial Distribution of Impacts:

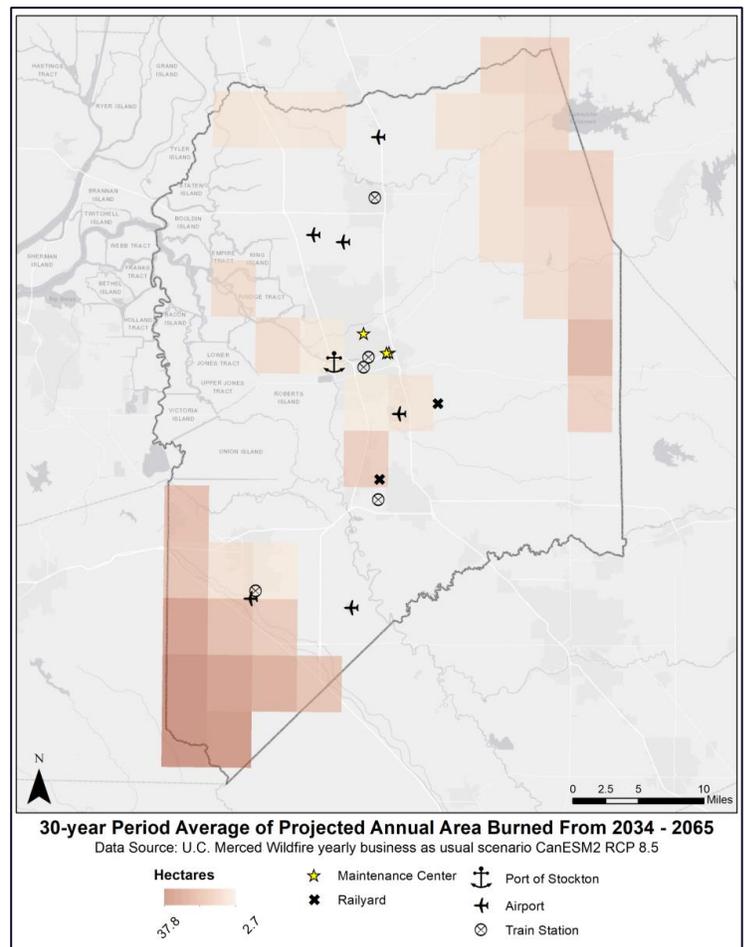
Mapped projections for average annual area burned for the period 2034 - 2065 (Figure 16) generally mirror the area designated by CAL FIRE as a fire hazard severity zone today (Appendix A, Figure 17).<sup>57</sup>

Both future wildfire projections and today's fire hazard severity zone indicate the greatest risk in the southwestern and northeastern sections of the county. In addition, future projections identify areas of growing risk along the I-5 corridor between Lathrop and Stockton and the area west of the Port of Stockton. As Appendix A, Figure 16 shows, the Tracy and Stockton Airports, Tracy ACE train station, the Port, and UP Intermodal Terminal, I-5 corridor are within areas with higher risk of wildfires than the rest of the county and disruptions in service could have ripple effects across the county.

### Impacts to Transportation System:

The road system is relatively resilient to direct physical impacts from wildfires, but wildfires can lead to temporary road closures, damaged traffic lights and signage, reduced visibility, and inhibited evacuation. Indirect impacts may occur post-wildfire should the fire be followed by rain in a sloped area and cause erosion and/or mudslides.<sup>58</sup> This is not a major risk in San Joaquin County, which is relatively flat.

Wildfires may also impact railroads with heat warping, melting metal components or causing wooden ties to combust. Such damage to tracks and rail infrastructure causes service disruption beyond the duration of the wildfire itself. Interruptions or damages to the Union Pacific Intermodal Terminal (which is located within a grid cell on Appendix A, Figure 16 that is projected to have several hectares burn annually) would have major negative consequences to the regional, state, and perhaps national economy. The facility provides expedited movement of double stack containers between the Port of Oakland and trans-shipment terminals in



**Appendix A, Figure 16. Average annual area burned over a 30-year period (2034-2065). A 30-year period was selected to reflect the time frame selected in Westerling et al.<sup>1</sup> Each of the grid cells mapped below is six by six kilometers.**

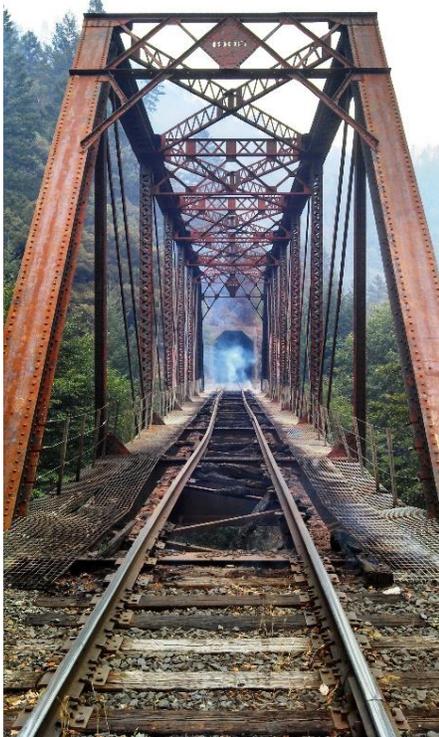
<sup>57</sup> CAL FIRE. Fire Hazard Severity Zone Maps. <https://osfm.fire.ca.gov/divisions/wildfire-prevention-planning-engineering/wildland-hazards-building-codes/fire-hazard-severity-zones-maps/#panel-cfc04a59-b28e-4f3e-a33b-73b57e5cbfb4>

<sup>58</sup> U.S. Department of Transportation & ICF International. 2014.

Pennsylvania and New Jersey. It also handles containers moving between California and Atlanta and connects Los Angeles with Dallas and Memphis.<sup>59</sup> This cross-country goods movement could be interrupted by a wildfire. In terms of commuter train movement, the Stockton ACE Train Station is also located in an area projected to experience an increase in average annual burn area. Any disruptions to the station would be felt by over 170,000 people (based on data from July 2018 to June 2019).<sup>60</sup>

Impacts of wildfires on airports and air travel have been documented. Wildfire flames too close to an airport can close airport operations.<sup>61</sup> Even if wildfire does not directly damage transportation assets, there can still be indirect effects. For example, wildfire smoke can cause flight delays and cancellations due to poor visibility and can affect worker safety due to poor air quality. A wildfire in the vicinity of the Stockton Airport could have wide reaching impacts given that the airport moved approximately 270 million pounds of landed cargo weight last

year and transported 100,000 passengers. The Tracy Airport is also located in the higher fire risk area, though consequences would not be as far reaching. The Tracy Airport's main role is general aviation and jet fuel sales, and hangar and tie down rentals, flight training, and aircraft rentals. It does not host a major commercial airline.<sup>62</sup>



**Appendix A, Figure 17. Fire damage to a railroad bridge (source: Bureau of Land Management)**

Another indirect impact associated with wildfire has emerged recently. PG&E's Public Safety Power Shutoffs (PSPSs) requires that electricity be temporarily cut under heightened fire risk conditions (low humidity and strong winds combined with certain topographies and fuel types)<sup>63</sup> to reduce the chance of fire caused by electrical equipment. While customers in highest fire-threat counties are most likely to be impacted, San Joaquin County is not immune to the shutoffs as was seen in October of 2019 when power was cut to the Town of Vernalis. Specific areas of the county that may be impacted in the future will depend on fire risk conditions. In general, PG&E power safety cuts may have wide reaching impacts on the transportation system such as loss of power to traffic signals and railroad crossings. The latter generally have battery backup power, which may last for a few hours. Plans must be in place to ensure that train crossing signals are always powered or otherwise operational. In addition, Caltrans, county, and city staff must coordinate to mark intersections with stop signs or ensure police officers can direct traffic should traffic lights lose power. The county and local governments

<sup>59</sup> <http://www.sicog.org/DocumentCenter/View/3721/Final-2018-RTPSCS-Technical-Appendix-L---Modal-Discussion?bidId=>

<sup>60</sup> Boardings by station provided by ACE (Sarah Rasheed over email, September 2019).

<sup>61</sup> U.S. Department of Transportation & ICF International. 2014.

<sup>62</sup> <http://www.sicog.org/DocumentCenter/View/17/2009-San-Joaquin-County-ALUCP---Amended-January-2018?bidId=>

<sup>63</sup> Pacific Gas and Electric Company. Amended 2019 Wildfire Safety Plan. February 6, 2019.

[https://www.pge.com/pge\\_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/Wildfire-Safety-Plan.pdf](https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/Wildfire-Safety-Plan.pdf)

have the adaptive capacity to develop the plans needed to support safe movement of traffic during power outages.

During PSPSs, both individual drivers and bus providers will find themselves unable to charge their electric vehicles. Bus providers must consider back up power given plans for the San Joaquin County bus providers to electrify their fleets by 2040. RTD has plans to construct a solar power facility to charge battery electric buses—such a project would help make the fleet resilient to power shutoffs by making buses independent of the grid. The next step will be for RTD to ensure that they’re meeting the specific transportation needs of the community during a power shutoff. Emergency planning for these circumstances must recognize that the community movement is likely to be outside of normal when various businesses are without power.

Finally, transportation providers rely on a functional cellular network to communicate changes in schedules, line closures, and other safety information to passengers. As such, a vulnerable cellular network during a power outage is also a vulnerability, unless providers develop alternative methods of communicating.

### *Specific Areas of Concern:*

Major areas of concern for wildfire risk include:

- 1) Stockton Airport
- 2) UPRR Intermodal Terminal
- 3) Electrical components of transportation system given PG&E power safety shutoff program
- 4) Tracy Municipal Airport
- 5) I-5 corridor which is an evacuation route (operating at a low level of service) and serves a route for more than five bus lines.

The consequences of interruption to the Stockton Airport, UPRR, and the Tracy Airport are described above. Interruptions to the I-5 would clearly be far reaching given it is major north-south corridor in the county and the region, plays a key role in the public transportation system, and emergency evacuation. As it is already operating at a low level of service, seemingly minor disruptions could have major impacts on the corridor.

## **D. Extreme Heat**

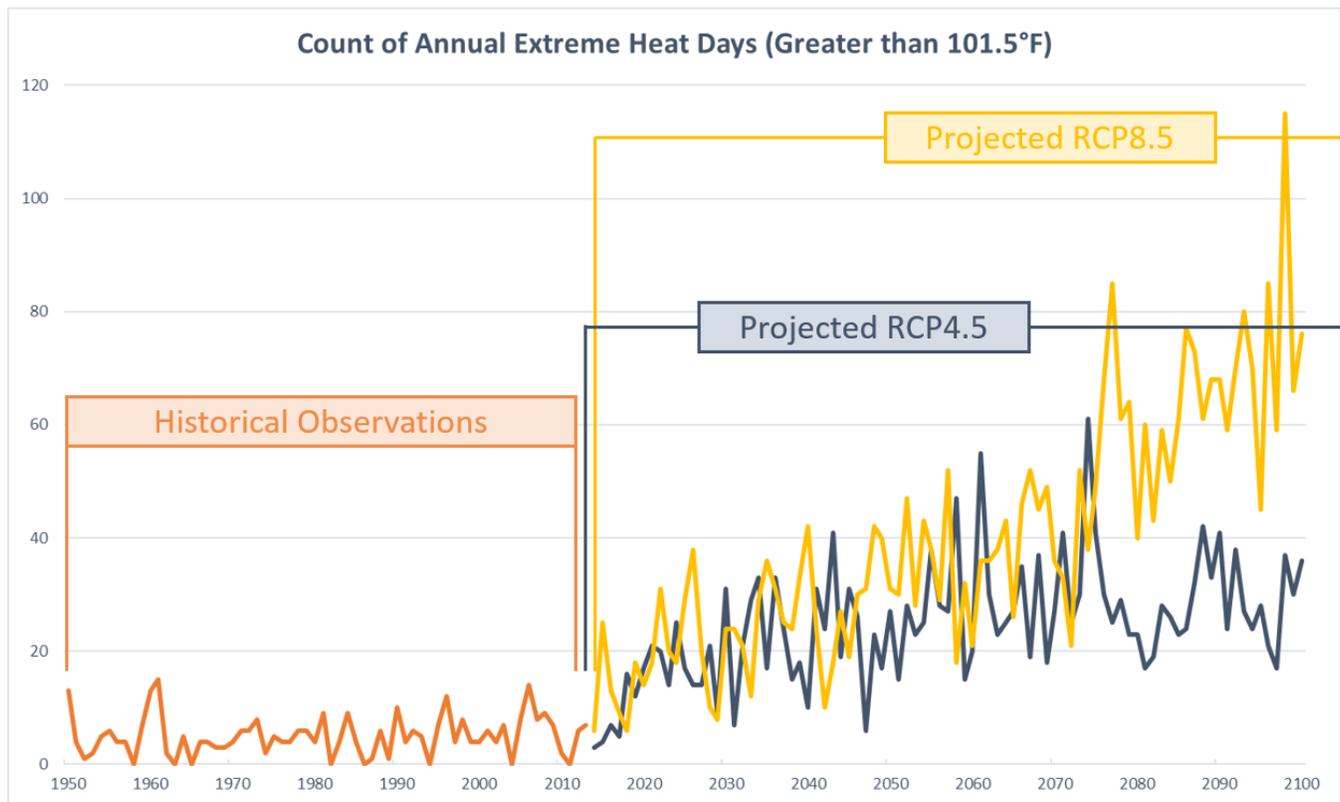
### *Description of Stressor:*

For most parts of the state, and certainly San Joaquin County, climate models show a significant rise in the number of days considered extremely hot for an area. There are several ways of defining the threshold temperature for extreme heat locally. We will apply the default definition for extreme heat threshold applied in California’s Fourth Climate Assessment: 98th historical percentile of the maximum and minimum temperatures from 1961 to 1990 between April and October. In San Joaquin County, the 98th percentile is 101.5 degrees Fahrenheit with observed historical data (1961-2005) indicating that extreme heat days occur four times per year on average.

### Overview of Projections:

Review of the heat projections produced through the LOCA Downscaled CMIP5 Climate Projection from Scripps Institution of Oceanography shows a consistent rise in number of extreme heat days (temperature over 101.5°F) over the coming decades. Historically (1950-2013), the number of extreme heat days averaged five days per year. The projection shows that the number of extreme heat days will reach an average of 22 times per year (2014-2065) under RCP 4.5 and 26 times per year under RCP 8.5. This increase in extreme heat days is shown in Figure 18 below.

**Appendix A, Figure 18. Annual extreme heat days (over 101.5°F) in San Joaquin County. Historical observed data are shown from 1950 to 2013 and projected days from 2014 to 2100 under RCP4.5 and RCP8.5.**



Based on this data, the County will face increasing frequency of extreme heat events.

*Impacts to Transportation System:*

These extreme heat days will impact passenger and freight rail. In order to reduce the risk of rails buckling at high temperatures, train operators must implement policies of reducing train speeds in the heat of the day. Various operators apply different policies, as indicated in Appendix A, Figure 19 below.<sup>64</sup>

**Appendix A, Figure 19. Railroad heat restrictions to prevent rail buckling.**

Railroad	Temperature (F)	Restricted Speed
Amtrak	95°F	Passenger: Max 80 mph
BNSF	85-115°F	Passenger: 70 mph to 50 mph Passenger: Max 65 mph Freight: 50 mph to 40 mph
UP	100-115°F	Passenger: 50 mph Freight: 40 mph

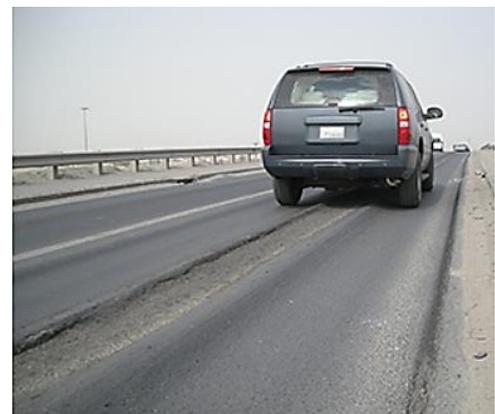
Amtrak, BNSF, and Union Pacific Railroad will certainly have to increase the frequency with which they operate under speed restrictions given rising temperatures. The consequence of regularly restricting speed and delaying schedules could be significant. San Joaquin County is one of the country’s biggest agricultural producers and is increasingly home to distribution centers. As such, on time movement of goods to support those industries is important to the local economy.

Extreme heat days also present challenges to all of the county’s airports. Potential damages range from runways (e.g. risk of concrete buckling) to issues with flight takeoff. When high temperatures and moisture reduce air density, aircraft lift is reduced. This means more runway space is needed for takeoff, which is a more pronounced issue at high altitudes. Reducing payload or restricting types of planes can also help manage this situation, which also has its economic consequences.

Increased heat will impact the county’s roads, with high temperatures over long periods causing pavement to soften, leading to rutting. Pavement is selected with an expected temperature range in mind.<sup>65</sup> As such, existing pavement was not designed for the extremes of our mid-century climate and will likely need to be replaced with new types of pavement binders to prevent or address deterioration.

Extreme heat days will also present challenges for the bus system as buses risk overheating. It may also be unhealthy for passengers to wait for buses outside.

Finally, the health and safety of workers is a challenge that cuts across all transportation assets. Managers of these transportation assets must implement policies to ensure the safety of their workers under extreme conditions.



**Appendix A, Figure 20. Example of severe rutting of asphalt pavement (source: FHWA, Public Roads Magazine)**

<sup>64</sup> Chinowsky, Paul, et al. "Impacts of climate change on operation of the US rail network." *Transport policy* (2017).

<sup>65</sup> U.S. Department of Transportation & ICF International. 2014.

## E. Drought

### *Description of Stressor:*

The latest research indicates, with medium-high confidence, that we can expect increasing frequency of drought in California. Recent studies suggest an increasing likelihood of a “mega-drought” occurring in the Southwestern U.S. in the 21st Century.<sup>66</sup> Such a drought has far reaching implications for California and these impacts apply to transportation along with other infrastructure.

### *Overview of Projections:*

Under California’s Fourth Climate Change Assessment, researchers modeled maximum temperature, minimum temperature, and average annual precipitation (among other variables) for an early and late 21st century mega drought (defined as 20 years). Below are the outputs for the watershed to the west of Stockton (covering Walker Basin Creek, Caliente Creek, Tejon Creek, Lake Paulina-Comanche Creek, Grapevine Creek) to provide example impacts for the San Joaquin area:

**Appendix A, Table 5. Projected daily maximum/minimum temperature and precipitation during an early century mega-drought**

	Observed Historical (1961—1990)	Drought Scenario (2023-2042)
Maximum daily temperature (calendar year)	74.1 degrees F	78.6 degrees F
Maximum daily temperature (calendar year)	47.2 degrees F	50.4 degrees F
Precipitation (accumulated rainfall and snowfall)	13.5 inches	11.3 inches

This modeling exercise shows a clear temperature increase and decline in annual precipitation under an extended drought scenario in the southwest.

### *Impacts to Transportation System:*

Drying and shrinking of wetlands and earth beneath roads can lead to cracking and splitting of asphalt. Drought may also weaken vegetation along roadways and other transportation assets, making the vegetation more susceptible to pests—this can lead to issues with debris.<sup>67</sup> Dry, cracked soil can also become prone to erosion during rainstorm. Drought may also lead to lower water levels in the delta which may impact ship docking at stationary (as opposed to floating) docks.<sup>68</sup>

<sup>66</sup>Cook, B.I., T.R. Ault, and J.E. Smerdon, 2015: Unprecedented 21st-century drought risk in the American Southwest and Central Plains. *Sci. Adv.*, 1, no. 1, e1400082, doi:10.1126/sciadv.1400082.

<sup>67</sup> Federal Highway Administration. *Vulnerability Assessment and Adaptation Framework*, 3<sup>rd</sup> edition. 2017.

[https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation\\_framework/climate\\_adaptation.pdf](https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/climate_adaptation.pdf)

<sup>68</sup> U.S. Department of Transportation & ICF International. 2014.

Drought may also increase the probability of wildfires and is often tied to extreme heat events. Drought is expected to have similar impacts across the entire county and region, so it is not possible to map specific drought impacts on the transportation system.

## Priority Vulnerabilities

The interdisciplinary working group reviewed the vulnerability assessment for each climate stressor and considered the vulnerabilities identified in light of the resilience goals for the project. In doing so, the working group identified a set of transportation assets considered highest priority for adaptation action given their exposure and sensitivity to climate impacts as well the consequence of disruption. The group considered adaptive capacity where possible. The following assets were flagged by several working group members as being highly vulnerable and in need of priority action:

- **SR-99 through Lodi:** This segment of SR-99 was identified as a priority vulnerability by the working group because it is within the 500-year floodplain and serves key functions for the local community and the region. Flood risk originates from the Mokelumne River, with berms west of SR-99 providing protection from flows slightly greater than the 100-year event.<sup>69</sup> SR-99 includes a bridge that crosses the Mokelumne River (and the 100-year floodplain) in Lodi. This section of freeway is a bus corridor (connecting Lodi and Stockton) and an evacuation corridor that is already operating at a deficient level of service. The route is already congested during rush hour, so it can become overwhelmed during an evacuation.

SR-99 is a key connection between Lodi and the Sacramento Region, and Lodi has many residents who commute to the Sacramento Region.<sup>70</sup> Significant disruptions would occur should the route face flooding and/or become overly congested during an evacuation. Although there are alternative (and slightly longer) routes between Lodi and the Sacramento Region (via I-5) and between Lodi and Stockton (via West Lane), effective communication procedures and adequate infrastructure is needed to inform the public of the need to reroute during a flood and/or evacuation.

- **South Stockton Neighborhood:** Major roadways running through the South Stockton neighborhood include S. El Dorado Street, S. Airport Way, and S. Wilson Way, all of which run North-South. SR-99 forms the eastern edge of the neighborhood, with I-5 forming the western edge of the neighborhood. East Charter Way and SR-4 run East-West through the neighborhood with SR-4 forming the northern boundary.<sup>71</sup>

Impacts to the transit system are a major concern for this neighborhood, which has a disproportionately high percentage of transportation-disadvantaged communities compared to the county as a whole. Several bus stops are within the 100-year floodplain and dozens are in the 500-year floodplain. While

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<sup>69</sup> City of Lodi. General Plan (2010): Safety Element. <https://www.lodi.gov/DocumentCenter/View/196/Chapter-8---Safety-PDF>

<sup>70</sup> SJCOG. RTP/SCS (2018): Appendix M1 Plan Performance <https://www.sjocog.org/DocumentCenter/View/3803/Final-2018-RTPSCS-Technical-Appendix-M---Plan-Performance-and-Regional-Progress-Report?bidId=>

<sup>71</sup> City of Stockton. General Plan Update (2014). <http://www.stocktongov.com/files/StocktonNeighborhoodsMap.pdf>

bus rerouting is likely an option in the event of an interruption, all changes must be effectively communicated to passengers. Bus and train stops in these transit-dependent neighborhoods also need to accommodate passengers' needs for protection from heat and rain as weather events become more extreme.

**Appendix A, Figure 21. Exposure of critical transportation assets and the South Stockton UPRR Railyard to flood risk in South Stockton**



Transit Stops	SJV Trucking Connectors	Evacuation Routes	Flood Zones	Limited Access	Supporting Services
● Not in Flood Zone	— 100-year	— 100-year	■ 100-year	— Highway	★ Maintenance Center
● 100-year	— 500-year	— 500-year	■ 500-year	— Major Road	✕ Railyard
● 500-year	— 500-levee	— 500-levee	■ 500-levee	▭ County Border	⚓ Port of Stockton
● 500-levee				⊗ Train Stations	✈ Airport

The Union Pacific Railroad Stockton Railyard is a support facility for railroad operations located within the neighborhood. Although the railyard is an area of “undetermined flood hazard” according to FEMA, it is immediately surrounded by 500-year floodplain. The railyard includes a locomotive service track, a locomotive maintenance shop, a freight car repair shop, a wastewater treatment plant, maintenance buildings and storage areas, and facilities supporting railroad operations. The Altamont Commuter Express (ACE) commuter rail uses a portion of the yard to service its trains.<sup>72</sup> Flooding of tracks and maintenance facilities could have broader system-wide impacts and create access issues for workers. In addition, any flooding of the area raises concerns about movement of any hazardous materials used or stored at the facilities.

- **Stockton Metropolitan Airport:** The Stockton Airport is playing an increasingly important role in the region, due to growth in passenger flights, new airlines and flights and growth in cargo transport. Total cargo weight jumped more than 80% in 2017 and then fell by 19% in 2018 (these values are not yet available for 2019).<sup>73</sup> Growth in cargo transport is driven in part by growth of warehouse and logistics jobs in the County, with an Amazon fulfillment center located at the airport. Amazon is now one of the major employers in the County.<sup>74</sup> Airport runways are located within the 100-year floodplain. Since timely delivery is important to logistics and Amazon’s business, interruptions due to flooding pose a serious economic risk. Wildfire and extreme heat could also impact business operations and perhaps limit future employment opportunities. Wildfire and smoke-related visibility impacts are of concern given that the airport lies in a location projected to have a minor increase in average annual area burned at mid-century. Increased flood protection infrastructure will likely be needed to address flood risk as well as contingency plans (e.g. shifting flights to cooler hours during a heat wave) to address extreme heat impacts.

The 2018 RTP includes over a dozen airport projects, including runway rehabilitation, taxiway reconstruction, and terminal expansion and modernization.<sup>75</sup> The latter project is included on the list of projects under SJCOG’s One Voice Program, a legislative advocacy program for the County that promotes issues of regional significance to federal legislators and agencies in Washington, D.C.<sup>76</sup> As federal, state, and private funds are invested in these projects, there will be opportunities to integrate resilient designs to support the longevity of the projects, regional economy, and surrounding communities and ecosystems under a changing climate.

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<sup>72</sup> California Air Resources Board. “Health Risk Assessment of the Union Pacific Railroad Stockton Railyard.” 2007. [https://ww3.arb.ca.gov/railyard/hra/up\\_stockton\\_hra.pdf?\\_ga=2.259367374.574678899.1579126071-599391694.1537899981](https://ww3.arb.ca.gov/railyard/hra/up_stockton_hra.pdf?_ga=2.259367374.574678899.1579126071-599391694.1537899981)

<sup>73</sup> Federal Aviation Administration. “CY 2018 Final All-Cargo Landed Weights” [https://www.faa.gov/airports/planning\\_capacity/passenger\\_allcargo\\_stats/passenger/media/cy18-cargo-airports.pdf](https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy18-cargo-airports.pdf)

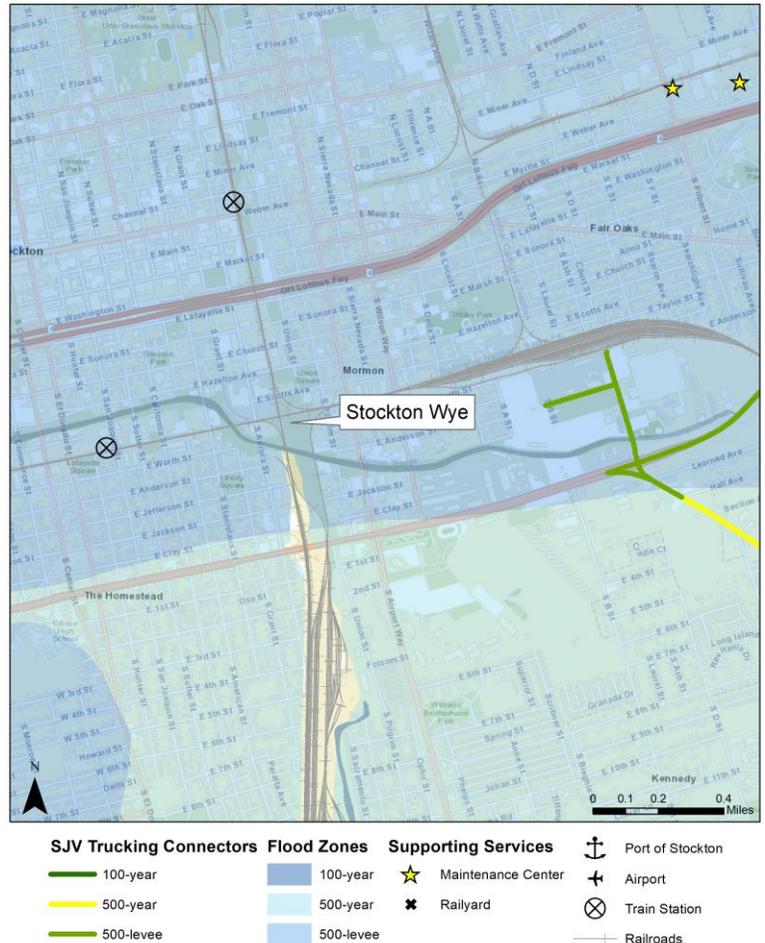
<sup>74</sup> California Employment Development Department. “Major Employers in San Joaquin County.” 2020. <https://www.labormarketinfo.edd.ca.gov/majorer/countymajorer.asp?CountyCode=000077>

<sup>75</sup> SJCOG. RTP/SCS (2018): Appendix F: Plan Project List <https://www.sjcog.org/DocumentCenter/View/3716/Final-2018-RTPSCS-Technical-Appendix-F---Plan-Project-List?bidId=>

<sup>76</sup> SJCOG. “2019 One Voice Project List” <https://www.sjcog.org/DocumentCenter/View/4728/2019-Project-Summary-List>

The Stockton Airport also provides military and emergency service functions, including hosting ground and aviation activities of the California Army National Guard.<sup>77</sup> Given that the National Guard provides important services domestically and abroad, interruption of their activities is problematic. Additional research is needed to determine how easily they can adapt their facility or relocate to meet their needs.

- Stockton Wye:** Stockton Wye is where tracks cross between the North-South Union Pacific Fresno Subdivision and the East-West BNSF Stockton Subdivision. New projects are moving forward to extend Northwest Wye tracks to allow direct movement of Union Pacific (UP) freight trains to and from the Port of Stockton without crossing the BNSF diamond to avoid delays and congestion for freight trains and grade crossings. This will support lower operating costs for trains serving the Port of Stockton. The Wye is currently mapped in the 500-year floodplain in an area with levees that may offer some level of flood protection, although the levees are not accredited for 500-year protection. Any disruption to this key intersection in the rail system would have significant impacts to goods movement from the Port and across the system.<sup>78</sup> The planned changes to the Wye may limit disruptions by creating additional connectivity and potentially prevent a single failure from delaying both UP and BNSF trains. It is important for train operators and the port to have repair and backup systems in place in the event of any disruption across their system and to prioritize repairs and protection action at critical points, such as the Wye.



**Appendix A, Figure 22. Flood risk at the Stockton Wye where the Union Pacific and BNSF tracks cross.**

Train operators can help the Wye and train system adapt to heat impacts by implementing a range of practices such as monitoring for extreme heat, slowing trains, and adjusting outdoor work schedules.

<sup>77</sup> SJCOG. “Stockton Metropolitan Airport Master Plan (2009)” <https://www.sigov.org/WorkArea/DownloadAsset.aspx?id=10378>

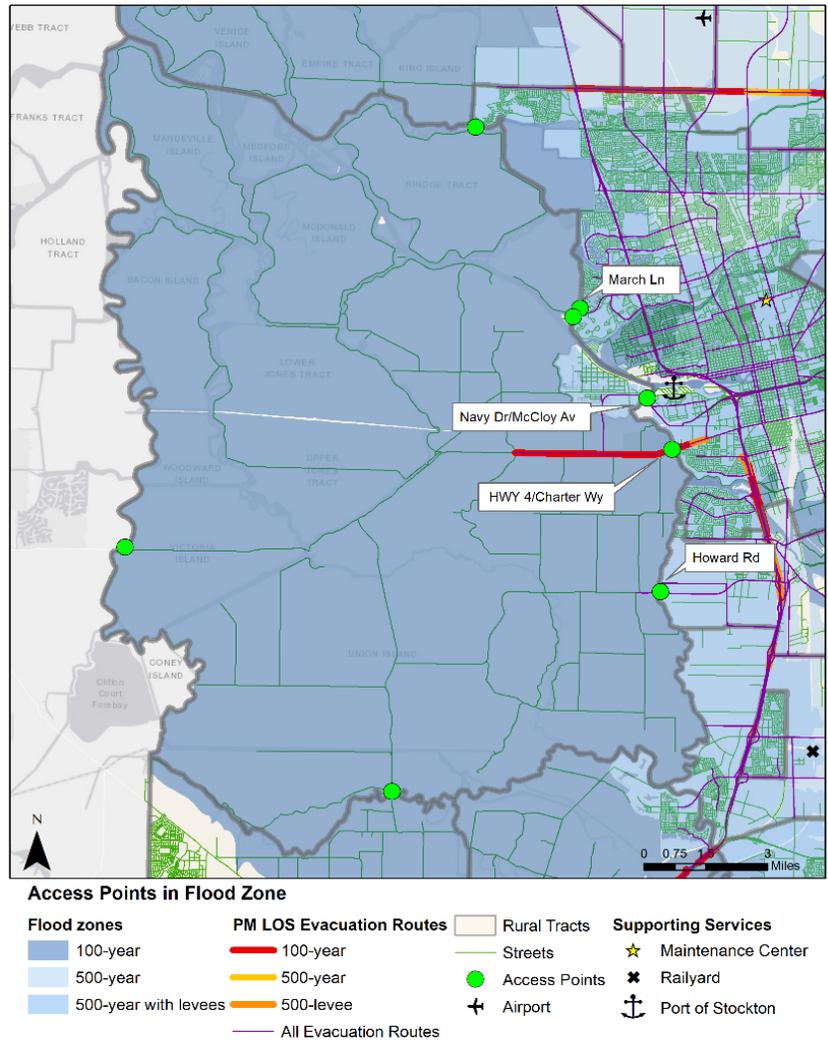
<sup>78</sup> SJCOG. “2017 One Voice Project: Stockton Freight & Passenger Rail Mobility Enhancement” <https://sjcog.org/DocumentCenter/View/612/San-Joaquin-Regional-Rail-Commission?bidId=>

- SR-4 from Stockton west to Contra Costa County.** Carrying approximately 10,000 vehicles per day (11 percent of which are trucks as of 2017), the route plays an important role in economic development; commuter, agriculture, and goods movement; and recreation access to the San Joaquin Delta. This road also plays an important role in evacuation from the San Joaquin Delta in the event of flooding, such as the breach of the Upper Jones Tract that occurred in 2004.<sup>79</sup>

This evacuation route is operating at a deficient level of service and runs through the 100-year floodplain. In addition, it transects tracts that are projected to be flooded under one foot of sea level rise (plus storm) scenario. It is important to reduce flood risk along this roadway because it serves a rural area with few alternative access points. The rural tract it connects to at the western edge of the county has a relatively low population (less than 1,500 people). The tract has eight access points in total, seven of which are in the 100-year floodplain.

SJCOG is promoting the SR-4 Corridor Improvement Project to expand lanes and safety of SR-4, which is the major road traversing the County.<sup>80</sup> Flood adaptation measures could be further integrated into the project.

- BNSF Intermodal Railyard, Stockton.** The facility lifts approximately 300,000 container units annually and serves as a major network hub between Northern California and the Midwest. Interruptions to the facility would have major economic consequences. There are additional plans to



**Appendix A, Figure 23. Flood risk to access points and evacuation routes in the rural, western side of the county**

<sup>79</sup> SJCOG. “2017 One Voice Project: SR 4 Corridor Improvements” <https://www.sjocog.org/DocumentCenter/View/580/San-Joaquin-County-?bidId=>

<sup>80</sup> SJCOG. “2017 One Voice Project: SR 4 Corridor Improvements” <https://www.sjocog.org/DocumentCenter/View/580/San-Joaquin-County-?bidId=>

expand the capacity of the facility. Future expansion and investment could provide opportunities to address flooding from its location in the 100-year floodplain.

The working group and study team also identified an additional set of vulnerable assets for further investigation:

- **Port of Stockton.** The Port is a key center of multi-modal logistics in the county and includes warehouse space, serves 130 tenants, has 700 acres for development and represents over 5,000 jobs. While the Port generally has 100-year flood protection, some of its access roads do not. In addition, it does not have accredited 500-year flood protection.
- **I-5 between Tracy and Lathrop.** This route operates at a deficient level of service but plays a key evacuation function and is heavily used by the bus system, serving more than five bus lines. This segment of I-5 is located within the 100-year floodplain.
- **Waterloo Road/CA-88.** This evacuation route originates in the 100-year floodplain and then moves east into the 500-year floodplain that serves the City of Stockton as well as residents of the Waterloo area. The rural and large elderly demographics in the Waterloo area must be accounted for in evacuation planning for this area. The Waterloo community consists of over 25% individuals aged 65 and above.
- **Bus stops serving transit-dependent census tracts in downtown Stockton, the Hammer Triangle area, and the Harrell Park area.** Approximately two dozen of these bus stops are in the 100-year floodplain, with several dozen located in the 500-year floodplain. Since the City of Stockton has the highest percentage of households without cars of all cities and census designated places in the county (10%), protection of the bus system is essential. This is especially important as the region seeks to improve transit and reduce single passenger car trips.

The list of assets above are priority vulnerabilities identified by the working group and study team to provide a starting point to direct adaptation planning in the region. Some of the vulnerabilities can be addressed through site-specific infrastructure investments (often requiring a combination of local, state, and regional investment and collaboration) and others may require cities or the county to revisit their evacuation procedures. Adaptation actions will be developed in a follow-up study led by SJCOG.

#### Topics for Future Study:

Assets for a more detailed future vulnerability assessment include:

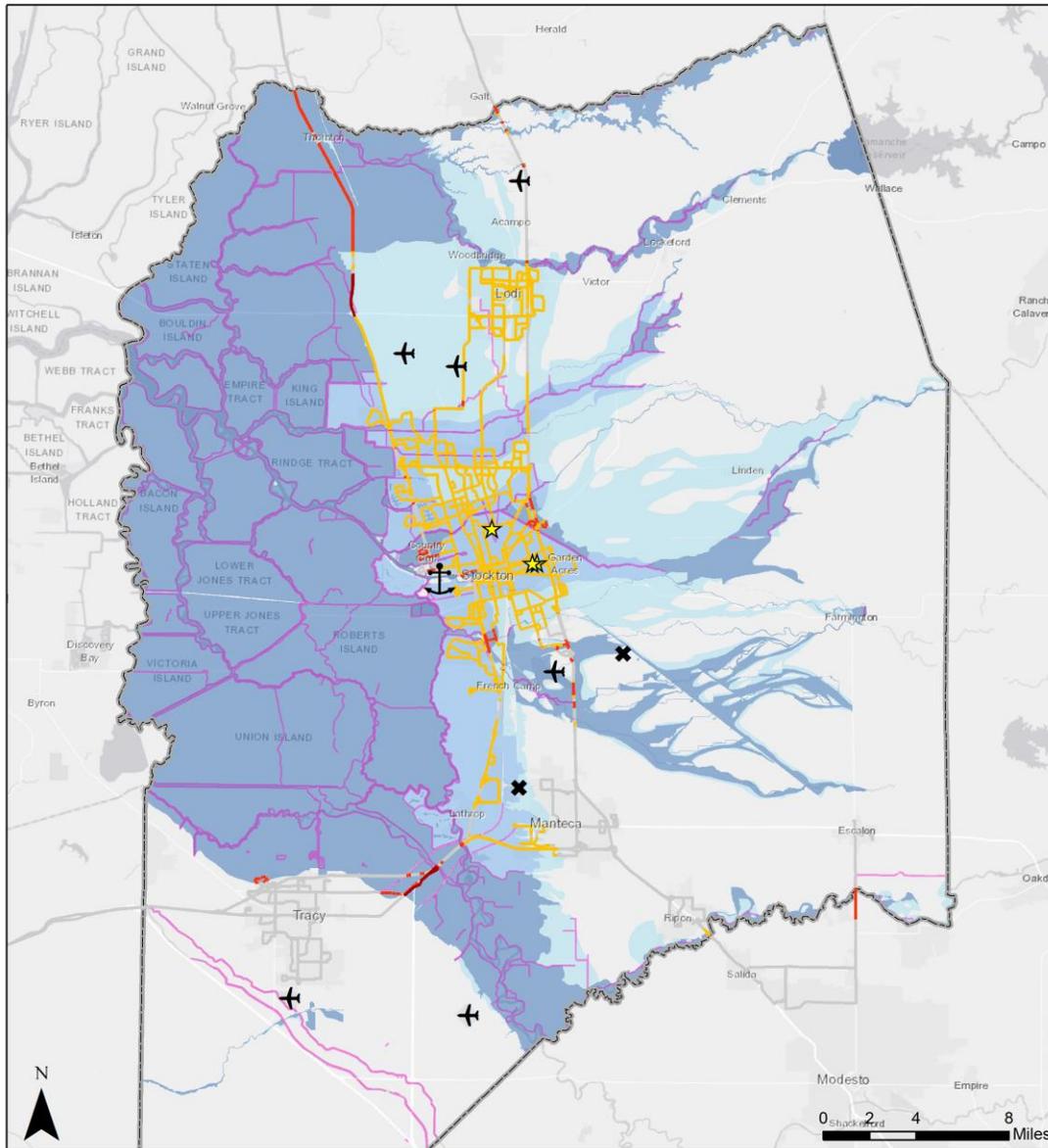
- **Railroad tracks**
- **Bridges** based on bridge clearance and condition data
- **Helipads** and their role in emergency services

## Appendix B: GIS Data Sources

Data Type	Layer	Source	File Name
Census Tract	Population	American Fact Finder	ACS_17_5YR_B01003_with_ann.csv
	Census Tracts	Census Bureau	CensusTract.shp
Congested Roadways	Basic Freeway Segments		SR120_BFS, SR205_BFS, SR4_BFS, SR580_BFS, SR99_BFS.shp
	Multi-Lane Highway Segments		SR132_MLH.shp
	RCMP Intersections		RCMP_Intersections.shp
	Two Lane Highway Segments		SR12_88_TLH, SR120_TLH, SR132_TLH, SR26_TLH, SR33_TLH, SR4E_TLH, SR4W_TLH.shp
Evacuation Routes	Evacuation Route	San Joaquin County GIS <a href="http://www.sjmap.org/evacmaps/">http://www.sjmap.org/evacmaps/</a>	EvacRoute_CL.shp
	Airports		Airports.shp
	Streets	San Joaquin County GIS sjmap.org	Streets.shp
	Trucking		SJV_Key_Connectors
Flood risk	FEMA Flood zones	<a href="https://msc.fema.gov">https://msc.fema.gov</a>	NFHL_06_20191015.gdb S_Fld_Haz_Ar
	1ft and 3ft SLR	Delta Stewardship Council	SLR_1foot.shp, SLR_3feet.shp
	Levees	<a href="https://msc.fema.gov">https://msc.fema.gov</a>	NFHL_06_20191015.gdb S_Levees
Ridership	Ridership	ACE	ACE Ridership by Station.ppx and .xlsx
Rural Transport	Rural Transport	SJCOG	Q3-4_to_3-8.shp
Trains	Trains	San Joaquin County GIS <a href="http://www.sjmap.org/evacmaps/">http://www.sjmap.org/evacmaps/</a>	Railroads.shp
Transit	tracy-ca-us (3)	SJCOG	
	Ripon Blossom Bus	SJCOG	
	Manteca 2019	SJCOG	
	Lodi Sep 2016	SJCOG	
	Escalon Dec 2018	SJCOG	
	RTD_Jan_2019	SJCOG	
Transit Hubs	Transit Hubs	SJCOG	Transit_Hubs.shp
	Additional Hubs	SJCOG	Mountain House Station from Valley Link Feasibility Report.pdf
Wildfires	U.C. Merced Wildfire yearly business as usual scenario CanESM2 RCP 4.5	<a href="https://cal-adapt.org/data/download/">https://cal-adapt.org/data/download/</a>	fire_CanESM2_45_AA.all.bau.1954-2100
	U.C. Merced Wildfire yearly business as usual scenario CanESM2 RCP 8.5	<a href="https://cal-adapt.org/data/download/">https://cal-adapt.org/data/download/</a>	fire_CanESM2_85_AA.all.bau.1954-2100
Bike Paths	Bike Paths	SJCOG	Bike Paths
	Updated Bike Paths	SJCOG	Stockton_BackboneNetwork_Data.gdb

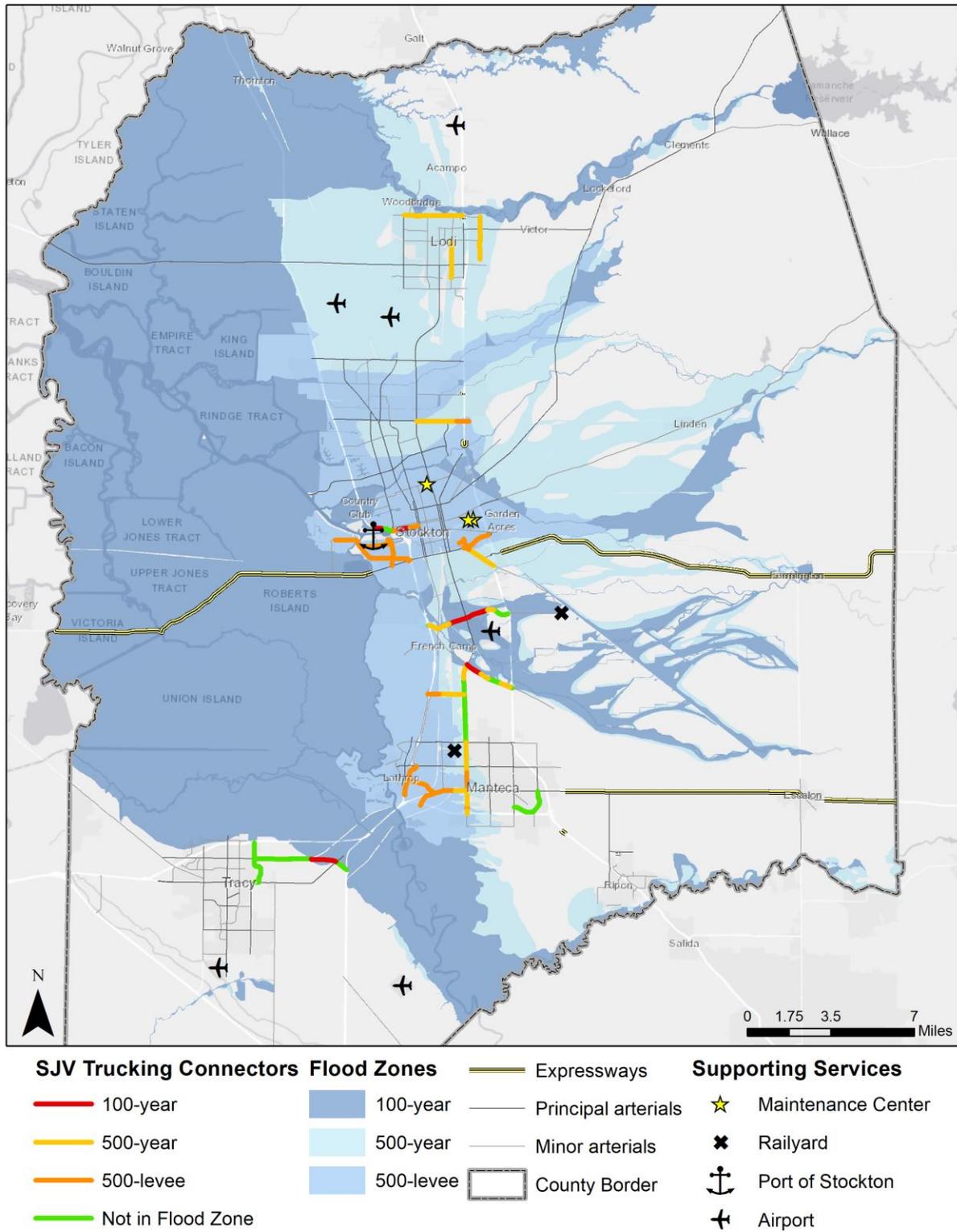
# Appendix C: Sea level rise and riverine flood risk exposure maps

Appendix C, Figure 1. Transit Route exposure to 1ft & 3ft of sea level rise and 100-year & 500-year floodplain

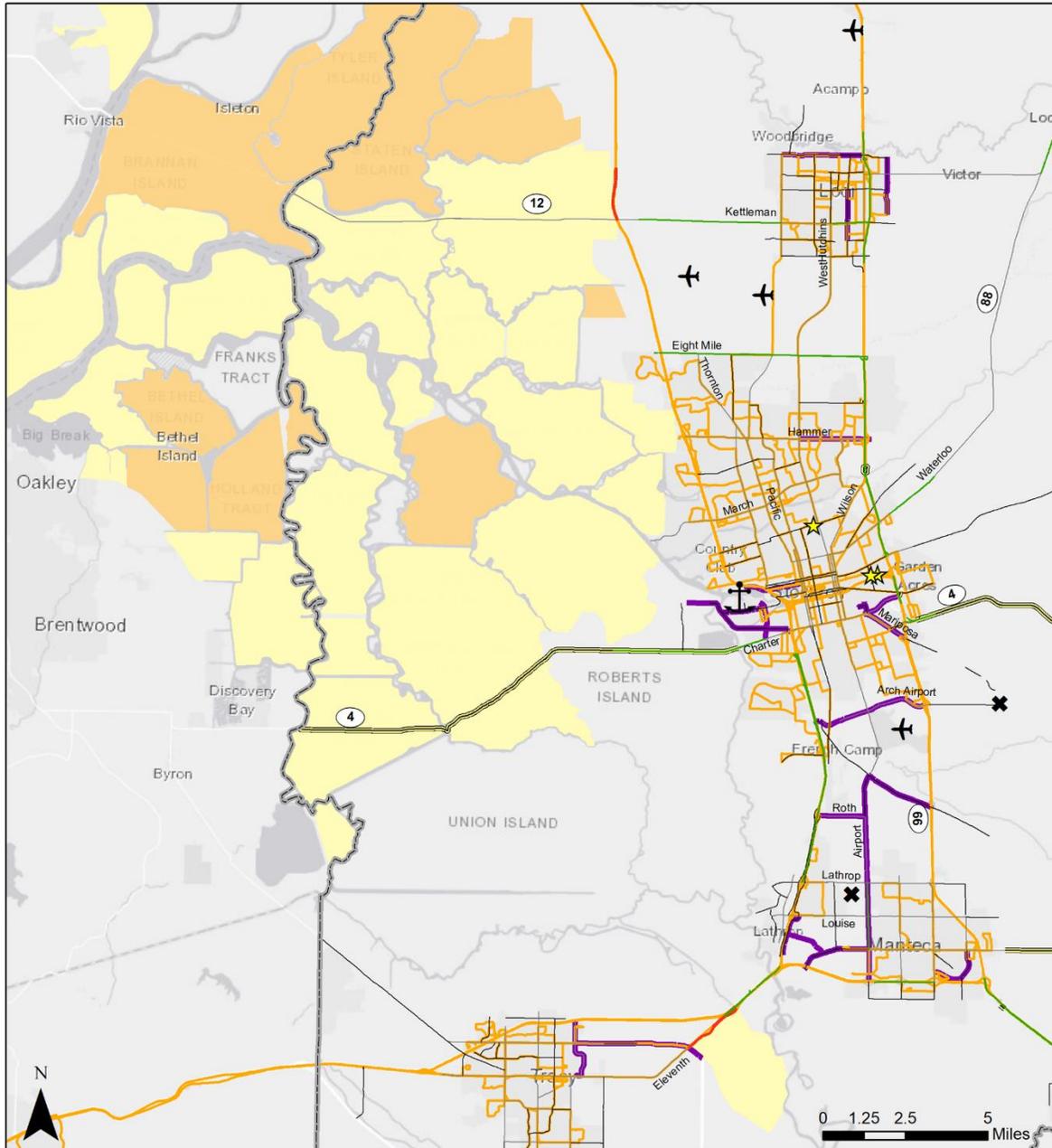


Transit Routes in Flood Zones	Flood Zones	Supporting Services
<span style="color: red;">—</span> 100-year	<span style="background-color: #4682B4;"> </span> 100-year	<span style="color: gold;">★</span> Maintenance Center
<span style="color: yellow;">—</span> 500-year	<span style="background-color: #ADD8E6;"> </span> 500-year	<span style="color: black;">✕</span> Railyard
<span style="color: red;">—</span> Sea Level Rise	<span style="background-color: #6495ED;"> </span> 500-levée	<span style="color: black;">⚓</span> Port of Stockton
<span style="color: gray;">—</span> Not in Flood Zone	<span style="border: 1px solid black;"> </span> County Border	<span style="color: black;">✚</span> Airport

**Appendix C, Figure 2. Goods movement: first- and last- mile connector exposure to 100-year & 500-year floodplain**



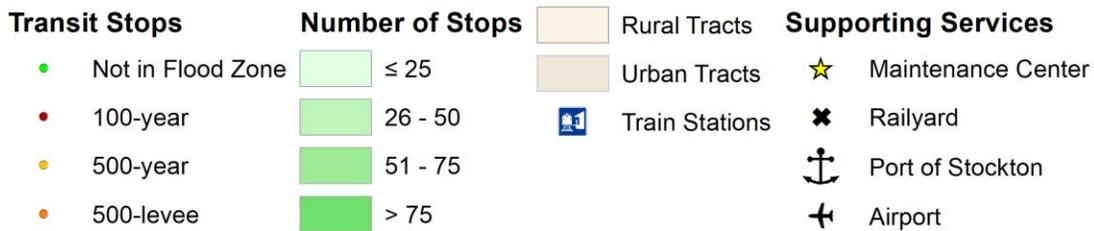
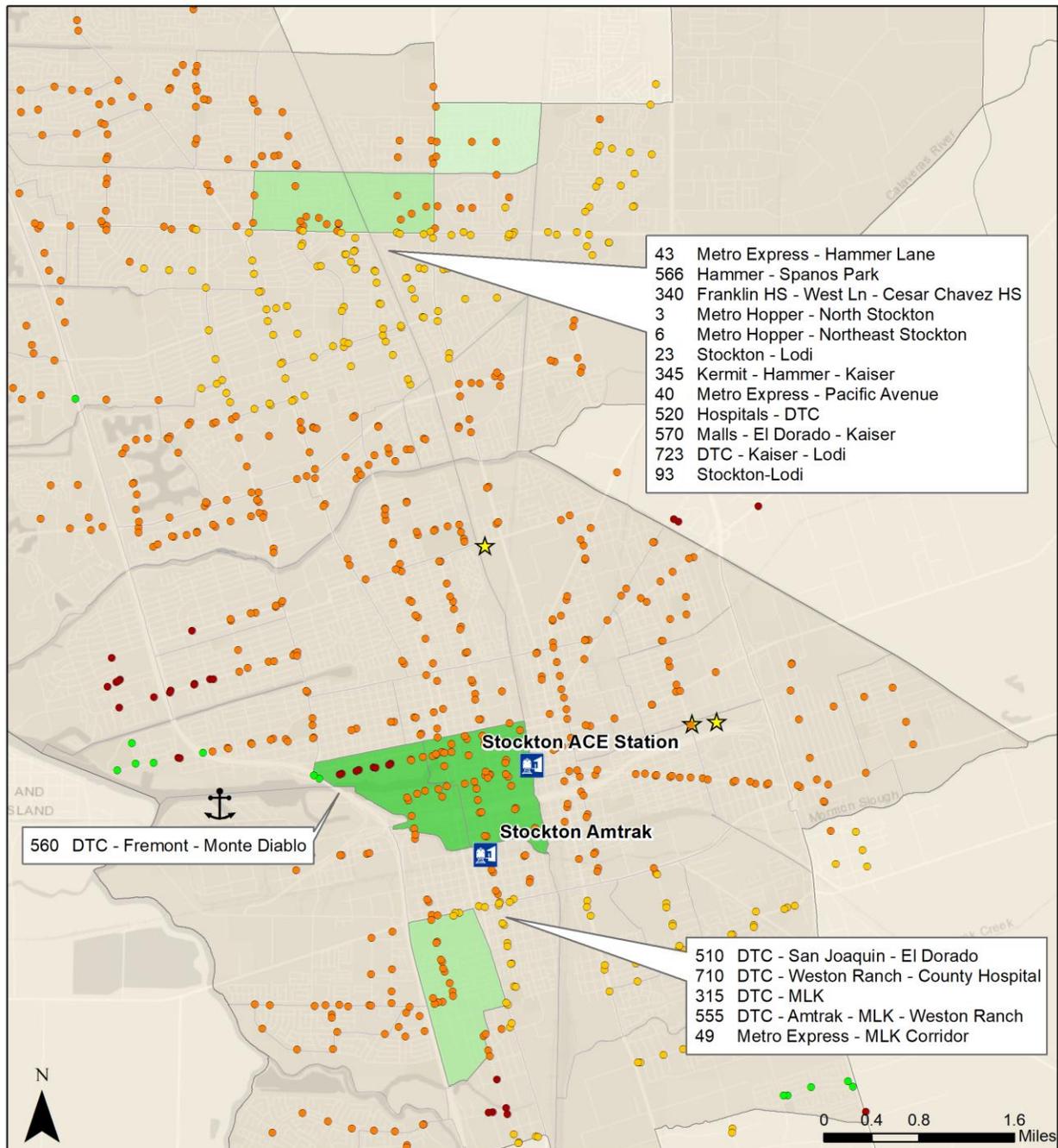
**Appendix C, Figure 3. Exposure of Transportation Assets to Sea Level Rise plus '97 storm**



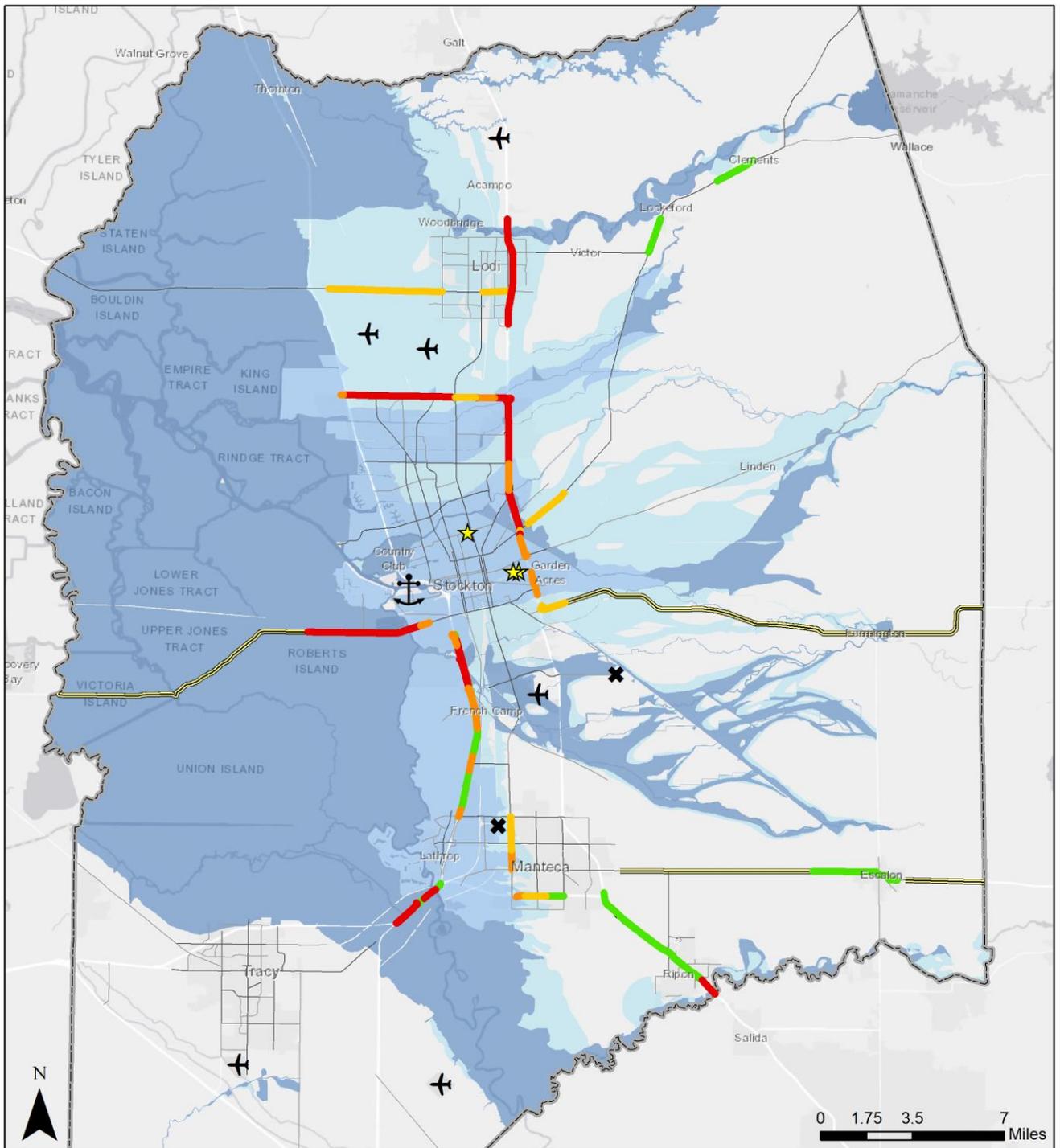
**Exposure of Transportation Assets to Sea Level Rise plus '97 storm**

- |                               |                       |                       |                    |                            |
|-------------------------------|-----------------------|-----------------------|--------------------|----------------------------|
| — Evacuation Routes PM LOS    | — Expressways         | <b>Sea Level Rise</b> | □ County Border    | <b>Supporting Services</b> |
| — Transit Routes in 1/3ft SLR | — Principal arterials | ■ 1-foot              | ⚓ Port of Stockton | ★ Maintenance Center       |
| — All Transit Routes          | — Minor arterials     | ■ 3-feet              | ✈ Airport          | ✖ Railyard                 |
| — SJV Key Trucking Connectors |                       |                       |                    |                            |

**Appendix C, Figure 4. Flood risk to transit stops serving transportation-disadvantaged urban tracts (higher than county average occurrence of all four characteristics of transportation disadvantage)**



Appendix C, Figure 5. Flood risk.



- | Evacuation Routes | Flood Zones | Expressways         | Supporting Services |
|-------------------|-------------|---------------------|---------------------|
| 100-year          | 100-year    | Expressways         | Maintenance Center  |
| 500-year          | 500-year    | Principal arterials | Railyard            |
| 500-levee         | 500-levee   | Minor arterials     | Port of Stockton    |
| Not in Flood Zone |             | County Border       | Airport             |

## Appendix D: Existing Adaptation Planning Efforts

The following is a summary of adaptation planning directly and indirectly targeted at transportation infrastructure in San Joaquin County. Preparation of this memo included a review of adaptation plans by the county, regional and state agencies, cities, and transportation managers. In cities where climate adaptation planning has been limited to date, this memo also provides a brief overview of hazard mitigation plans, general plan safety elements, and related plans given that adaptation planning and hazard mitigation are closely linked. All cities and counties are required by the state to integrate climate adaptation and resiliency strategies into the safety element of their general plan upon next revision (SB 379).

### Adaptation Planning at the county-scale:

1. **San Joaquin County Climate Change and Health Profile Report (2017):** This report, produced by the CA Department of Public Health and U.C. Davis, considers health impacts of climate change in the county and evaluates specific subgroups that are most vulnerable (e.g. very young, very old). While it does not evaluate risks to specific transportation assets, the report highlights climate-related extreme weather impacts to roads and impacts to access by emergency responders and health care personnel.
2. **San Joaquin County Emergency Operation Plan (2019):** The goal of this plan is to create an incident management structure and flexible platform for planning and responding to all hazards, incidents, events, and emergencies. Climate change is identified as one of the hazards facing the county. The plan identifies flood-related dam/levee failure and damage, drought, excessive heat, and climate change as among about a dozen hazards most likely to occur. Regarding climate change, the plan discusses how changing patterns of melting snowpack and rainfall could stress the levee system and dams.

The plan emphasizes the need to provide services to transit-dependent populations before, during, and after an incident. It describes the County Office of Emergency Services (primary) and Public Works (secondary) responsibilities for monitoring, identifying alternative routes, and coordinating recovery of transportation assets should transportation systems be damaged. The plan identifies Interstates 5, 205 and 580 and Highways 99, 12, 88, 4, 120, 132 and 26 as possible evacuation routes.

Several of the annexes to the plan are still being finalized. The following hazard annexes are currently available:

- a. **Extreme Heat (2018):** Identifies actions and division of responsibility for ensuring vulnerable populations have transportation access to cooling centers. It also highlights potential impacts of extreme heat to the transportation system and utilities.
  - b. **Flood and Dam Failure Hazard Annex (2019):** Focuses on agency coordination in the event of a flood. Flood zones are defined by the FEMA 100-yr and 500-yr floodplains, and notes that high-use highways and roadways are included in the floodplain. The FEMA-defined floodplains do not include future climate change projections.
3. **San Joaquin County General Plan (2016):** The Public Health and Safety element of the General Plan describes emergency response to natural hazard risks, including flooding, earthquakes, and liquefaction. The Public Health and Safety element of the General Plan aims to maintain efficient emergency response in the face of disasters and protect the county from potential effects of climate change. Four

communities (Bellota, Clements, Linden, and Lockeford) are identified as at risk for wildland fire. The General Plan includes an Appendix focused on sustainability policies and programs. In addition to GHG reduction programs, the appendix calls for a range of climate adaptation programs including creation of a program to monitor climate impacts and implement adaptive management strategies as well as a range of plans related to levee maintenance, multi-purpose flood control projects, and emergency flood response.

4. **Lower San Joaquin River and Delta South Regional Flood Management Plan (2014):** This plan was funded by the California Department of Water Resources to contribute to the Central Valley Flood Protection Plan (2017). This Lower San Joaquin Plan was developed through a multi-sector stakeholder process, led by San Joaquin Area Flood Control Agency, to describe a long-term, local vision for flood risk reduction. It identifies priority flood management projects. Though climate change hydrology was not available to integrate into the work, the report includes a list of the ways in which flood control projects are being designed to account for more extreme flows in the future.
5. **Regional Transportation Plan/Sustainable Communities Strategies (RTP/SCS) (2018).** The RTP/SCS identifies transportation infrastructure durability and resiliency as a priority and indicates that SJCOG will be partnering with local jurisdictions to ensure that the region is prepared for climate impacts and other natural hazards. The plan notes that regional resiliency to climate impacts will be achieved not only through resilient transportation investment, but also through increasing affordable housing availability, encouraging sustainable land use planning to reduce farmland loss, and investing in sustainable transportation modes. The RTP/SCS explains that local agency climate action plans are instrumental in these activities. The RTP/SCS will begin implementing adaptation planning efforts in the region by supporting a series of studies including the SJCOG Climate Adaptation and Resiliency Study.

### Adaptation Planning beyond the County-scale:

1. **Delta Regional Climate Change Vulnerability Assessment and Adaptation Strategy (in progress):** This strategy will provide critical support to the Delta Stewardship Council to improve understanding of region-specific climate risks and address how Sacramento-San Joaquin Delta communities, infrastructure, and the ecosystem can adapt to future conditions. Phase 1 is focused on assessing the vulnerability of the delta assets to climate impacts including changing precipitation and runoff patterns, air and water temperature, and sea level rise. In the adaptation phase (phase 2), the project will evaluate alternative responses that could be implemented in the San Joaquin Delta Region or elsewhere. For each recommended strategy, the project will include a general assessment of costs and benefits, governance, and opportunities for Council action and leadership.
2. **Central Valley Flood Protection Plan (CVFPP) (2017):** This update to the original 2012 plan refines the overall near-term and long-term investment needs and includes recommendations on policies and financing to support comprehensive flood risk management actions locally, regionally, and system wide. Key updates to the plan include significant state investment in levees and other flood risk reduction improvements to protect major urban areas and levee improvements and non-structural flood control improvements for small communities. Changes for rural areas include construction of all-weather access roads on top of rural levees and repair of identified weak spots in the levees. Other changes focus on improving operation and maintenance of the flood control system and better coordinating releases from

large reservoirs. The plan works toward 200-year flood protection for urban areas. In identifying flood risk and required upgrades to levees and reservoirs, the plan draws on models of the systems under projected climate change given changing hydrology and sea level rise.

3. **Caltrans District 10 Vulnerability Assessment (recently completed):** The assessment identifies potential exposure of the District 10 California State Highway System and other Caltrans assets to future changes in climate. Caltrans will use the vulnerability assessment to inform a subsequent adaptation plan.

**Summary:** Several existing county plans identify the need to adapt to a changing climate and protect transportation infrastructure from natural hazards and climate stressors. The importance of maintaining transportation systems for emergency operations is repeatedly stressed although only the Emergency Operations Plan calls out specific routes to be prioritized: interstates 5, 205 and 580 and highways 99, 12, 88, 4, 120, 132 and 26 as possible evacuation routes. To date, several county plans have examined the issue of flood risk in the county, with the CVFPP going into depth. This SJCOG study, the Delta Regional Climate Change Vulnerability Assessment (in progress) and Caltrans District 10 Vulnerability Assessment will be the first at the county scale (or beyond) to look at exposure to a range of climate impacts.

**Adaptation Planning at the City Level (within San Joaquin County):**

City	Plan	Climate Change Impacts Identified & Considered?	Natural Hazards Addressed (but not in terms of climate change)	Key transportation adaptation projects highlighted?	Additional Notes
Escalon	<a href="#">General Plan (2005, updated 2010)</a>	Plan calls on City to coordinate with regional agencies on transportation and climate impact projects.	Wildfire, flooding, seismic hazards	Plans calls for city to establish a network of streets to improve emergency vehicle access.	
Lathrop	Comprehensive General Plan (2004)	No	Flooding, seismic hazards Detailed descriptions of flood control and levee improvement plans with a focus on meeting FEMA 100-year flood protection.	Discussion of relocating the ACE train to Stewart Tract.	
Lathrop	General Plan Amendment of 2015: SB 5 200-Year Flood Protection	Calls out actions to consider climate change in planning, design, and maintenance of levees and flood control. Climate impacts are not specifically described/quantified in this document.	N/A		This amendment was created to address new “Urban Level of Flood Protection” requirements (200-year protection in urban areas) that were established since the last General Plan Update.

City	Plan	Climate Change Impacts Identified & Considered?	Natural Hazards Addressed (but not in terms of climate change)	Key transportation adaptation projects highlighted?	Additional Notes
Lodi	<a href="#">Climate Action Plan (2014)</a>	No	No. Plan is focused on GHG emissions reduction.	Calls for more telecommuting (intended to reduce GHGs)—this has the co-benefit of helping the community adapt in the event that transport is interrupted.	Strong focus on expanded transit.
Manteca	<a href="#">Climate Action Plan (2013)</a>	Yes, explains need to plan for wildfire and flood risk given climate impacts.	N/A	N/A	The plan states that at time of publication, there were no studies indicating increased flood risk in Manteca due to climate change (though plan notes that the science could change).
Manteca	<a href="#">General Plan (2010)</a>	No	Flooding, seismic hazards	N/A	SR120/McKinley Avenue Interchange Project begins construction this year.
Ripon	<a href="#">General Plan (2004)</a>	No	Wildfire, flooding	N/A	
Stockton	General Plan: Envision Stockton 2040 (2018)	To some extent. Calls for a comprehensive climate change vulnerability assessment upon next revision of the City's Local Hazard Mitigation Plan to inform development of adaptation and resilience policies.	Wildfire, seismic, flooding.		Includes plans to provide "Urban Level of Flood Protection" (200-year protection in urban areas).

City	Plan	Climate Change Impacts Identified & Considered?	Natural Hazards Addressed (but not in terms of climate change)	Key transportation adaptation projects highlighted?	Additional Notes
Stockton	<a href="#">Climate Action Plan (2014)</a>	No.	No.	N/A	Strong focus on expanded transit.
Tracy	<a href="#">Sustainability Action Plan (2011)</a>	No.	No.	N/A	26 actions to encourage transit and walking and reduce vehicle miles traveled.
Tracy	<a href="#">Tracy Local Hazard Mitigation Plan (update in process)</a>	No.	Flooding, wildfires, drought, extreme heat, seismic hazards.	N/A	Calls for improvements to specific levees. Identifies an area southwest of the city that has high fire risk (due to a history of fires).

\* The natural hazards described in these plans are likely directly or indirectly connected to climate change (i.e., change in magnitude/frequency). However, they are identified separately if the plan does not make a connection to climate change, nor does it anticipate how these hazards may change over time.

**Summary:** Cities in San Joaquin County have undertaken limited planning work to assess their vulnerability to the full range of climate impacts and comprehensively integrate adaptation into their General Plans, a climate action or resiliency plans, or similar documents. The City of Stockton has committed to a comprehensive climate change vulnerability assessment and adaptation planning process in the future. The cities and the county have already undertaken considerable effort to understand their flood risk, especially under 200-year flood conditions in urban areas to meet requirements of SB 5.<sup>81</sup> As shown in the table above, 200-year flood protection is being integrated into General Plan amendments. In addition, cities, the county, and reclamation districts are collaborating to address the 200-year flood protection requirement in reclamation districts (RD) of overlapping authority. For example, the county and Cities of Stockton, Lathrop, and Manteca have entered a Memorandum of Understanding to collaborate on levee improvements in RD 17. Though the 200-year flood protection requirement does not require addressing climate impacts, California Department of Water Resources recommends this.

<sup>81</sup> <http://www.stocktongov.com/government/departments/communityDevelop/cdBuildState.html>

**Adaptation Planning outside county boundaries:**

1. **BART Sustainability Action Plan (2017):** Assesses the BART system's vulnerability to extreme weather and future climate impacts and outlines strategies to address these vulnerabilities across the system.
2. **BART Sea Level Rise and Flooding Resiliency Study (ongoing):** Provides a more detailed assessment of sea level rise and flood vulnerability of a set of BART assets already flagged as facing higher flood risk. The study will result in plans and strategies to address these vulnerabilities.
3. **Capitol Corridor Alviso Wetland Railroad Adaptation Alternatives Study (in progress):** Evaluates sea level rise adaptation alternatives for railroad tracks in the Alviso wetland in order to improve resilience of railroad infrastructure, enhance habitat restoration, and ensure that such infrastructure can support plans for increased train capacity.
4. **Sacramento Regional Transportation Climate Adaptation Plan (2015):** Started with a high-level climate change vulnerability assessment and led to an adaptation plan for the region's transportation infrastructure (also high-level). The plan is a framework to guide future adaptation work and inform planning for transportation investments.
5. **Sacramento Transportation Project-Level Climate Adaptation Strategies for the Sacramento Region (in progress):** Building on the 2014 plan, will conduct a more detailed climate change vulnerability assessment for the transportation system and specific adaptation strategies. Outcomes from this project will include policies in SACOG's (Sacramento Area Council of Governments) MTP/SCS that specifically address climate impacts to the transportation network and strategies to ensure its resiliency. Outcomes will also include the integration of climate adaptation-related selection criteria into SACOG's biennial transportation funding programs.
6. **Caltrans District 4 Vulnerability Assessment (2018):** The assessment identifies potential exposure of the District 4 California State Highway System (San Francisco Bay Area) and other Caltrans assets to future changes in climate. The assessment considers sea level rise, storm surge, extreme precipitation, temperature change, and wildfires. Caltrans will use the vulnerability assessment to inform a subsequent adaptation plan. This work resulted in a public-facing summary document as well as a technical background report.

In neighboring counties, there are examples of detailed studies of transportation system vulnerability and adaptation planning, with some of these studies complete and other ongoing. These neighboring projects can serve as a source of lessons learned for designing, carrying out, and building momentum for this work.

# Appendix E: Regional Climate Change Summit: Agenda and Notes

## Regional Climate Change Summit Agenda

February 26, 2020 | 9:30-12:15 PM

SJCOG Board Room | 555 E Weber Ave, Stockton, CA 95202

### Summit Goals:

- Share key findings of climate adaptation report (top transportation vulnerabilities, planning gaps, opportunities for Regional Transportation Plan integration)
- Raise awareness of next adaptation study and opportunities to get involved
- Discuss related resilience planning in the broader region and brainstorm collaboration

### Agenda:

Time	Agenda Item
9:15-9:30	Arrival, coffee, registration
9:30-9:45	Welcome and Introductions
9:45-10:05	<b>Presentation: Key findings of SJCOG Climate Adaptation &amp; Resiliency Study and Next Steps</b> <ul style="list-style-type: none"> <li>○ Climate impacts across the county</li> <li>○ Priority vulnerabilities (transportation assets)</li> <li>○ Planning gaps</li> <li>○ Integration into Regional Transportation Plan (RTP)</li> <li>○ Next steps with next project</li> </ul>
10:05-10:15	Questions and Discussion
10:15-10:25	Break
10:25-11:20	<b>Panel: Adaptation planning in the broader region and applications to resilient transportation planning in San Joaquin County</b> <ul style="list-style-type: none"> <li>○ Harriet Ross, Delta Stewardship Council: <i>Climate Change Vulnerability Assessment and Adaptation Strategy</i></li> <li>○ Sinaren Pheng, Caltrans District 10: <i>District Climate Vulnerability Assessment and Adaptation Planning</i></li> <li>○ Rachael Hartofelis, Metropolitan Transportation Commission (MTC): <i>Integrating Sea Level Rise Impacts into the MTC's RTP Process</i></li> <li>○ Q &amp; A</li> </ul>
11:20-12:00	<b>Small Group Discussion</b> <ul style="list-style-type: none"> <li>○ Discuss integrating efforts, supporting community resilience, and prioritizing adaptation projects</li> </ul>
12:00-12:15	<b>Next Steps &amp; Wrap Up</b> <ul style="list-style-type: none"> <li>○ Next steps with follow-up study</li> </ul>

Total time: 2 hours 45 min

## San Joaquin Regional Climate Change Summit

### Meeting Notes

February 26 | 9:30-12:15 PM

SJCOG Board Room | 555 E Weber Ave, Stockton, CA 95202

#### Meeting Goals:

- Share key findings of climate adaptation report (top transportation vulnerabilities, planning gaps, opportunities for RTP integration)
- Raise awareness of Phase 2 study and opportunities for participants to get involved
- Discuss related resilience planning in the County and region and brainstorm opportunities for collaboration/ integration

#### 9:30-9:45: Welcome and Introductions

Welcoming remarks by SJCOG Executive Director, Andrew Chesley.

#### 9:45-11:20: Presentation: Key findings of SJCOG Climate Adaptation & Resiliency Study and Next Steps

Presentation by Christine Corrales (SJCOG) and Eliza Berry (ERG) covering:

- Climate impacts across the county
- Priority vulnerabilities (transportation assets)
- Planning gaps
- Integration into Regional Transportation Plan (RTP)
- Next steps with next project

See accompanying slide deck for more information.

#### Q & A with participants

- Ken from Caltrans: What about I-5 in Thornton area? It has flooded in the past. What about SR-12 in the delta. Are they on the priority list?
  - I believe that we discussed those flooding issues but that was not at the top of the prioritization list. We can follow up and see how much attention we gave that; we can reach out to you for more information.
- Does your project collaborate with a wider region? Waterways are connected. Are you focused only on the County?
  - This study focuses on the County specifically. We have tried to collaborate throughout the process with our partners. We have been in touch with Delta Stewardship Council (DSC) and Caltrans District 10.
  - Eliza (EB): I would also that add when considering the consequence of SR-4 in Contra Costa County we are considering commuters and movement of people outside of the region, such as SJ County residents traveling to the Bay Area or Sacramento for work. Our geographic focus is on SJ County, but we are trying to make those connections.
- You stated that it is hard to identify specific assets because climate impacts might impact many and at different degrees or times. How do you select which assets to consider?

- EB: For example, when looking at heat impacts across SJ County, the heat data sets we project forward are not at a fine enough scale to see a significant temperature difference across the County. In the scope of this study we can say there are concerns about adapting pavement in the future, or things like that. With that, you need to consider temperature parameters in selecting the appropriate pavement materials that can withstand temperature increases in the future. If we were doing a finer scale study, we could analyze what pavement material is being used and if it is equipped to handle the project temperature increases, but that was beyond the scope of this study.
- Ken from Caltrans: We are working on that issue specifically and we can talk about that more.
- When you discussed sea level rising by 1-2 feet, was that by 2030 or 2050?
  - That's by 2050.
- Has there been an increase in sea level rise (SLR) in the Bay in the last ten years?
  - Ken from Caltrans: We are seeing this trend; it is certainly been increasing.
- Is 3 feet the worst-case scenario? I've been reviewing data as well, and what I read says we might be there by 2100, but not by 2050. We anticipate a 1 to 2 feet rise by 2050. A rise of 3 feet I have not seen—and it's definitely not by 2050. Why are you including that?
- I am also wondering if the 1-3 feet projection includes a storm.
  - EB: In terms of 1-3 feet of SLR, we are following guidance from the Ocean Protection Council which encourages municipalities to determine what an acceptable level of risk is. 1 foot is a low projection when we can accept high risk, the higher projection is applied when we can only tolerate low risks (e.g. protecting a critical asset that absolutely cannot get wet like a power plant)--this is where we apply 3 feet. We wanted to cover the full range set up by the OPC. That's 1-3 feet in SF Bay, then we see the impact to the delta. We then mapped the impact of a storm event on top of that. It is worth noting that these are not high likelihood events. We were restricted because we are working with intermediate outputs. DSC is doing modeling right now and will be providing that data soon. Then we can dig in and consider all scenarios.
- For SLR, did you incorporate the Senate Bill-5 200-year flood plain that's impacting the SJ River?
  - EB: We've discussed the infrastructure improvements being made. We couldn't get the 200-year flood plain data because it is being produced by individual municipalities.

### **10:25-11:20: Panel Discussion and Q&A: Adaptation planning in the broader region and applications to resilient transportation planning in San Joaquin County**

Presentations by:

- Harriet Ross, Delta Stewardship Council: *Climate Change Vulnerability Assessment and Adaptation Strategy*
- Sinaren Pheng, Caltrans District 10: *District Climate Vulnerability Assessment and Adaptation Planning*
- Rachael Hartofelis, Metropolitan Transportation Commission (MTC): *Integrating Sea Level Rise Impacts into the MTC's RTP Process*

See accompanying slide decks for full presentations.

## Q & A with participants

- What are you learning about designing successful stakeholder and community outreach around resilience planning, an issue that cuts across so many issues and sectors?
  - Harriet: We are still in the vulnerability phase. It's important to reach delta communities. It's a very large area and we want to include the residents in the process, with a particular focus on vulnerable and disadvantaged communities. We are not far in the process. We are partnering with community-based organizations and have already contacted many of them. We are trying to figure out what process others want to be involved in and are interested in. In January, community organizations said they should be doing outreach to the locals since the state isn't as successful at connecting with people. We have limitations but are trying to contract with CBOs so they can do the outreach for us. Other agencies, like BCDC, have done that in the past. We have 31 cities within the delta and 6 counties. When we had our first stakeholder interview, we asked "How can we prepare the assessment so you will use it?" We don't have land use authority. We are preparing a plan for these communities and they need to be able to use it. You should engage stakeholders before you make any decisions, so you know what they actually need and want from you.
- Thank you to the panel. It's very exciting to see and hear. What does tribal engagement look like for your efforts?
  - Harriet, DSC: We have a tribal liaison at DSC with a National Heritage organization. There aren't many tribes in the delta area, but we are trying to connect. Again, we are not far in the process.
  - Rachel, MTC: We have community outreach with tribal organizations in the area. I can't speak to that because I work in a different sector of MTC. We have special presentations and designated staff who could provide more detailed information.
  - Sinaren, Caltrans: We have robust engagement. Our planning division engages tribal government. This study will feed back to them and we will share and get their input. We have engagement throughout the project development process.
- Question for Caltrans project: You had a graph that showed completed adaptive strategies by Dec 2020. Is this completing strategies or just planning for them?
  - Sinaren, Caltrans: It is for identifying strategies, like if there is a bridge that needs intervention, we will identify strategies to do that. If we cannot fix it, we will replace it. But implementation happens later.
- I want to build on that question—is that the adaptation priority report you're referring to?
  - Sinaren, Caltrans: Yes. That's what we are working on—it will identify strategies and assets, which will then be taken to preliminary project planning process. The regional version will be completed in Dec 2020 and the statewide version in spring 2021.
- Q about Caltrans plan: How do you incorporate transit impacts on vulnerable populations while identifying priorities?
  - Sinaren, Caltrans: They are actively involved in our project development process. We are looking at transit gaps so that we can incorporate them into initial transit planning process. We locked in the budget and scope early on, so we want to include gap analysis before we get to the end.

- Q for Rachel with MTC: Can you provide more context in terms of how your local agencies are involved in developing adaptation strategies and any lessons learned, so we can learn how to incorporate this into our RTP?
  - Rachel, MTC: When we looked at SLR specifically, that was a direct partnership with BCDC. All of their analysis is what we used to determine our vulnerabilities in the assessment. There is lots of engagement on that side. We've been looking at adaptation at a high level. We have feedback from stakeholders on what projects or measures are needed in certain areas (e.g. marsh restoration) to identify cost and what we could adapt or protect. We've worked with SFEI, BCDC, and agencies that work on the environment within our region. We also use EcoAtlas so we can see what projects are currently being done in the Bay. We have working groups every month and local groups come to those meetings and give us direct feedback. This allows us to see what people want us to focus on and what is important to them, what they identify as vulnerable. We have feedback routinely throughout the year. We do popups throughout the region to get feedback. We had an online game for people in case they couldn't come in person. We have feedback at every phase of the plan including analysis, strategies, landscape analysis, etc. There are lots of opportunities for local interaction.
- EB follow up Q: Beyond requests for support of projects, what requests are you getting from stakeholders for support? Your organizations cover large geographic areas. What support are they requesting?
  - Harriet, DSC: We make the vulnerability assessment so they can use information directly, like giving GIS Shapefiles in a format they can use. They want to use our info to get to SB 379 compliance which requires climate to be addressed in general plan by Jan 1, 2022. For cities and counties without their own vulnerability assessment, they're very interested since they don't have the capacity to do it on their own. For those with assessments, they want to see if they put something out there that is similar to what we put out there.
  - Rachel, MTC: One of the big things we've been asked is to provide a framework or guidance principles that we can all look towards and determine what our priorities are as a region. One thing incredibly helpful is our strong partnership with BCDC. They head up Regional Shoreline Assessment Strategy (RSAS) Project, which is 6 months and incorporates leaders from different agencies and communities so we can agree on principles and priorities. People continue to ask for that. It's important for conversations at the state level since we are all focused on SLR and climate, we need to get organized. Our implementation plan is coming up this fall.
  - Sinaren, Caltrans: Partnerships are important to us. For the priority reports, we will reach out to local stakeholders and we will share preliminary information so they can incorporate their study and their information into our study as well.

### **11:20-12:00: Small Group Discussions**

A summary of the questions discussed in small groups (and then shared with the whole room) is provided here:

1. *Where do you see opportunities for improving integration among resilience projects?*
  - Share data and metrics. What is already available and how can we use it?
  - Cross-corridors
  - Voluntary and/or cost-share agreements
2. *What can SJCOG do to support community resilience?*
  - Equity and social justice
  - New outreach methods (e.g. social media)
  - Identify main stressors to prioritize
  - Seminar series → active engagement
  - Build long-term relationships and personal connections with leaders
  - Provide list of options for jurisdictions to present to stakeholders and elected officials
3. *Moving forward, how can SJCOG (and others driving funds and action) refine the process for prioritizing adaptation projects?*
  - Start early with the Regional Transportation Plan
  - Risk assessment and timing (i.e. what issues need to be addressed immediately?)
  - Equity and tradeoffs for certain populations (e.g. children, seniors, disabled people)
  - More narrow focus on which areas will be impacted and pay attention to potential variances within assets
  - Ground truthing
4. *How can SJCOG ensure adaptation strategies address the needs of disadvantaged communities?*
  - Proper communication methods for the audience
  - Seek out leaders and build personal connections
  - Ask what they need and make the impacts of climate change connect with them personally (i.e. how will their home be affected?)
  - Engage one-on-one, on-the-ground
  - Language choice matters (e.g. calling oneself an “expert”)
  - Be cognizant of planning fatigue
  - Be intentional with what you are asking people to do
  - Provide resources and capacity building support
  - Provide incentives and be intentional about meeting design

### **12:00-12:15: Next Steps**

- We’ll integrate your feedback into our final report
- Next project will launch by Summer 2020
  - To get involved, please provide your contact info