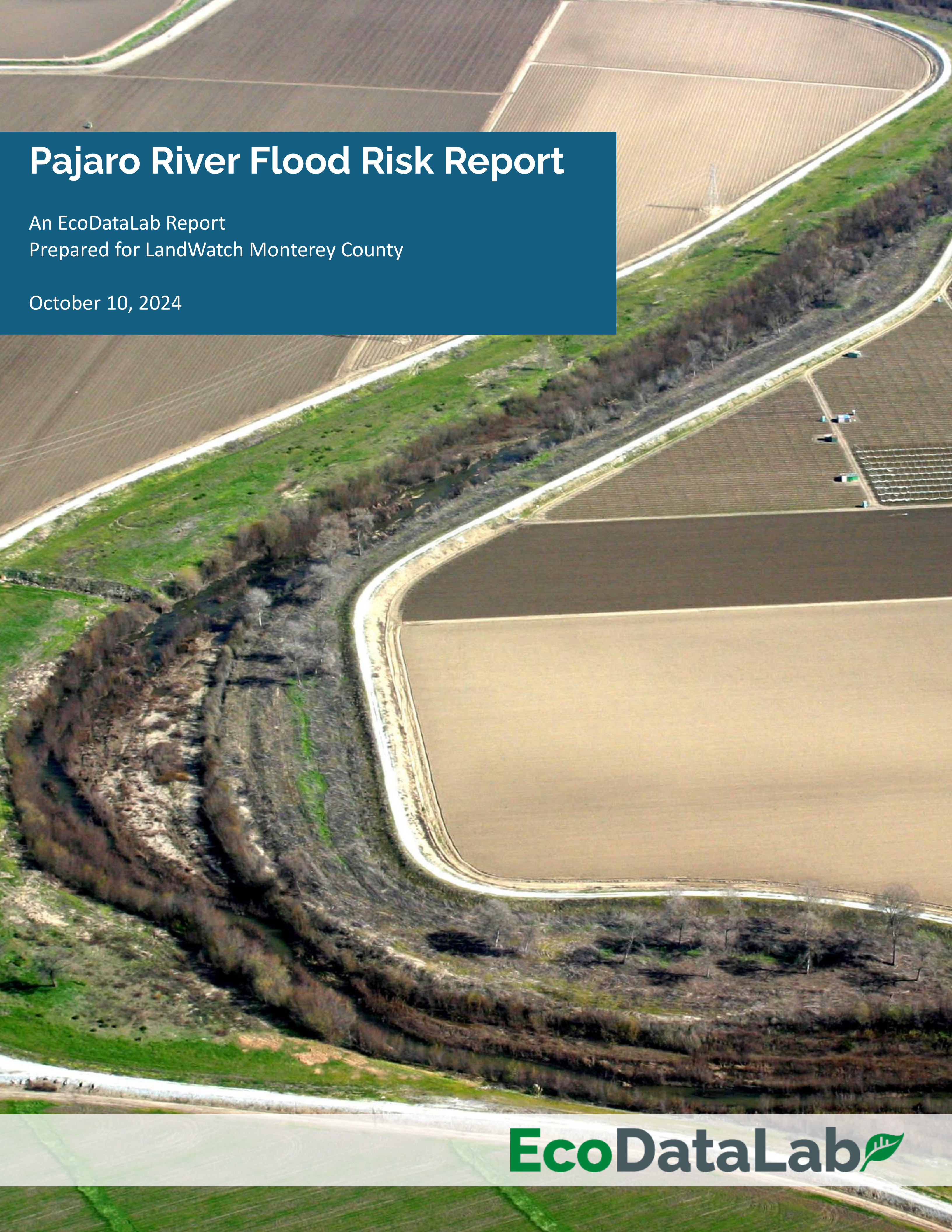
Pajaro River Flood Risk Report

An EcoDataLab Report
Prepared for LandWatch Monterey County

October 10, 2024



EcoDataLab

Table of Contents

Cover image courtesy of Jitze Couperus via Flickr.

Executive Summary

Based on currently available modeling, the Pajaro River Flood Risk Management Project (the Project) is likely to reduce the annual risk of flooding from levee overtopping to less than 1%, even after accounting for the impacts of climate change, for the entire town of Pajaro and most of Watsonville. Areas that are not shown as flooded in the 0.2% (500-year) floodplain map are likely sufficiently protected to accommodate long-term development, based on best currently available modeling.

Areas outside of Pajaro or Watsonville – particularly areas to the north or east – are not similarly protected and should not be considered for development. While the levees provide significant protection as designed, this protection still depends upon proper maintenance of the levees.

Background

The US Army Corps of Engineers (USACE) constructed a levee system on the Pajaro River and its tributaries in 1949. Since then, there have been major floods in 1955, 1958, 1995, 1998 and 2023, caused by overtopping or breaching of the levees[1]. At least four of these floods exceeded the design capacity of the original levees.

Erosion has also been an ongoing problem since the levees were constructed, in part due to the soils used in the original levees, which are unable to sustain plant growth to help maintain the levee structure[2]. Congress authorized re-construction of the levee system in 1963 and designs were finalized in 2019.

The Project is designed to protect Pajaro and Watsonville from future flooding. This memo examines whether the design of the project adequately accounts for future impacts of climate change, which is important information for possible future infill development in these communities, including the construction of new affordable housing.

Project Design

The Project primarily consists of new levees with an additional 100-foot setback from the current levee locations[3]. In most reaches of the Project, this is a 50-66%

---

[1] USACE, Pajaro River Flood Risk Management Project Final General Reevaluation Report and Integrated Environmental Assessment Revised December 2019, Executive Summary

[2] USACE, Pajaro River Flood Risk Management Project Final General Reevaluation Report and Integrated Environmental Assessment Appendix B Civil Design, April 2018

[3] Ibid.

increase in total channel width, significantly increasing the peak flow capacity of the system. In areas where widening the channel is not feasible (such as Reach 3, directly between Watsonville and Pajaro underneath the Main St. Bridge), new floodwalls are being added on top of rebuilt levees to add 4-10 feet of additional protection[4], which appears similarly likely to add close to a 50% increase in peak flow capacity.

New levees are also being added east of Pajaro, to prevent floodwaters from circuiting the levees; and north and east of Watsonville, along the Salsipuedes and Corralitos Creeks. Notably, agricultural land northeast of the Salsipuedes-Pajaro confluence is being left as unprotected floodplain area, to provide storage capacity during peak events. Overall, levees described in these designs are expected to provide protection against a 1% annual chance of exceedance (ACE) flood with 90% assurance for Watsonville and Pajaro, and protection against a 4% ACE flood for certain areas northeast of the tributaries.

The 4%, 1%, and 0.2% ACE composite floodplains are presented below[5]. All of Pajaro and much of Watsonville remains protected even at the 0.2% ACE.

---

[4] Ibid.

[5] USACE, Pajaro River Flood Risk Management Project Final General Reevaluation Report and Integrated Environmental Assessment Appendix D Hydraulics, November 2017

Figure 1. Recommended Plan 4% ACE Composite Floodplains (Overtopping Only)

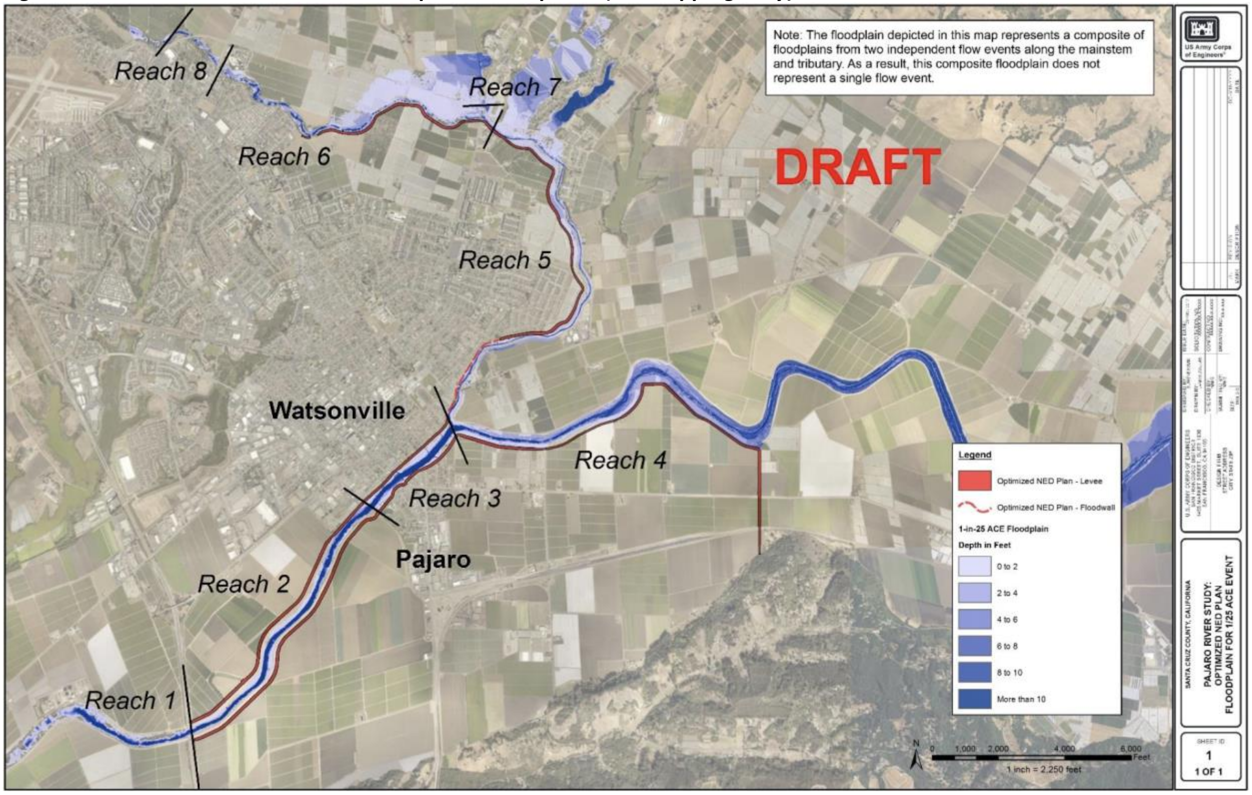


Figure 2. Recommended Plan 1% ACE Composite Floodplains (Overtopping Only)

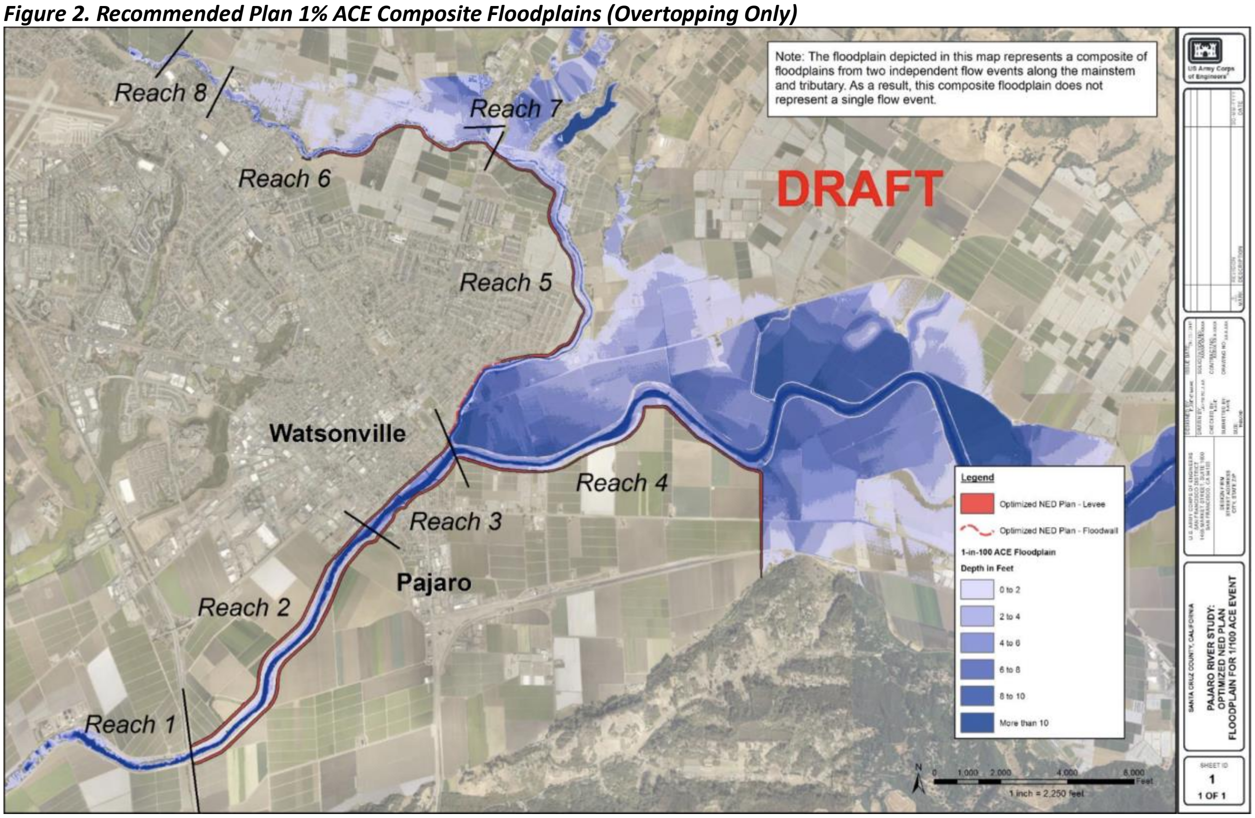
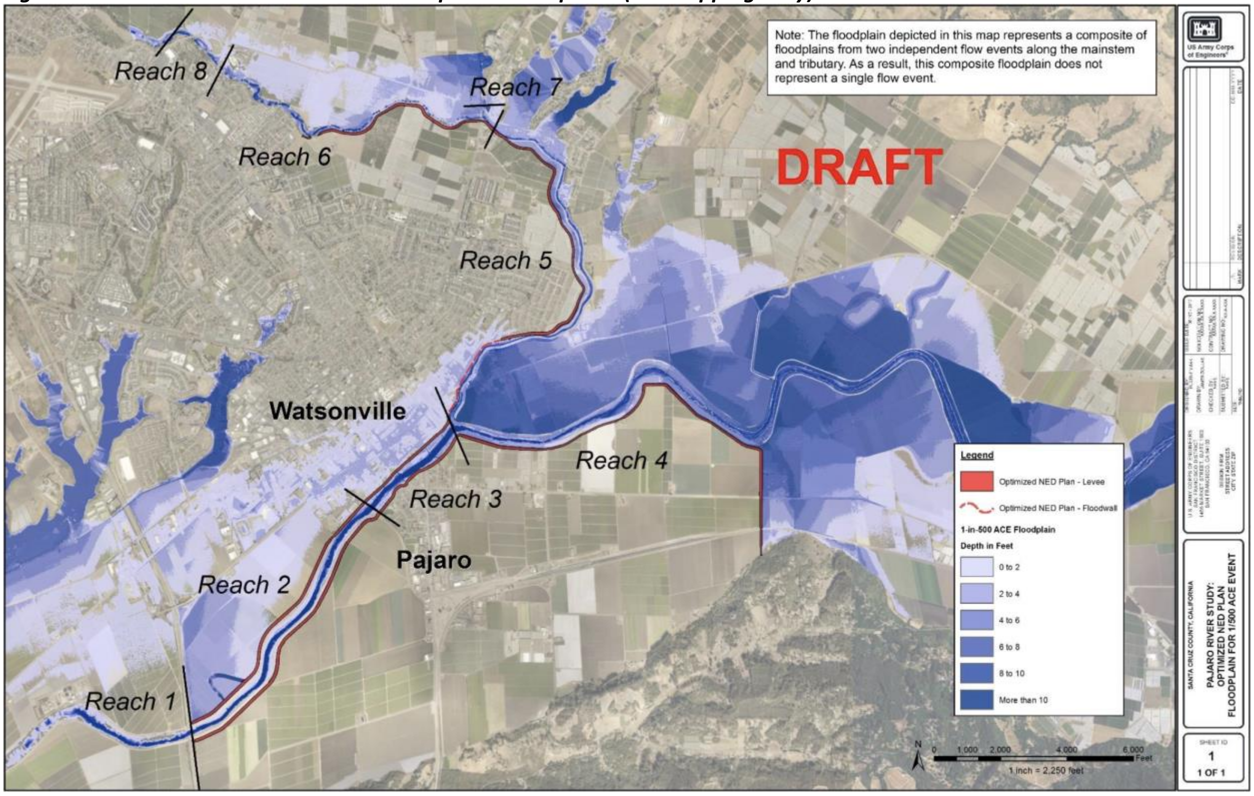


Figure 3. Recommended Plan 0.2% ACE Composite Floodplains (Overtopping Only)



Climate Impacts on the Pajaro Watershed

Summary of USACE Analysis

The Project report reviewed available literature and conducted hydrologic modeling based on climate projections to evaluate impacts from climate change on the Pajaro River watershed and determine if additional mitigations were warranted[6].

Appendix L describes a strong consensus in the literature that air temperature and extreme precipitation events will increase in California in the future, but no similarly clear consensus was found for the Central Coast region specifically.

A review of over 60 years of historical data collected in the Pajaro River watershed from USGS gauges at Freedom, CA (Corralitos Creek west of Watsonville) and at Chittenden, CA (Pajaro River east of Pajaro, after the Santa Clara Valley confluence) showed no statistically significant change in peak flows ($p = 0.30$ and 0.42, respectively)[7]. While some indicators of change were found in the Corralitos Creek

---

[6] USACE, Pajaro River Flood Risk Management Project Final General Reevaluation Report and Integrated Environmental Assessment Appendix L Climate Assessment, October 2018

[7] Ibid.

data, they were insufficient to indicate a trend. These data are shown in Figures 4 and 5.

Figure 4. Corralitos Creek annual peak streamflow, Freedom CA

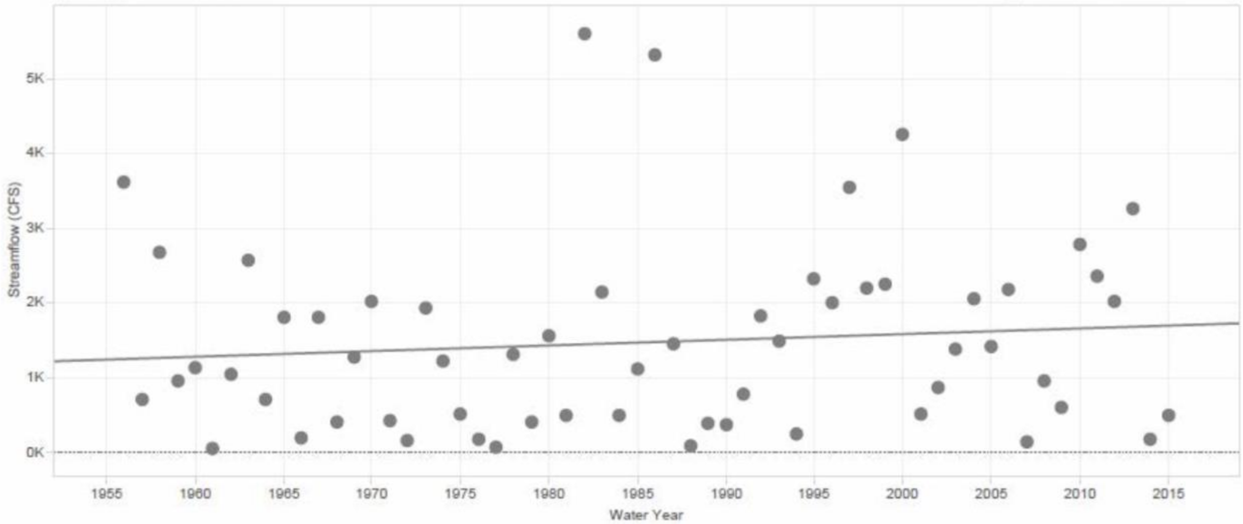
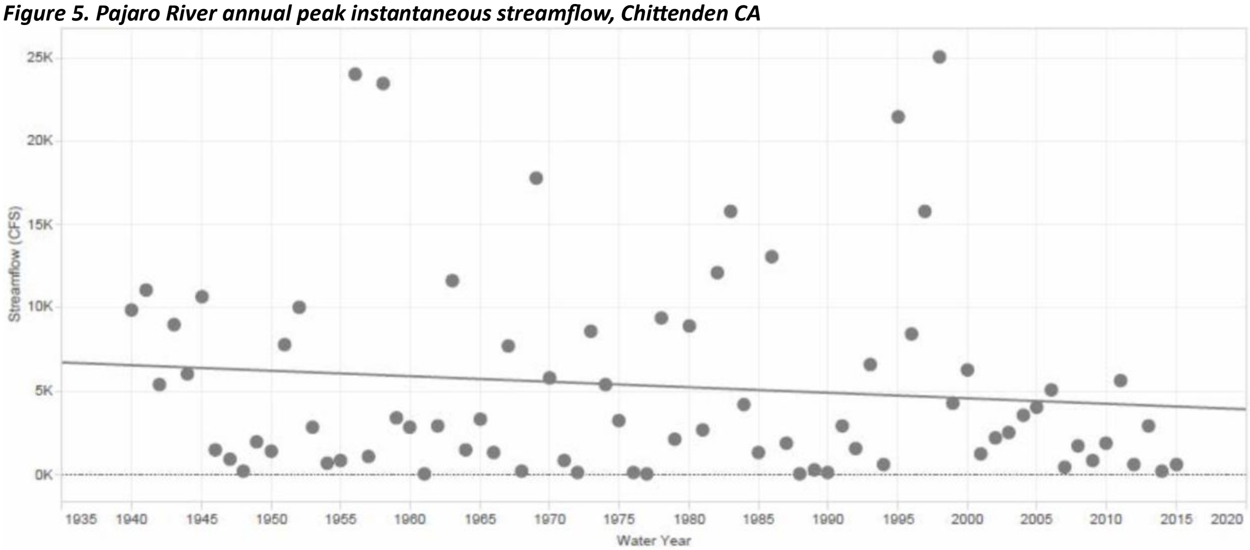


Figure 5. Pajaro River annual peak instantaneous streamflow, Chittenden CA



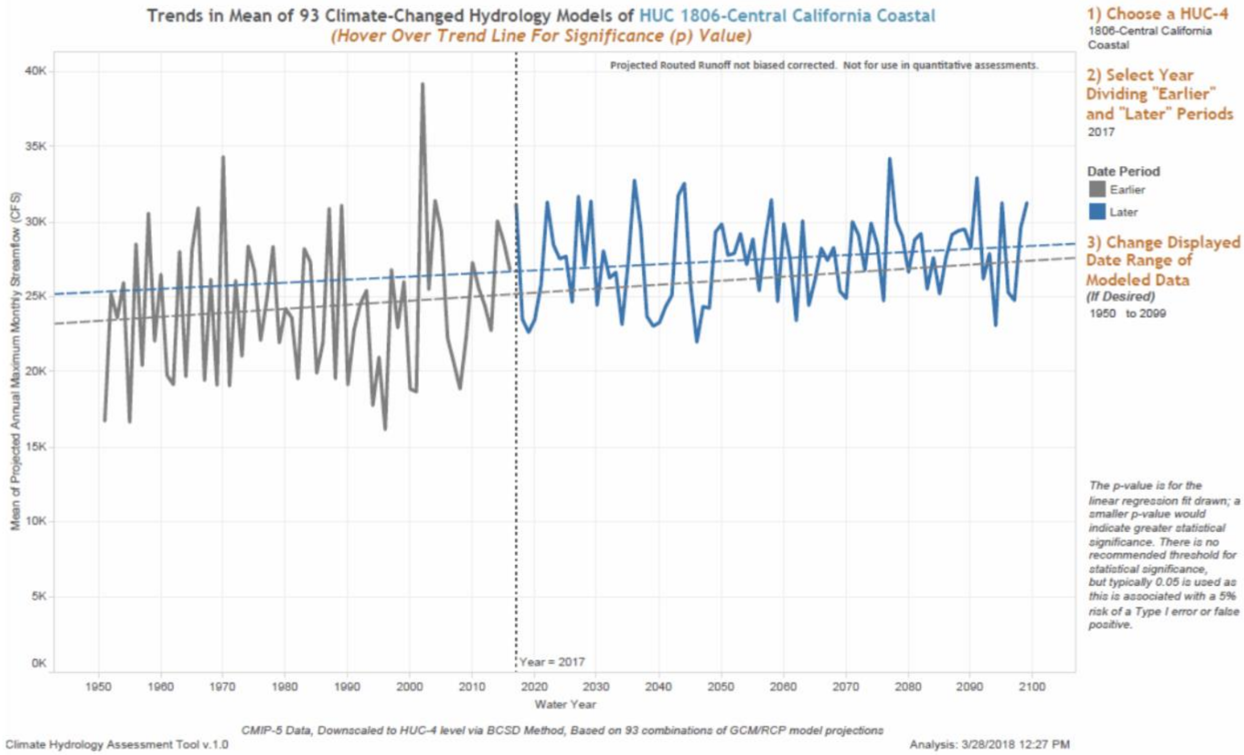
USACE conducted climate modeling at the Central Coast subregion[8] level (smaller geographies appear to have been unavailable due to modeling software constraints). An image of HUC-1806 (Central California Coast) from USGS is shown in Figure 6.

[8] Ibid.

Figure 6. Central California Coast Watershed Region

This climate modeling was computed using 93 different combinations of the Global Circulation Model (GCM) for different representative concentration pathways (RCPs). When averaging all 93 results, the maximum monthly runoff of the subregion (Figure 7) was projected to see no statistically significant change ($p = 0.11$).

Figure 7. Trends in average of 93 projections for Central California Coast region for annual maximum monthly discharge

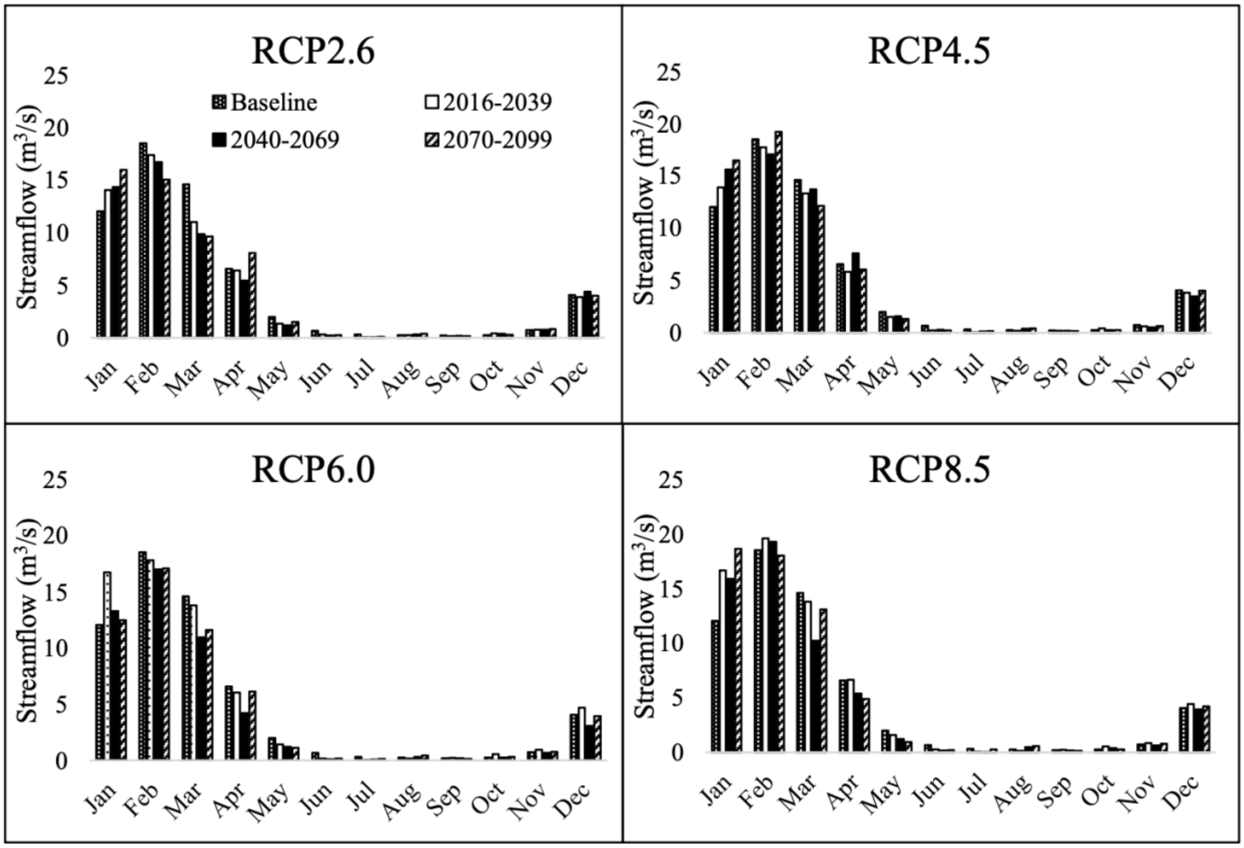


Supplemental Literature Review

EcoDataLab conducted additional literature review and found one paper modeling climate change-induced hydrology impacts in the Pajaro River basin, which was published after USACE's climate appendix was published. In *Analyzing the Effect of CMIP5 Climate Projections on Streamflow Within the Pajaro River Basin* (Bhandari et al, 2020), the authors modeled climate data for different RCPs and applied this modeling specifically to the Pajaro River Watershed area within the Santa Clara Valley. The authors used physically-based models that combine downscaled climate projections with local soil and slope data to evaluate impacts on streamflow.

Bhandari et al. found that this modeling suggested generally increased temperatures, and increased streamflow in January. The model results are shown in Figure 8.

Figure 8. Bhandari et al. (2020) modeled monthly average streamflow by time period and RCP



These model results are monthly average flows, not peak, and do not immediately translate to flood risks, which are determined by concentrated flows within a given period. However, it is notable that these modeling results do not appear to show any clear increase in overall streamflow, but rather primarily a shifting of streamflow to earlier parts of the wet season, without significantly exceeding current maximum monthly average flows.

This overall finding of shifting streamflow timing seems consistent with USACE's findings that there may be no statistically significant change in monthly peak runoff in the Central California Coastal subregion[9].

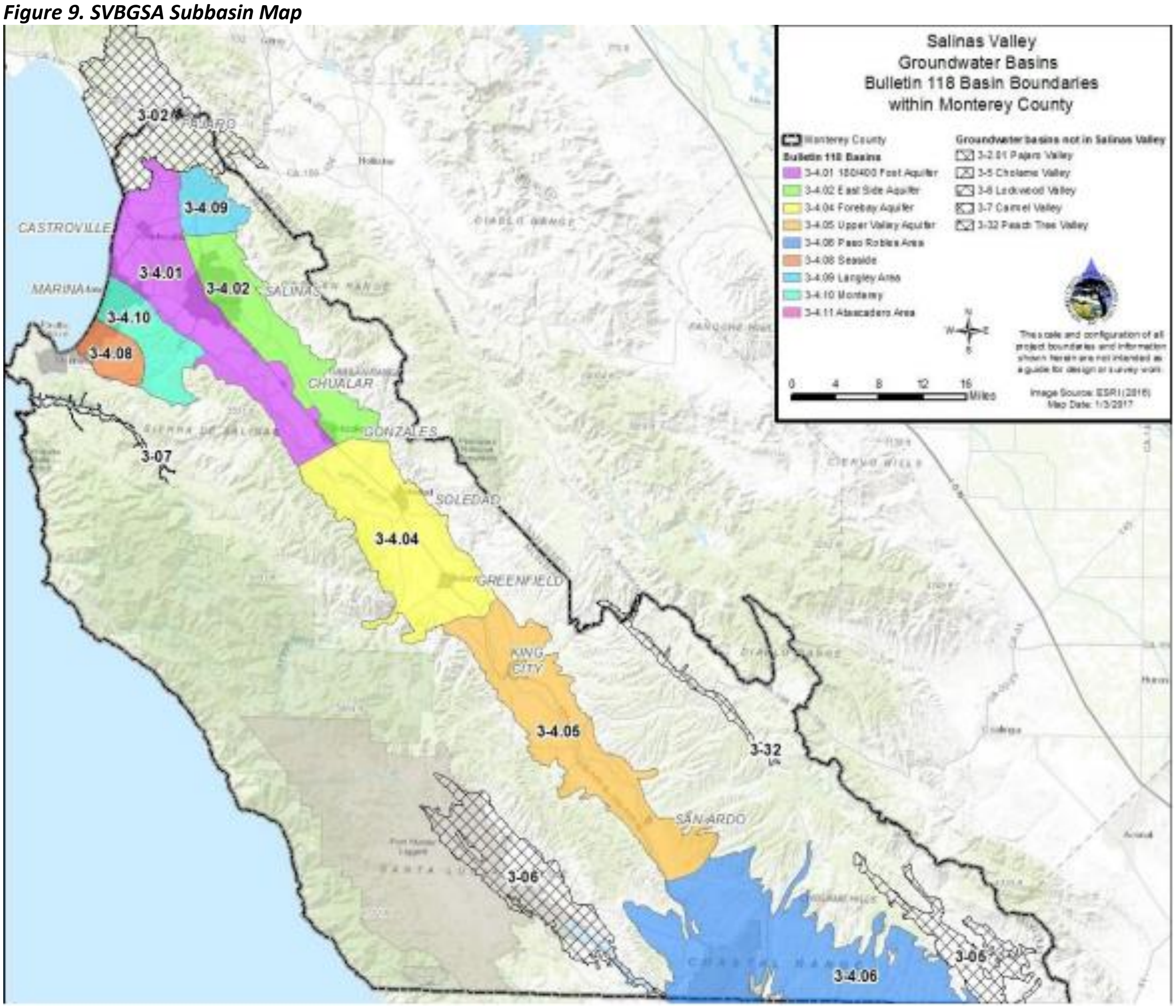
Climate Impacts on Surface Water Flows in the Salinas Valley

In addition to modeling prepared either as part of the Project or which specifically evaluated the Pajaro River watershed, data from the Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) was also reviewed for comparison. SVBGSA manages a portion of the Monterey County portion of the Salinas Valley

[9] Ibid.

Groundwater Basin. This groundwater basin includes 9 subbasins, of which 6 are under the SVBGS A’s jurisdiction. A map of the SVBGSA subbasins is shown in Figure 9.

Figure 9. SVBGSA Subbasin Map



SVBGSA recently prepared groundwater sustainability plans (GSPs) for each of the 6 subbasins under its jurisdiction. These GSPs include present data on surface water flows, as well as future projections under climate change in 2030 and 2070, using the average of 20 different global climate models. For each subbasin’s projected streamflow, the projections include both overland runoff to streams (i.e. precipitation that is not absorbed immediately into soils) and boundary stream inflows (flow from the adjacent subbasin or SVBGSA border), allowing an evaluation of where new flows come from in each subbasin.

SVBGSA's subbasin GSPs[10] generally anticipate a range of 2-20% increase in overland runoff, and an overall roughly 15-20% increase in outflow along the Salinas River. Most of this increase in outflow derives from an increase in inflow into the Salinas River from the San Antonio and Nacimiento Reservoirs. Because these reservoirs are outside the SVBGSA's jurisdiction, the change in flow from these facilities was based upon assumptions provided from the California Department of Water Resources (DWR).

Details on DWR's modeling methods that led to most of the projected increase were not readily available, and it is not clear that this increase in flow along the Salinas River is translatable to the Pajaro River. DWR's assumptions primarily affected outflows from the San Antonio and Nacimiento Reservoirs. These reservoirs are controlled outflows from the Los Padres National Forest, a heavily vegetated area with significant quantities of redwood, pine, and fir trees that not only cause coalescence from fog, but also grow in historically wetter microclimates. Estimates for increased flow from these facilities may be unique due to their setting and not similarly applicable to other watersheds. The vegetation (and likely historic microclimates) along the Pajaro River watershed is more similar to that of the Salinas Valley than that of Los Padres National Forest.

The change in flows based upon the SVBGSA's modeling within its Salinas Valley subbasins (excluding the increased flow from DWR assumptions about the San Antonio and Nacimiento Reservoir outflows) is about 5%. Overall, the modeling conducted by SVBGSA (excluding the assumptions provided by DWR) does not appear to suggest large increases in flow through 2070. This similarly aligns with the modeling conducted by Bhandari et al and by USACE.

Climate Impacts on Extreme Precipitation Events

While Bhandari et al and the SVBGSA's work (separate from DWR estimates of outflows from Los Padres National Forest) did not identify any large increases in average flows, this does not rule out any potential increases in flooding. Flooding impacts could still occur if the same amount of precipitation occurs in a shorter period of time, in an extreme precipitation event.

Further literature review was conducted to evaluate projected changes in precipitation intensity. In *Future Increases in North American Extreme Precipitation in CMIP6 Downscaled with LOCA* (Pierce et al, 2023), the authors modeled future

[10] https://svbgsa.org/subbasins/

projections of national climate impacts to 2075-2100 using the CMIP6 model, downscaled to a gridded 6 km resolution. Figure 10 shows the future return period for historically 100-year storms in 2075-2100, under the Shared Scenarios Pathway (SSP) 3-7.0 scenario (equivalent to roughly 4 ^{o}C of warming by 2100). This shows that 100-year storms would be expected roughly every 40 years in the Pajaro area.

Figure 10. Projected return period for 100-year storms under SSP 3-7.0 (Pierce et al, 2023)

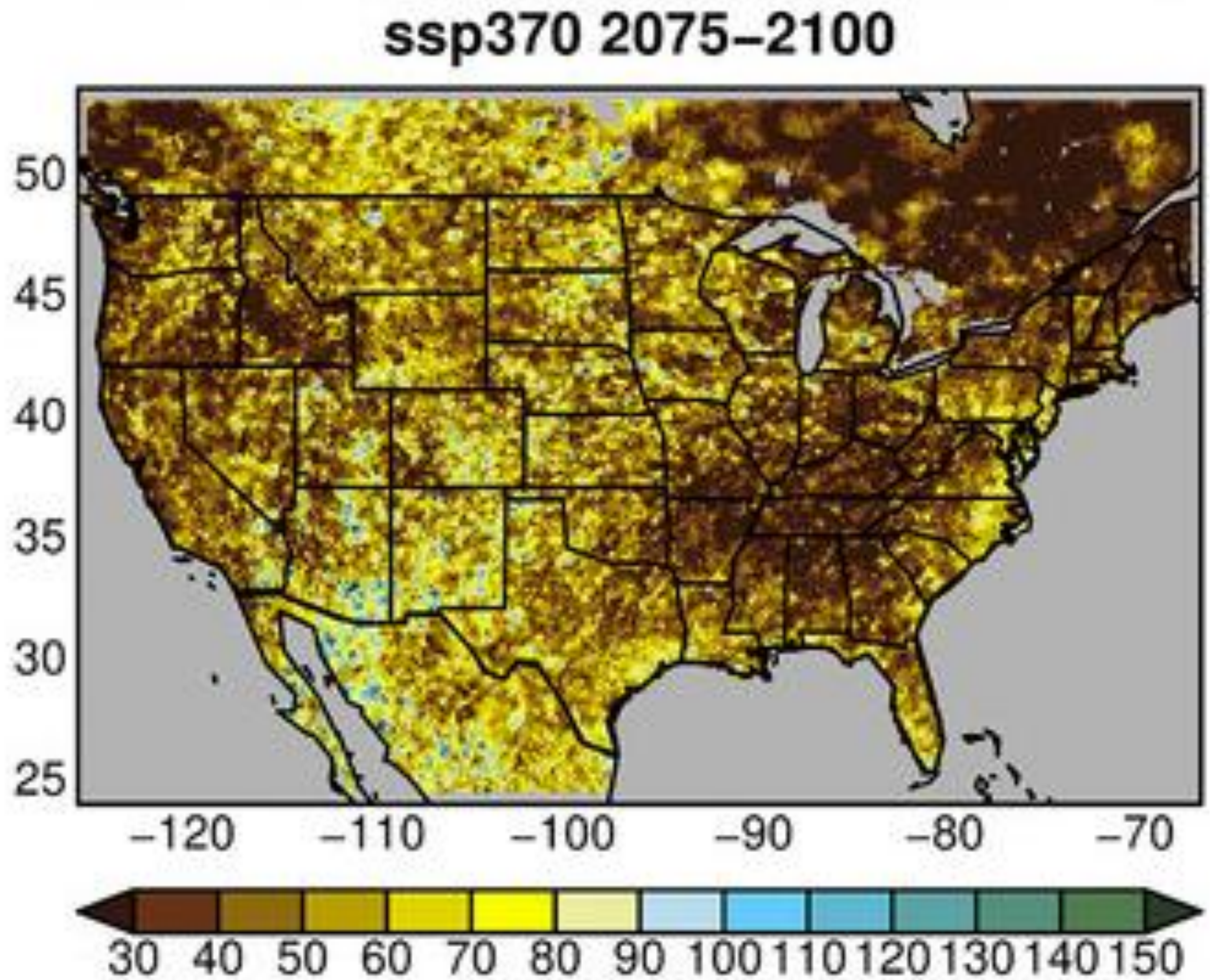
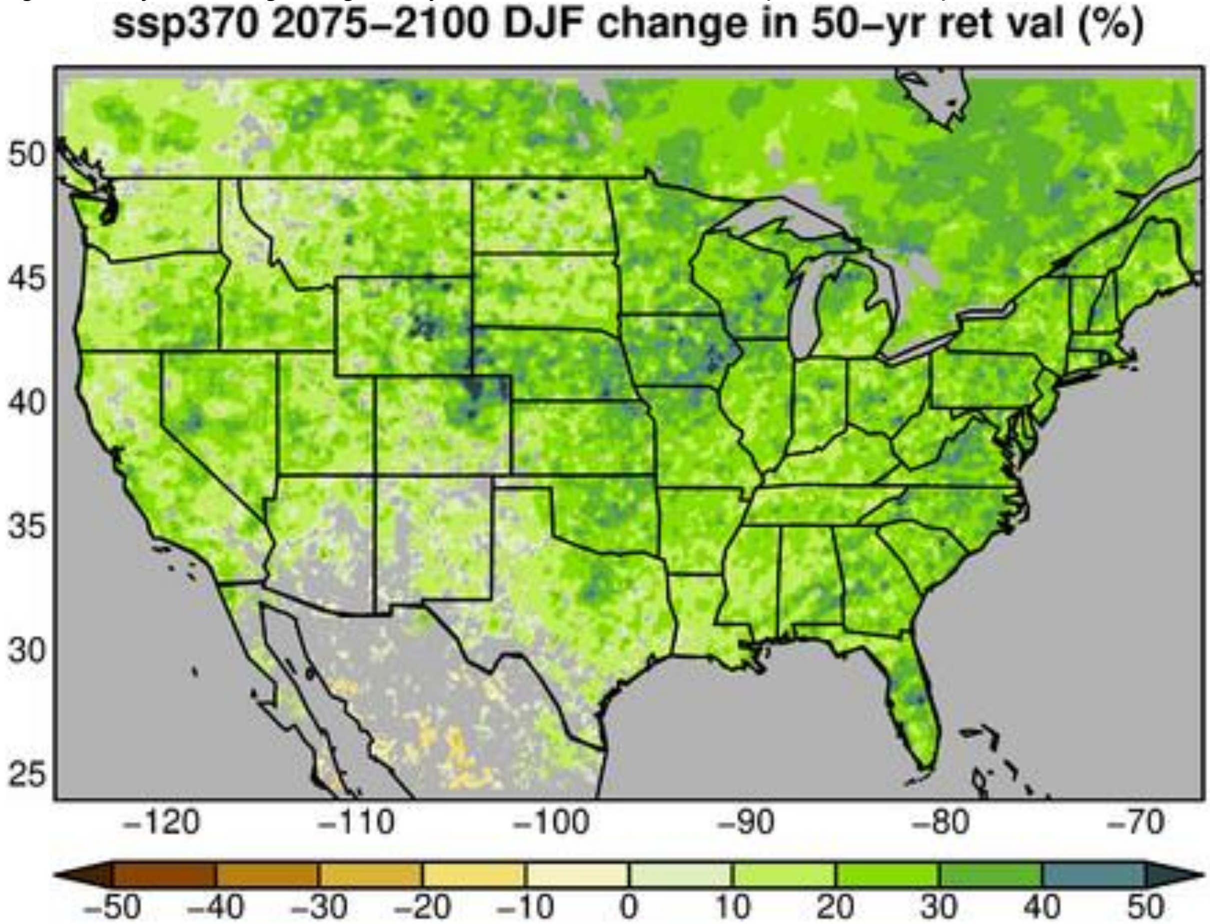


Figure 11 shows the percentage change in frequency for 50-year storms, under the same scenario and time period. This figure shows 50-year storms could be 30-40% more frequent, or roughly every 35-40 years.

Figure 11. Projected average change in 50-year return value under SSP 3-7.0 (Pierce et al, 2013)



With 50-year storms at 30-40% more frequent in December through February, and 100-year storms about 100% more frequent, extrapolating this shift while assuming a normal distribution means that a 500-year storm could be expected to arrive about once every 100 years, under the SSP-3.70 scenario.

The SSP 3-7.0 scenario used for these models is generally considered an unlikely outcome, as current policies are projected to reduce emissions enough to avoid this outcome (see e.g. "Emissions – the 'business as usual' story is misleading", Hausfather and Peters, 2020). Nevertheless, because USACE's engineering designs are expected to be sufficient to protect Pajaro even in the face of a 500-year storm, a more extreme climate-induced frequency increase to every 100 years will still mean Pajaro has a less than 1% chance of being flooded in any given year, consistent with USACE's original engineering objectives.

Summary and Conclusion

The modeling and evaluations conducted by USACE reviewed historical trends over the past 60 years and modeled future climate projections through 2100, and identified no statistically significant change in monthly peak flows. Other literature modeling monthly average flows on the Pajaro River under a variety of climate scenarios suggested a temporal shift in peak flows, but no evidence of a meaningful increase in monthly average flows. Climate modeling data from SVBGSA also suggests only small increases in annual total streamflow from precipitation and runoff within the Salinas Valley basin. However, national modeling under a scenario of significant climate change suggested a potential increase in frequency of severe storms, particularly in December through February (when precipitation peaks).

USACE's designs for the Pajaro River Flood Risk Management Project appear to dramatically increase the protection capabilities of the levee system, providing resilience even in the face of a 1-in-500-year flood (0.2% ACE) for the entire town of Pajaro and most of Watsonville. Even under the more severe climate modeling impacts, where a 500-year flood could be expected as frequently as roughly every 100 years, this design will still likely provide protection for Pajaro from those floods.

Areas outside of Pajaro or Watsonville – particularly areas to the north or east – are not similarly protected, however, and should not be considered for development. In addition, while the levees provide significant protection as designed, this protection still depends upon proper maintenance of the levees.

Overall, much of the currently available literature, data, and modeling do not suggest any significant change in average flows along the Pajaro River specifically, though there may be increased frequency of extreme precipitation in the area. While new data or improved models could show different results, at present there is very limited indication that changes should be anticipated in peak or average flows along the Pajaro River. There is some additional unknown risk associated with long-term failure to maintain the levees. However, the levees are designed to accommodate as much as a 5-fold change in flooding frequency on the Pajaro River while still providing 1-in-100-year flood protection for Pajaro and most of Watsonville.

Flood risks, even in a changing climate, should be adequately abated with the completion of this Project to support long-term development in areas not shown as flooded on the 0.2% ACE floodplain map.