Economic Benefits of MCWRA’s Investments in Water Infrastructure Projects for Salinas Valley

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Executive Summary

Introduction

This report presents the economic benefits associated with Monterey County Water Resources Agency's (MCWRA's) investments and management of water resource infrastructure in California's Salinas Valley. The analysis presented herein focuses on the economic benefits that have accrued to Salinas Valley stakeholders over a 51-year analysis period (1968 to 2018) from the construction and operation of the Nacimiento and San Antonio Reservoirs, the Castroville Seawater Intrusion Project (CSIP), and the Salinas Valley Water Project (SVWP, collectively, the Projects, Figure ES-1). It demonstrates the important effects that the Projects have had on the system and is intended to inform MCWRA's future assessments on stakeholders within the basin.

Figure ES-1. Summary of MCWRA Infrastructure Projects

MCWRA completed construction of **Nacimiento Dam/Reservoir** in 1957 and **San Antonio Dam/Reservoir** in 1967. The reservoirs retain more water in the Basin by capturing high winter flows and releasing them in the summer when recharge potential along the Salinas River is at its highest. Both facilities provide flood control and recreational benefits, and are operated to ensure adequate instream flows for fish and wildlife habitat. MCWRA also operates a four-megawatt hydroelectric power plant at Nacimiento Dam.

CSIP is a pipeline system that distributes recycled wastewater from the Monterey One Water Regional Treatment Plant, rediverted stored reservoir water, and groundwater to agricultural users. CSIP reduces groundwater pumping by providing an alternative supply, thereby increasing groundwater storage and slowing seawater intrusion. CSIP became operational in 1998.

The **SVWP** included modification of the spillway at Nacimiento Reservoir and installation of an inflatable dam along the Salinas River, the **Salinas River Diversion Facility (SRDF)**. The SRDF began operation in 2010; it allows for the rediversion of stored reservoir water into CSIP for use on irrigated lands, further offsetting the need for groundwater pumping near the coast. CSIP and SVWP provide a water supply that supports agricultural production on more than 12,000 acres of irrigated land.

The economic benefits evaluated as part of this report include:

- Avoided replacement of wells due to depleted groundwater levels and seawater intrusion
- Avoided costs resulting from reductions in overall groundwater pumping and decreased depth to groundwater, which in turn reduces pumping lift requirements (and associated pumping costs)
- Reduced flood risk and associated damages to buildings, structure, and agriculture
- Active and passive reservoir-related recreation opportunities
- Generation of hydropower

This report serves as an update to the "Salinas Valley Historical Benefits Analysis" (HBA), which was developed for MCWRA in 1998 to assess the benefits provided by Nacimiento and San Antonio Reservoirs. Since the original HBA, MCWRA has significantly changed its approach to managing water resources in the Salinas Valley. This has included the development of additional infrastructure and operational changes intended to further stabilize groundwater levels, reduce seawater intrusion, ensure adequate instream flows in the Salinas River for wildlife migration and habitat, and provide enhanced protection from flooding. This updated HBA accounts for the benefits associated with MCWRA's current infrastructure and operations and takes advantage of new tools, data, and knowledge that have been developed over the last 26 years. It also expands the range of benefits evaluated under the original HBA.

One Water Econ conducted this assessment in coordination with MCWRA and West Yost Associates, Inc. (West Yost), a hydrologic engineering consulting firm. West Yost has prepared a separate, complementary report that provides extensive detail on the hydrologic modeling and related physical benefits associated with MCWRA's water resource infrastructure and management. Together, these reports provide a comprehensive update to the 1998 HBA. West Yost's modeling and analysis served as key inputs into this economic assessment.

Study area

The study area for this HBA Update is MCWRA Assessment Zone 2C, which falls within the Salinas Valley in California's Central Coast region between the San Joaquin Valley and the Pacific Ocean. Figure ES-2 shows the MCWRA-defined groundwater subareas that make up Zone 2C. These aquifers serve as the primary source of water supply in the region.

Figure ES-2. MCWRA Zone 2C subareas

Both agricultural and municipal users place heavy demands on groundwater in the Salinas Valley. Agriculture is responsible for the greatest use of groundwater, accounting for approximately 90% of total metered pumping on an annual basis. Over the last several decades, groundwater pumping has exceeded the capability of the natural system to replenish aquifers in some parts of the Salinas Valley, exacerbating seawater intrusion and decreasing groundwater storage. The projects and programs that MCWRA has constructed in the study area have sought to address this imbalance.

Approach

This report compares the effects of the Projects against a scenario in which they had not been constructed. The Historical Scenario represents actual conditions within the Salinas Valley from October 1967 to September 2018. The Historical Scenario models incorporate projects and programs related to the San Antonio and Nacimiento Reservoirs during the period of their operation, with both reservoirs in operation throughout the model simulation period. The effect of raising the Nacimiento Dam spillway elevation (part of the SVWP) is included in the time series of reservoir releases beginning in 2009. Recycled water deliveries through CSIP are modeled beginning in 1998, while SRDF deliveries of rediverted stored reservoir water begin in 2010.

The No Projects Scenario removes the reservoirs and other MCWRA projects and management modifications from the Historical Scenario to simulate "without project" conditions. The difference in outcomes between the Historical and No Projects Scenarios is taken to represent the benefits associated with the construction and operation of the Projects.

Most of the benefits evaluated in this report are closely linked to the hydrologic and flood risk reduction benefits reported by West Yost in the HBA Update and can be monetized using avoided cost analysis. Some benefits, such as recreation benefits, can be more difficult to monetize because they are not bought and sold in a market and therefore do not have a directly observable market price. Economists have developed several methods for valuing these and other "non-market" goods and services. For this analysis, the project team valued non-market benefits using a secondary research approach called benefits transfer. Benefits transfer relies on values reported in the literature from primary or original valuation studies to estimate the potential value of non-market benefits for a specific study site.

Key findings

The HBA Update confirms that the Projects have resulted in significant hydrologic benefits, including increased fresh groundwater storage and reduced flooding across the Salinas Valley. This in turn has resulted in the following economic benefits:

- Higher groundwater levels have reduced the need to replace groundwater wells. This has avoided more than $107.4 million in well replacement costs over the 51-year analysis period (1968 to 2018), for an average annual benefit of $2.1 million.
- Higher groundwater levels have also reduced the energy required to pump groundwater in many areas, and in combination with deliveries from the CSIP and SVWP, have reduced overall groundwater pumping for irrigation. This has saved $67.9 million in groundwater pumping costs over the analysis period, for an average annual benefit of $1.3 million per year.
- The increase in fresh groundwater storage in Basin aquifers has decreased seawater intrusion from Monterey Bay. The HBA Update reports that seawater intrusion has been approximately 1,000 AFY lower in the Pressure Subarea than it would have been without the Projects. Assuming an average applied water rate of 2.0 acre-feet/acre, seawater intrusion under the No Projects scenario would have affected approximately 500 acres of farmland each year, with impacts to crops ranging from $21.7 to $86.9 M. This benefit has largely accrued to growers beginning in 1998, coinciding with deliveries of recycled water from CSIP.

- The reservoirs substantially reduced flooding along the Salinas River floodplain and the land and structures found there. This has resulted in avoided damages to buildings totaling $210.5 million over the study period, $4.1 million per year on average. The value of avoided flood damages to agricultural crops is estimated to be $211.0 million over the 51-year analysis, or $4.1 per year.

In addition to hydrologic and flood risk reduction benefits, the reservoirs have generated close to $800 million in recreational benefits between 1985 and 2018, an average annual benefit of $24 million. Between 1987 and 2018, Nacimiento dam generated 326 MWh of power, for a total value of $59.1 million. The generation of clean hydropower resulted in $16.0 million in avoided health-related costs from 1987 to 2018, an average annual benefit of $500,000. These benefits are further summarized in Table ES-1.

Table ES-1. Summary of Economic Benefits, MCWRA Water Resource Infrastructure and Management

Benefit	Project benefits		
	Description	Average annual value ($M)	Total value (51-year period, $M)
Water supply			
Avoided well replacement costs	Avoided construction/ replacement of 63 irrigation wells and 6 municipal wells	$2.11	$107.4
Avoided costs from reduced agricultural pumping and pumping lift	Avoided 498,100 AF of groundwater pumping. Increased well groundwater levels for by 4.5 feet on average.	$1.3	$67.9
Reduced seawater intrusion	Decreased seawater intrusion by approximately 68,000 AF.	Mostly occurred after 1998 (CSIP)	$53.6 (with range of $21.8 M to 86.9 M)
Flood risk reduction			
Avoided Damages to Buildings and Structures	Reduced flood damages to buildings, contents, and vehicles. Avoided damages to 210 - 457 buildings for 10- and 100-year flood events.	$4.13	$210.5
Avoided damages to agricultural crops	Reduces inundated acres by up to 16,496 (10-year event), thereby reducing revenue losses, damages, and re-establishment/clean up costs.	$4.14	$211.0
Recreation			
	64 M user days to Nacimiento and San Antonio Lakes, 1985 - 2018	$23.5 (over 34-years)	$797.4

Table ES-1 (continued)

Benefit	Project benefits		
	Description	Average annual value ($M)	Total value (51-year period, $M)
Hydropower			
Power generation	Nacimiento's hydroelectric power plant generated 9,833 MWh per year, 1987 to 2022 (average)	$1.85 (value of hydropower generated).	$59.1 (value of hydropower generated).
Avoided pollutant emissions	Projects avoided emissions of key air pollutants due to cleaner power source: 58 MT of NO_x, 24 MT of SO_2, 6 MT of $PM_{2.5}$, and 79,500 MT of CO_{2e} from 1987 - 2018.	$0.5	$16.0

1. Introduction and Background

This report presents an assessment of the economic benefits provided to stakeholders in California's Salinas Valley from construction and operation of Nacimiento and San Antonio Reservoirs, the Castroville Seawater Intrusion Project (CSIP), and the Salinas Valley Water Project (SVWP). It serves as an update to the "Salinas Valley Historical Benefits Analysis" (HBA), which was developed for the Monterey County Water Resources Agency (Agency, or MCWRA) in 1998 to assess the benefits provided by Nacimiento and San Antonio Reservoirs.

The analysis presented in this report focuses on the economic benefits associated with MCWRA's water infrastructure and management within the Salinas Valley, presenting benefits in monetary terms. One Water Econ conducted this assessment in coordination with MCWRA and West Yost Associates, Inc. (West Yost), a hydrologic engineering consulting firm. West Yost has prepared a separate, complementary report that provides extensive detail on the hydrologic modeling and related physical benefits associated with MCWRA's water resource infrastructure and management. Together, these reports provide a comprehensive update to the 1998 HBA. West Yost's modeling and analysis served as key inputs into this economic assessment.

1.1 Study purpose

Since the original HBA, MCWRA has significantly changed its approach to managing water resources in the Salinas Valley. This has included the development of additional infrastructure and operational changes intended to further stabilize groundwater levels, reduce seawater intrusion, ensure adequate instream flows in the Salinas River for wildlife migration and habitat, and provide enhanced protection from flooding. This updated HBA accounts for the benefits associated with MCWRA's current infrastructure and operations and takes advantage of new tools, data, and knowledge that have been developed over the last 26 years. It also expands the range of benefits evaluated under the original HBA.

Specifically, this report presents the economic benefits that have accrued to Salinas Valley stakeholders over a 51-year analysis period (1968 to 2018) from the construction and operation of the Nacimiento and San Antonio Reservoirs, CSIP, and SVWP (collectively, the Projects). The analysis quantifies and monetizes benefits related to water supply, flood risk reduction, recreation, and hydropower, and identifies to whom these benefits accrue. It demonstrates the important effects that the Projects have had on the system and is intended to inform MCWRA's future assessments on stakeholders within the basin.

1.2 Study area

The study area for this HBA Update is MCWRA Assessment Zone 2C, which falls within the Salinas Valley in California's Central Coast region between the San Joaquin Valley and the Pacific Ocean (Figure 1).

1.2.1 Overview

The Salinas Valley stretches along the Salinas River from its headwaters in San Luis Obispo County to its outlet to the Pacific Ocean at Monterey Bay, approximately 170 miles north near the town of Marina. This study concentrates on the portion of the watershed (known as Zone 2C) located north of San Miguel (near the Monterey and San Luis Obispo County border), where the Salinas Valley narrows after passing through the Paso Robles Basin.

Figure 1. Salinas Valley HBA Update study area

Within the study area, the Salinas River flows north-northwest through a valley between the Gabilan and Diablo Mountain Ranges (on the northeast side) and the Santa Lucia and Sierra de Salinas Mountain Ranges (to the southwest). Major tributaries within the study area include the Nacimiento River (on which Nacimiento Reservoir lies), the San Antonio River (on which San Antonio Reservoir lies), San Lorenzo Creek, Arroyo Seco, Alisal Creek, and El Toro Creek. The study area also includes some areas outside of the Salinas River watershed that are tributary to Elkhorn Slough and Monterey Bay. The Nacimiento and San Antonio Reservoirs are located at the southern end of the study area, within the Santa Lucia range.

Agriculture is the dominant land use within the study area. In 2022, the total value of agricultural production in Monterey County amounted to more than $5 billion, representing the third highest gross agricultural output among California counties. This value includes sales of vegetables and other high value crops from more than 300,000 irrigated acres,[i] much of which is located within the Salinas Valley. In the upstream portion of the study area (closer to the reservoirs), grazing and pasturelands are common, although an increasing amount of this area has been converted to vineyards in recent years. In the lower part of the watershed (closer to the Bay), groundwater is used for agricultural irrigation of lettuce, broccoli, artichokes, strawberries, cauliflower, and other fruits and vegetables.

Cities and unincorporated communities within the study area include Bradley, Castroville, Chualar, Gonzales, Greenfield, King City, Marina, Salinas, San Ardo, San Lucas, and Soledad. The population of these communities totaled approximately 257,900 in 2022, accounting for 60% of the total population in Monterey County.[ii] Salinas is by far the largest city in the study area, with just over 160,000 people. Both agricultural and municipal users place heavy demands on groundwater in the Salinas Valley and it is the dominant source of water in the region. Agriculture is responsible for the greatest use of groundwater, accounting for approximately 90% of total metered pumping on an annual basis.[iii]

1.2.2 Hydrologic setting

According to the California Department of Water Resources (DWR), several groundwater subbasins underlie the study area: the 180/400 Foot Aquifers and East Side Aquifer largely comprise the northern portion, the Forebay Aquifer underlies the central portion, and the Upper Valley Aquifer is located at the southern end. Three small subbasins, Langley Area, Seaside, and Monterey, also underlie portions of the north and northwest study area. MCWRA subdivides the Basin somewhat differently than DWR. Figure 2 shows the MCWRA-defined groundwater subareas that make up Zone 2C, including the Pressure, East Side, Forebay, Arroyo Seco, Upper Valley, and Below Dam Subareas. This HBA Update presents results based on MCWRA's Zone 2C Subarea definitions.

West Yost's accompanying report: *Salinas Valley Historical Benefits Analysis Update (2024)* contains a detailed description of the hydrological characteristics of the study area. In general, the Salinas River loses water to the Basin aquifers throughout the study area. However, natural replenishment of the Salinas Valley's underlying groundwater resources varies depending on location. The northern portion of the study area (lower watershed area) is characterized by a series of confined to semi-confined aquifers.

Figure 2. MCWRA Zone 2C subareas

Aquifers in this region (i.e., the Pressure subarea) are generally replenished by groundwater flows from further up the watershed, which in turn, are heavily influenced by percolation within the channels of the Salinas River and its tributaries. Replenishment of the East Side Subarea comes primarily from percolation of streams on the west side of the Gabilan Range. In the Forebay Subarea, sources of natural replenishment include groundwater outflow from the Upper Valley Subarea and, importantly, percolation from the Salinas River. The Upper Valley Subarea is primarily replenished through stream channel percolation from the Salinas River and its tributaries,[iv] but also receives some runoff from nearby mountain ranges and infiltration from precipitation.

Portions of the Basin have been in a condition of overdraft for decades due to its long history of intense irrigated agriculture, a near-total reliance on groundwater, and its complex hydrogeology. Overdraft has resulted in reductions in groundwater storage, depressed groundwater levels in all major water supply aquifers, and extensive seawater intrusion into the Basin. Manifestations of these issues occur most prominently in the northern part of the Basin, specifically the Pressure and East Side Subareas, where natural replenishment of depleted aquifers from the Salinas River is limited. DWR has categorized the non-adjudicated portions of the Basin as Medium or High Priority, and the 180/400 Foot Aquifer Subbasin as critically overdrafted.[1,v]

1.2.3 Water resources development

The development of water resources in the Salinas Valley has largely been driven by demand from irrigated agriculture, which increased over the course of the 20th century as irrigated acreage significantly expanded. According to West Yost, total groundwater pumping in MCWRA Zone 2C increased from approximately 400,000 acre-feet per year (AFY) in 1949 to a peak of 600,000 AFY by 1959. Declining groundwater levels during this period, especially in the northern part of the Basin, indicated that groundwater pumping was increasing beyond the capability of the natural system to replenish the aquifers, exacerbating seawater intrusion and decreasing groundwater storage. The projects and programs that MCWRA has constructed in the study area have sought to address this imbalance.

MCWRA completed construction of Nacimiento Dam in 1957, impounding the Nacimiento River and creating Nacimiento Reservoir with a maximum storage capacity of 377,900 AF. San Antonio Dam/Reservoir was completed in 1967 and has a maximum storage capacity of 335,000 AF. The reservoirs retain more water in the Basin by capturing high flows behind the dams in winter when they would otherwise flow out to the ocean, and releasing them in the summer when the recharge potential along the Salinas River is at its highest. Both facilities provide flood control benefits and recreation opportunities, and are operated to ensure adequate instream flows for key fisheries. MCWRA also operates a four-megawatt hydroelectric power plant at Nacimiento Dam. The completion of the Nacimiento and San Antonio Reservoirs led to a reversal of groundwater storage losses in the Forebay and Upper Valley Subareas (except during extended dry periods), but not in the Pressure and East Side Subareas. This is largely because of the spatial variability in the connection between the Salinas River and the underlying aquifers (see Section 1.2.2).

To help address seawater intrusion in the northern/coastal portion of the study area, MCWRA constructed the CSIP, a pipeline system that distributes recycled wastewater from the Monterey One Water Regional

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[1] The boundaries of the 180/400 Foot Aquifer Subbasin (classified by DWR) are similar to the boundaries of MCWRA's Pressure Subarea, although they do not fully overlap.

Treatment Plant, rediverted stored reservoir water, and groundwater to agricultural users in the area around the town of Castroville. The intention of CSIP is to reduce groundwater pumping by providing an alternative supply, thereby increasing groundwater storage through in-lieu recharge and slowing the advancement of seawater intrusion. Construction of CSIP started in 1995 and recycled water deliveries started in 1998.

In a continued effort to combat seawater intrusion, the Agency constructed the SVWP, which consisted of modification of the spillway at Nacimiento Reservoir and installation of an inflatable dam along the Salinas River near the City of Marina, the Salinas River Diversion Facility (SRDF). The SRDF began operation in 2010; it allows for the rediversion of stored reservoir water into CSIP pipelines for use on irrigated agricultural lands, further offsetting the need for groundwater pumping near the coast. Together, CSIP and SVWP provide a water supply that supports agricultural production on more than 12,000 acres of irrigated land.

As conditions and infrastructure in the Basin have changed, MCWRA has also modified its approach to operating the Nacimiento and San Antonio Reservoirs. Important alterations have resulted from the infrastructure projects described above and the development of the Salinas Valley Water Project Flow Prescription for Steelhead Trout in the Salinas River (2005), which was required as a condition of the permit for the SVWP. The Flow Prescription focused on modifying operations to support the migration of endangered Steelhead trout and protect critical fish and wildlife habitat below the Nacimiento and San Antonio Dams. It has resulted in an increase in minimum releases from both reservoirs and a change in downstream flow targets, including an increase in total flow rates during the conservation program season.

1.3 1998 HBA

The 1998 HBA investigated the benefits to Basin stakeholders from the construction and operation of Nacimiento and San Antonio Reservoirs starting from when Nacimiento Reservoir first became operational in 1958 to 1994. The study quantified benefits by simulating conditions in the Basin with and without the reservoirs using then-current tools. The 1998 HBA expressed benefits in monetary terms to illustrate the value that Basin stakeholders have received from the reservoirs.

The original HBA reports that from 1958 to 1994, the reservoirs' ability to impound water during the winter wet period and release it during drier periods led to more water being kept within the Basin, increased groundwater recharge and storage, higher groundwater levels, less seawater intrusion, and reduced flooding. This in turn resulted in an estimated $11.8 million per year (1998 USD) in economic benefits to stakeholders in the Basin. In 2024 USD, this amounts to $22.7 million per year.

Specific findings from the 1998 HBA economic assessment include:

- Higher groundwater levels resulting from the increased freshwater storage lessened the need for the replacement or modification (e.g., deepening) of extraction wells in the Basin, particularly in the Upper Valley Subarea. This resulted in approximately $1.5 million per year in reduced pumping costs and $89,000 per year in reduced well modification costs. In 2024 USD, these values amount to $2.8 million and $172,000, respectively.
- The decreased extent of seawater intrusion prevented the salinization of dozens of extraction wells in the coastal area, which otherwise would likely have needed to be replaced with deeper

wells. This resulted in $241,000 ($465,000 in 2024 USD) per year in avoided well replacement costs.

- The reservoirs substantially reduced flooding along the Salinas River floodplain and the land and structures found there. This resulted in approximately $5.5 million per year in increased crop income and reduced repair costs, and $4.5 million per year in reduced damages to structures and buildings, on average. In 2024 USD, these benefits total $19.2 million.

Since the original HBA was published, new infrastructure projects and operational changes have improved water resource management within the study area. There have also been substantial improvements in MCWRA's understanding of the Basin, additional data collection, and improvements to the computational tools necessary for conducting this type of analysis. This HBA Economic Assessment Update relies on these improvements and updates to provide a revised characterization of the economic benefits of MCWRA's investments for Basin stakeholders.

2. Approach and Methods

This chapter describes the methods and approaches used to perform the HBA Economic Analysis Update. First, we describe the "with" and "without" project scenarios that serve as the basis for the analysis. We then provide an overview of the inputs and economic methods used to quantify and monetize the benefits of the Projects. Additional detail on methods and assumptions related to specific benefits of the Projects are provided in relevant Chapters 3 through 7.

2.1. Analysis scenarios

An initial step to undertaking any economic analysis is defining the relevant baseline. The baseline represents "without project conditions" which, in this instance, allows for a comparison of the effects of the Projects against a scenario in which they had not been constructed. Basing this HBA update analysis on a comparison of "with and without project" conditions aligns with the methodology utilized in the 1998 HBA. Consistent with West Yost's approach for Salinas Valley HBA Update (hereinafter referred to as the HBA Update), this HBA Economic Assessment Update refers to the "with" and "without" project scenarios as the Historical Scenario and the No Projects Scenario, respectively.

2.1.1 Historical Scenario

The Historical Scenario represents actual conditions within the Salinas Valley from October 1967 to September 2018, the period for which available modeling tools were calibrated at the time of this study. To simulate historical hydrologic and flood conditions over the analysis period, the HBA Update used the Salinas Valley Integrated Hydrologic Model (SVIHM, developed by the United States Geological Survey, USGS) and the U.S. Army Corps of Engineer's (USACE's) Salinas River HEC-RAS model (Hydrologic Engineering Center River Analysis System) model, with some modifications and additions.

The Historical Scenario models incorporate projects and programs related to the San Antonio and Nacimiento Reservoirs during the period of their operation, with both reservoirs in operation throughout the model simulation period. The effect of raising the Nacimiento Dam spillway elevation is included in the time series of reservoir releases beginning in 2009, when the spillway modifications were completed as part of the SVWP. Recycled water deliveries from the Monterey One Water Regional Treatment Plant through CSIP are modeled beginning in 1998, while SRDF deliveries of rediverted stored reservoir water begin in 2010.

2.1.2 No Projects Scenario

The No Projects Scenario fulfills the same purpose for the HBA Update as did the "without reservoirs" scenario used for the 1998 HBA. It includes the following modifications to the Historical Scenario model:

- **Removal of the reservoirs:** The Historical Scenario uses historical reservoir releases (reported by MCWRA) as the streamflow inputs for the Nacimiento and San Antonio Rivers. For the No Projects Scenario, the streamflow inputs at these locations are replaced by estimated historical reservoir inflows, which are based on streamflow data from USGS gages upstream of the reservoirs.
- **Removal of recycled water deliveries to CSIP area**: The SVIHM simulates recycled water deliveries to satisfy crop demands within the CSIP area. The volume of delivery, which began in 1998, is based on historical records provided by MCWRA. The No Projects Scenario sets these deliveries to zero.

- **Removal of increased Nacimiento Dam spillway elevation (part of SVWP)**: The modification of the Nacimiento Dam spillway was completed in 2009. The impact of raising the spillway crest elevation is incorporated into the reservoir release time series for the Historical Scenario input. The use of reservoir inflows as the stream inflow inputs to the SVIHM in the No Projects Scenario removes the effect of the spillway raise.
- **Removal of SRDF operations (part of SVWP)**: As with the recycled water deliveries, the SVIHM makes rediverted water from the SRDF available to satisfy crop demands in the CSIP area. The volume of delivery, which began in 2010, is based on historical records provided by MCWRA. The No Projects Scenario sets these deliveries to zero.

The difference in outcomes between the Historical and No Projects Scenarios is taken to represent the benefits associated with the construction and operation of the Projects. Throughout this report (unless stated otherwise), this difference represents the Historical Scenario minus the No Projects Scenario, such that positive numbers represent a benefit of the Projects, and negative numbers represent a negative outcome (i.e., a cost) relative to without project conditions.

2.1 Economic Analysis Methods

The economic benefits associated with MCWRA's water infrastructure investments include:

- Avoided replacement of wells because of depleted groundwater levels and seawater intrusion
- Avoided costs resulting from reductions in overall groundwater pumping and decreased depth to groundwater, which in turn reduces pumping lift requirements (and associated pumping costs)
- Reduced flood risk and associated damages to buildings, structure, and agriculture
- Active and passive reservoir-related recreation opportunities
- Generation of hydropower

Most of these benefits are closely linked to the hydrologic and flood risk reduction benefits reported by West Yost in the HBA Update and can be monetized using avoided cost analysis. For example, as described in more detail in Chapter 3, output from the SVIHM allowed us to compare groundwater pumping volumes and depth to groundwater for individual wells under the Historical and No Project Scenarios based on time series hydrological data (e.g., pumping volume, depth to groundwater) and information on the characteristics of each well. We applied costs per AF to pump groundwater over different depths to estimate total pumping costs over time across all wells. Total costs were greater under the No Projects scenario, meaning that the Projects resulted in reduced (avoided) pumping costs for growers.

Some benefits, such as recreation and environmental benefits, can be more difficult to monetize because they are not bought and sold in a market and therefore do not have a directly observable market price. Economists have developed several methods for valuing these and other "non-market" goods and services (Figure 3). For this analysis, the project team valued non-market benefits including recreation benefits, using a secondary research approach called benefits transfer. Benefits transfer relies on values reported in the literature from primary or original valuation studies (e.g., a stated or revealed preference study) to estimate the potential value of non-market benefits for a specific study site. Benefits transfer is commonly used in economics, and there is a well-developed literature on how to correctly apply this method.[vi] When implemented correctly, with the recognition that the estimates are not intended to be precise, benefits transfer is accepted as a suitable method for estimating non-market benefits in various contexts.[vii]

2.2 Key Data Sources

As noted above, this study relies on inputs from the HBA Update to estimate the avoided costs resulting from increased groundwater levels, reduced groundwater pumping, and avoided flood damages under the Historical Scenario. Data from SVIHM included groundwater head elevations and pumping volumes under the Historical and No Project Scenarios, in addition to well characteristics (e.g., elevation of the top and bottom of the well intake screen, general well location, top of well elevation) for the 2,375 agricultural, municipal, and industrial wells within the study area. This data was provided in five-day time steps over the 51-year analysis period.

West Yost also provided outputs from the Salinas Valley HEC-RAS model related to the extent and depth of flooding under various storm return intervals (i.e., 100-year, 50-year, 25-year, and 10-year storm events). We combined this information with agricultural crop data from USGS, Monterey County, and the University of California Davis, with data on the location and characteristics of structures within the floodplain to estimate the avoided flood damages resulting from the Historical Scenario.

We supplemented data from the HBA Update with information gleaned from interviews with regional well drilling experts and local government staff, as well as information from published literature and reports. Additional detail on sources and data used value benefits is provided in the following chapters specific to each benefit.

Figure 3. Primary Nonmarket Valuation Approaches

Research approaches to estimate the value of non-market benefits, such as recreation and habitat improvements, include:

Stated Preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for a non-market good or service. They are based on the notion that there is some amount of market goods and services that people would be willing to trade off so they can benefit from a non-market good. Stated preference studies typically yield average per-person or per-household willingness to pay (WTP) estimates for survey respondents. These estimates can be extrapolated to the wider study population to provide an indication of the total value of non-market benefits.

Revealed Preference methods: estimate WTP using data gathered from observed choices that reveal the preferences (i.e., WTP) of individuals for nonmarket goods and services. The most common revealed preference methods are the hedonic pricing (statistical analysis to estimate the influence of different factors on observed market prices), travel cost (economic demand functions for recreation based on the choices people make to travel to a specific location), and averting behavior (infers values from defensive or averting expenditures) methods.

3. Avoided Well Replacement and Pumping Costs

This section describes the benefits to agricultural growers associated with the increase in fresh groundwater storage that the Projects have collectively provided over the study period. As noted above, this assessment relies on results from the HBA Update hydrologic benefits analysis, which are first summarized here.

3.1 HBA Update: Hydrologic Benefits Analysis Results

Results of the HBA Update confirm that the Salinas Valley has experienced an overall increase in fresh groundwater storage in Basin aquifers because of the Projects. This has manifested as increased groundwater head (i.e., increased groundwater levels in the well) and decreased seawater intrusion from Monterey Bay relative to the No Projects Scenario.[2]

The HBA Update indicates that higher groundwater heads are concentrated in two portions of the study area: the area between Castroville and Salinas (northern part of the study area) and the area adjacent to the Salinas River near Bradley downstream to Gonzales. By the end of the model period (September 2018), head was as much as 67 feet higher in portions of the Pressure Subarea in the area between Castroville and Salinas. Along the Salinas River, head was approximately 15 feet higher. While head in much of the study area was lower at the end of the model period compared to the start, this decline was substantially smaller than it would have been without the Projects. Head declined by up to approximately 3.0 feet per year in the area between Castroville and Salinas with the Projects, while the average annual head decline was approximately 3.3 feet per year in the same area without the Projects.

Increased groundwater heads reflect an increase in groundwater storage resulting from additional water entering the groundwater system and/or less water leaving the system. The HBA Update shows that the Projects have increased groundwater recharge from the Salinas River and its tributaries to the study area aquifers by 72,000 AFY, with most of this transfer occurring in the Upper Valley Subarea and the Forebay Subarea (southern/upstream portion of the study area). Higher head values have resulted in an increase in discharge to agricultural drains and a decrease in net recharge of approximately 45,000 AFY and 14,000 AFY, respectively, also mostly in the Upper Valley and Forebay Subareas. This means that under the Historical Scenario, groundwater heads in these areas are closer to the elevations of agricultural drains and close enough to the land surface to contribute significantly to the satisfaction of crop water demand.

The Projects have also reduced agricultural pumping by approximately 10,000 AFY, with most of the reduction taking place in the Pressure Subarea. The SVIHM simulates a reduction in agricultural pumping either because head in groundwater wells falls to a level where the well pump can no longer maintain the desired pumping rate, or because the irrigation demand of the crop decreases (e.g., because crops have increased access to groundwater within the root zone). In the Forebay and Upper Valley Subareas, the

[2] Head is a measurement of the pressure that the water stored in an aquifer is under, referenced to a vertical datum. It is commonly thought of as the elevation to which water would rise in a well or piezometer installed in an aquifer and is used to define groundwater levels. Changes in groundwater head are a proxy for changes in aquifer storage. As storage in aquifers declines, groundwater head declines, while increasing groundwater storage is represented by an increase in groundwater head.

reduction in agricultural pumping is likely a result of increased head levels. The difference in agricultural pumping in the Pressure Subarea mostly occurs from 1998 onward, indicating that the difference is likely due to the recycled water and rediverted surface water deliveries from CSIP. Modifications to reservoir operations resulting from SVWP and associated Flow Prescriptions (i.e., increased minimum flows) have also contributed to increased recharge in these areas.

Overall, the change in inflows and outflows through the groundwater system has resulted in more fresh groundwater storage under the Historical Scenario than there otherwise would have been without the Projects. Although overall storage declined by an average of approximately 11,000 AFY with the Projects, this storage loss would have been substantially greater – close to 31,000 AFY - without the Projects.

As detailed in Chapter 2 of the HBA Update, the SVIHM cannot directly simulate the extent of intrusion of seawater into the freshwater aquifers of the study area. However, the SVIHM-simulated flux of groundwater across the coast can be taken as a reasonable estimate for the rate of seawater intrusion (see Chapter 2 of the HBA Update for additional detail). Applying this approach, the model indicates a that the Projects decreased seawater intrusion by approximately 68,000 AF over the 51-year analysis period. Most of this difference (50,000 AF of the 68,000 AF) occurred in Pressure Subarea, while the remainder largely occurred outside of the Zone 2C impact area. The models also show that the cumulative difference in seawater intrusion across scenarios was minimal prior to 1998 (amounting to approximately 1,000 AF total). This indicates that the CSIP (which began recycled water deliveries in that year) and SVWP have significantly reduced seawater intrusion.

Finally, the analysis of regional groundwater quality impacts in the 1998 HBA was somewhat qualitative; however, it concluded that the reservoirs could be expected to have positive effects on groundwater quality in the Basin because of increased recharge in the riparian area. The HBA Update Hydrologic Analysis does not include a discussion of impacts on regional groundwater quality. They are therefore not valued as part of the economic assessment.

3.2 Economic Study Units

The 1998 HBA summarized the benefits provided by the Nacimiento and San Antonio Reservoirs on a spatial basis using subdivisions referred to as Economic Study Units (ESUs). These units provided a way to group together portions of the study area that experienced similar benefits (as quantified by the average annual groundwater head change). The 1998 HBA divided the hydrologic model into 12 ESUs.

Because the HBA Update utilized a different set of tools to quantify the hydrologic benefits of the Projects, West Yost developed a new ESU map to group portions of the study area together. As with the 1998 HBA, the ESU map is based on the groundwater head difference between the Historical and No Projects Scenarios, in this case using the September 2018 model results. The September 2018 results represent the cumulative difference between scenarios over the entirety of the 51-year simulation period, providing the most detailed understanding of the spatial variation in the benefit of the Projects.

Figure 4 shows the 13 ESUs used for this study. The ESUs follow MCWRA's Zone 2C Subarea boundaries, with subareas subdivided into multiple ESUs as dictated by the head differences between scenarios:

- The East Side Subarea is divided into 3 ESUs (1, 2, and 5)
- The Pressure Subarea is divided into 4 ESUs (3, 4, 6, and 7)
- The Forebay Subarea is divided into 2 ESUs (8 and 9)

Figure 4. Hydrologic Benefits Analysis Economic Study Units (ESUs)

- The Arroyo Seco Subarea is a single ESU (10)
- The Upper Valley Subarea is divided into 2 ESUs (11 and 12)
- Below Dam Subarea is a single ESU (13)

Consistent with the HBA Update, the results of this portion of the economic assessment are presented by ESU and Subarea.

3.3 Economic Benefits

Declines in groundwater head and storage have the potential to negatively affect the ability of groundwater wells to operate, particularly when head falls below the bottom of a well's intake screen or within the "impact zone" between the top and bottom of the screen. Even when this does not occur, decreased groundwater head requires more energy (and increases costs) to pump and lift water from below the ground. By increasing groundwater head relative to the No Project Scenario, the Projects have avoided significant costs for growers associated with these negative effects. The Projects have also reduced overall groundwater pumping in the Basin, further reducing pumping costs. The following sections describe these benefits in turn, including our approach for estimating avoided costs and the resulting monetized benefit estimates.

3.1.2 Avoided well construction/replacement costs

This section presents the avoided costs associated with the effect of the Projects on reducing the number of wells needing replacement due to depleted aquifer conditions. To conduct this analysis, the project team relied on well-level data provided by West Yost from the SVIHM. This data included groundwater head elevations and pumping volumes under the Historical and No Project Scenarios, in addition to well characteristics (e.g., elevation of the top and bottom of the well intake screen) for the 2,356 agricultural and municipal wells in the model. This data was provided in five-day time steps over the 51-year analysis period.

The project team applied a stepwise process to identify wells that would need replacement under the Historical and No Project Scenarios. First, we identified wells where groundwater head fell below the bottom of the well screen more than 20% of the time in a given year. The first year this occurred, we assumed the well was replaced and that the replacement well would continue to pump at levels identified in the database. Next, we identified wells where groundwater head fell within the "impact zone" defined by West Yost. The impact zone represents the area between the bottom of the well screen and ten feet below the top of the well screen. In the third year if groundwater head fell within the impact zone of a well more than 50% of the time, it was flagged for replacement. This is because some pumping can continue to occur when head falls within this zone, and it would not be immediately replaced.

To estimate the cost of replacing a well, the project team conducted interviews with well drilling experts in the region. This allowed us to better understand the various factors that affect when a well would be replaced and well replacement costs (e.g., depth, size, materials, how they vary across study area). Input from the interviewees informed the development of estimates for well replacement costs by ESU, as shown in Table 1. These differences are largely driven by the depth of the well necessary for continued pumping.

Table 1. Estimated well replacement costs by ESU (2024 USD)

	ESU 1-4	ESU 5-7	ESU 8-12
Removal/decommissioning of existing well	$40,000	$30,000	$20,000
Well construction	$1,500,000	$600,000	$175,000
Pump and installation of related equipment	$400,000 - $2,400,000	$275,000	$65,000
Total	**$2,940,000**	**$905,000**	**$260,000**

Our analysis indicates that the Projects avoided replacement of 69 wells within the study area relative to the No Projects Scenario. These wells are mostly concentrated in ESUs 3 (26 wells) and 11 (11 wells), with a handful of well replacements in each of ESUs 2, 6 through 9, and 12. Over the 51-year study period, this resulted in $107.4 million in avoided costs, an average of $2.11 million per year. Table 2 shows the distribution of avoided replacement wells and the associated avoided costs by ESU and Subarea. As shown, most wells identified for replacement are agricultural wells, although several are used for municipal purposes.

Table 2. Avoided well replacement costs (2024 USD), by Subarea and ESU, over 51-year analysis period

Subarea/ESU	Avoided well replacements	Avoided well replacement costs
East side		
1		
2	4	$11,760,000
5	-	-
Forebay		
8	5	$1,300,000
9	5	$1,300,000
Pressure		
3	26	$76,440,000
4	-	-
6	6	$5,430,000
7	8 (w/1 municipal)	$7,240,000
Arroyo Secco		
10	-	-
Upper Valley		
11	11 (w/4 municipal)	$2,860,000
12	4 (w/1 municipal)	$1,040,000
Total	**69 (w/6 municipal)**	**$107,370,000**

3.2.2 Avoided costs from reduced agricultural pumping and pumping lift

As described above, the Projects have led to substantially less agricultural pumping, especially in the Pressure Subarea, where there has been 299,000 AF less pumping over the 51-year analysis period than would have occurred without the Projects. Smaller reductions in agricultural pumping have taken place in the Upper Valley (approximately 104,000 AF) and Forebay (approximately 76,000 AF) Subareas. In addition, increased groundwater heads resulting from the Projects have reduced the distance required to lift groundwater to the surface in many areas. This also results in reduced pumping costs.

The dataset provided by West Yost allowed us to estimate total pumping volume and the depth of pumping (elevation at the top of the well minus groundwater head) under No Project and Historical Scenarios for the 2,356 wells included in the dataset. This in turn allowed us to estimate the difference in energy requirements (and associated pumping costs) across scenarios using the following equation:

$$kWh/AF = 1.0241 \times TDH/OPE$$ [3]

Where:

> TDH = total dynamic head, the sum of water level lift (depth to pumping) and pressure converted to lift. Pressure converted to lift = well pressure (50 psi) x 2.31 (conversion of psi to feet of head)
>
> OPE = overall pumping efficiency, assumed to be 0.6 for this analysis

The kWh per AF is multiplied by $0.2 per kWh, the current average price of energy in this region. This yields an estimated cost of pumping per AF per five-day time step over the 51-year analysis period for each well. This cost is multiplied by the total pumping volume to estimate total pumping costs. The difference in total pumping costs between the No Project and Historical Scenarios represents the avoided pumping costs associated with the Projects.

The project team's assessment indicates that the Projects have resulted in approximately 500,000 AF less pumping over the 51-year analysis period and have raised groundwater heads. Table 3 shows the total avoided pumping and total avoided pumping costs by ESU and Subarea, indicating that the Projects have saved growers $67.9 M in pumping costs over the analysis period, or an average of $1.3 M per year.

3.1.3 Seawater intrusion

The Projects have helped MCWRA slow seawater intrusion in the Salinas Valley, thereby reducing adverse effects associated with the loss of agricultural productivity due to impacts from elevated salinity. Elevated levels of salinity can directly impact crop production by inhibiting water and nutrient uptake by plants. Each crop has a salinity tolerance level, meaning salinity can increase to a certain point before crop yield begins to decline. As salinity levels reach the point of tolerance, yield begins to decline at a somewhat linear rate for each crop. While absolute tolerances vary, depending upon climate and soil conditions, the

[3] Canessa, P., S. Green and D. Zoldoske. 2011. Agricultural Water Use in California. A 2011 Update. Center for Irrigation Technology Staff Report. Accessed October 2024. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/cachuma/exbhts_2012feir/cachuma_feir_mu289.pdf

Table 3. Avoided pumping costs (2024 USD),
by Subarea and ESU, over 51-year analysis period

Subarea/ESU	Avoided pumping (AF)	Average difference in head (feet) at end of study period[a]	Avoided pumping costs
East side			
1	0	0.25	
2	7,100	6.4	$1,959,100
5	-	1.1	$1,060,300
Pressure			$-
3	273,100	8.9	$29,984,700
4	-	-0.59	$145,000
6	13,800	1.2	$1,308,100
7	11,600	0.91	$1,603,100
Forebay			$-
8	29,900	3.0	$4,004,800
9	46,400	4.5	$4,862,700
Arroyo Secco			$-
10	11,900	2.0	$1,769,500
Upper Valley			$-
11	56,000	6.4	$10,852,400
12	48,300	8.1	$10,356,700
Total	**498,100**		$67,906,400

a. Represents the average difference in head under No Projects and Historical Scenarios at end of study period (2018)

general relationship between yield and salinity (measured as conductivity) is reflected in the following equation:

$$Y_r = 100 - B(K_e - A)$$ [viii]

Where

Y_r = yield reduction
B = the percent yield decrease per unit salinity increase above the threshold.
Ke = conductivity level (salinity, typically measured in DeciSiemens per meter, or dS/m)
A = salinity threshold

As noted previously in this report, the SVIHM does not directly simulate the intrusion of seawater into the freshwater aquifers of the study area. However, the SVIHM-simulated flux of groundwater across the coast can be taken as a reasonable estimate for the rate of seawater intrusion. Based on this method, seawater intrusion has been approximately 1,000 AFY lower in the Pressure Subarea than it would have been without the Projects, representing a total decrease in seawater intrusion of approximately 50,000

AF over the 51-year analysis period.[4] More than 90% of the difference in seawater intrusion occurred in the 180-Foot and 400-Foot Aquifers, from which most wells within the Pressure Subarea draw groundwater.

Applying some simple assumptions demonstrates the magnitude of impacts that reduced seawater intrusion has had on agricultural productivity. In 2015, the California Central Coast Regional Water Quality Control Board (CCRWQCB) and U.S. EPA Region 9 published an assessment of salt impairments in the Lower Salinas River and Reclamation Canal watersheds.[5][ix] Based on data from various sources spanning 1971 to 2014, this study reports mean groundwater conductivity levels and total dissolved solids of 1.8 dS/m and 2,314 mg/L (equivalent to a conductivity of approximately 3.6 dS/m), respectively, in the coastal portion of the Pressure Subarea. This provides a range of values across which to assess potential salinity impacts on crop production.

Table 4 shows the average proportion of acres by crop type for crops within the coastal portion of the Pressure subarea and specifically, the coastal portion of ESU 3, which the main area of seawater intrusion underlies, over the 51-year analysis period. Lettuce, artichokes, and crucifers (e.g., broccoli, cauliflower) have accounted for most irrigated acres over time. Lettuce is moderately sensitive to salinity, while artichokes are considered moderately tolerant, with a relatively high salinity threshold of 4.9 dS/m. Other crops within the area that are sensitive or moderately sensitive to salinity include celery, cauliflower, onions, and strawberries. Today, pasture makes up a small portion of irrigated acres in this area (less than 1%), but in the early years of the study period accounted for close to 16%.

Assuming an average applied water rate of 2.0 AF/acre,[x] the 1,000 AFY reduction in seawater intrusion under the No Projects Scenario would have affected approximately 500 acres of farmland each year. Assuming the mix of crops, gross output per acre, and salinity tolerance levels shown in Table 4, Table 5 presents the reduction in gross output associated with the range of salinity levels reported by RWQCB and US EPA (2015). For this somewhat simple assessment, we assume that crops classified as “unspecified” or “other” are not impacted by elevated salinity levels.

In total, this assessment shows that impacts could range from $21.7 to $86.9 M over the 51-year analysis period (an average annual value ranging from $425,000 to $1.7 million). Most of this benefit largely accrued to growers beginning in 1998, coinciding with deliveries of recycled water from CSIP. The estimated reduction in output represents the direct impacts associated with reduced agricultural productivity. These direct impacts would result in indirect and induced effects, as the impact of reduced spending by farmers on supplies and labor rippled through the local economy. These impacts are not estimated as part of this study. Finally, this analysis does not account for crop switching or other adaptations to reduce salinity impacts but rather quantifies the impacts associated with reduced yields. For example, if rather than continuing to plant crops affected by salinity, the 500 impacted acres were converted to pasture, reductions in gross output would range from $10.4 to $75.6 million over the study period.

[4] An additional 18,000 AF reduction occurred outside of the Zone 2C impact area.

[5] This assessment informed the development of salt-related TMDLs by the CCRWQCB and a salt and nutrient management plan for the Salinas Valley aquifers.

Table 4. Crops within ESU 3 (coastal portion) - gross output and salinity tolerance

Crop type	% of coastal ESU 3 acres	Gross output per acre (2022 USD)[a]	Salinity threshold (dS/m)	% decrease in yield per 1-unit increase in salinity
Celery	2%	$18,900	1.8[b]	6%
Lettuce	44%	$14,900	1.3[b]	13%
Crucifers	18%	$9,400		
Broccoli			2.7[b]	9%
Cauliflower			1.8[d]	10%
Onions	0%	$7,600	1.4[c]	19%
Strawberries	2%	$97,200	1.0[b]	33%
Artichokes	19%	$11,200	4.9[c]	11%
Pasture	4%	$445	6.0	N/A
Other	11%	N/A	N/A	N/A

a. UC Davis Crop budgets and Monterey County crop report
b. Amacher et al. 2000
c. Shannon and Grieve 1999 (USDA)
d. Salinity thresholds for cauliflower are not available, set to threshold for cabbage because they are both brassicas and both classified as moderately sensitive to salt (UC Davis 2015)

Table 5. Benefits resulting from reduced seawater intrusion from Projects (avoided reduction in gross output, 1,000s $ over 51-year analysis period, 2022 USD)

Crop type	Salinity levels (dS/m)		
	1.8	2.7 (mid-point of range)	3.6
Celery	$ -	$412	$815
Lettuce	$9,472	$25,823	$42,175
Broccoli	$ -	$29	$1,529
Cauliflower	$36	$1,652	$3,267
Onions	$48	$150	$252
Strawberries	$12,194	$25,543	$38,893
Artichokes	$ -		
Pasture	$ -		
Total	$21,750	$53,610	$86,930

4. Flood Control Benefits

This section describes the flood control benefits associated with the construction and operation of the San Antonio and Nacimiento Reservoirs over the study period, including avoided damages to structures and agricultural resources (crops and soils). This assessment relied on results from the HBA Update flood control benefits analysis, which are first summarized here.

4.1 HBA Update: Flood Control Benefits Analysis Results

Results of the HBA Update show that the Projects have resulted in a decrease in the frequency and magnitude of flooding events along the Salinas River. The Nacimiento and San Antonio Reservoirs have provided this benefit by storing high flows during wet winter periods and releasing flows during drier parts of the year. The reservoirs act to attenuate flood peaks generated in the Nacimiento and San Antonio River watersheds rather than passing them directly to the Salinas River.

Flood Frequency Curves for the Salinas River at Bradley (located just downstream of the dams) indicate that the reservoirs reduce peak flows associated with the 100-year flood event by 28% - from approximately 159,000 cubic feet per second (cfs) without the Projects to 115,000 cfs with the Projects in place. For more frequent events, the Projects achieve larger proportional reductions; for example, the Historical Scenario shows a 58% reduction in the magnitude of peak flows associated with the 10-year event compared to No Projects (from 68,000 cfs to 28,000 cfs). This is because the reservoirs cannot capture the entirety of the highest flow events when reservoir capacity is not sufficient to fully store the event inflow.

The reduced magnitude of peak flows has resulted in less inundation of the Salinas River floodplain than would have occurred had the Projects not been in place. Without the projects, the 100-year flood would inundate 65,000 acres, compared to 60,000 acres with the Projects. Again, benefits are greater for more frequent events; results from the HBA Update indicate that the 10-year event would inundate 48,000 acres without the Projects and 32,000 with the Projects.

In addition to decreasing the extent of inundation, the Projects, by reducing the magnitude of peak flows, result in lower streamflow velocities in the Salinas River floodplain. This in turn decreases potential for erosion in the floodplain. For the 100-year flood, the area of high potential for erosion was estimated to be 11,000 acres with the Projects and 17,000 without.

4.2 Flood Study Units

The 1998 HBA summarized the flood risk reduction benefits provided by the Nacimiento and San Antonio Reservoirs on a spatial basis using subdivisions referred to as Flood Study Units (FSUs). These units reflect the portions of each ESU (i.e., the Economic Study Units described in the previous section) that are covered by the HEC-RAS flood model. While it does cover the floodplain, the HEC-RAS model does not cover the entire area of Zone 2C, and therefore some ESUs (i.e., 1 and 13) do not have corresponding FSUs. Consistent with the 1998 HBA and West Yost's HBA Update, this economic assessment presents results by FSU. Figure 5 shows the extent of FSUs across the study area.

Figure 5. HBA Update Flood Study Units (FSUs)

4.3 Avoided Damages to Buildings and Structures

4.3.1 Modeling approach and inputs

The project team estimated avoided flood damages to structures resulting from the Projects using USACE's HEC Flood Impact Analysis (HEC-FIA) software. HEC-FIA combines hydrologic modeling results with a terrain model that contains ground surface elevations to determine the depth of flooding for an inventory of structures in the flood area. The model then calculates damages to structures and structure contents using depth-to-damage functions specific to different structure types.

To estimate flood damages under the No Project and Historical Scenarios, we relied on hydrologic modeling results from HEC-RAS (provided by West Yost), including flood depth spatial layers for the 10-, 25-, 50-, and 100-year flood events with and without the Projects. Additional inputs included the terrain model that West Yost used in HEC-RAS for the HBA Update and USACE's 2022 National Structure Inventory (NSI). The NSI combines data from various sources to create a spatial layer with attributes for individual structures in the study area, including occupancy type (residential, commercial, industrial, public), building replacement value, ground elevation, foundation height, and other variables. The NSI indicates that in 2022, there were 17,074 structures within the study area FSUs. As shown in Table 6, FSU 3 has the most structures (9,830) followed by FSU 11 (3,085) and FSU 9 (2,698). The remaining FSUs have relatively few structures, ranging from 6 in FSU 2 to 538 in FSU 6.

Table 6. Number of structures in the 2022 National Structure Inventory for the Salinas River Valley, by building occupancy type and FSU

FSU	Commercial*	Industrial	Public	Residential	Total
2	1	4	0	1	6
3	1,430	256	113	8,031	9,830
4	19	5	0	262	286
6	40	25	4	469	538
7	11	28	0	50	89
8	12	30	1	71	114
9	189	35	26	2,448	2,698
10	4	7	2	75	88
11	316	108	38	2,623	3,085
12	71	20	5	244	340
Total	2,093	518	189	14,274	17,074

*The commercial occupancy category includes agricultural buildings.

Flood control benefits were estimated by comparing average annual flood-related damages under the No Projects and Historical Scenarios across flood event types. HEC-FIA calculates expected annual damages (EAD) from flooding based on the value of structures, their contents, and the estimated number of vehicles located on properties at the time of flooding. EAD is a metric that combines the likelihood of flood events (e.g., the 1% probability of a 100-year flood occurring each year) with the damages expected from each event. It reflects potential damages from flooding across all storm events based on damage calculations for specific events (i.e., the 10-, 25-, 50-, and 100-year events), extrapolating across the hydrograph.

To estimate the number of structures located in each FSU for each year of the 51-year study period, we analyzed population changes by Census tract for the Census tracts that intersect each FSU. Population data is available at the Census tract level from 1970 to 2020, with some cross walking necessary to match population data from 1970 to 1990 to population data from 1990 to 2020 at this geographic scale. We used this information to calculate an average annual growth rate by FSU, equating percent changes in population to percent changes in structures. For the extremely small FSUs (i.e., 2, 4, and 5) we assumed an average growth rate equal to the adjacent FSU because Census tract data is not granular enough to adequately estimate populations in these areas. Table 7 shows the average annual growth rate assumed for each FSU over the analysis period.

Table 7. Estimated average annual population growth rate by FSU, 1968-2018

FSU	Assumed average annual growth rate (%)
2	1.17%
3	1.17%
4	1.17%
5	1.11%
6	1.11%
7	-0.06%
8	-0.08%
9	5.30%
10	1.17%
11	0.36%
12	-0.15%
Weighted average	1.10%

4.3.2 Value of avoided damage to buildings and vehicles

Tables 8 and 9 show the estimated avoided flood damages that have resulted from the Projects by FSU, including average annual and cumulative damages avoided over the 51-year analysis period, respectively. The model indicates that over the analysis period, FSU 3 experiences the most damages across flood event types, accounting for 70% of total damages under the No Projects scenario, 77% under the Historical Scenario, and 65% of total avoided damages resulting from the Projects (No Project minus Historical Scenario). FSU 6 accounts for most of the remaining flood damages, with 26% under the No Projects Scenario, 18% in the Historical Scenario, and 31% of the avoided flood damage to structures resulting from the Projects.

Table 10 also shows the average annual damages that the Projects have avoided, but by building occupancy type rather than FSU. As shown, residential buildings account for the greatest percentage of total damages, followed by commercial structures.

Table 8. Average annual avoided flood damages by FSU, 1,000's of dollars (2024 USD)

FSU	Structural Damage	Contents Damage	Vehicle Damage	Total Avoided Damage
3	$1,380	$1,122	$170	$2,672
4	$1	$-	$-	$1
6	$954	$327	$8	$1,289
7	$2	$1	$-	$4
8	$1	$5	$1	$7
9	$6	$12	$2	$20
10	$22	$35	$3	$60
11	$-	$-	$-	$-
12	$25	$46	$4	$75
Total	$2,393	$1,548	$188	$4,128

Table 9. Avoided flood damages by FSU over 51-year analysis period, 1,000's of dollars (2024 USD)

FSU	Structural Damage	Contents Damage	Vehicle Damage	Total Damage
3	$70,399	$57,210	$8,650	$136,260
4	$43	$-	$-	$43
6	$48,679	$16,661	$392	$65,732
7	$120	$60	$-	$181
8	$61	$242	$61	$363
9	$313	$609	$104	$1,026
10	$1,113	$1,799	$171	$3,083
11	$-	$-	$-	$-
12	$1,297	$2,348	$185	$3,830
Total	$122,026	$78,929	$9,563	$210,517

Table 10. Average annual flood damages by building occupancy type and analysis scenario, 1,000's of dollars (2024 USD)

FSU	No Projects Scenario (NP)	Historical Scenario (Hist)	Avoided Damage (NP – Hist)
Commercial[a]	$1,428	$435	$993
Industrial	$115	$31	$83
Public	$19	$-	$19
Residential	$5,278	$2,187	$3,092
Total	$6,840	$2,653	$4,187[b]

a. The commercial category includes damage to agricultural buildings.
b. Total avoided damages do not exactly match those reported in Table 8 due to rounding.

As shown in Tables 8 and 9, structural damage to buildings constitutes the largest damage category, with building contents and vehicle damage accounting for a much smaller percentage of total damages from flooding. The average ratio of contents damage to structure damage is 60% across flood events, although this varies across structure and occupancy type. This ratio is typical when a large proportion of the flood damage is in the residential sector. Table 11 shows the difference in number of buildings flooded with and without the Projects, by building occupancy type and flood return interval.

Table 11. Avoided number of buildings flooded under various flood return periods, building occupancy type, No Project minus Historical Scenario

	Flood return period			
Building Occupancy Type	10-Year	25-Year	50-Year	100-Year
Commercial	33	21	30	24
Industrial	6	1	8	8
Public	1	1	1	4
Residential	170	89	167	420
Total	210	114	207	457

4.4 Avoided damages to agricultural crops

4.4.1 Modeling approach and inputs

To assess avoided damages to agricultural crops, we relied on data from HEC-RAS (provided by West Yost) on the depth and extent of flooding for the 10- , 25- , 50- and 100-year events under the No Project and Historical Scenarios. Table 12 shows the difference in total acres flooded by FSU for different flood return periods (this data includes all land use categories including non-agricultural acres). Consistent with findings from the HBA Update, it shows that in general, the greatest reductions in acres flooded occur for the smaller return period events (i.e., the 10- and 25-year events). This is because reservoir capacity (when partially full) is not sufficient to fully store inflows from the larger events.

Table 12. Difference in Inundated Acres, No Projects and Historical Scenarios, by flood return period

	Flood return period			
FSU	10-Year	25-Year	50-Year	100-Year
3	6,345	3,500	2,268	1,450
4	116	37	23	57
6	1,000	570	611	848
7	810	190	178	316
8	1,640	483	241	341
9	1,780	1,207	536	226
10	523	317	251	183
11	1,571	1,410	1,421	927
12	2,712	3,402	1,632	599
Total	16,496	11,116	7,161	4,947

Given the extent and depth of flooding by FSU, we used land use data for the Salinas Valley to determine which crops would be affected by flooding with and without the Projects. We relied on data developed by USGS for the SVIHM; this data contains 56 specified land use categories including both agricultural crops and non-agricultural uses (such as urban, riparian or woodlands). For each model year, USGS generated land use maps using a composite of available land use data from California DWR, Monterey County, and the National Land Cover Database (NLCD, USGS 2014) and a newly developed method that leverages the California Pesticide Use Reporting (CalPUR) database.

The CalPUR method provides greater detail for the identification and distribution of crops in the Salinas Valley than was previously available. In the past, row crops have often been only been identified under a general category such as "truck and vegetable crops" but are now identified in more detail by their specific crop type (e.g. lettuce or crucifers) – although an "unspecified" category is still used after applying the CalPUR method for row crops that cannot be identified. In the SVIHM model, these data are linked to individual model cells to provide water demand and other water use data in the spatial detail necessary for model runs. The data have now been released as spatial layers by the USGS and that can be used outside of SVIHM model calculations. Figure 6 shows the 2017 land use spatial data layer for SVIHM.

4.4.2 Crop data for calculating loss

To value crop losses associated with flooding, we calculated lost revenues minus variable costs already expended, re-establishment costs (if any), and land cleanup and rehabilitation costs resulting from the flood. We followed an approach developed by USACE in its 2002 Sacramento and San Joaquin River Basins Comprehensive Study;[xi] this approach was also applied in the Flood Rapid Assessment Model (FRAM) used by the California DWR to assess avoided flood damage benefits in applications for state grant funding (URS 2008). We updated crop returns (revenues minus variable costs already expended) and crop reestablishment costs in the FRAM model with available crop budget data from UC Davis (UC Davis, 2024), supplemented by Monterey County Crop Report data by for corroborating information on average returns per acre by crop. We then used the updated FRAM model to estimate the value of avoided flood damage by crop type.

Net revenue per acre is calculated as revenue minus variable costs expended prior to the month of the flood. Variable costs over a year are calculated as the weighted average of costs by month from the crop budget using the probability of flooding by month[6] – this means that costs expended in more frequent flood months (winter months) are weighted more heavily than costs in other months before the months of typical harvest. Based on this methodology, Table 13 shows per acre values by crop for net revenue and reestablishment costs.

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[6] Used the probability of flooding by month for the Sacramento region due to lack of similar information for Monterey County

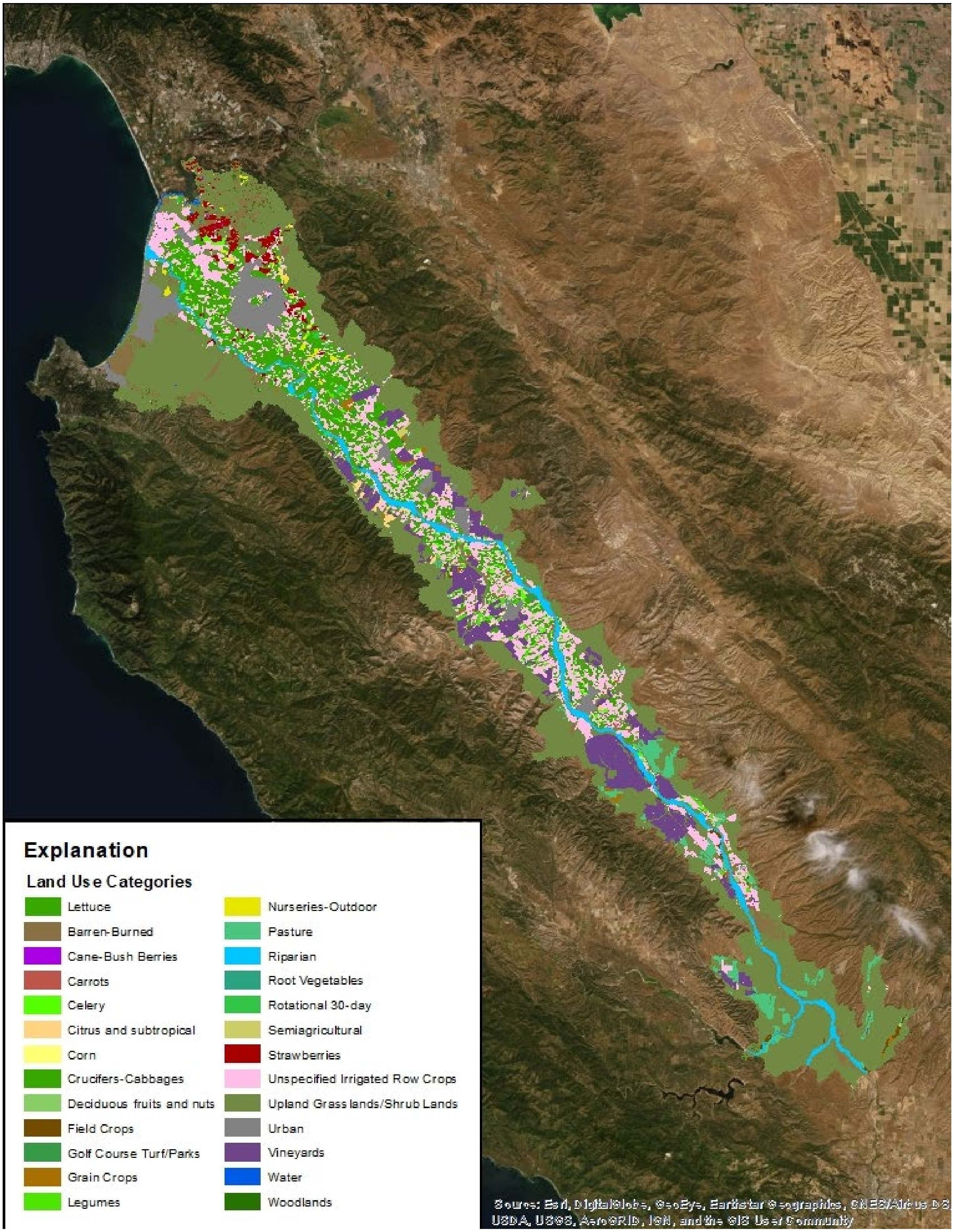

Figure 6. 2017 Land Use GIS Layer for Salinas Valley Integrated Hydrologic Model

Table 13. Crop flood damage estimate components, 2024 USD

Irrigated Crop	Net Revenue Per Acre ($/acre)	Re-establishment Cost ($/acre)[a]
Celery	$6,727	-
Legumes	$208	-
Lettuce	$4,575	-
Rotational*	$3,323	-
Crucifers	$2,072	-
Unspecified*	$3,323	-
Carrots	$2,874	-
Strawberries	$15,316	-
Artichokes	$8,689	-
Field	$299	-
Grain	$414	-
Deciduous	$3,530	$7,870
Vineyards	$5,247	$9,567
Pasture	$54	-
Tomato	$1,481	-
Onion	$4,248	-
Citrus	$10,962	$8,674

a. Annual crops do not have re-establishment costs
b. Rotational and Unspecified categories were valued at the average net revenue per acre of lettuce and crucifers (broccoli and cauliflower)

FRAM uses a threshold for the duration of flooding to determine whether crop re-establishment costs should be included in the damage estimate. If inundation lasts less than five days, only net revenue per acre and land cleanup and rehabilitation costs are included. If inundation lasts five days or longer, then re-establishment costs are also included. Re-establishment costs are only assumed for perennial crops in the Deciduous, Citrus, and Vineyard categories. The hydrologic analysis provided by West Yost does not calculate the duration of flooding, since the Salinas River HEC-RAS Model was run in a quasi-steady state to only represent the conditions under the peak flow magnitude. As a proxy, we assumed that flood depths of equal or greater than five feet would take more than five days to recede, while depths less than five feet would not. Note that flooding duration is not the same as the delay before farming operations can resume, which is often at least 1 to 2 months, including time needed for soil testing to assure that replanting is safe for human consumption.

Next, we used data provided by West Yost on soil erosivity by FSU to calculate land cleanup and rehabilitation costs. The original HBA expressed these costs by FSU as a function of soil erosivity. West Yost calculated soil erosivity by FSU in the same manner for the No Projects and Historical Scenarios. Thus, to estimate clean up and rehabilitation costs for this assessment, we updated these costs from the original HBA by FSU and erosivity category (low, medium, or high) to 2024 dollars. Updated costs are shown in Table 14.

Table 14. Land cleanup and rehabilitation cost, 2024 USD

Erosion Potential	Land Cleanup and Rehabilitation Cost Updated to 2024 Dollars ($/acre)
Low	$405
Medium	$1,773
High	$11,565

We applied the percentage of total acres in each erosion potential category by FSU to calculate the difference in weighted average land cleanup and rehabilitation costs for the No Projects Scenario and the Historical Scenario. Table 15 shows the difference in land cleanup and rehabilitation costs by FSU.

Table 15. Difference in land rehabilitation and cleanup costs, 2024 USD

FSU	Difference in Land Cleanup and Rehabilitation Cost (No Projects – Historical), ($/acre)
3	$597
4	$558
6	$1,120
7	$769
8	$933
9	-
10	$1,031
11	$765
12	$1,296

4.4.3 Avoided agricultural flood damages

For the study period (1968 to 2018), we estimated cumulative avoided agricultural flood damages using the USGS land use GIS data for the years 1992, 1997, 2002, 2007 and 2017. This allowed us to understand how crop damage from flooding in the Salinas Valley changes over time due to changes in the mix of crops each year. Table 16 shows the total acres flooded across all FSUs by land use type for 2017, as a percentage of the total acres flooded. Other years have a similar mix of acres flooded by land use type. Across all land uses, riparian acreage is the largest percentage of the total. Unspecified row crops are the highest percentage of agricultural acreage, followed by lettuce, crucifers (broccoli and cauliflower), and celery.

The difference in flooded agricultural acres based on 2017 land uses varies throughout the valley, based on a sampling of FSUs – FSU 3 closest to the coast, FSU 6 as the next major FSU down the valley from FSU 3, and FSU 11, which is higher in elevation and closer to the reservoirs. In almost all FSUs, the Projects avoid a significant amount of flooding of lettuce, crucifers, and unspecified row crops. In FSUs 3 and 4, a relatively large amount of acres planted in strawberries is not flooded as a result of the Projects; the

Projects reduce the greatest amounts of flooding of vineyard acreage and pasture in FSUs 11 and 12, respectively.

Table 16. Acres flooded by 10- and 100-year storm return period by crop type using the 2017 land use layer, as a percentage of the total acres flooded

Land Uses	10-Year Historical	10-Year No Project	100-Year Historical	100-Year No Project
Celery	1%	2%	2%	2%
Legumes	1%	1%	1%	1%
Lettuce	15%	19%	20%	21%
Crucifers	7%	9%	9%	9%
Unspecified	20%	25%	26%	26%
Carrots	1%	1%	1%	1%
Vineyards	0%	0%	1%	3%
Pasture	0%	1%	1%	1%
Urban	1%	1%	1%	1%
Riparian	43%	31%	26%	24%
Upland	9%	9%	9%	9%
Barren	0%	0%	1%	1%
Other	2%	1%	2%	1%
Total	100%	100%	100%	100%

Table 17 shows the total avoided agricultural crop damage by FSU for selected years, calculated based on the expected annual damage by scenario and across storm return periods, and accounting for the mix of crops for which flooding was avoided in that year. The USGS land use GIS data for 1997 are the same as the year 1992, so results for 1997 are omitted in this table for brevity.

Table 17. Avoided flood damages by FSU and selected year, 1,000's of dollars, 2024 USD

FSU	1977	1987	1992	2002	2007	2017
3	1,785	1,869	1,826	1,683	1,692	1,692
4	11	23	24	23	23	23
6	384	451	333	316	318	317
7	148	151	152	141	141	141
8	268	291	328	280	280	280
9	220	284	319	253	254	254
10	102	118	131	122	122	122
11	321	419	470	442	423	423
12	517	779	940	859	861	863
Total	3,756	4,385	4,523	4,116	4,112	4,114

Years in the GIS data before 1990 did not have the same row crop detail as years from 1990 and later. We used a summary of data by FSU and land use category from the SVIHM to allocate the difference in flooded agricultural acres from 1992 according to the crop mix in the SVIHM data for the years 1977 and 1987. Avoided crop losses for years in the study period not shown in Table 17 are assumed to be equal to the latest year in interval of years from that period (e.g. losses for each year from 1968 to 1976 are assumed to be equal to the losses estimated for 1977; losses for each year from 1978 to 1986 were assumed to be equal to the losses estimated for 1987).

In total, the value of avoided agricultural flood damage over the 51-year analysis period amounts to $211.0 million in 2024 USD.

5. Recreation benefits

This section summarizes the recreational benefits associated with Nacimiento and San Antonio Reservoirs, which both offer a range of recreational opportunities for residents of Monterey County and the broader region. First, we describe the recreational activities available at each reservoir and provide a summary of the approaches we used to value recreational benefits.[7] Limited data on historical revenues and visitation restricted the ability to estimate benefits prior to 1985 (see Section 5.2.1 for additional detail).

5.1 Overview of reservoir recreational activities

5.1.1 Nacimiento Reservoir

The Nacimiento Dam and Reservoir, located in northern San Luis Obispo County, was completed in 1957. The reservoir is 18 miles long with 165 miles of shoreline and a surface area of more than 7,000 acres at full storage capacity. Recreational opportunities at this reservoir include power boating, water sports (water skiing, wake boarding, tubing), kayaking and paddleboarding, camping, fishing, swimming, wildlife viewing, and picnicking. This reservoir has been operated by a concessionaire on behalf of Monterey County Parks since 2011, and the facilities have been branded as Lake Nacimiento Resort (the Resort).

By 1960, Nacimiento Reservoir had a small marina at the North Shore, along with two boat launch ramps, access roads and parking areas. The South shore was also outfitted with a store, marina, gas stations, campground and patrol boats. Over the years, these facilities have been upgraded. The Resort rents boats, water sports equipment and fishing gear at a 100-slip marina that was renovated in 2004. There are now five distinct campgrounds with more than 350 campsites, some with recreational vehicle (RV) water and electricity hookups. The Resort also provides fully furnished lodging accommodation options and RV rentals. The general store on site is open to guests year-round. For boating, Nacimiento is unrivaled in the region, offering many canyons that form lake fingers that can be explored by boat. The surrounding shorelines are heavily wooded with oak trees and provide habitat for golden and bald eagles, hawks, falcon, deer, wild pigs, and turkeys.

The reservoir is also home to many private boat docks located at homes and other buildings surrounding the reservoir. These docks provide direct access to the recreation opportunities described above and offer considerable benefits to the residents of Nacimiento. The number of private docks has increased over time – MCWRA reports that 261 private docks were registered in 1971, while 415 docks were registered as of 2023.

5.1.2 San Antonio Reservoir

Construction of San Antonio Dam and Reservoir was completed in 1965 and the recreation area opened to the public in the summer of 1967. At full capacity, the reservoir is 16 miles long with approximately 100 miles of shoreline and a surface area of 7,500 acres. This reservoir is managed by the Monterey County Parks Department (Parks), and features two main park areas, North Shore and South Shore. In 1990, eagle-watch tours were initiated at San Antonio Reservoir, and Parks added a Visitor Center in 2001. Year-round

[7] Note that this analysis focuses on recreational opportunities that are publicly available. Communities along the shores of Nacimiento also have access to shorelines with private boat ramps. These recreational users are not included in available user counts and are therefore not included in this analysis.

activities at this lake include picnicking, camping, fishing, hiking, swimming, boating, water sports, and horseback riding.

Recreational use at San Antonio Reservoir is dominated by camping. The South Shore is similar to Nacimiento, offering camping in heavily wooded areas with opportunities for wildlife viewing. There are approximately 400 sites with more developed camping amenities, such as bathrooms and hookups for RVs. The North Shore is more open and arid and offers shoreline camping and swimming opportunities that are not available at other locations. With only about 200 camp sites and fewer amenities, the North Shore draws recreational users looking for more peaceful and dispersed experiences. Additionally, an equestrian facility on the northeast side of the lake provides paddocks, camping, and a trail system for horseback riding.

Recreation at San Antonio Reservoir seems to be more susceptible to drought than recreation at Nacimiento Reservoir. From 1989 to 1992, the North Shore area was closed due to drought conditions, and park visitation is still recovering from closures and impacts associated with California's 2014 drought. In this more recent drought, the water storage at San Antonio Reservoir dropped to just 3% of its total capacity, and boats could no longer access the reservoir. A marina, lodging units, and stores on both the North and South Shores closed, and Park staff declined from 60 to just three full-time positions. This major drought also caused a sharp decline in the striped bass population, which was a major draw for recreational fishing at this lake. Additionally, the plants that grew in the absence of the lake during the drought are now covered with water, increasing nutrients and contributing to toxic algal blooms that have been reported most summers since 2014. The reservoir has started to recover from this period of drought, but fluctuations in water levels and algal bloom notifications have impacted lake visitation.

5.2 Methods and inputs for valuing recreational benefits

Individuals participate in recreation for physical activity and associated health benefits, leisure, improved mental health, and for building social capital. Because these benefits are not traded in the market, it can be difficult to establish the values associated with them. However, many researchers have conducted willingness-to-pay (WTP) surveys or revealed preference studies to estimate the value of a recreational experience across a range of activities. These studies yield what economists refer to as *direct use values*. Direct use values reflect the full amount (i.e., beyond any entrance fees) that individuals would be willing to spend to participate in a recreational activity.

Total benefits associated with participation in recreational activities are a function of direct use values and the recreational trips (often referred to as "user days" or visitor days) taken to each site. Direct use values can range significantly depending on the availability of similar recreation opportunities nearby, the type of recreational activities offered at a given location, the amount and quality of the recreational space, and other local conditions. To account for these various factors, this assessment relies on the USACE's Unit Day Value (UDV) method to estimate direct use values for the different activities available at the reservoirs. This method is explained in more detail below.

5.2.1 Visitation (user day) estimates

Recreational benefits depend on the annual number of recreational visits to the reservoirs, as well as the primary activities in which visitors participate. Annual visitation is calculated based on "user-days," which is defined as park use by one visitor for one day. For example, a family of four camping for two nights would count as eight user days. The value of one user-day depends on the primary recreational activities that visitors engage in during their time at the reservoirs.

As a first step to this assessment, we reviewed entry fee revenue data provided by Park staff for boating, camping, day use vehicle permits, and annual passes from July 2022 to June 2023 (FY2023) to better understand overall visitation patterns. At both reservoirs, all vehicles must purchase either a day use or per-night camping permit or use their annual pass to enter the parks. Visitors that intend to boat must purchase a boating permit in addition to a camping or day use pass. Passes are sold per vehicle, not per user. For the purposes of this report, a vehicle entry indicates one vehicle for one day. Because vehicles typically carry multiple people, we estimated the average persons per vehicle to calculate total user-days.

To estimate average persons per vehicle, we relied on a 2003 study by USACE that estimated average party size for different recreational activities.[8] This study was based on survey data from Lake Sonoma in Northern California, along with other USACE-operated lakes across the U.S. The average party size for visitors participating in both camping and boating was 3.5; for all other non-boating activities, the average party size was 2.8. Annual pass holder daily entry data from Lake Nacimiento Resort informed an average user day estimate for visitors with annual passes. We applied these estimates to the FY 2023 vehicle pass revenue data to generate approximate FY 2023 visitation estimates, as shown in Table 18.

Table 18. Visitation estimates for recreational users, by activity type, FY2023

Reservoir	Activity	User day estimates	% of total participation
Nacimiento Reservoir	Day use (no boat)	135,290	28%
	Camping (no boat)	195,357	40%
	Day use + boat	57,020	12%
	Camping + boat	102,920	21%
	Total boating	159,940	33%
	Total Visitors – Nacimiento	**490,586**	
San Antonio Reservoir	Day use (no boat)	27,017	61%
	Camping (no boat)	14,100	32%
	Day use + boat	2,035	5%
	Camping + boat	1,370	3%
	Total boating	3,405	8%
	Total Visitors – San Antonio	**44,522**	
Total visitors (both lakes)		**535,108**	

Nacimiento supported significantly higher recreational visits in FY2023, making up 92% of total visits at the reservoirs. This difference can be attributed in large part to the more developed nature of Nacimiento, as well as the decline in visitation that San Antonio has struggled with since the 2014 drought. The closure of lodgings, the marina, and a general store, along with persistent toxic algal blooms, continue to impact visitation to this day.

[8] Chang, W., D. B. Propst, D. J. Stynes, and R. S. Jackson. 2003. *Recreation Visitor Spending Profiles and Economic Benefit to Corps of Engineers Projects*. US Army Corps of Engineers: Recreation Management Support Program. ERDC/EL TR-03-21. One party was assumed to equal one vehicle for the purposes of this report.

Unfortunately, there is no comprehensive dataset that provides reservoir visitation by activity type over the analysis period. To estimate historical visitation, we applied a variety of methods, first using annual entry fee revenues to estimate the number of vehicles entering each park, and then converting vehicle counts to annual visitation numbers. We relied on input from park staff and other available resources to estimate participation in various activities at each reservoir.

We collected data from multiple sources for different years, as available:

- Revenue data for Nacimiento from 2010-2023, and for San Antonio for 2010-2020, and 2023, provided by Monterey Parks Department
- Revenue estimates for 1985 to 1993 for both reservoirs combined, from the SVWP Draft Environmental Impact Record (DEIR, 2001)[9]
- "Visitation units" for 1985 to 1994 for each reservoir from the SVWP Draft Economic Impact Report (DEIR, 2001)[10]
- Water elevation on July 1 for both lakes from 1967 to 2023, provided by MCWRA
- Nacimiento vehicle entries for 1994 to 2001, Nacimiento Water Supply Project Report on Recreational Use (NWSPR, 2002)
- 2006 visitor estimates for both lakes from the San Antonio and Nacimiento Rivers Watershed Management Plan (WMP, 2008)

As noted previously, revenue or visitation data are not available for either of the lakes prior to 1985; thus, the benefits analysis is limited to this period. Given available data, our first step was to project annual park entry fee revenues for each year from 1985 to 2018. Revenues at the parks mirror water levels in the reservoirs: when water levels decline, revenues (and visitors) also decline.[11] Water level data for both reservoirs are available for every year of the analysis period. Given that revenues and water levels are the most complete datasets obtained for this analysis, and that they are intricately tied, we developed regression equations to estimate revenues for years with missing revenue data.

Specifically, we applied three simple regression equations (one for Nacimiento and two for San Antonio) using data from years for which both entry fee revenues and water level data were available (applying updated 2022 USD revenue values for consistency). Because of the dramatic changes in revenues and activities at San Antonio associated with the drought, we divided the regression analysis for this reservoir into pre- and post-2014 drought. See Appendix X for additional detail on this estimation.

Next, we converted entry fee revenues to vehicle counts. For Nacimiento, the NWSPR provides vehicle entry estimates from 1994 through 2001. Additionally, the WMP provides visitation estimates for both

[9] The SVWP DEIR (2001) reports combined revenues for 1985-1994 for recreation activities at both reservoirs. To differentiate between the reservoirs, we applied the ratio of 'visitation units' from each park to the reported combined revenue to arrive at each reservoirs revenues.

[10] The SVWP DEIR records the number of visitation units sold and associated revenues for Nacimiento and San Antonio reservoirs. A unit is defined as either 1 overnight camping fee, 1 day use fee for either a vehicle or a boat, 1 yearly boat permit, or a set dollar amount of concession intakes. For the year 1994, we have both visitation estimates for Nacimiento from the NWSPR as well as unit estimates from the DEIR, allowing for an estimated conversion from units to visitation. This conversion factor is approximately 5.3 visits per recorded unit. This conversion was applied to the units to arrive at approximate visitation.

[11] Information gathered from interview with Parks official Nathan Merkle, October 2023.

lakes for 2006. Revenue to vehicle conversions were therefore only necessary from 2002 through 2005, and for 2007 to 2018 at Nacimiento and 1995 to 2018 (except 2006) for San Antonio. This was done using an average ratio of vehicle entries to revenues.

For Nacimiento, the average ratio of revenues to vehicle entries is approximately 0.22, meaning that every $100 in revenues represented 22 vehicles. This ratio was multiplied by revenues to arrive at an estimated count of vehicle entries. For San Antonio, the average ratio from pre-drought years (1995-2013) was 0.27; for post-drought years, the ratio of vehicle entries was 0.3, which was applied to years 2014 through 2018. This lower ratio likely indicates higher costs of vehicle entry.

Figure 7 shows estimates of revenues over time at both reservoirs in 2023 USD; this includes revenue data provided by various sources, as described above. The precipitous declines in revenues at San Antonio from 1989 to 1992, and starting again in 2014, coincide with periods of severe drought that caused parts of the recreation area to close. The Nacimiento revenue data from 2011 onwards were provided to Parks by the concessionaire, so spikes and drops in revenue are less well understood.

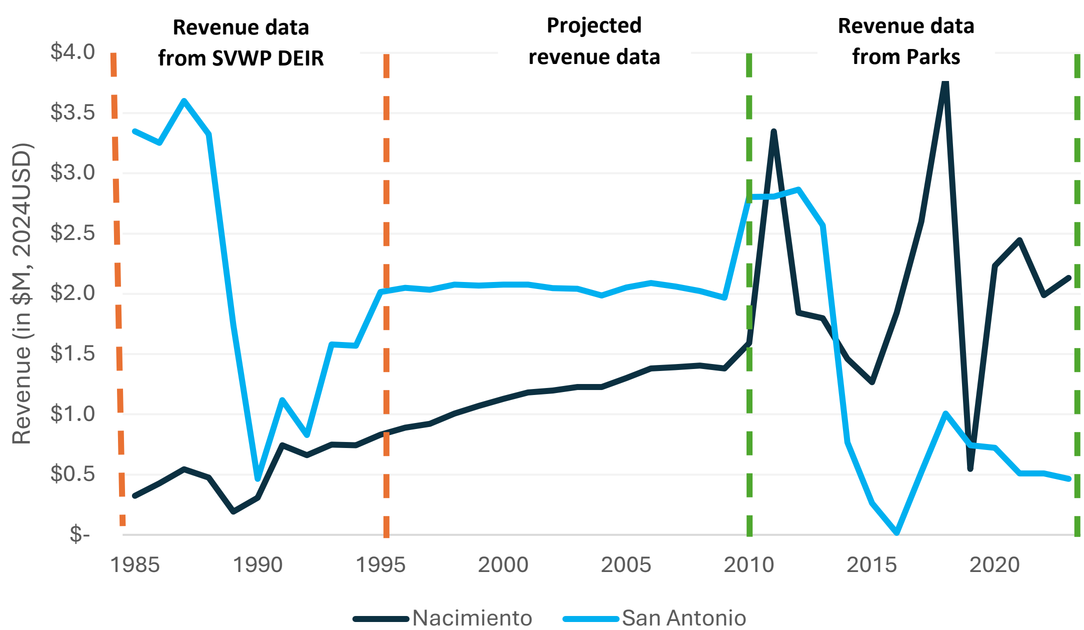

Figure 7. Revenues over time at Nacimiento and San Antonio Reservoirs, 2024 USD
Source: Revenue records from Monterey County Parks, SVWP DEIR (2001), and projections

The final step was to convert vehicle counts to user-day estimates by activity type. Here again we relied upon the USACE study (2003) to determine average visitors per vehicle. In that study, party size is differentiated based on activity. Using proportional activity estimates inferred from interviews with park staff (Tables 19 and 20), we multiplied the percentage of visitors participating in different activity categories, by the total estimated number of vehicles, and then again by the visitors per vehicle by activity type from the USACE study (2003). This yields an estimate of user-days by primary recreational activity. As discussed in the next section, this distinction in activities is important for valuing the user-days.

Table 19. Percent of activities by different types of users at Nacimiento Reservoir

Activity	Day Use Vehicles (28%)^	Day Use Boating (12%)	Camping & Boating (21%)	Camping (No Boating) (40%)
Fishing	10%	20%	10%	10%
Boating & swimming		30%	40%	
Shoreline swimming & picnicking	70%			60%
Paddleboarding & kayaking	10%			
Hiking & wildlife viewing	10%			
Boating water sports*		50%	50%	20%
Just camping				10%

^Percentages in the top row reflect proportion of total visitation
*Sports include water skiing, wake surfing, and wakeboarding

Table 20. Percent of activities by different types of users at San Antonio Reservoir

Activity	Day Use Vehicles (41%)^	Day Use Boating (15%)	Camping & Boating (13%)	Camping (No Boating) (32%)
Fishing	50%	55%	55%	35%
Boating & swimming	40%	20%	30%	
Shoreline swimming & picnicking				30%
Paddleboarding & kayaking				
Hiking & wildlife viewing	10%			
Boating water sports*		25%	15%	
Just camping				35%

^Percentages in the top row reflect proportion of total visitation
*Sports include water skiing, wake surfing, and wakeboarding

Adjustments to the tables above were made to estimate user-days by activity at San Antonio Reservoir after the 2014 drought based on communication with Parks officials. Prior to the drought, most visitors went to San Antonio for striped bass fishing. After the drought, declines in fish populations and water quality issues resulted in significantly fewer boaters visiting the lake. We therefore decreased the proportion of fishing visits to San Antonio across all permit categories (e.g., day use vehicles, day use boating, etc.) so that they accounted for less than half of all visitor activities.

5.2.2 Day use values

To estimate the economic benefits of recreational opportunities at San Antonio and Nacimiento, each visitor-day was valued using USACE UDVs for Recreation (FY 2023). The UDV method includes five criteria by which to judge the quality and value of recreational experiences, as summarized in Table 21. Each criterion is evaluated based on characteristics of the recreational site and assigned a point value according to local expert opinion. The point values are then summed and converted to dollar values (see Table 22), which are updated annually by USACE based on the category of recreation day.

At these two reservoirs, there are two categories of relevant recreation days according to the UDV method: *general recreation* and *general fishing recreation*. The general recreation and general fishing recreation categories both involve activities that are accessible and attractive to outdoor recreational users broadly. General recreation includes boating, water sports, kayaking and paddleboarding, swimming, hiking, camping, wildlife observing, and equestrian activities. General fishing recreation additionally includes fishing from the shore and from boats.

Table 21. USACE Unit Day Value Ranking, adapted from USACE (2023)

Criteria	Judgement factor	Total possible points
Recreation Experience	Count of general (camping, hiking, riding, cycling, fishing, boating) and high quality (uncommon activities) activities: minimum to numerous	30
Availability of opportunity	Count of the alternative options that are readily available: several within a short travel time to none within a 2-hour travel time	18
Carrying capacity	Quality and capacity of facilities and their impact on the natural resources: minimum facility for development to ultimate facilities	14
Accessibility	Ranking of quality of site and facility access: limited access to high standard good access	18
Environmental Quality	Rating of aesthetic quality and factors that could limit aesthetics: low to outstanding aesthetic qualities	20
Total possible points		100

Nacimiento Reservoir

Based on input from park staff, the project team assigned general recreation a point value of 63 out of 100 for Nacimiento Reservoir. This value considers the variety of available activities at Nacimiento, such as fishing, swimming, kayaking and paddleboarding, boating and water sports, and camping. Nacimiento scored highly based on the limited availability of other water sport amenities within an hour drive, and the adequate facility amenities such as a general store, lodging, and a marina for renting boats and other equipment. Scoring also reflects good accessibility to the site, and reasonable access to the lake, as well as aesthetic environmental qualities of the area. Nacimiento's carrying capacity was rated below average due to crowding during peak season, and the environmental quality category was impacted by the homes and private facilities visible from the lake. We also assigned general fishing recreation a point value of 63 out of 100 for many of the same reasons. This scoring yields a unit day value (or direct use value) of $12.00 for general recreation and $13.13 for general fishing.

Table 22. USACE use values by point value and recreation category (FY2024)

Point values	General recreation values ($)	General fishing and hunting values ($)
0	$5.05	$7.26
10	$6.00	$8.21
20	$6.63	$8.84
30	$7.58	$9.79
40	$9.47	$10.73
50	$10.73	$11.68
60	$11.86	$12.94
70	$12.31	$13.57
80	$13.57	$14.52
90	$14.52	$14.84
100	$15.15	$15.15

San Antonio Reservoir

San Antonio Reservoir day use values for the recreational amenities prior to 2014 drought were evaluated separately from the period from 2014 through 2018. For pre-drought points, San Antonio scored 64 out of 100. This score reflects the high-quality boating and fishing that attracted much higher visitation, as well as the variety of other available activities at San Antonio Reservoir, such as fishing, swimming, kayaking and paddleboarding, equestrian facilities, and camping equestrian trails. San Antonio Reservoir scored highly based on the limited availability of other shoreline camping opportunities nearby and the marina and lodging amenities that were open prior to 2014. This scoring yields a unit day value (or direct use value) of $12.04 for general recreation and $13.19 for general fishing.

As described previously, the recreational experience and available amenities declined after the drought in 2014. For this period, general recreation and general fishing were assigned a point value of 51 out of 100 for recreation unit day values at San Antonio. Scoring reflects the limited carrying capacity due to the marina and lodging closing after the drought. The aesthetic value declined post drought given the annual toxic algal blooms that impact recreational opportunities every summer since 2014. This scoring yields a unit day value of $10.35 for general recreation and $11.44 for general fishing per visit.

5.3 Value of recreational benefits

To value the benefits of recreation, we applied the unit day values summarized above to the visitation estimates described in Section 5.1. The unit day value ratings are broken out by general recreation and general fishing, so it was necessary to estimate the number of visitors in each category (day use, camping and boating) whose main recreational activity during their trip to the lake included fishing. Here we applied the activity estimates provided by Parks officials based on recent visitation. Figure 8 shows the breakout of general recreation and general fishing across both reservoirs.

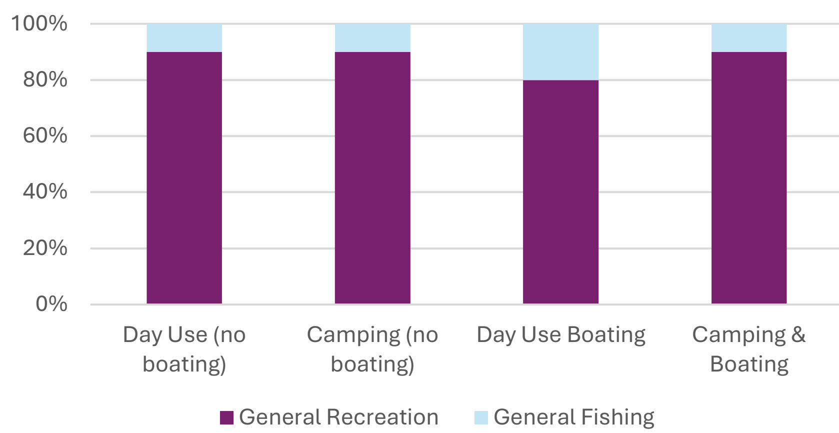

Figure 8(a). Visitation for recreation and fishing at Nacimiento Reservoir, 1985 - 2018

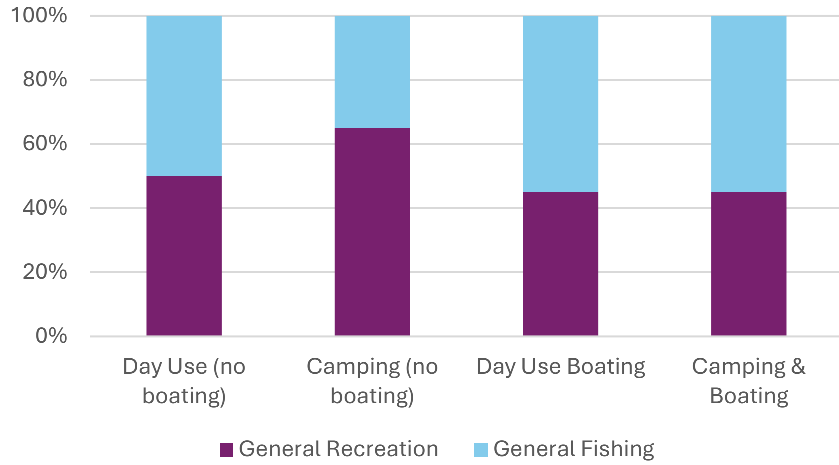

Figure 8(b). Visitation for recreation and fishing at San Antonio Reservoir, 1985-2013

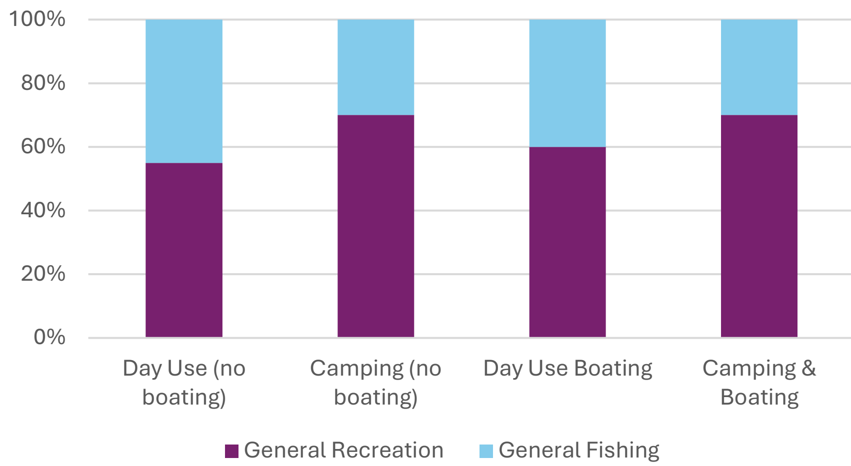

Figure 8(c). Visitation for recreation and fishing at San Antonio Reservoir, 2014-2018

Despite the loss of striped bass after the 2014 drought, fishing remains a primary draw for visitors at San Antonio Reservoir. Only 10% to 20% of visitors at Nacimiento participate in fishing, while 30% to 40% of visitors at San Antonio Reservoir are primarily there to fish. Unit day values for general fishing are higher at both lakes than those for general recreation. Despite lower unit day values generally for San Antonio compared with Nacimiento, the higher fishing values at San Antonio combined with the higher proportion of visitors participating in recreation make this a valuable recreational asset.

From 1985 to 2018, we estimate that the two reservoirs combined hosted over 64 million visitor days (Table 23). Most visitor-days at San Antonio occurred prior to the drought, when the reservoir hosted a significantly greater number of recreators who were attracted to the park's high-quality fishing, camping, and lodging amenities. In total, the reservoirs generated $797,450,000 in estimated recreational benefits for users during the period 1985-2018, an average annual benefit of more than $24 million.

Table 23. Total Recreational Benefits of Nacimiento and San Antonio Reservoirs, 1985-2018 (2024USD)

Reservoir	Category	Unit Day Value (per visit)	Total Visitor Days	Total Value
Nacimiento	General Recreation	$12.00	16.4M	$196.3
	General Fishing	$13.13	2.1M	$27.0
	Nacimiento Total		**18.4M**	**$223.2**
San Antonio 1985-2013	General Recreation	$12.04	24.3M	$292.0
	General Fishing	$13.19	21.2M	$279.5
	LSA Pre-Drought Total		**45.5M**	**$571.5**
San Antonio 2014-2018	General Recreation	$10.44	149,500	$1.6
	General Fishing	$11.38	97,800	$1.1
	LSA Post-Drought Total		**247,300**	**$2.7**
Total			**64.1M**	**$797.4**

6. Hydro-electric generation

Nacimiento Dam has a 4-megawatt (MWh) hydroelectric power plant that was built in 1987 on the dam's south side. The hydropower generated at Nacimiento is renewable energy that is valuable for its ability to avoid energy generated from other sources, including sources that generate more emissions. This section quantifies the value associated with hydropower generated at Nacimiento and monetizes the value of the related reduction in emissions.

6.1.1 Power generation

Based on data provided by MCWRA, Nacimiento's two-unit hydroelectric power plant generated an average of 9,833 MWh per year from 1987 to 2022. This includes two years of zero power generation from both generating units in 1989 and 1990, and a total of four other years of zero power generation from Unit 1, from 2014 through 2016 and in 2022. Maximum annual power generated from both units combined at Nacimiento was 20,052 MWh in 2005.

To value the hydropower generated, we used the cost of energy to the relevant power customers in California for each year of the analysis period.[12] From 2014 to 2022, power generated at the Nacimiento dam was sold to the Bay Area Rapid Transit (BART) system. To evaluate the cost of alternative power sources during this time, we applied the price of power sold to the transportation sector in California. For the years 1987 through 2013, power generated at Nacimiento Dam was sold to PG&E and distributed through the grid to all sectors. To value power from Nacimiento in these years, we used the average price of power sold in California in each year to all user sectors (residential, commercial, industrial, and transportation), weighted by the amount of power consumed by each sector in each year. Prices from each year were inflated to 2024 dollars using the Consumer Price Index (CPI) for energy expenditures.

Based on these assumptions, the total value of power generated at Nacimiento from 1987 to 2018 was $59.1 million. This represents the value of power generated, rather than an avoided cost (i.e., BART and PG&E would have purchased power from elsewhere if not from MCWRA).

6.1.2 Avoided power generation emissions

The hydropower generated at Nacimiento is also valuable for the air quality emissions it avoids. Avoiding power generation supplied through the electric power grid means avoiding emissions from the mix of fuels used at California power plants (and any imported power) over time. The mix of energy generation fuel sources has changed over time, as baseload power generation has shifted away from coal to natural gas and some renewables. The value of avoided emissions from non-renewable energy sources can be calculated based on the avoided health care costs associated with pollution from those emissions.

To estimate the benefit of reduced air pollutants, the project team used annual air quality emission rates (pound of pollutants per MWh of energy produced in California), available from the U.S. EPA's EGRID database (Emissions & Generation Resource Integrated Database) and EPA's AVERT (Avoided Emissions and geneRation Tool) model.[xii] Emissions reported in EGRID and AVERT include nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter 2.5 ($PM_{2.5}$) and carbon dioxide (CO_2). California emissions rates are

[12] Data on historical energy prices by use sector came from the Energy Information Administration, Form HS861. Energy Information Administration. 2023. Annual Electric Power Industry Report, Form EIA-861 detailed data files. https://www.eia.gov/electricity/data/eia861/ Accessed: November 6, 2023

reported in EGRID from 1996 to 2021 and in AVERT from 2007 to 2018. EGRID data are not collected every year; to accommodate these data gaps, we applied a year's value in every subsequent year until a new value was available. An average of five years of emission rates from 1996 to 2000 was applied every year from 1987 to 1995 for which emission rate estimates were not available. In addition, PM2.5 is the only pollutant for which emission rates are only available in AVERT. To estimate emission rates prior to 2007, we based on the correlation between other emission rates (NO_x) over the analysis period.

To estimate the value of avoided emission-related pollutants (including NOx, SO2 and PM2.5), we used EPA's national benefit-per-ton estimates for reductions in $PM_{2.5}$ and $PM_{2.5}$ precursor emissions (including NOx and SO2) for the electricity generating sector (Table 24).[xiii] These values were created using the air quality valuation model BenMAP (Benefits Mapping and Analysis Program). BenMAP is a software package and database that allows users to estimate the health-related benefits of air quality improvements based on established health impact functions (HIFs). The HIFs are derived from epidemiology studies that relate pollutant concentrations to specific health endpoints (e.g., premature mortality, chronic bronchitis, heart attacks, and other illnesses). Using values from the literature, BenMAP applies estimates of willingness-to-pay to avoid specific adverse health effects and avoided health care cost estimates to calculate benefits in monetary terms.[13]

Table 24. Dollar value per ton of directly emitted $PM_{2.5}$ and $PM_{2.5}$ precursors reduced from the electricity generating sector
(2024 USD, 3% discount rate[a,b])

Benefit per ton		
NO_x[c]	SO_2	Directly emitted $PM_{2.5}$
$13,262	$87,456	$311,539

Source: U.S. EPA 2018

a. Values updated to 2024 from 2015 USD, using CPI
b. Discount rate is applied because health effects associated with one-ton reduction in emissions do not occur all within the same year. This study assumes is a "cessation" lag between changes in PM exposures and the total realization of changes in health effects as follows: 30% of mortality reductions in the first year, 50% over years 2 to 5, and 20% over the years 6 to 20 after the reduction in $PM_{2.5}$.
c. Estimates for NO_x and SO_2 include a reduction in premature mortality. While these emissions are not directly linked to mortality risk, these estimates reflect the contribution of these gases to PM2.5 and ozone formation, and associated mortality risk.

To monetize the value of avoided carbon dioxide equivalent emissions, we applied the Social Cost of Carbon (SCC) to the CO_{2e} emissions avoided as a result of hydropower production. The SCC was developed by the Intergovernmental Panel on Climate Change (IPCC) Interagency Working Group (IWG) based on models that estimate the global impacts from climate change.[xiv] The SCC represents the damages caused per ton of CO_{2e} emitted, including damages related to illness, property value reductions associated with climate change, agricultural productivity, and environmental remediation related expenditures. The U.S. EPA recently updated the SCC to $146 per metric ton (2024 USD).[xv]

[13] EPA (2018) notes that care should be taken in applying the national average estimates reported in Table 24 to emission reductions occurring in any specific location. Health outcomes and associated monetary values can range significantly based on the local population, geography, and power generation mix, among other factors. For example, the marginal cost of emitting one unit of SO_2 in a remote area may be lower than the marginal cost of the same unit of pollution emitted in a densely populated area, because emissions in populated areas generate greater health damages.

Table 25 presents the value of avoided emissions associated with the generation of more than 326,000 MWh at Nacimiento dam (over the analysis period, 1987 to 2018). As shown, hydropower generation resulted in $16.0 million in avoided health-related costs from 1987 to 2018, an average annual benefit of $500,000 (from 1987 to 2018).

Table 25. Avoided Emissions from Nacimiento Hydropower Generation, 1987 -2018

	NOx	SO2	PM2.5	CO2
Avoided Emissions (metric tons)	58	24	**6**	79,500
Value (2024$)	766,000	2,139,000	1,514,000	11,576,000

7. Summary

This report presents the economic benefits provided to stakeholders in California's Salinas River Basin from construction and operation of Nacimiento and San Antonio Reservoirs, CSIP, and SVWP (the Projects). It serves as an update to the "Salinas Valley Historical Benefits Analysis" (HBA), which was developed for MCWRA in 1998 to assess the benefits provided by Nacimiento and San Antonio Reservoirs. The HBA Update (developed by West Yost) confirms that the Projects have resulted in significant hydrologic benefits, including increased fresh groundwater storage and reduced flooding across the Salinas Valley. This in turn has resulted in the following economic benefits:

- Higher groundwater levels have reduced the need to replace groundwater wells. This has avoided more than $107.4 million in well replacement costs over the 51-year analysis period (1968 to 2018), for an average annual benefit of $2.1 million.
- Higher groundwater levels have also reduced the energy required to pump groundwater in many areas, and in combination with deliveries from the CSIP and SVWP, have reduced overall groundwater pumping for irrigation. This has saved $67.9 million in groundwater pumping costs over the analysis period, for an average annual benefit of $1.3 million per year.
- Results of the HBA Update confirm that the increase in fresh groundwater storage in Basin aquifers has decreased seawater intrusion from Monterey Bay. The HBA Update reports that seawater intrusion has been approximately 1,000 AFY lower in the Pressure Subarea than it would have been without the Projects. Assuming an average applied water rate of 2.0 AF/acre, seawater intrusion under the No Projects scenario would have affected approximately 500 acres of farmland each year, with impacts to crops ranging from $21.7 to $86.9 M. This benefit has largely accrued to growers beginning in 1998, coinciding with deliveries of recycled water from CSIP.
- The reservoirs substantially reduced flooding along the Salinas River floodplain and the land and structures found there. This has resulted in avoided damages to buildings totaling $210.5 million over study period, $4.1 million per year on average. The value of avoided flood damages to agricultural crops is estimated to be $211.0 million over the 51-year analysis, or $4.1 per year, on average.

In addition to hydrologic and flood risk reduction benefits, the reservoirs have generated close to $800 million in recreational benefits between 1985 and 2018, an average annual benefit of more than $24 million. Between 1987 and 2018, Nacimiento dam generated 326 MWh of power, for a total value of $59.1 million. The generation of clean hydropower resulted in $16.0 million in avoided health-related costs from 1987 to 2018, an average annual benefit of $500,000.

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