Draft

SANTA BARBARA AIRPORT

Climate Vulnerability Assessment and Risk Evaluation

Prepared for
City of Santa Barbara

December 2024

Image Source: Max Rosenberg, February 19, 2024 (https://www.edhat.com/news/santa-barbara-airport-begins-phased-reopening-tuesday/)

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115 S. La Cumbre Lane
Suite 300
Santa Barbara, CA 93105
805.914.1500
esassoc.com

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EXECUTIVE SUMMARY

The Santa Barbara Airport (SBA), a key regional asset with a history of flooding, is preparing a Climate Adaptation Plan. As a first step in the planning process, SBA has prepared this Climate Vulnerability Assessment and Risk Evaluation to understand its susceptibility to future sea level rise and increased precipitation due to climate change. The assessment focuses on SBA's exposure to flooding and inundation from the surrounding Carneros, Tecolotito, and San Pedro Creeks; Goleta Slough; groundwater; and the ocean. This assessment projects the increase in flooding with climate change and evaluates potential impacts to SBA and will inform the development of an adaptation plan to reduce these potential impacts. To comply with the requirements of the airport's Part 139 Airport Operating Certificate, a technical memorandum providing a framework of the Part 139 requirements and potential impacts to the airport's ability to meet those requirements is included as **Appendix A.**

Historic and Current Flooding

The three creeks and Goleta Slough have been modified and managed. Expansions of the airport twice necessitated the realignment of Carneros Creek (between 1967 and 1975 and in 2006). Sediment is periodically dredged from portions of San Pedro Creek and Tecolotito Creek (outside airport property) and Carneros Creek (within airport property) to reduce flood risk. Historically, the Goleta Slough inlet mouth was mechanically breached after two weeks of closure to alleviate flood risk and for vector (mosquito) control. In 2012, mechanical breaching was discontinued because regulatory permits for this maintenance were not renewed due to environmental restrictions and associated costs. Mechanical breaching is now only conducted with emergency permits when the airport is threatened.

Historical records indicate that SBA has periodically flooded since opening. The most severe floods occurred in 1969 and 1995, causing significant disruption to airport operations and infrastructure. Recent years have seen an increase in flooding frequency, with four significant events in the past decade and three closures due to flooding in the last two years, highlighting the risk posed to SBA by climate change and changes in precipitation intensity.

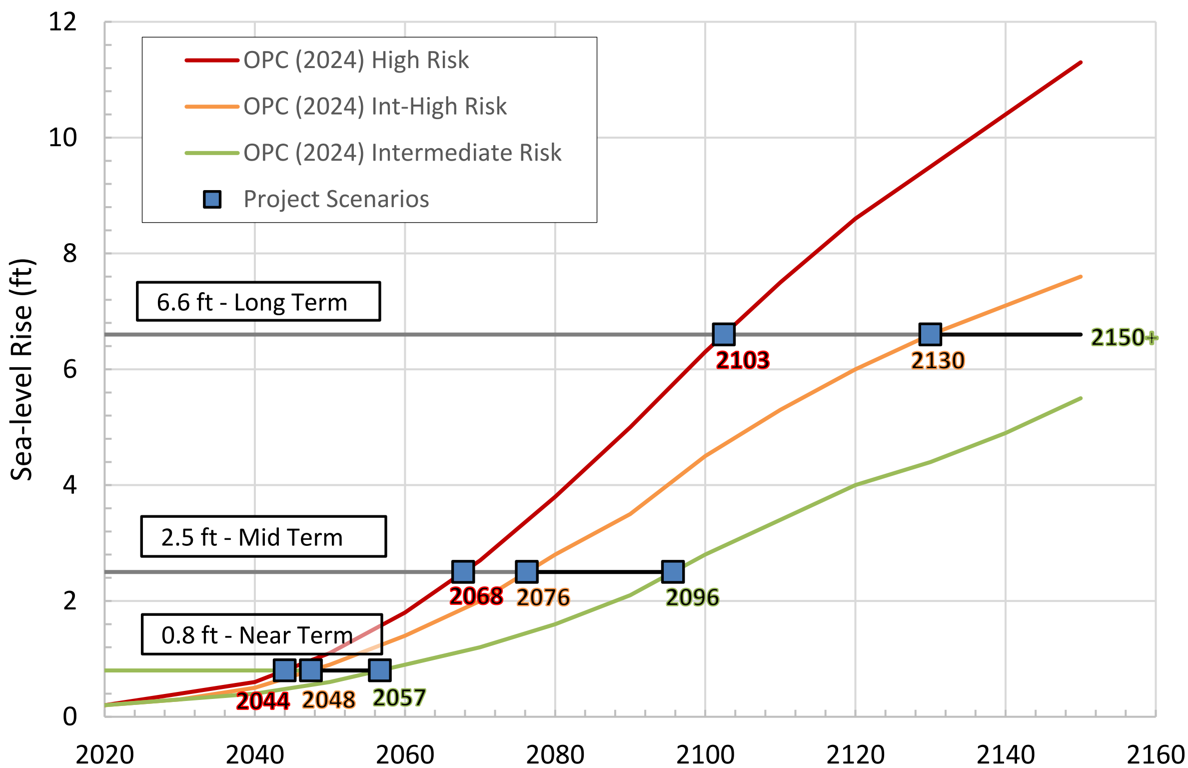
Sea Level Rise Scenarios

This assessment uses the 2024 California Ocean Protection Council (OPC) guidance and analyzes sea level rise amounts of 0, 0.8, 2.5, and 6.6 feet, consistent with sea level rise amounts selected for the City of Santa Barbara's Sea Level Rise Adaptation Plan. The assessment uses the Intermediate-High risk scenario from the 2024 OPC guidance, which represents a precautionary projection that is the plausible high-end projection for 2100 should rapid ice sheet loss contribute to sea level rise. It also considers that sea level rise could happen slower in the Intermediate Scenario and faster in the High Scenario. The Intermediate Scenario represents a more likely scenario in the near and mid-term that most closely tracks with observed changes in emissions and sea levels to date. The High Scenario represents a high future emissions and high warming scenario with large contributions from rapid ice-sheet melt. Under the

Intermediate-High risk scenario (and for the range between the Intermediate and High Scenarios), the estimated timing of the sea level rise amounts is:

- 0.8 feet of sea level rise (ft SLR): 2048 in the Intermediate-High Scenario (range from 2044 in the High Scenario to 2057 in the Intermediate Scenario), which is referred to as near term
- 2.5 ft SLR: 2076 (2068 in the High Scenario to 2096 in the Intermediate Scenario), referred to as mid term.
- 6.6 ft SLR: 2130 (2103 in the High Scenario to 2150 or later in the Intermediate Scenario), referred to as long term.

The projected sea level rise amounts and dates for these scenarios are shown graphically in **Figure ES-1**. This report uses dates for sea level rise amounts that correspond to the Intermediate-High Scenario. As discussed above and in Section 3, this report acknowledges that sea level rise could occur sooner in the low probability High Scenario and later in the Intermediate Scenario.



SOURCE: 2024 OPC Guidance

Figure ES-1.
Sea Level Rise Projections and Project Scenarios

Flood Hazards Analyses

Three primary hazards were analyzed: fluvial flooding due to extreme rainfall runoff, creek discharge, and high water levels in Tecolotito, Carneros, and San Pedro Creeks; flooding from Goleta Slough; and tidal inundation. The changes to the recurrence of each of these hazard sources with sea level rise were examined. Based on historical flooding events at the site, three levels or thresholds of flooding were selected for this assessment: a lower level flooding that is limited to the Northwest (NW) Quadrant and the edge of the runways, a higher level of flooding that inundates the main runways and necessitates airport closure, and more extreme flooding of the entire airport.

Global climate model results were used to estimate increases in the frequency of extreme precipitation and fluvial flooding with climate change. Additionally, a model of Goleta Slough water level and mouth opening and closure was used to estimate changes in flooding from Goleta Slough with sea level rise. Tidal inundation and groundwater analyses were performed using the United States Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS 3.0) results. CoSMoS results were also used to assess the rise and emergence of groundwater due to sea level rise as an additional hazard.

The assessment results project that flood events will become significantly more common and severe in the future (2024 to 2100) (**Table ES-1**). The chance of NW Quadrant storm flooding occurring at least once in any given year, 12% under past conditions, rises to 28% annual chance with future (2024 to 2100) increased precipitation due to climate change. Recent storm events may indicate that extreme precipitation is already increasing due to climate change. Compounding the effects of increased precipitation, sea level rise will further increase the annual chance of NW Quadrant storm flooding to 29% with 0.8 feet of sea level rise (2048) and 100% with between 0.8 and 2.5 feet of sea level rise (2048 to 2076) and greater amounts of sea level rise. Similarly, the annual chance of runway flooding and airport closure rises from 7% with past conditions to 21% with future precipitation, remains a 21% chance with 0.8 feet of sea level rise (2048), and rises to 61% with 2.5 feet of sea level rise (2076). The risk of the entire airport flooding, previously 1% annual chance, rises to 3% with future precipitation and 4% with 0.8 to 2.5 feet of sea level rise (2048 to 2076).

TABLE ES-1. FLOOD THRESHOLD ANNUAL CHANCE SUMMARY

	Sea Level Rise and Precipitation Scenarios	NW Quadrant & Edge of Runway Flooded (11 ft WSE[a])	Runways Flooded, Airport Closed (12.5 ft WSE)	Entire Airport Flooded (14 ft WSE)
Baseline	0 ft, Past Precipitation	12%	7%	1%
Near Term	0 ft, Future Precipitation (2024 – 2100)	28%	21%	3%
	0.8 ft[b] (2048)	29%	21%	4%
Mid Term	2.5 ft (2076)	100%	61%	4%
Long Term	6.6 ft (2130)	100%	100%	100%

Annual chance is the probability of flooding occurring in any given year
NOTES:
a. WSE = approximate water surface elevation.
b. All scenarios above 0 ft SLR assume future precipitation.

The following summarizes flood hazards and risk analyses results for near, mid, and long term:

- Near term: with increased future precipitation (2024 to 2100) due to climate change, results show flooding in the NW Quadrant more than doubles from a 12% annual chance to 28% annual chance, runway flooding and airport closure triples from 7% to 21% annual chance, and entire airport flooding also triples from 1% from 3% annual chance. With 0.8 feet of sea level rise and increased precipitation (2048), flood risks increase slightly compared to risks with increased precipitation alone.
- Mid term: at some point between 0.8 and 2.5 feet of sea level rise and with increased precipitation (2048 to 2076), results show NW Quadrant flooding increases to 100% annual chance. With 2.5 feet of sea level rise, results show runway flooding and airport closure increases from 21% to 61% annual chance and entire airport flooding remains a 4% annual chance.
- Long term: with between 2.5 and 6.6 feet of sea level rise (2076 to 2130), results show the annual chance of the entire airport flooding increases to 100%. With about 3.3 feet of sea level rise (2087), tidal flooding of the airport is likely to occur on a biweekly basis, rendering the airport inoperable. Under this scenario, which could occur with between 2.5 and 3.3 feet of sea level rise (2076 to 2087), the airport is not operational. Vulnerabilities are expected to increase for all assets and operations except for certain assets north of Hollister Avenue.

The above flood hazards results are based on flooding from the surrounding channels onto the airport due to high creek flows and slough and tide water levels. A separate analysis of the airfield storm drain system was also conducted to evaluate potential flooding from direct precipitation onto airfield. The storm drain analysis evaluated flooding due to storm drains backing up and causing ponding. Under past precipitation conditions, a 5-year storm is expected to cause ponding impacting multiple taxiways, the terminal area and its surroundings, the NW Quadrant, and northeast buildings and hangars. Future precipitation (2024 to 2100) and 0.8 feet of sea level rise (2048) is anticipated to exacerbate ponding to a level that encroaches on the runways. This analysis is integrated with the creek and coastal flooding analyses for the vulnerability assessment.

The CoSMoS groundwater hazard results indicate that the depth to groundwater is already very shallow (0 – 3.3 ft) throughout most of the site, with areas of potential groundwater emergence at the North ends of Runways 15R/33L and 15L/33R. With 0.8 feet of sea level rise, the areas of emergence are expected to expand slightly. With 2.5 feet of sea level rise, Taxiways A, B, and E are expected to be impacted by emergent groundwater. Groundwater emergence at 6.6 feet of sea level rise was not analyzed because consistent tidal flooding is projected in the area.

The vulnerability of the following SBA assets were assessed: Federal Aviation Administration (FAA)-owned navigational aids (NAVAIDs) and electrical equipment, utility poles, instrument landing system, rotating beacon, Medium Intensity Approach Light System with Runway Alignment Indicator Lights (MALSR), precision approach path indicator, runway end identifier lights, remote transmitter/receiver, electrical vault, glide slope system and Runway Visual Range (RVR), security equipment, airport electrical equipment, storm drain infrastructure, fiber-optic, sanitary sewer infrastructure, gas infrastructure, water infrastructure, fuel tank sites, buildings, airport access roads, parking lots, and the airport operations area.

Vulnerability Assessment

Vulnerability was assessed and ranked from low to high based on a combination of an asset's exposure level (which flood threshold the asset is exposed during), sensitivity (consequence of exposure), and adaptive capacity (ability to modify or change in response to a hazard). The most vulnerable assets were found to be the NW General Aviation Aprons, Runways 15R/33L and 15L/33R, Glide Slope Antenna and RVR, Remote Transmitter Receiver, Air Traffic Control (ATC) Tower, Sanitary Sewer Infrastructure, and Storm Drain Infrastructure (**Table ES-2**, **Figure ES-2**). The next most vulnerable are the SE and NE General Aviation Aprons, Taxiways, Terminal Apron, Airport Rotating Beacon, Instrument Landing Systems (ILS), MALSR System, Precision Approach Path Indicator, Runway End Identifier Lights, Airport Access Roads, Airport Maintenance Buildings, Airport Rescue and Firefighting (ARFF) Station, SE Terminal Building, NW Buildings/Hangars, Fuel Tank Sites, Gas Infrastructure, Long-Term and Short-Term Parking Lots, and Water Infrastructure. Specifics of particular asset exposure and vulnerability are included in the report in Table 9. The vulnerability of airport operations was also considered. Three of four airport operations categories have high vulnerability: Disembarking at the Terminal, Closure of Private Aviation Operations, and Closure of Commercial Runway (7/25). Flooding of Runways 15R/33L and 15L/33R has medium vulnerability. Adaptation of any of the airport operations areas would require significant effort.

TABLE ES-2. ASSET VULNERABILITY SUMMARY

Vulnerability Level	Assets	
High	• Northwest General Aviation Aprons • Runways 15R/33L and 15L/33R • Glide Slope Antenna and Runway Visual Range • Remote Transmitter Receiver	• Air Traffic Control Tower • Sanitary Sewer Infrastructure • Storm Drain Infrastructure
High – Medium	• Southeast General Aviation Aprons • Northeast General Aviation Aprons • Taxiways • Terminal Apron • Airport Rotating Beacon • Instrument Landing Systems (Localizer, Automated Surface Observing System, Airport Surveillance Radar, Distance Measuring Equipment) • Medium Intensity Approach Lighting System • Precision Approach Path Indicator • Runway End Identifier Lights	• Airport Access Roads • Airport Maintenance Buildings • Airport Rescue and Firefighting Station • Southeast Terminal Building • Northwest Buildings/Hangars • Fuel Tank Sites • Gas Infrastructure • Long-Term Parking Lots • Short-Term Parking Lots • Water Infrastructure

Economic Analysis

The economic assessment focuses on the expected costs of storm-related flight delays and cancellations in the event that the main departure runway floods, resulting in an airport closure. The analysis provides insight into the expected annual loss; specifically the expected costs to the airport, commercial operators, commercial passengers, and general aviation.

Based on the results of the flood hazards analysis, SBA's annual reports, current flight data, and projected future aviation from the updated Master Plan, this analysis estimates future losses. Specifically, it relies on the annual chance of runway flooding and historical flight impacts and costs associated with runway flooding. The average flood event closure duration is 21.6 hours, with 21 canceled flights, while a severe flood event can lead to 25.5-hour closures and 34 canceled flights.

Annual costs associated with flooding will increase until the airport is no longer operational, which could occur with between 2.5 and 3.3 feet of sea level rise (2068 to 2108). For an average storm, total undiscounted losses through 2075 (which corresponds with about 2.5 feet of sea level rise in the Intermediate High Scenario and 3.3 feet of sea level rise in the High Scenario) are projected to be $68,537,000, with discounted losses at $11,292,000. With severe storms, total undiscounted losses could reach $158,831,000, with discounted losses of $36,508,000. Passengers could bear the highest percentage of losses (up to 71%), with a significant portion related to delays and cancellations. The airlines could face substantial operating losses due to additional labor expenses, fuel, maintenance, and operating expenses from flight delays and cancellations. Airport revenue losses during full shutdowns are estimated at $120,000 per operational day, or $8,500 per hour.

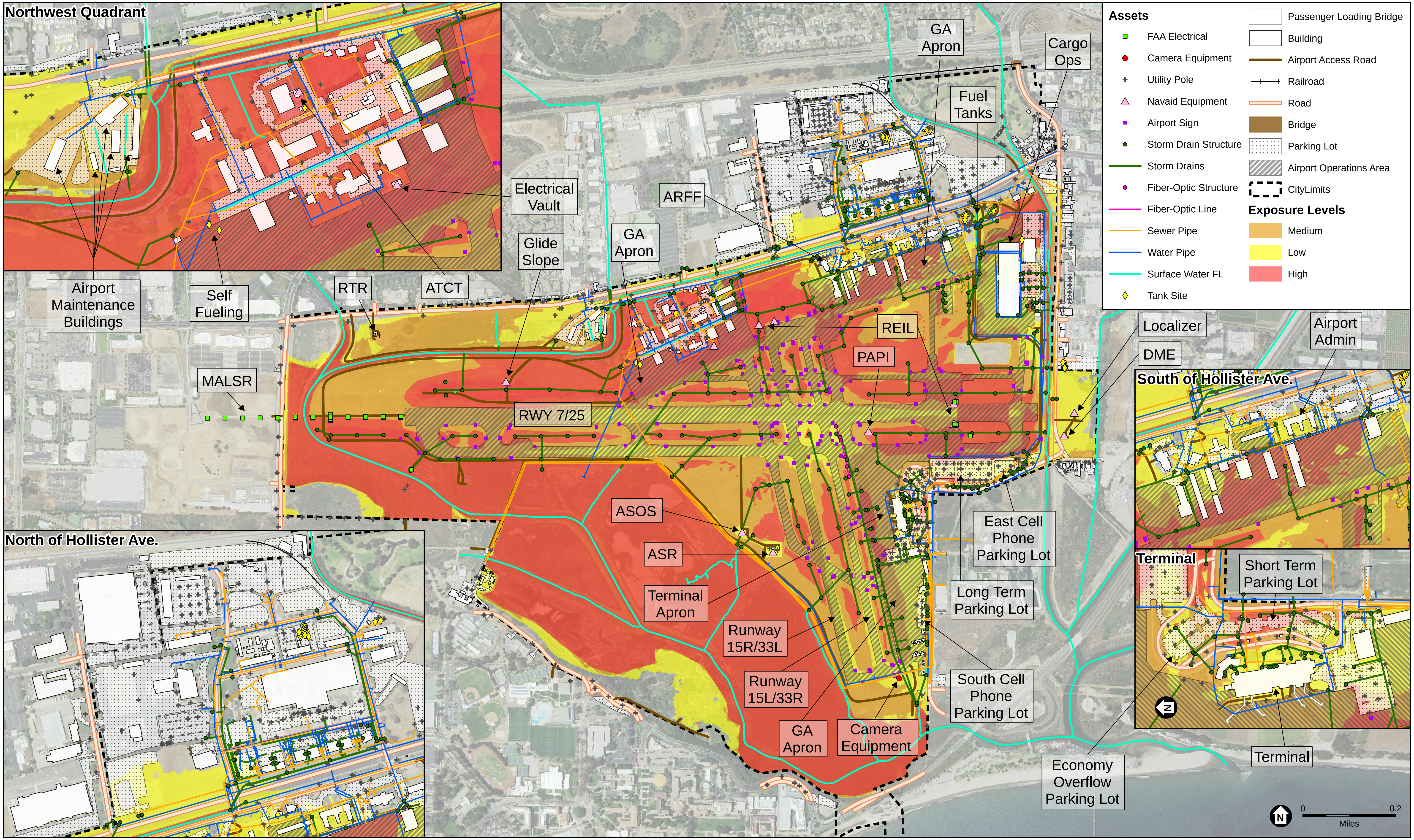
General aviation constitutes 80% of all flights at SBA. However, data on general aviation flights and potential impacts are limited. Attempts to estimate losses relied on the limited data available, largely charter flight impacts. General aviation will likely be less impacted by storms and inundation, due to alternate airports and greater flexibility; however, a survey of general aviation customers could augment these results.

Habitat Change

An inundation frequency habitat model was applied to Goleta Slough to predict future habitats based on changes in ground surface elevations and inundation levels with sea level rise. Subtidal habitats are expected to expand by up to 46 acres with 6.6 feet of sea level rise. Mudflat habitats are expected to expand by nearly 200 acres with the same rise, potentially providing additional habitat for shorebirds, but impacting existing marsh habitats and water quality. Low to mid marsh areas are likely to increase, while high marsh and transitional habitats are expected to decrease, leading to a potential loss of plant species and their dependent animals due to limited area available for upslope habitat migration.

Conclusions and Next Steps

SBA is located in a flood-prone area, and many of its assets and operations are vulnerable to flooding that will worsen with increasing precipitation and sea level rise in the future. Habitats within Goleta Slough are also anticipated to be impacted by sea level rise. The findings of the vulnerability assessment will be used to identify adaptation strategies that will reduce the vulnerabilities and risks to SBA assets and Goleta Slough habitat. These adaptation strategies will be described in a Climate Adaptation Plan.



SOURCE: ESA/SB County, USGS, NAIP, GSD, Santa Barbara Airport, UCSB, GWSD

Santa Barbara Airport Sea Level Rise Adaptation Plan . D202201087.00

Figure ES-2
Asset Exposure Levels

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1. INTRODUCTION

The City of Santa Barbara (City) has initiated this study to develop a Climate Vulnerability Assessment and Risk Evaluation (CVARE) for the Santa Barbara Airport (SBA). The purpose of this assessment is to evaluate vulnerabilities and risks for airport assets and operations due to coastal and flood hazards with future projected sea level rise and increased precipitation caused by climate change.[1] The following sections summarize background on the airport and surrounding Goleta Slough.

In addition, to comply with the requirements of the airport's Part 139 Airport Operating Certificate, a technical memorandum providing a framework of the Part 139 requirements and potential impacts to the airport's ability to meet those requirements is included as **Appendix A**.

1.1 Background

The Santa Barbara Airport is owned and operated by the City of Santa Barbara and has served as the region's primary airport for over 80 years. It is located in Santa Barbara County in the South Coast Region, approximately 10 miles west of downtown Santa Barbara. SBA is surrounded by Carneros Road to the west, Hollister Avenue and the Southern Pacific Railroad to the north, South Fairview Avenue to the east, and the UC Santa Barbara main campus to the southwest. The property is comprised of 948 acres, approximately 600 acres of which house the airport's aviation facilities. Approximately 50 acres are used for non-aviation and commercial purposes. The remaining 300 acres encompass a portion of Goleta Slough, a coastal wetland with high biodiversity in which many species reach their northern and southern limits. The airport and surrounding area are depicted in **Figure 1**.

Goleta Slough has a 45 square mile watershed, including seven creeks: Atascadero, Carneros, Las Vegas, Maria Ygnacia, San Jose, San Pedro, and Tecolotito Creeks. SBA itself is bordered to the west by Carneros and Tecolotito Creeks and to the east by San Pedro Creek.

SBA has historically been prone to flooding. Major floods have forced the closure of the airport in 1969, twice in 1995, 1998, 2017, 2023, and twice in 2024. As the climate changes and sea levels rise, the risk of flooding at SBA is expected to increase. Airport assets may be subjected to flooding from three primary sources:

- Existing and future fluvial flooding from Carneros, Tecolotito, and San Pedro Creeks associated with extreme precipitation events
- Flooding caused by elevated water levels in Goleta Slough associated with increased stream flow into the Slough, a closed inlet mouth condition, and sea level rise
- Tidal inundation associated with sea level rise

[1] This report focuses on sea level rise and increased precipitation as primary climate stressors for the airport and does not consider other potential climate stressors.

1.2 Relevant Regional Projects

There have been multiple efforts in the areas immediately surrounding SBA to study vulnerability to sea level rise and plan adaptation. These projects and their findings are summarized below to provide context for SBA area's sea level rise planning.

1.2.1 Goleta Slough Area Sea Level Rise and Management Plan

In 2015, the *Goleta Slough Area Sea Level Rise and Management Plan* (ESA, 2015a) was published to provide coordinated management of the slough and provide a healthy slough ecosystem throughout the environmental hazards and changes associated with sea level rise. The 2015 plan provided updates to previous management plans and provided new information and analysis of how conditions are projected to be altered with climate change into the future.

Goleta Slough is a lagoon (aka coastal estuary) formed behind Goleta Beach that has been significantly reduced in size and function due to natural processes and development of the surrounding area. Its water surface is controlled by the conditions of Goleta Beach and the lagoon mouth channel that forms through the beach. These channel mouth conditions change seasonally: the mouth typically closes in the summer due to sand build-up from wave energy and opens in winter when rain events fill the slough and breach the beach berm, scouring the channel. The slough remains open to tidal influence until the berm reaccumulates.

Before 2013, managed mechanical breaches of the lagoon inlet were conducted by the Santa Barbara Flood Control District during periods of extended mouth closure. The purpose of these breaches was to abate flooding risk and prevent mosquitos from breeding in the slough. In 2013, the Flood Control District discontinued this practice due to high costs expected for the biological studies necessary to renew the permits. Some breaches have taken place on an emergency basis in the period since to alleviate flood risks from rapidly rising lagoon water levels. The City of Santa Barbara has commissioned studies to assess the impacts associated with managed breaches on lagoon ecology and planning for long-term slough management (ESA, 2015a).

This management plan's key findings regarding sea level rise at the slough were:

- Management of the slough inlet will significantly impact water levels and habitat distribution
- Manage the slough to provide tidal circulation, maintain water quality and species diversity, and increase species and habitat resilience
- Establish plans for the long-term management of the slough mouth including monitoring and compliance with future regulations
- Sediment deposition into the slough from the surrounding watershed should be encouraged to maximize accretion relative to sea level rise
- Minimize construction of sensitive assets within flood hazard areas
- Identify and pursue projects to protect key areas and vulnerable infrastructure

SOURCE: ESA/SB County, USGS, NAIP, GSD, Santa Barbara Airport, UCSB, GWSD

Santa Barbara Airport Sea Level Rise Adaptation Plan . D202201087.00

Figure 1

Santa Barbara Airport

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Goleta Sanitary District Climate Adaptation Plan

In 2022, the Goleta Sanitary District (GSD) undertook a study to develop a climate adaptation plan for GSD's wastewater collection, treatment, recovery, and discharge facilities (ESA, 2022). The GSD Water Resource Recovery Facility is located immediately southeast of the airport and treats wastewater from SBA's sanitary sewer collection system in addition to other areas including a large area of Goleta. GSD's Firestone Road Pump Station and other GSD wastewater assets are within or adjacent to SBA property. The plan identifies vulnerable assets to sea level rise and provides adaptation strategies the District can take. The District is also threatened by sea level rise and its associated impacts on tidal inundation, fluvial flooding, and lagoon flooding from Goleta Slough. The report's key findings regarding sea level rise were:

- Chronic tidal inundation, erosion, and groundwater rise are likely to impact District assets in the future by increasing inflow and infiltration and pumping and treatment costs, while causing floatation issues and exposing facilities to erosion. Floodwater seepage through unsealed manholes and other structures will lead to increased flow rates within the collection system, potentially beyond the capacity of the collection system to convey wastewater.
- Fluvial and estuarine flooding will worsen in the future and more District assets will be exposed with sea level rise.
- Recommendations that the District consider establishing a groundwater monitoring network; conducting geotechnical investigations; monitoring coastal erosion; assessing San Pedro Creek bank stabilization; floodproofing the Firestone Road Pump Station; and coordinating with SBA, UC Santa Barbara, and Goleta West Sanitary District.

Vulnerable GSD assets on or adjacent to SBA property include the Firestone Road Pump Stations and structures (manholes, cleanouts, and interceptors). See Section 6.1.5 for discussion of the vulnerability of these assets and how they impact SBA.

2. HISTORIC AND CURRENT FLOODING

2.1 Creek and Flood Management

2.1.1 County Sediment Management

Over time, sediment tends to deposit and build up in the stream beds of the creeks adjacent to the airport. This reduces the flood capacity of the creeks, making it more likely for the creeks to overtop their banks and cause flooding during storm events. The County of Santa Barbara excavates and removes sediment from several creek reaches to increase flood capacity and reduce flood risk. The County performs sediment removal on a regular basis under programmatic permits and, when necessary, as emergency operations under emergency permits. Sediment removed is disposed of at an approved landfill or used for construction when possible. For sediment removed under emergency permits that meets permitted criteria for beach disposal, the County places removed sediment at Goleta Beach.

For Carneros Creek, the County removes sediment from an approximately 0.1-acre basin south of Hollister Avenue. More recent sediment removal occurred in 2023 and 2024 under an emergency permit and the regular maintenance program in 2021. Sediment has been regularly removed from San Pedro Creek every 2 to 6 years under programmatic permits, and as an emergency operation in 2023. Sediment is not regularly removed from Tecolotito Creek, as the creek does not accumulate as much sediment as San Pedro and Carneros Creeks.

2.1.2 Creek Channel Realignment

Around 1975, the main SBA runway was extended by 1,000 feet, prompting the realignment of Carneros Creek around the runway. This adjustment resulted in the creek's path forming almost right-angled corners around the airport area. In 2006, the main runway was relocated 800 feet to the west to accommodate Runway Safety Areas, which required the rerouting of both Tecolotito and Carneros Creeks. This latest realignment led to a more curved path for the creeks, eliminating the previously sharp angled flows (ESA, 2015a). Before the relocation, Carneros Creek flowed southwest through Goleta Slough.

2.1.3 Goleta Slough Mouth Management

Water levels in Goleta Slough are controlled by the presence and elevation of the beach berm at the inlet mouth at Goleta Beach (ESA, 2015a). Under natural conditions, the mouth seasonally cycles between open and closed inlet conditions. During summer months, when wave energy is significantly reduced, the beach accumulates sediment, building up and naturally closing the slough inlet. When the inlet mouth is closed, wave overtopping and stream inflows fill the slough. At a certain point, usually during a rainfall event, the water level of the slough overtops the berm, and the inlet breaches. As this happens, the breach scours a channel through the berm, opening up the mouth to tidal influences. As the streamflow lessens and sand reaccumulates, a sill forms that limits tidal effects. Over time this sill builds up, once again closing the inlet mouth, and the cycle repeats.

Closure of the slough mouth for extended periods of time can cause local flooding, fish kills, and provide habitat for mosquito breeding that impacts public health. Therefore, prior to 2012, the Santa Barbara County Flood Control District regularly breached the berm at the slough mouth within two weeks of mouth closure.

This practice was discontinued in 2012 when the existing permits for the activity expired. Emergency permits are now required for any mechanical breach of the mouth inlet. Since this change in mouth management, there has been a significant increase in migratory waterfowl such as Mallards, Canada Geese, Double-Crested Cormorants, and Great Blue Heron, potentially posing a hazard to airport operations. Santa Barbara County Vector Control also reported a hundredfold rise in mosquito population (Rincon, 2015).

Emergency permits have been used to breach the slough mouth on three occasions. In fall 2012, the slough mouth was breached under emergency permit ahead of winter storms. In February 2014, water levels rapidly rose in the slough during a storm event, posing a flood risk to SBA, and the slough mouth was breached under emergency permit. Again in December 2014, the mouth was breached with an emergency permit to abate flood risk caused by rapidly rising slough water levels in a precipitation event. In addition to the breaching, water was siphoning of out of the slough in May 2013 under an emergency permit. In 2017, the last time the mouth was managed, the berm was lowered but not breached under an emergency permit to reduce potential environmental impacts including potential wildlife stranding due to draining the slough.

2.2 Flood History and Damages, Assets

SBA has been subject to flooding during major storm events since commercial air service began at the site in 1936. Its geographic location in a coastal wetland system at the convergence of five major streams makes SBA especially susceptible to flooding. This section outlines the significant historical flooding events at the site and describes the recent storm events that have led to airport closures.

2.2.1 Flood History

Historic maps show that Goleta Slough once contained an extensive open-water embayment at the location of the present-day Santa Barbara Airport. As a result of the cattle ranching era and the Great Flood of 1862, sediment deposition filled and converted the open-water area to a vegetated coastal marsh. Development and filling of the marsh have also significantly changed the site conditions and constrained Goleta Slough.

Historical records indicate that SBA flooded in 1935, 1941, 1969, 1998, 2005, 2008, 2010, 2017, 2023, and twice each in 1995 and 2024. Observational data is relatively sparse in the early period of airport operations from the 1930s through the 2000s. Therefore, there is an incomplete record of the Goleta Slough mouth conditions, precipitation, and stream flow during the flood events prior to 2000.

In 1969, water completely surrounded the main terminal, and in 1995 and 1998 all three runways were flooded, closing the airport for several days. The 1969 event caused the highest water level observed in Goleta Slough in historical record, submerging nearly the entire airport runway, access roads, and parking lots. Atascadero Creek streamflow was 4,000 cubic feet per second (cfs), coupled with substantial ocean wave energy. The first 1995 storm event caused ponding on low-lying runway areas and deposited a significant amount of sediment on the runways and taxiways. Peak streamflow in Atascadero Creek was over 10,000 cfs. The airport was closed for several days as a result (ESA 2015).

2.2.2 Recent Flooding

Airport flooding has become more frequent in recent years, with four significant flooding events in the past decade, and three in the last two years. This section details these recent flooding events.

February 17, 2017

4.31 inches of precipitation at the site on February 16 and 17, 2017 led to serious flooding of the airfield and flooding of the last 1,000 ft of Runway 7-25 (NOAA, 2024; News Channel 3-12, 2017). The Air Traffic Tower was closed due to staffing issues caused by closure of Highway 101. Private and commercial flights were grounded, and the airport was closed in the afternoon of February 17. It reopened at 7:30 am the following morning (KCLU, 2017). This event was the first time the airport closed due to flooding since 1998.

January 9, 2023

4.50 inches of precipitation at the airport between January 8 and 9, 2023 caused flooding starting the morning of January 9 (NOAA, 2024). At 10:00 am an evacuation order was issued for the Northwest (NW) Quadrant, followed by the cancelling of all commercial flights at 12:00 pm. The entirety of Runway 7-25 was underwater at 1:54 pm. Clean up efforts began at 10:00 am on January 10 and the airport began reopening at 3:20 pm. There was property damage to the Signature T hangars, Hangars 2 and 10, Building 317, and the buildings on Firestone Avenue.

February 1 and 4, 2024

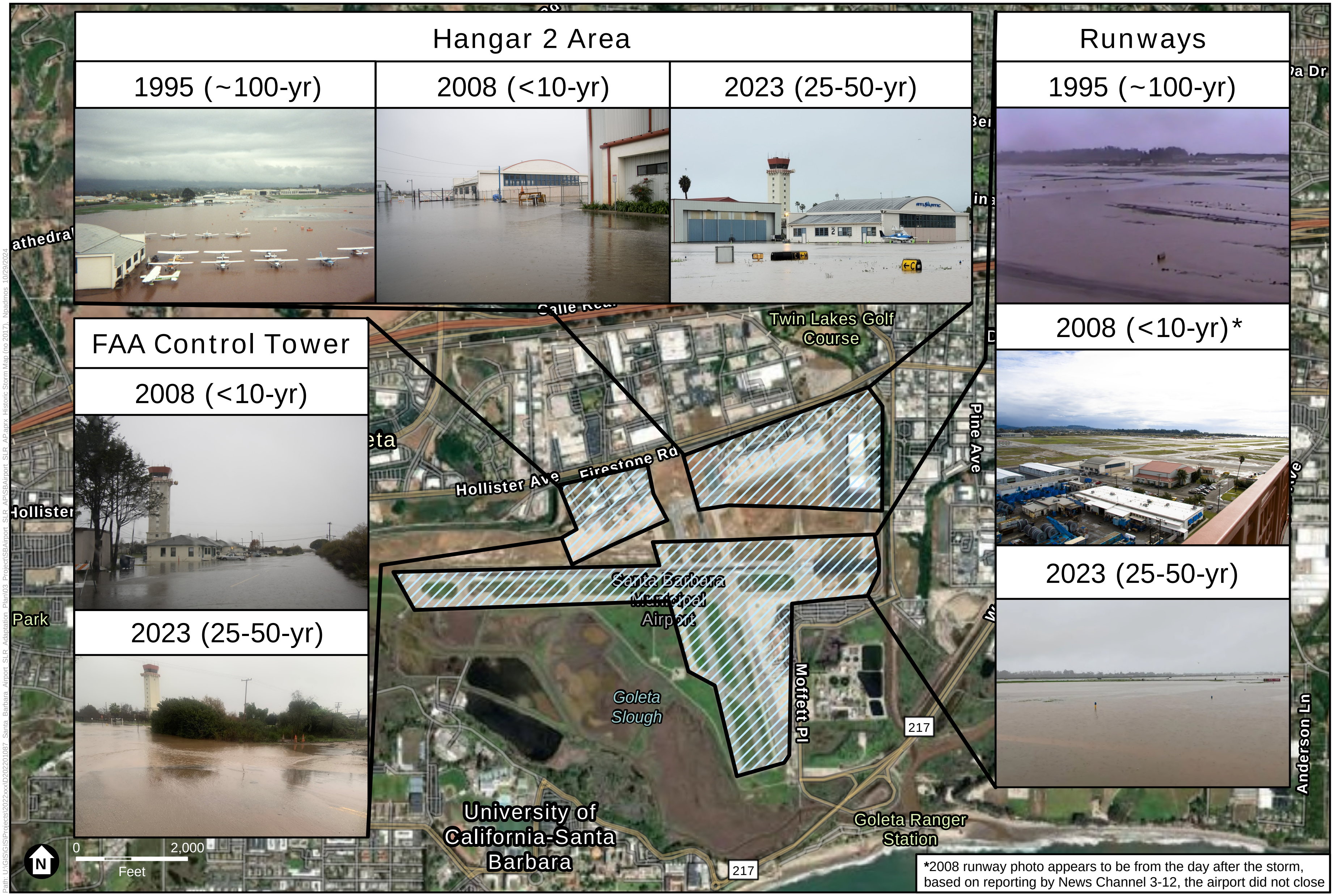
A combined 3.37 inches of precipitation on January 31 and February 1, 2024, led to unexpectedly severe flooding after which the airport sought a local emergency declaration to remove sediment from Carneros Creek ahead of the upcoming February 4 storm event (NOAA, 2024).

The February 4 storm caused 3.50 inches of rain on the 4th and 5th, leading to flooding of Firestone Ditch along Hollister Ave and of Carneros Creek. An evacuation order for NW Quadrant tenants was issued at 4:17 pm on February 4, before complete airport closure and cancellation of all general aviation flights at 4:58 pm (NOAA, 2024). Operations resumed at 1:00 pm on February 5.

February 19, 2024

The February 19, 2024, flooding was caused by 3.57 inches of rainfall from the afternoon of February 18 into the morning of February 19 (NOAA, 2024; SBPWD, 2024b). The airport closed due to flooding around 4 am on February 19. The airport announced that “the airfield and surrounding areas experienced a significant amount of flooding, but we’re happy to report there was no major damage” and began a phased reopening at 5:30 am on February 20 (SBA, 2024).

Figure 2 summarizes areas impacted in previous flooding events and the approximate recurrence interval of each event.



SOURCE: ESRI, Noozhawk, Coastal Care, ESA, 2024

D202201087.00 - Santa Barbara Airport SLR Adaptation Plan

Figure 2
Images of Historic Flooding at Key Sites of the Santa Barbara Airport

ESA

3. VULNERABLE COMMUNITIES

In 2015, the California Coastal Commission adopted interpretive guidelines for addressing sea level rise. The guidelines recognize the coastal hazards which are addressed by the 1972 Coastal Act. In 2016, the Coastal Act was amended to give the Commission new authority to specifically consider environmental justice. In 2019, the Coastal Commission adopted an environmental justice policy to address social inequity in the coastal zone, including to recognize that climate change “will have disproportionate impacts on communities with the least capacity to adapt,” and underscoring its longstanding mandate to protect California’s coast for all Californians (CCC, 2019).

The City of Santa Barbara completed a local Sea Level Rise Adaptation Plan in February 2021. In that plan guiding principles were laid out to provide a foundation for future project decisions, with the following principles relating directly to the protection of vulnerable communities:

> *“Encourage:*
>
> *a. Adaptation strategies that broadly protect the community’s health, safety, and welfare.*
>
> *b. Equitable sharing of costs and benefits of sea-level rise and related hazards*
>
> *c. Adaptation strategies that benefit or minimize impacts to vulnerable populations that may have higher sensitivity and lower adaptive capacity to hazards” (ESA, 2021)*

Several factors have been shown to correlate with a higher sensitivity and/or lower adaptive capacity to hazard that should be factored into planning for the impacts of sea level rise. These factors include, among others: income and poverty, race, language spoken, age, housing types (percent rentals), and household type.

SB 535 and AB 1550 require the State of California to invest certain percentages of climate cap and trade mitigation funds to identified disadvantaged and low-income communities. CalEPA developed a tool called CalEnviroScreen for assessing what constitutes a disadvantaged community. As defined in AB 1550, “low-income communities” are census tracts with median household incomes at or below 80 percent of the statewide median income or with median household incomes at or below the threshold designated as low income by the California Department of Housing and Community Development State Income Limits.

3.1 Santa Barbara Airport

Although, due to the Federal Aviation Administrations’ restrictions, no housing for residential populations can be located on Santa Barbara Airport land, the airport is located on the ancestral lands of the Chumash people. The Chumash were the first inhabitants of this region and serve as its original stewards. The Airport specifically sits on what is now known as the Goleta Slough - an area that has a long and rich history for the Chumash people. The area was originally home to a thriving population of Chumash residents, including the village of Helo', for thousands of years.

Santa Barbara Airport recognizes the vibrant history of the Chumash people and respects their cultural connections to the land. We are committed to honoring their legacy by collaborating with them today and into the future.

In efforts to directly combat discrimination and/or lack of consideration of disadvantaged populations, the City of Santa Barbara reviews and updates the Title VI Plan every three years. This plan outlines required efforts which are to be made by the Santa Barbara Airport through the utilization of Title VI programs as well as collecting and maintaining demographic data of airport employees and communities which may be impacted by airport operations. The most recent review and dispersal of the City of Santa Barbara's Title VI Plan occurred in February of 2024. Findings relevant to communities impacted by current airport operations and planned airport projects are as follows:

Existing Airport Facilities	Affected Community Impacted by Operation of the Facility
Runway 7-25	City of Goleta, Eastern Goleta Valley
Runway 15L-33R	None
Runway 15R-33L	None
Airline Terminal	None
Southfield Redevelopment Project	None

Airport Facility Construction Projects	Affected Community Impacted by Construction of the Facility
Southfield Redevelopment Project	None
Airline Terminal Improvement Project	None
Taxiway H Extension Project	None

The Title VI Plan can be reviewed under **Appendix B** of this document.

The Santa Barbara Airport directly employs over 60 people. Of these employees, 30 percent qualify as economically disadvantaged, and 10 percent qualify as severely disadvantaged. These figures do not describe all personnel who work on airport property (i.e., airline employees, TSA employees, etc.) Closure of airport operations due to hazardous climate events may place these individuals in situations of serious economic distress. The adaptation measures identified to reduce airport vulnerability in the next phase of this project aim to reduce the likelihood of airport closure, thus reducing these employees' risk of economic duress.

3.2 Old Town Goleta

A disadvantaged community identified by CalEPA's CalEnviroScreen tool is located along the eastern boundary of the Santa Barbara Airport within the area identified as Old Town in the City of Goleta's 2015 Coastal Hazards Vulnerability Assessment and Fiscal Impact Report. Old Town is situated along the primary thoroughfare (Hollister Avenue), is the historic center of the city and characterizes the small-town character of the city. It consists of commercial, industrial, light manufacturing, residential, and open space areas. The industrial area and a mobile home park are within the Coastal Zone. The SB 535 disadvantaged community encompasses approximately 1.5 square miles and is housed primarily by renters, with only 28% of households being owner occupied. Of the total community population, 36% fall within low-income status and the entire area is within the 80th percentile of housing burden. These factors indicate low adaptive capacity to climate impacts, as previously stated. This community is composed predominantly by persons of color with 67% of the population being of Hispanic descent, 6% of Asian descent, 2% black, and 2% identifying as two or more races (EPA, 2024).

Though it is difficult to map homeless populations, it should be noted that the City of Goleta identified 196 unhoused persons living within Goleta City limits through their By-Name List in May of 2024, a program facilitated by the City of Goleta's Homelessness Strategic Plan (City of Goleta, 2024). This population is extremely vulnerable to climatic hazards and should also be considered within the disadvantaged population surrounding the airport.

The southwest portion of the Old Town community is vulnerable to flooding in scenarios of over 3 feet of sea-level rise, as well as the southwestern portions being in the 96th percentile for flood risk (EPA, 2024). The risks posed to this community were identified in the City of Goleta's 2015 Coastal Vulnerability Assessment and adaptation measures to reduce their vulnerability were identified in that report. Since the publication of the City of Goleta's Vulnerability Assessment, this area has been majorly impacted by flooding events. During the intense rain on February 17th, 2017, the Santa Barbara County Emergency Management office issued a warning for the high likelihood of Hollister Avenue flooding in Old Town (Bolton, 2017). The massive storm on January 9th, 2023, resulted in a 5.5-foot diameter sinkhole, measuring 36 inches deep, in Old Town's Jonny D. Wallis Neighborhood Park (City of Goleta, 2023).

3.3 Isla Vista

Isla Vista is an unincorporated disadvantaged community encompassing a 0.5 square-mile area located roughly one mile southwest of the Santa Barbara Airport. Surrounded on three sides by the University of California, Santa Barbara (UCSB), Isla Vista is located on a coastal bluff overlooking the Pacific Ocean and the entire community is located within the Coastal Zone. Isla Vista is a unique community in that its primary resident population is a semi-permanent student body attending UCSB as well as Santa Barbara City College. The current population of Isla Vista is approximately 20,000; some 13,000 of whom are students.

Due to the temporary nature of residency in Isla Vista, only 1% of homes in the area are owner-occupied. Most of the original housing stock dates from the 1960's and 1970's. This community has a high population of economically disadvantaged residents with 85% of the community falling into the low-income category. Of the total population 46% of residents are people of color with 21% of residents being of Hispanic descent, 16% of Asian descent, 6% black, and 3% identifying as two or more races (EPA, 2024).

The community is not at immediate risk due to hazards such as flooding and sea level rise, but erosion of the coastal bluff due to water impacts does currently pose a major hazard to Isla Vista residents.

3.4 Resources

SB 535 and AB 1550 require the State of California to invest certain percentages of climate cap and trade mitigation funds to identified disadvantaged and low-income communities. Proposition 68, passed in 2018, authorizes a $4.1 billion for state and local parks, natural resources protection, climate adaptation, water quality, and flood protection. Projects that benefit disadvantaged and severely disadvantaged communities are given priority for funding. The recently passed SB 867 also provides funding towards climate resilience and adaptation, requiring that at least 40% of the total funds available be allocated to projects that provide meaningful and direct benefits to disadvantaged communities, and 10% for projects providing direct benefits to severely disadvantaged communities.

The Santa Barbara Airport hopes to work in tandem with surrounding agencies and organizations to mitigate climate hazards and provide equitable adaptation measures. Resilient Cities Catalyst is currently drafting the Goleta Slough Area Coastal Resilience Adaptation Plan in efforts to preserve and protect the culturally and ecologically significant lands of the Goleta Slough. Santa Barbara County is currently drafting an Environmental Justice Element aiming to address the needs of unincorporated Environmental Justice Communities such as Isla Vista. The University of California, Santa Barbara, adopted a Sea Level Rise Adaptation in June of 2024 with adaptation measures targeting coastlines near airport property. The City of Goleta is continuing efforts proposed in their 2015 Coastal Hazards vulnerability Assessment and Fiscal Impact Report. The Santa Barbara Airport Climate Adaptation Plan will add to the efforts in the area to protect our most vulnerable communities.

4. SEA LEVEL RISE SCENARIOS

This section documents the planning horizons and sea level rise scenarios evaluated for the Santa Barbara Airport Climate Vulnerability Assessment and Risk Evaluation. This study evaluates coastal hazards for existing conditions and three (3) future sea level rise scenarios for the project: 0.8 feet of sea level rise (ft SLR) (2048), 2.5 ft sea level rise (2076), and 6.6 ft sea level rise (2130). These sea-level rise scenarios are consistent with the latest State guidance and available coastal hazard maps for the Santa Barbara area, including United States Geological Survey (USGS) CoSMoS 3.0 (O'Neill, et al., 2018) and coastal hazard mapping by ESA for Coastal Resilience Santa Barbara County (ESA, 2015a). Section 3.1 summarizes California State guidance on sea level rise, and Section 3.2 presents the sea level rise scenarios and planning horizons (timeframes for analysis) for the project.

4.1 California State Sea Level Rise Policy Guidance

The California Ocean Protection Council (OPC) recently finalized the State of California Sea Level Rise Guidance: 2024 Science and Policy Update[2] (OPC, 2024), which provides projections for sea level rise at various locations along the coast of California through 2150. OPC produced this guidance in partnership with the California Ocean Science Trust (OST) and a scientific Task Force. The guidance is based on the National Oceanic and Atmospheric Administration (NOAA) 2022 Global and Regional Sea Level Rise Scenarios for the United States (Sweet, et al., 2022), which provides updated sea level rise scenarios for the United States based on global projections from the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report. The updated 2024 guidance presents five sea level rise scenarios and values that incorporate: (1) sea level rise observations, estimated and modeled projections, and uncertainties, and (2) a range of global greenhouse gas emissions scenarios, which rely on shared socioeconomic pathways (SSPs).[3]

Note that future global greenhouse gas emissions and warming scenarios drive the sea level rise projections reported by the OPC. Emissions scenarios are influenced by societal choices and therefore their likelihood of occurrence is inherently uncertain. Sea level rise scenarios are determined by modeling a range of global emissions projections and considering a range of uncertainties in sea level rise processes. Due to the inherent uncertainty of future global greenhouse gas emissions scenarios, the probability of sea levels rising a specific amount by a specific date cannot be determined. Instead, the probability of exceedance of a particular sea level rise scenario provided by the 2024 OPC guidance is contingent or conditional on the assumption of a particular future emissions and warming scenario.

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2 https://opc.ca.gov/2024/06/for-immediate-release-ocean-protection-council-adopts-updated-guidance-to-help-california-prepare-for-and-adapt-to-rising-seas/

3 SSP background from OPC 2024 guidance: *Developed more recently, the SSPs are a collection of narrative descriptions of alternative futures of socio-economic development in the absence of climate policy intervention. Five SSPs describe five different pathways that the world could take, drawing on data including population, economic growth, education, urbanization, and the rate of technological development. The SSPs are important inputs into the IPCC sixth assessment and are used to explore how societal choices will affect greenhouse gas emissions. Pathways 5-85 (SSP 585) assumes heavy fossil-fueled development with high percentage of coal and energy-intensive lifestyles worldwide and assumes a radiative forcing of 8.5 W/m^2.*

The State of California Sea Level Rise Guidance (2024) provides the following sea level rise scenarios and risk aversion applications:

Low Scenario: "Aggressive emissions reductions leading to very low future emissions; the scenario is on the lower bounding edge of plausibility given current warming and sea level trajectories, and current societal and policy momentum."

Intermediate-Low Scenario: "A range of future emissions pathways; a reasonable estimate of the lower bound of most likely sea level rise in 2100 based on support from sea level observations and current estimates of future warming."

Intermediate Scenario (Low Risk Aversion): "A range of future emissions pathways; could include contribution from low confidence processes. Based on sea level observations and current estimates of future warming, a reasonable estimate of the upper bound of most likely sea level rise in 2100." The OPC guidance states:

> *"For short-term adaptation actions (e.g., as part of an adaptation pathways approach) the Intermediate Scenario is recommended, regardless of risk category. This is because multiple lines of evidence identify the Intermediate Scenario as being most likely in the near-term (i.e., 2050) … For low-risk averse projects, it is recommended that the Intermediate Scenario be applied." (OPC 2024)*

Low risk aversion is appropriate for adaptive, lower consequence projects (e.g., unpaved coastal trails).

Intermediate-High Scenario (Medium-High Risk Aversion): "Intermediate-to-high future emissions and high warming; this scenario is heavily reflective of a world where rapid ice sheet loss processes are contributing to sea level rise." OPC guidance states:

> *"For medium-high risk averse applications, the Intermediate-High Scenario is recommended. Although there is a 0.1% chance of exceeding the Intermediate-High Scenario in 2100 (assuming 3°C of warming and no low confidence processes) the state recommends a precautionary approach, when possible, to maximize preparedness and resilience. Furthermore, if there is greater than 4°C warming and contribution from low confidence processes, there is a 20% chance of exceeding the Intermediate-High Scenario in 2100 (high levels of warming). Additionally, because medium-risk averse projects have longer lifespans, the Intermediate-High Scenario provides an additional buffer should the project need to persist further into the future than originally planned for." (OPC 2024)*

Medium-high risk aversion is appropriate as a precautionary projection that can be used for less adaptive, more vulnerable projects or populations that will experience medium to high consequences as a result of underestimating sea level rise (e.g., coastal housing development).

High Scenario (Extreme Risk Aversion): "High future emissions and high warming with large potential contributions from rapid ice-sheet loss processes; given the reliance on sea level contributions for processes in which there is currently low confidence in their understanding, a statement on the likelihood of reaching this scenario is not possible." However, assuming high emissions and considering the range of model projections for a high emissions scenario without contribution from low confidence processes, the

High Scenario's sea level rise estimates have 0.1% or less chance of exceedance by 2100. [4] The OPC states that this scenario "should be used with caution and consideration of the underlying assumptions." The OPC report that:

> *"For extreme risk averse applications, the High Scenario may be appropriate, however, there are limited situations in which designing and constructing to the High Scenario will be necessary and/or feasible without significant logistical tradeoffs. If significant constraints do not exist, then designing to the High Scenario is recommended, all other factors being equal. However, it is likely that in most situations, factors like the urbanized nature of existing communities, location of existing facilities, requirements to provide service to existing development, and fiscal constraints will make incorporating the High Scenario into initial project design infeasible. The adaptation pathways approach is therefore recommended, in which a smaller amount of sea level rise is incorporated into initial project design while also developing options to address higher sea level rise amounts in the future … Although the High Scenario has an effectively zero percent chance of being exceeded in 2100 (assuming 3°C of warming and no low confidence processes), extreme risk averse projects have anticipated lifespans beyond 2100 and therefore should be prepared for both worst case values at 2100, as well as higher amounts of sea level rise that are expected beyond 2100." (OPC 2024)*

Extreme risk aversion is appropriate for high consequence projects with little to no adaptive capacity and which could have considerable public health, public safety, or environmental impacts (e.g., airport, coastal power plant, wastewater treatment plant, etc.).

The updated guidance recommends evaluation of the Intermediate and Intermediate-High, and consideration of the High Scenario during long term planning of very critical infrastructure such as airports. This study uses the Intermediate, Intermediate-High, and High Scenarios for time frames of sea level rise thresholds (see Section 3.2.2).

Several changes were made from the previous State of California Sea Level Rise Guidance (OPC, 2018). The updated 2024 guidance removes the extreme sea level rise scenario (H++) that was included in the previous guidance. The H++ Scenario assumed rapid ice sheet loss on Antarctica, which could drive rates of sea level rise 30-40 times faster than the sea level rise experienced over the last century. This scenario is not included in the 2024 update, as the rates and amounts of sea level rise are not supported by best available science. Additionally, the 2024 guidance provides a greater certainty of sea level rise through 2050, with a California statewide average of 0.8 feet (Intermediate Scenario). By 2100, the expected range of sea level rise is between 1.6 and 3.1 feet (Intermediate-Low to Intermediate Scenarios), although higher amounts cannot be ruled out. Beyond 2100, sea level rise uncertainty increases, with the potential for statewide sea levels to rise from 2.6 to 11.9 feet or greater by 2150 (Intermediate-Low to High Scenarios).

4 As stated in OPC (2024): "It is important to note that probabilistic projections do not provide actual probabilities of occurrence of sea level rise but provide probabilities that the ensemble of climate models used to estimate contributions of sea-level rise (from processes such as thermal expansion, glacier and ice sheet mass balance, and oceanographic conditions, among others) will predict a certain amount of sea-level rise." Also, note that the High Scenario has an 8% chance of exceedance when accounting for low confidence processes associated with Antarctica and Greenland ice-sheet loss.

While the CA OPC guidance provides projections through 2150, it is important to note that sea level rise is expected to continue for centuries, because the earth's climate, cryosphere,[5] and ocean systems will require time to respond to the emissions that have already been released to the atmosphere. Although sea level rise is typically presented as a range in the amount of sea level rise that will occur by a certain date (e.g., 0.6-1.1 feet of sea level rise by 2050), it can also be presented as a range of time during which a certain amount of sea level rise is projected to occur (e.g., 1.6 feet of sea level rise between 2060 and 2080). Even if emissions are reduced to levels consistent with the low-emissions-based projections, sea level will continue to rise to higher levels, just at a later date.

The CA OPC guidance recommends utilizing data from one of twelve NOAA tide gauges that are located along the coast of California. Using the data from the nearest tide gauge to the project site can capture local variations due to tectonic activity or subsidence. The nearest NOAA tide gauge to Santa Barbara Airport is located in Santa Barbara Harbor.

Table 1 presents State-recommended projections for the Santa Barbara area in terms of Low, Intermediate-Low, Intermediate, Intermediate-High, and High Scenarios. The recommended scenarios for evaluation (Intermediate, Intermediate-High, and High) are outlined by a dark blue box.

TABLE 1. OPC (2024) STATE GUIDANCE: PROJECTED SEA LEVEL RISE FOR SANTA BARBARA AREA IN FEET

Year	Low	Int-Low	Intermediate	Int-High	High
2020	0.1	0.2	0.2	0.2	0.2
2030	0.2	0.3	0.3	0.3	0.4
2040	0.3	0.4	0.4	0.5	0.6
2050	0.3	0.5	0.6	0.9	1.1
2060	0.4	0.6	0.9	1.4	1.8
2070	0.5	0.7	1.2	2.0	2.7
2080	0.5	0.9	1.6	2.8	3.8
2090	0.5	1.1	2.1	3.5	5.0
2100	0.6	1.2	2.8	4.5	6.3
2110	0.6	1.4	3.4	5.3	7.5
2120	0.7	1.5	4.0	6.0	8.6
2130	0.7	1.7	4.4	6.6	9.5
2140	0.7	1.9	4.9	7.1	10.4
2150	0.8	2.0	5.5	7.6	11.3

SOURCE: 2024 OPC Guidance

NOTES:

- Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion.
- The Intermediate, Intermediate-High, and High Scenarios outlined by the dark blue box are evaluated and used to estimate time frames of sea level rise referenced in this study. See Section 3.2 for further discussion.

5 The cryosphere is the portions of the Earth's surface where water is in solid form, like glaciers and ice caps.

4.1.1 California Coastal Commission Sea Level Rise Policy Guidance

In July 2024, the California Coastal Commission (CCC) released a Public Review Draft 2024 SLR Policy Guidance Update (CCC, 2024). The SBA CVARE was prepared prior to this update. Future phases of SBA adaptation planning will consider the CCC guidance update once the guidance is finalized

In 2021, the CCC released the Critical Infrastructure Guidance for Sea Level Rise Adaptation Planning with specific guidance for sea level rise adaptation of at-risk critical infrastructure (CCC, 2021). The CCC Critical Infrastructure Guidance is based on the previous 2018 OPC California Sea Level Rise Guidance (OPC, 2018), which is superseded by the 2024 OPC guidance. The CCC Critical Infrastructure Guidance is summarized below for reference.

The CCC 2021 guidance document is focused on transportation and water/wastewater infrastructure and builds upon the 2018 science update to the CCC Sea Level Rise Policy Guidance (CCC, 2018). The purpose of the critical infrastructure guidance is to provide policy and planning information to inform sea level rise planning and adaptation decisions that are consistent with the California Coastal Act. The guidance presents key considerations for successful infrastructure adaptation planning with specific recommendations for each infrastructure category, describes the regulatory framework for infrastructure adaptation planning and provides model policies.

Consistent with direction from OPC 2018 guidance on the potential for extreme sea level rise, CCC recommended evaluating the extreme risk aversion (H++) scenario for critical infrastructure due to the long lifespans and significant consequences associated with extreme sea level rise and related hazard impacts. CCC guidance was to:

> *"understand and plan for the H++ scenario, not necessarily to site and design for the H++ scenario. In other words, in some cases it may not be appropriate or feasible to site or design a project today such that it will avoid the impacts associated with, for example, ~10 feet of sea level rise (the approximate H++ scenario in 2100 for much of the California coast). However, it is important to analyze this scenario to understand what the associated impacts could be and to begin planning options to adapt to this scenario if and when it occurs, and to ensure that the risks and benefits of economic investments in critical infrastructure are fully understood." (CCC, 2021)*

Given that the 2024 OPC guidance is the best available science and does not include the H++ Scenario, the superseded OPC 2018 guidance's extreme risk aversion (H++) scenario is not considered in this study.

4.2 Selected Sea Level Rise Scenarios for this Study

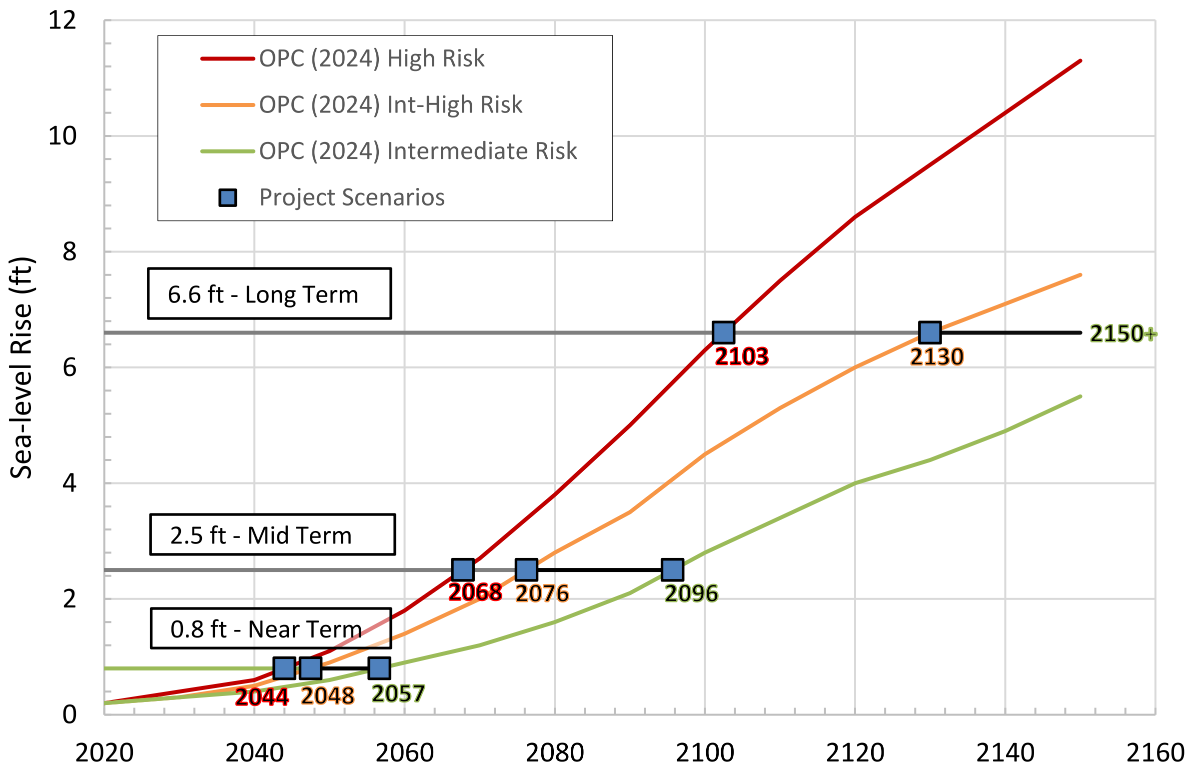
Sea level rise scenarios were selected for this study by considering the 2024 OPC guidance discussed above (which is based on the latest sea level rise science) and the availability of existing sea level rise hazard data for this study.

4.2.1 Sea Level Rise Scenarios

In 2021, the City's Sea Level Rise Adaptation Plan (ESA, 2021) analyzed the following sea level rise projections combined with a no storm and 100-year storm scenario: 0.8 ft sea level rise by 2030; 2.5 ft sea level rise by 2060; and 6.6 ft sea level rise by 2100. The timing of these sea level rise amounts corresponds to a superseded "medium-high risk scenario" from the 2018 State of California Sea Level Rise Guidance (OPC, 2018). The 2024 OPC guidance, which supersedes the 2018 guidance, provides updated timing for these three scenarios, as described in the Planning Horizons section. This Report continues to look at the same amounts of sea level rise (existing, 0.8 ft, 2.5 ft, and 6.6 ft) combined with storm scenarios, but uses updated timing or planning horizons for these sea level rise amounts.

4.2.2 Planning Horizons

As described in Section 3.1, the probability of exceeding the High Scenario in 2100 is less than 0.1% for all warming levels without considering low confidence processes. With very high emissions and warming and contributions from the low confidence processes, this probability increases to 8% (OPC, 2024). This study considers the range of Intermediate to High Scenario planning horizons for each sea level rise amount. **Figure 3** presents a chart of the sea level rise projections and project scenarios based on the OPC 2024 guidance. **Table 2** below summarizes the sea level rise scenarios used for this study and anticipated timing based on updated sea level rise guidance. In the following sections, this report uses dates for sea level rise amounts that correspond to the Intermediate-High Scenario. As discussed above per **Figure 3** and **Table 2** below, this report acknowledges that sea level rise could occur sooner in the low probability High Scenario and later in the Intermediate Scenario.



SOURCE: 2024 OPC Guidance

Figure 3.
Sea Level Rise Guidance Projections and Project Scenarios

TABLE 2. SEA LEVEL RISE SCENARIOS WITH TIMING BASED ON 2024 OPC GUIDANCE

	Sea Level Rise Scenario (Risk Aversion Application) Projected Dates		
Sea Level Rise Amount in Feet	**Intermediate Scenario (Low Risk Aversion)**	**Intermediate-High Scenario (Medium-High Risk Aversion)**	**High Scenario (Extreme Risk Aversion)**
0.8	2057	**2048**	2044
2.5	2096	**2076**	2068
6.6	After 2150	**2130**	2103

NOTE: This report uses dates for sea level rise amounts that correspond to the Intermediate-High Scenario (in bold above) and acknowledges that sea level rise could occur sooner in the low probability High Scenario and later in the Intermediate Scenario.

5. FLOOD HAZARDS ANALYSES

This chapter discusses the methods and results of the analyses that were performed to quantify current and future flood risks to SBA and its assets. An analysis of each source of flooding was performed, including fluvial and coastal sources. In addition, future precipitation and historical flooding of the site were assessed. These analyses were synthesized to establish the chance of flooding from each source in a year, as well as the combined likelihood of flooding at three threshold extents from all sources. The changes in these flooding risks with rising sea level and increased precipitation intensity were also analyzed and estimated.

5.1 Flood Thresholds Analysis

This section presents the methods used to analyze historical flooding of SBA, flood thresholds defined for this study, the types of flooding that could impact the site, and how those forms of flooding are likely to increase in the future by changes to precipitation intensity and sea level rise.

5.1.1 Flood History

Historic flood events of the site were analyzed to assess the frequency of flooding, the extent of flooding following different storm magnitudes, and which regions of the site are most prone to flooding. Information around flooding events was taken from news stories on airport flooding and closure, publicly available precipitation data from Santa Barbara County Department of Public Works (SBCDPW) rain gages and precipitation records, and estimated storm frequency and tidal data from NOAA. The results of the flood history assessment are detailed in **Table 3** below.

5.1.2 Flood Thresholds

Based on the flood history assessment, three thresholds of flooding that impact the airport were defined for the purposes of this assessment. In order of increasing severity, the flood thresholds are:

1. Flooding of just the NW Quadrant near Carneros Creek,
2. Flooding of the runways that causes airport closure, and
3. Flooding of the entire airport property.

Northwest Quadrant Flooding

The first area of the airport to flood during storm events is the NW Quadrant, bordering Carneros Creek to the west, and Firestone Road to the north. Historic flood events during which flooding was limited to the NW Quadrant area include events in years 2005, 2008, and 2010. As shown in **Figure 4**, the approximate extent of flooding for the NW Quadrant threshold includes open space areas adjacent to the runways, but does not extend to the runways. Based on airport topography, it is estimated that this level of flooding corresponds to a water surface elevation of approximately 11 ft. Historically, there were eight events leading to airport closure between 1950 and 2020, indicating that NW Quadrant flooding threshold has a recurrence interval of approximately 10 years with past precipitation conditions. Storm drain modeling results (Section 4.3) for ponding during a 5-year precipitation event are also included in the NW Quadrant flood threshold and extent.

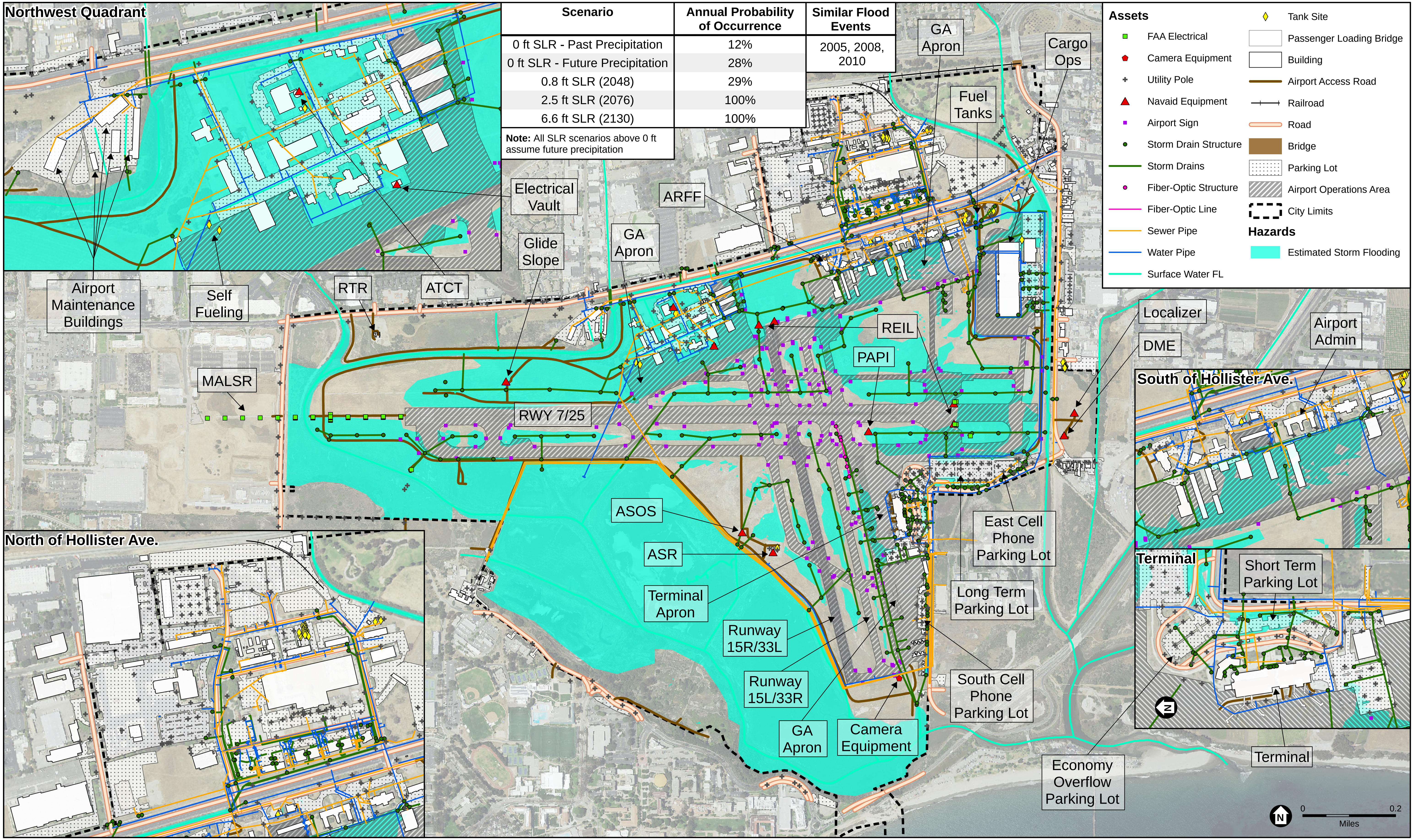
TABLE 3. HISTORIC FLOODING EVENTS AT SANTA BARBARA AIRPORT

Date	Daily Precipitation at SBA (in)	Daily Precipitation at San Marcos Pass (in)	NOAA Storm Frequency (SBA Location)	Max Tide of Max Rainfall Day	NW Quadrant Flooding?	Runway Flooding?	Airport Closure?
1935	—	—	—	—	N/A	—	—
1941	—	—	—	—	N/A	—	—
Jan. 19, 1969	1.96 (19th) **3.14 (20th)**	3.00 (18th) **10.88 (19th)** 4.72 (20th) 5.20 (21st)	5-year	—	Yes	Yes	Yes
Jan. 10, 1995	0.23 (9th) **2.40 (10th)** 0.21 (11th)	5.50 (9th) **8.60 (10th)** 3.50 (11th)	2-year	—	Yes	Yes	Yes
Mar. 10, 1995	0.09 (9th) **3.94 (10th)** 0.97 (11th)	0.20 (9th) **6.60 (10th)** 1.00 (11th)	10-year	—	Yes	Yes*	Yes
Feb. 2, 1998	—	4.00 (2nd) 6.00 (3rd)	—	—	Yes	Yes	Yes
Jan. 10, 2005	**2.83 (9th)** 2.02 (10th)	2.30 (8th) **9.36 (9th)** 7.89 (10th)	5-year	—	Yes*	No*	No
Jan. 24, 2008	**4.16 (23rd)** 0.7 (24th)	**2.71 (23rd)** 2.38 (24th)	10-year	**6.56 (23rd)** 5.96 (24th)	Yes	No	No
Jan. 22, 2010	**1.53 (21st)** 0.56 (22nd)	1.89 (21st) 1.79 (22nd)	2-year	**5.80 (21st)** 5.64 (22nd)	No*	No	No
Feb. 17, 2017	0.15 (16th) **4.16 (17th)**	**8.75** 24-hr max	5-year	4.65 (16th) **5.05 (17th)**	Yes	Yes	Yes
Jan. 9, 2023	0.28 (8th) **4.22 (9th)**	**16.49** 24-hr max	25-year	6.01 (8th) **5.85 (9th)**	Yes	Yes	Yes
Feb. 4, 2024	**2.39 (4th)** 1.11 (5th)	**6.21** 24-hr max	5-year	**5.78 (4th)** 6.17 (5th)	Yes	Yes	Yes
Feb. 19, 2024	**2.22 (18th)** 1.35 (19th)	**10.05** 24-hr max	2-year	**5.43 ft (18th)** 5.77 ft (19th)	Yes	Yes	Yes

NOTES:

* In these events, it is unclear from available information whether the runway flooded or not.

1. The estimated storm frequencies may be underestimated as precipitation depths were taken from the local airport gage, not accounting for varied precipitation in the watershed.
2. Precipitation at SBA is daily maximum values, NOAA frequency was determined by finding the maximum daily precipitation, counting it as the 24-hour max, and then rounding up two intervals to be conservative.



Scenario	Annual Probability of Occurrence	Similar Flood Events
0 ft SLR - Past Precipitation	12%	2005, 2008, 2010
0 ft SLR - Future Precipitation	28%	
0.8 ft SLR (2048)	29%	
2.5 ft SLR (2076)	100%	
6.6 ft SLR (2130)	100%	

Note: All SLR scenarios above 0 ft assume future precipitation

SOURCE: ESA/SB County, USGS, NAIP, GSD, Santa Barbara Airport, UCSB, GWSD

Flood extent southeast of Goleta Slough based on CoSMoS 1-yr Coastal Storm with 10-yr Creek Discharge (0 ft Sea Level Rise); flood extent northwest of Goleta Slough based on FEMA flood profiles, SBA information, M&H 5-year stormwater ponding and ESA estimate

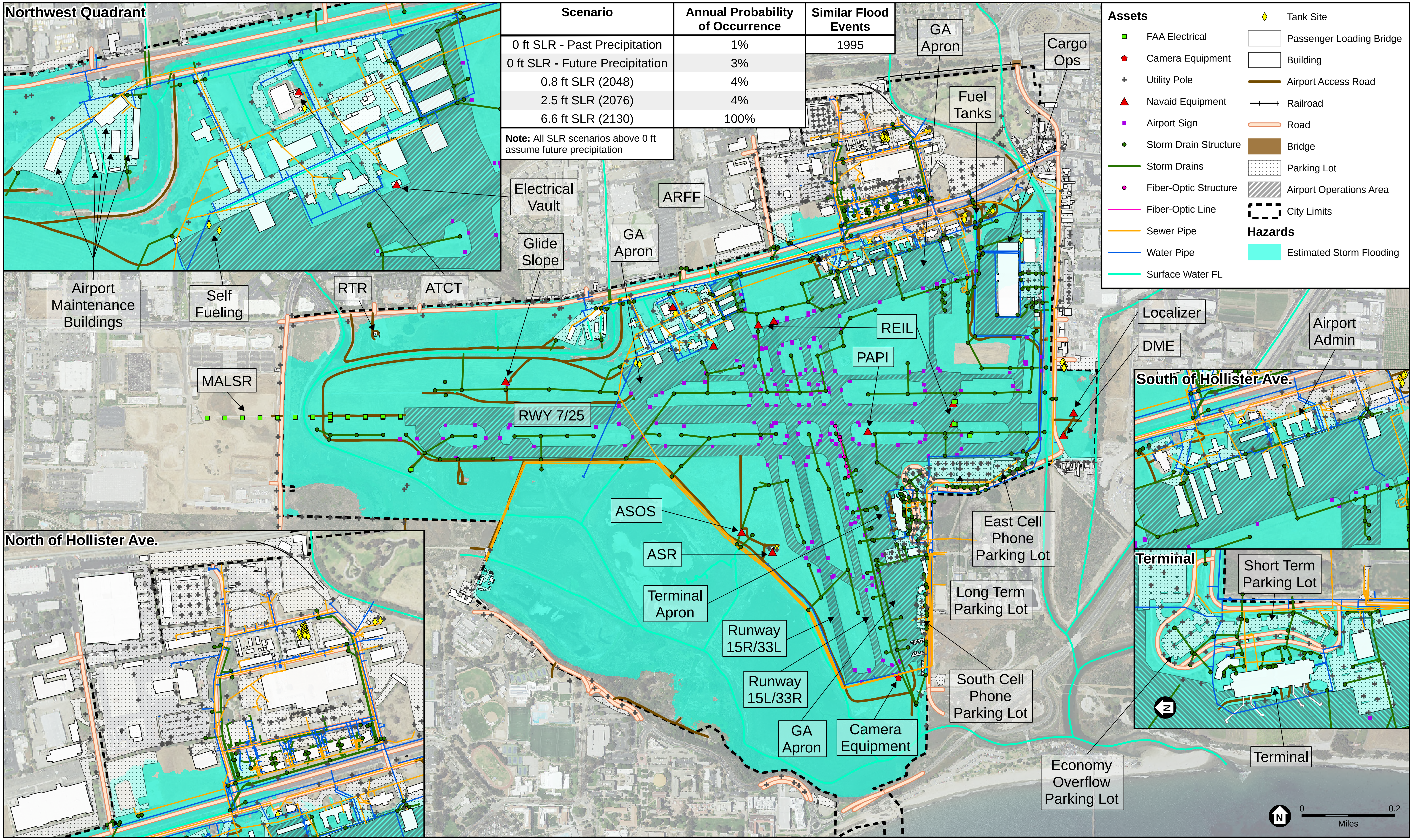
Santa Barbara Airport Sea Level Rise Adaptation Plan . D202201087.00

Figure 4

Northwest Quadrant Flooded, Runway Not Flooded, Airport Open Threshold - Asset Exposure

Figure 5. Runways Flooded, Airport Closed Threshold – Asset Exposure

11x17 figure



SOURCE: ESA/SB County, USGS, NAIP, GSD, Santa Barbara Airport, UCSB, GWSD

Flood extent from CoSMoS 100-yr Coastal Storm with 7-yr Creek Discharge (6.6 ft Sea Level Rise)

Santa Barbara Airport Sea Level Rise Adaptation Plan . D202201087.00

Figure 6

Entire Airport Flooded Threshold - Asset Exposure

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Runway Flooding, Airport Closure

The decision to close the airport is primarily influenced by the inundation of Runway 7-25 (SBA staff, pers. comm.). SBA would continue to operate if there is unobstructed pavement on Runway 7-25 extending to the terminal, and the airport would remain operational. Therefore, flooding of Runway 7-25 corresponds to airport closure. This extent of flooding has previously occurred in the years 1969, 2017, 2023, and 2024. Based on airport topography, it is estimated that this level of flooding corresponds to a water surface elevation of approximately 12.5 ft. There were five events leading to airport closure between 1950 and 2020, indicating that the runway flooding, airport closure threshold has a recurrence interval of approximately 15 years with past precipitation conditions. The USGS CoSMoS flood extent results for a 20-year coastal storm occurring simultaneously with 5-year creek discharges was used to represent this flood threshold. (**Figure 5**).

Entire Airport Flooding (FEMA 100-year Flood)

The most severe airport flooding threshold considered is flooding of the entire airport property. The January 1995 flood event has been the most severe flooding the site has experienced on record and is comparable to the 100-yr FEMA flood map extent. The approximate extent of this flooding is shown in **Figure 6**. It's estimated that this flooding threshold corresponds to a water elevation of approximately 14 ft. As this threshold was based on the 100-yr flood map extent, it was assumed to have a 100-yr recurrence interval under current conditions.

5.2 Flooding from Offsite Sources

This section presents the methods and findings of the sea level rise analysis for sources of potential flooding to the airport. The hazards examined are lagoon flooding from Goleta Slough, fluvial flooding, and tidal flooding. ESA applied analyses to each source to understand the likely extent of each source of flooding under past precipitation conditions, and future precipitation conditions with 0, 0.8, 2.5, and 6.6 feet of sea level rise. The changes in the likelihood of flooding occurring due to any of these sources was also assessed for each precipitation and sea level rise scenario.

5.2.1 Lagoon Flooding

Goleta Slough is a 440-acre coastal wetland system located directly southwest of SBA. The conditions of the lagoon during storm events can have a significant effect on flooding extents at the airport. Geomorphic and environmental factors such as precipitation, coastal waves, sedimentation, and whether the lagoon mouth is open or closed are all key factors in determining hydrologic conditions within the lagoon. It is also possible that under certain conditions the water level could rise to a point that it causes flooding at the airport.

In a 2015 study of Goleta Slough, ESA developed the Quantified Conceptual Model (QCM), which provides a framework for predicting the long-term evolution of lagoon mouth conditions and lagoon water levels using empirical data and parameterizations to quantify lagoon hydrology, coastal influences, and lagoon mouth hydraulics (ESA, 2015b; Behrens, et al., 2015). In the 2015 study, sea level rise scenarios of 0, 2.5, and 6.6 feet of sea level rise were simulated at Goleta Slough. Here, an 8-year QCM simulation of Goleta Slough was performed considering existing conditions, increased precipitation conditions, as well as near term (0.8 ft), mid term (2.5 ft), and long term (6.6 ft) sea level rise scenarios. Increased precipitation conditions were modeled by increasing stream discharge during storm events (stream discharges greater than 100 cfs) by 25%, a 1:1 increase with the precipitation increase expected during future storm events.

Historically, the Santa Barbara Flood Control District mechanically breached the lagoon by excavating through the beach berm during extended periods of closure with the goal of reducing flood risk and improving water quality. In 2012, the Flood Control District discontinued managed lagoon breaching because of the high costs of conducting the biological studies necessary to renew the permits. Since then, only a limited number of breaches have occurred under emergency permits strictly to prevent flooding during major rain events. These breaches have typically limited the channel bed elevation (i.e., the mouth channel thalweg) to 9 ft NAVD88. With sea level rise, emergency mouth management would be required more frequently with higher associated costs to maintain a 9 ft NAVD88 channel elevation.

This study assumes that no emergency lagoon mouth breaching would take place during storm events. QCM results for the lowest and highest levels of ocean tides, simulated lagoon water levels and thalweg elevations at the mouth are reported in **Table 4**.

TABLE 4. RANGES OF MODELED WATER LEVELS AND THALWEG ELEVATIONS IN GOLETA SLOUGH

Case	Sea Level Rise (feet NAVD)	Precipitation	Breaching	Ocean Tides (feet NAVD)	Modeled Lagoon Water Levels (feet NAVD)	Modeled Thalweg Elevations (feet NAVD)
1	0	Past	None	-2.4–7.4	1.0–10.1	1.0–8.6
2	0	Future	None	-2.4–7.4	1.0–10.3	1.0–8.6
3	0.8	Future	None	-1.6–8.2	1.8–10.7	1.8–9.4
4	2.5	Future	None	0.1–9.9	3.5–11.5	3.5–11.1
5	6.6	Future	None	4.2–14.0	5.5–15.2	7.6–15.2

An extreme value analysis (EVA) was performed on the results of the QCM to determine the recurrence interval of each flood threshold under each precipitation/sea level rise scenario. For this analysis, the Gumbel Least Squares method was used. On-site elevations indicate that an 11 ft water surface elevation (WSE) would lead to NW Quadrant flooding, 12.5 ft WSE would cause runway flooding and airport closure, and 14 ft WSE would lead to entire airport flooding, equivalent to a FEMA 100-yr flood event. These WSEs and the results of the EVA were used to determine the recurrence interval of each flood threshold.

Under current conditions, Goleta Slough water levels rise to 11 ft, leading to NW Quadrant flooding, with an estimated 39-year recurrence interval. This recurrence interval is expected to shorten to 30-years with increased precipitation, to 17-years with increased precipitation and 0.8 feet of sea level rise, to 4-years after 2.5 feet of sea level rise and to 1-year with 6.6 feet of sea level rise.

Presently, water levels in the slough reach 12.5 feet and cause runway flooding and airport closure with a 200-year recurrence interval. With future precipitation, the return interval is expected to lower to 140 years, after which 0.8 feet of sea level rise is expected to lower the recurrence interval to 83 years, 2.5 feet to 28 years, and 6.6 feet to 2 years.

Finally, Goleta Slough water elevations rise to 14 feet and flood the entire airport under current conditions with an estimated 1,000-year recurrence interval. With future precipitation, 0.8, 2.5, and 6.6 ft of sea level rise, this recurrence interval is anticipated to lower to 680 years, 410 years, 210 years, and 4.4 years, respectively.

5.2.2 Fluvial Flooding

Historically, the primary driver of flooding at SBA has been from creek overtopping from Carneros, Tecolotito, or San Pedro Creeks. Therefore, it is important to examine the water surface elevations along each of these creeks during storm events, and how these elevations change with increased precipitation and sea level rise.

Existing Conditions Water Levels

An assessment of the offsite water surface elevations for the 5-year and 25-year storm events was performed using data compiled from the Federal Emergency Management Agency (FEMA) and the Goleta Slough water level gage maintained by the County of Santa Barbara. FEMA effective Flood Insurance Study 06083C provides flood profiles for the 10-year, 100-year, and 500-year storms for Tecolotito, Carneros, and San Pedro creeks (FEMA, 2018). The Goleta Slough gage measures water levels in Goleta Slough and has been collecting water level data since May 2013 (County of Santa Barbara, 2023). Examples of these FEMA flood profiles for Tecolotito and San Pedro creeks are show in **Figures 7 and 8**.

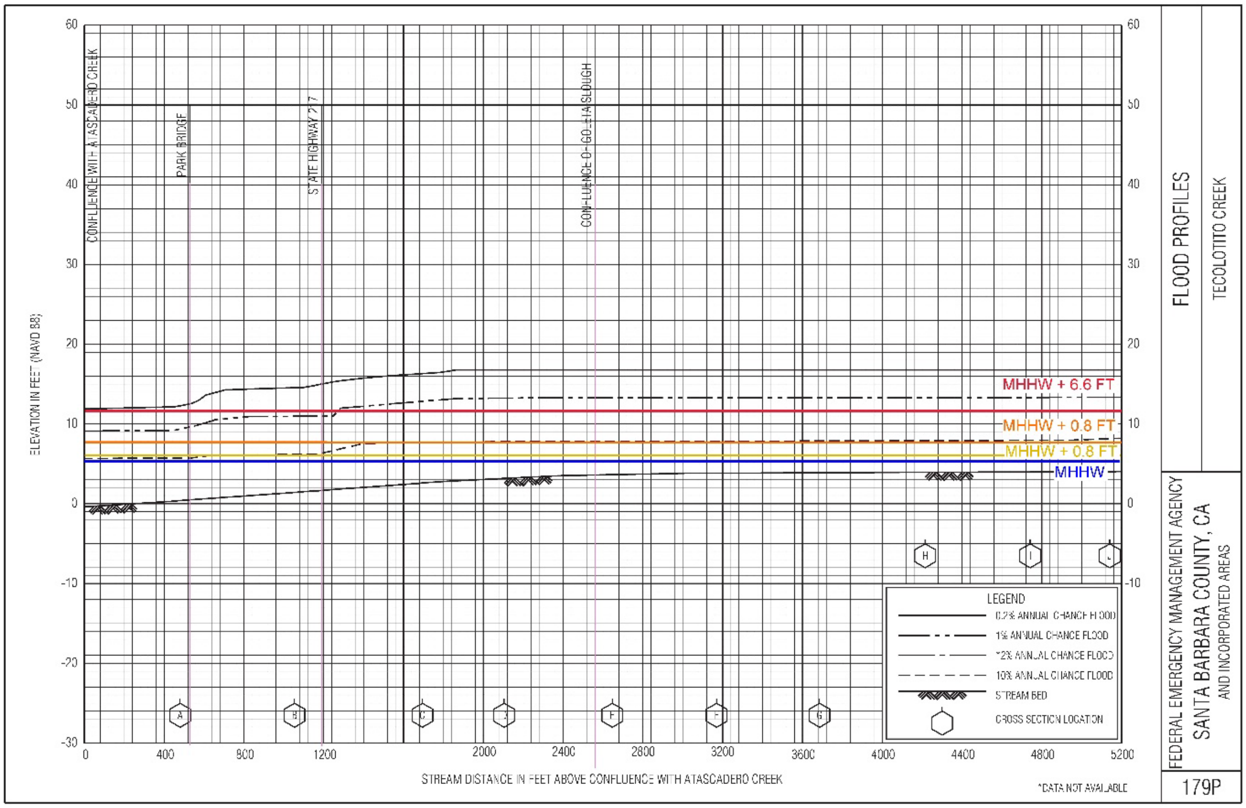
The 5-year and 25-year water surface elevations were determined by interpolating between the 1-, 10-, and 100-year water levels at FEMA flood profile station locations along Tecolotito, Carneros, and San Pedro Creeks. The 1-year water level at each station was assumed to be the larger of two values:

- The FEMA bed elevation (based on the flood profiles) plus two feet of water depth, or
- The 1-year water level at the Goleta Slough gage, which was determined by performing an extreme value analysis on the Goleta Slough gage data from 2013 to 2023.

The interpolated 5-year and 25-year water surface elevations were compared to the 5-year and 25-year water surface elevations calculated from the extreme value analysis from the Goleta Slough gage water levels. Where the resulting values from the extreme value analysis were higher than the interpolated values, the extreme value analysis water levels were used. The results of this analysis are shown in Table 7 and were used as inputs in the storm drain analysis described in Section 4.2.

Future Conditions Precipitation and Water Levels

ESA leveraged precipitation data from the latest release of the Coupled Model Intercomparison Project 6 (CMIP6) general circulation models (GCM) to estimate projected changes in extreme precipitation frequency for the Atascadero Creek/Goleta Slough watershed. CMIP6 is an ensemble of GCMs that simulate global physical processes between the atmosphere, ocean, and land surface and its response to increasing greenhouse gas concentrations. Because the CMIP data is provided at a very coarse resolution, ESA used the localized construction analogue version 2 (LOCA2) downscaled dataset from the CMIP GCMs specifically for California that is provided at a 3-kilometer resolution (Pierce, et al, 2023).

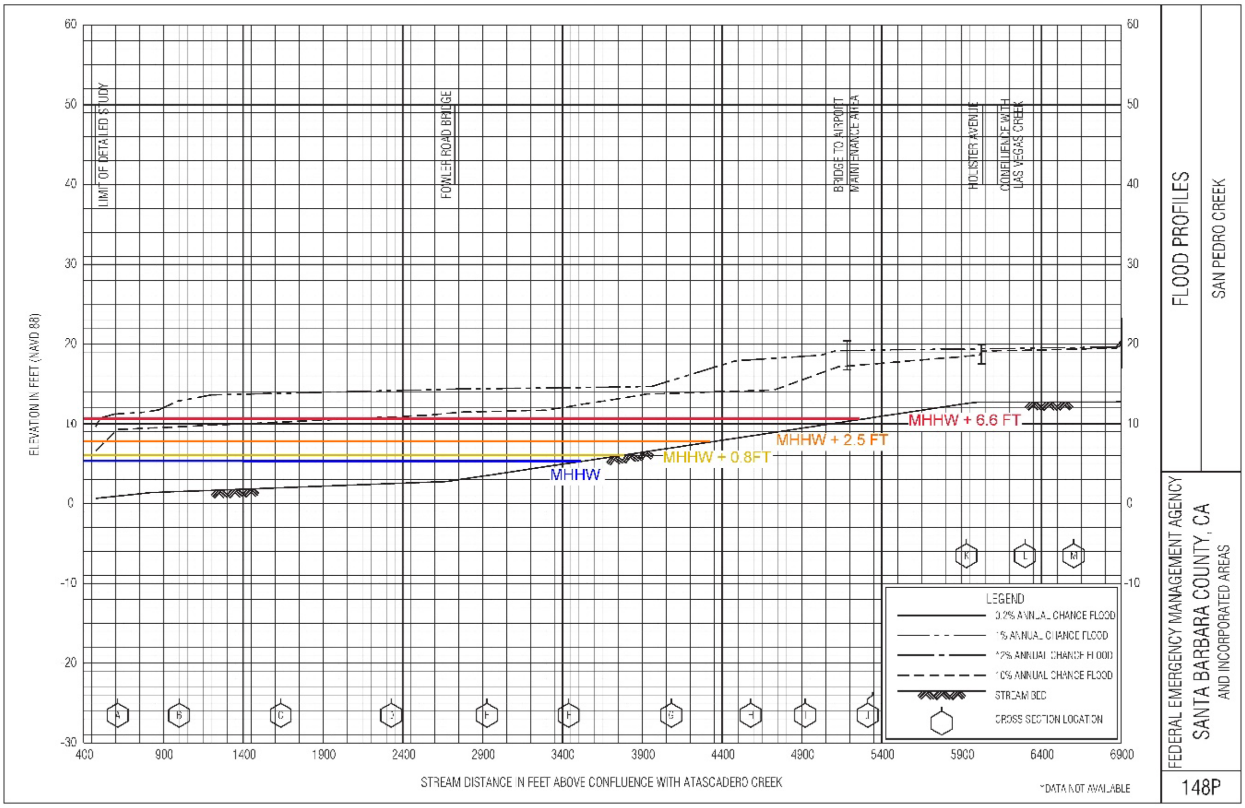


SOURCE: FEMA, ESA, 2024

Figure 7.
FEMA Flood Profile for Downstream Tecolotito Creek with Mean Higher High Water Levels under Sea Level Rise Scenarios

ESA selected 13 of the downscaled CMIP models from the LOCA2 (Localized Constructed Analogs) dataset that most accurately simulated California's observed climate records. ESA used LOCA2 results for a very high emissions trajectory (SSP 585) and the mean of the 13 models. This approach is comparable to a scenario between the Intermediate-Low and Intermediate sea level rise scenarios per NOAA's 2022 Global and Regional Sea Level Rise Scenarios for the United States (Sweet, et al., 2022). Note that using approximately one to two standard deviations above the mean of the 13 models would be comparable to the Intermediate-High sea level rise scenario and would result in greater increases in extreme precipitation frequencies than reported below.

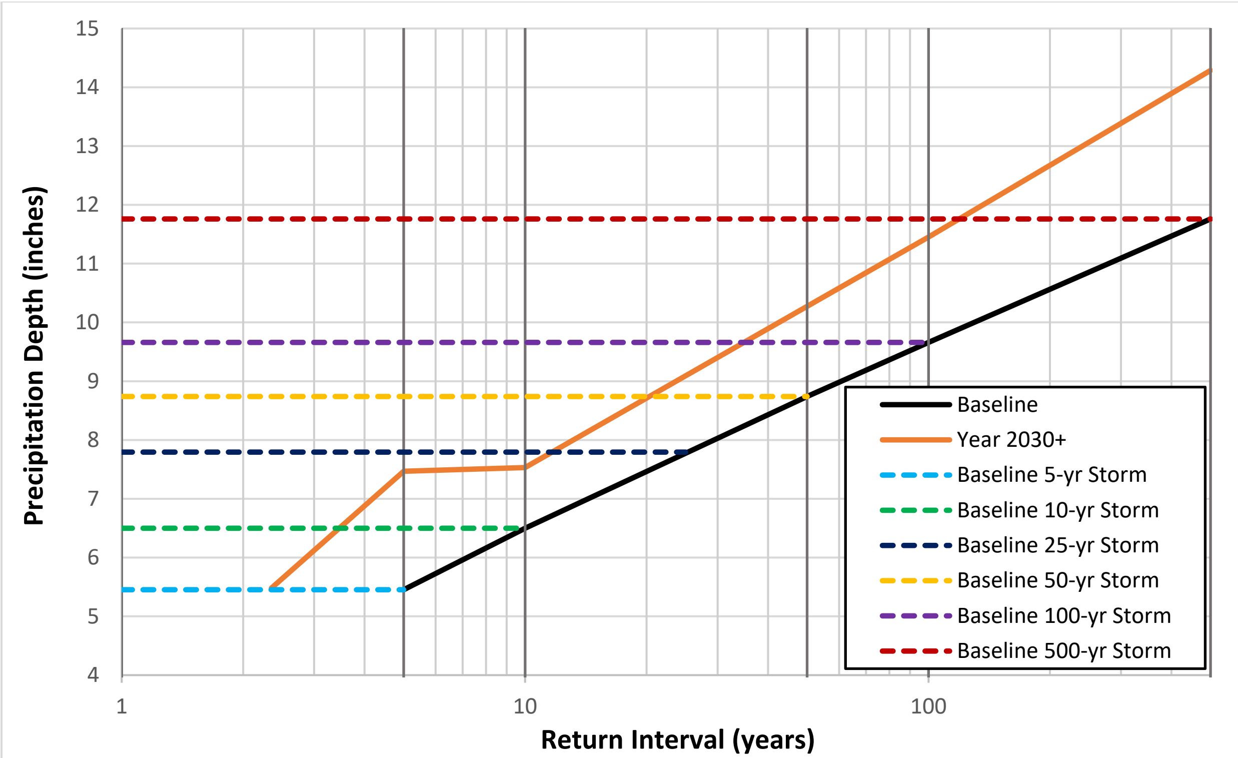
LOCA2 provides a simulation of 24-hour rainfall depths from 1950 to 2100. ESA extracted LOCA2 results for each 3-kilometer climate grid cell that intersected the watershed. ESA conducted extreme value analysis of the modeled rainfall simulation for a baseline period from 1950 to 2100, the future period from 2030 to 2100, and compared results to estimate the increase in future extreme rainfall. The increase in future extreme rainfall was applied to NOAA Atlas 14 precipitation estimates, which were captured at an 800m cell resolution. These were then scaled accordingly with the overlapping LOCA2 grid cell results to determine future precipitation. The increase in rainfall was averaged over the watershed.



SOURCE: FEMA, ESA, 2024

Figure 8.
FEMA Flood Profile for Downstream San Pedro Creek with Mean Higher High Water Levels under Sea Level Rise Scenarios

Figure 9 shows the 24-hour precipitation return interval curves for the Goleta Slough watershed from ESA's analysis for baseline conditions (i.e., past climate conditions, black line) and future projected climate conditions (orange line, based on a simulation from 2030 to 2100 and therefore labeled as "Year 2030+"). The dashed lines in Figure 9 show the precipitation depth for various rainfall event return intervals for baseline (existing) precipitation. ESA estimated the change in return interval (i.e., increase in frequency) of these rainfall events with future conditions from the return interval for the point where the dashed lines intersect the "Year 2030+" orange line. For example, the baseline 50-yr rainfall event is projected to become the future 20-yr rainfall event. The magnitude of the current 20-year event, which is the approximate storm event that floods the airport, will become the magnitude of the future 5-year event. Results show the magnitude and frequency of future extreme rainfall depths increase compared to baseline conditions. Note that the baseline rainfall return interval curves are only used to estimate the increase in rainfall event frequency. To estimate the increased 24-hour rainfall intensity, the percent change in rainfall event intensity from this analysis of LOCA2 results would need to be applied to the NOAA Atlas 14's 24-hour rainfall event estimates. The modeled projections could already be occurring now; therefore, the report refers to the future precipitation period as 2024 to 2100, instead of 2030 to 2100.



SOURCE: ESA, 2024

Figure 9.
Future Estimated Precipitation

The future water levels in the lagoon mouth are driven by a combination of sea level rise and future precipitation levels. The results of the QCM, described previously, provide lagoon water levels for each sea level rise scenario. QCM water levels were compared to FEMA flood profile water levels (0 sea level rise conditions). For each sea level rise scenario, where the QCM water level exceeded the flood profile water level developed by interpolating FEMA profiles as described above, the QCM water level was used because in that case the lagoon water would drive water levels at those stations. The resulting creek profiles for current and future 5-year storms are shown in **Table 5**.

TABLE 5. WATER SURFACE ELEVATIONS (WSE) FOR PAST 5-YEAR AND FUTURE 5-YEAR STORMS

Station	Location	Past 5-yr Storm	Future 5-yr Storm (0 ft SLR)	Future 5-yr Storm (0.8 ft SLR)	Future 5-yr Storm (2.5 ft SLR)	Future 5-yr Storm (6.6 ft SLR)
Tecolotito Creek Water Surface Elevation (ft NAVD)						
1870	Upstream of 217 bridge (location of 100yr storm break in slope)[a]	8.4	9.40	10.76	12.08	16.23
4920	Goleta Slough (location of 10yr storm break in slope)[b]	8.4	9.60	10.76	12.08	16.23
5640	Goleta Slough (location of 10yr storm break in slope)	8.7	10.32	10.76	12.08	16.23
10045	Confluence with Carneros Creek	9.8	11.20	11.20	12.08	16.23

Station	Location	Past 5-yr Storm	Future 5-yr Storm (0 ft SLR)	Future 5-yr Storm (0.8 ft SLR)	Future 5-yr Storm (2.5 ft SLR)	Future 5-yr Storm (6.6 ft SLR)
11100	Downstream of Hollister Ave (location of 10yr storm break in slope)	10.4	11.70	11.70	12.08	16.23
Carneros Creek Water Surface Elevation (ft NAVD)						
0	Confluence with Tecolotito Creek	9.8	11.20	11.20	12.08	16.23
2450	Downstream of Firestone Road (location of 10yr storm break in slope)	10.1	11.32	11.32	12.08	16.23
2475	Downstream of Firestone Road (location of 100yr storm break in slope)	10.2	11.35	11.35	12.08	16.23
2600	At Firestone Road (location of 100yr storm break in slope)	10.8	12.10	12.10	12.10	16.23
San Pedro Creek Water Surface Elevation (ft NAVD)						
1200	Upstream of 217 bridge (location of 100yr storm break in slope)	9.5	10.97	10.97	12.08	16.23
3310	Upstream of Fowler Rd bridge (location of 10yr storm break in slope)	11.1	12.50	12.50	12.50	16.23
3930	Between Fowler Rd and bridge to airport (location of 10yr storm break in slope)	13.2	14.06	14.06	14.06	16.23
3960	Between Fowler Rd and bridge to airport (location of 100yr storm break in slope)	13.2	14.07	14.07	14.07	16.23
4480	Between Fowler Rd and bridge to airport (location of 100yr storm break in slope)	13.7	15.25	15.25	15.25	16.23
4710	Between Fowler Rd and bridge to airport (location of 10yr storm break in slope)	13.8	15.41	15.41	15.41	16.23
5000	Between Fowler Rd and bridge to airport (location of 100yr storm break in slope)	15.8	16.97	16.97	16.97	16.97
5120	Downstream of bridge to airport (location of 10 & 100yr break in slope)	16.5	17.70	17.70	17.70	17.70
6010	Downstream of Hollister Ave (location of 10yr storm break in slope)	18.1	18.78	18.78	18.78	18.78

5.2.3 Tidal Inundation (CoSMoS)

As described in Section 4.4, the USGS Coastal Storm Modeling System (CoSMoS 3.0) provides projections of tidal inundation, coastal flooding, and beach and bluff erosion for existing conditions and with sea level rise in the Santa Barbara region (USGS 2018). Tidal inundation modeled by CoSMoS represents inundation from typical monthly spring tide conditions.

The annual chance of tidal flooding was determined based on the areas of the airport that are within the extent of tidal inundation from CoSMoS results. If an area is within the flood extent while no storm event is occurring (i.e., the tidal inundation extent), the area was designated as having a 100% flood risk, whereas if the area is not within the tidal inundation extent, is was assumed to not be impacted by coastal flooding under that scenario. For example, with 0.8 feet of sea level rise, the runways are not within in the coastal flood extent zone and were therefore assumed to have a 0% chance of coastal flooding. With 6.6 feet of sea level rise, all of the runways are within the coastal flood extent zone and were therefore designated a 100% annual chance of coastal flooding. Areas that are in the flood-prone low-lying area, but not the flood extent zone, were given a 50% annual chance of coastal flooding.

Tidal inundation does not impact the site under existing sea levels. After 0.8 feet of sea level rise (2048), the entire airport remains outside the tidal inundation hazard zone. With 2.5 feet of sea level rise (2076), the edges of runways are expected to experience a 100% chance of exposure to tidal inundation. Additionally, portions of the runways are in flood-prone low-lying areas, meaning these areas have a 50% annual chance of tidal inundation. With between 2.5 and 3.3 feet of sea level rise (2076 to 2087), the entire airport operations area has a 100% annual chance of tidal inundation. Similarly, at 6.6 feet of sea level rise (2130) the airport remains inoperable.

5.2.4 Combined Flooding Probabilities

ESA performed a combined flooding probabilities analysis to determine the total likelihood of airport flooding under various combined precipitation and sea level rise scenarios. Total annual chance of flooding is a combination of flooding risk from fluvial flooding, lagoon flooding, and tidal inundation.

In this combined analysis, the likelihood of fluvial flooding was calculated based on historical flooding. For instance, in the 60 years between 1960 and 2020, there were four storm events that caused airport closure, meaning airport flooding has historically occurred with an approximately 15-year recurrence interval. These historical recurrence intervals were adjusted to future precipitation conditions using the GCM model results (Figure 9).

For each precipitation event and sea level rise scenario, ESA calculated the annual chance and recurrence interval of airport flooding. The results are shown in **Tables 6 and 7**. Recurrence intervals were calculated by combining the probabilities of flooding from each flooding source (fluvial, lagoon, and tidal). Annual probabilities of flooding were calculated by combining the individual probabilities of each flooding source and subtracting the probabilities of flooding from multiple sources occurring in one year, which prevents double-counting flood events that occur in the same year. Flood events are assumed to occur independently (i.e., the occurrence of a fluvial event does not impact the likelihood of a tidal event).

ESA conducted these analyses assuming a fixed water surface elevation triggers each threshold of flooding. 11 ft water surface elevation causes NW Quadrant flooding, 12.5 ft water surface elevation causes runway flooding and airport closure, and 14 ft water surface elevation floods the entire airport. Results show that the frequency of occurrence of each flood threshold increases due to increased precipitation and sea level rise. Over time, each flood threshold may occur during less intense precipitation events due to sea level rise.

TABLE 6. FLOOD THRESHOLD ANNUAL CHANCE SUMMARY

	Sea Level Rise and Precipitation Scenarios	NW Quadrant & Edge of Runway Flooded (11 ft WSE[a])	Runways Flooded, Airport Closed (12.5 ft WSE)	Entire Airport Flooded (14 ft WSE)
Baseline	0 ft, Past Precipitation	12%	7%	1%
Near Term	0 ft, Future Precipitation (2024–2100)	28%	21%	3%
	0.8 ft[b] (2048)	29%	21%	4%
Mid Term	2.5 ft (2076)	100%	61%	4%
Long Term	6.6 ft (2130)	100%	100%	100%

Annual chance is the probability of flooding occurring in any given year
NOTES:
a. WSE = water surface elevation
b. All scenarios above 0 ft SLR assume future precipitation

TABLE 7. FLOOD THRESHOLD RECURRENCE INTERVAL SUMMARY

	Sea Level Rise and Precipitation Scenarios	NW Quadrant & Edge of Runway Flooded (11 ft WSE[a])	Runways Flooded, Airport Closed (12.5 ft WSE)	Entire Airport Flooded (14 ft WSE)
Baseline	0 ft, Past Precipitation	7.9-yr	15-yr	100-yr
Near Term	0 ft, Future Precipitation (2024–2100)	3.6-yr	5-yr	29-yr
	0.8 ft[b] (2048)	3.4-yr	4.8-yr	28-yr
Mid Term	2.5 ft (2076)	< 1-yr	1.6-yr	27-yr
Long Term	6.6 ft (2130)	< 1-yr	< 1-yr	< 1-yr

Recurrence interval is the average time between flooding events
NOTES:
a. WSE = water surface elevation
b. All scenarios above 0 ft SLR assume future precipitation

With increasing future precipitation rates, the annual chance of flooding at each threshold would more than double compared to current conditions, from 12% to 28% for NW Quadrant and edge of runway flooding, from 7% to 21% for runway flooding that causes airport closure, and 1% to 3% for entire airport flooding. Marginal (1% or less) increases in annual chance of flooding are expected with 0.8 feet of sea level rise. With 2.5 feet of sea level rise, flooding of the NW Quadrant and edge of runway is expected to occur at least annually, while the chance of runway flooding and airport closure in a given year rises to 61% and the risk of the entire airport flooding remains at 4%. With approximately 2.5 to 3.3 feet of sea level rise (2076 to 2087), tidal flooding of the airport is likely to occur on a biweekly basis, rendering the airport inoperable.

5.3 Storm Drain Analysis

ESA and Mead & Hunt performed an analysis to evaluate the potential flooding caused by storm drains backing up onto SBA property under storm conditions and with sea level rise. ESA determined offsite water surface elevations, which were then used by Mead & Hunt to determine the onsite flood extents.

5.3.1 Methods

ESA provided Mead & Hunt with water surface elevation profiles along Tecolotito, Carneros, and San Pedro creeks. Profiles were derived from the fluvial and lagoon flooding models for past precipitation conditions with no sea level rise, and future precipitation conditions with 0, 0.8, 2.5, and 6.6 feet of sea level rise (Table 5). The methods for determining these profiles are described in detail above in Section 4.2.2.

To incorporate the typical rise and fall of water levels along creeks during storm events into the storm drain analysis, ESA provided Mead & Hunt with a time-series of surface elevations at each creek station for the 24-hour period surrounding the peak water level. This time-series was developed using water level data from the SBCPWD Goleta Slough stream gage during the January 2023 storm event and adjusted to each station based on the FEMA bed elevation and peak water level for each scenario (SBCPWD, 2024a).

Using the offsite water surface elevations as boundary conditions, Mead & Hunt developed a hydrology and hydraulics model to evaluate onsite water levels. For conservative results, the onsite stormwater analysis incorporates the time-series of surface elevations with the peak elevations temporally aligned with the peak discharge rates. The future 5-year, 24-hour event (existing 20-year, 24-hour event) was determined by interpolating between the 10-year and 25-year total rainfall depths from the South Coast 24-Hour Rainfall Parameters, yielding a value of 6.1 inches of total rainfall. Mead & Hunt ran four (4) future condition models using the Future 5-year, 24-hour rainfall, one (1) with a zero sea level rise condition and three (3) with varying values of increased sea level as supplied by ESA. A complete description of the methods used is included as **Appendix B**.

5.3.2 Results

A past precipitation conditions 5-year storm with 0 feet of sea level rise is expected to cause widespread ponding across the site with limited encroachment onto airport operations areas. The sites impacted by this ponding are the NW Quadrant, the Terminal Area and surrounding parking lot, and the Northeast buildings and hangars. Ponding is also anticipated on Taxiways B and E and the edges of Taxiways A, A-5, and F. No runways are obstructed.

With increased intensity future precipitation, the extents of ponding increase. More severe ponding is expected in the NW Quadrant, Terminal Area and parking lot, and NE buildings and hangars. Ponding spreads to affect Taxiways A, A-1, A-5, B, C, D, E and F along with the north edges of Runways 15R/33L and 15L/33R. Runway 7-25 remains unobstructed, with light ponding along the edges.

Sea level rise of 0.8 feet is expected to marginally increase ponding extent. Ponding in the Terminal Area and parking lot will extend. Other areas are more severely impacted by ponding. Surface water is expected on the southern end of runway 15R/33L and to encroach on the eastern edge of Runway 7-25.

Under existing and 0.8 ft sea level rise scenarios, flooding is dominated by rainfall runoff and creek flooding. With 2.5 ft of sea level rise or more, the risk of direct flooding from creeks is greater than a 20% annual chance of occurrence. ESA and Mead & Hunt modeled storm drains with 2.5 and 6.6 ft assuming no creek flooding in Appendix B. In the subsequent adaptation phase of this project, these results will be used to inform performance of storm drain systems with adaptation measures that reduce direct creek flooding.

5.4 Coastal Hazards Mapping

The hazards mapping analysis consists of a spatial assessment of hazard exposure that overlays the Santa Barbara Airport assets with hazard maps. Tidal inundation, coastal storm flooding, groundwater rise and beach and bluff erosion with sea level rise were obtained from the USGS CoSMoS 3.0 (USGS 2018). Wave hazards were not analyzed because the site is not vulnerable to waves. Tidal inundation and coastal storm flooding hazard zones compiled for this study include corresponding low-lying areas mapped by CoSMoS that may also inundate or flood. These data build upon the data collected for the Goleta Sanitary District Climate Adaptation Plan (ESA 2022), which were for the existing conditions, 2.5-, and 6.6-feet sea level rise scenarios. The data collected for this study are for the 3.3-, 4.1-, and 4.9-feet sea level rise scenarios and cover the extent of the Santa Barbara Airport and Goleta Slough.

A majority of SBA property is shown as flooded under all of the CoSMoS storm scenarios (shown in **Figure 10**), which indicates that the CoSMoS data do not clearly show the increase in flooding that occurs with sea level rise. For example, the existing conditions, annual storm scenario shows a significant amount of the airport runways as flooded, even though flooding has not historically occurred annually at the airport. This condition occurs because the annual coastal storm event is modeled coincident with a 10-year fluvial event, resulting in elevated water levels that flood the airport runways. The combined tidal inundation and coastal storm flooding maps show different combinations of high creek discharge and high tide levels, instead of showing a clear progression of flooding with sea level rise.

Groundwater emergence was evaluated using CoSMoS data to identify areas that may become flooded as groundwater ponds at the ground surface in certain areas. Hydraulic conductivity (K_h) values of 0.1 m/day and 1.0 m/day were assessed, with 1.0 m/day being chosen as appropriate based on a USGS review of Santa Barbara area groundwater basins (Paulinski et al, 2018) and 0.1 m/day showing a conservatively higher projection of groundwater emergence. As shown in **Figure 11,** areas that may become flooded by groundwater under existing conditions include portions of the runways, taxiways, terminal area, parking lots, and roads. With sea level rise, the extent of flooding due to groundwater emergence slightly increases in these areas, specifically in the terminal area and Taxiways A, B, and E. Sea level rise of 6.6 ft was omitted from groundwater emergence analyses as the airport becomes tidally inundated with 6.6 ft of sea level rise. CoSMoS data indicate that groundwater depths may be shallow for much of the SBA property under existing conditions and will become increasingly shallow, which may impact buried infrastructure.

5.5 Flood Hazards Results

Based on the results of the flood hazards analysis, several conclusions can be summarized for each sea level rise scenario.

Existing Conditions. Existing and historic flooding is dominated by rainfall runoff and creek flooding. Historic flooding indicates that the airport runways are flooded (causing airport closure) by the 20-year fluvial storm event from creek overtopping. Storm drain modeling performed by Mead & Hunt indicates that some storm drain backup and ponding occurs on airport property under the past 5-year storm scenario.

Projected Increase in Precipitation. Global climate modeling indicates a projected increase in precipitation, which increases the risk of flooding from creek overtopping. The chance of flooding is projected to double or triple in frequency compared to historic flooding. Extreme rainfall over the past two winters may reflect increased precipitation due to climate change. More frequent and extensive flooding due to inadequate capacity of the storm drain system is expected to occur. The future 20% annual chance (5-year) event is expected to cause airport closure due to flooding at the terminal and the edge of the runway.

0.8 ft sea level rise (2048). With 0.8 ft of sea level rise, there may not be a large effect on flood risk because fluvial flood water levels dominate and are significantly higher than tide levels.

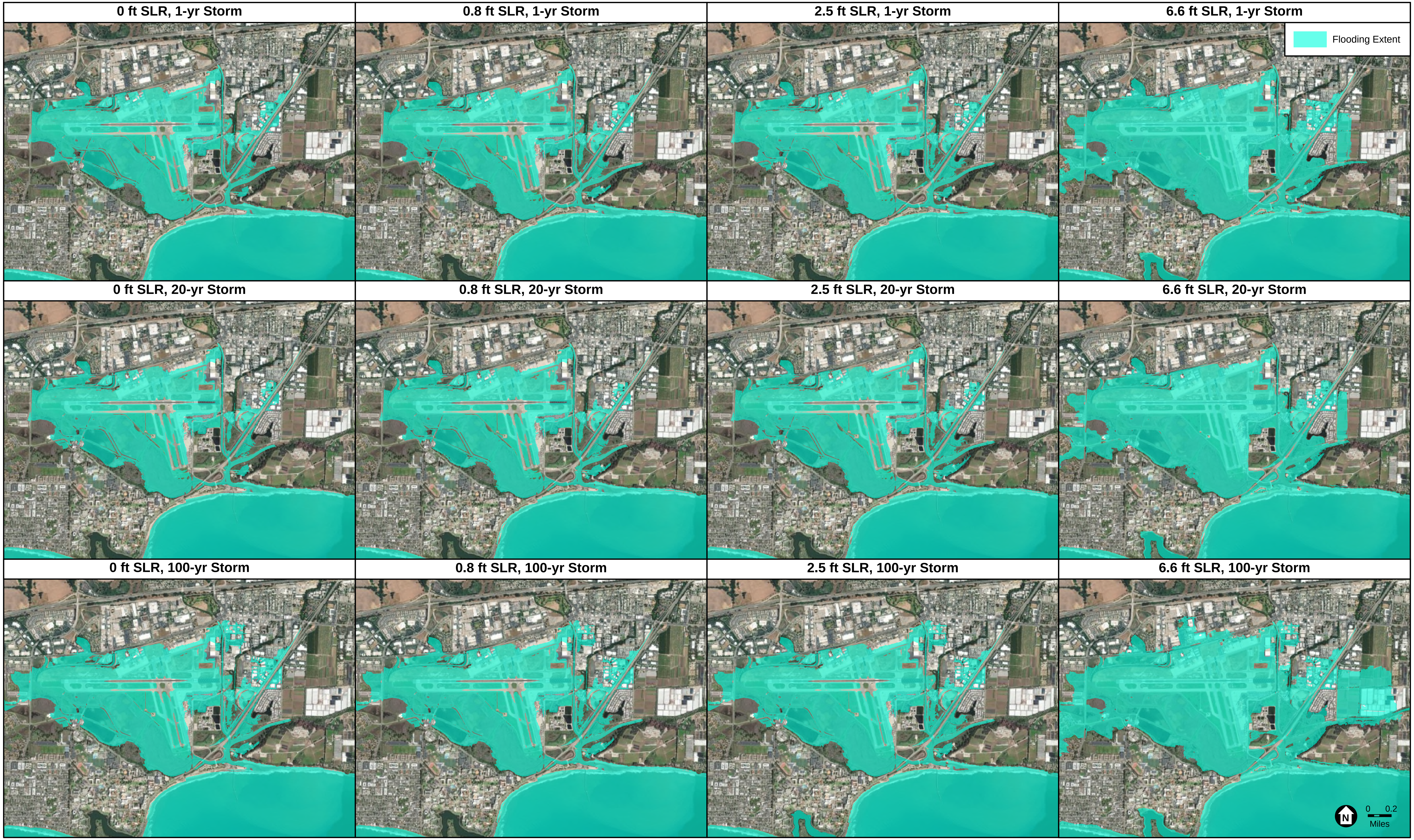
2.5 ft sea level rise (2076). With 2.5 ft of sea level rise, the risk of flooding to the NW Quadrant and edge of runways increases to a 100% annual chance of occurrence (1-year event). The risk of runway flooding/airport closure increases to an approximately 60% chance of occurrence or more.

6.6 ft sea level rise (2130). 6.6 ft of sea level rise would likely cause regular runway flooding and airport closure due to tidal inundation and would result in a 100% annual chance of entire airport flooding during storms.

Groundwater Inundation. Groundwater emergence occurs under existing conditions in portions of the runways, taxiways, terminal area, parking lots, and roads according to CoSMoS mapping. The extents of ponding from groundwater emergence are predicted to slightly increase with sea level rise.

5.6 Next Steps

The next step to refine this analysis would be to perform combined numerical flood modeling of fluvial flooding with increased precipitation and sea level rise. Additionally, the storm drain system can be integrated into the model.



SOURCE: ESA/SB County, USGS, NAIP, GSD, Santa Barbara Airport, UCSB, GWSD

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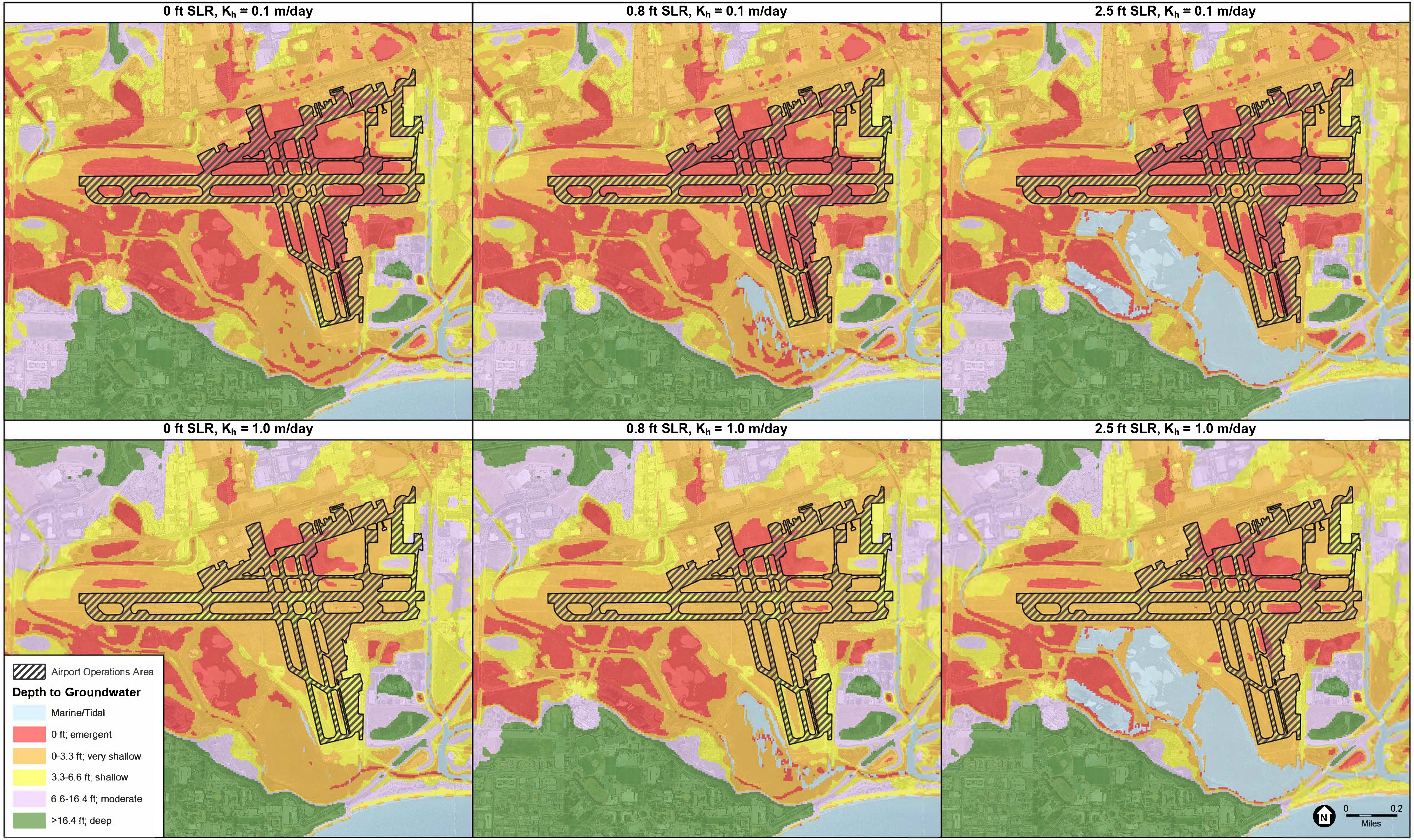
Figure 10

CoSMoS Flood Extent, 0, 0.8, 2.5, and 6.6 ft SLR, and 1-yr, 20-yr, and 100-yr Storms



SOURCE: ESRI, ESA/SB County, USGS, Santa Barbara Airport, UCSB, GWSD

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Figure 11

CoSMoS Groundwater Depth, 0, 0.8, and 2.5 ft SLR, and K_h 0.1 and 1.0 m/day

6. ASSETS

SBA asset GIS data were provided by the City of Santa Barbara. The airport has the following assets:

- **Airport Electrical Equipment:** includes all airfield signs located along the airport operations areas, Runways 7-25 and 15R-33L edge and threshold lights, taxiway edge lights, Runway Guard Lights (RGLs), Windsock, Apron Lighting, and Airfield Electrical Vault.
- **FAA-owned Navaids and Electrical Equipment:** includes the Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR), Glideslope Antenna, Glideslope Shelter, Instrument Landing System (ILS), Runway Visual Range (RVR) equipment, Remote Transmitter Receiver (RTR), Runway 25 Precision Approach Path Indicator (PAPI), Runway 25 Runway End Identifier Lights (REILs), Runway 15R REILs, and Airport Rotating Beacon. The ILS includes the following equipment: Localizer, Localizer building, Distance Measuring Equipment (DME), Airport Surveillance Radar (ASR), and Automated Surface Observing System (ASOS).
- **Utilities:** includes storm drain, sanitary sewer, water, gas, security, and fiber-optic infrastructure. Fuel and water tanks are located throughout the airport property.
- **Buildings:** in the NW Quadrant, buildings include the Airport Electrical Vault, offices, hangars, storage, ATC tower, NOAA Atmospheric River Observatory, Above All Flight School, Airport Maintenance Buildings, and others. North of Hollister Ave, buildings include offices, businesses, storage facilities, and others. South of Hollister Ave, buildings include offices (including Airport Administrative and Security Operations Center), hangars, storage, Above All Flight School, SBA Visitors Center, Aircraft Rescue and Fire Fighting station (ARFF Station), Cargo Operations Building, and others. The airport terminal area includes the terminal building, passenger boarding bridges (PBB), and facility offices. In the SE Quadrant buildings mainly include hangars.
- **Security Equipment:** includes camera equipment for surveillance, airport perimeter fence, and several airport manual and automatic gates.
- **Airport Access Roads:** roads provide access to various points throughout the airport property. Several roads provide direct access to the airport, including James Fowler Road, Moffett Place, Firestone Road, Sandspit Road, and Hollister Avenue. Additionally, Highway 101, Highway 217, and Fairview Avenue do not provide direct airport access, but are critical for those traveling to the site. Along these access roads are bridges critical to airport access including three primary bridges on Hollister Ave spanning Tecolotito, Carneros, and San Pedro creeks along with a bridge on Firestone Road crossing Carneros Creek and bridges at Matthews Street and James Fowler Road spanning San Pedro Creek.
- **Parking Lots:** parking lots serve office areas for airport staff or other personnel working at the airport and the terminal building. Parking lots include among others: Long-Term Lot, Short-Term Lot, Economy (or Overflow) Lot, Cell Phone Lot East, and Cell Phone Lot South.
- **Airport Operations Area:** includes runways, taxiways, blast pads, aprons, and shoulders.

7. VULNERABILITY ASSESSMENT

This chapter presents the methods and findings of the flood and sea level rise vulnerability assessment using spatial data for hazard zones (described in Section 4) and airport assets (described in Section 5) and operations. To develop an effective adaptation plan and policies to address flood and sea level rise vulnerability, the risk of not taking action must be understood first. For this reason, the vulnerability assessment analyzes impacts from a hypothetical "no action" scenario in which SBA does not prepare for or respond to sea level rise. By considering this scenario, SBA, neighboring jurisdictions and other decision makers can understand the full potential impacts of flooding and sea level rise, identify areas and/or individual assets with the greatest vulnerabilities, and then plan adaptation to reduce identified vulnerabilities.

The vulnerability assessment considers airport assets (buildings, utility infrastructure, etc.) and operations within the airport area. Potential flood impacts to four primary airport operations were considered: 1) impact to disembarking at the terminal; 2) closure of private aviation operations (NW Quadrant); 3) closure of commercial runways; and 4) closure of either Runway 15L/33R or 15R/33L. The vulnerability of assets and operations scenarios were assessed for each sea level rise scenario, considering the flood thresholds described in Section 4.1.

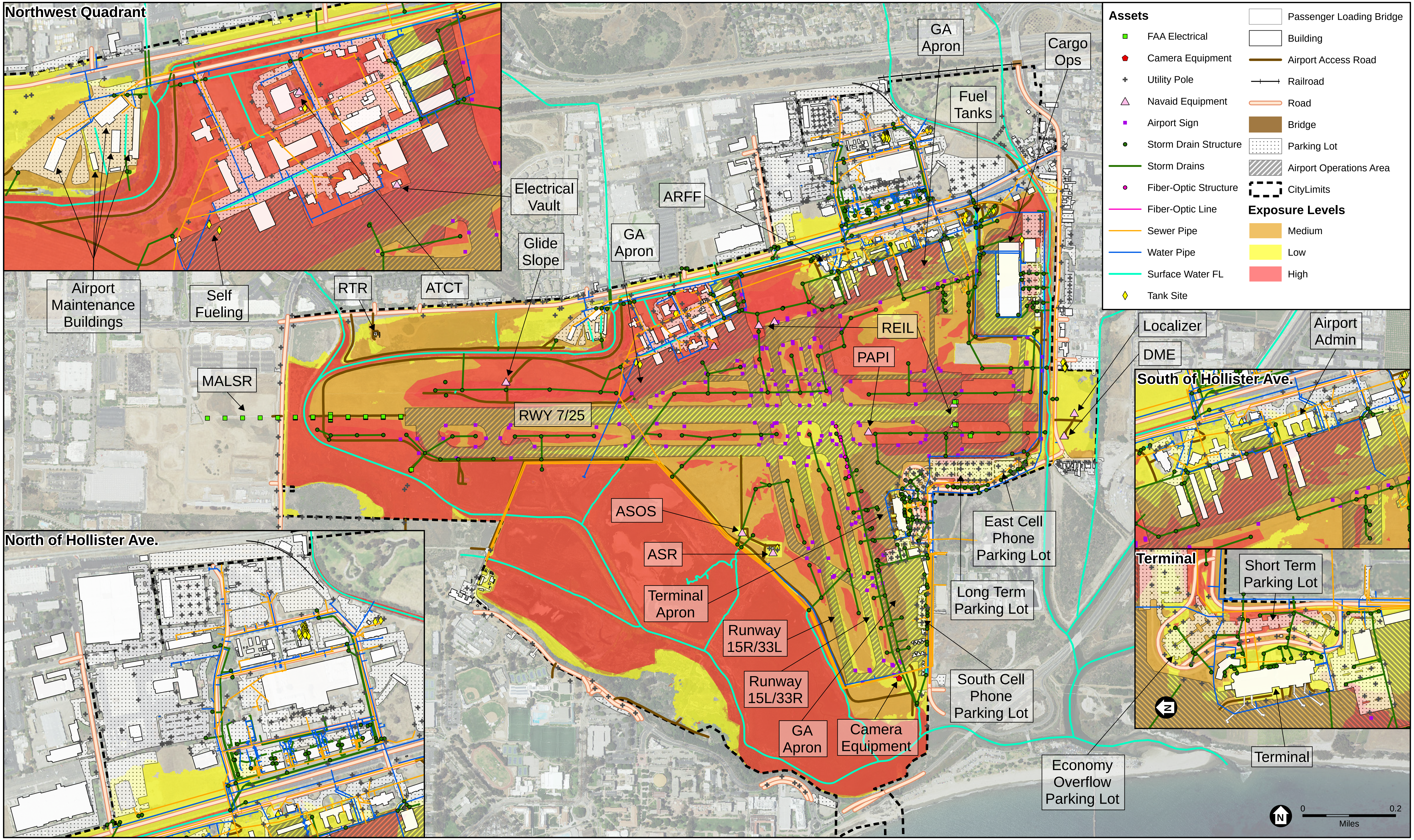
Section 6.1 presents a summary of asset-specific vulnerabilities. Section 6.2 presents an evaluation of potential consequences to airport operations based on the identified vulnerabilities. Section 6.3 presents an economic analysis of potential impacts.

7.1 Asset Vulnerability

This section presents a summary of asset vulnerabilities to flooding with sea level rise and climate change. The vulnerability of each asset category was assessed based on three factors:

Hazard Exposure: Each asset was assigned a flooding exposure level of low, medium or high depending on which flood threshold the asset is mapped in **Figure 12**. Assets that are exposed during the lowest flood threshold (i.e., an event that impacts only the NW Quadrant) are designated as high exposure level (meaning more likely to occur), while an asset that is only exposed during the highest storm threshold (entire airport flooded) is designated as low exposure level (occurring less often). As noted below, the flood thresholds are approximately characterized by an average flood water surface elevation (WSE) and the annual chance of exposure for each varies by sea level rise and precipitation scenario (**Table 8**).

1. **Low** (less likely) – asset is exposed only in the Entire Airport Flooded, Airport Closed flood threshold as shown in the current FEMA floodplain (WSE of 14 ft NAVD).
2. **Medium** – asset is exposed in the Runways Flooded, Airport Closed flood threshold (WSE of 12.5 ft NAVD).
3. **High** (more likely) – asset is exposed in the NW Quadrant Flooded threshold (WSE of 11 ft NAVD).



SOURCE: ESA/SB County, USGS, NAIP, GSD, Santa Barbara Airport, UCSB, GWSD

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Figure 12
Asset Exposure Levels

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TABLE 8. HAZARD EXPOSURE LEVEL SUMMARY

Hazard Exposure Level	Approximate WSE to Expose Asset (ft)	Annual Chance				
		0 ft SLR, Past Precipitation	0 ft SLR, Future Precipitation (2024 – 2100)	0.8 ft SLR (2048)	2.5 ft SLR (2076)	6.6 ft SLR (2130)
Low	14	1% to 7%	3% to 21%	4% to 21%	4% to 61%	100%
Medium	12.5	7% to 12%	21% to 28%	21% to 29%	61% to 100%	100%
High	11	over 12%	over 28%	over 29%	100%	100%

NOTE: all scenarios above 0 ft SLR assume future precipitation

Sensitivity: Each asset was assigned a level of sensitivity and/or consequence of exposure.

1. **Low** – Flooding would have no or a low impact on the asset function. The asset would be able to quickly rebound from the impact.
2. **Medium** - Flooding would cause minor damage or temporary operational interruption.
3. **High** - Flooding would cause significant damage or longer-term operational interruption (direct or indirect) including impacts to public safety. The asset would require significant effort to rebound from the impact.

Adaptive capacity: refers to the ability of an asset to change in response to hazard exposure with rising sea-levels.

1. **High** - The asset could be easily modified to reduce/avoid flooding impacts.
2. **Medium** - The asset requires moderate effort to modify and reduce flooding impacts.
3. **Low** – The asset requires significant effort to modify and adapt or adaptation would cause ripple effects to the wider system (e.g., sewer system or other infrastructure).

7.1.1 Asset Vulnerability Summaries

The following sections summarize future hazard exposure and vulnerability of each asset category including the following:

- Past impacts and damages
- Future hazard exposure
- Asset sensitivity
- Asset adaptive capacity.

Date ranges for sea level rise vulnerabilities included in the following summaries are based on the OPC 2024 sea level rise guidance timing associated with the Intermediate and High Scenarios (i.e., for the dates of sea level rise vulnerabilities in parentheses below, the first date corresponds to the High Scenario and the second date corresponds to the Intermediate Scenario).

- Near term:
  - With increased precipitation due to climate change (projected to occur over the time period from 2024 to 2100), the chance and frequency of flooding and associated vulnerabilities are expected to increase relative to the past. Hazard analysis results show flooding in the NW Quadrant more than doubles from a 12% annual chance to 28% annual chance, runway flooding and airport closure triples from 7% to 21% annual chance, and entire airport flooding also triples from 1% to 3% annual chance. Increased precipitation due to climate change may have at least in part contributed to SBA flooding over the past two years.
  - With 0.8 feet of sea level rise and increased precipitation (2048), flood vulnerabilities increase, but not necessarily significantly, compared to current sea levels with increased precipitation. Results show flooding in the NW Quadrant increases from 28% to 29% annual chance, runway flooding remains at a 21% annual chance, and entire airport flooding increases from 3% to 4% annual chance.
- Mid-term: At some point between 0.8 and 2.5 feet of sea level rise and with increased precipitation (2048 to 2076), results show NW Quadrant flooding increases to 100% annual chance. With 2.5 feet of sea level rise, results show runway flooding and airport closure increases from 21% to 61% annual chance and entire airport flooding remains a 4% annual chance.
- Long term: with between 2.5 and 6.6 feet of sea level rise (2076 to 2130), results show the annual chance of the entire airport flooding increases to 100%. With about 3.3 feet of sea level rise (2087), tidal flooding of the airport is likely to occur on a biweekly basis, rendering the airport inoperable. Under this scenario, the airport is not operational. Vulnerabilities are expected to increase for all assets and operations except for certain assets north of Hollister Avenue.

The vulnerability of airport assets to flooding and sea level rise is a combination of the likelihood of being flooded (hazard exposure), consequence of being flooded (sensitivity), and ability to be modified (adaptive capacity). **Table 9** summarizes asset exposure, sensitivity, and adaptive capacity rankings and the composite vulnerability ranking based on the ranks described in the section above. A more detailed explanation of each asset's hazard exposure, sensitivity, and adaptive capacity is provided below.

TABLE 9. ASSET VULNERABILITY SUMMARY

Asset	Hazard Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Airport Electrical Equipment				
Airfield Signs	High – Low	Medium	Low	High – Medium
Airfield Lighting	High – Low	Medium	Low	High – Medium
Apron Lighting	Medium	Low	Medium	Medium – Low
Electrical Vault	Low	High	Low	High – Medium
Fiber-Optic	Medium	Low	Medium	Medium – Low
Airport Operations Area				
General Aviation Aprons (NW)	High	Medium	Low	High
General Aviation Aprons (SE)	Medium	Medium	Low	High – Medium
General Aviation Aprons (NE)	Medium	Medium	Low	High – Medium
Runway 7/25	Medium – Low	Medium	Low	Medium

Asset	Hazard Exposure	Sensitivity	Adaptive Capacity	Vulnerability
Runway 15R/33L	High	Medium	Low	High
Runway 15L/33R	High	Medium	Low	High
Taxiways	High – Low	Medium	Low	High – Medium
Terminal Apron	Medium	Medium	Low	High – Medium
FAA-Owned NAVAIDs and Electrical Equipment				
Airport Rotating Beacon	High	High	High	High – Medium
Glide Slope Antenna and RVR	High	High	Low	High
ILS (Localizer, ASOS, ASR, DME)	Low	High	Low	High – Medium
MALSR System	Medium – Low	High	Low	High – Medium
Precision Approach Path Indicator	Medium	High	Medium	High – Medium
Runway End Identifier Lights	High – Medium	High	Medium	High – Medium
Remote Transmitter Receiver	Medium	High	Low	High
Infrastructure				
Airport Access Roads	High – Low	Medium	Low	High – Medium
Buildings				
Airport Maintenance Buildings (NW)	Medium	Medium	Low	High – Medium
ATCT (NW)	High	Medium	Low	High
ARFF Station	Low	High	Low	High – Medium
Terminal Building (SE)	Medium	Medium	Low	High – Medium
Airport Admin and Ops	Low	Medium	Low	Medium
Cargo Operations Buildings (NE)	Low	Medium	Low	Medium
Various Buildings/Hangars (NW)	High – Medium	Medium	Low	High – Medium
Various Buildings/Hangars (NE)	Medium – Low	Medium	Low	Medium
Various Buildings/Hangars (SE)	Low	Medium	Low	Medium
Various Buildings (North Hollister)	Low	Medium	Low	Medium
Fuel Tank Sites	High – Low	High	Medium	High – Medium
Gas Infrastructure	High – Low	Medium	Low	High – Medium
Parking Lots				
Cell Phone Lot East	Medium	Low	Low	Medium
Cell Phone Lot South	Low	Low	Low	Medium – Low
Economy (Overflow) Lot	Low*	Medium	Low	Medium
Long-Term Lot	Medium	Medium	Low	High – Medium
Short-Term Lot	Medium	Medium	Low	High – Medium
Sanitary Sewer Infrastructure	High – Low	High	Low	High
Storm Drain Infrastructure	High – Low	High	Low	High
Utility Poles	High – Low	Low	Low – Medium	Medium – Low
Water Infrastructure	High – Low	Medium	Low	High – Medium
Security Equipment				
Camera Equipment	Low	High	High	Medium – Low
Various Fence and Gates	High – Low	Low – Medium	Medium	Medium

NOTE:
* = Asset is not included in any of the hazard zones.

Based on this analysis, the most vulnerable assets to sea level rise and increased precipitation are the NW General Aviation Aprons, Runways 15R/33L and 15L/33R, Glide Slope Antenna and RVR, Remote Transmitter Receiver, ATC Tower, Sanitary Sewer Infrastructure, and Storm Drain Infrastructure. Other areas with increased vulnerability (High - Medium) are SE and NE General Aviation Aprons, Taxiways, Terminal Apron, Airport Rotating Beacon, ILS, MALSR System, Precision Approach Path Indicator, Runway End Identifier Lights, Airport Access Roads, Airport Maintenance Buildings, ARFF Station, SE Terminal Building, NW Buildings/Hangars, Fuel Tank Sites, Gas Infrastructure, Long-Term and Short-Term Parking Lots, and Water Infrastructure.

Note that all percent annual chance of flooding estimates mentioned in the asset-specific vulnerability discussions below are based on approximate hazard analysis results. The following future hazard exposure results are common to all assets:

- With up to 0.8 feet of sea level rise and increased precipitation (2024 – 2048), the hazard exposure may not significantly increase from the exposure estimated for current sea level and increased precipitation. Note that the current/future exposure with increased precipitation is expected to be higher than in the past as discussed for each asset below. This hazard exposure result is not repeated for asset discussion below.
- With between 2.5 to 6.6 feet of sea level rise (2076 – 2130), the annual chance flooding increases to 100% for all assets (except certain assets north of Hollister Ave) and the airport is not expected to be operational. This important hazard exposure result is repeated for asset discussion below for completeness.

Past impacts and damages are only discussed for assets for which information was available. Other past impacts and damages may have occurred, but this information was not available for this study. Discussion of exposure to groundwater emergence assumes a hydraulic conductivity of 1.0 m/day for the site.

7.1.2 Airport Electrical Equipment

Airfield Signs

- **Past Impacts and Damages –** Signs were flooded during recent events at the airport. Electrical equipment was deactivated during the flood and signs were not damaged by the flood.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least a 21% to 28% annual chance of flooding most of the airport signs, and a 3% chance of flooding all of the signs.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100% for most of the airport signs, and 4% to 61% for all of the signs.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Medium) –** Signs could be damaged or become unreadable from flooding. While important for navigation within the airport, damages to signs are not likely to disrupt airport operations.
- **Asset Adaptive Capacity (Low) –** Although signs would likely take comparatively low effort to move up and out of flood-prone elevations, sign elevations are tied to the elevation of the pavement and existing ground. Per FAA requirements, no sign component should be within 12 inches of any

aircraft part. Raising the elevation of the signs only will also violate FAA grade requirements for Taxiway Object Free Areas.

- **Vulnerability: High – Medium**

Airfield Lighting

- **Past Impacts and Damages –** Airport lighting was flooded during recent events at the airport. Electrical equipment was deactivated during the flood and lights were not damaged by the flood.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least a 21% to 28% annual chance of flooding most of the airport lights, and a 3% chance of flooding all of the lights.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100% for most of the airport lights, and 4% for all of the lights.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Medium) –** Lights could be damaged or submerged from flooding and not be seen. While important for navigation within the airport, damages are not likely to disrupt airport operations.
- **Asset Adaptive Capacity (Low) –** Relocation of airfield lights will not be possible as light locations are mostly tied to pavement features. Raising lights will also require modifications to the pavement and infield elevations.
- **Vulnerability: High – Medium**

Apron Lighting

- **Past Impacts and Damages –** No known damage from flooding
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 21% to 28% annual chance for this equipment to be flooded.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* **–** Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Low) –** Apron lighting is elevated. Risks to this equipment could include damage to ground-level electrical equipment or damage to the light pole. Apron lighting improves safety on the aprons by increasing visibility. Damage to this equipment will not disrupt regular airport operations.
- **Asset Adaptive Capacity (Medium) –** Apron Lighting fixtures are elevated and will be easier to protect. However, ground-level equipment and poles may require relocation.
- **Vulnerability: Medium – Low**

Electrical Vault

- **Past Impacts and Damages –** No known recent damage from flooding.
- **Future Hazard Exposure (Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – The area has at least 28% annual chance of exposure. The electrical vault is raised above the FEMA Base Flood Elevation and therefore has up to a 3% annual chance of flooding and low exposure ranking.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to up to 100% for the area and up to 4% for the vault.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding is 100%, the airport is not operational.
- **Asset Sensitivity (High) –** The electrical vault contains critical equipment that's failure would disrupt service but was built above the FEMA 100-yr floodplain and is not anticipated to be vulnerable to flooding damage.
- **Asset Adaptive Capacity (Low) –** The vault is already located above the FEMA 100-yr floodplain and has a degree of floodproofing, but it would be difficult to move or adapt were its current location to become flood-prone.
- **Vulnerability: High – Medium**

Fiber-Optic

- **Past Impacts and Damages –** There are no known past impacts or damages due to flooding.
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least 21% annual chance of flooding to the area containing fiber-optic infrastructure.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Low) –** Fiber-optic assets are important for communication and data transmittal, but are not essential infrastructure. They are not likely to be damaged as they are primarily underground and protected, so have a low risk of harm from flooding and inundation.

  Fiber optic cabinets will not be accessible during flood events.
- **Asset Adaptive Capacity (Medium) –** The fiber-optic assets are located underground and likely already water-proofed, making them less likely to be damaged by flooding, but it may be difficult to adapt the system to inundation by saline surface water and groundwater. The fiber optic cable could be replaced with materials that are more resistant to the effects of saline surface water and groundwater.
- **Vulnerability: Medium – Low**

7.1.3 Airport Operations Area

General Aviation Aprons

- **Past Impacts and Damages -** Past general aviation apron flooding has occurred. Varying degrees of flooding have led to airport closure, discussed in more detail in Section 2.2.2. Flooding has required cleanup and caused damage.
- **Future Hazard Exposure (High - Medium)**
  - *Current/future risk with increased precipitation (2024 – 2100)* –The general aviation aprons have between 21% and 28% chance of flooding. Specifically:
    - *General Aviation Apron (NW):* **over 28 %**
    - *General Aviation Apron (SE):* **21% to 28%**
    - *General Aviation Apron (NE):* **21% to 28%**
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to a range between 61% and 100%
    - *General Aviation Apron (NW):* **100%**
    - *General Aviation Apron (SE):* **61% to 100%**
    - *General Aviation Apron (NE):* **61% to 100%**
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100% for all general aviation aprons, the airport is not operational.
    - *General Aviation Apron (NW):* **100 %**
    - *General Aviation Apron (SE):* **100%**
    - *General Aviation Apron (NE):* **100%**
- **Asset Sensitivity (Medium) –** Risks to the general aviation aprons include the temporary loss of access for aircraft to access the aprons and aircraft service providers, potential damage to private aircraft and support equipment. Flooding can carry sediment that needs to be cleared from the area and may contribute to long-term pavement damage and eventual replacement.
- **Asset Adaptive Capacity (Low) –** The general aviation aprons are large areas that are fixed by function as they are connected to aircraft support services in the fixed based operators (FBOs) and hangars, meaning it would require extraordinary effort to relocate or floodproof.
- **Vulnerability: High**

Runway 7/25

- **Past Impacts and Damages -** Past runway flooding has led to airport closure, discussed in more detail in Section 2.2.2. Flooding has required cleanup and caused damage.
- **Future Hazard Exposure (Medium - Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 21% to 28% annual chance of flooding at the 7 and 25 ends requiring runway closure.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100%.

  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance of flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Medium) –** Risks to Runway 7/25 includes the temporary loss of function of the runway. Flooding can carry sediment that needs to be cleared from the area and may contribute to long-term pavement damage and eventual replacement. Disruption to the airport operations area could halt airport functioning for long periods depending on the location affected and extent of damage.
- **Asset Adaptive Capacity (Low) –** This area is fixed and large, meaning it would require extraordinary effort to relocate or floodproof.
- **Vulnerability: Medium**

Runway 15R/33L and 15L/33R

- **Past Impacts and Damages -** Past runway flooding has led to airport closure, discussed in more detail in Section 2.2.2. Flooding has required cleanup and caused damage.
- **Future Hazard Exposure (High) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least a 28% annual chance of flooding at the 15 ends, leading to closure. Most of the runways have a very shallow (0 to 3.3 ft) depth to groundwater, with areas of shallow (3.3 ft to 6.6 ft) groundwater at the 33 ends, and small areas of emergent groundwater at the 15 ends.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of runways flooding and forcing closure increases to 100%. The extent of emergent groundwater at the 15 end of the runways increases slightly.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding is 100%, the airport is not operational.
- **Asset Sensitivity (Medium) –** Risks to Runway 15R/33L and 15L/33R includes the temporary loss of function of the runway. Flooding can carry sediment that needs to be cleared from the area and may contribute to long-term pavement damage and eventual replacement. Disruption to the airport operations area could halt airport functioning for long periods depending on the location affected and extent of damage.
- **Asset Adaptive Capacity (Low) –** This area is fixed and large, meaning it would require extraordinary effort to relocate or floodproof.
- **Vulnerability: High**

Taxiways

- **Past Impacts and Damages -** Past taxiway flooding has occurred. Varying degrees of flooding has led to airport closure, discussed in more detail in Section 2.2.2. Flooding has required cleanup and caused damage.
- **Future Hazard Exposure (High - Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least a 28% annual chance of taxiway flooding occurring in the NW Quadrant. 3% to 28% annual chance of flooding at other taxiways, depending on location. Groundwater depth is shallow (3.3 to 6.6 ft) to very shallow (0 to 3.3 ft) on the majority of taxiways. CoSMoS results show a small area of emergent groundwater on the north end of Taxiway E.

  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100% for taxiways in the NW Quadrant. Annual chance rises to 4% to 61% for other taxiways, dependent on location. Groundwater depth remains shallow to very shallow on most taxiways. Taxiways A, B, and E may be susceptible to emergent groundwater.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Medium) –** Risks to taxiways include the temporary loss of function of the taxiway and circulation issues for transiting aircraft. Flooding can carry sediment that needs to be cleared from the area and may contribute to long-term pavement damage and eventual replacement. Disruption to the taxiways could halt or disrupt airport functioning for long periods depending on the location affected and extent of damage.
- **Asset Adaptive Capacity (Low) –** The taxiways are large and numerous with fixed locations, meaning it would require extraordinary effort to relocate or floodproof.
- **Vulnerability: High – Medium**

Terminal Apron

- **Past Impacts and Damages -** Past terminal apron flooding has occurred. Varying degrees of flooding has led to airport closure, discussed in more detail in Section 2.2.2. Flooding has required cleanup and caused damage.
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 21% to 28% annual chance of terminal apron flooding. The terminal apron may have a very shallow (0 to 3.3 ft) depth to groundwater.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100%. The terminal apron area may become susceptible to emergent groundwater.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Medium) –** Risks to the terminal apron include the temporary loss commercial airlines ability to access the terminal gates, potential damage to airline and airport equipment stored on the ramp, and potential damage to terminal boarding bridges. Flooding can carry sediment that needs to be cleared from the area and may contribute to long-term pavement damage and eventual replacement.
- **Asset Adaptive Capacity (Low) –** The terminal apron is a large area that is fixed by function as it is connected to the terminal building, meaning it would require extraordinary effort to relocate or floodproof.
- **Vulnerability: High – Medium**

7.1.4 FAA Owned NAVAIDs and Electrical Equipment

Airport Rotating Beacon

- **Past Impacts and Damages –** No recent known damage.
- **Future Hazard Exposure (High) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least a 28% annual chance for the base of the structure to be flooded. Components that are not floodproofed could be damaged. The projected frequency of flooding may also cause damage to floodproofed or waterproofed components over time.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – A 100% annual chance for the base of the structure to be flooded. Vulnerabilities increase.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding is 100%, the airport is not operational.
- **Asset Sensitivity (High) –** The rotating beacon is elevated. Risks to this structure could include damage to ground-level electrical equipment or damage to the support structure itself. This system is important for visibility, and damage may interrupt operations.
- **Asset Adaptive Capacity (High) –** As the beacon is already elevated, it would be easier to protect than other assets.
- **Vulnerability: High – Medium**

Glide Slope Antenna and RVR Equipment

- **Past Impacts and Damages –** No recent known damage from flooding.
- **Future Hazard Exposure (High) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least a 28% annual chance of flooding to this area.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 100%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding is 100%, the airport is not operational.
- **Asset Sensitivity (High) –** Risks to these structures could include damage to ground-level electrical equipment or damage to the structure itself.
- **Asset Adaptive Capacity (Low) –** These are complex systems that would be difficult to move, and need to be positioned appropriately for airplane visibility, making adaptation more difficult.
- **Vulnerability: High**

ILS (Localizer, Localizer Building, ASOS, and ASR)

- **Past Impacts and Damages –** No recent known damage for this equipment.
- **Future Hazard Exposure (Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 3% to 21% annual chance of flooding to these areas.

  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 4% to 21%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (High) –** Risks to these structures could include damage to ground-level electrical equipment or damage to the support structures themselves. Electrical systems are integral to airport operations and interruption to their functioning could cause significant operational interruptions.
- **Asset Adaptive Capacity (Low) –** These systems are intricate and sensitive making them difficult to relocate or adapt.
- **Vulnerability: High – Medium**

MALSR System

- **Past Impacts and Damages –** The FAA MALSR System was recently out of commission for a few weeks. The cause of the issue is not known but could be related to recent flooding. The outage of this system caused disruptions to the commercial traffic generally operating at the airport as it prevented operations during low visibility conditions otherwise allowed with the MALSR.
- **Future Hazard Exposure (High - Low)**
  - *Current/future risk with increased precipitation (2024 – 2100)* - At least a 28% annual chance for portions of the MALSR system and the FAA electrical building to be flooded, and a 21% to 28% chance for the entire MALSR system within airport property to be flooded. Components that are not floodproofed are expected to be damaged. The projected frequency of flooding may also cause damage to floodproofed or waterproofed components over time.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* - Portions of the MALSR system are expected to be flooded at least once every year. The annual chance for the entire MALSR system within airport property and electrical substation to be flooded increases to 61% to 100%. The severity of vulnerabilities described above are expected to increase (i.e., vulnerabilities increase).
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* - Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (High) –** The risks to these assets include damage to electrical equipment if the equipment is not adequately floodproofed. Increased flooding may damage electrical equipment near the MALSR system. Increased flooding of the building that houses electrical equipment for the MALSR system may also damage the MALSR system. Electrical systems are integral to airport operations and interruption to their functioning could cause significant operational difficulties and interruptions.
- **Asset Adaptive Capacity (Low – Medium) –** Some components may be easily located or replaced, but adapting the entire system would likely require significant effort.
- **Vulnerability: High – Medium**

Runway 25 Precision Approach Path Indicator

- **Past Impacts and Damages –** No recent known damage.
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 21% to 28% annual chance for the base of the lighting structures to be flooded.

  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (High) –** Risks to this structure could include damage to ground-level electrical equipment or damage to the support structure itself. It is essential for safe aircraft landing procedures. Failure would cause serious operational issues.
- **Asset Adaptive Capacity (Medium) –** These systems could likely be altered to some degree to adapt to increased flood risk with moderate effort.
- **Vulnerability: High – Medium**

Runway End Identifier Lights for Runway 25 and Runway 15R

- **Past Impacts and Damages –** Runway 15R REILs were recently not functioning due to a wiring issue.
- **Future Hazard Exposure (High) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – An at least 28% annual chance of flooding.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 100%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* **–** Annual chance of flooding is 100%, airport is not operational.
- **Asset Sensitivity (High) –** Important for seeing the runway end, but failure would not necessarily interrupt airport operations.
- **Asset Adaptive Capacity (Medium) –** Location of this equipment cannot be modified. Waterproofing, or other hardening would likely take moderate effort.
- **Vulnerability: High – Medium**

Remote Transmitter Receiver

- **Past Impacts and Damages –** No recent known damage from flooding.
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 21% to 28% annual chance for this equipment to be flooded.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* **–** Annual chance of flooding increases to 61% to 100%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* **–** Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (High) –** Failure of this equipment will reduce the range of communication of the Air Traffic Control Tower, but it would not interrupt airport operations.
- **Asset Adaptive Capacity (Low) –** This system includes antennas and buildings that will be difficult to relocate.
- **Vulnerability: High**

7.1.5 Infrastructure

Airport Access Roads

- **Past Impacts and Damages –** Access roads have flooded previously, requiring clean up and repairs.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least a 28% annual chance of flooding roads in the NW Quadrant and adjacent to Goleta Slough. The remainder of access roads will have a 21% to 28% annual chance of flooding, with the exception of some roads south of Hollister Ave and east of South Fairview Ave, which will have a 3% to 21% annual chance of flooding.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 100% in the NW Quadrant and adjacent to Goleta Slough. The remainder of access roads will have a 61% to 100% annual chance of flooding, with the exception of some roads south of Hollister Ave and east of S Fairview Ave, which will have a 4% to 61% annual chance of flooding. The Firestone Road crossing over Carneros Creek and Firestone Ditch will be overtopped in the medium exposure condition. The section of Hollister Road between Tecolotito and Carneros Creek will be inundated. Portions of Moffet Place, James Fowler Road, and South Fairview Ave also fall within the medium exposure area.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* **–** Annual chance flooding increases to 100%, the airport is not operational. The Firestone Road crossing over Firestone Ditch and the James Fowler Road crossing over San Pedro Creek will be overtopped in the low exposure condition. The section of Hollister Road between Tecolotito and Carneros Creek will be inundated. Portions of Moffet Place, James Fowler Road, and South Fairview Ave also fall within the low exposure area.
- **Asset Sensitivity (Medium) –** Risks to these areas include the temporary loss of function of the area and loss of access to facilities. Flooding can cause erosion damage to unpaved roads. Depending on the level of damage and extent of flooding, could be an inconvenience, or could cause significant disruptions to operations.
- **Asset Adaptive Capacity (Low) –** Roads are fixed structures that would require significant effort to relocate or adapt.
- **Vulnerability: High – Medium**

Buildings

- **Past Impacts and Damages –** Flooding has significantly impacted and damaged buildings in past flood events.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* –
    - Airport Maintenance Building (Medium – Low): A 3% to 21% chance of flooding.
    - Air Traffic Control Tower (High): At least a 28% chance of flooding.
    - ARFF Station (Low): At least a 3% chance of flooding.
    - Terminal Building (Medium): A 21% to 28% chance of terminal flooding.
    - Airport Administration and Operations (Low): At least a 3% chance of flooding.

- Cargo Operations Building (Low): At least a 3% chance of flooding.
- Various Buildings/Hangars NW Quadrant (High – Medium): A 21% to over 28% annual chance of flooding buildings in the area.
- Various Buildings/Hangars NE Quadrant (Low – Medium): A 21% chance of flooding hangars. At least 3% chance of flooding most buildings in the area.
- Various Buildings/Hangars SE Quadrant (Low): At least 3% chance of flooding buildings in the area.
- North of Hollister Ave (Low): Potential 3% to 21% annual chance of flooding two buildings.

– *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* –

- Airport Maintenance Building (Medium – Low): Annual chance of flooding increases to 21% to 61%.
- Air Traffic Control Tower (High): An over 29% chance of flooding.
- ARFF Station (Low): At least a 4% chance of flooding.
- Terminal Building (Medium): Annual chance of flooding increases to 61% to 100%.
- Airport Administration and Operations (Low): An over 4% chance of flooding.
- Cargo Operations Building (Low): At least a 4% chance of flooding.
- Various Buildings/Hangars NW Quadrant (High – Medium): A 61% to 100% annual chance of flooding buildings in the area.
- Various Buildings/Hangars NE Quadrant (Medium – Low): Annual chance of flooding increases to 61% to 100% for hangars and 4% to 61% for most buildings in the area.
- Various Buildings/Hangars SE Quadrant (Low): Annual chance of flooding increases to 4% to 61%.
- North of Hollister Ave (Low): Flooding risk of two buildings increases to potential 4% to 61% annual chance.

– *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.

- **Asset Sensitivity (High - Medium) –** Flood risks to buildings can include structural and utility damage. Depending on building function, flooding could be a minor issue with no impact on airport functioning, or a critical issue that severely disrupts airport operations. The critical buildings that will disrupt airport operations are the air traffic control tower and the ARFF Station.
- **Asset Adaptive Capacity (Low) –** As fixed structures, it takes significant effort to floodproof buildings, especially if each building in flood prone areas require adaptation.
- **Vulnerability –**
  - Airport Maintenance Building: Medium
  - Air Traffic Control Tower: High
  - ARFF Station: High – Medium
  - Terminal Building: High – Medium
  - Airport Administration and Operations: Medium

- Cargo Operations Building: Medium
- Various Buildings/Hangars NW Quadrant: High – Medium
- Various Buildings/Hangars NE Quadrant: Medium
- Various Buildings/Hangars SE Quadrant: Medium
- North of Hollister Ave: Medium

Fuel Tank Sites

- **Past Impacts and Damages –** There are no known past impacts or damages to aircraft fuel tanks.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 3% to 21% to an over 28% annual risk, depending on location. One of the fuel tanks, which include jet fuel, diesel, AVGAS, and Mogas; and one of the propane tanks are located on the NW apron and are within the high exposure area.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Exposure increases to 4% to 61% or 100%, varying by tank location. This includes two of the fuel tanks and both of the propane tanks that are on the NW GA Apron and are within the medium exposure area.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational. There are three fuel tanks and both of the propane tanks that are on the NW GA Apron and that are within the low exposure zone.
- **Asset Sensitivity (High) –** Tanks are necessary for airport operations. Depending on tank location, material, and auxiliary equipment, flooding could cause damages due to corrosion, disruption of electrical, buoyancy forces on a partially full/empty tank, and perhaps other issues.

  Many of the tanks, however, are not within an exposure zone and are not expected to be affected by the included sea level rise scenarios. The fuel water separator located south of Firestone Road on the east side of the airport will not be affected by any of the included sea level rise scenarios.

- **Asset Adaptive Capacity (Medium) –** It would likely take moderate effort to increase the floodproofing of all tank sites. Temporary flood barriers can be set up around tank areas, although these barriers are typically 3ft in height and would not be able to withstand the conditions of the low exposure scenario. The tanks can also be relocated to areas with a lower hazard exposure, such as the NE Quadrant, however, this may impact airport operations especially in the NW Quadrant.
- **Vulnerability: High – Medium**

Gas Infrastructure

- **Past Impacts and Damages –** There are no known past impacts or damages to gas infrastructure.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 3% to 21% to an over 28% annual chance of exposure, dependent on location.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – At least 4% to 61% to a 100% chance of exposure by location.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.

- **Asset Sensitivity (Medium) –** Increased sea levels and flooding are not anticipated to impact buried gas infrastructure that is designed to be corrosion resistant. Groundwater and soil salinity could lead to increased pipe corrosion (particularly for older pipes) and failure.
- **Asset Adaptive Capacity (Low) –** Adjusting the alignment of the gas infrastructure to avoid flood-prone areas will require significant efforts. To avoid relocating the gas infrastructure alignment, gas pipes that are not resistant to corrosion may be replaced with corrosion-resistant materials.
- **Vulnerability: High – Medium**

Parking Lots

- **Past Impacts and Damages –** Parking lots have flooded during past storm events.
- **Future Hazard Exposure (Medium – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – In general, parking lots in the NW Quadrant have at least a 28% chance of flooding exposure while parking lots surrounding the terminal and northeast region of the site have a 3% to 21% flooding risk. Parking lots North of Hollister Ave have a less than 3% annual chance of flooding.
    - Cell Phone Lot East (Medium): A 21% to 28% chance of flooding.
    - Cell Phone Lot South (Low): At least a 3% annual chance of flooding
    - Economy (Overflow) Lot (Low): under 3% annual chance of flooding.
    - Long-Term Lot (Medium): 21% to 28% chance of flooding.
    - Short-Term Lot (Medium): 21% to 28% chance of flooding.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Flooding risk rises to 100% in the NW Quadrant parking lots, 4-61% surrounding the terminal and northeast region. Flooding risk remains below 4% for parking lots north of Hollister Avenue.
    - Cell Phone Lot East (Medium): 21% to 61% chance of flooding.
    - Cell Phone Lot South (Low): An over 4% annual chance of flooding
    - Economy (Overflow) Lot (Low): less than 4% annual chance of flooding.
    - Long-Term Lot (Medium): 21% to 61% chance of flooding.
    - Short-Term Lot (Medium): 21% to 61% chance of flooding.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* **–** Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Medium – Low) –** Risks to these areas include temporary loss of functionality and access to the areas. Prolonged or chronic flooding could cause lasting damage or erosion. Flooding of these areas may affect or disrupt service but is not necessary to interrupt airport operations.
- **Asset Adaptive Capacity (Low) –** As large, fixed assets, it would be difficult and require significant effort to adjust the exposure or sensitivity of the parking lots.
- **Vulnerability –**
  - Cell Phone Lot East: Medium
  - Cell Phone Lot South: Medium – Low
  - Economy (Overflow) Lot: Medium

- Long-Term Lot: High – Medium
- Short-Term Lot: High – Medium

Sanitary Sewer Infrastructure

- **Past Impacts and Damages –** Past flooding and elevated groundwater levels may have contributed to infiltration and inflow into the sewer system. A sewage spill from a Goleta West Sanitary District force main (to the west of SBA) occurred in February 2024 and was caused by corrosion from the outside of a sanitary sewer pipe. While this may be unrelated to SBA flooding, it serves as an example of the potential vulnerability to SBA sanitary sewer infrastructure. Per Goleta West Sanitary District:

  > *"The external corrosion was caused by imperfect external corrosion protection, potentially caused by damage during installation, coupled with severely corrosive soils that contain high chloride concentrations."*[6]

- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – Increased risk of erosion around the Goleta West Sanitary District-owned sewer pipeline that crosses Goleta Slough, which could affect and expose the pipe. For SBA assets: at least 28% annual chance of ponding above structures causing increased inflow to sanitary sewer maintenance holes in the NW Quadrant due to stormwater overtopping the maintenance hole structures. Maintenance holes south of Hollister Avenue and near the terminal could be vulnerable to increased inflow due to a 21% to 28% chance of flooding in the area. Maintenance holes south of the terminal have a 3% to 21% chance of increased inflow. 61% of the sanitary sewer forcemain, 13% of the gravity sanitary sewer pipe network, 14 of sanitary sewer maintenance holes, 23 of sanitary sewer cleanouts, and the lift station west of the intersection of Firestone Road and Adams Road are all within the high exposure area.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Erosion vulnerabilities around the sewer pipeline that crosses the Goleta Slough increase. Inflow vulnerabilities increase to 100% annual chance in the NW Quadrant, 61% to 100% south of Hollister Ave and near the terminal, and 4% to 61% south of the terminal. 61% of the sanitary sewer forcemain, 40% of the gravity sanitary sewer pipe network, 15 of the sanitary sewer maintenance holes, one of the interceptor tanks on the NE GA Apron, 35 sanitary sewer cleanouts and all of the lift stations that are operated by SBA are within the medium exposure area. Most of the affected structures are located in the NW and NE Quadrants, however, there are several cleanouts in the parking lots by the Terminal building that are at risk in the medium exposure condition.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational. 97% of the sanitary sewer forcemain, 51% of the sanitary sewer gravity pipe network, 32 sanitary sewer maintenance holes, two of the interceptor tanks, 61 sanitary sewer cleanouts, and both of the lift stations that are operated by SBA, and the Goleta Sanitary District-owned Firestone Road Pump Station are within the low exposure area. There is also a drain inlet located within the wash rack that will be inundated in the low-exposure scenario. Sanitary sewer maintenance holes and sanitary sewer cleanouts that are northeast of Hollister Avenue or northeast of the GA Apron will not be affected in the low exposure condition.
- **Asset Sensitivity (High) –** The risk to Goleta West Sanitary District and Goleta Sanitary District sewer infrastructure, including infiltration and inflow, is high. Flooding of maintenance holes is

[6] https://goletawest.org/february-2024-spill-updates

expected to increase inflow to the sanitary sewer system. As groundwater is already high in the area, infiltration due to rising groundwater may not increase as significantly with sea level rise. Groundwater and soil salinity could lead to increased pipe corrosion (particularly of older pipes) and potential sewage spills due to pipe failure. Increased inflow from the flooding of maintenance holes and infiltration can lead to surcharging of the sanitary sewer system.

Additionally, the sewer forcemain pipeline, owned by Goleta West Sanitary District, that crosses Goleta Slough may be subject to exposure and damage from increased channel flow and erosion. Failure could lead to significant health and sanitation problems. The Goleta West Sanitary District sanitary sewer system ties into the Goleta Sanitary District sewer system and ultimately goes to Goleta Sanitary District's wastewater treatment facility to the east of the Terminal. Increased inflow due to infiltration or other means could lead to the wastewater treatment facility to be overloaded and unable to handle the increased flows.

Maintenance holes, lift stations, and cleanouts will not be accessible during flood conditions. The lift station pumps may become overloaded and fail due to increased pumping requirements if the sanitary sewer system experiences significantly increased inflow. Flooding can lead to stormwater flowing into the sanitary sewer system via the interceptor tanks located at the northeast end of the airfield.

- **Asset Adaptive Capacity (Low) –** It would require significant effort to adjust the existing sewer infrastructure at the site. Leaking or damaged pipes would need to be identified and replaced to reduce the effects of infiltration. The pumps in the lift stations could be either resized or redesigned for redundancy in the event of future flooding. Maintenance holes, cleanouts, and other above ground infrastructure have limited flexibility in terms of location.
- **Vulnerability: High**

Storm Drain Infrastructure

- **Past Impacts and Damages –** No recent known damage. Capacity has presumably been temporarily negatively affected by high surrounding water surface elevations on multiple occasions.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – Storm drain inlets in the vicinity of the NW Quadrant have at least a 28% annual chance of flooding. Most of the remaining storm drain inlets have a 21% to 28% chance of flooding, with a few near the runway intersection having a 3% to 21% chance of flooding.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 100% for storm drain inlets in the vicinity of the NW Quadrant. Most of the remaining storm drain inlets have a 61% to 100% chance of flooding, with a few near the runway intersection having a 4% to 61% chance of flooding. Vulnerabilities increase.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (High)** – The storm drain system capacity is currently limited when water elevations at the outfalls are at their peak. Sea level rise further reduces the capacity of the existing storm drain system with higher water levels. Additional stormwater infrastructure risks include sediment clogs, which could require an increase in maintenance with increased flooding. As groundwater is already high in the area, infiltration due to rising groundwater may not increase significantly with sea level rise. Groundwater and soil salinity could lead to increased pipe corrosion (particularly of older pipes). Outfalls may have reduced capacity due to higher water elevations at the outfalls. An increase in deposited sediment at the outfalls due to sea level rise may also reduce storm

drain capacity, leading to increased flooding. Failure of the storm drain system could cause widespread flooding that would interrupt airport service for prolonged periods.

- **Asset Adaptive Capacity (Low)** – It would require significant effort to adjust the existing storm drain infrastructure at the site. Increasing the size and capacity of structures and pipes could help to some extent but would have limitations based on outfall conditions and site grades.
- **Vulnerability: High**

Utility Poles

- **Past Impacts and Damages –** No recent damage to this equipment. Generally utility poles are located on landside pavement. Damage to this asset will not have a significant impact on airport operations.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – Between a 3% and an over 28% annual chance of flooding depending on utility pole location.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 4% to 100% dependent on location of the pole.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* **–** Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Low) –** These assets are usually designed to withstand various weather conditions and made of materials that are resistant to water damage, making the asset not especially susceptible provided the elevated utility is not exposed to floodwater.
- **Asset Adaptive Capacity (Low – Medium) –** Likely difficult to relocate or replace with hardened alternatives.
- **Vulnerability: Medium – Low**

Water Infrastructure

- **Past Impacts and Damages –** There are no known past impacts or damages to water infrastructure.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 3% to 21% to an over 28% annual chance of exposure, dependent on location. 11% of pipes are within the high exposure area. There are 15 valve locations and 12 fire hydrants that within the high exposure area.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – At least 4% to 61% to a 100% chance of exposure by location. 31% of pipes are within the medium exposure area. There are 25 valve locations and 17 fire hydrants within the medium exposure area. Most of these assets are near the NW GA Apron, however, there are a few valves and hydrants in the terminal and long term parking lots that will be affected in the medium exposure condition.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational. 60% of pipes are within the low exposure area. There are 70 valve locations and 35 fire hydrants that are within the low exposure area. The effected above ground water infrastructure are located throughout the airport; however, the valves and fire hydrants northeast of the NE GA Apron or northeast of Hollister Avenue will not be affected by flood impacts.

- **Asset Sensitivity (Medium) –** Increased sea levels and flooding are not anticipated to impact buried water infrastructure that are designed to be corrosion resistant. Groundwater and soil salinity could lead to increased pipe corrosion (particularly of older pipes) and failure. Increased storm impacts to above ground components of water infrastructure could lead to damage. Contamination of the water system by the sanitary sewer system could occur if there are leaks in both systems.

  Increased storm impacts could lead to damage to above ground components of water infrastructure, such as fire hydrants and water valve boxes. Water valves cannot be accessed if the valve boxes are underwater and the valve box assemblies could be at risk of corrosion. Fire hydrants will not be operational for sea level rise over 2.5ft and will be difficult to access at all levels of flooding. If the fire hydrants are exposed to sea water for long enough, there is a risk of corrosion.

- **Asset Adaptive Capacity (Low) –** It would require significant effort to adjust the existing water infrastructure at the site. Addressing adverse flooding effects to the pipes would involve identifying leak and damaged pipe locations and replacing those sections. Fire hydrants and valve locations have limited flexibility in terms of location.
- **Vulnerability: High – Medium**

7.1.6 Security Equipment

Camera Equipment

- **Past Impacts and Damages –** No known damage due to recent flooding.
- **Future Hazard Exposure (Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 3% to 21% annual chance of flooding to the camera equipment area.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 4% to 61%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Low) –** Interruption to functioning may not significantly impact airport operations.
- **Asset Adaptive Capacity (High) –** Camera systems are relatively easy to relocate or adjust to higher positions.
- **Vulnerability: Medium – Low**

Various Fence and Gates

- **Past Impacts and Damages –** No known damage due to recent flooding.
- **Future Hazard Exposure (High – Low) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – 3% to over 28% annual chance of flooding of the various fence and gates on the airfield.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 4% to 100%.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%, the airport is not operational.
- **Asset Sensitivity (Medium – Low) –** Flooding of the fence and gate will not significantly impact airport operations. However, it will impact access to the airfield, mainly through automatic gates.

- **Asset Adaptive Capacity (Medium) –** Relocation of fence alignment may not be feasible as it is tied to the property line. Electrical equipment for automatic gates will require relocation or flood-proofing.
- **Vulnerability: Medium**

7.1.7 Airport Operations

Potential flood impacts to four primary airport operations categories were considered: 1) impact to disembarking at the terminal; 2) closure of private aviation operations ; 3) closure of commercial runway (7/25); and 4) closure of either Runway 15L/33R or 15R/33L.

While impactful to the individual assets, very few asset flood impacts would restrict aircraft operations at the airport. For example, aircraft can still land and takeoff from SBA without operable runway lights (in the day) or an operational control tower.

The vulnerability summary for the assets that could impact these operations are described in section 6.1 of this report. The paragraphs below analyze how the four operational categories are affected by the individual assets.

Disembarking at Terminal

- **Past Impacts –** Although past terminal apron flooding has occurred, it is not known whether disembarking passengers has been attempted during flooding.
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – 21% to 28% annual chance of flooding for areas that will impact this operation category.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61 to 100% chance for areas critical for disembarking.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%.
- **Operation Category Sensitivity (Medium) –** The airport will not be required to close due to the inability to disembark passengers at the terminal. However, not being able to disembark will severely affect commercial operators at the airport. Passenger disembarking is currently being performed either through passenger boarding bridges at Gates 1, 2, 3, and 4 or through ground loading at Gates 5A through 5D. If the terminal building does not lose power during flooding on the apron, passengers may disembark through the passenger boarding bridges rather than ground. Baggage handling and disembarking passengers at ground level will be severely impacted. This will cause delays or cancellations of several commercial flights. Other assets affecting the ability of passenger disembarking at the terminal are taxiways and runways. If taxiways are closed due to flooding, aircraft would not be able to transit from the runway to the apron areas.
- **Asset Adaptive Capacity (Low) –** Passenger disembarking may be less vulnerable with the installation of a passenger boarding bridge for Gate 5. However, the ability to use the passenger boarding bridges is tied to having power at the terminal. Improving ground disembarking for passenger and baggage handling will require relocating the terminal apron pavement and the terminal apron building as these two elements are tied together.
- **Vulnerability: High**

Closure of Private Aviation Operations

- **Past Impacts –** Areas that affect private operations at the airport have flooded during recent events. These areas include various aprons used by Fixed Base Operators (FBO) but also taxiways that connect these aprons to the runways. Although past terminal apron flooding has occurred, it is not known the extent of the impact that flooding had on private aviation operations.
- **Future Hazard Exposure (High – Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – At least 21% annual chance of flooding for all areas within this operation category. Apron areas in the NW Quadrant have more than 28% chance to flood.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100% chance for areas critical for private aviation.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%.
- **Operation Category Sensitivity (High) –** Closure of private aviation operations could occur when general aviation apron areas are flooded or when taxiways connecting the runways to the general aviation apron areas are flooded. General aviation apron and taxiways are generally located on the north side of Runway 7/25 and separated from areas where commercial traffic occurs. Closure of private aviation operations will not lead to an airport shutdown, although it will severely affect FBOs.
- **Asset Adaptive Capacity (Low) –** Flood-proofing or relocating areas for private aviation operations will require significant efforts. SBA may plan to relocate FBOs that are in more flood-prone areas to areas of the airport with a lower flood hazard. During flooding events that impact specific aprons or taxiways, aircraft may be relocated and re-routed to other airport areas that are less prone to flooding.
- **Vulnerability: High**

Closure of Commercial Runway (7/25)

- **Past Impacts –** Runway 7/25 has flooded during past rain events. Flooding led to closure of the runway and interruptions of airport operations.
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 21% to 28% annual chance of flooding for areas that will impact this operation category.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100% chance for areas critical to this operation category.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%.
- **Operation Category Sensitivity (High) –** As most of the airport traffic operations utilize Runway 7/25, flooding of this runway will generally lead to closure of the airport which will affect airport operations for several days. Taxiway access from Runway 7/25 and terminal apron access is a requirement for passenger airlines to be able to access and disembark at the terminal building. Other assets such as NAVAIDs, airfield electrical equipment, or air traffic control tower may affect operations at the airport but will not lead to airport shutdown. Closure of the commercial runway may also occur if all exit taxiways are flooded, and aircraft would not be able to exit the runway. However, based on the “Runways flooded” scenario, it appears that this scenario is not realistic.
- **Asset Adaptive Capacity (Low) –** In order to avoid closure of the commercial runway, the runway should be raised or relocated. This would require extraordinary planning and engineering efforts as

the reconfiguration would affect large areas of the airport and other assets that are functional to the runway.

- **Vulnerability: High**

Closure of Runway 15R/33L or 15L/33R

- **Past Impacts –** Runways 15R/33L and 15L/33R (also referred to as "crosswind runways") have flooded during past rain events resulting in closing the runways. Closure of these runways generally does not lead to interruptions of airport operations if Runway 7/25 is open.
- **Future Hazard Exposure (Medium) –**
  - *Current/future risk with increased precipitation (2024 – 2100)* – A 21% to 28% annual chance of flooding for areas that will impact this operation category.
  - *0.8 to 2.5 ft Sea Level Rise (2048 – 2076)* – Annual chance of flooding increases to 61% to 100% chance for areas critical to this operation category.
  - *2.5 to 6.6 ft Sea Level Rise (2076 – 2130)* – Annual chance flooding increases to 100%.
- **Operation Category Sensitivity (Medium) –** The crosswind runways are generally utilized by small general aviation aircraft. Flooding of these runways usually does not lead to closure of the airport. As mentioned earlier in the report, other assets such as NAVAIDs, airfield electrical equipment, or air traffic control tower may affect operations on these runways, however, closure will occur only with flooding of the runway pavement. Similar to what described for the previous airport operation category, closure of the crosswind runways may also occur if all exit taxiways are flooded, and aircraft would not be able to exit the runways. However, based on the "Runways flooded" scenario, it appears that this scenario is not realistic.
- **Asset Adaptive Capacity (Low) –** In order to avoid closure of the crosswind runways, the runways should be raised. This would require extraordinary planning and engineering efforts as the reconfiguration would affect large areas of the airport and other assets that are functional to the runways.
- **Vulnerability: Medium**

7.2 Economic Analysis

This section outlines the expected annual loss from flooding events estimated for SBA. The economic estimates leverage historical cost and closure information provided by the Santa Barbara Airport for recent severe storms, alongside industry data, cost benchmarks, and estimates from academic publications of the cost of flight delays and cancellations. This analysis provides insight into the expected annual loss; however, it **does not constitute a full cost-benefit analysis**. Section 6.3.1 provides an overview of the FAA's recommendations for analyzing project costs and benefits. Section 6.3.2 details information about Santa Barbara Airport operations and revenues relevant to this analysis. Section 6.3.3 summarizes the relevant cost information specific to Santa Barbara, and Section 6.3.4 presents the results of the economic analysis. Finally, Section 6.3.5 considers consumer and airline demand in continued airport operations.

7.2.1 Cost Benefit Analysis Guidance

The scope of the economic analysis does not constitute a full benefit-cost analysis (BCA). However, all methods used in this analysis align with FAA methods as laid out in their comprehensive guidance, updated in 2024 (FAA, 2024). This includes FAA estimates of various costs of delay, such as the cost of passenger time. The FAA requires a BCA for capital projects because financial analysis alone “does not measure full costs and benefits of projects to the aviation public” (FAA, 2024). For the purposes of this report, financial analysis would not address the full costs of delays and cancellations, especially considering passengers' willingness to pay to avoid delays and the secondary costs of delays and cancellations.

This analysis measures the benefits of improvements in flood resilience and/or mitigation of severe flooding as the “avoided costs” of preventing or reducing flight delays. The costs of flight delays and cancellations are measured in the following ways:

- Cost to passengers of flight delays.
- Cost to the airport of flight delays.
- Cost to the airline locally and through network interruption (multiplier) effect.

The FAA’s guidance follows generally accepted practices by economists. It specifies assumptions and considerations for inclusion in economic analysis, including (FAA, 2024):

- The FAA mandates a 7% discount rate, which is higher than rates often used in climate change modeling.
- The FAA mandates that all costs be in constant or “real” dollars; all costs in this report are updated to 2024 dollars;[7]
- The projected future growth (or shrinkage) of the airport must be considered.
- The FAA provides economists with its own “in-house” estimates of the costs of passenger delays, aircraft delays, etc., which are incorporated in this report.

Additionally, the FAA cautions against examining the macroeconomic impacts of airport projects and strongly advises economists to take a national perspective if one airport gains and another loses in a local market. The guidance states, “macroeconomic impacts accruing to a community as a result of an airport project are difficult to quantify and frequently represent transfers from other regions” (FAA, 2024). This assumes that changes in capacity and operations at one airport will impact neighboring airports, rendering the macroeconomic benefits insignificant on a national or regional scale. For example, increased operations at Airport A may result in increased employment in City A, but would likely reduce demand at Airport B, resulting in decreased employment in City B. In fact, section 6(b)(3) of OMB Circular A-94 generally rules out consideration in BCAs of employment or output multipliers that purport to measure the secondary effects of government expenditures in measured social benefits and costs (FAA, 2024). Although this assessment is not a comprehensive BCA, it adheres to this stipulation and does not address secondary effects such as employment.

Finally, the discussion of avoided costs in this report includes several “hard-to-quantify” considerations discussed throughout the literature and industry guidance. In these instances, where the costs cannot be stated in dollar values, the FAA recommends “identification and description of those benefits and costs

[7] See https://fred.stlouisfed.org/series/gdpdef and https://www.bea.gov/data/prices-inflation/gdp-price-deflator. The FAA recommends the use of the US Dept. of Commerce’s GDP deflator rather than the consumer price index since airport costs include non-consumer products. The latest data available for this report is Q1 2024 (March 31, 2024).

which cannot be evaluated in dollar terms—referred to in this guidance as 'hard-to-quantify.' 'Hard-to-quantify' considerations should be listed and described for the decision-maker" (FAA, 2024).

7.2.2 Santa Barbara Airport Operations

The FAA classifies the Santa Barbara Municipal Airport as a small hub, meaning it handles 0.05 – 0.25% of national passenger enplanements (boardings) (SBA Master Plan Update, 2024). In 2023, over 1.4 million passengers traveled through SBA, a 4.8% increase from 2022 (Santa Barbara Airport Master Plan, 2024). General aviation (private, charter, business jet etc.) made up 80% of operations, with 18% commercial operations and 2% military (Santa Barbara Airport, 2024). On average, there were 183 operations per day in 2023, with the busiest month in October (Santa Barbara Airport, 2024).

Operations

Five carriers currently provide commercial service to SBA—Alaska, American, Delta, Southwest, and United Airlines. With an average of 22 departures each day, these airlines offer direct service to 12 destinations: Atlanta, Dallas, Denver, Las Vegas, Los Angeles, Oakland, Phoenix, Portland, Sacramento, Salt Lake City, San Francisco, and Seattle (SBA Master Plan Update, 2024).

Due to the prevalence of general aviation at SBA, this analysis aims to determine the impacts of flooding on both commercial and general aviation. However, because of the nature of private aircraft and available data (e.g., the FAA does not report on general aviation), the bulk of this analysis focuses on commercial flights and passengers. Despite this, the results capture most flood impacts to the public, as the greatest number of passengers are affected by disruptions to commercial travel due to the far greater capacity of commercial flights, not to mention the prohibitive cost of private charters. For example, the average commercial capacity of SBA departures is 136, compared to 6 on a private charter (capacity estimates from: Axon Aviation, United Airlines, Southwest Airlines, Alaska Airlines, American Airlines, FAA (2024)).

Revenues

According to data from the Santa Barbara Airport Department Second Quarter Review for FY2022 (**Table 10**), Terminal Leases provide the largest share of airport revenues at year's-end, followed by Federal Relief Grants, Commercial Aviation Leases, Commercial/Industrial Leases, and Non-Commercial Aviation. While commercial aviation contributes a larger share of revenue than non-commercial aviation, the difference is small. However, the impact of commercial aviation across all revenue categories is significantly greater than that of general aviation because commercial aviation sustains many of the services that generate terminal revenues due to much higher passenger counts.

The analysis of expected annual economic losses from flood-related closures does not consider the lost revenue to terminal businesses and assumes that business lease payments to the airport remain unchanged. Similarly, this analysis does not consider the impact of flood events on commercial/industrial leases. However, it should be noted that storm events are likely to damage airport-owned land and buildings in the commercial/industrial area, reducing revenues over time as that area becomes less viable with increased flooding.

TABLE 10. HISTORIC SANTA BARBARA 2022 MID-YEAR REVENUES

Account Description	2022 Year to Date Actuals (March)	Projected at 2022 Year's End
Leases – Commercial/Industrial	2,399,395	5,020,002
Leases – Terminal	1,601,170	8,513,681
Leases – Non-Commercial Aviation	2,128,876	4,593,249
Leases – Commercial Aviation	1,885,318	5,247,569
Investment Income	73,377	130,599
Federal Relief Grant	5,003,428	6,344,534
Miscellaneous	182,176	484,550
Transfer In	1,125,428	123,117
Revenue Total	**14,399,169**	**30,459,302**

7.2.3 Flood Event: Damage, Delay, and Cancellation Cost Estimates

This analysis measures delay and cancellation costs to (1) the airport, (2) the airline operators, and (3) the passengers. Industry research indicates that the cost of schedule changes and airport closures is borne mostly by the airline operators and the passengers, at 32% and 37% respectively (ITIJ 2022, HRA 2023). The cost components, relevant data sources, and estimates for each category are discussed below.

Values of Economic Losses

Airport: Damage, Maintenance, and Emergency Response

This study estimates Santa Barbara Airport's expected expenses for facility damage, maintenance (e.g., road clearing, debris removal), and emergency response based on data provided for the 2023 and 2024 storms.

SBA provided estimated damage expenses for the 2023 storm and both 2024 storms, as well as comprehensive damage, maintenance, and emergency response costs for the late 2024 storm.

- Total Damages for 2023 = $212,000
- Total for early Feb 2024 = $177,000
- Total for Late February 2024 = $879,000
  - Damages = $760,000
  - Road Impacts = $25,000
  - Debris Removal = $53,000
  - Emergency Protective Measures = $15,000

Airport: Revenue Loss

In addition to direct expenses, airport closures also impact airport revenues. A 2020 analysis of airport closures in Frankfurt, Germany, simulated service disruption during peak operating hours at the airport. Using data on passenger traffic and airline schedules and a passenger recovery algorithm, the researchers determined that the airport loses 88% of its revenues during a full shutdown (Wendt et al., 2020). Applying this finding to SBA's annual revenues for FY22, as reported in their 2023 "Department Financial and Staffing Summary", yields an expected operational day revenue loss of approximately $120,000, or $8,500 per operating hour the airport is shutdown, adjusted for inflation (based on a 14-hour day, with operations generally occurring between 0600 and 2000) (City of Santa Barbara, 2023).

While the European market differs from the US market, the findings provide a grounded result from which to estimate SBA's losses. SBA could consider a more in-depth look at the last decade of weather-related delays and closures, including the impact of each closure on its revenues. Without a site-specific analysis, proxy airports provide a strong indication of the financial impacts.

Airlines & Airport: Operating Losses

Flight delays are expensive. In addition to the airport revenue losses that occur when an airport is closed (estimated above), both airlines and airports incur substantial losses when flights are delayed. These costs include additional labor expenses for flight and ground crews, extra fuel (especially if flights are delayed midair, which is often the case), and additional maintenance and operating expenses. Airlines.org, a non-profit organization, estimated in 2023 that the cost of delay was $101 per minute[8] (Airlines.org, 2023); this estimate has been updated to 2024 dollars. Over two-thirds of delay costs arise from labor and fuel expenses (Airlines.org, 2023).

Passengers: Delay and Cancellation

Passengers also incur losses, both in terms of their time and lost productivity, as well as additional travel expenses (e.g., gas, parking, and hotels). AirHelp (2022) estimated passenger losses based on a national survey of 1,300 airline passengers and an analysis of annual delays in the USA, EU, and Australia. Their nationwide analysis of the USA, using Department of Transportation estimates for the value of passenger time, determined the average loss per passenger, in terms of lost value of time and lost productivity (e.g., missed work), to be $67.50 in 2022 dollars or $68.50 in 2024 dollars (AirHelp, 2022). The travel company Fodors (2023) applied data from AirHelp's survey responses to estimate an additional loss in parking, meals, hotels, etc., amounting to $320.50 in 2024 dollars. To account for the differences in passenger experience, this analysis applies both the AirHelp time and productivity number and the Fodors comprehensive number.

Commercial Airlines: Cancellation

The cost of flight cancellation to an airline operator is distinct from the cost of flight delay discussed above. Eurocontrol (2023), a pan-European civil-military organization supporting European aviation, provides recommended cancellation cost estimates based on the type of aircraft, type of carrier, and passenger capacity for a flight canceled on the day of operation (https://ansperformance.eu/economics/cba/standard-inputs/chapters/cancellation_cost.html). Based on current (June 2024) flight schedules, flights in Santa Barbara typically involve narrow-body, traditional network carriers with an average capacity of 136 passengers. To account for the subset of commercial flights that operate on smaller jets (such as the Embraer 175), this analysis uses the more conservative estimate of costs from Eurocontrol's

[8] $101 is an average of all flights across the United States and includes operating costs for both the airline and the airport

recommendations, which is €16,640 in 2020, or $22,357 converted to 2024 U.S. dollars. This cost to the airline applies to canceled commercial flights, not delayed or diverted flights.

According to Eurocontrol, the estimated cost captures:

- Service recovery costs (i.e., passenger care and compensation costs such as passenger vouchers, drinks, telephone calls, hotels)
- Loss of revenue
- Interlining costs
- Loss of future value (i.e., passenger opportunity cost expressed in value)
- Crew and catering costs
- Passenger compensation for denied boarding and missed connections, estimated based on the application of Regulation (EC) No 261/2004
- Luggage delivery costs
- Operational savings (e.g., fuel, airport and navigation fees, maintenance, handling outstations, lounge outstations)

Ground handling costs (e.g., ramp services, passenger services, and field operation services) are not included in the estimation.

It is important to note that these cost estimates are based on the European market, which has different regulations on compensation for passengers. A study recreating the Eurocontrol model for US domestic *delays* (not cancellations) found that costs were often underestimated, suggesting these estimates are likely conservative (Ferguson, 2013). To refine the estimates, SBA could reach out to their primary carriers (Southwest, Alaska, United, and American Airlines) to obtain domestic narrow-body cancellation costs.

General Aviation: Charter Flights

General aviation refers to civilian aircraft operations that are not scheduled or commercial. This includes private and non-commercial aircraft, such as those used for recreational, business, and humanitarian purposes but does not include commercial airlines or military operations. General aviation constitutes approximately 80% of all flights in and out of Santa Barbara Airport (Santa Barbara Airport, 2024). Based on current air traffic data at SBA, there were around 135 general aviation flights per day in January-February of 2024 (Flightradar24, 2024). While most of these flights are unscheduled, information is available for a subset of flights from Flightradar24's daily logs, which include arrival and departure locations, aircraft type, and carrier/charter information as applicable (Flightradar24, 2024). Comparing the scheduled flights to SBA's reported general aviation traffic indicates that approximately 33% of all general aviation flights are scheduled, and of these scheduled flights, 40% are confirmed charter flights (SBA Annual Report, 2024; Flightradar24, 2024).

Over half of these scheduled charter flights are twin-engine jet planes typically used by corporate executives, celebrities, and individuals with high net worth. These planes typically rent for between $3,500 to $18,000 per hour, or an estimated $20,000 for the average 4-hour flight time (Stratos Jet Charter, 2024; EVOJETS Pricing Basics, 2024; Clay Lacy, 2024).

The remainder of scheduled general aviation flights involve single-engine or turbo-propeller planes, which are less expensive to operate, typically carry fewer passengers, and generally have shorter flight ranges. These aircraft typically rent for $300 to $1,400 per hour Stratos Jet Charter, 2024; EVOJETS Pricing Basics, 2024; Clay Lacy, 2024). To be conservative, this study assumes a 2-hour flight at $500 per hour or $1,000 per flight lost. The $500 per hour estimate reflects that most of these planes are smaller single-engine planes.

Most private charter providers advertise working closely with customers to devise alternative plans in case of inclement weather (e.g., NetJet meteorology policy) and promote their flexibility in such events (e.g., JetTheWorld). Thus, the cost to charter a flight cannot serve as an estimate for the cost of weather-related cancellation. To capture costs to operators and charter passengers, this analysis constructs a cost estimate assuming:

- Charter flights comprise 33% of all general aviation[9]
- Charter services operate a mix of twin-engine jets (66%) and piston or single-engine aircraft (33%).
- General aviation has significantly greater flexibility, and therefore, 50% of flights will reroute to an alternate airport within 1 hour's drive (4 alternate airports) rather than cancel.

Losses for canceled flights are based on:

- Operator revenue losses (10% of charter price)
- Passenger losses (similar to commercial aviation, $383[10] per customer)

Losses for rerouted flights are based on:

- Additional operator costs (fuel, landing fees, etc.)[11]
- Passenger inconvenience and lost time (based on a 1-hour reroute, DOT value of time)

General Aviation: Private Aircraft

In addition, SBA has several non-scheduled flights by private operators. Data on these flights was not obtainable, and it is assumed that these unscheduled flights can be more easily moved, delayed, or canceled. This analysis assumes that unscheduled general aviation flights fall into this category. Consequently, losses for 66% of general aviation could not be estimated. It is recommended that the airport conduct a survey of its general aviation customers to better understand their losses from storm events.

Estimated Event Losses

To estimate losses from fluvial and coastal flooding as modeled, this study applies the estimated value of losses suffered by the airport, commercial airlines, commercial airline passengers, and general aviation to recent historical storms that resulted in SBA closure. This approach generated an estimate for the loss

9 Based on scheduled general aviation flights (Flightradar24)

10 Charter flight passengers would likely spend more per night (e.g., hotel prices over $800/night, hired cars, dining). However, there is not an equivalent survey for charter passengers to provide this data. SBA could include spending in the event of cancellations in their passenger survey and/or general aviation survey.

11 https://pilotinstitute.com/airport-fees/.

associated with a typical flood event (based on the 2017, 2023, and early 2024 storms, **Table 11**) and a severe flood event (based on the late 2024 storm). See Section 4.1.1 for a detailed discussion of historical flooding events.

TABLE 11. RECENT STORMS RESULTING IN SANTA BARBARA AIRPORT CLOSURE (SBA DATA; FAA ASQPS 2024)

Date	Rain Inches	Closure Length (Hours)	Damage	Scheduled Flights	Cancelled Flights
2/17/17	4.31	16.5	No	28	18
1/9/23	4.50	27.33	Building 317, (Hangar 1), Norman Firestone Road	35	23
2/4/24	3.50	21	Buildings 312, 313, 314, 315, and 317	38	23
2/19/24	3.57	25.5	Minor	38	34

This analysis focuses on events resulting in the closure of Runway 7/25 (the main runway). It assumes that:

- All commercial flights (18% of all flights) use Runway 7/25.
- NW Quadrant and/or auxiliary runway flooding has no impact on commercial flights.
- General Aviation (80% of flights) may use the two shorter auxiliary runways (except for large private jets) under normal conditions.

In the event of flooding of the two auxiliary runways, the airport will endeavor to accommodate general aviation flights on the main runway. This may result in delays for general aviation flights but not cancellations.

From the information provided by SBA, news articles discussing the airport closures, and data from the FAA's Airline Service Quality Performance System (ASQPS), the impact of each storm on commercial flights was determined. Passenger estimates are based on an analysis of daily schedules indicating aircraft type and airline. The maximum passenger capacity for each airline configuration was determined from information available on the airline websites. The average passenger load for 2023, 83.5%, was applied to these capacities (FRED, 2024). The results of this estimate are shown in **Table 12**.

TABLE 12. ESTIMATED FLIGHT AND PASSENGER IMPACTS FOR RECENT STORMS

Runway Flood	Closure Duration (Hours)	Flights Cancelled	Arrival Delay (mins)	Departure Delay (mins)	Passengers Impacted by Cancellation	Passengers Impacted by Delay
Average	21.61	21	21	9.72	2,677	1,411
Severe	25.5	34	475	1,428	4,301	252

SOURCE: Estimates derived from the FAA's ASQPS reports on delays and cancellations, applying average passenger capacities for the aircraft types on a representative sample of SBA's flights, and average domestic passenger loads.

The cost estimates discussed in Section 6.3.2 were then applied to the flight and passenger impacts for each storm type, as shown in **Table 13**. Due to the variance in cancellations and reported airport damages, two storm types represent the potential severity of flood events. It is likely that, based on the flood and vulnerability analysis, the severe scenario costs will apply.

TABLE 13. ESTIMATED COSTS FOR RECENT STORMS

Runway Flood	Airport Revenue Costs	Airport Expenses	Commercial Airline Costs Cancellation	Commercial Airline Costs Delay	Passenger Cancellation Loss (Additional Costs)	Passenger Cancellation Loss (Time & Productivity)	General Aviation (Charter Only)*	Total Estimated Loss
Average	$92,100	$194,700	$476,900	$18,000	$842,000	$280,000	$149,400	$2,112,600
Severe	$119,400	$853,000	$760,100	$515,000	$1,352,700	$311,900	$213,500	$4,221,300

7.2.4 Expected Annual Loss

To understand the economic impact of projected increases in fluvial and coastal flooding over the expected life of Santa Barbara Airport (to 2075, which corresponds with about 2.5 feet of sea level rise in the Intermediate High Scenario and 3.3 feet of sea level rise in the High Scenario), the expected economic loss from an event resulted in full airport closure—the flooding of Runway 7/25—was applied to the annual chance of such an event as modeled. **Table 14** revisits the results of the flooding analysis, showing the annual chance of each type of flood event. **Table 15** provides a summary of average and severe storm event costs.

TABLE 14. ANNUAL CHANGE OF FLOOD OCCURRENCE (MODELED)

Location	Historical Impacts to Commercial Service	Airport Closure	Annual Chance of Flood Occurrence					
			0 ft SLR and Current Precipitation	0 ft, Future Precipitation (2024 – 2100)	0.8 ft (2048)	1.3 ft (2058)	2.5 ft (2076)	6.6 ft (2130)
NW Quadrant	Only impact to private service	No	12%	28%	29%	32%	100%	100%
Runway	Delays and cancellations of 12–26 hours	Yes	7%	21%	21%	21%	61%	100%
Full Airport	Delays and cancellations of 24+ hours	Yes	1%	3%	4%	4%	4%	100%

TABLE 15. SUMMARY OF EVENT COSTS

Storm Type	Airline	Airport	Passengers	General Aviation
Average	$495,000	$286,800	$1,181,400	$149,400
Severe	$1,275,200	$972,400	$1,760,200	$213,500

The 2024 OPC Guidance Intermediate-High Scenario was used for economic analyses. This scenario projects the following amounts of sea level rise: 0.8 feet in 2048, 1.3 feet in 2058, 2.5 feet in 2076, and 6.6 feet in 2130. For simplicity, the economic analysis uses dates rounded to the nearest 5 years.

For the economic analysis, flooding in the NW quadrant was assumed to have no impact on flight operations outside of delays to private aviation. These costs are considered “hard to quantify.” Similarly, expected maintenance costs were not provided and are also considered “hard to quantify.” The airport should consider both costs in its adaptation decisions and should survey general aviation customers to better understand the impacts of an NW quadrant flood event.

Additionally, this analysis assumes that a full airport flood will have the same impacts on flights as a severe Runway 7/25 flooding event—full cancellation or diversion of all scheduled and unscheduled flights. Therefore, the table below shows the expected costs for Runway 7/25 flooding over the expected operational life of the airport (to 2075).

The expected economic loss from runway flooding and full airport flooding over the expected life of the airport is presented in **Table 16**. The FAA-recommended 7% discount rate is applied. Growth rates for commercial aviation, passengers served, and general aviation flights from the Aviation Forecast (Santa Barbara Airport, 2023 are also applied. For full annual results, see Appendices C and D.

TABLE 16. EXPECTED TOTAL ECONOMIC LOSSES, 2025-2055

Storm Type	Airport	Airlines	Commercial Passengers	General Aviation	Total
Undiscounted Losses 2025-2055					
Average Storm	$1,982,000	$4,092,000	$18,701,000	$1,218,000	$25,992,000
Severe Storm	$6,720,000	$10,541,000	$27,862,000	$1,740,000	$46,863,000
Discounted Losses 2025-2055					
Average Storm	$825,000	$1,627,000	$5,994,000	$496,000	$8,942,000
Severe Storm	$2,798,000	$4,193,000	$8,930,000	$709,000	$16,629,000

Expected losses for the 2025-2055 period take into account projected changes in operations as discussed in the Aviation Activity Forecast (Santa Barbara Airport, 2023) prepared for the Santa Barbara Airport Master Plan. This analysis applies the specific growth rates for commercial operations, commercial passenger enplanements, and general aviation provided for 2021-2041. Calculations for 2041 to 2055 assume that growth continues at the same rate as projected to 2041. Accounting for project growth, SBA may face expected losses between $23 million and $43 million for a severe storm. As shown in **Table 17**, extending the forecast to 2075, SBA may face expected losses between $68 and $158 million, undiscounted.

TABLE 17. EXPECTED TOTAL ECONOMIC LOSSES, 2025-2075

Storm Type	Airport	Airlines	Commercial Passengers	General Aviation	Total
Undiscounted Losses 2025-2075					
Average Storm	$3,186,000	$7,095,000	$56,227,000	$2,029,000	$68,537,000
Severe Storm	$17,134,000	$28,154,000	$109,010,000	$4,533,000	$158,831,000
Discounted Losses 2025-2075					
Average Storm	$895,000	$1,801,000	$8,051,000	$543,000	$11,292,000
Severe Storm	$5,774,000	$8,733,000	$20,532,000	$1,469,000	$36,508,000

"Discounted Losses" account for the FAA recommended 7% annual discount rate. This has a significant impact on projected losses, especially since it is greater than the highest growth rate (4.8% annually for passengers) and significantly higher than the growth rates for aviation operations. Discounted losses over the next 30 years range from $9 million to $16.6 million. In either scenario, the majority of losses are born by passengers. By 2075, discounted losses range from $11.3 to $36.5 million.

7.2.5 Demand Considerations

The flood hazard results indicate that with between 2.5 to 6.6 feet of sea level rise (2076 – 2130), the annual chance flooding increases to 100% for all assets (except certain assets north of Hollister Ave) and the airport is not expected to be operational. As early as about 2075, climate conditions will render SBA inoperable. However, considering the conditions for flight demand, significant recurrent flooding may alter passenger and/or airline operator preferences and force closure sooner. If commercial airlines end flights to SBA, the airport could still serve general aviation aircraft (similar to Oxnard or Camarillo) until flood hazard conditions render it inoperable, but this would significantly reduce revenues and deprive the central coast of a regional hub airport, forcing all commercial traffic south to the Los Angeles area airports.

Considerations for passenger and airline demand are discussed below.

Projected Increased Future Demand

According to the March 2023 Master Plan Aviation Activity Forecast (Santa Barbara Airport,2023), SBA projects steadily increased demand of just under 5% annually (4.8%). This brings total enplanements (boardings) from 342,000 in 2021 to 878,000 by 2041. Increases in commercial aircraft capacity primarily drive this change, with a small increase in commercial operations and minimal increases in other general aviation, with one exception, discussed below. Essentially, larger commercial aircraft carrying more passengers will bring more activity to the airport.

This increase in commercial demand is already occurring. SBA saw 50% growth from 2022 to 2024—an increase from 800,000 to 1.2 million passengers. Passenger counts *are not the same* as enplanements (boardings). The Aviation Analysis, however, indicated that this might be an isolated trend, and projects a much smaller growth rate annually (4.8%) (Santa Barbara Airport, 2023). The Master Plan aims to "help the airport adjust to the expected increase in passenger traffic over the next two decades to over 1.8 million passengers per year." (SB Independent), including terminal improvements to add 33,000 square feet of passenger serving space in the terminal (https://flysba.santabarbaraca.gov/projects/terminal-improvement-project)

Factors Driving Increased Demand

The Master Plan Aviation Analysis projected demand increases using a multivariable regression analysis. Key variables were chosen based on their correlation to enplanements between 2015 and 2019. Economic considerations are a particularly strong driver for SBA flight demand. Key variables include:

- Population
- County employment

- County income per capita
- County gross regional product
- County retail sales.

General Aviation Demand

In addition to commercial aviation, the Aviation Activity Forecast shows continued demand for general aviation, however, demand decreases over time. The 2023 Forecast indicates that a total of 141 general aviation aircraft were housed at SBA, a decline from 202 aircraft in 2011 and 188 in 2016 (Santa Barbara Airport 2023). The report attributes the decline to two main factors: (1) a shortage of hangar space, (2) a general decline in the demand for general aviation.

The majority of general aviation aircraft (104 of 141 in 2021) are single engine piston planes. However, the relatively small amount of jet planes, mostly used for private charters, are the most economically relevant to SBA since these planes can easily rent for $10,000 an hour.

In 2021 there were 25 of these aircraft, down from 29 in 2011 (Santa Barbara Airport, 2023). Significantly, the SBA's Master Plan growth forecasts project that the demand for these jet plane flights/enplanements will grow by 9.1% from 2021-2041, almost twice as fast as the growth in the airport overall (Santa Barbara Airport, 2023).

The Master Plan also indicates that almost half (54%) of operations in SBA are "itinerant," meaning flights by aircraft not based at SBA; so SBA's planes serve roughly half of all demand. Itinerant aircraft may be more likely to reroute or cease operations out of SBA during inclement weather. Due to the high prevalence of general aviation and the lack of data available, SBA could consider surveying itinerant and SBA-based general aircraft operators about their preferences and their response to severe flood events.

Demand Preference Considerations

This analysis included a literature review on consumer behavior towards airlines and airports to determine how delays from increased flood recurrence and resulting airport closure might influence passenger preferences and the major airline operators' interest in continued service at SBA.

Losses incurred by Passengers & Schedule Predictability

Consumer losses due to schedule predictability factor into passenger preferences and decision making, especially when choosing a departure airport or travel route. These losses can be significant during severe disruptions, such as weather-related closure. The FAA (2020, pp/ 59-60) guidelines recognize that passengers also incur losses when flights are delayed or cancelled, and these losses can be quantified. Passengers' time is valuable, and the FAA guidelines recognize the economic principle of willingness to pay, to avoid delays, which is valued at approximately $50 per hour. This loss is also often referred to as "consumers surplus." Declines in consumer surplus result in changes in consumer purchase behavior. For air travel, consumer surplus refers to "the change in welfare resulting from a change in generalized travel costs," of which time is a major factor (Burghouwt, 2019).

In addition to time, if a flight is delayed, consumers will experience out of pocket costs, such as meals and hotels, but also costs that do not involve a direct cash transfer, but still involve an economic loss. The

FAA's guidelines (pp. 59–60) allow one to account for "the cost of resources allocated to accommodate potential delays." The AirHelp (2023) study discussed previous attempts to quantify these costs, placing them at $383/day. This estimate likely does not capture the cost of the inconvenience, the stress of booking a new trip, and the uncertainty when facing cancellation or indefinite delay. These non-market impacts, while hard to quantify, also contribute to future decisions and consumer behavior.

While this analysis does not attempt to examine how increased schedule unpredictability may influence passenger preferences to fly out of or into SBA, the literature suggests that perceived uncertainty reduces demand. Same passengers may simply not want to deal with the risk of cancellation or delay and may make alternate travel plans or choose another departure airport. The FAA does not consider the economic impacts of these "transfers," but they would impact SBA and the airlines operating there.

SBA could coordinate with its commercial airline operators to determine if storm events reduce demand. SBA could also consider surveying their passengers to better understand factors in their choice of SBA.

Substitutes – Alternate Airports

Passengers who fly through SBA have other choices and the long-term viability of SBA also depends upon what choices passengers make. The literature on the economics of airports focuses on the choices available to consumers (e.g., see Yan, 1997, and Redondi, 2013). For charter flights and general aviation, our analysis recognizes the relative availability of substitutes and potential losses to these passengers are thus significantly less.

For commercial flights, the relevant market includes both LAX and Burbank (BUR) airports. A series of severe disruptions or storms could potentially shift the demand for air travel away from SBA toward LAX or BUR. However, it is worth noting that Highway 101 is often closed at the same time that Santa Barbara's airport is shut down, including during the storms discussed in this report. Accordingly, access to LAX and Burbank airports could also likely be reduced during severe storms, and may not be accessible for some customers lacking alternate access routes.

For general aviation, there are several alternative airports within approximately one hour of SBA. One of the "selling points" for private charters is their flexibility, especially in the face of inclement weather (Jet the World, 2024). The closest alternate airports are Santa Ynez, Oxnard, and Camarillo. Santa Ynez has a short runway (2,804 feet), which would limit use to smaller aircraft (AirNav). None of the twin-jet charters would be able to land there due to the shorter runway, however, 40% of all *scheduled* general aviation flights could. However, Oxnard and Camarillo both could support much of the general aviation currently operating out of SBA. Additionally, slightly further, airports include Lompoc and Santa Maria, in North Santa Barbara County. The ready availability of other runways, and the significance of itinerant general aviation at SBA, suggest that the general aviation market may be more susceptible to the availability of substitutes than the commercial market.

8. HABITAT CHANGE

Rising sea levels can affect wetland habitats in coastal regions, especially in tidal wetlands. Some wetland habitats may be able to keep pace with modest sea level rise through natural accretion processes while others may convert to different habitat types. Increased inundation and saltwater intrusion with sea level rise will force existing marsh habitats to migrate upslope to higher elevations. Many existing marshes next to developed areas or steeper terrain are vulnerable to sea level rise because these areas are not able to support wetland system migration. Understanding the nature of these marsh habitat shifts, where they are likely to occur, and potential habitat impacts/losses is essential to increase the resilience of these vital systems.

This section provides the methods and findings of the marsh habitat change analysis and habitat vulnerability assessment. ESA established the current habitat types in the airport's vicinity, assessed how they are likely to change with rising sea level, and summarized potential vulnerability of these habitats to sea level rise.

8.1 Habitat Change Analysis

Existing and future marsh habitats in the project area were assessed using existing ground elevations, sea level rise projections, sediment accretion rates, and inundation-elevation relationships established for marsh habitats subtypes/vertical bands. The following sections describe the methodology used to evaluate marsh habitat change and summarize potential habitat conditions with sea level rise.

8.1.1 Methodology

An Inundation Frequency habitat model from the Goleta Slough Area Sea Level and Management Plan was applied to the Goleta Slough system in open mouth conditions. This model predicts future habitats based on ground surface elevations of the area relative to tides and the range of inundation frequencies characteristic of different habitat types.

Wetland species occupy different areas of tidal marsh dependent on the amount of time the area is submerged (inundation frequency). Relationships between inundation frequency and habitat type have been developed from study of habitats at several coastal lagoons in the Santa Barbara area (Hubbard, pers. comm., 2013). These habitat types, their associated inundation frequency, and the elevation band that experiences that rate of inundation are shown in **Table 18** (ESA, 2015).

TABLE 18. MARSH HABITAT TYPE WITH ASSOCIATED INUNDATION FREQUENCY AND ELEVATION BAND

Habitat Type	Inundation Frequency	Elevation (ft NAVD)
Subtidal	100%	0 and below
Mudflat	45 – 100%	0 to 2.8
Low Marsh	20 – 45%	2.8 to 4
Mid Marsh	5 – 20%	4 to 5.3
High Marsh	0 – 5%	5.3 to 6.8
Transition	< 5%	6.8 to 8.8
Upland	0%	8.8 and above

In a tidal estuary like Goleta Slough, the frequency of inundation at a given location is determined by the elevation relative to the local tides. As sea level rises, habitat inundation frequency increases and leads to habitat conversion. For example, with 2.5 feet of sea level rise, a high marsh habitat area (currently 6 feet NAVD) would convert to low marsh habitat (3.5 feet NAVD).

However, it is also necessary to account for accretion, the vertical rise in marsh elevation from organic and inorganic matter buildup that raises the ground surface elevation. Based on 2021 modeling by Thorne et al., accretion rates in intermittently closed lagoons like Goleta Slough range from 2 mm/yr (sediment starved) to 7.5 mm/yr (sediment rich). A separate study of Pescadero Marsh, a sediment rich marsh in Monterey County, showed an accretion rate of 5 mm/yr, likely placing an upper limit on accretion at Goleta Slough (Revell, 2021). Therefore, an accretion rate of 3.5 mm/yr was selected for Goleta Slough in this analysis.

As accretion is dependent on time, a date (year) was used for each sea level rise scenario (0.8 ft, 2.5 ft, and 6.6 ft). The OPC Intermediate sea level rise scenario was used to determine these time horizons, which projects that 0.8 ft of sea level rise occurs in 2057, 2.5 feet of sea level rise occurs in 2096, and 6.6 ft of sea level rise occurs beyond the year 2150 (for simplicity, 2150 was used for this analysis). Using the more likely Intermediate Scenario provides a more confident projection of potential habitat evolution with sea level rise. Applying the Intermediate-High or High sea level rise scenarios would generally reveal greater loss of marsh habitats through drowning of marshplains and conversion to subtidal habitat.

In this analysis, change in an area’s relative elevation above sea level was determined using the difference in sea level rise and the estimated marsh accretion over the associated timeframe. In concept, an existing marsh is able to keep pace with sea level rise as long as accretion is similar to the rate of sea level. Once sea level rises faster than marsh accretion, habitat begins to convert to lower elevation habitats (with higher inundation frequency) shown in Table 18 above.

The method outlined above was used to map future habitats extents by adjusting the elevations associated with each habitat type based on the projected amount of future sea level rise and accretion. This method was applied to all points within the analysis area, a region that was bounded by Highway 101 to the North, the coastline excluding beaches to the South, Storke Road to the West, and Maria Ygnacio Creek to the East. All developed areas within the analysis extent were assumed to remain developed and not considered to be future wetland areas in the calculations. Additionally, all regions that are currently defined as fluvial channels or estuarine subtidal by the San Francisco Estuary Institute’s (SFEI) California Aquatic Resources Inventory (CARI) (SFEI 2010) were excluded from analysis as it was assumed to remain fluvial channel/subtidal. It should be noted that this CARI existing waterways area was manually adjusted to reflect the realignment of Tecolotito and Carneros Creeks. Coastal LiDAR topography data provided by NOAA in 2018 was used for ground surface elevations in the area.

8.1.2 Results

The expected future extents of each habitat type are shown in **Figure 13**. The anticipated areas of each habitat zone are displayed in **Table 19**.

TABLE 19. HABITAT CHANGE ANALYSIS RESULTS

Habitat Type	Existing Conditions	0.8 ft SLR (2057)	2.5 ft SLR (2096)	6.6 ft SLR (2150)
Analysis Domain (acres)				
Analysis Area	3180			
Developed Areas	2210			
Existing Fluvial/Subtidal	33			
Habitat Areas (acres)				
Subtidal (see notes)	0	0	0	44
Mudflat	1	3	21	194
Low Marsh	13	17	50	64
Mid Marsh	38	57	119	75
High Marsh	129	128	73	74
Transition	104	101	115	68
Upland	638	616	543	402

SOURCE: ESRI, CARI, SFEI, NOAA, ESA, 2024

NOTES: Existing developed and existing fluvial habitats are assumed constant; habitat acreages represent the remaining area in the analysis domain. Subtidal acreage projections with SLR are the acreage of subtidal habitat projected in addition to existing subtidal habitat. Green cells indicate an increase in habitat area compared to existing conditions, orange cells indicate a decrease compared to existing conditions, grey indicate no change.

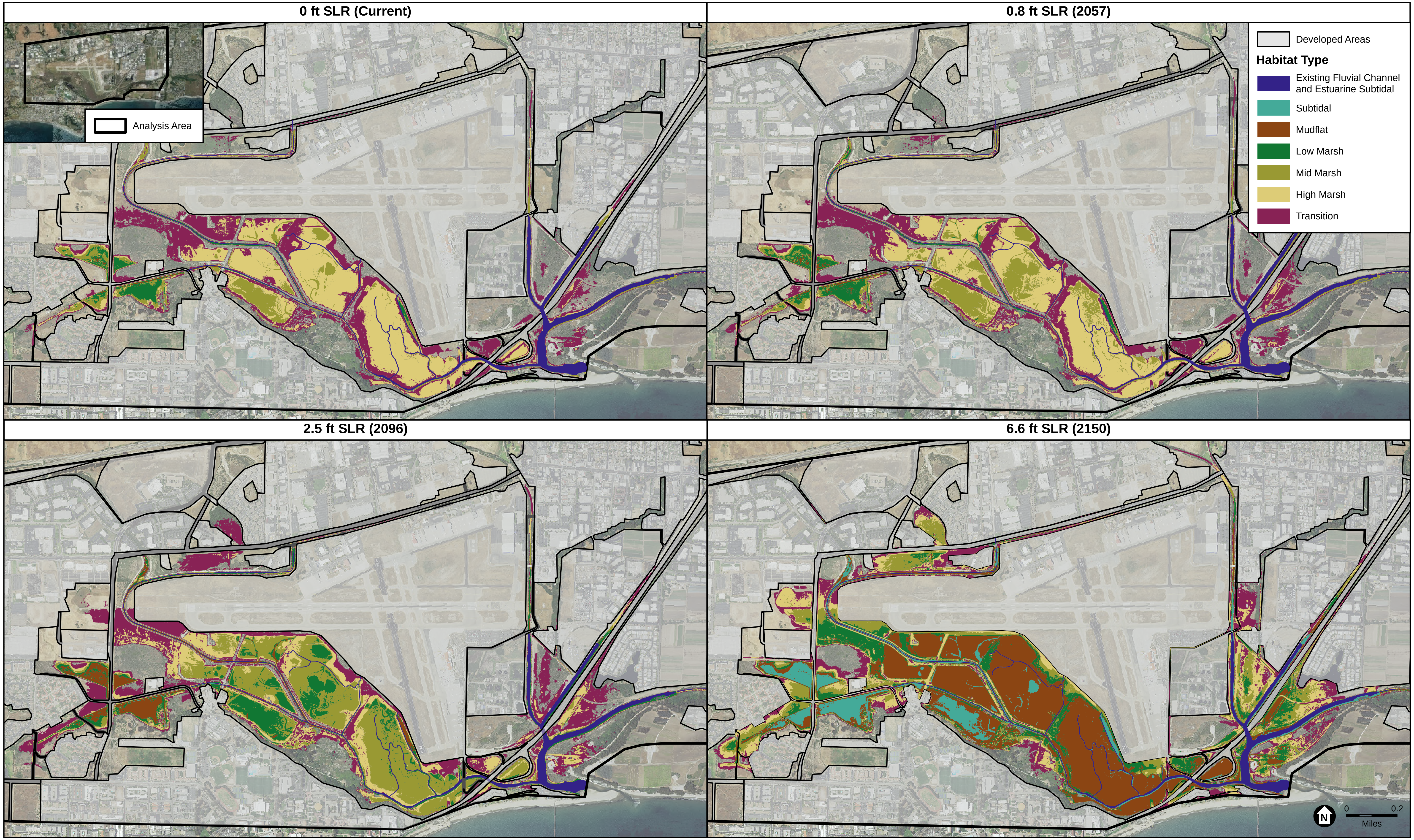
The results of the analysis show that rising sea levels lead to a general increase in intertidal, low marsh, and mid marsh habitats and a general decrease in high marsh, transition, and upland habitats (see Figure 12 and Table 11). The subtidal habitat acreage does not change significantly until higher amounts of sea level rise between 2.5 and 6.6 ft. In Figure 13, the predominant differences visible in 0.8 ft of sea level rise compared to current habitats is the change from transitional habitat to high marsh and the change from high marsh to mid marsh. Between 0.8 ft and 2.5 ft of sea level rise, much of the existing high marsh areas convert to mid marsh and existing mid marsh converts to low marsh. In addition, there is additional transitional habitat north of Los Carneros creek in the northwest region of the airport. Results show a significant increase in intertidal areas between the Airport and UCSB campus. With between 2.5 and 6.6 ft of sea level rise, the majority of Goleta Slough existing marshplains convert to intertidal and subtidal habitat.

8.2 Habitat Vulnerability Assessment

This section expands on the results of the habitat change analysis for each habitat type to identify the likely changes to their extent and their vulnerability to sea level rise.

8.2.1 Fluvial and Subtidal

Fluvial and subtidal habitats are permanently inundated, even during low tides, and are hydraulically connected to the ocean via the lagoon mouth. Habitat change analysis results indicated little to no change in subtidal habitat extent with up to 2.5 feet of sea level rise. With 6.6 feet of sea level rise, the subtidal zone grows by 44 acres to encompass the western portion of Goleta Slough.



SOURCE: ESRI, CARI, SFEI, NOAA, ESA, 2024

Santa Barbara Airport Sea Level Rise Adaptation Plan . D202201087.00

Figure 13

Habitat Change with a 3.5 mm/yr Accretion Rate and 0, 0.8, 2.5, and 6.6 ft SLR

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Under 6.6 feet of sea level rise, there are unlikely to be major changes to the fluvial and subtidal habitat areas. There is little risk of loss of these habitat areas due to sea level rise. With 6.6 feet of sea level rise, there is potential for minor increases in fish habitat and small benefits to fish passage. However, the quality of the overall slough ecosystem may be impacted with sea level rise due to changes in the extent of neighboring marsh and transitional habitats.

8.2.2 Mudflat

Mudflat habitats are areas that are inundated frequently (modeled inundation frequency of 45% to 100%). from 1% to 100% of the time. Tidal marsh vegetation occurs in the upper part of this range (inundated roughly 45% to 100% of the time). At Goleta Slough, these areas typically range from 0 to 2.8 ft NAVD. The model results show an increase in mudflat habitat area (unvegetated) with sea level rise, with three additional acres with 0.8 feet of sea level rise, 21 acres mostly in the western region of the slough added with2.5 ft SLR, and almost 200 acres with 6.6 ft SLR. With 6.6 ft SLR, the majority of Goleta Slough marsh habitats convert to subtidal and mudflat habitats.

Increased extents of tidal unvegetated mudflats could provide additional habitat opportunities for certain shorebirds. However, the increase in mudflat habitat comes at the expense of existing higher marsh habitats and this shifting balance could potentially affect characteristic plant species, nesting habitat for birds, carbon sequestration and water quality in these areas.

8.2.3 Low to Mid Marsh

Salt marshes are wetland habitats periodically inundated by high tides approximately 5% to 45% of the time. At Goleta Slough, these habitats typically occur between approximately 2.8 ft NAVD (low marsh) and 5.3 ft NAVD (mid marsh). These areas are characterized by plant species that are specialized to thrive in saline environments. Much of the marsh plain surrounding slough channels in the western slough is mid salt marsh (i.e., 4 ft NAVD to 5.8 ft NAVD). With sea level rise of 0.8 feet, low and mid marsh areas are expected to increase by migrating upslope into existing high marsh and transitional habitat areas. Low marsh areas are expected to increase by four acres with 0.8 feet of sea level rise, by 37 acres with 2.5 ft of SLR, and 51 acres with 6.6 ft of SLR. Compared to existing conditions, mid marsh areas are anticipated to expand by 19 acres with 0.8 ft SLR, 81 acres with 2.5 ft SLR, and 37 acres with 6.6 ft SLR.

The availability of upslope areas around Goleta Slough provides migration space with moderate sea level rise, which could eventually result in new habitat opportunities for marsh plant species. However, with 6.6 feet of sea level rise marsh habitats have limited upland areas to migrate into due to existing development/land use and areas with steep slopes.

8.2.4 High Marsh and Transitional

High salt marsh and transitional habitat areas have highly saline soils and are typically inundated less than 10% of the time. At Goleta Slough, these regions are typically associated with elevations between 5.3 and 8.8 ft NAVD. Currently, the majority of existing marsh habitat areas within Goleta Slough, are high marsh and transitional. With sea level rise these habitats would be expected to migrate upslope while their current locations transition to low marsh, mid marsh, or intertidal habitats. Compared to existing conditions, high marsh areas are expected to decrease by one acre with 0.8 feet of sea level rise, 56 acres with 2.5 ft of SLR, and 55 acres with 6.6 ft SLR. Compared to existing conditions, transitional habitat areas are anticipated to decrease by 22 acres with 0.8 feet of sea level rise, by 95 acres with 2.5 ft of SLR, and by 236 acres with 6.6 ft of SLR.

Increased sea level and tidal inundation in Goleta Slough would cause existing transitional and high marsh habitat areas to convert to mid and low marsh. While these existing habitats can naturally migrate upslope, the available area is limited by developed areas and land uses surrounding the slough. Conversion of these habitats may lead to loss of plant species associated with these habitat conditions and the animals that depend on those plants.

9. CONCLUSIONS AND NEXT STEPS

The following sections summarize the key findings and conclusions of the flood hazard analyses (Chapter 4), the vulnerability assessment (Chapter 6) and the habitat change assessment (Chapter 7). Additionally, the next steps SBA could take to address vulnerabilities and adapt to sea level rise are discussed.

9.1 Conclusions

SBA is located in a flood-prone area, and many of its assets have vulnerabilities to fluvial and lagoon flooding that will worsen with increasing precipitation and sea level rise in the future. Findings for each hazard and vulnerability analyses are summarized below.

9.1.1 Flood Hazard Analyses

Analysis of the hazards in the area surrounding SBA indicate that fluvial flooding, lagoon flooding, and tidal inundation are the primary risks to SBA assets with sea level rise. Investigation of the extents of historical flood events and current topography of the area indicated that there are three significant flooding thresholds that impact the airport:

- NW Quadrant: The least severe flooding threshold. Flooding in the NW Quadrant, bordering Carneros Creek to the east and Firestone Road to the north. Estimated water surface elevation of approximately 11 feet. Example events are 2005, 2008, and 2010.
- Runways Flooded, Airport Closure: Intermediate severity flooding threshold. There is flooding of the main runways causing airport closure. Estimated water surface elevation of 12.5 feet. 2017, 2023, and both 2024 events are examples of this degree of flooding.
- Entire Airport Flooded: The most severe flooding threshold. The entire runway is inundated with flood water. An estimated water surface elevation of 14 feet. The January 1995 event is the most comparable event to this flooding extent.

Lagoon Flooding

The Quantified Conceptual Model (QCM), a model for predicting the long-term changes in lagoon mouth conditions and water levels, was used to estimate changes in lagoon flooding at the airport with 0, 0.8, 2.5, and 6.6 feet of sea level rise.

A 39-year flood event causing NW Quadrant flooding at Goleta Slough is expected to become a 30-year event with increased precipitation, a 17-year event with 0.8 feet of sea level rise, a 4-year event with 2.5 feet, and a 1.1-year event with 6.6 feet of sea level rise. Similarly, a current 200-year event causing runway flooding and airport closure could become a 140-year event with future precipitation, an 83-year event with 0.8 feet of sea level rise, a 28-year event with 2.5 feet, and a 1.9-year event with 6.6 feet of sea level rise. Lastly, a current 1,000-year event causing entire airport flooding could become a 680-year event with 0.8 feet of sea level rise, a 410-year event with 2.5 feet, a 210-year event with 6.6 feet, and a 4.4-year event with 6.6 feet of sea level rise.

Fluvial Flooding

Fluvial flooding at the airport, primarily driven by water levels in Carneros, Tecolotito, and San Pedro creeks, is expected to worsen with increased precipitation and sea level rise. The Coupled Model Intercomparison Project 6 (CMIP6) general circulation models (GCM) were used to estimate future changes in extreme precipitation frequency. The results indicate that the magnitude and frequency of future extreme rainfall depths will increase compared to baseline conditions. Consequently, a future 5-year storm is anticipated to be equivalent in magnitude to a past 20-year storm, which currently floods SBA and causes closure.

Flood profiles were developed under past and future rainfall conditions with 0, 0.8, 2.5, and 6.6 feet of sea level rise for Carneros, Tecolotito, and San Pedro Creeks using FEMA profiles and the QCM results. These profiles were used as inputs for the storm drain analysis summarized below.

Tidal Inundation

Tidal inundation analyses were performed using the USGS Coastal Storm Modeling System (CoSMoS 3.0). Under current conditions, tidal inundation does not pose a risk to SBA. With 0.8 feet of sea level rise (2048) the airport remains outside the hazard zone. Sea level rising 2.5 feet (2076) exposes the edge of the runway to 100% annual risk of tidal inundation and the runways to approximately 50% annual exposure risk. After 6.6 feet of sea level rise (2130), the annual chance of flooding for the entire airport increases to 100% and the airport is not expected to be operational.

Combined Risks

Risks of flooding from each source under each precipitation and sea level rise scenario were combined to create annualized flooding chances for each scenario. Under current precipitation conditions, there is a 12% annual chance of NW Quadrant flooding, a 7% risk of runways flooding and airport closure, and a 1% chance of the entire airport flooding. With future precipitation conditions (2024 to 2100), these risks rise to 28%, 21%, and 3%, respectively. Sea levels rising by 0.8 feet (2048) marginally increase the chance of NW Quadrant flooding to 29% and entire airport flooding to 4%. However, with 2.5 feet of sea level rise (2076), the NW Quadrant is expected to flood at least annually, the annual risk of runways flooding, and airport closure rises to 61% while the entire airport flooding risk remains 4%. With between 2.5 and 3.3 feet of sea level rise (2076 to 2087), tidal flooding of the airport is likely to occur on a biweekly basis rendering the airport inoperable. With 6.6 feet of sea level rise (2130), the airport remains inoperable.

Storm Drain Analysis

A 5-year storm under past precipitation conditions is expected to lead to ponding across the airport, impacting the NW Quadrant, Terminal Area, and Northeast buildings and hangars. Multiple taxiways (B and E) will be obstructed, but runways will remain clear. With future precipitation conditions, the ponding during a 5-year storm will more severely affect these areas area and extend to more taxiways (A, B, C, D, E, and F) and the edge of all runways. With 0.8 feet of sea level rise, ponding marginally increases to affect Taxiway B and encroach on Runways 15R/33L and 7-25. These results will later be used to inform storm drain systems with adaptive measures to reduce direct creek flooding.

9.1.2 Vulnerability Assessment

Asset Vulnerability

Asset vulnerability is assessed as a combination of an asset's exposure level, sensitivity, and adaptive capacity. Each airport asset was assessed in each category from high to low as described in **Table 20** and an overall aggregated vulnerability score was assigned.

TABLE 20. ASSET VULNERABILITY RATINGS SUMMARY

Rating	Hazard Exposure	Sensitivity	Adaptive Capacity
Low	Exposed only in the Entire Airport Flooded, Airport Closed flood threshold	Flooding would have no or a low impact on the asset function. Asset would quickly rebound	The asset could be easily modified to reduce/avoid flooding impacts
Medium	Exposed in the Runways Flooded, Airport Closed flood threshold	Flooding would cause minor damage or temporary operational interruption	The asset requires moderate effort to modify and reduce flooding impacts
High	Exposed in the NW Quadrant Flooded threshold	Flooding would cause significant damage or longer-term operational interruption	The asset requires significant effort to modify and adapt

SBA assets in each vulnerability category are as follows:

- High: NW General Aviation Aprons, Runways 15R/33L and 15L/33R, Glide Slope Antenna and RVR, Remote Transmitter Receiver, ATC Tower, Sanitary Sewer Infrastructure, and Storm Drain Infrastructure.
- High – Medium: SE and NE General Aviation Aprons, Taxiways, Terminal Apron, Airport Rotating Beacon, ILS, MALSR System, Precision Approach Path Indicator, Runway End Identifier Lights, Airport Access Roads, Airport Maintenance Buildings, ARFF Station, SE Terminal Building, NW Buildings/Hangars, Fuel Tank Sites, Gas Infrastructure, Long-Term and Short-Term Parking Lots, and Water Infrastructure.
- Medium: Runway 7/25, Airport Admin and Ops Building, Cargo Operations Building, NE and SE Buildings/Hangars, North Hollister Buildings/Hangars, East Cell Phone and Economy (Overflow) Parking Lots, and Fences and Gates.
- Medium – Low: South Cell Phone Parking Lot, Utility Poles, and Security Camera Equipment.
- Low: None

Airport Operations

Although flooding impacts individual assets, very few asset flood impacts would restrict aircraft operations at the airport. Out of the four airport operations categories considered, three have a high vulnerability: Disembarking at the Terminal; Closure of Private Aviation Operations; and Closure of Commercial Runway (7/25). Impacts to these operations could include flight delays or cancellations, or, in the case of commercial runway (7/25) flooding, airport closure. Closure of either Runway 15R/33L or 15L/33R has a medium vulnerability. Flooding of these runways does not generally lead to airport closure. Adaptation of any of the four airport operations areas would require significant efforts.

9.1.3 Economic Analysis

The economic analysis of SBA's flood vulnerability underscores the significant financial implications of both average and severe storm events on passengers, airlines, and the airport's revenues, with projected total undiscounted losses for average storms reaching approximately $25.99 million from 2025 to 2055, and severe storms up to $46.86 million over the same period. When applying a (federally mandated) 7% discount rate, these figures adjust to $8.94 million and $16.63 million, respectively.

The impacts to general aviation are less quantifiable than those of commercial aviation due to limited data. However, the impacts to most general aviation (smaller planes) is also likely to be less severe due to the ability of auxiliary runways and substitute airports to accommodate most flights.

9.1.4 Habitat Change

Sea level rise is expected to cause significant changes to the habitats within Goleta Slough. High marsh and transitional habitats are expected to migrate upslope with sea level rise, while their current locations transition to other habitats. High marsh areas are expected to be reduced by two acres compared to current areas with 0.8 feet, 53 acres with 2.5 feet, and 51 acres with 6.6 feet of sea level rise. Transitional habitat areas are anticipated to decrease by 3, 10, and 8 acres after 0.8, 2.5, and 6.6 feet of sea level rise respectively. This conversion could lead to a loss of plant species and dependent animals due to the limited area available for upslope migration, which is surrounded by developed areas.

Low to mid marsh areas are likely to gradually increase in area with sea level rise as they migrate upslope into existing high marsh and transitional habitat areas. Low marsh areas are expected to increase by five acres at 0.8 feet, 40 acres at 2.5 feet, and 55 acres at 6.6 feet of sea level rise compared to existing areas. Mid marsh areas are anticipated to expand by 20 acres at 0.8 feet, 80 acres at 2.5 feet, and 39 acres at 6.6 feet of sea level rise. As low and mid marsh habitats migrate to higher elevation areas, these habitats could be impacted by the proximity of developed areas.

Mudflat habitats are anticipated to expand by 2 to20 acres between 0.8 and 2.5 feet of sea level rise before expanding by nearly 200 acres with 6.6 feet of sea level rise. This will potentially provide additional habitat for shorebirds, but this expansion could impact existing marsh habitats and water quality.

Channel and subtidal habitats are projected to remain largely unchanged with up to 2.5 feet of sea level rise before expanding by 46 acres with 6.6 feet of sea level rise, with potential associated minor increases in fish habitat.

9.2 Next Steps

The next phase of this project includes the development of a Climate Adaptation Plan that identifies and describes adaptation strategies to reduce the vulnerabilities and risks to SBA assets and Goleta Slough habitat identified in the vulnerability assessment. Planning will begin with a comprehensive study of adaptation options for threatened portions of the airport. The plan will consider a range of flood protection, accommodation, and retreat strategies that retain a safe and functioning airfield using approaches and infrastructure that are nature-based or "green," traditional or "hard/grey," and "green/grey" hybrids of the two. The plan will also evaluate the feasibility and order of magnitude costs for options to adapt SBA infrastructure. Additionally, the plan will provide a decision-making framework that identifies triggers and timelines for future adaptation options.

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Appendix A. Mead & Hunt Technical Memorandum DRAFT – SBA Sea-Level Rise and Part 139 Certification

Technical Memorandum DRAFT

To: Nick Garrity, PE, ESA Associates
From: Corbett Smith, CM
Reviewed by: Mandy O'Hara, PE
Date: June 14, 2024
Subject: SBA Sea-Level Rise and Part 139 Certification

1. Introduction and Background

As part of the Santa Barbara Airport (SBA) Sea-Level Rise Adaptation Plan, Mead & Hunt was asked to provide insight into how flooding and sea-level rise could impact the airport's Part 139 Airport Operating Certificate. This letter will provide a framework of the Part 139 requirements and potential impacts to the Airport's ability to meet those requirements and maintain an Airport Operating Certificate (AOC).

2. Regulatory Requirements

14 CFR Part 139 FAA Regulations state that scheduled commercial aircraft with 10 seats or more cannot operate into an airport unless the airport is certificated in compliance with Part 139, meaning the airport has the required infrastructure, services, policies, and procedures in place so scheduled commercial aircraft can safely operate.

Part 139 identifies four classes of certificated airports. The respective class of airport is based on the type and size of commercial aircraft the airport may accommodate. Section 139.5 describes the four classes of airports. Santa Barbara Airport is a Class I airport. The four classes of certification are summarized below:

Class I Airport: An airport that is certified to serve scheduled operations of large[a] air carrier aircraft that can also serve unscheduled passenger operations of large air carrier aircraft and/or scheduled operations of small[b] air carrier aircraft.

Class II Airport: An airport certified to serve scheduled operations of small air carrier aircraft and the unscheduled passenger operations of large air carrier aircraft. A Class II airport cannot serve scheduled large air carrier aircraft.

Class III Airport: An airport certified to serve scheduled operations of small air carrier aircraft. A Class III airport cannot serve scheduled or unscheduled large air carrier aircraft.

Class IV Airport: An airport certified to serve unscheduled passenger operations of large air carrier aircraft. A Class IV airport cannot serve scheduled large or small air carrier aircraft.

[a] Large aircraft are defined by having 31 or more passenger seats.
[b] Small aircraft are defined by having more than 9 passenger seats, but less than 31 passenger seats.

Part 139 requires the FAA to issue Airport Operating Certificates (AOC) to airports that:

- Serve scheduled and unscheduled air carrier aircraft with more than 30 seats (large air carrier aircraft);
- Serve scheduled air carrier operations in aircraft with more than nine seats but less than 31 seats (small air carrier aircraft).

3. Certification Manual Elements

The FAA requires that each Part 139 certificate holder (airport) create, adopt, and comply with an Airport Certification Manual (ACM). This manual details compliance regulations for Part 139 and must be kept current at all times. The elements of the manual are defined in **Table 1**.

TABLE 1: REQUIRED AIRPORT CERTIFICATION MANUAL ELEMENTS

	MANUAL ELEMENTS	AIRPORT CERTIFICATE CLASS	
		Class I – III	Class IV
1	Lines of succession of airport operational responsibility	X	X
2	Each current exemption issued to the airport from the requirements of this part	X	X
3	Any limitations imposed by the Administrator	X	X
4	A grid map or other means of identifying locations and terrain features on and around the airport that are significant to emergency operations	X	X
5	The location of each obstruction is required to be lit or marked within the airport's area of authority	X	X
6	A description of each movement area available for air carriers and its safety areas and each road described in § 139.319(k) that serves it	X	X
7	Procedures for avoidance of interruption or failure during construction work of utilities serving facilities or NAVAIDS that support air carrier operations	X	
8	A description of the system for maintaining records, as required under § 139.301	X	X
9	A description of personnel training, as required under § 139.303	X	X
10	Procedures for maintaining the paved areas, as required under § 139.305	X	X
11	Procedures for maintaining the unpaved areas, as required under § 139.307	X	X
12	Procedures for maintaining the safety areas, as required under § 139.309	X	X
13	A plan showing the runway and taxiway identification system, including the location and inscription of signs, runway markings, and holding position markings, as required under § 139.311	X	X

	MANUAL ELEMENTS	AIRPORT CERTIFICATE CLASS	
		Class I – III	**Class IV**
14	A description of and procedures for maintaining the marking, signs, and lighting systems, as required under § 139.311	X	X
15	A snow and ice control plan, as required under § 139.313	X	
16	A description of the facilities, equipment, personnel, and procedures for meeting the aircraft rescue and firefighting requirements, in accordance with §§ 139.315, 139.317 and 139.319	X	X
17	A description of any approved exemption to aircraft rescue and firefighting requirements, as authorized under § 139.111	X	X
18	Procedures for protecting persons and property during the storing, dispensing, and handling of fuel and other hazardous substances and materials, as required under § 139.321	X	X
19	A description of and procedures for maintaining the traffic and wind direction indicators, as required under § 139.323	X	X
20	An emergency plan, as required under § 139.325	X	X
21	Procedures for conducting the self-inspection program, as required under § 139.327	X	X
22	Procedures for controlling pedestrians and ground vehicles in movement areas and safety areas, as required under § 139.329	X	
23	Procedures for obstruction removal, marking, or lighting, as required under § 139.331	X	X
24	Procedures for the protection of NAVAIDS, as required under § 139.333	X	
25	A description of public protection, as required under § 139.335	X	
26	Procedures for wildlife hazard management, as required under § 139.337	X	
27	Procedures for airport condition reporting, as required under § 139.339	X	X
28	Procedures for identifying, marking, and lighting construction and other unserviceable areas, as required under § 139.341	X	
29	Any other item that the Administrator finds is necessary to ensure safety in air transportation	X	X

3.1 Elements of Specific Relevance to Flooding

Bold added for relevance to flooding impacts.

3.1.1 § 139.305 Paved Areas

(4) Except as provided in paragraph (b) of this section, **mud, dirt, sand, loose aggregate, debris, foreign objects**, rubber deposits, and other contaminants must be removed promptly and as completely as practicable.

(6) The pavement must be sufficiently **drained** and free of depressions to prevent ponding that obscures markings or impairs safe aircraft operations.

3.1.2 § 139.309 Safety Areas

(b) Each certificate holder must maintain its safety areas as follows:

(2) Each safety area must be drained by grading or storm sewers to **prevent water accumulation**.

3.1.3 § 139.319 Aircraft Rescue and Firefighting: Operational Requirements

(g) Vehicle readiness. Each vehicle required under § 139.317 must be maintained as follows:

(3) Any required vehicle that becomes inoperative to the extent that it cannot perform as required by paragraph (g)(1) of this section must be replaced immediately with equipment having at least equal capabilities. If replacement equipment is not available immediately, the certificate holder must **notify the Regional Airports Division Manager and each air carrier** using the airport in accordance with § 139.339. If the required Index level of capability is not restored within 48 hours, the airport operator, unless otherwise authorized by the Administrator, **must limit air carrier operations on the airport** to those compatible with the Index corresponding to the remaining operative rescue and firefighting equipment.

(h) Response requirements.

(1) With the aircraft rescue and firefighting equipment required under this part and the number of trained personnel that will assure an effective operation, each certificate holder must:

(i) Respond to each emergency during periods of air carrier operations; and

(ii) When requested by the Administrator, demonstrate compliance with the response requirements specified in this section.

(2) The response required by paragraph (h)(1)(ii) of this section must achieve the following performance criteria:

(i) **Within 3 minutes** from the time of the alarm, at least one required aircraft rescue and firefighting vehicle must reach the midpoint of the farthest runway serving air carrier aircraft from its assigned post or reach any other specified point of comparable distance on the movement area that is available to air carriers and begin application of the extinguishing agent.

(ii) **Within 4 minutes** from the time of alarm, all other required vehicles must reach the point specified in paragraph (h)(2)(i) of this section from their assigned posts and begin application of an extinguishing agent.

(k) **Emergency access roads.** Each certificate holder must ensure that roads designated for use as emergency access roads for aircraft rescue and firefighting vehicles are maintained in a condition that will **support those vehicles during all weather conditions**.

3.1.4 § 139.327 Self-inspection Program

(a) In a manner authorized by the Administrator, each certificate holder must inspect the airport to assure compliance with this subpart according to the following schedule:
   (1) Daily, except as otherwise required by the Airport Certification Manual;
   (2) When required by any unusual condition, such as construction activities or meteorological conditions, that may affect safe air carrier operations; and
   (3) Immediately after an accident or incident.

3.1.5 § 139.339 Airport Condition Reporting

In a manner authorized by the Administrator, each certificate holder must—
   (a) Provide for the collection and dissemination of airport condition information to air carriers.
   (b) In complying with paragraph (a) of this section, use the NOTAM system, as appropriate, and other systems and procedures authorized by the Administrator.
   (c) In complying with paragraph (a) of this section, provide information on the following airport conditions that may affect the safe operations of air carriers:

(1) Construction or maintenance activity on movement areas, safety areas, or loading ramps and parking areas.
(2) Surface irregularities on movement areas, safety areas, or loading ramps and parking areas.
(3) Snow, ice, slush, or water on the movement area or loading ramps and parking areas.
(4) Snow piled or drifted on or near movement areas contrary to § 139.313.
(5) Objects on the movement area or safety areas contrary to § 139.309.
(6) Malfunction of any lighting system, holding position signs, or ILS critical area signs required by § 139.311.
(7) Unresolved wildlife hazards as identified in accordance with § 139.337.
(8) Nonavailability of any rescue and firefighting capability required in §§ 139.317 or 139.319.
(9) Any other condition as specified in the Airport Certification Manual or that may otherwise adversely affect the safe operations of air carriers.

   (d) Each certificate holder must prepare and keep, for at least 12 consecutive calendar months, a record of each dissemination of airport condition information to air carriers prescribed by this section.
   (e) FAA Advisory Circulars contain methods and procedures for using the NOTAM system and the dissemination of airport information that are acceptable to the Administrator.

4. Deviations

Section 139.113 states, "In emergency conditions requiring immediate action for the protection of life or property, the certificate holder may deviate from any requirement of subpart D of this part, or the Airport Certification Manual, to the extent required to meet that emergency. Each certificate holder who deviates from a requirement under this section must, within 14 days after the emergency, notify the Regional Airports Division Manager of the nature, extent, and duration of the deviation. When requested by the Regional Airports Division Manager, the certificate holder must provide this notification in writing."

This exclusion gives the Airport wide latitude in addressing emergency situations such as flooding.

5. Conclusion

The potential exists for future flooding impacts at SBA to impact some of the required facilities/inspections/staff actions at the airport; however, through the use of the NOTAM system and elements required in the ACM, the Airport can mitigate many of these impacts. The Deviations section described above also allows the Airport to respond as needed to specific emergencies. There is a relatively low risk of the Airport losing its 139 certification due to flood related impacts. The significant action of the FAA revoking an AOC would likely only occur as a result of long-standing non-compliance and/or non-reporting of deficiencies. In the long-term scenarios where the Airport could be more often completely flooded, the Airport will likely struggle to meet the above Part 139 requirements.

Appendix B.
Santa Barbara Airport Title VI Plan

Appendix C.
Mead & Hunt Technical Memorandum – SBA SLR – Future Conditions Onsite Hydrology & Hydraulics Model Results

Technical Memorandum

To:	Amber Inggs, PE (ESA)
From:	Bob Thayne, PE and Olivia Burke, EIT (Mead & Hunt)
Reviewed by:	Mandy O'Hara, PE (Mead & Hunt)
Date:	March 8, 2024
Subject:	SBA SLR – Future Conditions Onsite Hydrology & Hydraulics Model Results

1. Introduction and Background

Mead & Hunt is supporting ESA on the Sea Level Rise (SLR) Adaptation Plan for the Santa Barbara Airport (SBA). ESA provided water surface elevations for the future 5-year design rainfall event and four SLR scenarios: 0 feet (ft), 0.8 ft, 2.5 ft, and 6.6 ft. ESA stated the future 5-year design storm is equivalent to the current 20-year design rainfall event based on the global climate model. ESA performed extreme value analyses (EVA) for each of the existing water levels (from FEMA), as well as the output from their lagoon model (Quantified Conceptual Model). The higher of the values was provided at select stations along Tecolotito, Carneros, and San Pedro creeks. Mead & Hunt incorporated this data into the existing conditions hydrologic and hydraulic model which was developed as part of the SBA Drainage Master Plan (under development by Mead & Hunt) using XPSWMM Version 2020.1 modeling software.

Larger future rainfall events, that is, larger than the future 5-year rainfall event taken as an equivalent of the current 20-year rainfall event, were not modeled by Mead & Hunt. This decision was based on the assumption that larger rainfall events would typically correspond with larger return-interval flood events. Flood events such as the current 25-year flood are shown (per current FEMA data and mapping) to inundate the airport with floodwater, thus negating the usefulness of analyzing the stormwater system.

2. Rainfall

ESA provided three water surface elevation scenarios for the future 5-year, 24-hour design rainfall event, being taken as equivalent to the current 20-year, 24-hour design rainfall event. Mead & Hunt updated the XPSWMM model for the future 5-year, 24-hour event using 20-year rainfall by interpolating between the 10-year and 25-year total rainfall depths from the South Coast 24-Hour Rainfall Parameters. Interpolation between the 10- and 25-year rainfall depths yields a value of 6.1 inches of total rainfall for the 20-year, 24-hour event. See the attached **Rainfall Interpolation Worksheet**.

3. Boundary Conditions

ESA provided water level elevations at FEMA River Stations in the adjacent creeks/slough, considering both creek levels during a storm and from tidal influences. Mead & Hunt interpolated between the given stations to obtain the water level elevations at all the outfalls. These values were entered into the XPSWMM models. The locations of the modeled stormwater outfalls and the locations of the FEMA River Stations is shown in **Exhibit: Outfall Boundaries**. The water level elevations at each outfall are summarized below in **Table 1**. It is noted that as SLR increases in severity, the effects of SLR increasingly dominate more outfall locations working from downstream to upstream along the creek alignments.

Table 1: Water Level Elevations at Stormwater Outfalls

Outfall	Current 5-year Storm with 5-year Water Levels	Future 5-year Storm 0 ft SLR	Future 5-year Storm 0.8 ft SLR	Future 5-year Storm 2.5 ft SLR	Future 5-year Storm 6.6 ft SLR
2	10.82	12.10	12.10	12.10	16.23
1	9.98	11.27	11.27	12.08	16.23
26	9.64	11.06	11.13	12.08	16.23
14	9.46	10.91	11.05	12.08	16.23
13	9.13	10.64	10.92	12.08	16.23
10	9.06	10.58	10.89	12.08	16.23
12	9.04	10.56	10.88	12.08	16.23
17	8.54	9.86	10.76	12.08	16.23
11	8.43	9.44	10.76	12.08	16.23
9	8.43	9.40	10.76	12.08	16.23
Northeast Corner	17.31	18.24	18.24	18.24	18.24
Ampersand	13.68	15.27	15.27	15.27	16.23
5	12.63	13.64	13.64	13.64	16.23
6	10.84	12.29	12.29	12.44	16.23
Parking C	10.49	11.96	11.96	12.35	16.23
Parking B	10.30	11.78	11.78	12.30	16.23
Parking D	10.21	11.69	11.69	12.28	16.23
Parking E	10.03	11.52	11.52	12.23	16.23

4. Models

In addition to including an existing condition hydrology and hydraulics model of the Existing 5-year, 24-hour rainfall event for comparison, Mead & Hunt ran four (4) future condition models using the Future 5-year, 24-hour rainfall, one (1) with a zero sea level rise condition and three (3) with varying values of increased sea level as supplied by ESA. In the models, static water surface elevations were applied at the stormwater outfall locations using the values shown in Table 1.

5. Results

The various XPSWMM models produced hydraulic grade lines (HGL) throughout the onsite storm drain systems. The HGL were used to establish resulting water surface elevations throughout the storm drain systems and across the airfield. Using topographic data and tools in AutoCAD and GIS, water surface elevations were visualized spatially in GIS as inundation (ponding) areas. The attached exhibit shows the spatial results of Onsite Stormwater Ponding from the five scenarios, specifically highlighting encroachments where the water surface mapping intersects pavements and/or buildings. The results are also being transmitted as GIS shapefiles. Additionally, a shapefile for each scenario showing the approximate depths of ponding is provided.

SANTA BARBARA AIRPORT (SBA)
SEA LEVEL RISE ADAPTATION PLAN

SANTA BARBARA CITY AGREEMENT NO. 28,228
1942500-221500.01
03/08/2024

OUTFALLS AND FEMA RIVER STATIONS LOCATIONS

Mead & Hunt

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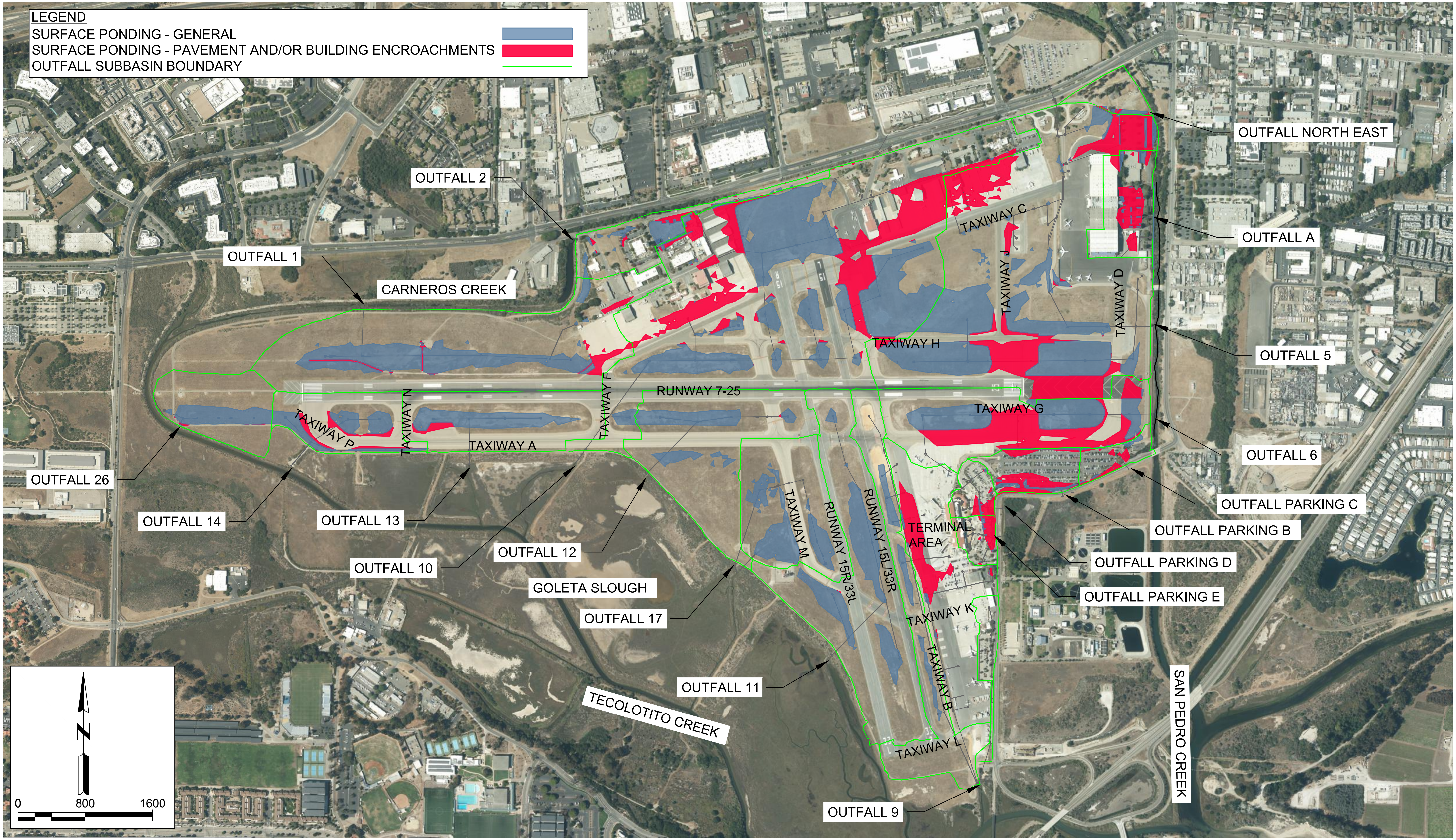
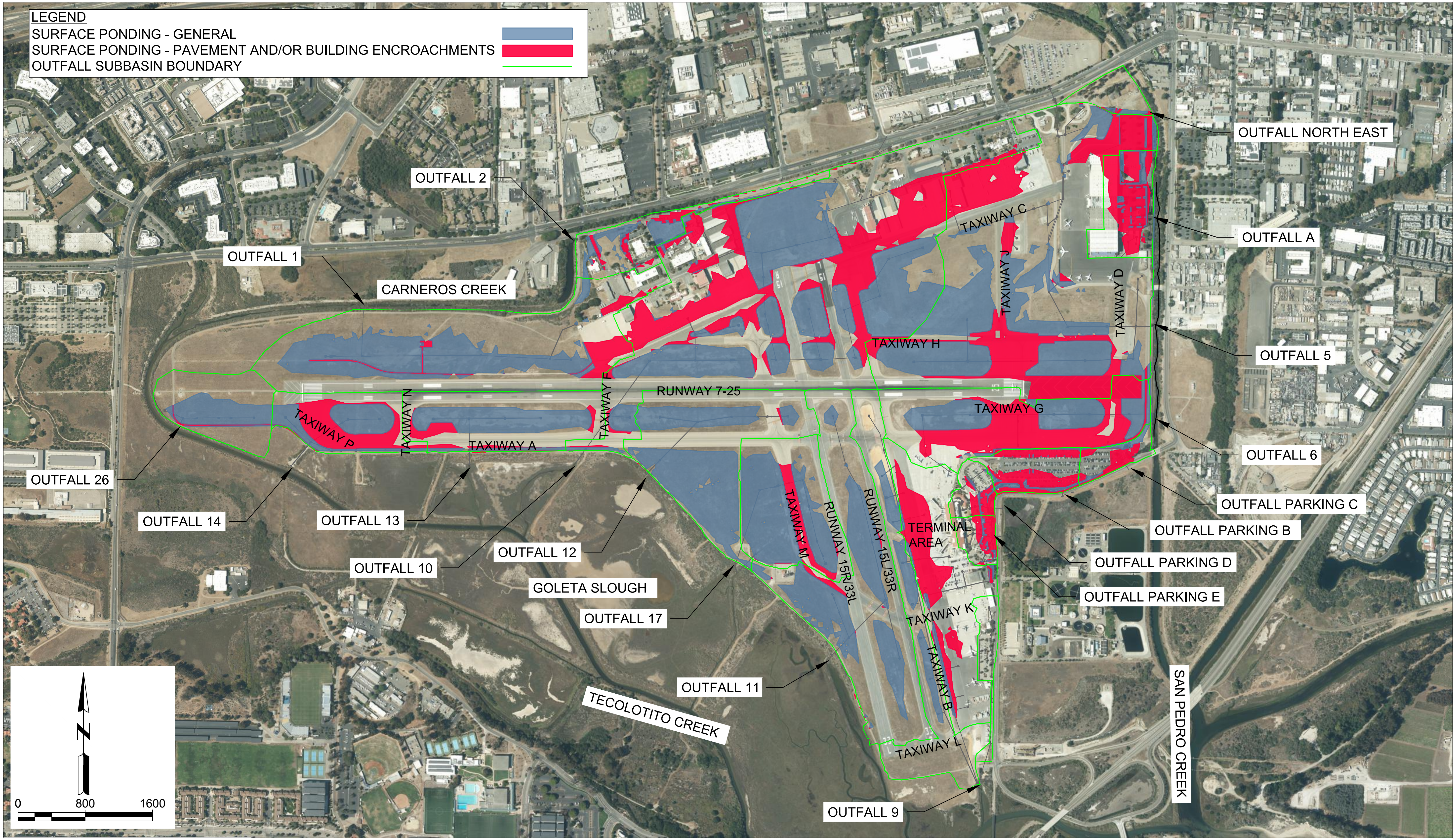


SANTA BARBARA AIRPORT (SBA)
SEA LEVEL RISE ADAPTATION PLAN

SANTA BARBARA CITY AGREEMENT NO. 28,228
1942500-221500.01
06/07/2024

Onsite Stormwater Ponding Existing 5yr Results, 0 ft SLR - Peak Runoff and Peak Outfall Water Levels Coinciding

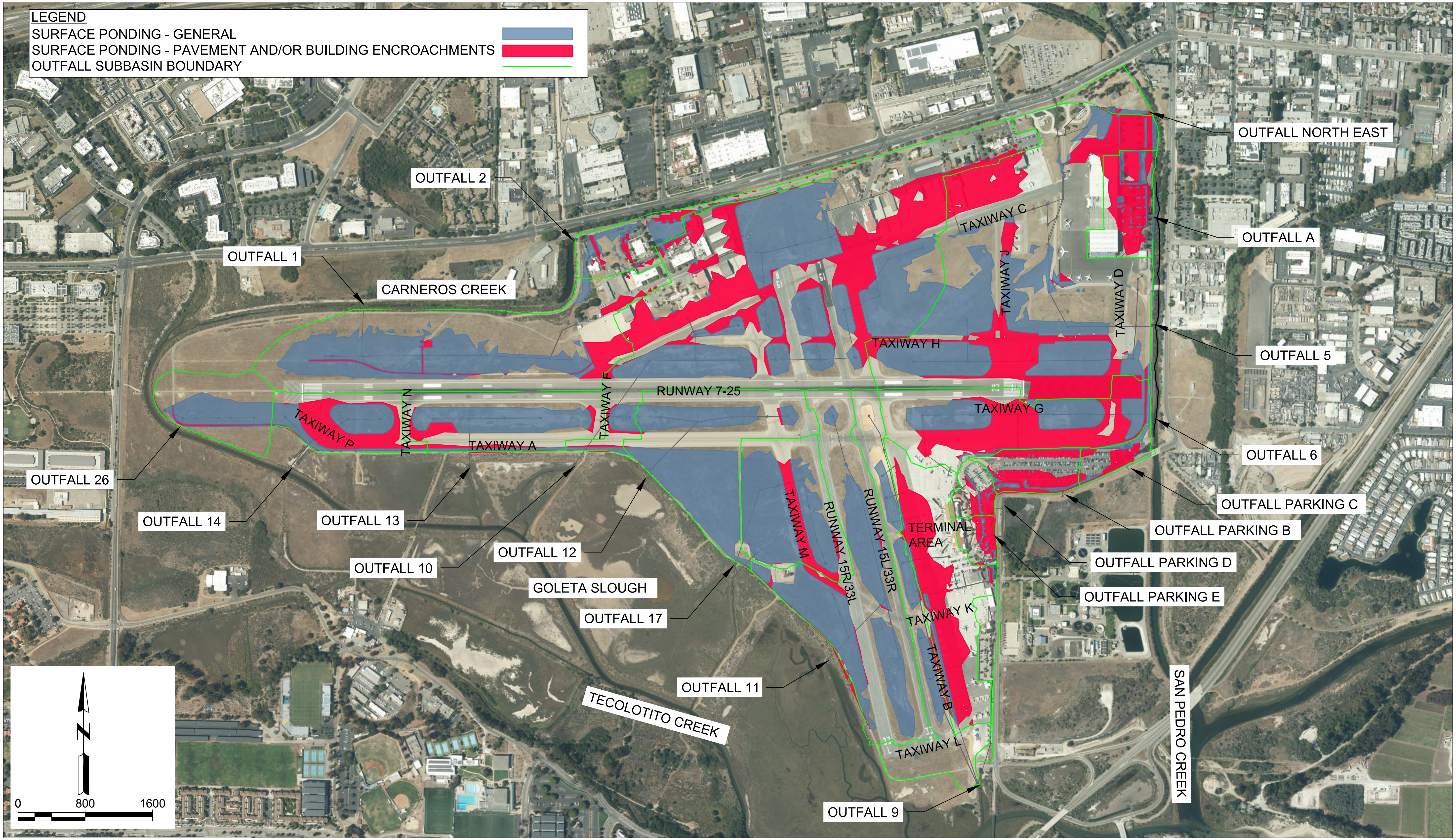
Mead & Hunt



SANTA BARBARA AIRPORT (SBA)
SEA LEVEL RISE ADAPTATION PLAN

SANTA BARBARA CITY AGREEMENT NO. 28,228
1942500-221500.01
06/17/2024

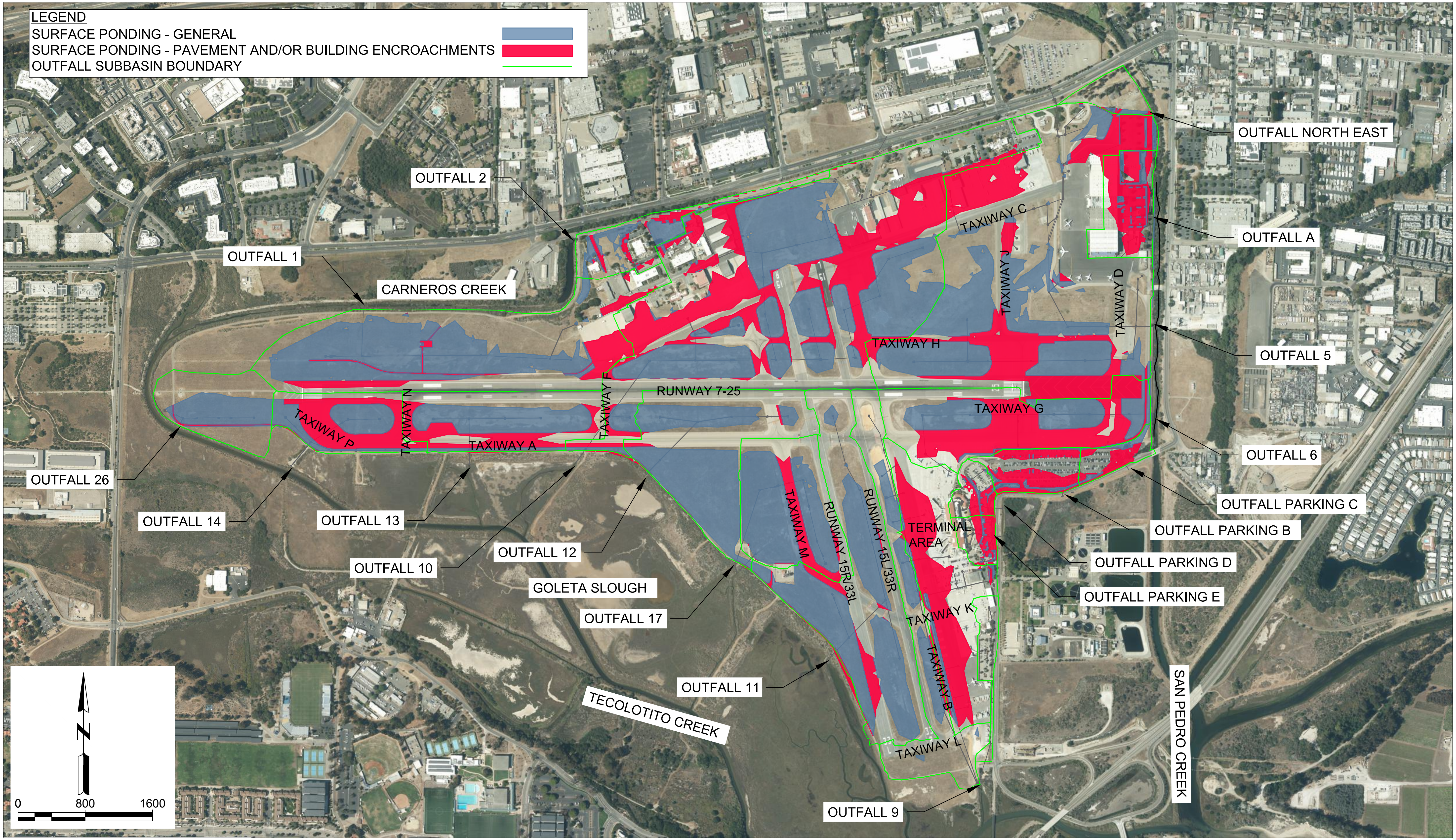
Onsite Stormwater Ponding Future 5yr Results, 0 ft SLR - Peak Runoff and Peak Outfall Water Levels Coinciding



SANTA BARBARA AIRPORT (SBA)
SEA LEVEL RISE ADAPTATION PLAN

SANTA BARBARA CITY AGREEMENT NO. 28,228
1942500-221500.01
06/17/2024

Onsite Stormwater Ponding Future 5yr Results, 0.8 ft SLR - Peak Runoff and Peak Outfall Water Levels Coinciding

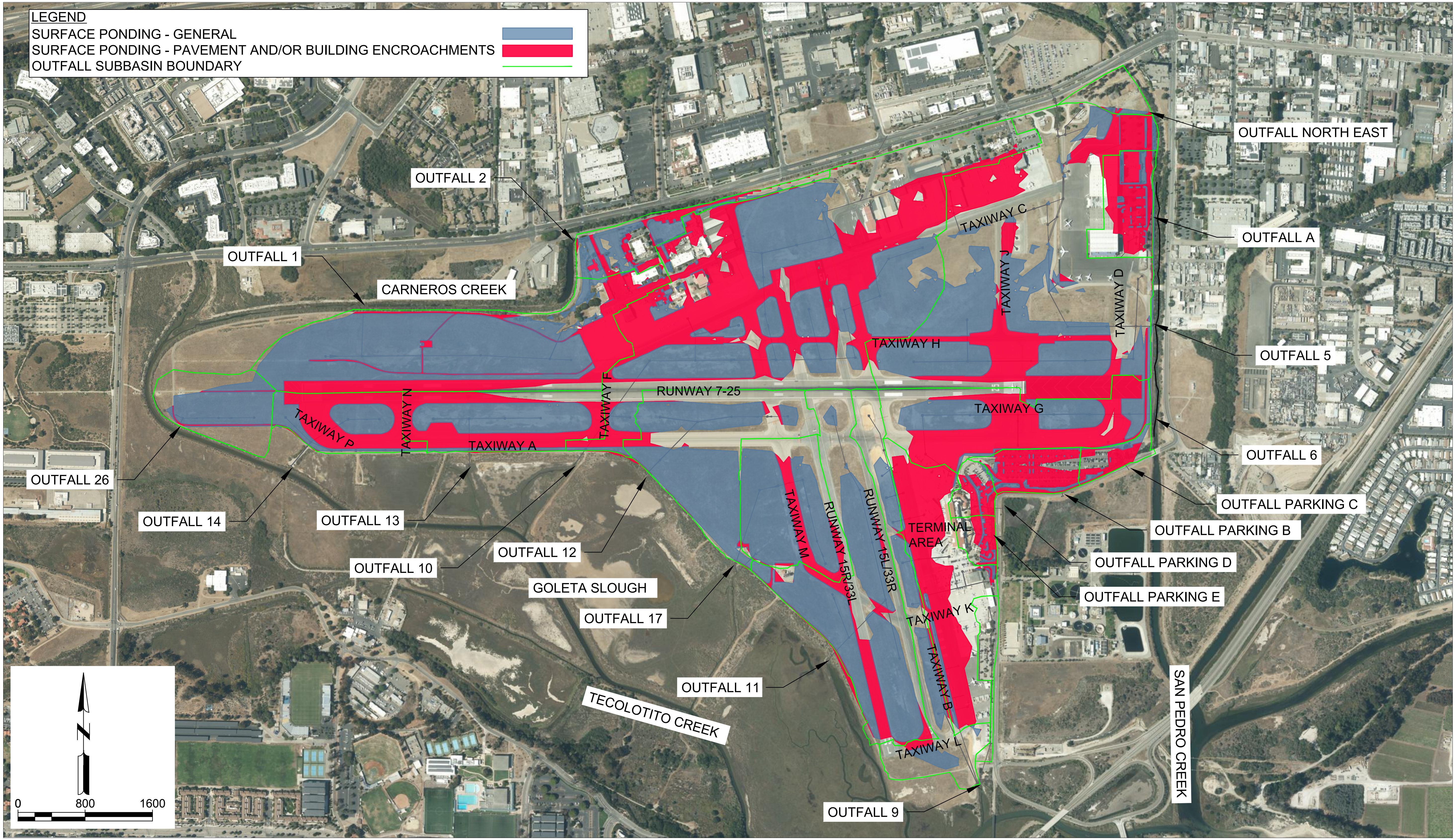


SANTA BARBARA AIRPORT (SBA)
SEA LEVEL RISE ADAPTATION PLAN

SANTA BARBARA CITY AGREEMENT NO. 28,228
1942500-221500.01
06/17/2024

Onsite Stormwater Ponding Future 5yr Results, 2.5 ft SLR - Peak Runoff and Peak Outfall Water Levels Coinciding

Mead & Hunt



SANTA BARBARA AIRPORT (SBA)
SEA LEVEL RISE ADAPTATION PLAN

SANTA BARBARA CITY AGREEMENT NO. 28,228
1942500-221500.01
06/17/2024

Onsite Stormwater Ponding Future 5yr Results, 6.6 ft SLR - Peak Runoff and Peak Outfall Water Levels Coinciding

Mead & Hunt

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RAINFALL INTERPOLATION WORKSHEET
Santa Barbara Airport
24-hour Rainfall Values

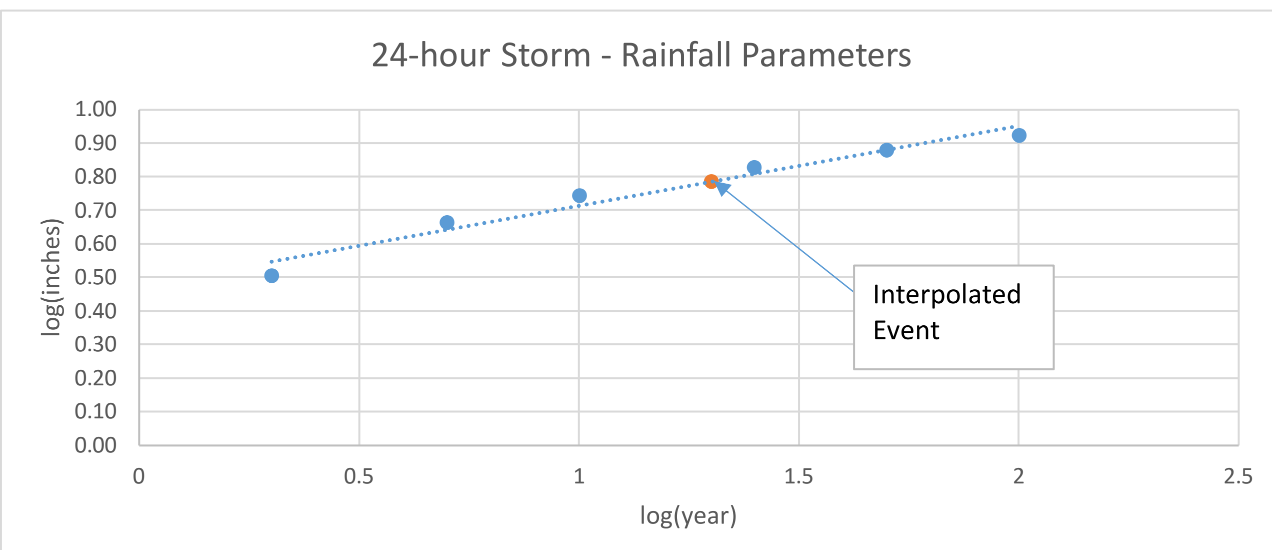
Known Values[1]

Storm Recurrence Interval	**log(year)**	**Rainfall (in)**	**log(rainfall)**
2	0.301029996	3.2	0.51
5	0.698970004	4.61	0.66
10	1	5.55	0.74
25	1.397940009	6.71	0.83
50	1.698970004	7.56	0.88
100	2	8.38	0.92

[1]Source: County of Santa Barbara Flood Control and Water Concertvation District - Standard Conditions of Project Plan Approval, Rainfall Amounts, 24-hour totals

Interpolated Values

Storm Recurrence Interval	log(year)	log(rainfall)	(inches)
20	1.30103	0.7851335	6.10



Appendix D.
Annual Expected Economic Loss
– Average Storm

					Undiscounted					Discounted (FAA rate)				
Year	Runway 7/25 Flood Annual Chance	Commercial	Charter (Non-scheduled Air Taxi)	Commercial Enplanements	Airport Costs	Airline Costs	Commercial Passeneger Costs	General Aviation	Total Undiscounted	Airport Costs	Airline Costs	Commercial Passeneger Costs	General Aviation	Total Discounted
2025	21%	14,885	10,334	1,403,133	$ 60,223	$ 103,941	$ 248,102	$ 31,383	$ 443,649	$ 60,223	$ 103,941	$ 248,102	$ 31,383	$ 443,649
2026	21%	15,032	11,700	1,470,483	$ 60,223	$ 104,967	$ 260,011	$ 35,531	$ 460,732	$ 56,283	$ 98,100	$ 243,001	$ 33,207	$ 430,591
2027	21%	15,500	11,740	1,541,066	$ 60,223	$ 108,235	$ 272,491	$ 35,652	$ 476,602	$ 52,601	$ 94,537	$ 238,004	$ 31,140	$ 416,282
2028	21%	15,857	11,780	1,615,038	$ 60,223	$ 110,724	$ 285,571	$ 35,773	$ 492,292	$ 49,160	$ 90,384	$ 233,111	$ 29,202	$ 401,857
2029	21%	16,221	11,820	1,692,559	$ 60,223	$ 113,271	$ 299,278	$ 35,895	$ 508,667	$ 45,944	$ 86,414	$ 228,318	$ 27,384	$ 388,060
2030	21%	16,594	11,860	1,773,802	$ 60,223	$ 115,876	$ 313,643	$ 36,017	$ 525,760	$ 42,938	$ 82,618	$ 223,623	$ 25,680	$ 374,860
2031	21%	16,830	11,900	1,858,945	$ 60,223	$ 117,522	$ 328,698	$ 36,139	$ 542,583	$ 40,129	$ 78,310	$ 219,026	$ 24,081	$ 361,546
2032	21%	16,939	11,920	1,948,174	$ 60,223	$ 118,286	$ 344,476	$ 36,200	$ 559,185	$ 37,504	$ 73,663	$ 214,522	$ 22,544	$ 348,233
2033	21%	17,050	11,940	2,041,686	$ 60,223	$ 119,055	$ 361,011	$ 36,262	$ 576,551	$ 35,050	$ 69,291	$ 210,112	$ 21,105	$ 335,558
2034	21%	17,160	11,961	2,139,687	$ 60,223	$ 119,829	$ 378,339	$ 36,323	$ 594,715	$ 32,757	$ 65,179	$ 205,791	$ 19,758	$ 323,485
2035	21%	17,272	11,981	2,242,392	$ 60,223	$ 120,608	$ 396,500	$ 36,385	$ 613,716	$ 30,614	$ 61,311	$ 201,560	$ 18,496	$ 311,982
2036	21%	17,300	12,000	2,350,027	$ 60,223	$ 120,804	$ 415,532	$ 36,442	$ 633,001	$ 28,612	$ 57,393	$ 197,416	$ 17,314	$ 300,734
2037	21%	17,419	12,041	2,462,828	$ 60,223	$ 121,638	$ 435,477	$ 36,566	$ 653,904	$ 26,740	$ 54,009	$ 193,357	$ 16,236	$ 290,341
2038	21%	17,540	12,082	2,581,044	$ 60,223	$ 122,477	$ 456,380	$ 36,691	$ 675,771	$ 24,990	$ 50,824	$ 189,381	$ 15,225	$ 280,421
2039	21%	17,661	12,123	2,704,934	$ 60,223	$ 123,322	$ 478,286	$ 36,815	$ 698,647	$ 23,356	$ 47,826	$ 185,488	$ 14,278	$ 270,947
2040	21%	17,782	12,164	2,834,771	$ 60,223	$ 124,173	$ 501,244	$ 36,941	$ 722,581	$ 21,828	$ 45,006	$ 181,674	$ 13,389	$ 261,897
2041	21%	17,900	12,200	2,970,840	$ 60,223	$ 124,994	$ 525,304	$ 37,050	$ 747,571	$ 20,400	$ 42,340	$ 177,939	$ 12,550	$ 253,228
2042	21%	18,024	12,241	3,113,441	$ 60,223	$ 125,856	$ 550,518	$ 37,176	$ 773,774	$ 19,065	$ 39,843	$ 174,280	$ 11,769	$ 244,957
2043	21%	18,148	12,283	3,262,886	$ 60,223	$ 126,725	$ 576,943	$ 37,302	$ 801,193	$ 17,818	$ 37,493	$ 170,697	$ 11,036	$ 237,044
2044	21%	18,273	12,325	3,419,504	$ 60,223	$ 127,599	$ 604,636	$ 37,429	$ 829,888	$ 16,652	$ 35,282	$ 167,187	$ 10,349	$ 229,471
2045	21%	18,399	12,367	3,583,640	$ 60,223	$ 128,480	$ 633,659	$ 37,556	$ 859,918	$ 15,563	$ 33,202	$ 163,749	$ 9,705	$ 222,219
2046	21%	18,526	12,409	3,755,655	$ 60,223	$ 129,366	$ 664,074	$ 37,684	$ 891,348	$ 14,545	$ 31,244	$ 160,383	$ 9,101	$ 215,272
2047	21%	18,654	12,451	3,935,927	$ 60,223	$ 130,259	$ 695,950	$ 37,812	$ 924,244	$ 13,593	$ 29,401	$ 157,085	$ 8,535	$ 208,614
2048	21%	18,783	12,493	4,124,851	$ 60,223	$ 131,158	$ 729,356	$ 37,941	$ 958,677	$ 12,704	$ 27,667	$ 153,855	$ 8,003	$ 202,230
2049	21%	18,912	12,536	4,322,844	$ 60,223	$ 132,063	$ 764,365	$ 38,070	$ 994,720	$ 11,873	$ 26,036	$ 150,692	$ 7,505	$ 196,106
2050	21%	19,043	12,578	4,530,340	$ 60,223	$ 132,974	$ 801,054	$ 38,199	$ 1,032,450	$ 11,096	$ 24,500	$ 147,594	$ 7,038	$ 190,228
2051	21%	19,174	12,621	4,747,797	$ 60,223	$ 133,891	$ 839,505	$ 38,329	$ 1,071,948	$ 10,370	$ 23,055	$ 144,559	$ 6,600	$ 184,585
2052	21%	19,306	12,664	4,975,691	$ 60,223	$ 134,815	$ 879,801	$ 38,459	$ 1,113,299	$ 9,692	$ 21,696	$ 141,587	$ 6,189	$ 179,164
2053	21%	19,440	12,707	5,214,524	$ 60,223	$ 135,745	$ 922,032	$ 38,590	$ 1,156,590	$ 9,058	$ 20,416	$ 138,676	$ 5,804	$ 173,954
2054	21%	19,574	12,750	5,464,821	$ 60,223	$ 136,682	$ 966,289	$ 38,721	$ 1,201,916	$ 8,465	$ 19,212	$ 135,824	$ 5,443	$ 168,945
2055	21%	19,709	12,794	5,727,133	$ 60,223	$ 137,625	$ 1,012,671	$ 38,853	$ 1,249,372	$ 7,911	$ 18,079	$ 133,032	$ 5,104	$ 164,126
TOTAL to 2055		548,906	376,765	95,810,466	$ 1,866,918	$ 3,832,962	$ 16,941,195	$ 1,144,188	$ 23,785,264	$ 807,535	$ 1,588,273	$ 5,729,623	$ 485,153	$ 8,610,584
2056	21%	19,845	12,837	6,002,035	$ 60,223	$ 138,575	$ 1,061,279	$ 38,985	$ 1,299,062	$ 7,394	$ 17,013	$ 130,296	$ 4,786	$ 159,490
2057	21%	19,982	12,881	6,290,133	$ 60,223	$ 139,531	$ 1,112,221	$ 39,118	$ 1,351,092	$ 6,910	$ 16,010	$ 127,617	$ 4,488	$ 155,026
2058	21%	20,120	12,925	6,592,059	$ 60,223	$ 140,494	$ 1,165,607	$ 39,251	$ 1,405,575	$ 6,458	$ 15,066	$ 124,994	$ 4,209	$ 150,726
2059	21%	20,258	12,969	6,908,478	$ 60,223	$ 141,463	$ 1,221,556	$ 39,384	$ 1,462,627	$ 6,036	$ 14,177	$ 122,424	$ 3,947	$ 146,583
2060	21%	20,398	13,013	7,240,085	$ 60,223	$ 142,439	$ 1,280,191	$ 39,518	$ 1,522,371	$ 5,641	$ 13,341	$ 119,906	$ 3,701	$ 142,590
2061	21%	20,539	13,057	7,587,609	$ 60,223	$ 143,422	$ 1,341,640	$ 39,652	$ 1,584,938	$ 5,272	$ 12,555	$ 117,441	$ 3,471	$ 138,738
2062	21%	20,681	13,101	7,951,814	$ 60,223	$ 144,412	$ 1,406,039	$ 39,787	$ 1,650,461	$ 4,927	$ 11,814	$ 115,026	$ 3,255	$ 135,022
2063	21%	20,823	13,146	8,333,501	$ 60,223	$ 145,408	$ 1,473,529	$ 39,922	$ 1,719,082	$ 4,604	$ 11,117	$ 112,661	$ 3,052	$ 131,436
2064	21%	20,967	13,191	8,733,509	$ 60,223	$ 146,411	$ 1,544,258	$ 40,058	$ 1,790,951	$ 4,303	$ 10,462	$ 110,345	$ 2,862	$ 127,972
2065	21%	21,112	13,235	9,152,718	$ 60,223	$ 147,422	$ 1,618,382	$ 40,194	$ 1,866,222	$ 4,022	$ 9,845	$ 108,076	$ 2,684	$ 124,627
2066	21%	21,257	13,280	9,592,048	$ 60,223	$ 148,439	$ 1,696,065	$ 40,331	$ 1,945,058	$ 3,759	$ 9,264	$ 105,854	$ 2,517	$ 121,394
2067	21%	21,404	13,326	10,052,467	$ 60,223	$ 149,463	$ 1,777,476	$ 40,468	$ 2,027,630	$ 3,513	$ 8,718	$ 103,678	$ 2,360	$ 118,269
2068	21%	21,552	13,371	10,534,985	$ 60,223	$ 150,494	$ 1,862,795	$ 40,606	$ 2,114,118	$ 3,283	$ 8,204	$ 101,546	$ 2,214	$ 115,246
2069	21%	21,701	13,416	11,040,664	$ 60,223	$ 151,533	$ 1,952,209	$ 40,744	$ 2,204,709	$ 3,068	$ 7,720	$ 99,458	$ 2,076	$ 112,322
2070	21%	21,850	13,462	11,570,616	$ 60,223	$ 152,578	$ 2,045,915	$ 40,882	$ 2,299,599	$ 2,867	$ 7,265	$ 97,413	$ 1,947	$ 109,492
2071	21%	22,001	13,508	12,126,006	$ 60,223	$ 153,631	$ 2,144,119	$ 41,021	$ 2,398,995	$ 2,680	$ 6,836	$ 95,410	$ 1,825	$ 106,752
2072	21%	22,153	13,554	12,708,054	$ 60,223	$ 154,691	$ 2,247,037	$ 41,161	$ 2,503,112	$ 2,505	$ 6,433	$ 93,449	$ 1,712	$ 104,098
2073	21%	22,306	13,600	13,318,041	$ 60,223	$ 155,759	$ 2,354,894	$ 41,301	$ 2,612,177	$ 2,341	$ 6,054	$ 91,527	$ 1,605	$ 101,527
2074	21%	22,460	13,646	13,957,307	$ 60,223	$ 156,833	$ 2,467,929	$ 41,441	$ 2,726,427	$ 2,188	$ 5,697	$ 89,645	$ 1,505	$ 99,035
2075	61%	22,615	13,692	14,627,257	$ 174,934	$ 458,707	$ 7,512,847	$ 120,786	$ 8,267,274	$ 5,939	$ 15,572	$ 255,044	$ 4,100	$ 280,655
SUBTOTAL to 2075		972,930	641,974	290,129,854	$ 3,186,092	$ 7,094,668	$ 56,227,183	$ 2,028,798	$ 68,536,741	$ 895,242	$ 1,801,437	$ 8,051,435	$ 543,471	$ 11,291,586
2076	61%	22,771	13,739	15,329,366	$174,933.97	$ 461,872	$ 7,873,463	$ 121,197	$ 8,631,466	$ 5,550	$ 14,654	$ 249,800	$ 3,845	$ 273,849
2077	61%	22,928	13,786	16,065,175	$174,933.97	$ 465,059	$ 8,251,390	$ 121,609	$ 9,012,991	$ 5,187	$ 13,790	$ 244,664	$ 3,606	$ 267,247
2078	61%	23,086	13,833	16,836,304	$174,933.97	$ 468,268	$ 8,647,456	$ 122,022	$ 9,412,680	$ 4,848	$ 12,976	$ 239,634	$ 3,381	$ 260,839
2079	61%	23,245	13,880	17,644,446	$174,933.97	$ 471,499	$ 9,062,534	$ 122,437	$ 9,831,404	$ 4,531	$ 12,211	$ 234,707	$ 3,171	$ 254,619
2080	61%	23,406	13,927	18,491,380	$174,933.97	$ 474,752	$ 9,497,536	$ 122,853	$ 10,270,075	$ 4,234	$ 11,491	$ 229,881	$ 2,974	$ 248,580
2081	61%	23,567	13,974	19,378,966	$174,933.97	$ 478,028	$ 9,953,418	$ 123,271	$ 10,729,651	$ 3,957	$ 10,813	$ 225,155	$ 2,788	$ 242,714
2082	61%	23,730	14,022	20,309,156	$174,933.97	$ 481,326	$ 10,431,182	$ 123,690	$ 11,211,132	$ 3,698	$ 10,176	$ 220,525	$ 2,615	$ 237,014
2083	61%	23,893	14,069	21,283,996	$174,933.97	$ 484,648	$ 10,931,879	$ 124,111	$ 11,715,571	$ 3,456	$ 9,576	$ 215,991	$ 2,452	$ 231,475
2084	61%	24,058	14,117	22,305,628	$174,933.97	$ 487,992	$ 11,456,609	$ 124,533	$ 12,244,067	$ 3,230	$ 9,011	$ 211,550	$ 2,300	$ 226,091
2085	61%	24,224	14,165	23,376,298	$174,933.97	$ 491,359	$ 12,006,526	$ 124,956	$ 12,797,775	$ 3,019	$ 8,480	$ 207,200	$ 2,156	$ 220,855
2086	61%	24,391	14,213	24,498,360	$174,933.97	$ 494,749	$ 12,582,839	$ 125,381	$ 13,377,903	$ 2,821	$ 7,979	$ 202,940	$ 2,022	$ 215,763
2087	61%	24,560	14,262	25,674,281	$174,933.97	$ 498,163	$ 13,186,815	$ 125,807	$ 13,985,719	$ 2,637	$ 7,509	$ 198,768	$ 1,896	$ 210,810
2088	61%	24,729	14,310	26,906,647	$174,933.97	$ 501,600	$ 13,819,783	$ 126,235	$ 14,622,552	$ 2,464	$ 7,066	$ 194,681	$ 1,778	$ 205,990
2089	61%	24,900	14,359	28,198,166	$174,933.97	$ 505,061	$ 14,483,132	$ 126,664	$ 15,289,791	$ 2,303	$ 6,649	$ 190,678	$ 1,668	$ 201,298
2090	61%	25,072	14,408	29,551,678	$174,933.97	$ 508,546	$ 15,178,322	$ 127,095	$ 15,988,897	$ 2,152	$ 6,257	$ 186,758	$ 1,564	$ 196,731
2091	61%	25,245	14,457	30,970,158	$174,933.97	$ 512,055	$ 15,906,882	$ 127,527	$ 16,721,398	$ 2,012	$ 5,888	$ 182,918	$ 1,466	$ 192,284
2092	61%	25,419	14,506	32,456,726	$174,933.97	$ 515,588	$ 16,670,412	$ 127,960	$ 17,488,895	$ 1,880	$ 5,541	$ 179,157	$ 1,375	$ 187,953
2093	61%	25,594	14,555	34,014,649	$174,933.97	$ 519,146	$ 17,470,592	$ 128,396	$ 18,293,067	$ 1,757	$ 5,214	$ 175,473	$ 1,290	$ 183,734
2094	61%	25,771	14,605	35,647,352	$174,933.97	$ 522,728	$ 18,309,180	$ 128,832	$ 19,135,675	$ 1,642	$ 4,907	$ 171,865	$ 1,209	$ 179,623
2095	100%	25,949	14,654	37,358,425	$286,777.00	$ 862,844	$ 31,455,772	$ 211,918	$ 32,817,312	$ 2,516	$ 7,570	$ 275,954	$ 1,859	$ 287,898
TOTAL		1,459,468	925,812	786,427,011	$ 6,796,615	$ 17,299,953	$ 323,402,906	$ 4,615,290	$ 352,114,764	$ 959,137	$ 1,979,195	$ 12,289,734	$ 588,888	$ 15,816,954

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Appendix E.
Annual Expected Economic Loss – Severe Storm

					Undiscounted					Discounted (FAA rate)				
Year	Runway 7/25 Flood Annual Chance	Commercial	Charter (Non-scheduled Air Taxi)	Commercial Enplanements	Airport Costs	Airline Costs	Commercial Passeneger Costs	General Aviation	Total Undiscounted	Airport Costs	Airline Costs	Commercial Passeneger Costs	General Aviation	Total Discounted
2025	21%	14,885	10,334	1,403,133	$ 204,205	$ 267,791	$ 369,635	$ 44,833	$ 886,465	$ 204,205	$ 267,791	$ 369,635	$ 44,833	$ 886,465
2026	21%	15,032	11,700	1,470,483	$ 204,205	$ 270,436	$ 387,378	$ 50,759	$ 912,778	$ 190,846	$ 252,744	$ 362,036	$ 47,438	$ 853,064
2027	21%	15,500	11,740	1,541,066	$ 204,205	$ 278,856	$ 405,972	$ 50,932	$ 939,965	$ 178,361	$ 243,563	$ 354,592	$ 44,486	$ 821,001
2028	21%	15,857	11,780	1,615,038	$ 204,205	$ 285,269	$ 425,459	$ 51,105	$ 966,038	$ 166,692	$ 232,865	$ 347,301	$ 41,717	$ 788,575
2029	21%	16,221	11,820	1,692,559	$ 204,205	$ 291,831	$ 445,881	$ 51,279	$ 993,196	$ 155,787	$ 222,636	$ 340,160	$ 39,120	$ 757,704
2030	21%	16,594	11,860	1,773,802	$ 204,205	$ 298,543	$ 467,283	$ 51,453	$ 1,021,484	$ 145,595	$ 212,857	$ 333,166	$ 36,685	$ 728,304
2031	21%	16,830	11,900	1,858,945	$ 204,205	$ 302,783	$ 489,713	$ 51,627	$ 1,048,328	$ 136,070	$ 201,757	$ 326,316	$ 34,401	$ 698,545
2032	21%	16,939	11,920	1,948,174	$ 204,205	$ 304,751	$ 513,219	$ 51,715	$ 1,073,890	$ 127,169	$ 189,784	$ 319,607	$ 32,205	$ 668,765
2033	21%	17,050	11,940	2,041,686	$ 204,205	$ 306,732	$ 537,853	$ 51,802	$ 1,100,593	$ 118,849	$ 178,521	$ 313,036	$ 30,150	$ 640,555
2034	21%	17,160	11,961	2,139,687	$ 204,205	$ 308,726	$ 563,670	$ 51,891	$ 1,128,492	$ 111,074	$ 167,926	$ 306,599	$ 28,225	$ 613,825
2035	21%	17,272	11,981	2,242,392	$ 204,205	$ 310,733	$ 590,727	$ 51,979	$ 1,157,643	$ 103,807	$ 157,961	$ 300,296	$ 26,423	$ 588,487
2036	21%	17,300	12,000	2,350,027	$ 204,205	$ 311,239	$ 619,081	$ 52,061	$ 1,186,586	$ 97,016	$ 147,867	$ 294,121	$ 24,734	$ 563,738
2037	21%	17,419	12,041	2,462,828	$ 204,205	$ 313,386	$ 648,797	$ 52,238	$ 1,218,626	$ 90,669	$ 139,147	$ 288,074	$ 23,194	$ 541,085
2038	21%	17,540	12,082	2,581,044	$ 204,205	$ 315,549	$ 679,940	$ 52,415	$ 1,252,109	$ 84,738	$ 130,942	$ 282,151	$ 21,750	$ 519,581
2039	21%	17,661	12,123	2,704,934	$ 204,205	$ 317,726	$ 712,577	$ 52,593	$ 1,287,101	$ 79,194	$ 123,220	$ 276,350	$ 20,397	$ 499,160
2040	21%	17,782	12,164	2,834,771	$ 204,205	$ 319,918	$ 746,780	$ 52,772	$ 1,323,676	$ 74,013	$ 115,953	$ 270,668	$ 19,127	$ 479,761
2041	21%	17,900	12,200	2,970,840	$ 204,205	$ 322,033	$ 782,626	$ 52,928	$ 1,361,793	$ 69,171	$ 109,084	$ 265,102	$ 17,929	$ 461,286
2042	21%	18,024	12,241	3,113,441	$ 204,205	$ 324,255	$ 820,192	$ 53,108	$ 1,401,761	$ 64,646	$ 102,651	$ 259,652	$ 16,813	$ 443,761
2043	21%	18,148	12,283	3,262,886	$ 204,205	$ 326,493	$ 859,561	$ 53,289	$ 1,443,548	$ 60,417	$ 96,597	$ 254,313	$ 15,766	$ 427,094
2044	21%	18,273	12,325	3,419,504	$ 204,205	$ 328,745	$ 900,820	$ 53,470	$ 1,487,241	$ 56,464	$ 90,901	$ 249,084	$ 14,785	$ 411,234
2045	21%	18,399	12,367	3,583,640	$ 204,205	$ 331,014	$ 944,059	$ 53,652	$ 1,532,930	$ 52,770	$ 85,540	$ 243,963	$ 13,865	$ 396,138
2046	21%	18,526	12,409	3,755,655	$ 204,205	$ 333,298	$ 989,374	$ 53,834	$ 1,580,711	$ 49,318	$ 80,496	$ 238,947	$ 13,002	$ 381,762
2047	21%	18,654	12,451	3,935,927	$ 204,205	$ 335,598	$ 1,036,864	$ 54,017	$ 1,630,684	$ 46,092	$ 75,749	$ 234,034	$ 12,192	$ 368,067
2048	21%	18,783	12,493	4,124,851	$ 204,205	$ 337,913	$ 1,086,634	$ 54,201	$ 1,682,953	$ 43,076	$ 71,282	$ 229,222	$ 11,434	$ 355,014
2049	21%	18,912	12,536	4,322,844	$ 204,205	$ 340,245	$ 1,138,792	$ 54,385	$ 1,737,627	$ 40,258	$ 67,078	$ 224,509	$ 10,722	$ 342,567
2050	21%	19,043	12,578	4,530,340	$ 204,205	$ 342,592	$ 1,193,454	$ 54,570	$ 1,794,822	$ 37,625	$ 63,122	$ 219,893	$ 10,055	$ 330,694
2051	21%	19,174	12,621	4,747,797	$ 204,205	$ 344,956	$ 1,250,740	$ 54,756	$ 1,854,657	$ 35,163	$ 59,400	$ 215,372	$ 9,429	$ 319,364
2052	21%	19,306	12,664	4,975,691	$ 204,205	$ 347,337	$ 1,310,775	$ 54,942	$ 1,917,259	$ 32,863	$ 55,897	$ 210,944	$ 8,842	$ 308,545
2053	21%	19,440	12,707	5,214,524	$ 204,205	$ 349,733	$ 1,373,693	$ 55,129	$ 1,982,760	$ 30,713	$ 52,601	$ 206,606	$ 8,291	$ 298,211
2054	21%	19,574	12,750	5,464,821	$ 204,205	$ 352,146	$ 1,439,630	$ 55,316	$ 2,051,297	$ 28,704	$ 49,499	$ 202,358	$ 7,775	$ 288,336
2055	21%	19,709	12,794	5,727,133	$ 204,205	$ 354,576	$ 1,508,732	$ 55,504	$ 2,123,018	$ 26,826	$ 46,580	$ 198,198	$ 7,291	$ 278,895
TOTAL TO 2055		548,906	376,765	95,810,466	$ 6,330,357	$ 9,875,205	$ 25,239,912	$ 1,634,555	$ 43,080,028	$ 2,738,194	$ 4,092,010	$ 8,536,304	$ 693,076	$ 16,059,584
2056	21%	19,845	12,837	6,002,035	$ 204,205	$ 357,023	$ 1,581,151	$ 55,693	$ 2,198,072	$ 25,071	$ 43,833	$ 194,123	$ 6,838	$ 269,864
2057	21%	19,982	12,881	6,290,133	$ 204,205	$ 359,486	$ 1,657,047	$ 55,882	$ 2,276,620	$ 23,431	$ 41,248	$ 190,131	$ 6,412	$ 261,222
2058	21%	20,120	12,925	6,592,059	$ 204,205	$ 361,967	$ 1,736,585	$ 56,072	$ 2,358,829	$ 21,898	$ 38,815	$ 186,222	$ 6,013	$ 252,948
2059	21%	20,258	12,969	6,908,478	$ 204,205	$ 364,464	$ 1,819,941	$ 56,263	$ 2,444,873	$ 20,465	$ 36,526	$ 182,393	$ 5,639	$ 245,024
2060	21%	20,398	13,013	7,240,085	$ 204,205	$ 366,979	$ 1,907,298	$ 56,454	$ 2,534,936	$ 19,126	$ 34,372	$ 178,643	$ 5,288	$ 237,430
2061	21%	20,539	13,057	7,587,609	$ 204,205	$ 369,511	$ 1,998,848	$ 56,646	$ 2,629,211	$ 17,875	$ 32,345	$ 174,970	$ 4,959	$ 230,149
2062	21%	20,681	13,101	7,951,814	$ 204,205	$ 372,061	$ 2,094,793	$ 56,839	$ 2,727,898	$ 16,706	$ 30,438	$ 171,373	$ 4,650	$ 223,166
2063	21%	20,823	13,146	8,333,501	$ 204,205	$ 374,628	$ 2,195,343	$ 57,032	$ 2,831,208	$ 15,613	$ 28,643	$ 167,849	$ 4,360	$ 216,465
2064	21%	20,967	13,191	8,733,509	$ 204,205	$ 377,213	$ 2,300,720	$ 57,226	$ 2,939,363	$ 14,591	$ 26,954	$ 164,398	$ 4,089	$ 210,032
2065	21%	21,112	13,235	9,152,718	$ 204,205	$ 379,816	$ 2,411,154	$ 57,420	$ 3,052,595	$ 13,637	$ 25,364	$ 161,018	$ 3,835	$ 203,853
2066	21%	21,257	13,280	9,592,048	$ 204,205	$ 382,436	$ 2,526,890	$ 57,616	$ 3,171,147	$ 12,745	$ 23,868	$ 157,707	$ 3,596	$ 197,916
2067	21%	21,404	13,326	10,052,467	$ 204,205	$ 385,075	$ 2,648,180	$ 57,812	$ 3,295,272	$ 11,911	$ 22,461	$ 154,465	$ 3,372	$ 192,209
2068	21%	21,552	13,371	10,534,985	$ 204,205	$ 387,732	$ 2,775,293	$ 58,008	$ 3,425,238	$ 11,132	$ 21,136	$ 151,289	$ 3,162	$ 186,719
2069	21%	21,701	13,416	11,040,664	$ 204,205	$ 390,408	$ 2,908,507	$ 58,205	$ 3,561,325	$ 10,404	$ 19,890	$ 148,178	$ 2,965	$ 181,437
2070	21%	21,850	13,462	11,570,616	$ 204,205	$ 393,101	$ 3,048,115	$ 58,403	$ 3,703,825	$ 9,723	$ 18,717	$ 145,131	$ 2,781	$ 176,352
2071	21%	22,001	13,508	12,126,006	$ 204,205	$ 395,814	$ 3,194,425	$ 58,602	$ 3,853,045	$ 9,087	$ 17,613	$ 142,147	$ 2,608	$ 171,455
2072	21%	22,153	13,554	12,708,054	$ 204,205	$ 398,545	$ 3,347,757	$ 58,801	$ 4,009,308	$ 8,492	$ 16,574	$ 139,225	$ 2,445	$ 166,737
2073	21%	22,306	13,600	13,318,041	$ 204,205	$ 401,295	$ 3,508,450	$ 59,001	$ 4,172,950	$ 7,937	$ 15,597	$ 136,362	$ 2,293	$ 162,189
2074	21%	22,460	13,646	13,957,307	$ 204,205	$ 404,064	$ 3,676,855	$ 59,202	$ 4,344,326	$ 7,418	$ 14,677	$ 133,558	$ 2,150	$ 157,804
2075	61%	22,615	13,692	14,627,257	$ 593,167	$ 1,181,808	$ 11,193,047	$ 172,551	$ 13,140,573	$ 20,137	$ 40,120	$ 379,979	$ 5,858	$ 446,093
SUBTOTAL TO 2075		972,930	1,018,740	385,940,320	$ 17,133,776	$ 28,153,836	$ 109,010,223	$ 4,532,837	$ 158,830,672	$ 5,773,785	$ 8,733,214	$ 20,531,770	$ 1,469,463	$ 36,508,232
2076	61%	22,771	13,739	15,329,366	$ 593,167	$ 1,189,962	$ 11,730,313	$ 173,138	$ 13,686,581	$ 18,819	$ 37,754	$ 372,166	$ 5,493	$ 434,232
2077	61%	22,928	13,786	16,065,175	$ 593,167	$ 1,198,173	$ 12,293,369	$ 173,727	$ 14,258,435	$ 17,588	$ 35,527	$ 364,514	$ 5,151	$ 422,781
2078	61%	23,086	13,833	16,836,304	$ 593,167	$ 1,206,441	$ 12,883,450	$ 174,317	$ 14,857,375	$ 16,438	$ 33,432	$ 357,020	$ 4,831	$ 411,720
2079	61%	23,245	13,880	17,644,446	$ 593,167	$ 1,214,765	$ 13,501,856	$ 174,910	$ 15,484,698	$ 15,362	$ 31,461	$ 349,679	$ 4,530	$ 401,032
2080	61%	23,406	13,927	18,491,380	$ 593,167	$ 1,223,147	$ 14,149,945	$ 175,505	$ 16,141,763	$ 14,357	$ 29,605	$ 342,489	$ 4,248	$ 390,700
2081	61%	23,567	13,974	19,378,966	$ 593,167	$ 1,231,587	$ 14,829,142	$ 176,101	$ 16,829,997	$ 13,418	$ 27,860	$ 335,447	$ 3,984	$ 380,708
2082	61%	23,730	14,022	20,309,156	$ 593,167	$ 1,240,085	$ 15,540,941	$ 176,700	$ 17,550,893	$ 12,540	$ 26,217	$ 328,550	$ 3,736	$ 371,043
2083	61%	23,893	14,069	21,283,996	$ 593,167	$ 1,248,641	$ 16,286,906	$ 177,301	$ 18,306,015	$ 11,720	$ 24,671	$ 321,795	$ 3,503	$ 361,689
2084	61%	24,058	14,117	22,305,628	$ 593,167	$ 1,257,257	$ 17,068,678	$ 177,904	$ 19,097,005	$ 10,953	$ 23,216	$ 315,179	$ 3,285	$ 352,633
2085	61%	24,224	14,165	23,376,298	$ 593,167	$ 1,265,932	$ 17,887,974	$ 178,509	$ 19,925,582	$ 10,236	$ 21,847	$ 308,698	$ 3,081	$ 343,862
2086	61%	24,391	14,213	24,498,360	$ 593,167	$ 1,274,667	$ 18,746,597	$ 179,115	$ 20,793,546	$ 9,567	$ 20,558	$ 302,351	$ 2,889	$ 335,365
2087	61%	24,560	14,262	25,674,281	$ 593,167	$ 1,283,462	$ 19,646,434	$ 179,724	$ 21,702,787	$ 8,941	$ 19,346	$ 296,135	$ 2,709	$ 327,131
2088	61%	24,729	14,310	26,906,647	$ 593,167	$ 1,292,318	$ 20,589,463	$ 180,336	$ 22,655,283	$ 8,356	$ 18,205	$ 290,046	$ 2,540	$ 319,148
2089	61%	24,900	14,359	28,198,166	$ 593,167	$ 1,301,235	$ 21,577,757	$ 180,949	$ 23,653,107	$ 7,809	$ 17,131	$ 284,083	$ 2,382	$ 311,406
2090	61%	25,072	14,408	29,551,678	$ 593,167	$ 1,310,213	$ 22,613,489	$ 181,564	$ 24,698,433	$ 7,298	$ 16,121	$ 278,242	$ 2,234	$ 303,895
2091	61%	25,245	14,457	30,970,158	$ 593,167	$ 1,319,254	$ 23,698,937	$ 182,181	$ 25,793,539	$ 6,821	$ 15,170	$ 272,521	$ 2,095	$ 296,607
2092	61%	25,419	14,506	32,456,726	$ 593,167	$ 1,328,357	$ 24,836,485	$ 182,801	$ 26,940,810	$ 6,375	$ 14,276	$ 266,917	$ 1,965	$ 289,533
2093	61%	25,594	14,555	34,014,649	$ 593,167	$ 1,337,522	$ 26,028,637	$ 183,422	$ 28,142,748	$ 5,958	$ 13,434	$ 261,429	$ 1,842	$ 282,663
2094	61%	25,771	14,605	35,647,352	$ 593,167	$ 1,346,751	$ 27,278,011	$ 184,046	$ 29,401,975	$ 5,568	$ 12,642	$ 256,054	$ 1,728	$ 275,992
2095	100%	25,949	14,654	37,358,425	$ 972,405	$ 2,223,023	$ 46,864,518	$ 302,740	$ 50,362,686	$ 8,531	$ 19,502	$ 411,131	$ 2,656	$ 441,819
TOTAL		2,008,374	1,302,578	882,237,476	29,376,355	54,446,625	507,063,124	8,227,826	599,113,931	5,990,441	9,191,188	26,846,217	1,534,344	43,562,190

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