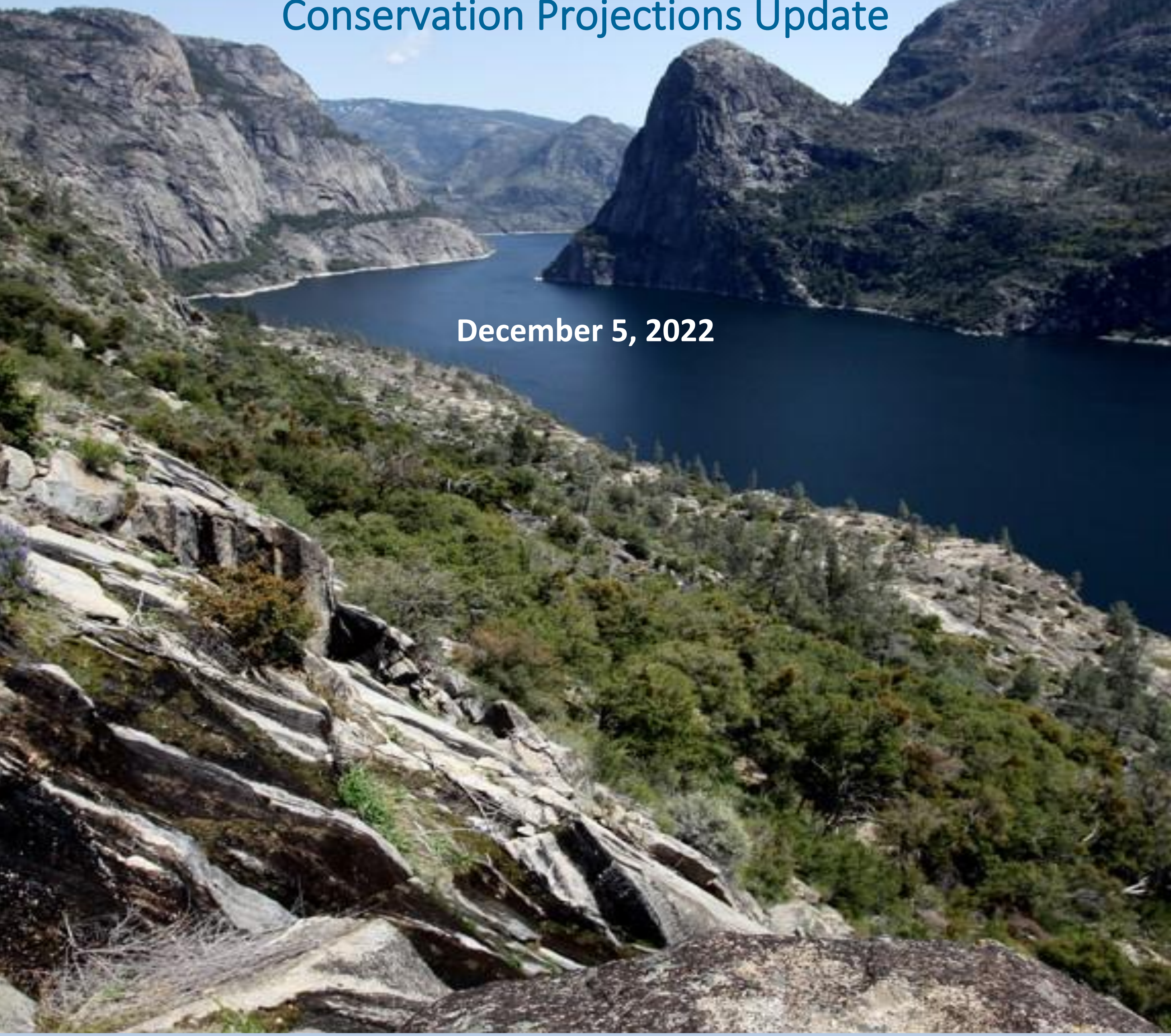
BAWSCA

Bay Area Water Supply & Conservation Agency

Regional Water Demand and Conservation Projections Update



December 5, 2022

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ACKNOWLEDGMENTS

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LIST OF ABBREVIATIONS AND ACRONYMS

2014 Project	2014 BAWSCA Regional Water Demand and Conservation Projections
2020 Demand Study	2020 Regional Water Demand and Conservation Projections Study
2022 Demand Study Update	2022 Regional Water Demand and Conservation Projections Study Update
AB	Assembly Bill
ABAG	Association of Bay Area Governments
ACWD	Alameda County Water District
AWS	Alternative Water Supply
AWWA	American Water Works Association
BAWSCA	Bay Area Water Supply and Conservation Agency
BC	Brown and Caldwell
BLS	U.S. Bureau of Labor Statistics
ccf	Hundred Cubic Feet
CDD	Community Development Department
CEC	California Energy Commission
CII	Commercial, Industrial, and Institutional
CO_2	Carbon Dioxide
CPI	Consumer Price Index
CWS	California Water Service
Data Workbook	Data-Intensive, Multi-Spreadsheet Microsoft Excel File
DOF	Department of Finance
DSS Model	Demand Side Management Least Cost Planning Decision Support System
DWR	California Department of Water Resources
EMID	Estero Municipal Improvement District
FY	Fiscal Year
GPCD	Gallons per Capita per Day
gpf	Gallons per Flush
gpm	Gallons per Minute
GVMID	Guadalupe Valley Municipal Improvement District
IPCC	Intergovernmental Panel on Climate Change
Ln	Logarithm
LTVA	Long-Term Vulnerability Assessment
MF	Multifamily
MID	Municipal Improvement District
MG	Million Gallons
MGD	Million Gallons per Day
MWELO	Model Water Efficient Landscape Ordinance
MWM	Maddaus Water Management
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NRW	Non-Revenue Water
PPIC	Public Policy Institute of California
psi	Pounds per Square Inch
R^2	R-Squared
RHNA	Regional Housing Needs Allocation
RCP	Representative Concentration Pathways
RWS	San Francisco Regional Water System
SB	Senate Bill
SB X7-7	Water Conservation Act of 2009
SF	Single Family
SFPUC	San Francisco Public Utilities Commission
SWP	State Water Project
SWRCB	State Water Resources Control Board
TM	Technical Memorandum
TPF	Transformed Peaking Factor
UWMP	Urban Water Management Plan
Valley Water	Santa Clara Valley Water District
WCDB	Water Conservation Database
WEMP	Water Efficiency Master Plan
WPR	Western Policy Research

EXECUTIVE SUMMARY

In June 2020, the Bay Area Water Supply and Conservation Agency (BAWSCA) completed a Regional Water Demand and Conservation Projections Study (2020 Demand Study [MWM, WPR, and BC, 2020]) as Phase 3 of its *"Making Conservation a Way of Life"* Strategic Plan. In the final months of the Phase 3 effort, the COVID-19 global pandemic began and changed patterns in water use throughout the region due to public health requirements that shut down or slowed some parts of the economy, changed how businesses operate, affected population, and shifted some water suppliers' demands between non-residential and residential deliveries.

These changes have the potential to impact both near-term and long-term population and employment projections as well as water use across many sectors. Additionally, new information became available during (or shortly following) BAWSCA's preparation of the 2020 Demand Study, including:

- Results from participating BAWSCA agencies' adopted 2020 Urban Water Management Plans.[1]
- Assigned Regional Housing Needs Allocations housing projections.
- Details related to the water use objective for the state's water use efficiency regulations (i.e., *Making Water Conservation a California Way of Life* [DWR, 2016]).

As a result, BAWSCA decided to update the 2020 Demand Study (as Phase 4 of BAWSCA's Making Water Conservation a Way of Life Strategic Plan) to meet two specific objectives:

> <u>Objective 1:</u> Reflect new data that became available since the 2020 Demand Study's completion. This included updated population and demand projections, water supply projections, and the impact of the COVID-19 pandemic on BAWSCA regional water demand.
>
> <u>Objective 2:</u> Better understand and quantify uncertainty associated with demand estimates and the variables that influence water demands, such as population, employment, climate change, housing densification, landscape transformation, conservation adoption, and rate increases. In light of the deep uncertainty associated with these variables and their individual and combined effects on future water demands, BAWSCA planned to conduct sensitivity analyses to evaluate the relative significance of key variables and determine a range of demand forecasts based on potential future scenarios.

This report documents the analyses and results of these objectives which is called the 2022 Regional Water Demand and Conservation Projections Study Update (2022 Demand Study Update).

Background on the 2022 Water Demand Study

BAWSCA actively collaborates with its member agencies to develop comprehensive water demand projections for the region. In 2014, BAWSCA completed its first *Regional Water Demand and Conservation Projections* project (2014 Study [MWM and WPR, 2014]) to support the development of its Long-Term Reliable Water Supply Strategy. The 2014 Project developed long-term demand projections through 2040 and short-term demand projections that account for rebound in water demand associated with economic recovery from the 2008–2013 recession.

After the 2014 Demand Study completion, the local Bay Area economy continued to recover. However, the state was also experiencing a major drought, which had begun in 2014, that was significantly decreasing water demand for all BAWSCA member agencies. In the worst year of the drought (2015), overall water use among the BAWSCA agencies was reduced by 27% compared to 2013 demand levels.

[1] Not all BAWSCA agencies were required to submit a UWMP and as such, throughout this report, whenever agency UWMPs are mentioned, it only is applicable to those agencies that submitted them. Agencies that were not required to submit UWMPs provided future supply projection data via their individual Data Workbooks.

BAWSCA initiated the 2020 Demand Study in January 2019 to update water demand and conservation projections for each BAWSCA agency given the significant change in conditions following the 2014 Demand Study and since the 2020 UWMPs, which were due in July 2021, would require many of the same projections. The study was completed in June 2020 with a key goal of capturing how regional water demand would likely rebound as California's water supplies recovered from the 2014–2017 drought.[2] The results of the 2020 Demand Study were intended to support the 2020 UWMPs through the 25-year planning horizon, considering the impacts of the recent drought on short- and long-term water demand and BAWSCA's Long-Term Reliable Water Supply Strategy implementation.

This 2022 Demand Study Update began after the 2020 UWMPs were submitted in July 2021 by the individual BAWSCA member agencies. The 2022 Demand Study Update was a collaborative effort between BAWSCA and its member agencies to incorporate new information and sensitivity analyses to assess how a range of influences could impact future demand. Over the course of the study, input was solicited from the aforementioned groups through multiple forums, including workshops, stakeholder engagement, one-on-one communication, and web-based meetings. A stakeholder process was implemented for the 2022 Demand Study Update's sensitivity analysis consisting of representatives from eight entities who provided feedback on the variables and scenarios within the sensitivity analysis.

Data Collection and Analysis Process

The data collection process for the 2022 Demand Study Update was conducted via a data collection and verification file, i.e., a quantitative, data-intensive multi-spreadsheet Microsoft Excel file (Data Workbook). The Data Workbook was used to collect, organize, and verify the necessary input data to provide the best available information for the demand update and sensitivity analysis from each individual BAWSCA member agency. The data collected included monthly water production and water consumption from 1995 through 2021, unemployment projections, water rates, service area demographics, and more items as described in Section 2 and Section 3 of this report. The data collected for the 2022 Demand Study Update was used to revise the DSS Model data analysis (discussed in Section 4) and the sensitivity analysis (discussed in Section 6).

The Demand Side Management Least Cost Planning Decision Support System Model (DSS Model), in combination with an Econometric Model, was used to determine short- and long-term demand projections for each BAWSCA agency and region-wide. Descriptions of the DSS Model and the Econometric Model are included in Appendix A and Appendix B, respectively.

2022 BAWSCA Water Demand Update Results

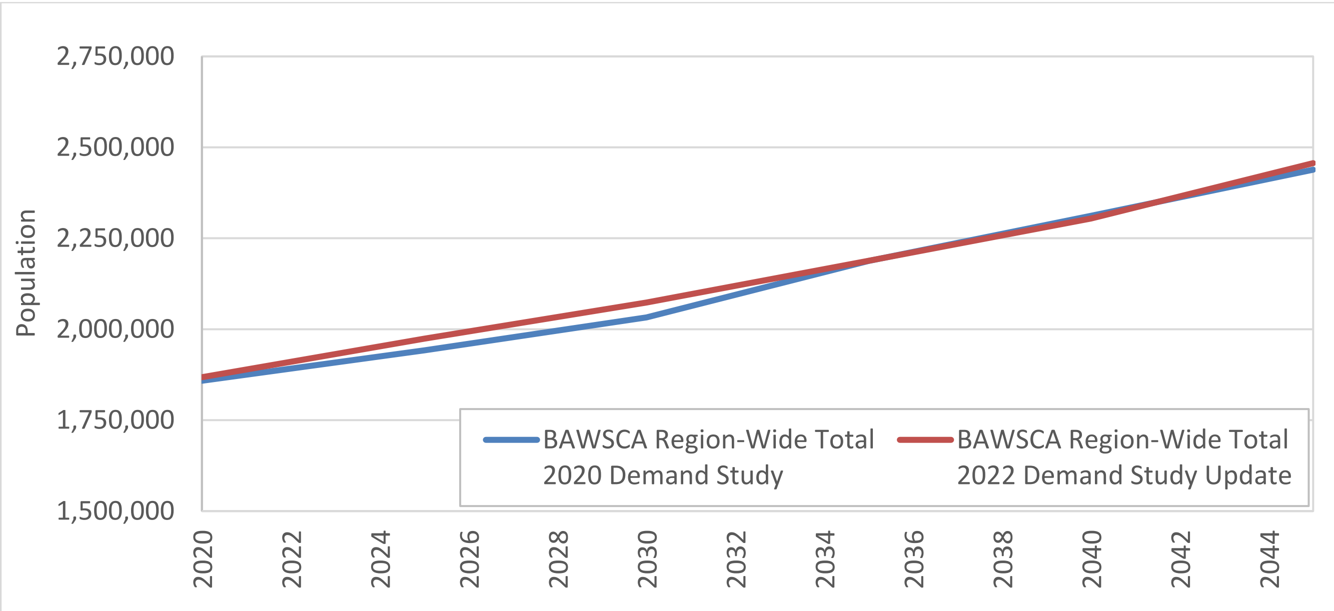
The 2022 Demand Study Update included key elements including an update to service area population and water demands. This study also included new items that extend beyond the 2020 Demand Study including demand breakdowns by customer class and a sensitivity analysis. Results of each of these areas are described below.

Updated Service Area Population Projections

The total BAWSCA service area population projections are presented in Figure ES-1. These projections were obtained by each member agency's Data Workbook and are based on each agency's 2020 UWMP, Association of Bay Area Governments (ABAG) Plan Bay Area 2040 data, and ABAG Plan Bay Area 2050 data or other adopted data sources. As shown in Figure ES-1, the overall BAWSCA region-wide population projections increased by 0.7% by 2045 compared to results from the 2020 Demand Study. This increase in population projections is the result of updated information received by each agency since the completion of the 2020 Demand Study. The updated population projections show a growth rate of 32% between 2020 and 2045.

[2] Drought conditions first emerged during the winter of 2012/2013, then continued to worsen in subsequent years, which caused state authorities to mandate drought response actions starting in 2014 until early 2017.

Figure ES-1. BAWSCA Region-Wide Population Projection 2020 Demand Study vs. 2022 Demand Study Update



Note: The lines in the above figure are close because the population forecasts changed only minorly between the 2020 Demand Study and 2022 Demand Study Update.

Updated Water Demand and Usage Projections

In the 2020 Demand Study, demand forecasts were developed for each agency to account for conservation from passive (i.e., codes/standards) and active conservation programs. For the 2022 Demand Study Update, demand projections were updated to reflect what the BAWSCA agencies published in their 2020 UWMPs. Based on these updated demand projections, water demands are projected to increase 20% from 2025 to 2045 after accounting for the effects of the existing plumbing code, future active conservation savings, and climate change. These results are shown in Table ES-1.

In comparison to the 2020 Demand Study, by 2045 the total water demand projections for BAWSCA agencies have increased by 1.6% for demands with active and passive conservation. Key reasons for the demand increase from the 2020 Demand Study to the 2022 Demand Study Update are as follows:

- **Population:** Overall BAWSCA region-wide population projections increased 0.7% by 2045, as displayed in Figure ES-1.
- **Recycled Water:** There are more agencies planning to increase their recycled water since more recycled water projects are being developed. Per Section 5.2 recycled water increased by approximately 2% in 2045 projection when compared to the 2020 Demand Study.

Other factors impacting the projected increase in water demand in 2045 include job projections, conservation, and planned future land uses. As shown in Section 5, 8 out of 27 BAWSCA agencies have the same projected water demand as the 2020 Demand Study.

Table ES-1. 2022 Demand Study Update Future Water Projections

Water Demands without Passive Conservation (MGD)					
	2025	**2030**	**2035**	**2040**	**2045**
2022 Demand Study Update	231.5	244.0	260.1	276.2	296.5
2020 Demand Study	240.3	251.1	266.7	280.0	293.6
Percent Change	-3.7%	-2.8%	-2.5%	-1.4%	1.0%
Water Demands with Passive Conservation (MGD)					
	2025	**2030**	**2035**	**2040**	**2045**
2022 Demand Study Update	222.8	230.2	240.7	251.9	267.7
2020 Demand Study	228.9	234.3	244.3	253.1	262.4
Percent Change	-2.6%	-1.8%	-1.4%	-0.4%	2.0%
Water Demands with Passive and Active Conservation (MGD)					
	2025	**2030**	**2035**	**2040**	**2045**
2022 Demand Study Update	219.0	224.7	234.5	244.8	260.4
2020 Demand Study	225.1	229.2	238.8	247	256.3
Percent Change	-2.7%	-2.0%	-1.9%	-0.9%	1.6%

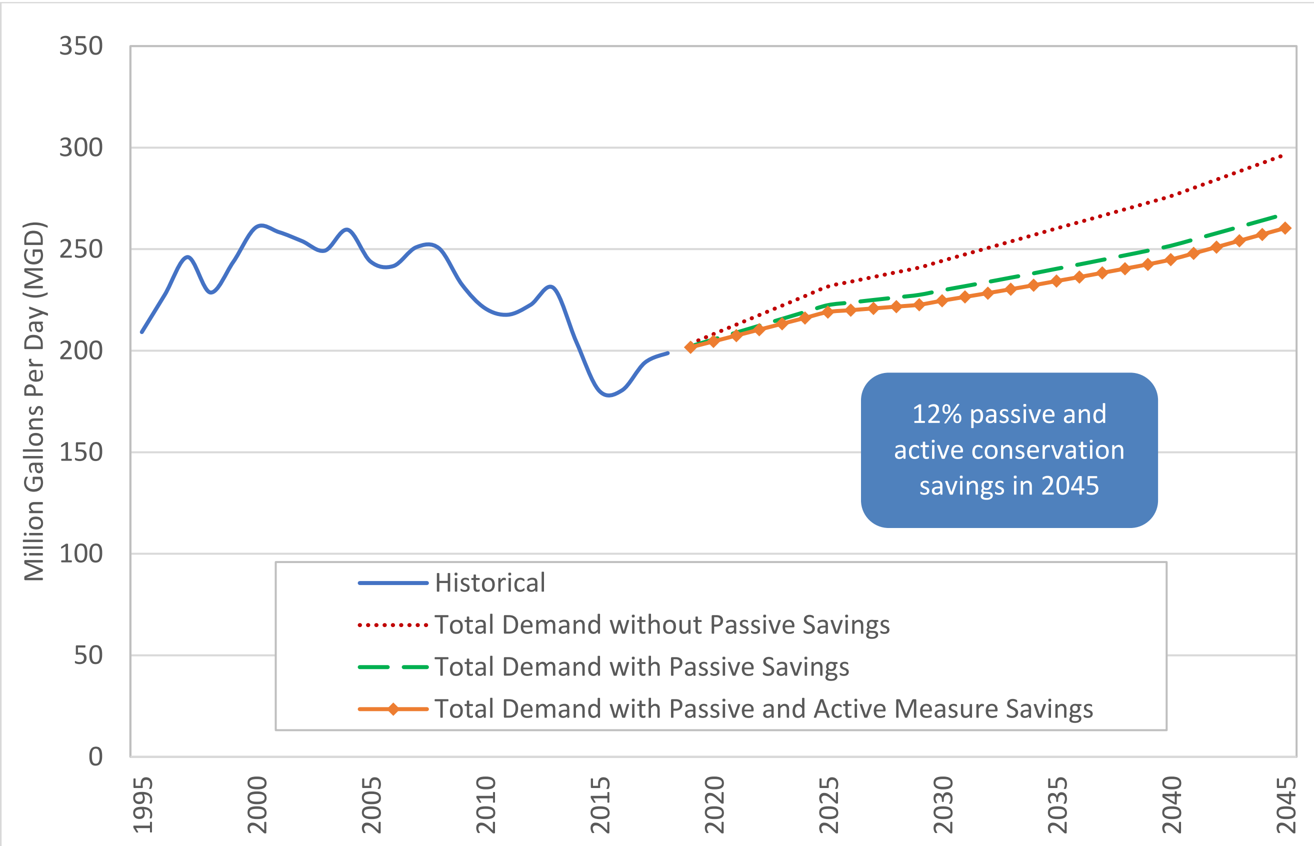
Notes:

1. *MGD = million gallons per day.*
2. *Total water demand accounts for the total projected demand in a service area water system regardless of source, which could be from SFPUC, groundwater, surface water, recycled water, brackish groundwater desalination, the State Water Project, or Santa Clara Valley Water District.*

Figure ES-2 presents the combined BAWSCA region-wide water demand projections with and without passive and active conservation. Total water demand is defined as total water consumption plus non-revenue water. Water consumption is defined as water delivered to individual customers for use.

Figure ES-3 presents updated historical and projected gross per capita water use and residential per capita water use in the BAWSCA region through 2045.

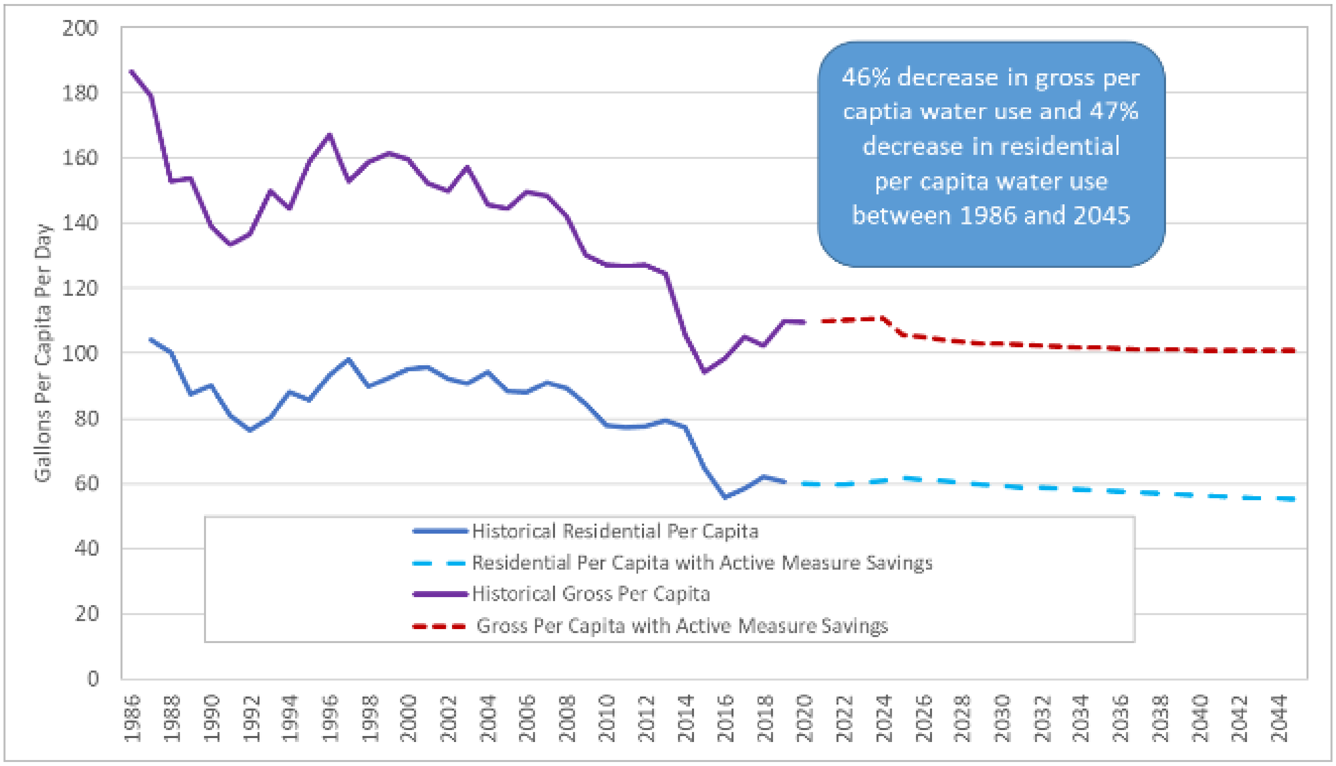
Figure ES-2. Updated BAWSCA Region-Wide Demands to 2045



Notes:

1. *Water demands are based on data provided from 1995 through 2021. This analysis was completed during the COVID-19 pandemic using the best available data.*
2. *Total projections account for the total projected water demand in a service area water system regardless of source. Sources include purchases from SFPUC, groundwater, surface water, recycled water, brackish groundwater desalination, the State Water Project, or Santa Clara Valley Water District.*

Figure ES-3. Updated Total BAWSCA Gross and Residential Per Capita Water Use



Notes:

1. *To be consistent with the methodology used for the BAWSCA Annual Survey, recycled water has been removed from the per capita calculations; therefore, the above information is a potable-only per capita value.*
2. *Residential water use includes some irrigation, as not all agencies have dedicated irrigation meters.*

Updated BAWSCA Region-Wide Demand Projections by Customer Class

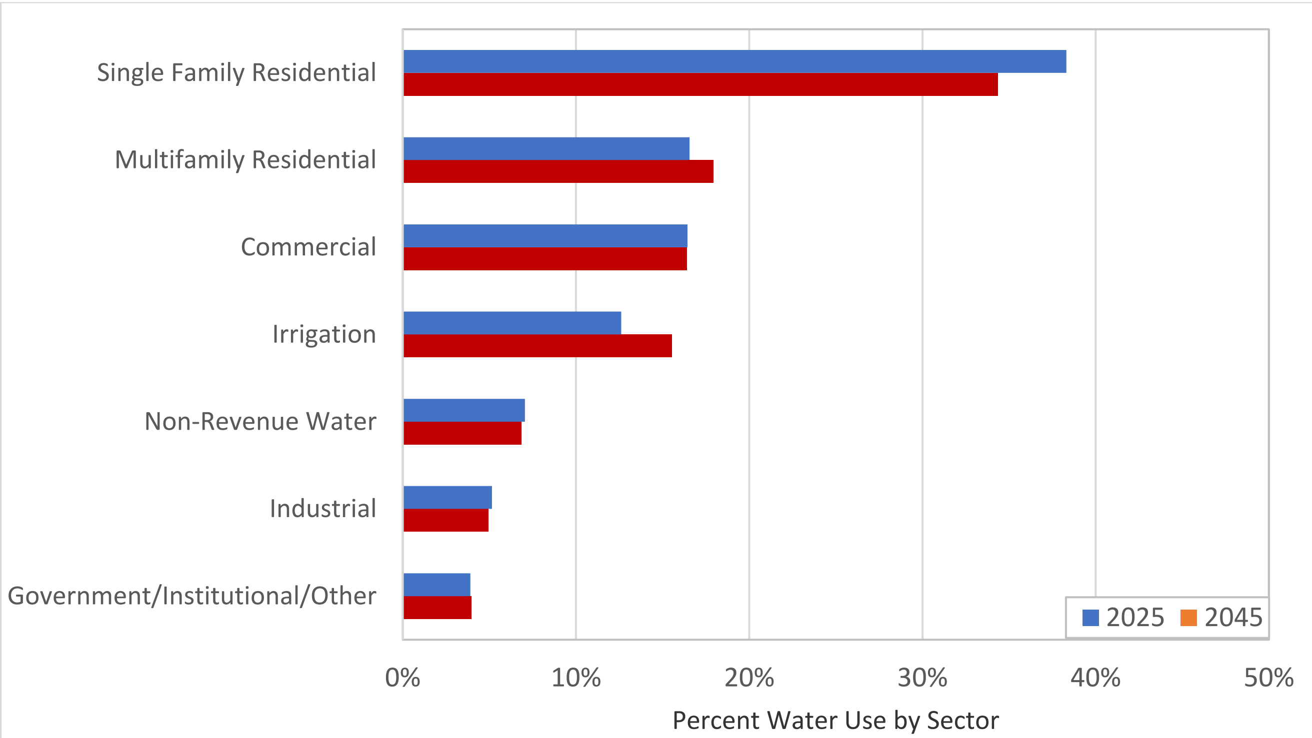
Each BAWSCA member agency defines its own customer categories for billing. The total number of water accounts as a BAWSCA region-wide sum is projected to be greater than 450,000 in 2025 and 540,000 in 2045, an increase of 20%.

Figure ES-4 summarizes the BAWSCA region-wide demand projections by customer class between 2025 and 2045. While the proportion of projected demands attributed to each customer category is estimated to remain relatively consistent, the following trends are noteworthy:

- Water use percentage in the Single Family Residential customer category is projected to decrease from 2025 to 2045, mainly due to active conservation efforts and a slowdown in single family new development.
- The water use percentage in the Irrigation customer category is projected to increase by 2045. One explanation for this is the inclusion of more recycled water in projected demand per the 2020 UWMPs. The majority of BAWSCA agencies label their recycled water as irrigation water use. As such, there has been an increase in the BAWSCA agencies including recycled water in future water supply as well as an increase in recycled water volume for those agencies that had included it previously.
- Multifamily Residential water use percentage is projected to increase by 2045 compared to 2025. This is due to an increase in multifamily account growth since more development is planned in the multifamily sector.

- The projected water use percentage by customer category with active conservation depicts a minimal shift in water use breakdown between the years 2025 and 2045 for the following BAWSCA customer categories: Commercial, Industrial, Government/Institutional/Other, and Non-Revenue Water.

Figure ES-4. Projected Water Use Percentage by Customer Class CY 2025 and CY 2045



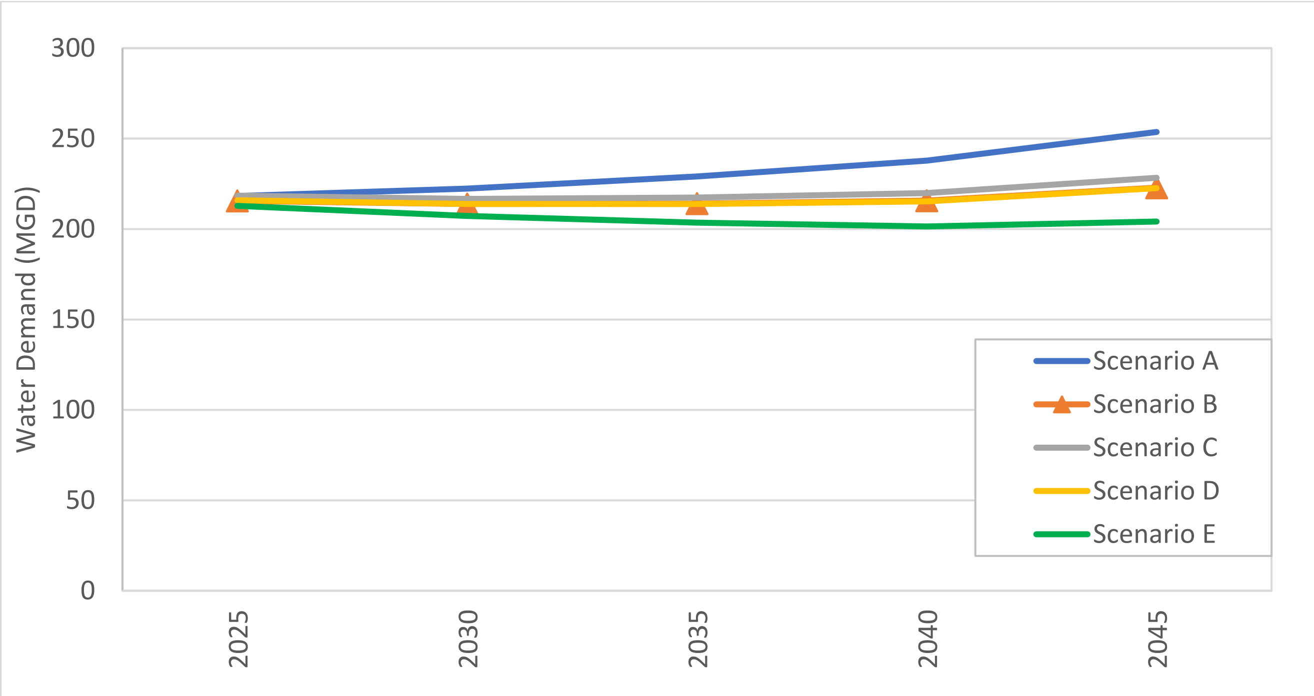
Note: Non-Revenue Water is potable water only. Irrigation, Government/Institutional/Other, and Commercial include both potable and recycled water.

Sensitivity Analysis of the 2022 Water Demand Update Results

Most water demand forecasting models are deterministic and provide information on a single future demand. A sensitivity analysis, however, can help explain how the uncertainty of variables in the model affects demand estimates. The sensitivity analysis study for the 2022 Demand Study Update considers a planning horizon through the year 2045 and multiple variables that could influence demands in the BAWSCA agencies' service areas, such as population and economic growth, housing density, long-term climate change, water rates, water conservation, seasonal weather, and economic cycles. Several criteria are required for variables incorporated into the forecast model for the sensitivity analysis. Variables must have a demonstrated correlation to water demands, be measurable, and be supported by data (or reasonable estimates). Five unique scenarios were developed using a combination of variables that are referred to as Scenario A through Scenario E (Figure ES-7).

Scenario A exhibits the highest demand because population growth is assumed to occur at the high end of the simulation range (1.1% per year), while rate increases are assumed to be no greater than inflation, which removes a significant source of downward pressure on demand. Of the various demand drivers, population growth remains the most important source of upward pressure. On the other end of the spectrum is Scenario E, which assumes population growth will be at the lower end of the simulation range (0.52% per year), while all the downward pressures on water demand, such as increasing housing density, rate increases, and conservation, remain operational over time. The other scenarios (B through D) that incorporate the key assumptions in various combinations remain clustered between Scenarios A and E. Only Scenario E predicts a slightly lower demand over time. All other scenarios either indicate rising demand (Scenario A) or somewhat minimal increase over time (Scenarios B through D).

Figure ES-5. Future Water Demands as Projected Under Sensitivity Analysis Scenarios A Through E



Note: Scenario B and Scenario D have similar values causing the lines to overlap in the figure. As a result, Scenario B has been given symbol markers to help illustrate its value path.

Findings and Recommendations

BAWSCA updated the previous 2020 Demand Study as Phase 4 of BAWSCA's Making Water Conservation a Way of Life Strategic Plan to incorporate new information available and sensitivity analyses to assess how a range of influences could impact future demand. Results from the analysis have shown that the changes between the 2020 Demand Study and the 2022 Demand Study Update are modest and are influenced by updated population projections and increased recycled water projections, as more recycled water projects are being developed. Based on these updated demand projections, water demands are projected to increase 20% from 2025 to 2045 after accounting for the effects of the existing plumbing code, future active conservation savings, and climate change. By comparison, the population projections show a growth rate of 24% between 2025 and 2045.

Additional findings on the BAWSCA region-wide demand projections by customer class have shown that the percentage of water use in the Single Family Residential customer category is projected to decrease, mainly due to active conservation efforts and a slowdown in single family new development, while Multifamily Residential water use is projected to increase by 2045 compared to 2025 since more development is planned in this sector. The projected water use percentage by customer category with active conservation depicts a minimal shift in water use breakdown between the years 2025 and 2045 for Commercial, Industrial, Government/ Institutional/Other, and Non-Revenue Water.

The sensitivity analysis study for the 2022 Demand Study Update considered a planning horizon through 2045 and multiple variables that could influence demands in the BAWSCA agencies' service areas, such as population and economic growth, housing density, long-term climate change, water rates, water conservation, seasonal weather, and economic cycles. Five unique scenarios were developed using a combination of variables and as illustrated in Figure ES-7 the range of scenarios varied by up to 50 MGD from 204 MGD to 254 MGD in 2045. These sensitivity analysis findings can assist regional and agency-level water use forecasts and provide potential refinements to BAWSCA agencies' water use efficiency programs as the agencies continue to strive to optimize available water supplies. They can also assist BAWSCA and the member agencies in considering future investments in local and regional projects including consideration of development of new water supplies. Furthermore, BAWSCA can compare results from this analysis to actual conditions and water use in the future to validate the accuracy of a variable's impact on water demand.

As observed in the sensitivity analysis, of the various demand drivers, population growth remains the most important source of upward pressure and should be closely observed in the future when analyzing water demand projections. Since the first Regional Demand Study published in 2004, BAWSCA population projections have closely aligned with actual population in the BAWSCA service area. This consistent, close alignment has increased confidence in BAWSCA's projected water demands but should be consistently updated to adjust for future changes in population patterns.

Recommendations to assist with future BAWSCA demand forecasting and planning efforts:

- Continue to track COVID-19 pandemic impacts on employment and total water production. Revisit water demands as appropriate to incorporate recent events into planning efforts.
- Compare observed population growth and climate conditions with the results of this study to be able to anticipate if demands are being contained within the projected demand model.
- Continue to track how and why demands could shift in the future including representation of the key drivers of demand, namely temperature, efficiency improvements, and population growth. This would allow for a more explicit treatment of uncertainty and a continued understanding of how and when climate, population, and customer water use are driving demand.
- Use updated water demand numbers to support implementation of BAWSCA's Long-Term Reliable Water Supply Strategy and to help make decisions on SFPUC's Alternative Water Supply plan.
- Engage in the state processes to establish the requirements associated with implementing the Assembly Bill 1668, and Senate Bill 606 legislation.
- Support BAWSCA agencies in taking steps to differentiate between residential and non-residential dedicated irrigation use in their billing systems to support compliance with the state requirements and improve future per capita water use forecasting.
- Continue collaborating with member agencies to evaluate regional implementation of identified conservation programs which have high water-savings potential and agency interest.

1 INTRODUCTION

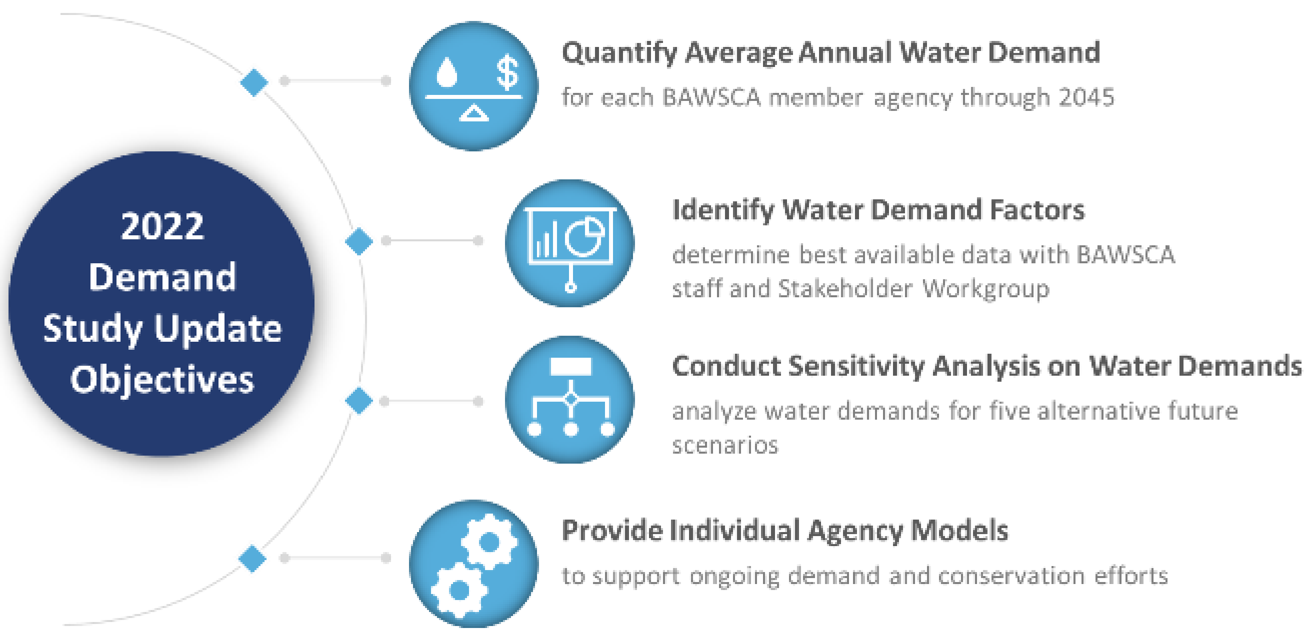
This 2022 Regional Water Demand and Conservation Projections Study Update (2022 Demand Study Update) report summarizes the adjustments made to the water demand estimates in the 2020 Regional Water Demand and Conservation Projections Study (2020 Demand Study [MWM, WPR, and BC, 2020]) for each Bay Area Water Supply and Conservation Agency (BAWSCA) member agency and for the BAWSCA region as a whole.

1.1 Goals and Objectives

Recently, a substantial shift in the challenges and drivers for water management has occurred, in part because of the recent drought, water supply conditions, and the need to comply with pending water conservation regulations. This 2022 Demand Study Update will allow BAWSCA to implement additional water use conservation measures in line with current conditions regarding water sustainability and reliability. The 2022 Demand Study Update considers best management practices consistent with current regulations and best practices in the industry. It also considers the BAWSCA agencies' capabilities and practices and how they may need to be further developed in relation to new legislation.

The overall goal of the 2022 Demand Study Update was to develop transparent, defensible, and uniform demand and conservation projections for each BAWSCA member agency using a common methodology that could be implemented to support regional planning efforts and individual agency work. Pursuant to this goal, specific objectives were developed, as detailed in Figure 1-1.

Figure 1-1. BAWSCA 2022 Demand Study Update Objectives



1.2 Approach and Methodology

To accomplish the above objectives, each BAWSCA member agency's water demand and conservation savings were forecasted through 2045 using a combination of two models – an econometric model and the Demand Side Management Least Cost Planning Decision Support System Model (DSS Model) developed by Maddaus Water Management (MWM). The purpose of using two tools was to leverage the strengths of each to obtain the best forecast through 2045.

Econometric modeling is a statistical approach used to determine the impact of factors such as economic conditions, weather, rates, and conservation on water demands. The econometric model is used to project, based on historical patterns, the future rebound in water demand associated with short-term effects (e.g., economic recovery, drought conditions, etc.) while also considering other factors, such as water rate increases and weather. During the 2020 Demand Study, the econometric modeling was completed outside the DSS Model then later incorporated as a feature into each member agency's model.

The DSS Model prepares long-range, detailed water demand and conservation savings projections to enable a more accurate assessment of the impact of water efficiency programs on demand. The DSS Model can use either a statistical approach to forecast demands (e.g., an econometric model) or it can use forecasted increases in population and employment to evaluate future demands. Furthermore, the DSS Model evaluates conservation measures using benefit-cost analysis, with the present value of the cost of water saved and benefit-to-cost ratio as economic indicators. The analysis is performed from various perspectives, including utility and community perspectives. For the 2022 Demand Study Update, historical data was updated in the DSS Models, however the conservation measures were not altered. BAWSCA member agencies also used the DSS Model to forecast demands in their 2004, 2006, 2009, 2014, and 2020 planning efforts.

1.3 Project Partners

The 2022 Demand Study Update was completed as a collaborative effort among BAWSCA staff, BAWSCA member agencies, and the consultant project team (MWM Project Team), which was led by MWM in association with Brown and Caldwell (BC) and Western Policy Research (WPR). Over the course of the 2022 Demand Study Update, input was solicited from the aforementioned groups through multiple forums, including workshops, one-on-one communication, and web-based meetings. BAWSCA member agencies' roles in the 2022 Demand Study Update included submitting data and associated technical information for use in individual agency DSS Models.

Stakeholder Workgroup

As part of this project, BAWSCA identified and convened external stakeholders (such as non-governmental organizations, policy researchers, land use planners, and others) to form a Stakeholder Workgroup. This workgroup collaboratively solicited input and diverse perspectives regarding future growth and development patterns as well as water use trends. Seven organizations accepted the invitation to participate in the workgroup: The Pacific Institute, San Mateo County Office of Sustainability, Association of Bay Area Governments (ABAG), San Francisco Estuary Partnership, Sustainable Silicon Valley, Tuolumne River Trust, and The Brattle Group.

The MWM Project Team conducted three 90-minute virtual stakeholder engagement meetings:

- **Meeting 1 (March 2022):** The MWM Project Team presented the project approach and solicited stakeholder input on key variables impacting future water demand on which the sensitivity analysis should focus. Stakeholders' responses were collected through live polling (using Poll Everywhere). Stakeholders were asked to provide any known data sources.
- **Meeting 2 (June 2022):** The MWM Project Team presented preliminary scenarios for the sensitivity analysis. Stakeholder feedback was collected then reflected in adjustments to the sensitivity analysis.
- **Meeting 3 (November 2022):** The MWM Project Team presented final scenarios and results for the sensitivity analysis.

1.4 Relationship to Other Planning Efforts

For the 2020 Demand Study, in September 2018 the BAWSCA Board of Directors unanimously approved BAWSCA's Strategic Plan Phase 1[3] recommendations, including the recommendation to update the water demand and conservation projections for BAWSCA member agencies using a common methodology.

[3] Maddaus Water Management et al. (2018). *Bay Area Water Supply and Conservation Agency's "Making Conservation A Way of Life" Strategic Plan – Phase 1*.

In addition to providing critical input for BAWSCA regional conservation planning efforts, the 2020 Demand Study demand projections were used by individual BAWSCA member agencies in developing their 2020 UWMPs.

Prior efforts, as listed below, have developed regional demand and conservation projections for the BAWSCA region using the DSS Model:

- San Francisco Public Utilities Commission (SFPUC) *Wholesale Customer Water Demand Projections* (URS Corp. and MWM, 2004)
- SFPUC *Wholesale Customer Water Conservation Potential* (URS Corp., MWM, Jordan Jones & Goulding, 2004)
- *Projected Water Usage for BAWSCA Agencies* (BC and MWM, 2006)
- *BAWSCA Water Conservation Implementation Plan* (MWM and BC, 2009)
- *BAWSCA Regional Water Demand and Conservation Projections* (MWM and WPR, 2014)
- *BAWSCA Regional Water Demand and Conservation Projections* (MWM, WPR, and BC, 2020)

These prior efforts proved to be a robust means to support environmental documents like the *Water System Improvement Program – Program Environmental Impact Report* (SFPUC, 2006), member agency UWMPs, conservation planning (e.g., the BAWSCA Regional Water Conservation Program and development of the BAWSCA Water Conservation Database [WCDB]),[4] and development and implementation of BAWSCA's Long-Term Reliable Water Supply Strategy.

The 2022 Demand Study Update is connected to multiple other BAWSCA and member agency planning efforts including:

- Demand forecasts aligned with the BAWSCA member agencies' 2020 UWMPs.
- Future local and regional conservation and supply efforts.
- Upcoming 2022–2023 update to the BAWSCA WCDB.
- Conservation water savings to include recent information related to the urban water use objective mandated by the State of California.

[4] BAWSCA. (n.d.) Water Conservation Database website. http://wcdb.bawsca.org/

2 DATA COLLECTION AND VERIFICATION PROCESS

This section documents the data collection and verification process for the 2022 Demand Study Update. This was critical to the modeling process to ensure the best available information was used to update each member agency's DSS Model historical inputs, data analysis, and sensitivity analysis. Described herein are the types of data collected and the steps taken to obtain and verify the data.

2.1 Data Collection Process Overview

The data collection process for the 2022 Demand Study Update was conducted using a data-intensive, multi-spreadsheet Microsoft Excel file (Data Workbook). The Data Workbook was used to collect, organize, and verify the input data necessary to provide the best available information for the demand update and sensitivity analysis. The required data was organized into individual Data Workbooks and distributed to the BAWSCA member agencies (one per agency). This task was streamlined since the workbooks had pre-existing data from the 2020 Demand Study effort (see data sources in Table 2-1).

BAWSCA member agencies completed and verified the Data Workbooks through the following steps:

1. **Distribution of files to individual agencies:** The Data Workbooks were distributed to the individual agencies in October 2021 via BAWSCA's WCDB.
2. **Instructional webinar:** A webinar to disseminate information related to the data collection process was held in November 2021 for member agencies. During the webinar, BAWSCA staff and the MWM Project Team reviewed the Data Workbook contents with member agencies and provided instructions for completing the files. Agencies who were unable to attend the webinar were provided access to the webinar recording.
3. **Data Workbook completion by agencies:** Each member agency reviewed and completed its individual workbook, which required:
   - Verifying existing data that remained from the previous efforts or was pre-populated in the Data Workbook by the MWM Project Team.
   - Data entry of missing information, as applicable.
4. **Data Workbook submission by agencies:** Agencies submitted the files through the WCDB from November 2021 to mid-March 2022 after completing Step 3.
5. **Data Workbook review and refinement**: The MWM Project Team reviewed the submitted individual workbooks in the order received. If further data and refinement were required, BAWSCA staff and the MWM Project Team contacted the individual member agency to obtain the necessary information.

2.2 Types of Data Collected

The impetus for the types of data collected was the specific data needs for the demand update and sensitivity analyses. The data collected can be broadly categorized into a few major groups as listed in Table 2-1 and detailed below.

Service Area Data

Data including water rates, population, and total employment (jobs) was collected to show the historical and future growth in the service area. The service area data was used for the sensitivity analysis.

Service Area Demographics

Service area demographics were collected regarding historical and projected population using previous DSS Models, 2020 UWMPs, the 2019 ABAG 2040 Plan Bay Area Projections,[5] Draft ABAG 2050 Plan Bay Area

[5] ABAG. (2018). Plan Bay Area 2040, accessed August 2022. http://2040.planbayarea.org/reports. Association of Bay Area Governments, & Metropolitan Transportation Commission. Plan Bay Area 2040 Growth Projections [computer file]. San Francisco, CA: Association of Bay Area Governments & Metropolitan Transportation Commission. ABAG 2040 Plan Bay Area

Projections[6] (population and employment forecasts, which were updated as part of ACWD's Water Efficiency Master Plan [WEMP]),[7] and Regional Housing Needs Allocation (RHNA) 2023–2031 data.[8] These demographics were used for the sensitivity analysis.

Economy
Data from the U.S. Bureau of Labor Statistics (BLS)[9] on historical employment and unemployment was collected for the individual BAWSCA agency service areas (at the city level) to attempt to capture the change in work force between 1995 and 2020 (2021 was not available when the data was collected). The economic data was used for the sensitivity analysis.

Urban Water Management Plans
Agencies were asked to provide UWMP data for the California Department of Water Resources (DWR) Table 4-3 (Projected Demand for years 2020–2045) and DWR Table 6-9 (Projected Supply for years 2020–2045) in 5-year increments. This information was used as a source and reference for Tables 5-5 and 5-7 as shown in Section 5 of this report.

Projected Supply Production
Agencies were asked to provide projected supply production (i.e., treated water supply, not total allocated supply) by source for years 2025–2045 in 5-year increments as shown in Figure 4-1 and Table 4-1 in Section 4 of this report. Additionally, BAWSCA can use this data for its Annual Survey, to share with SFPUC for use in updating its Water Supply and Demand Yield Worksheet, and for other purposes.

Water Loss
Agencies provided American Water Works Association (AWWA) water loss data for 2016–2021, where available. This information was used to update the DSS Models with the most current water loss information.

Weather
Data was collected from the local National Oceanic and Atmospheric Administration (NOAA) weather station(s) closest to each agency. Data types included temperature maximum, temperature minimum, temperature average, and precipitation for the years 1995–2021. The weather data was used for the sensitivity analysis.

Conservation
Select data was collected from the WCDB and agency-provided information ranging from 2009–2021. The conservation data was used for the sensitivity analysis.

Other
Each agency was asked to provide any information regarding new development ordinances or comments received from DWR regarding the agency's 2020 UWMP (if one was filed). Collected data was used as background information when analyzing each agency's service area for the sensitivity analysis.

Table 2-1 categorically lists the individual data elements collected and includes further details regarding timeframe, units, and sources.

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was used instead of ABAG 2050 Plan Bay Area to remain consistent with sources used in the 2020 UWMP, with the exception of one BAWSCA agency (ACWD) that used the draft ABAG 2050 (see next footnote).

[6] Ibid. Draft Plan Bay Area 2050, accessed August 2022. https://abag.ca.gov/our-work/land-use/plan-bay-area-2050. The Draft Plan Bay Area 2050 was used by ACWD for this 2022 Demand Study Update since ABAG 2050 projections were also used for ACWD's Water Efficiency Master Plan and 2020 UWMP.

[7] ACWD. (n.d.). Water Efficiency Master Plan web page. https://www.acwd.org/waterefficiencymasterplan

[8] Association of Bay Area Governments. (2021). *Regional Housing Needs Allocation 2023–2031*. https://abag.ca.gov/our-work/housing/rhna-regional-housing-needs-allocation

[9] U.S. Bureau of Labor Statistics. (n.d.). Local Area Unemployment Statistics web page. https://data.bls.gov/PDQWeb/la

Table 2-1. Data Collected from Member Agencies

Model Input Parameter	Timeframe	Unit(s)	Source(s)
Service Area Data			
Water Production by Supply Source	Varied–2021 (based on agency input)	Volume	WCDB Agencies
Consumption and Accounts	Varied–2021 (based on agency input)	Volume	WCDB Agencies DSS Models DWR Public Water Systems Surveys
Top 200 Commercial, Industrial, and Institutional (CII) Users*	2019 and 2020	CII Business Type and Volume	Agencies
Single Family Water Rates	1995–2021	$/Volume	Agencies
Commercial Water Rates	1995–2021	$/Volume	Agencies
Single Family Sewer Rates	1995–2021	$/Volume	Agencies
Abnormal Years	Varied (based on agency input)	Years	Agencies
Agency Information	Current	N/A	Agencies
Contact Information	Current	Name, Number, Email	Agencies
Planning Documents	Varied (based on agency input)	N/A	2015 and 2020 UWMPs Water Shortage Contingency Plans Agencies
Customer Classes	Varied (based on agency input)	N/A	DSS Models Agencies
Projected Production by Supply Source	2025–2030	Volume	Agencies
2022 Demand Study Update Data			
Projected Demand	2020–2045	Volume	2020 UWMPs
Projected Supply	2020–2045	Volume	2020 UWMPs
Service Area Demographics			
Historical Service Area Population	1995–2020	People/ Residents	DSS Models 2015 and 2020 UWMPs Agencies

Model Input Parameter	Timeframe	Unit(s)	Source(s)
Projected Population	2021–2045	People/ Residents	Plan Bay Area 2040 (ABAG 2019, for each agency's service area) Draft Plan Bay Area 2050 (Alameda County Water District [ACWD] only) 2020 UWMPs DSS Models Agencies
Housing	2010–Varied (based on agency input)	People/Residents, Housing Units	Agencies Planning Department(s)
Economy			
Historical Service Area Employment	1995–2020	Jobs	DSS Models Agencies
Projected Jobs	2021–2045	Jobs	Plan Bay Area 2040 (ABAG 2019, for each agency's service area) Draft Plan Bay Area 2050 (ACWD only) DSS Models Agencies
Unemployment Rates	1995–2020	Percent (%)	U.S. Bureau of Labor Statistics
Weather			
Historical Weather Data	1995–2021	Temperature (°F) Precipitation (inches)	NOAA
Conservation			
Historical Conservation	2004–2021	Varied	WCDB Agencies
Other			
New Development Ordinances	Current	N/A	Agencies

* *Not all agencies have 200 CII accounts, and some agencies were unable to provide data for all 200 accounts.*

2.3 Agency Verification

The last step in the data collection process was final agency verification of the data. Once all data had been collected and compiled, each agency received a copy of its Final Data Workbook. A representative for each agency was asked to complete the BAWSCA Agency Data Verification Signature Form and confirm the data was correct and appropriate to use in the demand update and sensitivity analysis modeling.

3 2022 DEMAND STUDY UPDATE VARIABLES – HISTORICAL AND PROJECTED

This section documents the demand projection variables developed for the 2022 Demand Study Update. This section describes 1) the demand projection analysis methodology; 2) the variables implemented into the Demand Model; and 3) historical and projected values.

3.1 Econometric Analysis and Demand Methodology Overview

The demand projection update for each BAWSCA member agency used a combination of two analytic models – the econometric model and the DSS Model. Two tools were used to leverage the strengths of each tool to obtain a suite of demand recovery scenarios through 2045. For the full demand methodology overview, see the 2020 Demand Study report.[10]

The econometric analysis estimated the relative impact of various factors on water demand. These results are provided in Appendix C, Table C-1, and Figure C-1. A more detailed description of the econometric modeling framework can be found in Appendix B of this report and in the 2020 Demand Study report.

3.2 Demand Projection – Agency Input and Review

As part of this 2022 Demand Study Update's collaborative approach, one instructional webinar conference call and two workshops were held to facilitate BAWSCA member agencies' understanding of, and involvement in, developing the forecasting methodology and analysis. In addition, each member agency was provided with its individual results in written form and asked to approve the results.

- **Instructional Webinar –** A webinar with member agencies was held on October 12, 2021, to give an overview of the project, review the Data Workbook, and provide an overview of the DSS modeling methodology. To maximize agency participation, the webinar was recorded and offered to those who could not attend.
- **Agency Communication and Technical Memorandum 1 (TM-1) –** In mid-April 2022, agencies were provided a copy of their individual results via TM-1. Agencies were able to email questions or set up virtual calls to review the demand analysis results and make any necessary modifications.
- **Written Approval of Data Workbook and Demand Values –** In late April 2022, individual agencies were asked to submit written approval via a signature form that their demand values appeared reasonable and the data submitted in the Data Workbook was accurate. The sensitivity analysis did not proceed until all agencies approved their submitted data and demand values from TM-1.
- **Agency Communication and Technical Memorandum 2 (TM-2) –** In May 2022, agencies were provided a copy of the results from the regional supply demand and conservation projections. TM-2 discussed results from the supply projection analysis, top CII users analysis, COVID-19 impacts analysis, and water demands by customer class. Results are included in Section 4 of this report.
- **Demand Study Update Workshop 1 –** On May 26, 2022, a workshop was held for BAWSCA agencies to review the demand update and analysis results and to answer questions. During the workshop, real examples of COVID-19 impact results were shared by multiple BAWSCA agencies.
- **Agency Communication and Technical Memorandum 3 (TM-3) –** On October 3, 2022, agencies were provided a copy of the results from the sensitivity analysis. This included results using seven demand variables combined in unique ways to create five water demand forecast scenarios. Results are included in Section 7 of this report.

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[10] Bay Area Water Supply & Conservation Agency's Regional Water Demand and Conservation Projections, 2020. https://bawsca.org/uploads/pdf/BAWSCA_Regional_Water_Demand_and_Conservation%20Projections%20Report_Final.pdf

- **Sensitivity Analysis Results Workshop 2 –** On October 11, 2022, a workshop was held for BAWSCA agencies to review the sensitivity analysis results and to answer questions.

3.3 Population and Long-Term Economic Growth (Jobs)

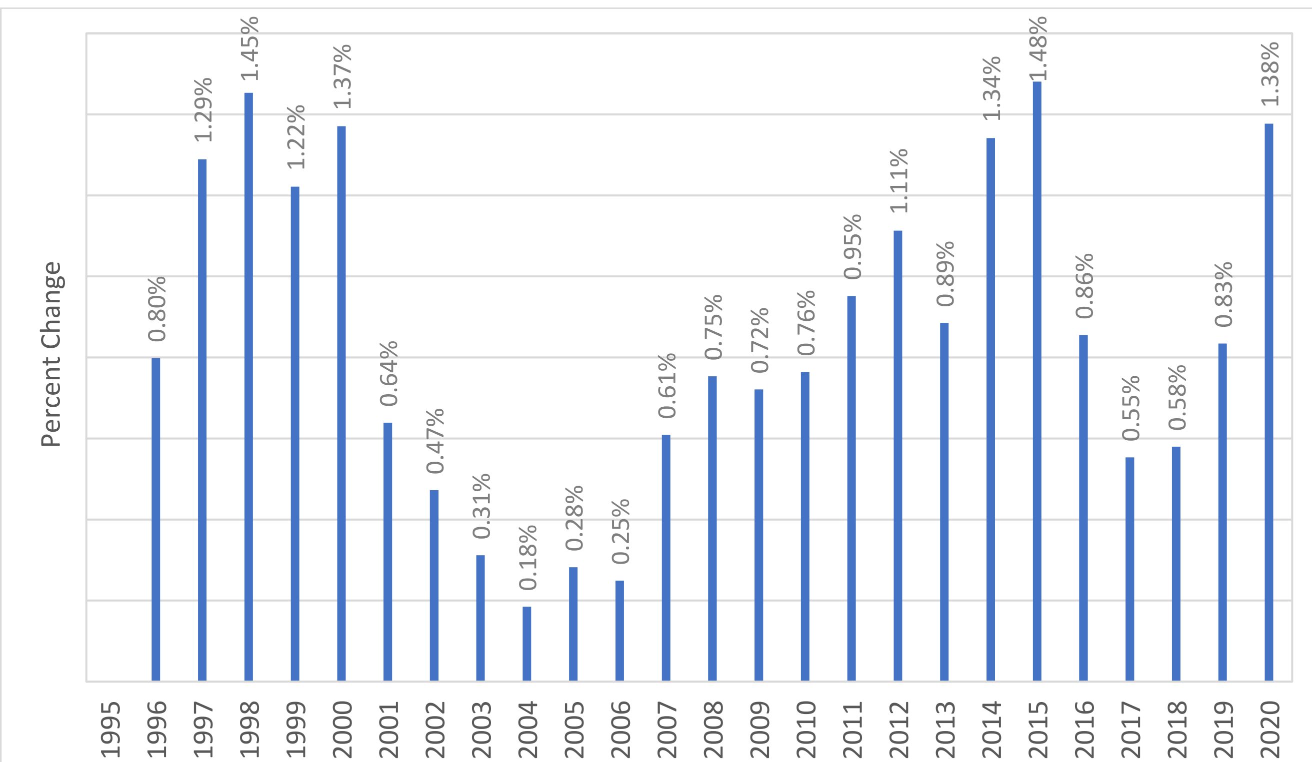
Population and employment projections through 2045 were provided and confirmed by each BAWSCA member agency through the data collection process described in Section 2. Population projections were obtained from one of the following sources:

- ABAG 2040 Plan Bay Area
- Draft ABAG 2050 Plan Bay Area
- 2020 UWMPs
- Other publicly adopted sources as provided by each BAWSCA member agency

Over the past few decades, many of the rapidly growing sectors of the national economy have established a large footprint in the San Francisco Bay Area. As a result, the larger nine-county Bay Area has experienced population growth during this time. This trend has been supported by the Bay Area's world-class universities, venture capital, industry-leading employers, and the ability to attract a talented global workforce.

Figure 3-1 shows the year-over-year rate of population growth in BAWSCA's service area from 1995–2020. Across the 25-year period, population grew by an average rate of 0.84% per year. Notable downturns occurred during the 2000s, initially because of the dotcom crash then followed by the Great Recession. These downturns illustrate the effect of external forces on the Bay Area's economy and demographics.

Figure 3-1. Year-Over-Year Percent Change in BAWSCA's Population, 1995–2020



Source: Historical population supplied by the individual BAWSCA agencies via their Data Workbooks.

Because historical jobs data is not consistently reported by BAWSCA member agencies, constructing a graph for jobs analogous to Figure 3-1 is not possible; however, jobs and population generally track closely, since economic opportunities drive population growth.

BAWSCA agencies report projections of expected growth in population and jobs for their service areas in their individual UWMPs and typically use population and jobs projections compiled by ABAG. Based on ABAG projections for 2020–2045, BAWSCA agencies collectively anticipate population growth of 1.1% per year, which is faster than the observed average between 1995 and 2020 (0.84% per year), and job growth of 1.0% per year.

ABAG projections for the larger nine-county San Francisco Bay Area show an opposite trend than that of BAWSCA's service area, meaning jobs are expected to grow at a higher rate (1% per year) than population (0.9% per year) between 2020 and 2045.

The California Department of Finance (DOF) has also prepared projections of future population growth between 2020 and 2045. The DOF's population projections only account for births, deaths, and estimates of net migration at the state and county level. ABAG's estimates consider these same factors along with future economic conditions and are provided at the census tract level, thus generally resulting in higher projections compared to the DOF.

According to the DOF, total population of the three counties where BAWSCA's member agencies are located (Alameda, San Mateo, and Santa Clara counties) is expected to grow by 0.52% per year between 2020 and 2045. Although BAWSCA member agencies only account for slightly more than 40% of the tri-county area where they are located, historical population growth rates have been identical. Between 1995 and 2020, population in the tri-county area grew by 0.84% per year as well, the same average growth rate as the BAWSCA member agencies during this period.

The two population growth projections (DOF's 0.52% per year and ABAG's 1.1% per year) bracket the observed historical growth rate of 0.84% per year almost symmetrically. Conditions that could lower growth rate include:

- Economic dampening, similar to the mid- to late 2000s.
- Restrictive U.S. policies on international immigration.
- Loss of jobs from automation or from migration due to the Bay Area's high housing costs.[11]

In 2020 and 2021, California's total population declined, particularly in coastal counties.[12] On the contrary, ABAG's population growth estimate, which is higher and generally the source adopted by BAWSCA agencies, assumes vibrant economic conditions, along with policy changes that result in housing affordability and transit-oriented development as outlined in ABAG's *Plan Bay Area 2050*.[13]

Since the first BAWSCA Regional Demand Study published in 2004, the ABAG-projected population has closely aligned with actual population in the BAWSCA service area, as shown in Figure 3-2. This consistent, close alignment has increased confidence in the ABAG-forecasted population and given it credence as a valid source and basis for use in the 2022 Demand Study Update.

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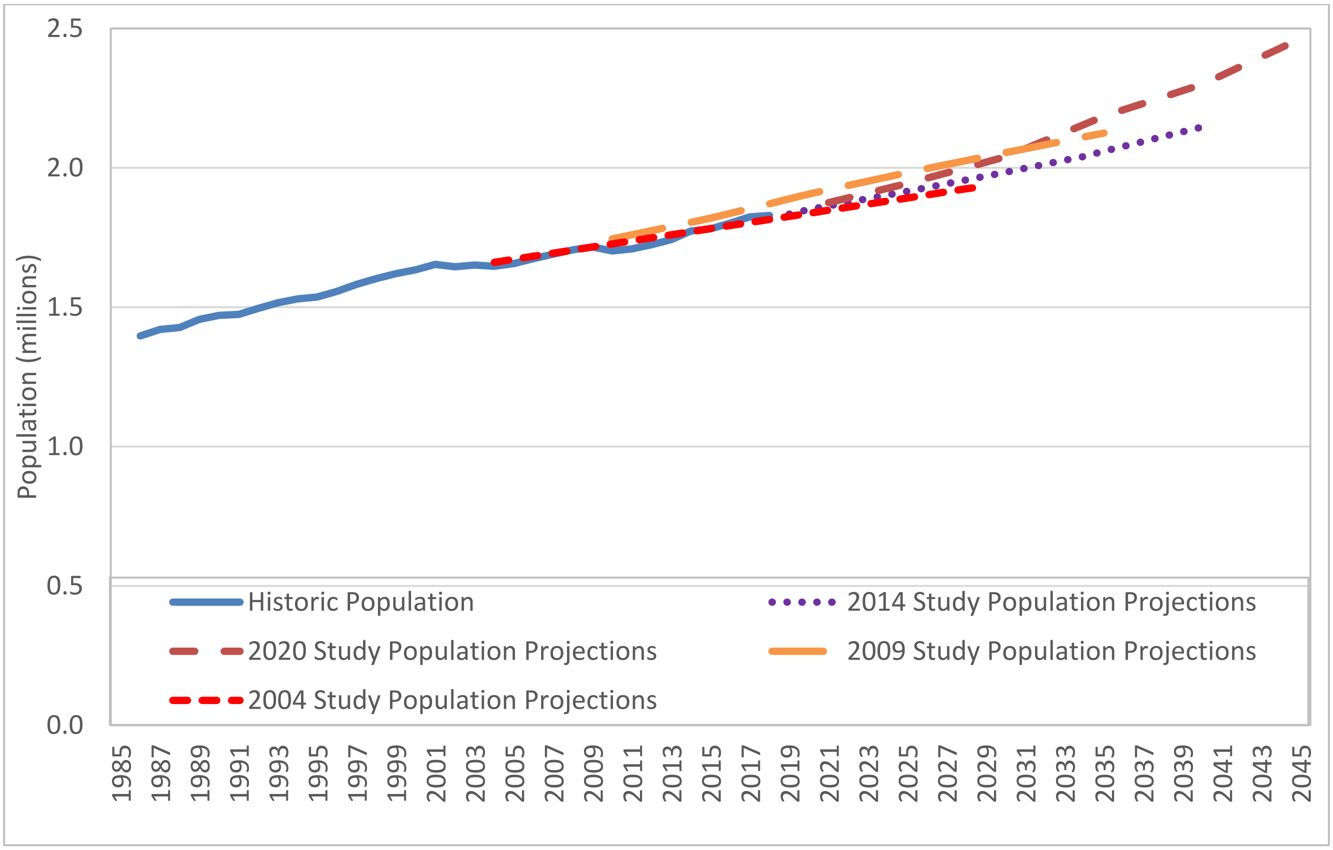
[11] San Francisco Bay Area Planning and Urban Research Association (SPUR). (2021). *Four Future Scenarios for the San Francisco Bay Area: Planning for the Region in the Year 2070*.

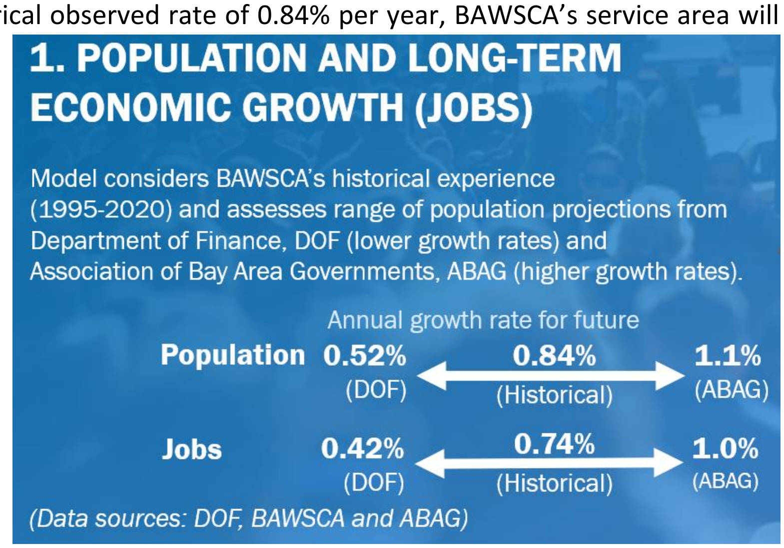
[12] Department of Finance (DOF). (2022). *Slowing State Population Decline Puts Latest Population at 39,185,000*, Press Release dated May 2, 2022.

[13] Association of Bay Area Governments. Draft Plan Bay Area 2050. (2022). Retrieved August 2022 from https://abag.ca.gov/our-work/land-use/plan-bay-area-2050

Figure 3-2. Projected vs. Actual Population



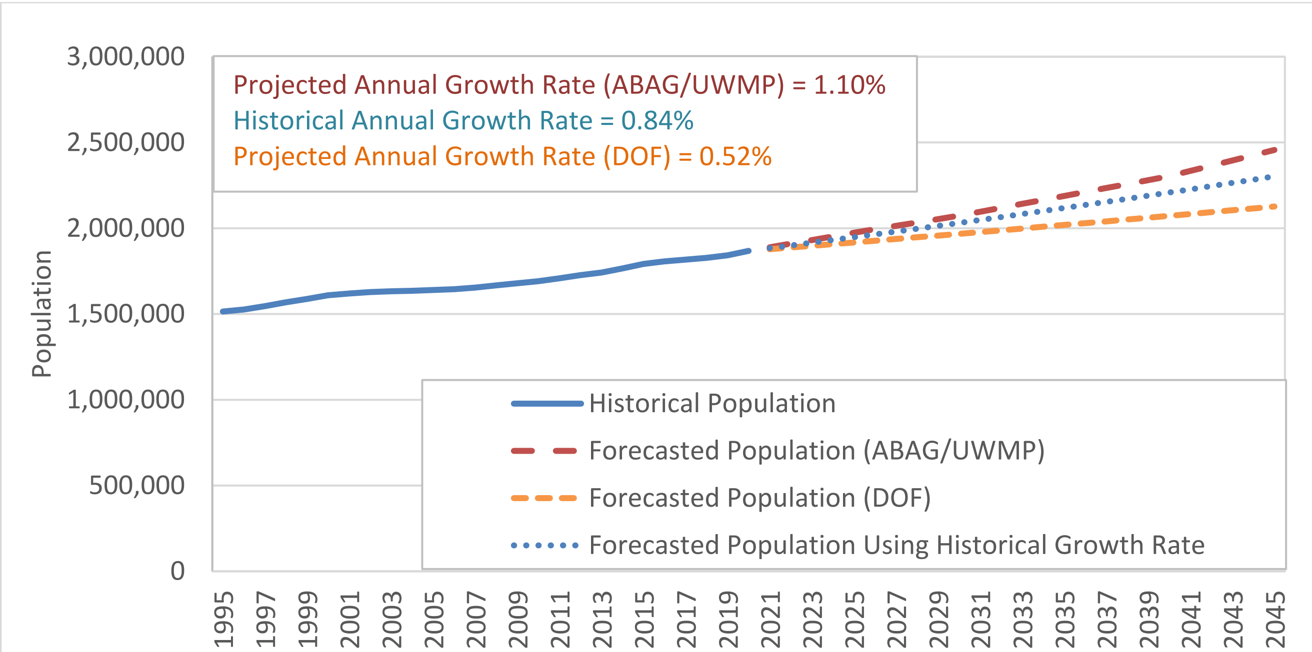
Based on the alternative population growth scenarios, BAWSCA's region-wide population in 2045 is projected to range between 2.13 to 2.46 million people based on growth rates of 0.52% and 1.1% per year, respectively (Figure 3-3). If population grows at the historical observed rate of 0.84% per year, BAWSCA's service area will include around 2.3 million people by 2045. The sensitivity of the range is approximately +/-7% in 2045 compared to the 0.84% per year projection based on observed historical data.



Jobs growth rate, corresponding to the lower population growth rate projections of 0.84% (historical average) or 0.52% (DOF projection), is not available. Since ABAG's jobs growth rate is 0.1% lower than its population growth rate, it is assumed the jobs growth rate under the alternative lower population projections would also be 0.1% lower.

For the 2020 Demand Study, population projections for 2020 were 1,858,392 for the BAWSCA region-wide service area. During the 2022 Demand Study Update, BAWSCA agencies reported their actual 2020 population as part of their 2020 UWMPs. The 2020 actual population was 1,868,090 for the BAWSCA region-wide service area. There is only a 0.5% increase between the projected and actual 2020 populations.

Figure 3-3. Projected BAWSCA Region-Wide Population



3.4 Housing Density (Single Family vs. Multifamily)

The impact of increased housing density was not directly accounted for by all BAWSCA agencies during the 2020 Water Demand Study but has now been incorporated in the 2022 Demand Study Update. Typically, per capita consumption is higher among single family users compared to multifamily due to landscape water use.[14] Improving housing affordability and meeting environmental requirements (e.g., Bay-Delta Plan instream flows) and climate goals (e.g., reduced greenhouse gas emissions) require future development to favor denser housing with easy access to public transportation. *Plan Bay Area 2050* (ABAG, 2021) has a higher forecasted population growth that emerges from models favoring denser housing and naturally associated investments in transportation infrastructure intended to maintain reasonable commute times. Given that ABAG's higher population growth projections are contingent on the successful implementation of supportive housing policies and transportation funding, it is necessary to incorporate housing density projections while developing water demand scenarios.

The mix of housing between single family (SF) and multifamily (MF) categories changes slowly over time (Table 3-1). The rate of change in housing mix also depends on the housing location within the BAWSCA service area.

Table 3-1 shows total estimates of dwelling units in the BAWSCA agencies' collective service areas between 1995 and 2020. While the share of total dwelling units accounted for by the single family sector does not appear to move much over time (62.0% in 1995 versus 61.4% in 2020), this is misleading. For example, between 1995 and 2000 roughly 70% of new dwelling units added to the BAWSCA region-wide service area were single family; between 2015 and 2020, the single family share of newly added units had dropped to 42%. In other words, the latest trend already favors denser housing than that of a couple decades ago.

[14] Kiefer, J. and L. Krentz. (2018). *Water Use in the Multi-Family Housing Sector*. Project #4554. Denver, Co.; Water Research Foundation, accessed online August 2022. https://www.waterrf.org/sites/default/files/file/2019-07/SWMC18-Kiefer_Krentz.pdf

Table 3-1. BAWSCA Region-Wide Housing Unit Totals, 1995–2020

Year	Total SF Housing Units	Total MF Housing Units	Total Housing Units	SF Housing Units as Percent of Total
1995	348,485	213,487	561,972	62.0%
1996	350,374	214,014	564,388	62.1%
1997	351,437	214,234	565,671	62.1%
1998	353,696	214,871	568,567	62.2%
1999	356,682	216,911	573,593	62.2%
2000	360,068	218,655	578,723	62.2%
2001	362,310	219,575	581,885	62.3%
2002	366,311	221,390	587,701	62.3%
2003	370,305	223,834	594,139	62.3%
2004	373,976	224,703	598,679	62.5%
2005	377,942	226,735	604,677	62.5%
2006	381,108	227,410	608,518	62.6%
2007	383,144	227,626	610,770	62.7%
2008	384,742	228,073	612,815	62.8%
2009	385,965	227,902	613,867	62.9%
2010	387,965	227,622	615,587	63.0%
2011	387,902	227,490	615,392	63.0%
2012	387,393	228,090	615,483	62.9%
2013	386,196	228,020	614,216	62.9%
2014	388,098	230,567	618,665	62.7%
2015	389,826	233,916	623,742	62.5%
2016	390,874	236,832	627,706	62.3%
2017	392,450	239,283	631,733	62.1%
2018	394,663	243,297	637,960	61.9%
2019	398,924	246,656	645,580	61.8%
2020	404,438	253,787	658,225	61.4%

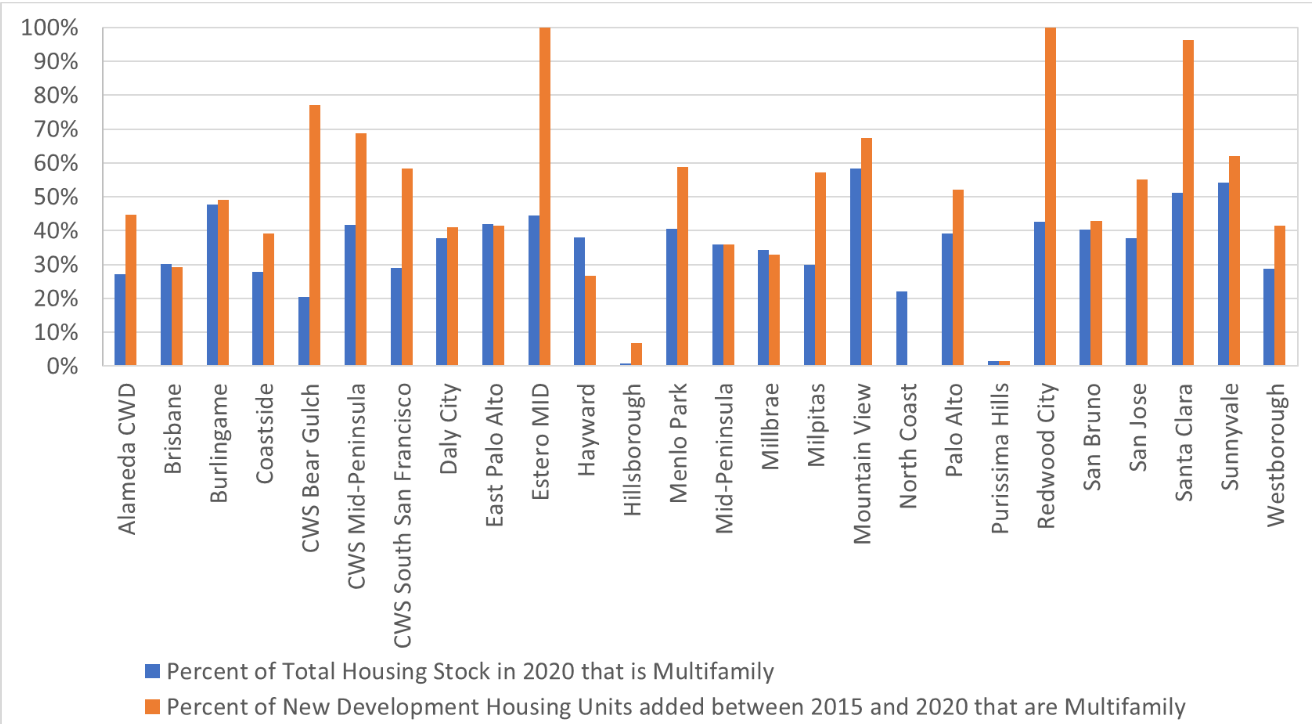
Housing density trends vary considerably across BAWSCA agencies (Figure 3-4 and Table 3-2). In general, new housing added between 2015 and 2020 (orange bars) exhibits greater emphasis on multifamily than the entire housing stock as it existed in 2020 (blue bars). Extreme examples include Estero (serving Foster City) and Redwood City where all new additions between 2015 and 2020 were multifamily units. Conversely, more affluent communities, such as Hillsborough and Purissima Hills, continue to develop predominantly single family housing. However, even in these two communities, a small but increasing bias toward multifamily housing has developed. The only exception is North Coast (serving Pacifica) which added only single family housing between 2015 and 2020. This is immaterial, however, due to North Coast's slow growth (only six dwelling units were added to its housing stock during this time).

Table 3-2. BAWSCA Agency Specific Housing Unit, 2015–2020

Agency	Number of New Housing Added, 2015–2020
Alameda County Water District	4,508
Brisbane/GVMID	168
Burlingame, City of	686
CWS - Bear Gulch District	635
CWS - Mid Peninsula District	2,386
CWS - South San Francisco District	899
Coastside County Water District	898
Daly City, City of	1,121
East Palo Alto, City of	372
EMID/Foster City	381
Hayward, City of	2,699
Hillsborough, Town of	246
Menlo Park, City of	1,284
Mid-Peninsula Water District	416
Millbrae, City of	305
Milpitas, City of	1,794
Mountain View, City of	2,617
North Coast County Water District	6
Palo Alto, City of	1,821
Purissima Hills Water District	321
Redwood City, City of	975
San Bruno, City of	1,455
San Jose, City of	881
Santa Clara, City of	2,927
Sunnyvale, City of	4,315
Westborough Water District	367

Note: Stanford University is excluded from the table above because the university tracks housing units differently than cities and water agencies.

Figure 3-4. Recent Changes in BAWSCA Member Agency Housing Stock

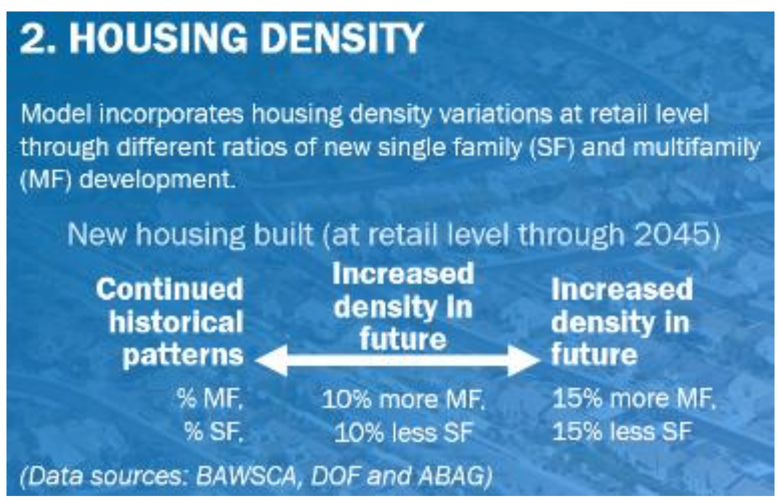


Note: Stanford University is excluded from the figure above because the university tracks housing units differently than cities and water agencies.

Since existing neighborhoods are different and resist rapid change, evaluating the influence of the changing housing mix on future water demand is better accomplished by indexing a member agency's alternative future scenario to its current housing situation, rather than using BAWSCA region-wide averages. Therefore, the housing analysis was completed at the individual agency level to capture the unique changes for each BAWSCA agency service area.

To simulate the impact of increasing housing density on regional water demand, three future development options were created that assume:

1. A member agency's new housing mix will have the same SF/MF ratio as dwelling units added to the housing stock between 2015 and 2020.
2. The SF/MF housing mix of new construction will move 10% closer to MF housing by 2045.
3. The SF/MF housing mix of new construction will move 15% closer to MF housing by 2045.



For example, if an agency's dwelling unit additions between 2015 and 2020 exhibit a 60:40 ratio in favor of SF units, by 2045 the MF share of new additions to housing stock is assumed to linearly increase to 50% and 55% under Options 2 and 3, respectively. Because agencies like Estero and Redwood City only added MF units between 2015 and 2020, Options 2 and 3 assume the cities would continue to add only MF units to their housing stock through 2045.

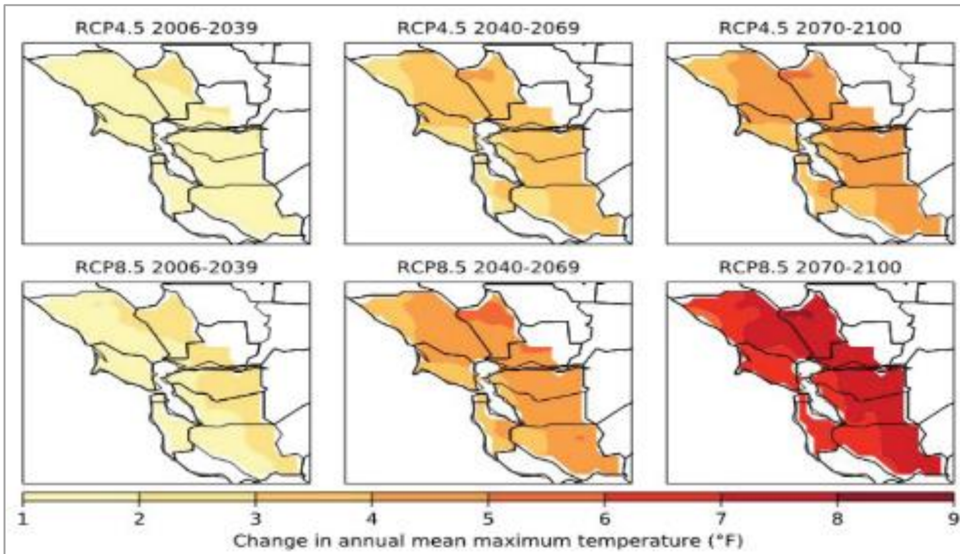
3.5 Long-Term Climate Change

The Public Policy Institute of California (PPIC) has predicted that five climate pressures will impact the future of California's water management: warming temperatures, shrinking snowpack, shorter and more intense wet seasons, more variable precipitation, and rising seas.[15] Some of these pressures are already apparent. The climate impact on water supply is predicted to significantly exceed the impact on water demand.

Precipitation in the Bay Area will continue to have high variability year-to-year with hydrologic years fluctuating between extremes of wet and dry years. The largest winter storms in the Bay Area are anticipated to become more powerful and potentially more damaging. Due to an anticipated future increase in air temperature, it is assumed California and the Bay Area will experience longer and deeper droughts that could impact the water supply.

The Intergovernmental Panel on Climate Change (IPCC) regularly releases technical results of assumed global temperatures.[16] This information can be locally applied, as was done in the *San Francisco Bay Area Region Report, California's Fourth Climate Change Assessment*.[17] In this report, several future climate change scenarios, referred to as Representative Concentration Pathways (RCP), were developed. RCP4.5 represents a mitigation scenario where global carbon dioxide (CO_2) emissions peak by 2040. RCP8.5 represents the business-as-usual scenario where CO_2 emissions continue to rise throughout the 21st century. Figure 3-5 shows the spatial changes in annual mean of maximum daily temperatures across nine Bay Area counties under RCP4.5 and RCP8.5.

Figure 3-5. Bay Area Historical and Projected Mean Maximum Temperatures



Spatial patterns of projected model-average change in annual mean maximum temperature (unit: °F) under RCP4.5 and RCP8.5 for three time periods: 2006-2039 (early-21st century), 2040-2069 (mid-21st century), and 2070-2100 (late 21st-century). Unit is °F.

Source: Ackerly, David, Andrew Jones, Mark Stacey, Bruce Riordan. (U.C., Berkeley). (2018.)

[15] Public Policy Institute of California (PPIC). (2021). *Priorities for California's Water*, accessed online October 2022. https://www.ppic.org/publication/priorities-for-californias-water/

[16] Intergovernmental Panel on Climate Change. (n.d.). The Intergovernmental Panel on Climate Change website, accessed August 2022. https://www.ipcc.ch/

[17] Ackerly, David, Andrew Jones, Mark Stacey, Bruce Riordan. (University of California, Berkeley). (2018.) *San Francisco Bay Area Region Report, California's Fourth Climate Change Assessment*, publication number: CCCA4-SUM-2018-005, accessed online August 2022. https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-005_SanFranciscoBayArea_ADA.pdf

According to California's *Fourth Climate Change Assessment*, the Bay Area's historical temperature increased 1.7 degrees Fahrenheit (°F) from 1950 to 2005. The report also predicts that annual mean maximum temperatures will increase by 1 to 2 °F in the early 21st century (between 2006 and 2039), then increase by an additional 3.3 °F in the mid-21st century (between 2040 and 2069). This increment for the mid-21st century rises to 4.4 °F if the Bay Area remains under the high emissions scenario RCP8.5, also known as "business-as-usual."

The temperature change in the *Fourth Climate Change Assessment* is divided between two periods (early-21st century and mid-21st century). For the BAWSCA 2022 Demand Study Update, the period of focus was 2020–2045. Therefore, it was necessary to combine the two periods to get an overall temperature change for the length of the BAWSCA 2022 Demand Study Update.

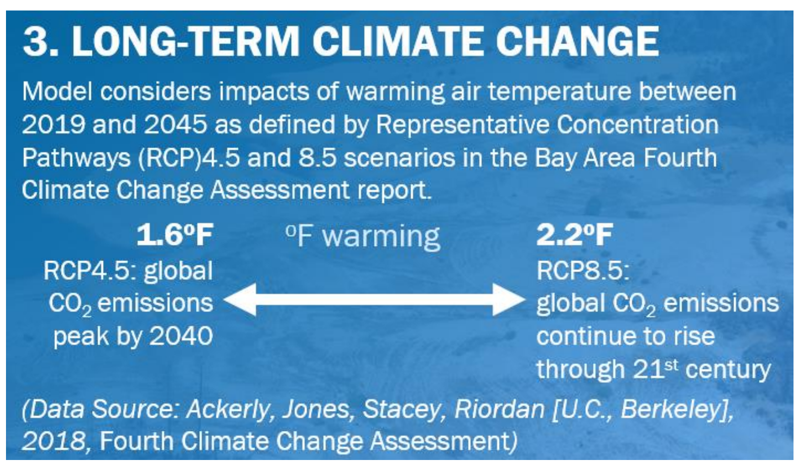
Following are the considerations and methodology used to calculate the average annual temperature change for each of the stated time periods:

- The *Fourth Climate Change Assessment* estimates temperatures in the early 21st century (2006–2039) would increase 1 to 2 °F. This study uses the average (1.5 °F), which equates to an average annual temperature increase of 0.045 °F for the 34-year period.
- The *Fourth Climate Change Assessment* estimates the temperatures in the mid-21st century (2040–2069) would increase by 3.3 °F, which equates to an average annual temperature increase of 0.114 °F for the 30-year period.

Calculating the increase within each period for the 2022 BAWSCA Demand Study Update required three steps:

1. Calculate a value for the 21 years from 2020 to 2039, which equates to an estimated temperature change of 0.93 °F.
2. Calculate a value for the six years from 2040 to 2045, which equates to an estimated temperature change of 0.66 °F.
3. Add the two values from step 1 and step 2 to get a total temperature increase of 1.6 °F (rounded) for 2020–2045.

In summary, for the BAWSCA 2022 Demand Study Update scenario RCP4.5, the predicted annual mean temperature increase in the early 21st century of 1.6 °F[18] was incorporated into the demand forecast for all scenarios for the 2019–2045 period. A similar methodology was used for RCP8.5 to combine early- and mid-21st century values to get the predicted annual mean temperature increase of 2.2 °F.



In December 2021, the Water Research Foundation and SFPUC published a report on a Long-Term Vulnerability Assessment (LTVA) for SFPUC's Water Enterprise.[19] The LTVA devotes a significant portion of the study to climate change vulnerability. Rather than predicting one most-likely future scenario, the LTVA assessed vulnerabilities across a wide range of future conditions, including changes in precipitation, temperature, in-stream flow requirements and other regulatory changes, water demand, and infrastructure failures.

[18] Ibid.

[19] San Francisco Public Utilities Commission (SFPUC). (n.d.). San Francisco Water Power Sewer Long Term Vulnerability Assessment web page, accessed August 2022. https://sfpuc.org/about-us/reports/long-term-vulnerability-assessment

The goal of the LTVA was to help quantitatively and qualitatively assess to what extent climate change would be a threat to the San Francisco Regional Water System (RWS) in comparison to, or in combination with, other external drivers of change over the 2020–2070 period. A range of demand changes above baseline were evaluated to understand the climate change impact on vulnerability, but the impact of climate variability on water demand in the BAWSCA service area was not analyzed. After review of the LTVA report by BAWSCA staff, the BAWSCA 2022 Demand Study Update stakeholders and the MWM Project Team, no relevant climate change data was found for inclusion in the BAWSCA sensitivity analysis, since the focus of the study was on the impact of climate change on the RWS and not on water demand in the BAWSCA service area.

3.6 Water Price

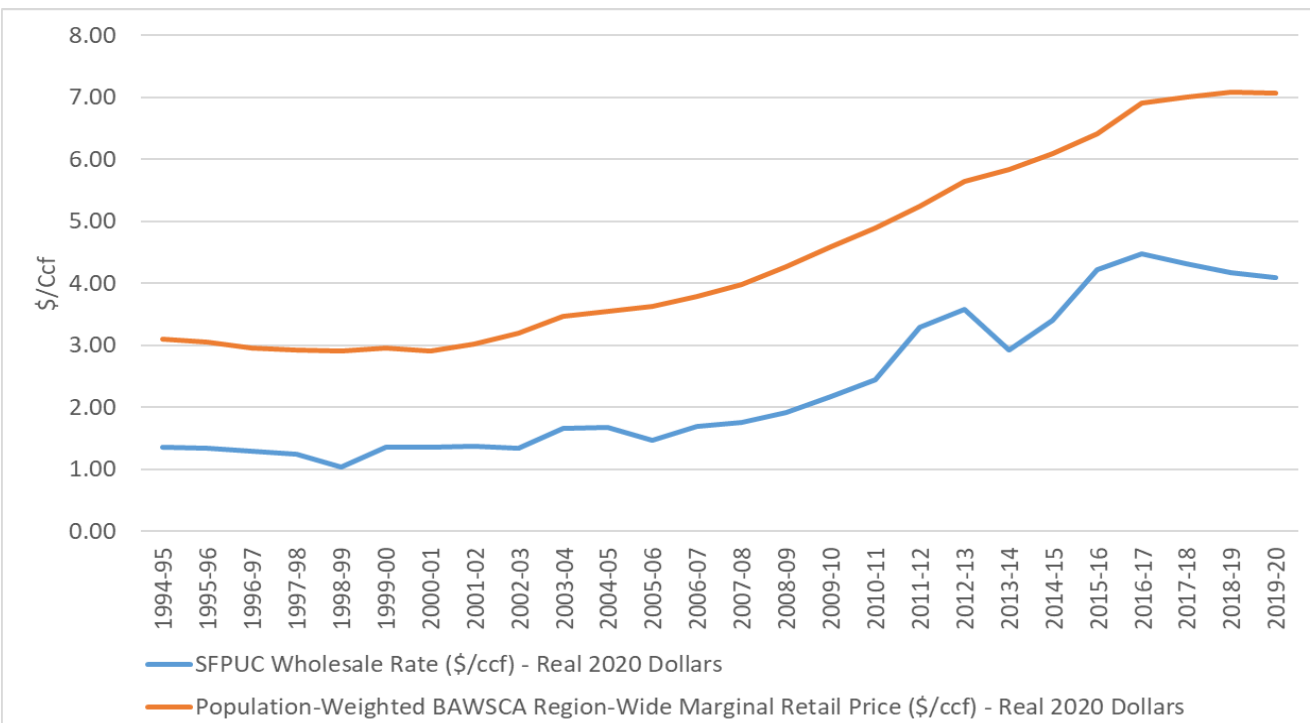
Literature on water demand demonstrates that price elasticity of water demand, while low, is not zero. Therefore, it is expected that future increases in marginal price will continue to play a dampening role on regional water demand. How large a role is uncertain for two reasons:

1. Reliable estimates of future marginal price increases are not available through 2045.
2. How residents react to these future price increases, especially if they arrive in conjunction with other disruptions (e.g., use of irrigation restrictions to deal with more-frequent droughts, greater irrigation demand because of climate change), may cause Bay Area residents to significantly alter their landscape choices.

Reviewing the recent past trends on water rates helps to inform the development of alternative futures.

Figure 3-6 shows escalation in the marginal price of water for the average resident in BAWSCA's service area. The graph also shows SFPUC's wholesale price of water. Both are shown in real 2020 dollars (i.e., the impact of inflation has been removed). As expected, both curves track closely. The retail price of water is greater than SFPUC's wholesale price because maintaining the retail water distribution system for delivery to the final customer brings added costs that must be recovered by retail agencies.

Figure 3-6. BAWSCA Region-Wide Marginal Price of Retail Water and SFPUC Wholesale Rates



Note: ccf = hundred cubic feet

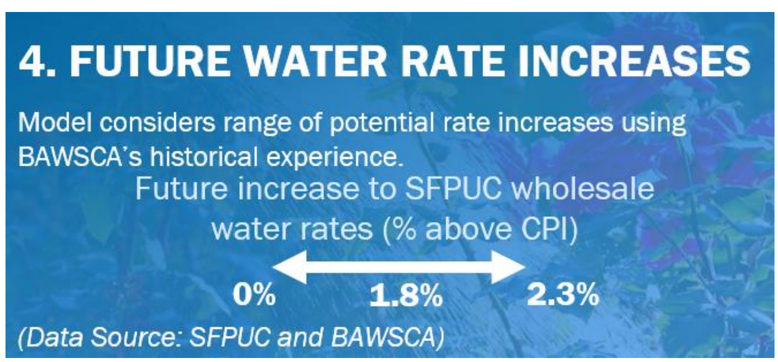
Between 1995 and 2020, the marginal retail price of water increased by approximately 3.3% per year, and SFPUC's wholesale price by 4.5% per year. This was a period when SFPUC undertook significant capital investments to improve its RWS.

Table 3-3 shows SFPUC's projected water rates over the next five years. No data is available beyond fiscal year (FY) 2026-27. On a levelized basis, projected SFPUC rates amount to a nominal wholesale rate escalation of about 5% per year. Assuming a normal inflation rate of 2% per year (the Federal Reserve's target inflation rate), real wholesale rates are expected to rise 3% per year[20] instead of the historical 4.5% per year when significantly greater capital expenditures were earmarked for system upgrades. If the annual 4.5% growth in wholesale rates has translated in the past into a 3.3% growth rate in the retail marginal price of water, then the best approximation of future growth in retail marginal prices, when only real wholesale rates are expected to grow by 3% per year, becomes 1.8% per year (3.3% – 1.5%). This is still a significant increase over time. A real escalation rate of 1.8% per year implies the marginal price of water will be roughly 56% greater in 2045 relative to 2020.

Table 3-3. SFPUC Current and Projected Wholesale Water Rates Over the Next Five Fiscal Years

Current and Projected Rates	Nominal Dollars Per CCF
FY2021-22	$4.10
FY2022-23	$4.75
FY2023-24	$5.25
FY2024-25	$5.25
FY2025-26	$5.25
FY2026-27	$5.25

Adaptation and mitigation of climate change effects, especially under the more severe RCP8.5 scenario, are possibilities that might compel SFPUC to engage in a new round of large capital expenditures. If climate change reduces the availability of imported water supplies, SFPUC may have to seek alternative water sources. This 2022 Demand Study Update assumes retail marginal water prices will grow by 2.3% per year to cover these new capital expenditures, which will raise the real marginal price of water by 76% in 2045 relative to 2020. Section 6.1 discusses in greater detail how assumptions about the effect of future conservation interact with price effects, and why assuming future price increases greater than 2.3% per year raises the risk of double counting conservation savings.



SFPUC provides a quarterly report for the Alternative Water Supply (AWS) Program[21] that serves to evaluate new projects that will help meet future water supply needs in the SFPUC service area. The AWS Program looks beyond existing infrastructure and surface water supplies of the RWS and local groundwater sources to new and diverse or "alternative" water supply options. Such alternative options include groundwater banking, surface water storage expansion with a potential for diverse water supply sources, water transfers,

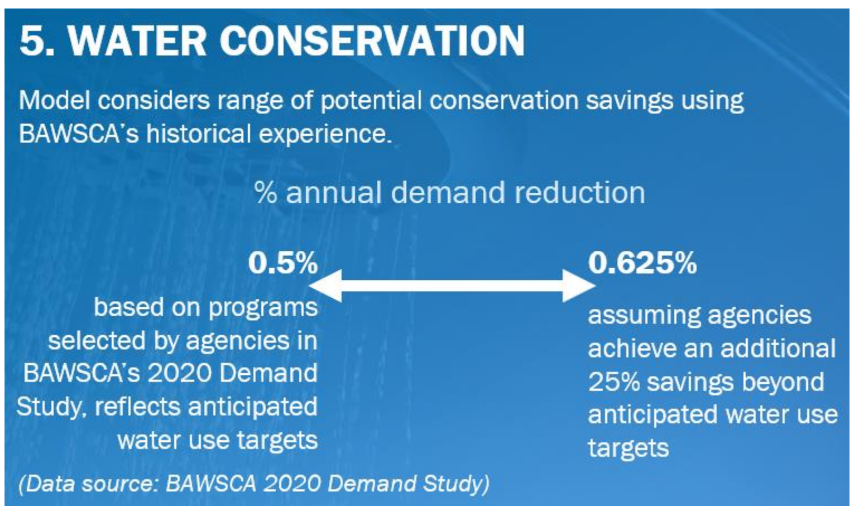
[20] If inflation turns out to be higher than 2% in the next few years, as will likely be the case, SFPUC will have to raise its nominal wholesale rates faster than what it has released to date.

[21] San Francisco Public Utilities (SFPUC). (n.d.). Alternative Water Supply Planning Program web page, accessed September 2022. https://sfpuc.org/programs/future-water-supply-planning/alternative-water-supplies

purified water (potable reuse), and desalination. The AWS Program also looks to technological innovations and other tools that can increase supply or reduce demand. Although there are some estimated costs for the projected AWS projects, not all project costs or the direct impacts on increased customer water prices are known at this time; however, it is anticipated that increases in capital expenditures could increase future water rates.

3.7 Water Conservation

Since the year 2000, individual BAWSCA agencies have carefully quantified water conservation activities and associated passive and active water savings using a DSS Model that is periodically updated during each round of planning studies. In the 2020 Demand Study, BAWSCA agencies were actively involved in the process to develop future conservation programs and funding. This involvement included participating in workshops and one-on-one meetings, helping review technical memorandums with individual agency results, providing copies of agency DSS Models, and participating in the discussion throughout the entire project to develop customized programs appropriate for their agency. Each BAWSCA agency shared, reviewed, and ultimately approved its modeling results. Further details of this process and individual agency involvement can be found in the 2020 Demand Study report. The conservation analyses undertaken for the 2020 Demand Study were used for capturing likely savings from plumbing codes (passive savings) and active programs for the 2022 Demand Study Update as well. On a BAWSCA region-wide basis, these analyses suggest passive and active conservation measures are likely to reduce per capita water demand by roughly 0.5% per year.



Since BAWSCA's 2020 Demand Study report, policy changes and climatic conditions in California have occurred and influenced the current and future direction of BAWSCA's water conservation efforts. In 2018, the California Legislature enacted two key policy bills—Senate Bill 606 (SB 606)[22] and Assembly Bill 1668 (AB 1668)[23]—to implement a new framework for long-term water conservation and drought planning for water suppliers. The two bills provide new and expanded authorities and requirements that affect water conservation and drought planning for urban, agricultural, and small water suppliers, as well as rural communities.

As of August 2022, pending state regulations prompted by the state's adoption of AB 1668 and SB 606 include several key objectives that focus on water use both inside and outside residential homes, implementing best management practices for commercial businesses, and reducing distribution system water losses (for compliance with SB 555-mandated Water Loss Performance Standard). Another objective is to reduce residential indoor water use to 42 gallons per person per day by the year 2030. In the future, it is assumed regulations, more frequent and severe droughts, and higher temperatures will drive more active conservation. Focus on landscape transformation is occurring in many parts of the state. The 2022 Demand Study Update considers a level of conservation that yields 25% higher savings compared to the 2020 Demand Study. The 2022 Demand

[22] California State Legislature. Senate Bill 606 (Hertzberg), May 31, 2018, accessed online September 2022. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB606

[23] Ibid. Assembly Bill 1668 (Friedman), May 31, 2018, accessed online September 2022. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB1668

Study Update conservation analysis yields an overall combined water savings for the BAWSCA service area of 0.625% annual demand reduction.

As part of the process to determine the higher level of conservation, multiple studies were reviewed, including the report by the Pacific Institute titled *The Untapped Potential of California's Urban Water Supply: Water Efficiency, Water Reuse, and Stormwater Capture*.[24] Additionally, the San Francisco Bay Area Planning and Urban Research Association (SPUR) report titled *Water for a Growing Bay Area*, released in October 2021,[25] looked at the Bay Area's regional water demand through the year 2070. Both the Pacific Institute and SPUR reports were carefully reviewed and used as a reference validation for the assumed future water savings in the 2022 Demand Study Update.

3.8 Seasonal Weather

As part of the 2022 Demand Study Update, precipitation data and maximum air temperature were collected for each BAWSCA member agency. The information was used at an individual agency level to capture the impact of monthly weather fluctuations on historical water demand. The estimated impact of temperature on historical water demand becomes the basis for predicting the impact of rising temperature due to climate change. Seasonal weather was included in all the scenarios analyzed in the 2022 Demand Study Update and reflects precipitation and temperature as experienced in a normal year (defined as the average weather experienced by BAWSCA agencies between 1995 and 2006). A further description of the connection between weather and historical water demand can be found in the 2020 Demand Study report.

6. SEASONAL WEATHER

This is based on past year-to-year fluctuations (precipitation and max. air temperature).

(Data Source: NOAA, 1995-2020)

3.9 Economic Cycles

In recent decades, the Bay Area has experienced multiple economic cycles. These conditions were included in the base of all five demand sensitivity scenarios (the five scenarios are described in Section 6) and tracked through unemployment, which was selected as the appropriate variable to represent economic cycles as it tracks water demand the closest. The unemployment rate was run at the individual agency level in the models and compiled as an overall BAWSCA region-wide average annual rate (Figure 3-7) to depict the economic cycles over the past few decades. A further description of the connection between the unemployment rate and water demand is provided in the 2020 Demand Study report.

7. ECONOMIC CYCLES

Model considers short-term economic cycles based on Bureau of Labor Statistics (BLS) local area unemployment rates.

(Data Source: BLS)

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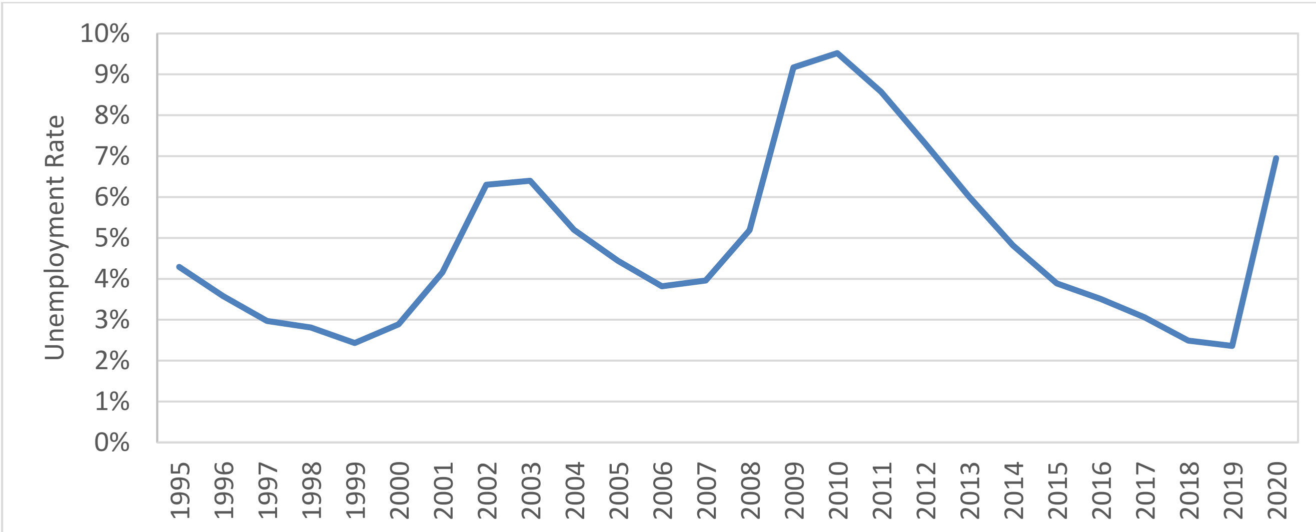
[24] Pacific Institute. (2022). *The Untapped Potential of California's Urban Water Supply: Water Efficiency, Water Reuse, and Stormwater Capture*, accessed online August 2022. https://pacinst.org/publication/california-urban-water-supply-potential-2022/

[25] San Francisco Bay Area Planning and Urban Research Association (SPUR). (2022). *Water for a Growing Bay Area*, accessed online August 2022. https://www.spur.org/publications/spur-report/2021-10-21/water-growing-bay-area

Figure 3-7. BAWSCA Average Annual Unemployment Rate



3.10 Future Workplaces (COVID-19)

As described in greater detail in Section 4.5, the COVID-19 pandemic increased uncertainties about water demand throughout the BAWSCA service area. Considering the pandemic is not over, the resulting long-term impacts to BAWSCA's water use patterns remain uncertain and were not included in the BAWSCA sensitivity analysis described in Section 6. The review of monthly water uses for 2019, 2020, and 2021 indicated that the pandemic altered patterns of water use in residential and CII sectors for 12 BAWSCA agencies, likely due to changes in indoor versus outdoor water use, especially with known vacancies in CII customer accounts. Water use at the BAWSCA region-wide level shows a slight increase in residential water use and slight decrease in commercial use.

4 REGIONAL SUPPLY PROJECTIONS AND CUSTOMER CLASS DATA ANALYSIS

This section documents the BAWSCA region-wide analysis for water supply projections, customer class water demand breakdown, highest commercial water users analysis results, and a review of water use patterns and trends due to the COVID-19 pandemic. This section includes tables and graphical representations of specific data collected and analyzed for each BAWSCA member agency.

4.1 Data Analysis Overview

The data analysis effort included compiling 27 BAWSCA agency Data Workbooks, extracting the data, then analyzing and interpreting the data. The BAWSCA agencies provided more detailed information than in previous efforts, including 2020 UWMP data, historical drought restriction implementation, projected production by supply source, water system audit information, and housing data. All submitted data, including monthly water use from 1995 to 2021, was used in the analysis.

The benefit of this analysis is to further refine future water demand forecasts and support BAWSCA water conservation program planning efforts. For example, the customer class water breakdown and the highest commercial water users analysis provide insights on how to proceed with the SB 606 and AB 1668 regulations on CII billing data classification and CII best management practices.

4.2 Water Supply Projections

As part of the 2022 Demand Study Update, the MWM Project Team collected projected water supply by source from each BAWSCA member agency (Figure 4-1 and Table 4-1). From 2025 to 2045, there are projected significant increases in five supply sources:

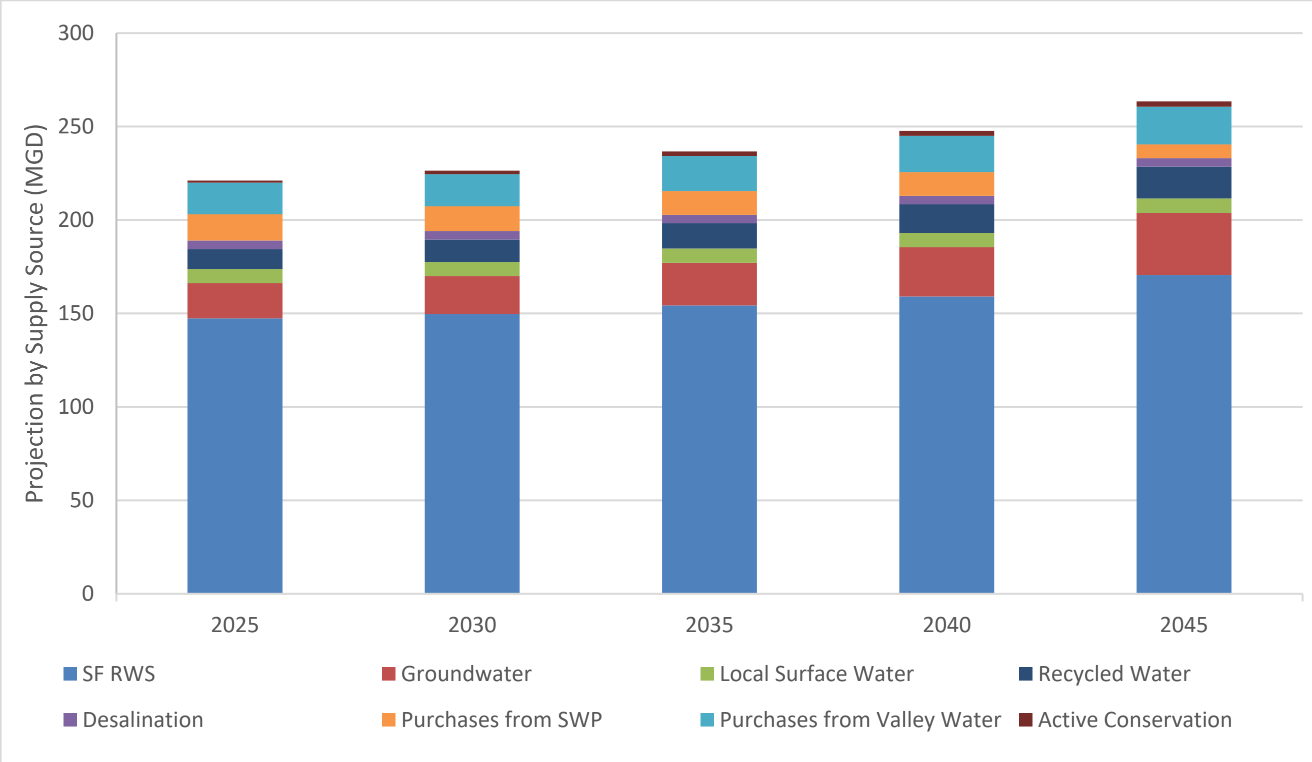
1. Active Conservation: 155% or 1.7 million gallons per day (MGD)
2. Groundwater: 77% or 14.4 MGD
3. Recycled Water: 59% or 6.3 MGD
4. Purchases from Valley Water: 20% or 3.3 MGD
5. San Francisco RWS: 16% or 24.0 MGD

However, in the same timeframe, there is a projected decrease of 48% (-6.8 MGD) in purchases from the State Water Project (SWP). There is only one agency in the BAWSCA service area that uses SWP water. That agency's demand already accounts for conservation, both active and passive. Therefore, those values from the SWP water supply were subtracted to eliminate double counting on the supply side.

The two other supply sources are expected to remain relatively constant.

Total production for all supply sources in the BAWSCA region overall is projected to increase by 20% (43.1 MGD) in 2045 as compared to 2025.

Figure 4-1. BAWSCA Region-Wide Projected Water Production by Supply Source (Annual Average)



The information in Table 4-1 was provided by each of the individual BAWSCA member agencies and closely aligns with DWR Table 6-9 in the 2020 UWMPs, for those agencies that were required to submit a UWMP. The agencies that were not required to submit UWMPs provided the future supply projection data via their individual Data Workbooks.

Table 4-1. BAWSCA Region-Wide Projected Water Production by Supply Source

Supply Source	Annual Average (MGD)						% Change, 2025–2045
	2025	2030	2035	2040	2045	Total Change, 2025–2045	
Purchases from San Francisco RWS	146.4	149.8	154.5	158.8	170.4	24.0	16%
Groundwater	18.8	20.3	22.8	26.4	33.2	14.4	77%
Local Surface Water	7.5	7.6	7.6	7.7	7.7	0.2	3%
Recycled Water	10.7	12	13.5	15.3	17	6.3	59%
Desalination (brackish groundwater)	4.6	4.6	4.6	4.6	4.6	0	0%
Purchases from SWP[1]	14.1	13.2	12.8	12.6	7.3	-6.8	-48%
Purchases from Valley Water	16.9	17.2	18.7	19.4	20.2	3.3	20%
Active Conservation[2]	1.1	1.9	2.3	2.6	2.8	1.7	155%
Total Production	**220.1**	**226.6**	**236.8**	**247.4**	**263.2**	**43.1**	**20%**

[1] State Water Project (SWP) purchases are limited to one BAWSCA agency that holds SWP contracts with DWR. This agency's demand already accounts for conservation, both active and passive. Therefore, those demand values were subtracted from the SWP water supply to avoid double counting.

[2] Active conservation is beyond already-achieved conservation within the BAWSCA service area. Active conservation is considered by some agencies to be a water supply source because investments in water conservation are viewed as viable options to meet future water demands. Active conservation is included as either an additional supply source, as shown in this table, or a reduction in water demand; it is not counted in both.

4.3 Customer Demand Breakdown

Each BAWSCA member agency defines its own customer categories for billing. The total number of water accounts as a BAWSCA region-wide sum is projected to be greater than 450,000 in 2025 and 540,000 in 2045, an increase of 20%.

To reflect the categories in the UWMPs (as reflected in the *Urban Water Management Plan Guidebook 2020*[26] [DWR, 2021]) and the BAWSCA Annual Report, the MWM Project Team combined water demand projections into seven general categories:

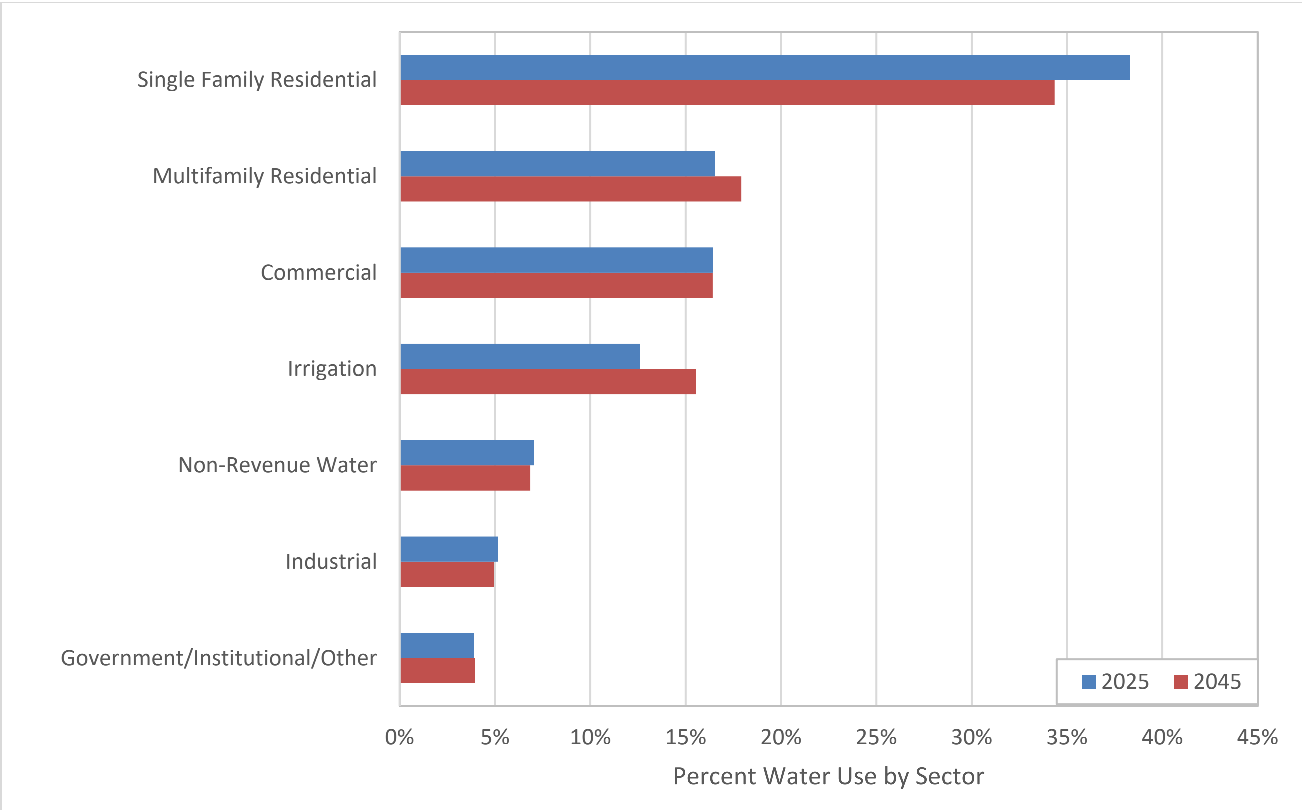
1. Single Family Residential
2. Multifamily Residential
3. Commercial
4. Industrial
5. Government/Institutional/Other
6. Irrigation
7. Non-Revenue Water

Figure 4-2 summarizes the BAWSCA region-wide demand projections by customer class between 2025 and 2045. While the proportion of projected demands attributed to each customer category is estimated to remain relatively consistent, the following trends are noteworthy:

- The most noticeable shifts in water use breakdown between projected years 2025 and 2045 occurs in Single Family Residential and irrigation customer categories.
    - Water use percentage in the Single Family Residential customer category is projected to decrease, mainly due to active conservation efforts and a slowdown in single family new development.
    - The water use percentage in the irrigation customer category is projected to increase by 2045. One explanation for this is the inclusion of more recycled water in projected demand per the 2020 UWMPs. The majority of BAWSCA agencies label their recycled water as irrigation water use. As such, there has been an increase in the BAWSCA agencies including recycled water in future water supply and an increase in recycled water volume for those agencies that had included it previously.
- Multifamily residential water use percentage is projected to increase from 2025 to 2045. This is due to an increase in multifamily account growth since more development is planned in the multifamily sector.
- The projected water use percentage by customer category with active conservation depicts a minimal shift in water use breakdown between 2025 and 2045 for the following BAWSCA customer categories: Commercial, Industrial, Government/Institutional/Other, and Non-Revenue Water.

[26] California Department of Water Resources. (2021). *Urban Water Management Plan Guidebook 2020*. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans/Final-2020-UWMP-Guidebook/UWMP-Guidebook-2020---Final-032921.pdf

Figure 4-2. Projected Water Use Percentage by Customer Class CY 2025 and CY 2045



Note: Non-Revenue Water is potable water only. Irrigation, Government/Institutional/Other, and Commercial include both potable and recycled water.

4.4 Commercial Large Users Analysis

Knowing which users to target for the most water-savings potential in conservation programs in the commercial sectors will help BAWSCA and its agencies use time and resources most effectively. To assist in this effort, BAWSCA agencies were asked to provide monthly water use for their top 200 CII users for 2019 and 2020 (if 200 were available), along with the associated commercial industry type for those users (see Figure 4-3). Fourteen BAWSCA agencies provided this data for a total of 2,800 commercial businesses. These commercial businesses were then categorized into 15 business types. From that dataset, the MWM Project Team extracted three key metrics to evaluate those CII Large User account categories:

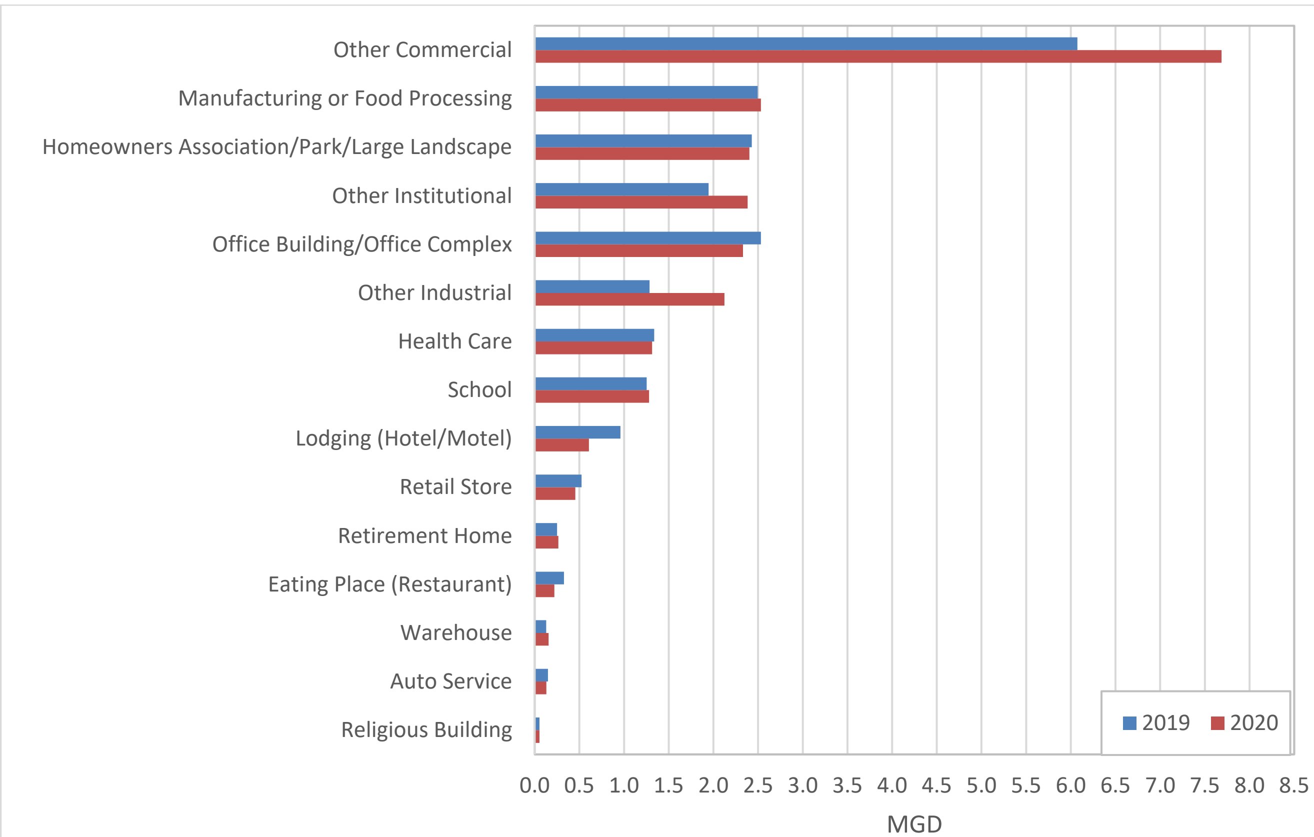
- The highest total volume of demand
- The highest quantity of large volume-using businesses
- The largest change in total volume of demand

The MWM Project Team had the following observations based on the data depicted in Figure 4-3:

- Five water use categories had the largest water demand in both 2019 and 2020:
    - Other Commercial (includes all businesses that did not fit into the other 14 categories)
    - Manufacturing or Food Processing
    - Homeowners Association/Park/Large Landscape
    - Other Institutional
    - Office Buildings/Office Complex

- The largest water use changes between 2019 and 2020 were in six water use categories:
    - Other Commercial
    - Other Institutional
    - Office Building/Office Complex
    - Other Industrial
    - Lodging (Hotel/Motel)
    - Eating Place (Restaurant)
- In 2020, when compared to 2019, many of the categories above showed decreased water use, likely due to the COVID-19 pandemic, as many non-essential businesses either shut down or reduced their water use, moving them out of the CII Large User category. This is further discussed in Section 4.5.

Figure 4-3. BAWSCA Agencies' CII Large User Annual Water Demand for 2019 and 2020



Note: BAWSCA agency Data Workbooks were released to the agencies on October 28, 2021. The 19 CII categories provided by DWR were released November 17, 2021. Due to the earlier project timeline, the 15 categories used for this analysis were sourced from the Water Research Foundation's Principal CII Categories.

The MWM Project Team had the following observations based on the data in Table 4-2:

- The five business types with the greatest number of large water-using businesses in 2019 and 2020 were:
    - Other Commercial (includes all businesses that did not fit into the other 14 categories)
    - Office Buildings/Office Complex
    - Other Institutional
    - Homeowners Association/Park/Large Landscape
    - Eating Place (Restaurant)

- There were notable changes in the number of businesses from 2019 to 2020 for the following categories:
    - Eating Place and Other Commercial number of businesses decreased by 4 and 7, respectively.
    - Other Industrial number of businesses increased by 11.
- These minor shifts in the number of businesses, likely due to the COVID-19 pandemic, might be temporary, as further discussed in Section 4.5. It is also likely that the number of businesses for Other Industrial increased due to the shift of top CII users, as non-essential commercial business activity (e.g., office buildings and restaurants) changed as a result of the COVID-19 pandemic.

Table 4-2. BAWSCA Agencies' Number of CII Large Users by Business Type for 2019 and 2020

Category	2019	2020
Other Commercial	936	929
Office Building/Office Complex	480	474
Other Institutional	343	344
Homeowners Association/Park/Large Landscape	176	172
Eating Place (Restaurant)	151	147
Retail Store	141	141
School	110	109
Manufacturing or Food Processing	104	114
Lodging (Hotel/Motel)	93	93
Other Industrial	88	99
Health Care	66	65
Auto Service	46	47
Religious Building	28	28
Retirement Home	27	27
Warehouse	11	11

Note: The table represents 2,800 data points from the 14 BAWSCA agencies that provided detailed data.

4.5 COVID-19 Pandemic Analysis

Around the time BAWSCA completed its 2020 Demand Study, the COVID-19 global pandemic began in March 2020, which prompted state and local governments to issue emergency orders to protect public health. This resulted in changes to water use patterns, population, employment, and property vacancies throughout the region. The pandemic exacerbated pre-existing uncertainties regarding the Bay Area's future economy and demographics in light of technological advancements in automation and artificial intelligence, national immigration policies, and competition for employees among other metropolitan centers in the U.S. and abroad.[27] Since the earlier 2020 Demand Study project timeline was January 2019 through June 2020, the COVID-19 pandemic-related changes to water consumption patterns, population, employment, and vacancies were not incorporated into the 2020 Demand Study analysis or projections.

However, as part of the 2022 Demand Study Update, BAWSCA was interested in assessing recent water use trends that could be attributed to the COVID-19 pandemic remote work mandates and associated temporary business closures. To support this assessment, the MWM Project Team reviewed 2019, 2020, and available 2021 monthly water use data for residential and CII customer categories to identify changes in water use trends. The review showed that patterns of water use in residential and CII sectors for 12 BAWSCA agencies were altered by

[27] Association of Bay Area Governments (ABAG). (2019). "The Future of Jobs: Perspective Paper." https://abag.ca.gov/news/future-jobs-horizon-perspective-paper-released

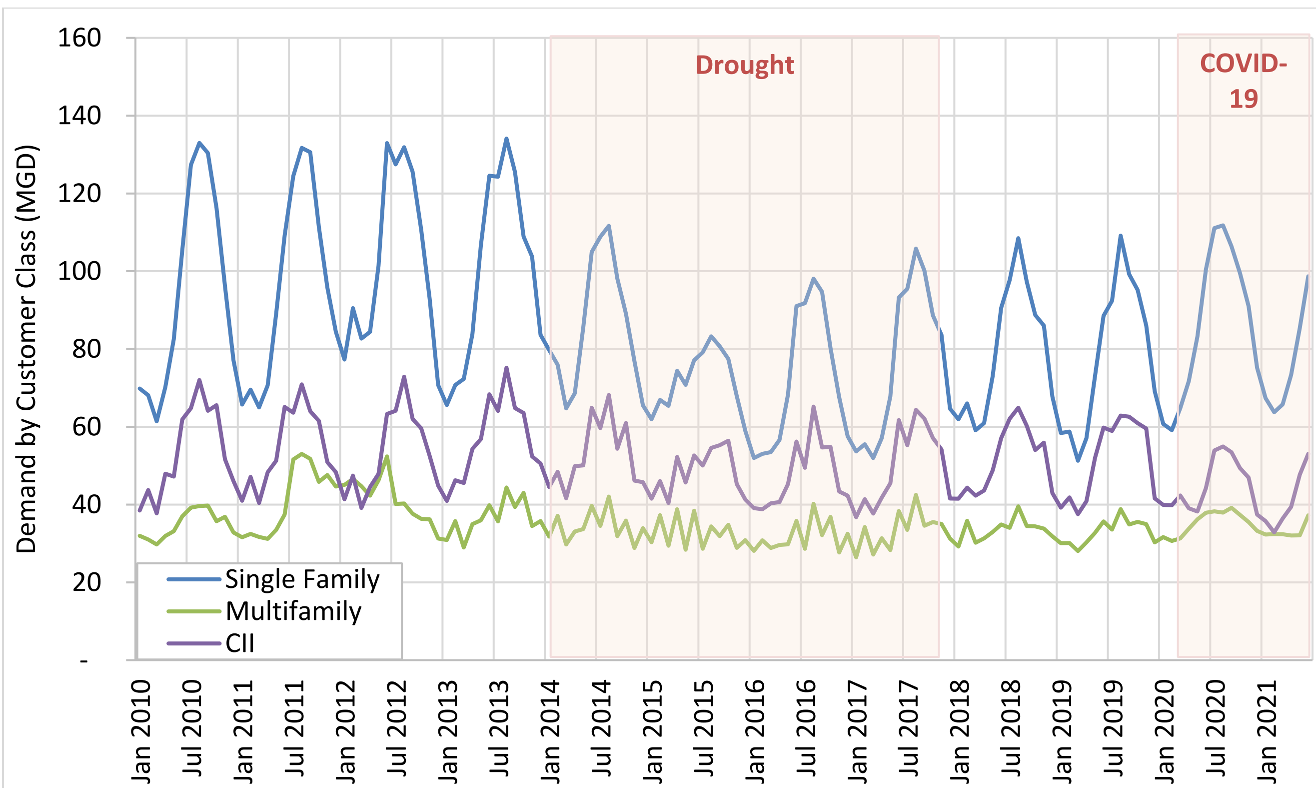
the global pandemic. These water use pattern changes were likely due to known vacancies in CII customer accounts which resulted in lower indoor water use from employees no longer working onsite. A slight increase in residential water use and slight decrease in commercial use at the BAWSCA region-wide level was also indicated, as shown in Figure 4-4.

The MWM Project Team updated the existing DSS Models created for the BAWSCA member agencies to incorporate information from the data collection effort and monthly water use data from 2019, 2020, and (as available) 2021.

BAWSCA Region-Wide Analysis Results

Figure 4-4 presents BAWSCA region-wide Single Family, Multifamily, and CII water use between 2010 and 2021. The 2014–2017 drought has been included in this figure to highlight comparative changes in demand and to serve as context when evaluating the impact of the COVID-19 pandemic.

Figure 4-4. BAWSCA Region-Wide Demand by Customer Class for COVID-19 Analysis



Note: Demands are shown for the past 10.5 years. The graph goes to June 2021, as this is the last month for which all BAWSCA agencies provided historical consumption data.

The MWM Project Team compared 2017–2019 monthly average water use to 2020 monthly water use for all BAWSCA agencies. Table 4-3 documents the percentage difference between these two data sets, illustrating the relative increase in residential water use and relative decrease in commercial use for April-December 2020 when the most restrictive COVID-19-mandated shutdowns were in place.

Table 4-3. Comparison of BAWSCA Region-Wide 2017–2019 Average Consumption Demands to 2020 Consumption Demands by Customer Class

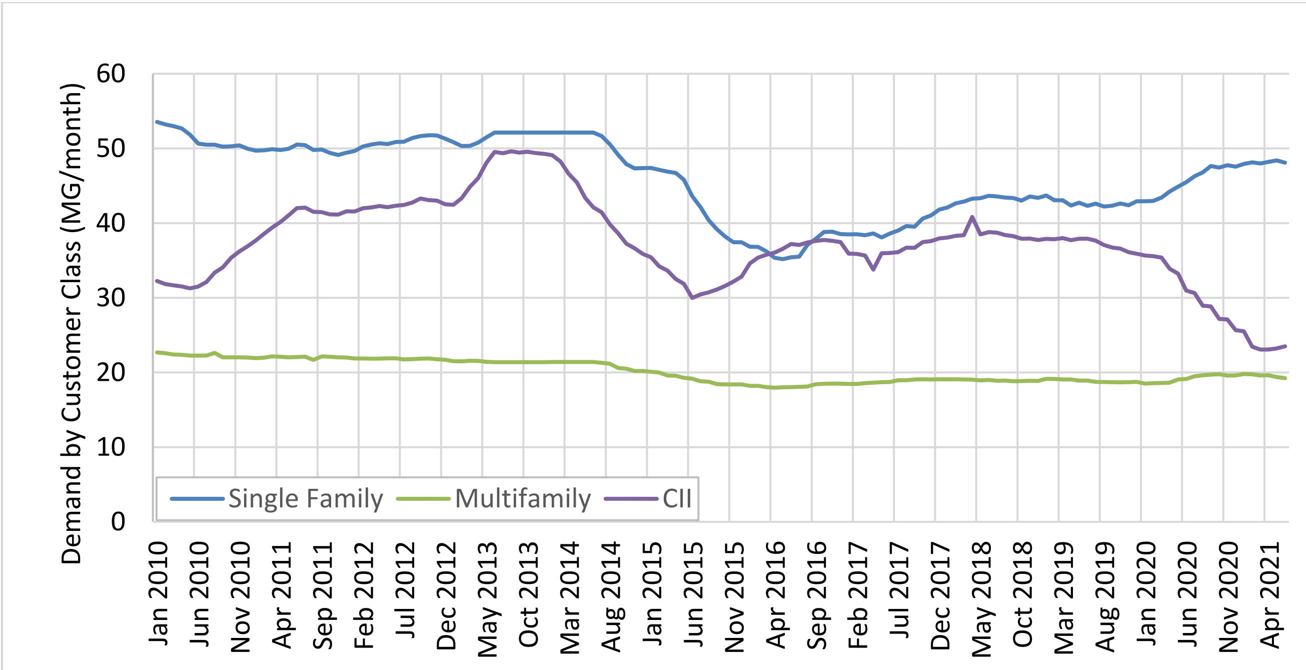
	Single Family Percent Difference	Multifamily Percent Difference	CII Percent Difference
Jan	5%	11%	2%
Feb	-2%	-8%	-6%
Mar	20%	10%	8%
Apr	23%	9%	-7%
May	17%	15%	-22%
Jun	11%	4%	-26%
Jul	17%	14%	-8%
Aug	4%	-6%	-14%
Sep	8%	13%	-13%
Oct	10%	6%	-14%
Nov	7%	3%	-17%
Dec	12%	7%	-11%

Individual Agency Analysis Results

To further examine the impacts of the COVID-19 pandemic, the MWM Project Team reviewed the average monthly water use data from 2017–2019 compared to 2020 on an individual member agency basis. In addition, the MWM Project Team analyzed the top CII users, population, and jobs data for each agency. Following are three agency examples to illustrate significant, moderate, and minimal-to-no impact from the COVID-19 pandemic using average monthly CII water use data from April-December 2020:

- **Significant Impact (greater than 30% decrease in CII water use):** Figure 4-5 shows a BAWSCA agency where the CII sector was significantly affected by the COVID-19 pandemic. Multifamily demands remained relatively stable for this agency; however, beginning in 2020, single family water demand increased, and CII water demand decreased. Three BAWSCA agencies experienced a significant impact on their water use in 2020 assumed to be related to the COVID-19 pandemic. These medium-sized agencies are job centers and have more work travelers and tourists. Due to reduced travel from the pandemic, agencies with a lot of travelers saw a further reduction in their CII sector water use. Based on the top 200 CII users, these agencies have a higher percentage of hospitality facilities and office buildings that were impacted by near-100% vacancies during the state-mandated shutdowns.
- **Moderate Impact (20-30% decrease in CII water use):** Figure 4-6 shows a BAWSCA agency where the CII sector was moderately affected by the COVID-19 pandemic. Multifamily demands remained relatively stable for this agency; however, beginning in April 2020, single family water demand did show an increase while CII water demand temporarily decreased. Nine BAWSCA agencies experienced a moderate impact on their water use in 2020 assumed to be related to the COVID-19 pandemic. These agencies include a variety of sizes and a mixture of work centers, bedroom communities, and communities balanced between commercial and residential.
- **Minimal-to-No Impact (less than 20% decrease in CII water use):** Figure 4-7 shows a BAWSCA agency that did not experience any significant changes in residential or commercial customer classes due to the COVID-19 pandemic. Fifteen BAWSCA agencies experienced minimal-to-no impact on their water use in 2020 assumed to be related to the COVID-19 pandemic. These agencies included a variety of sizes and a mixture of work centers, bedroom communities, and communities balanced between commercial and residential.

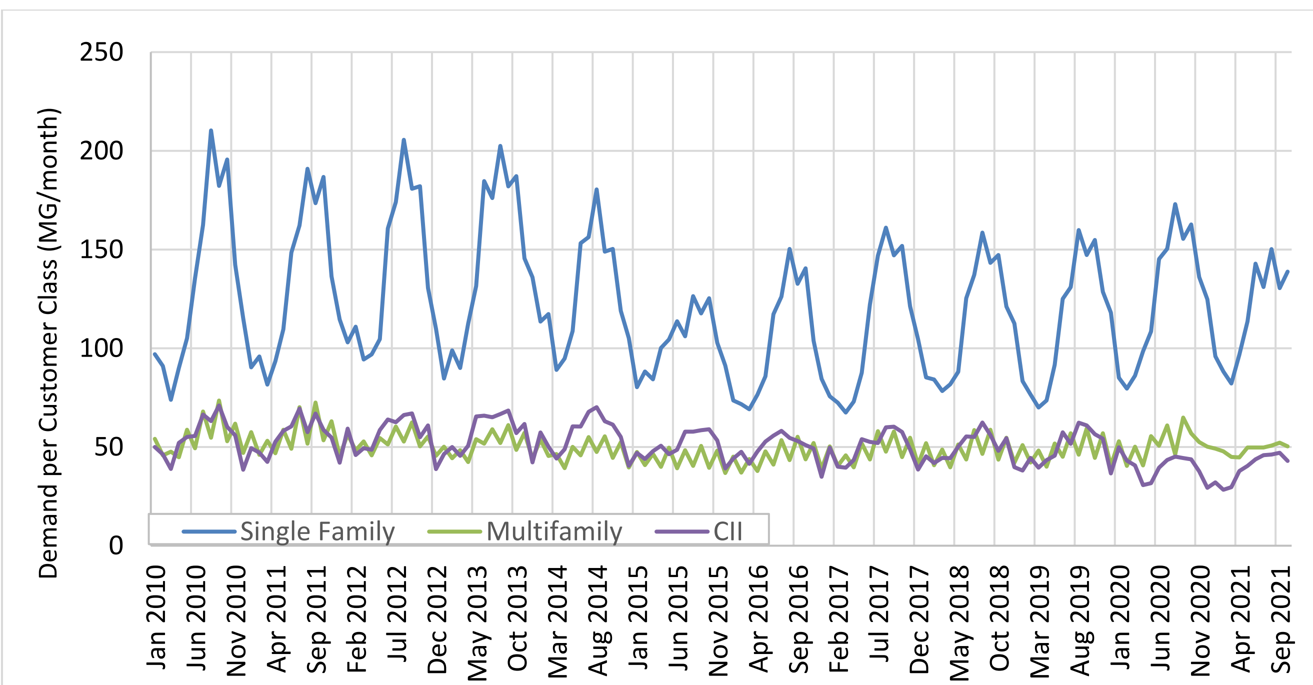
Figure 4-5. Example of BAWSCA Agency With Significant Water Demand Impacts During COVID-19 Pandemic



Notes:

1. *This individual BAWSCA agency provided historical water use data until June 2021.*
2. *Graph is presented on a million gallons (MG) per month basis to allow easy review of the monthly COVID-19 pandemic-mandated restrictions and because this agency only provided bimonthly data.*

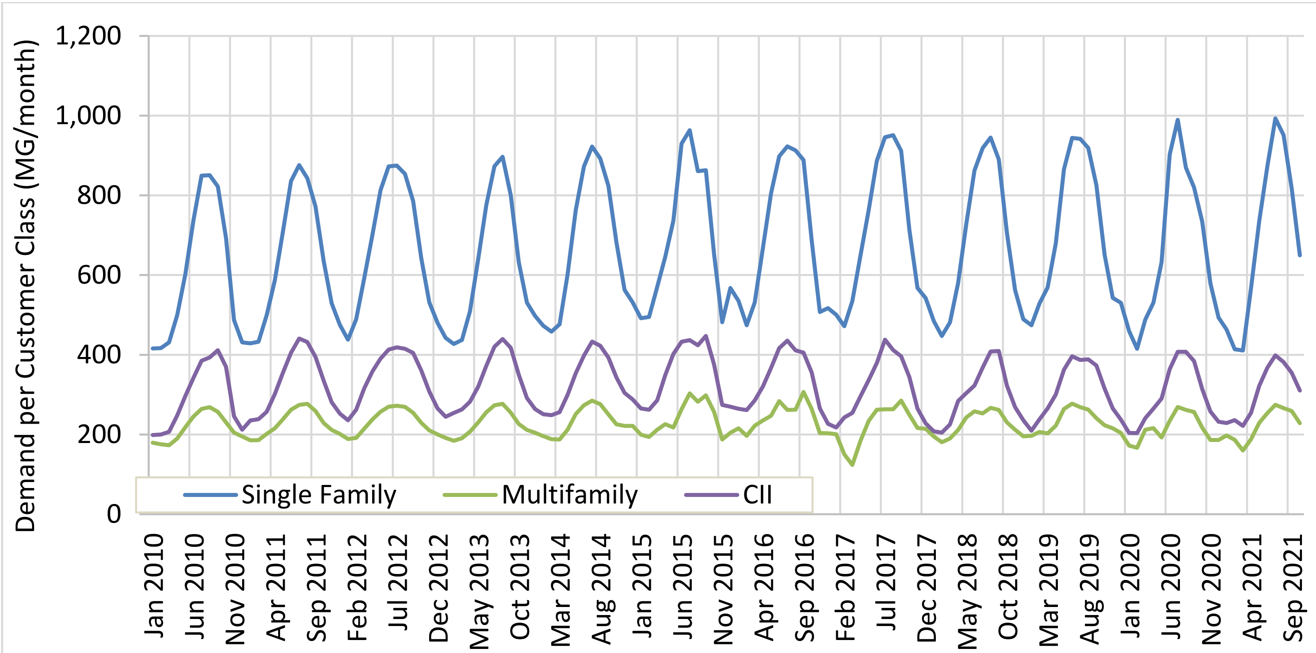
Figure 4-6. Example of BAWSCA Agency With Moderate Water Demand Impacts During COVID-19 Pandemic



Notes:

1. *This individual BAWSCA agency provided historical water use data until October 2021.*
2. *Graph is presented on an MG per month basis to allow easy review of the monthly COVID-19 pandemic-mandated restrictions and because this agency only provided bimonthly data.*

Figure 4-7. Example of BAWSCA Agency With Minimal Water Demand Impacts During COVID-19 Pandemic



Notes:

1. *This individual BAWSCA agency provided historical water use data until October 2021.*
2. *Graph is presented on an MG per month basis to allow easy review of the monthly COVID-19 pandemic-mandated restrictions and because this agency only provided bimonthly data.*

5 UPDATE TO THE PROJECTED WATER DEMAND AND CONSERVATION SAVINGS ANALYSIS AND RESULTS

This section reviews historical and future population and employment growth. It also presents the results of the water demand update for each individual BAWSCA member agency and for the BAWSCA region.

5.1 Updated Population and Employment Historical and Future Projections Analysis

As described in Section 3, BAWSCA has multiple sources of population but primarily uses ABAG data. For the 2022 Demand Study Update, each BAWSCA member agency was able to review and approve its individual population and employment numbers. Table 5-1 and Figure 5-1 present the BAWSCA region-wide historical and projected population and employment data.

Table 5-1. Updated BAWSCA Region-Wide Historical and Projected Population and Employment

Year	Population	Employment (Jobs)
1995*	1,514,473	1,044,179
2000*	1,609,643	1,129,881
2005*	1,640,287	1,064,347
2010*	1,691,733	1,033,325
2015*	1,787,857	1,072,024
2020*	1,868,090	1,155,261
2025	1,974,169	1,205,801
2030	2,073,412	1,262,266
2035	2,188,306	1,323,224
2040	2,304,145	1,375,110
2045	2,456,566	1,482,538

**Historical population and employment are based on BAWSCA records as reported by individual member agencies.*

Figure 5-1. Updated BAWSCA Region-Wide Historical and Projected Population and Employment

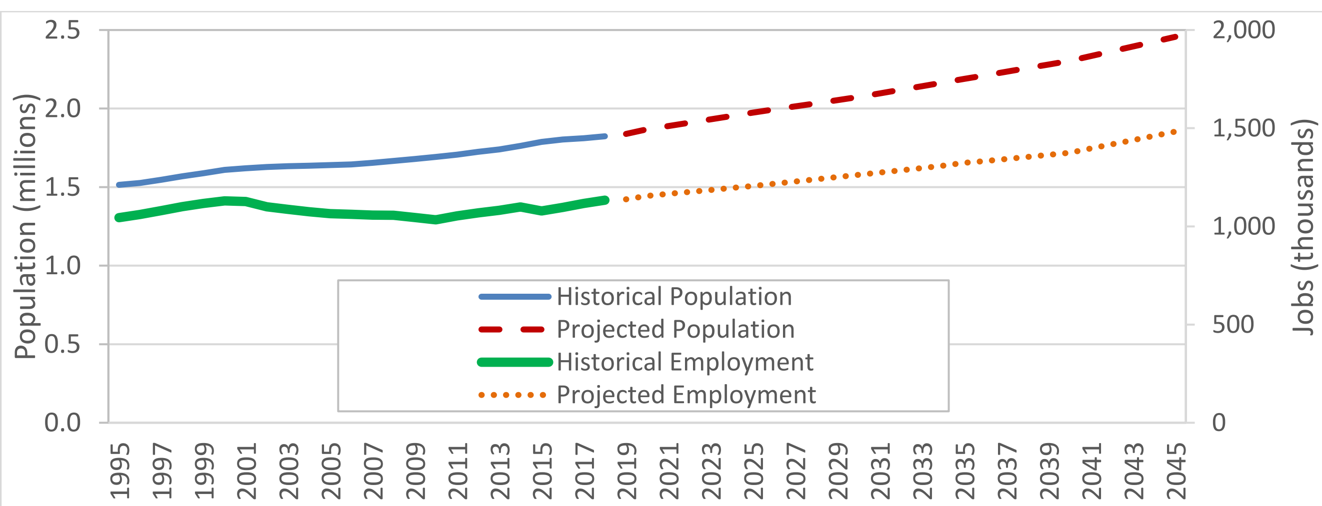


Table 5-2 presents individual BAWSCA member agency population projections. Each agency was given the ability to select the source it felt best represented its service area.

Table 5-2. Updated BAWSCA Member Agency Population Projections

Service Area	Projection Source	2025	2030	2035	2040	2045
Alameda County Water District (ACWD)	2020 UWMP	362,400	371,100	379,000	387,000	442,100
Brisbane/Guadalupe Valley Municipal Improvement District (GVMID)	Previous DSS Model; model updated in 2018 for Water Supply Assessment	5,134	5,417	5,702	5,987	6,272
Burlingame, City of	2020 UWMP	34,592	36,024	37,457	38,889	40,322
California Water Service (CWS) – Bear Gulch District	2020 UWMP	60,907	61,255	61,778	62,302	62,835
CWS – Mid-Peninsula District	2020 UWMP	139,142	142,138	144,913	147,802	150,974
CWS – South San Francisco District	2020 UWMP	65,539	66,028	66,759	69,100	71,550
Coastside County Water District	2020 UWMP	18,991	19,238	19,371	19,472	19,573
Daly City, City of	2020 UWMP	115,671	119,147	123,020	127,028	131,037
East Palo Alto, City of	2020 UWMP	27,215	28,589	30,062	31,646	33,230
Estero Municipal Improvement District (EMID)/Foster City	2020 UWMP	36,932	37,602	38,848	40,107	41,366
Hayward, City of	2020 UWMP	181,670	202,553	225,836	251,795	280,738
Hillsborough, Town of	2020 UWMP	11,940	12,783	12,783	12,783	12,783
Menlo Park, City of	2020 UWMP	23,383	25,166	27,675	30,184	33,174
Mid-Peninsula Water District	2020 UWMP	29,711	30,008	31,010	31,961	32,912
Millbrae, City of	2020 UWMP	22,846	26,774	26,657	27,081	27,505
Milpitas, City of	2020 UWMP	90,400	98,100	106,000	113,178	120,356
Mountain View, City of	2020 UWMP	91,810	98,080	104,350	110,630	116,900
North Coast County Water District	2020 UWMP	38,790	39,380	39,600	40,510	41,330
Palo Alto, City of	2020 UWMP	71,982	75,130	78,130	81,426	84,574
Purissima Hills Water District	Preliminary 2019 ABAG	6,833	6,898	7,025	7,112	7,199
Redwood City, City of	2020 UWMP	93,765	97,128	100,614	104,247	107,947
San Bruno, City of	2020 UWMP	45,865	46,472	47,080	51,922	56,764

Service Area	Projection Source	2025	2030	2035	2040	2045
San Jose, City of*	Brown and Caldwell consultation	48,082	60,695	85,043	101,637	103,960
Santa Clara, City of	2020 UWMP	137,215	142,425	151,715	159,500	167,285
Stanford University	Office of Institutional Research and Decision Support	34,748	36,922	39,226	41,342	43,525
Sunnyvale, City of	2020 UWMP	165,436	174,880	184,862	195,414	205,966
Westborough Water District	2020 UWMP	13,170	13,480	13,790	14,089	14,388
TOTAL		**1,974,169**	**2,073,412**	**2,188,306**	**2,304,144**	**2,456,565**

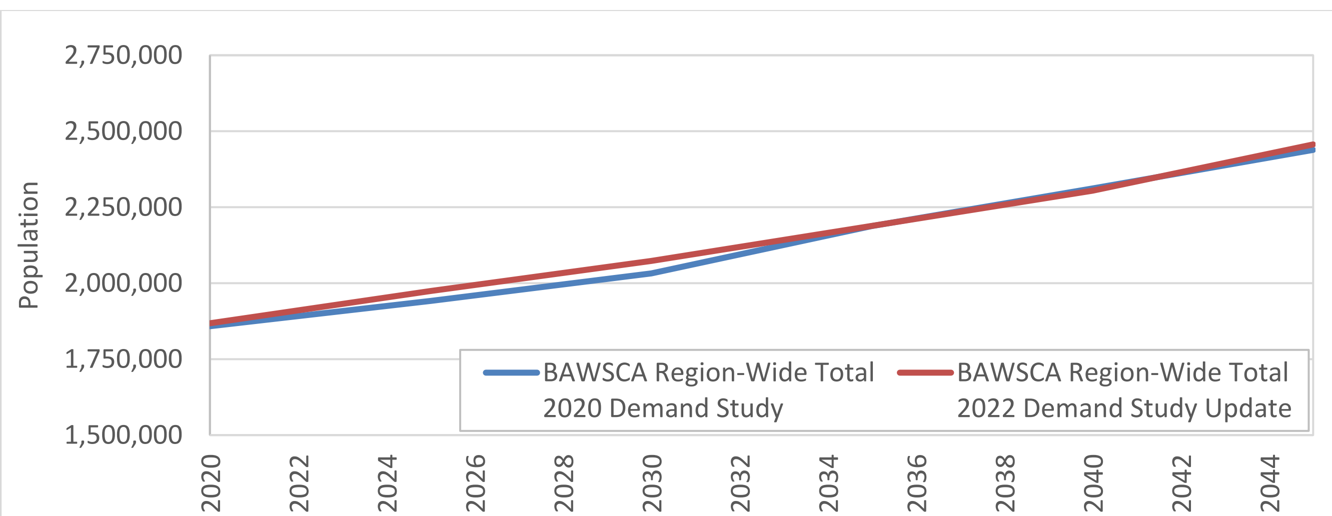
* *Service area population estimates for San Jose represent San Jose Municipal Water System's northern San Jose service area, not the entire service area of the City of San Jose.*

As part of the analysis for the 2022 Demand Study Update, a comparison was made between the 2020 and 2022 Demand Study population values. Overall, BAWSCA region-wide population projections increased 0.7% by the year 2045, as displayed in Table 5-3 and Figure 5-2.

Table 5-3. BAWSCA Region-Wide Population Projection 2020 Demand Study vs. 2022 Demand Study Update

	BAWSCA Region-Wide Total 2020 Demand Study Population	BAWSCA Region-Wide Total 2022 Demand Study Update Population	Numerical Difference in Population	Percent Change (2020 Demand Study to 2022 Demand Study Update)
2020	1,858,392	1,868,090	9,698	0.5%
2025	1,941,725	1,974,169	32,444	1.7%
2030	2,032,304	2,073,412	41,108	2.0%
2035	2,187,849	2,188,306	457	0.0%
2040	2,311,562	2,304,145	(7,417)	-0.3%
2045	2,438,515	2,456,566	18,051	**0.7%**

Figure 5-2. BAWSCA Region-Wide Population Projection 2020 Demand Study vs. 2022 Demand Study Update



Note: The lines in the above figure are close because the population forecasts changed only minorly between the 2020 Demand Study and 2022 Demand Study Update.

5.2 Updated BAWSCA Regional Demand Projections

For the purposes of these regional projections, the demand projections for future planning were verified by each member agency through the TM-1 signature form and are presented in Table 5-4. These demand projections were developed using an econometric modeling approach as described in Section 3. The econometric modeling approach assumed normal weather, a normal economy, price escalation projections that vary by agency, historical active conservation efforts, and passive conservation plumbing codes.

Demand projections are based on data provided from 1995 through 2021. This analysis was completed during the COVID-19 pandemic using the best available data. Demands were updated using published demands from the 2020 UWMPs.

As shown in Table 5-4, in comparison to the 2020 Demand Study, by 2045, the cumulative total water demand projections for BAWSCA agencies in the 2022 Demand Study Update increased by 1.6% for demands with active and passive conservation. The following are key reasons for the demand increase:

- **Population:** Overall BAWSCA region-wide population projections increased 0.7% by 2045, as displayed earlier in Table 5-3.
- **Recycled Water:** There are more agencies planning to increase their recycled water since more recycled water projects are being developed. Per the 2022 Demand Study Update, recycled water increased by approximately 2% in 2045 projection when compared to the 2020 Demand Study.

Other factors impacting the projected increase in water demand in 2045 include job projections, conservation, and planned future land uses.

Table 5-4. 2022 Demand Study Update Future Water Projections

Water Demands without Passive Conservation (MGD)					
	2025	**2030**	**2035**	**2040**	**2045**
2022 Demand Study Update	231.5	244.0	260.1	276.2	296.5
2020 Demand Study	240.3	251.1	266.7	280.0	293.6
Percent Change	-3.7%	-2.8%	-2.5%	-1.4%	1.0%
Water Demands with Passive Conservation (MGD)					
	2025	**2030**	**2035**	**2040**	**2045**
2022 Demand Study Update	222.8	230.2	240.7	251.9	267.7
2020 Demand Study	228.9	234.3	244.3	253.1	262.4
Percent Change	-2.6%	-1.8%	-1.4%	-0.4%	2.0%
Water Demands with Passive and Active Conservation (MGD)					
	2025	**2030**	**2035**	**2040**	**2045**
2022 Demand Study Update	219.0	224.7	234.5	244.8	260.4
2020 Demand Study	225.1	229.2	238.8	247	256.3
Percent Change	-2.7%	-2.0%	-1.9%	-0.9%	1.6%

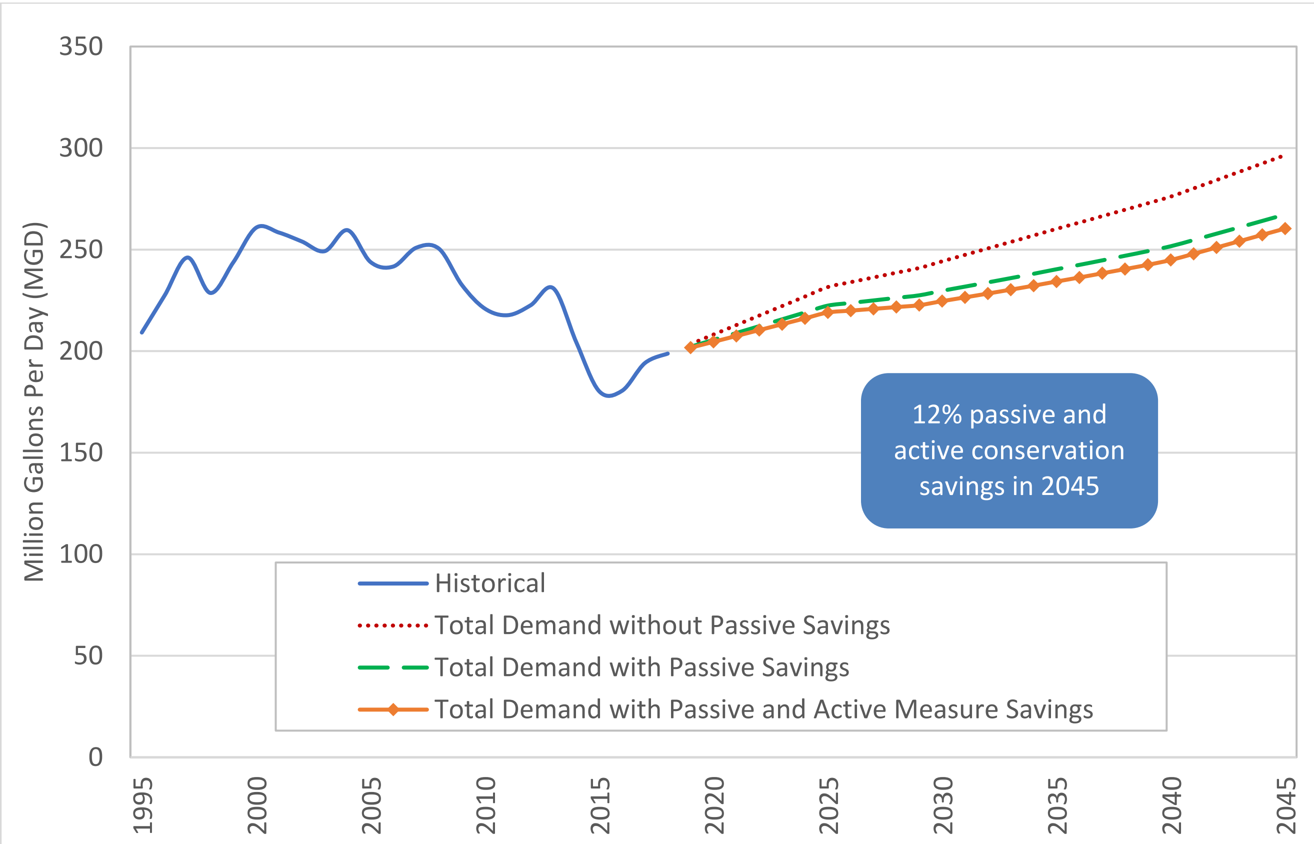
Note: Total water demand accounts for the total projected demand in a service area water system regardless of source, which could be from SFPUC, groundwater, surface water, recycled water, brackish groundwater desalination, the SWP, or Valley Water.

Figure 5-3 presents the combined BAWSCA region-wide water demand projections with and without passive conservation, and with active water conservation. Total water demand is defined as total water consumption plus non-revenue water. Water consumption is defined as water delivered to individual customers for use.

Figure 5-4 illustrates the projected 76% population increase with a 0.1% demand decrease between 1986 and 2045. The demand shown in this chart includes both passive and active conservation measure savings.

Figure 5-5 represents the gross and residential per capita water use for BAWSCA. The gross per capita value is the total production, including non-revenue water. Both the gross and residential per capita water use exclude recycled water. The figure illustrates a 47% decrease in residential per capita water use between 1986 and 2045.

Figure 5-3. BAWSCA Region-Wide Demands with Active Conservation Savings to 2045



Notes:

1. *Water demands are based on data provided from 1995 through 2021. This analysis was completed during the COVID-19 pandemic using the best available data.*
2. *Total projections account for the total projected water demand in a service area water system regardless of source. Sources include purchases from SFPUC, groundwater, surface water, recycled water, brackish groundwater desalination, the State Water Project, or Santa Clara Valley Water District.*

Figure 5-4. Updated Historical and Projected Population and Demand

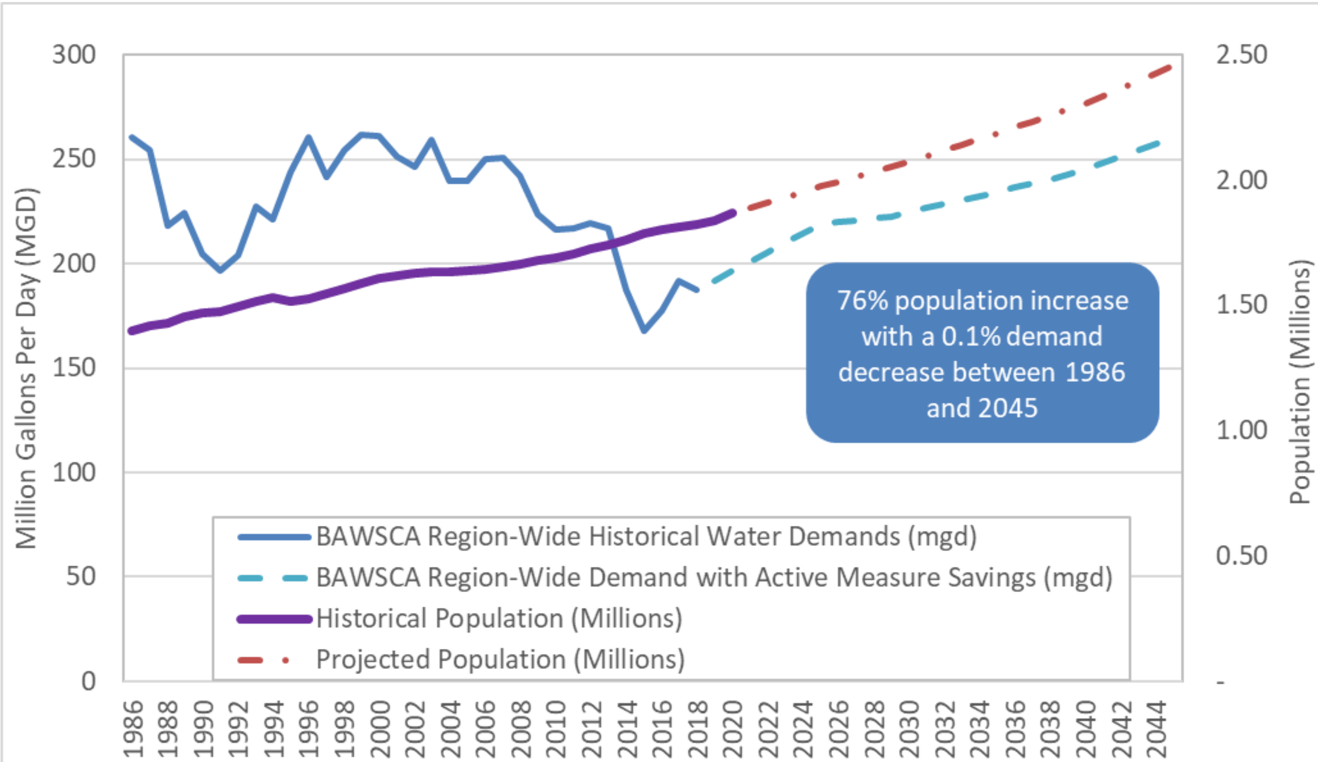
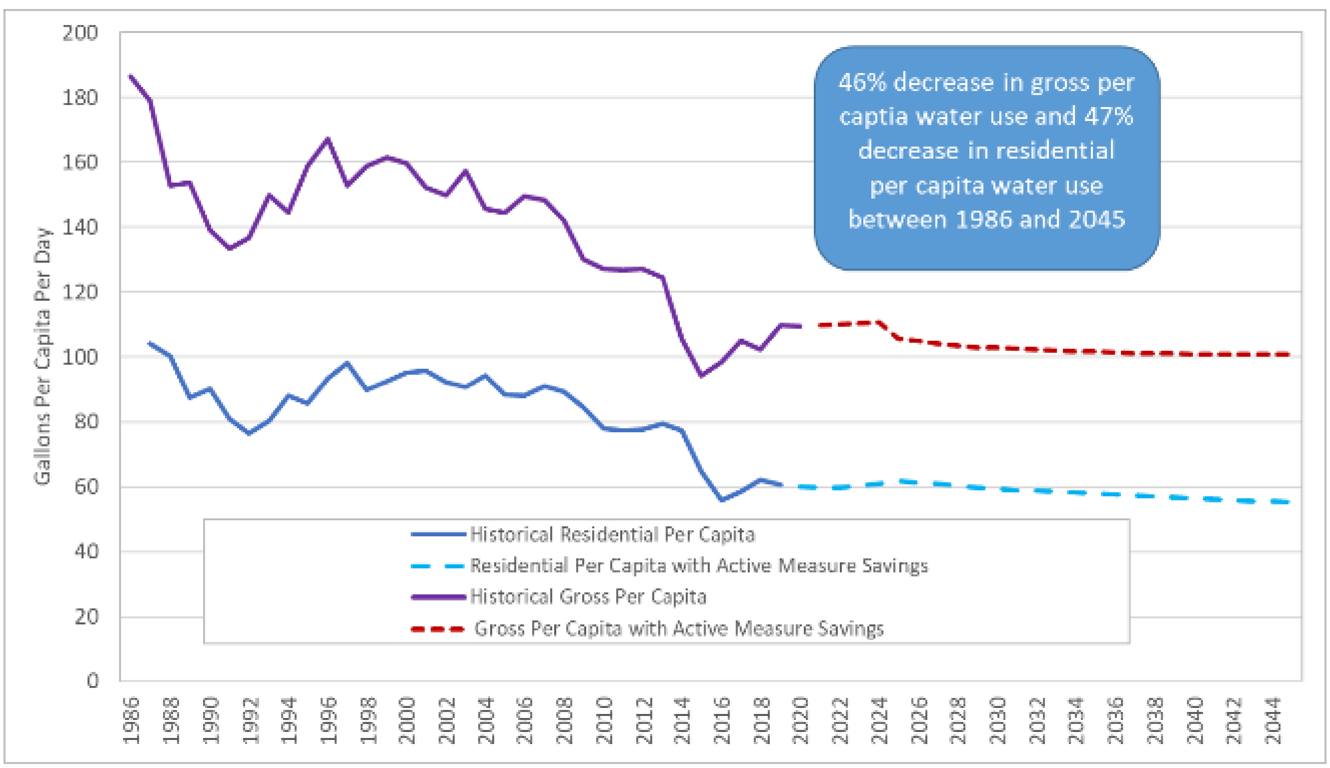


Figure 5-5. Updated Total BAWSCA Gross Per Capita Demands



Notes:

1. *To be consistent with the methodology used for the BAWSCA Annual Survey, recycled water has been removed from the per capita calculations; therefore, the above information is a potable-only per capita value.*

2. *Residential water use includes some irrigation, as not all agencies have dedicated irrigation meters.*

5.3 Updated Individual BAWSCA Agency Water Demands

The individual BAWSCA member agency demands were updated for the 2022 Demand Study Update. More detail on each of these demand tables and passive conservation can be found in the 2020 Demand Study and Appendix C of this report. Tables 5-5, 5-6, and 5-7 present the updated BAWSCA individual member agency water demand projections through 2045, including:

- Demands without future passive conservation savings
- Demands with projected passive conservation savings
- Demands with projected passive and active conservation savings

Included in Table 5-5 is a brief description of what changed for each agency from the 2020 Demand Study published in June 2020 to the 2022 Demand Study Update. For example, an agency may have updated its population data or recycled water demand projections due to availability of more current data. The data for the 2022 Demand Study Update was mainly obtained from each agency's 2020 UWMP except for the three BAWSCA agencies that did not submit a UWMP. As shown in Table 5-5, eight agencies have the same projected water demand as the 2020 Demand Study. These include the three BAWSCA agencies that are not required to submit a UWMP

Table 5-5. Updated Demand Projections without Passive Conservation Savings (MGD)

Service Area	2025	2030	2035	2040	2045	Notes on Changes from 2020 Demand Study to 2022 Demand Study Update
Alameda County Water District (ACWD)	41.5	42.5	43.5	44.6	53.3	• Population and job projections were updated as part of ACWD's Water Efficiency Master Plan (WEMP) using the Draft Plan Bay Area 2050. • Conservation measures were revised/added to as part of the WEMP. • WEMP and associated DSS Model were used for the 2020 UWMP.
Brisbane, City of/Guadalupe Valley Municipal Improvement District (GVMID)	0.9	0.9	0.9	1.0	1.0	• Future Baylands Development was removed from population and job projections. Additionally, year 2020 was updated to reference the 2020 U.S. Census Bureau and projected years 2030 and 2040 to reference Brisbane/GVMID's Planning Department projections. Updated the increase in service area population and decrease in jobs. • Irrigation demand was updated to plan for a new city park, which would use 4 million gallons per year.

Service Area	2025	2030	2035	2040	2045	Notes on Changes from 2020 Demand Study to 2022 Demand Study Update
Burlingame, City of	4.3	4.5	4.8	5.0	5.3	• Burlingame/EKI Environment & Water updated population and employment in the DSS Model to match the General Plan. • Removed recycled water from DSS Model, as previous agency-labeled recycled water is not Title 22 compliant (i.e., the water only undergoes primary and secondary treatment) and is considered non-potable. The non-potable water is used only inside the plant and not for irrigation. • Non-revenue water (NRW) demands were adjusted after the UWMP was submitted, as the UWMP NRW demands were not adjusted for removal of recycled water and Millennium Project customer categories in the DSS Model.
California Water Service (CWS) - Bear Gulch District	11.9	11.9	12.1	12.1	12.1	• Updated CalWater Demand Model for the 2020 UWMP.
CWS - Mid-Peninsula District	13.5	13.9	14.4	14.7	15.1	• Updated CalWater Demand Model for the 2020 UWMP.
CWS - South San Francisco District	7.0	7.1	7.3	7.7	8.2	• Updated CalWater Demand Model for the 2020 UWMP.
Coastside County Water District	2.1	2.1	2.1	2.1	2.1	• No changes.
Daly City, City of	6.9	8.1	8.3	8.5	8.7	• Recycled water was updated for 2030–2045. • Recycled water in the 2020 UWMP differed from the DSS Model; however, after discussion, the City requested that recycled water demand projections be delayed from 2025 until 2030, as the recycled water facility will not be online until 2030. UWMP recycled water demand projections were used for 2030 onward.
East Palo Alto, City of	2.1	2.2	2.4	2.9	3.4	• No changes.

Service Area	2025	2030	2035	2040	2045	Notes on Changes from 2020 Demand Study to 2022 Demand Study Update
Estero Municipal Improvement District (EMID)/Foster City, City of	4.6	5.0	5.2	5.4	5.7	• Population projections were updated for the total EMID service area and were based on Foster City's Community Development Department (CDD) estimate for Foster City population plus Mariner Island Tract population data. • Job projections were updated for the total EMID service area and were based on the CDD estimate for Foster City jobs plus Mariner Island Tract job data. • Model was adjusted to start in 2021. • All conservation measures that started in 2019 were updated to start in 2021.
Hayward, City of	19.5	21.2	22.9	24.7	26.6	• Recycled water demand projections were added to the 2020 UWMP.
Hillsborough, Town of	3.3	3.5	3.5	3.5	3.5	• Population projections were updated for the 2020 UWMP. • 2020 UWMP population projections were based on RHNA Cycle 6 allocation annual population growth estimates.
Menlo Park, City of	3.7	3.9	4.2	4.5	4.7	• Population projections were updated by the City's Planning Division to account for frontloading of development between 2020 and 2025.
Mid-Peninsula Water District	3.1	3.2	3.3	3.4	3.4	• No changes.
Millbrae, City of	2.4	2.7	2.7	3.2	3.6	• No changes.
Milpitas, City of	12.2	12.8	13.6	14.2	14.8	• Recycled water demand projections were updated for the 2020 UWMP. • The UWMP 2020 projected population was sourced from DOF. 2015 UWMP population projections were used for 2025–2035 along with the Plan Bay Area 2040 value for 2040 with interpolation between 2035 and 2041–2045.
Mountain View, City of	11.3	12.0	12.7	13.5	14.2	• No changes.

Service Area	2025	2030	2035	2040	2045	Notes on Changes from 2020 Demand Study to 2022 Demand Study Update
North Coast County Water District	2.6	2.6	2.7	2.7	2.8	• Recycled water demand projections were added to the 2020 UWMP.
Palo Alto, City of	11.1	11.5	11.9	12.3	12.7	• Population and job projections were updated based on the City's 2030 Comprehensive Plan. • Model was adjusted to start in 2020. • No growth in recycled water. • All conservation measures that started in 2019 were updated to start in 2020.
Purissima Hills Water District	2.1	2.1	2.2	2.2	2.2	• No changes.
Redwood City, City of	10.4	11.0	11.6	12.0	12.3	• Recycled water demand projections were increased for the 2020 UWMP.
San Bruno, City of	3.5	4.0	4.4	4.8	4.8	• Water demand projections in the 2020 UWMP were based on projections developed for the City's 2021 Water System Master Plan. The demand projections were developed based on planned future land uses and updated unit water use factors.
San Jose, City of	6.1	6.9	8.9	12.6	13.0	• North San Jose population values were updated. • San Jose provided updated North San Jose demand values.
Santa Clara, City of	22.4	24.4	26.4	28.3	30.5	• Growth projections for recycled water were updated in the DSS Model from the 2020 UWMP.
Stanford University	3.2	3.4	3.6	3.9	4.1	• No changes.
Sunnyvale, City of	18.9	19.7	23.5	25.4	27.4	• Growth projections for recycled water were updated in the DSS Model from the 2020 UWMP.
Westborough Water District	0.9	0.9	1.0	1.0	1.0	• No changes.
TOTAL*	**231.5**	**244.0**	**260.1**	**276.2**	**296.5**	

**Total projections account for the total projected water demand in a service area water system regardless of source. Sources include purchases from SFPUC, groundwater, surface water, recycled water, brackish groundwater desalination, the State Water Project, or Santa Clara Valley Water District*

Table 5-6. Updated Demand Projections with Passive Conservation Savings (MGD)

Service Area	2025	2030	2035	2040	2045
Alameda County Water District	40.5	40.5	40.7	41.1	48.3
Brisbane/GVMID	0.9	0.9	0.9	0.9	0.9
Burlingame, City of	4.1	4.2	4.4	4.6	4.7
CWS - Bear Gulch District	11.7	11.7	11.7	11.7	11.7
CWS - Mid Peninsula District	13.1	13.3	13.6	13.8	14.1
CWS - South San Francisco District	6.9	6.9	7.0	7.3	7.7
Coastside County Water District	1.9	1.9	1.9	1.8	1.8
Daly City, City of	6.4	7.3	7.3	7.3	7.4
East Palo Alto, City of	1.9	2.0	2.1	2.5	3.0
EMID/Foster City	4.5	4.8	4.9	5.0	5.2
Hayward, City of	18.3	19.3	20.4	21.6	22.9
Hillsborough, Town of	3.2	3.4	3.4	3.4	3.3
Menlo Park, City of	3.6	3.7	3.9	4.1	4.3
Mid-Peninsula Water District	2.9	2.9	3.0	3.0	3.0
Millbrae, City of	2.3	2.6	2.5	2.9	3.3
Milpitas, City of	11.9	12.2	12.7	13.1	13.5
Mountain View, City of	10.8	11.2	11.7	12.1	12.6
North Coast County Water District	2.4	2.4	2.3	2.3	2.3
Palo Alto, City of	11.1	11.3	11.5	11.7	12.0
Purissima Hills Water District	2.1	2.1	2.1	2.1	2.2
Redwood City, City of	9.8	10.1	10.5	10.7	10.8
San Bruno, City of	3.3	3.6	3.9	4.2	4.1
San Jose, City of	5.8	6.3	7.9	11.0	11.2
Santa Clara, City of	21.4	23.0	24.7	26.4	28.2
Stanford University	3.1	3.3	3.5	3.7	4.0
Sunnyvale, City of	18.0	18.4	21.4	22.8	24.4
Westborough Water District	0.9	0.9	0.8	0.8	0.8
TOTAL*	**222.8**	**230.2**	**240.7**	**251.9**	**267.7**

** Total projections account for the total projected water demand in a service area water system regardless of source. Sources include purchases from SFPUC, groundwater, surface water, recycled water, brackish groundwater desalination, the SWP, or Valley Water.*

Table 5-7. Updated Demand Projections with Passive and Active Conservation Savings (MGD)

Service Area	2025	2030	2035	2040	2045
Alameda County Water District	39.8	39.4	39.3	39.4	46.5
Brisbane/GVMID	0.9	0.9	0.9	0.9	0.9
Burlingame, City of	4.0	4.2	4.3	4.4	4.6
CWS - Bear Gulch District	11.4	11.3	11.4	11.3	11.3
CWS - Mid Peninsula District	12.9	13.0	13.2	13.4	13.6
CWS - South San Francisco District	6.7	6.7	6.8	7.1	7.5
Coastside County Water District	1.9	1.9	1.9	1.8	1.8
Daly City, City of	6.3	7.2	7.2	7.2	7.2
East Palo Alto, City of	1.9	1.9	2.1	2.5	2.9
EMID/Foster City	4.4	4.5	4.6	4.7	5.0
Hayward, City of	18.1	18.9	20.0	21.1	22.5
Hillsborough, Town of	3.2	3.3	3.3	3.3	3.3
Menlo Park, City of	3.5	3.7	3.9	4.1	4.3
Mid-Peninsula Water District	2.9	2.8	2.9	2.9	2.9
Millbrae, City of	2.3	2.5	2.5	2.9	3.2
Milpitas, City of	11.7	12.0	12.4	12.7	13.1
Mountain View, City of	10.5	10.9	11.2	11.5	11.9
North Coast County Water District	2.3	2.3	2.3	2.3	2.3
Palo Alto, City of	10.4	10.5	10.6	10.9	11.2
Purissima Hills Water District	2.1	2.1	2.1	2.1	2.2
Redwood City, City of	9.6	9.8	10.1	10.3	10.4
San Bruno, City of	3.3	3.6	3.9	4.1	4.1
San Jose, City of	5.8	6.2	7.8	10.9	11.2
Santa Clara, City of	21.2	22.7	24.3	25.9	27.7
Stanford University	3.1	3.3	3.5	3.7	3.9
Sunnyvale, City of	17.9	18.2	21.2	22.6	24.1
Westborough Water District	0.9	0.9	0.8	0.8	0.8
TOTAL*	**219.0**	**224.7**	**234.5**	**244.8**	**260.4**

**Total projections account for the total projected water demand in a service area water system regardless of source. Sources include purchases from SFPUC, groundwater, surface water, recycled water, brackish groundwater desalination, SWP, or Valley Water.*

6 SCENARIOS FOR WATER DEMAND SENSITIVITY ANALYSIS

This section includes a description of the five alternative future scenarios that were developed and quantified as part of the 2022 Demand Study Update sensitivity analysis and a description of the quantification methodology that was used. Further information about the variables input into the water demand sensitivity analysis can be found in Section 3.

6.1 Scenario Quantification Methodology

To generate water demand forecasts under alternative future scenarios requires quantifying the cumulative impact of input assumptions related to each of the variables:

- Population and Jobs Growth
- Housing Density Changes
- Water Rate Escalation
- Water Conservation
- Long-Term Climate Change

The water demand forecast is conducted using a basis of per capita demand for each BAWSCA agency and applying the assumed range of each variable as described in Section 6.2 by first calculating the future impact of changes in housing density, water rate escalation, water conservation, and climate change on per capita demand. The per capita estimates are then converted into total demand (as an average annual rate with units of MGD) by multiplying future per capita demand with estimates of future population. Corrections are applied where jobs-per-capita indicates significant changes over time, which suggests a changing mix of residential and CII demand in a service area.

Population and Jobs Growth

Population and jobs projections are available from the individual BAWSCA agencies, based largely on ABAG projections. These indicate a BAWSCA region-wide population growth rate of 1.1% and jobs growth rate of 1.0% per year, although these growth rates vary across agencies. These population and jobs estimates are proportionally downscaled such that BAWSCA region-wide population growth rates fall to either 0.84% or 0.52% per year, and jobs growth rates fall to 0.74% or 0.42% per year. One of these three sets of population and jobs projections then becomes an input into any given scenario. The proportional downscaling maintains relative growth rate differences across agencies evident in their ABAG-sourced projections.

Although population and jobs are used in the final step of the methodology to convert per capita demand into total demand, population is a necessary input for the housing density forecasting algorithm.

Housing Density Changes

Future changes in the stock of single family and multifamily housing depends on assumed proportions of the mix of new housing that will be constructed in a service area and the rate of population growth. A stock and flow model[28] takes year-over-year addition of new residents and converts it into the number of single family and multifamily units that need to be built in an agency's service area. This stock and flow modeling approach requires input data on persons-per-dwelling in a single family and multifamily housing unit (obtained from the American Community Survey[29]) and the proportion of new housing units that must either be single or multifamily

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[28] "Stock and flow (or level and rate) diagrams are ways of representing the structure of a system with more detailed information than is shown in a causal loop diagram." (Source: Vensim. (n.d.). Vensim Help web page, accessed August 2022. https://www.vensim.com/documentation/usr05.html)

[29] U.S. Census Bureau. (2022). American Community Survey (ACS) web page, accessed August 2022. https://www.census.gov/programs-surveys/acs

(varies across agencies, time, and scenario). The previous year's housing mix is then updated to reflect the new units added to the stock because of population growth. This algorithm is run separately for each agency and scenario using agency-specific population projections and persons-per-dwelling estimates.

The housing density algorithm predicts an increasing share of multifamily housing over time in all member agencies, but to varying extents to account for each service area's socioeconomic characteristics and preferences. The impact of this on water demand is quantified using results of the econometric model, which suggests that per capita demand drops by 7.4% for every 10% shift in the housing mix toward multifamily (e.g., multifamily share increasing from 40% to 50% over time). A smaller percentage shift would generate a proportionally smaller water demand impact.

Water Price Escalation

Another input for each scenario is the future growth rate in the marginal price of water. As mentioned earlier, marginal price in real dollars rose by 3.3% per year between 1995 and 2020 on a population-weighted, BAWSCA region-wide basis; however, not every agency's experience was identical because some have access to less expensive water supply sources than the SFPUC supplies. It is important to preserve these interagency differences by taking each agency's historical escalation rate and downscaling it to mimic BAWSCA region-wide assumptions of 1.8% and 2.3% escalation rate per year. For example, where a scenario posits 1.8% per year escalation in the marginal price of water, an agency's historical escalation rate would be reduced by 1.5% (the difference between 3.3% and 1.8%) instead of making a uniform assumption across all agencies. Similarly, where a scenario posits a 2.3% escalation in the marginal price of water, an agency's historical escalation rate would be reduced by 1.0%.

The impact of rate increases on water demand is quantified using results of the econometric model, which suggests that per capita demand drops by 1.6% for every 10% increase in the real marginal price of water. Accordingly, if marginal prices increase at a rate of 1.8% or 2.3% per year, per capita demand can be expected to drop by roughly 0.29% (1.8*0.16) or 0.37% (2.3*0.16) per year, respectively. Actual predicted effects vary across agencies.

Water Conservation

As described earlier, the 2020 Demand Study conservation analysis yielded an overall combined active and passive water savings for the BAWSCA service area of 0.5% annual demand reduction. Conservation savings from Scenarios C and E may increase by an additional 25% due to changing public norms regarding landscape designs and impacts from climate change, more frequent droughts, new California water conservation standards, and so forth. The increase of conservation by 25% in both Scenarios C and E represents conservation reduction of per capita demand by 0.625% (0.5*1.25) per year in the future.

Prior analyses indicate significant variation in the impact of passive and active conservation programs across agencies. This interagency variation is preserved. When a scenario posits that conservation will reduce per capita demand by 0.5% per year, agency-specific results from the 2020 Demand Study are used directly. For the more aggressive scenario of conservation reducing per capita demand by 0.625% per year, agency-specific expected savings are increased by 25%.

Long-Term Climate Change

As discussed earlier, BAWSCA member agencies are expected to experience gradual warming over time with daily temperatures in 2045 likely to be higher by 1.6 ^{o}F or 2.2 ^{o}F compared to 2020, depending on whether global emissions unfold according to the RCP4.5 or RCP8.5 climate change scenarios, respectively.

The impact of this long-term temperature increase on water demand is estimated using results of the econometric model. The model is used to predict the percentage by which per capita demand would have been greater in 2020 had daily temperatures either been 1.6 ^{o}F (corresponding to RCP4.5) or 2.2 ^{o}F (corresponding to

RCP8.5) greater than normal. The increase predicted either for the RCP4.5 or RCP8.5 scenario is merged in over time, starting with zero impact in 2020, linearly rising to either of the above-mentioned percentage multipliers by 2045. The climate change multiplier is calculated separately for each agency since the econometric model suggests that response of water demand to temperature varies across agencies. Wealthier service areas with greater landscape area (i.e., higher outdoor use) show greater responsiveness to temperature variation than those with much smaller landscape area (or lower outdoor use).

6.2 Scenario Descriptions

To quantify water demand related to various alternative future conditions, BAWSCA developed and analyzed scenarios that feature a unique combination of variables as described in Section 3. BAWSCA staff, the MWM Project Team, and the Stakeholder Workgroup provided input to this process. BAWSCA selected five scenarios for the 2022 Demand Study Update analysis that are referred to as Scenario A through Scenario E.

Scenario A

Scenario A represents a scenario similar to the 2020 Demand Study. In Scenario A, the Bay Area's economy would remain similar in stability to the recent past. This scenario reflects water conservation, population, and job projections as published in the individual agencies' 2020 UWMPs and incorporates detail for housing units. This important refinement reflects actual development data, which includes more multifamily development and results in slightly lower demands than the 2020 Demand Study (less than 1% overall difference).

The alternative future envisioned under Scenario A (shown in Table 6-1) is framed by causes and effects:

Causes

- No severe technological, geopolitical, or climate disruption to the Bay Area's economy.
- New residential development remains consistent with recent trends.
- Water conservation reduced demand by 0.5% annually (consistent with BAWSCA 2020 Demand Study).

Effects

- During the 2020–2045 period, jobs and population grow as projected in 2020 UWMPs (i.e., higher rates than the previous 25 years).

Table 6-1. Basis for Projection in Scenario A

Scenario A				
Variable			**Basis for Projection**	
1. Population and Economic Growth	Annual growth rate for future population and jobs	Population: 0.52% (DOF) Jobs: 0.42% (DOF)	0.84% (Historical) 0.74% (Historical)	1.1% (ABAG) 1.0% (ABAG)
2. Housing Density	New housing built (at retail level through 2045)	Continued historical patterns (% SF, % MF)	Increased density in future (10% more MF, 10% less SF)	Increased density in future (15% more MF, 15% less SF)
3. Long-Term Climate Change	°F warming	1.6°F RCP4.5: global CO2 emissions peak by 2045		2.2°F RCP8.5: global CO_2 emissions continue to rise through 21st century
4. Water Rates	Future increase to SFPUC wholesale water rates above Consumer Price Index (CPI)	0% (Consistent with CPI)	1.8%	2.3% (75% rate increase by 2045)
5. Conservation	% Annual Demand Reduction	0.5% (Programs selected in BAWSCA's 2020 Demand Study)		0.625% (Assuming agencies achieve an additional 25% savings beyond selected water conservation programs)
6. Seasonal Weather **7. Economic Cycles**		**Applied to all scenarios to set baseline demand** (Normalizes demand for seasonal weather fluctuations and short-term economic cycles)		

Note: Grayed out text means that this information was not selected for the particular scenario.

Scenario B

In Scenario B, the concept was to model data currently available at the local and state level, update and revise assumptions used in the 2020 Demand Study, and use all best available information as of 2022. Scenario B reflects a stable Bay Area economy. This scenario also incorporates a continuation of historical population trends (0.84% annual growth rate), which are slightly less than the ABAG future projections (1.1% annual growth rate) and uses the water conservation savings (average of a 0.5% annual demand reduction per year) as published in the individual agencies' 2020 UWMPs. Scenario B includes an increase in housing density as recent home prices and MF housing development have risen, the latter due to limited space and affordable housing unit requirements.

The alternative future envisioned under Scenario B (shown in Table 6-2) is framed by causes and effects:

Causes

- No severe technological, geopolitical, or climate disruption to the Bay Area's economy.
- Denser residential development tempers housing prices and commute times.

Effects

- Long-term jobs and population growth during the 2020–2045 period follows trends of the previous 25 years.

Table 6-2. Basis for Projection in Scenario B

Scenario B				
Variable			**Basis for Projection**	
1. Population and Economic Growth	Annual growth rate for future population and jobs	Population: 0.52% (DOF) Jobs: 0.42% (DOF)	0.84% (Historical) 0.74% (Historical)	1.1% (ABAG) 1.0% (ABAG)
2. Housing Density	New housing built (at retail level through 2045)	Continued recent (2015-2020) patterns (% SF, % MF)	Increased density in future (10% more MF, 10% less SF)	Increased density in future (15% more MF, 15% less SF)
3. Long-Term Climate Change	°F warming	1.6°F RCP4.5: global CO2 emissions peak by 2045		2.2°F RCP8.5: global CO_2 emissions continue to rise through 21st century
4. Water Rates	Future increase to individual BAWSCA agency water rates above CPI	0% (Consistent with CPI)	1.8%	2.3% (75% rate increase by 2045)
5. Conservation	% Annual Demand Reduction	0.5% (Programs selected in BAWSCA's 2020 Demand Study)		0.625% (Assuming agencies achieve an additional 25% savings beyond selected water conservation programs)
6. Seasonal Weather **7. Economic Cycles**		**Applied to all scenarios to set baseline demand** (Normalizes demand for seasonal weather fluctuations and short-term economic cycles)		

Scenario C

In Scenario C, a greater increase in climate change and higher housing densification were modeled and a more aggressive temperature increase for the Bay Area under RCP8.5 was reflected. The climate change and weather variability increases could necessitate expanded infrastructure and water supply portfolio diversification. According to the SFPUC AWS projects list, by 2045 multiple infrastructure changes may be needed, which could lead to higher water rates. Rising air temperatures would expand the water demand of certain plant types and increase the driver for water conservation activity, such as landscape transformation.

Scenario C includes an even greater increase in housing density as recent home prices have risen, and there is a trend to build more multifamily housing due to limited space and required affordable housing unit allocations.

The alternative future envisioned under Scenario C (shown in Table 6-3) is framed by causes and effects:

Causes

- Successful implementation of housing densification policies and transportation investments considerably improve housing affordability and reduce commute times.
- Climate change worsens, which requires significant investments in alternative water supply resources, water conservation, and other mitigation.

Effects

- Jobs and population growth exceeds historical (1995–2020) average.
- Housing densification, coupled with large rate increases and conservation, continues to dampen water demand growth.

Table 6-3. Basis for Projection in Scenario C

Scenario C				
Variable			**Basis for Projection**	
1. Population and Economic Growth	Annual growth rate for future population and jobs	Population: 0.52% (DOF) Jobs: 0.42% (DOF)	0.84% (Historical) 0.74% (Historical)	1.1% (ABAG) 1.0% (ABAG)
2. Housing Density	New housing built (at retail level through 2045)	Continued recent (2015-2020) patterns (% SF, % MF)	Increased density in future (10% more MF, 10% less SF)	Increased density in future (15% more MF, 15% less SF)
3. Long-Term Climate Change	°F warming	1.6°F RCP4.5: global CO2 emissions peak by 2045		2.2°F RCP8.5: global CO_2 emissions continue to rise through 21st century
4. Water Rates	Future increase to SFPUC wholesale water rates above CPI	0%	1.8%	2.3% (75% rate increase by 2045)
5. Conservation	% Annual Demand Reduction	0.5% (Programs selected in BAWSCA's 2020 Demand Study to meet anticipated water use targets)		0.625% (Assuming agencies achieve an additional 25% savings beyond anticipated water use targets)
6. Seasonal Weather **7. Economic Cycles**		**Applied to all scenarios to set baseline demand** (Normalizes demand for seasonal weather fluctuations and short-term economic cycles)		

Scenario D

In Scenario D, a greater climate change increase—similar to Scenario C—was modeled, but with the assumption that fatigued customers would no longer respond with additional water conservation activities. Scenario D reflects a more aggressive temperature increase under RCP8.5 for the Bay Area. The climate change and weather variability increases could necessitate expanded infrastructure and water supply portfolio diversification. According to the SFPUC AWS projects list, by 2045 multiple infrastructure changes may be needed, which would lead to higher water rates.

The alternative future envisioned under Scenario D (shown in Table 6-4) is framed by causes and effects:

Causes

- No severe technological or geopolitical disruption to the Bay Area's economy.

- New residential development remains consistent with recent trends.
- Climate change worsens, which requires significant investments in alternative water supply resources.
- Conservation fatigue.

Effects

- Long-term jobs and population growth during the 2020–2045 period follows trends of previous 25 years.
- Less response to conservation.
- Water rates increase to pay for alternative water supply sources.

Table 6-4. Basis for Projection in Scenario D

Scenario D				
Variable			**Basis for Projection**	
1. Population and Economic Growth	Annual growth rate for future population and jobs	Population: 0.52% (DOF) Jobs: 0.42% (DOF)	0.84% (Historical) 0.74% (Historical)	1.1% (ABAG) 1.0% (ABAG)
2. Housing Density	New housing built (at retail level through 2045)	Continued recent (2015-2020) patterns (% SF, % MF)	Increased density in future (10% more MF, 10% less SF)	Increased density in future (15% more MF, 15% less SF)
3. Long-Term Climate Change	°F warming	1.6°F RCP4.5: global CO2 emissions peak by 2045		2.2°F RCP8.5: global CO_2 emissions continue to rise through 21st century
4. Water Rates	Future increase to individual BAWSCA agency water rates above CPI	0% (consistent with CPI)	1.8%	2.3% (75% rate increase by 2045)
5. Conservation	% Annual Demand Reduction	0.5% (Programs selected in BAWSCA's 2020 Demand Study)		0.625% (Assuming agencies achieve an additional 25% savings beyond selected water conservation programs)
6. Seasonal Weather **7. Economic Cycles**		**Applied to all scenarios to set baseline demand** (Normalizes demand for seasonal weather fluctuations and short-term economic cycles)		

Scenario E

In Scenario E, lower population increase and lower job growth were modeled under the assumption customers would respond with additional water conservation activities. This scenario reflects a more aggressive temperature increase under RCP8.5 for the Bay Area. The climate change and weather variability increases could necessitate expanded infrastructure and water supply portfolio diversification. According to the SFPUC AWS projects list, by 2045 multiple infrastructure changes may be needed, which would lead to higher water rates.

The alternative future envisioned under Scenario E (shown in Table 6-5) is framed by causes and effects:

Causes

- Job automation, job relocation (out of Bay Area), remote work flexibility, and generational retirement wave.
- High housing prices.
- Worsening climate change, which requires significant investments in alternative water supply resources, water conservation, and other mitigation.

Effects

- Slow job growth, population, and economy.
- Higher water rates.
- Housing densification coupled with large rate increases and conservation, which continues to dampen water demand growth.

Table 6-5. Basis for Projection in Scenario E

Scenario E				
Variable			**Basis for Projection**	
1. Population and Economic Growth	Annual growth rate for future population and jobs	Population: 0.52% (DOF) Jobs: 0.42% (DOF)	0.84% (Historical) 0.74% (Historical)	1.1% (ABAG) 1.0% (ABAG)
2. Housing Density	New housing built (at retail level through 2045)	Continued recent (2015-2020) patterns (% SF, % MF)	Increased density in future (10% more MF, 10% less SF)	Increased density in future (15% more MF, 15% less SF)
3. Long-Term Climate Change	°F warming	1.6°F RCP4.5: global CO2 emissions peak by 2045		2.2°F RCP8.5: global CO_2 emissions continue to rise through 21st century
4. Water Rates	Future increase to individual BAWSCA agency water rates above CPI	0%	1.8%	2.3% (75% rate increase by 2045)
5. Conservation	% Annual Demand Reduction	0.5% (Programs selected in BAWSCA's 2020 Demand Study to meet anticipated water use targets)		0.625% (Assuming agencies achieve an additional 25% savings beyond anticipated water use targets)
6. Seasonal Weather **7. Economic Cycles**		**Applied to all scenarios to set baseline demand** (Normalizes demand for seasonal weather fluctuations and short-term economic cycles)		

Table 6-6 briefly summarizes which levels from the seven water demand variables were used in Scenarios A through E.

Table 6-6. Variables Included in Scenarios A Through E

Variable	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
Population and Economic Growth	1.1% Pop 1.0% Job	0.84% Pop 0.74% Job	1.1% Pop 1.0% Job	0.84% Pop 0.74% Job	0.52% Pop 0.42% Job
Housing Density	Continue historical 2015–2020 patterns	10% more MF, 10% less SF	15% more MF, 15% less SF	Continue historical 2015–2020 patterns	10% more MF, 10% less SF
Long-Term Climate Change	1.6°F	1.6°F	2.2°F	2.2°F	2.2°F
Water Rates	0% rate increase above CPI	1.8% rate increase above CPI	2.3% rate increase above CPI	2.3% rate increase above CPI	2.3% rate increase above CPI
Water Conservation	0.5% annual GPCD reduction	0.5% annual GPCD reduction	0.625% annual GPCD reduction	0.5% annual GPCD reduction	0.625% annual GPCD reduction
Seasonal Weather	Included for all scenarios to set baseline demand				
Economic Cycles	Included for all scenarios to set baseline demand				

6.3 Estimation of Total Demand from Per Capita Demand

Once future per capita demand is obtained at different points in time factoring in the effects of rising housing density, price increases, conservation, and climate change, it is a straightforward matter of splitting total per capita demand into its residential and non-residential portions and multiplying these estimates with projected population to derive total demand in MGD. At this last step, however, a final correction is incorporated into the estimate of total non-residential demand to account for changes in the jobs-per-capita ratio over time. For most agencies, this ratio does not change significantly, which implies that the balance between residential and non-residential demands is likely to remain consistent.

All computations are completed at the agency level, then the estimates are rolled up to generate BAWSCA region-wide estimates of total water demand; however, the impact of this final correction is minimal for BAWSCA region-wide estimates of water demand.

7 PROJECTIONS UNDER FUTURE WATER DEMAND SCENARIOS

All information and data gathered for the 2022 Demand Study Update demand variables were analyzed under the various scenarios to provide a range of water projections for the BAWSCA service area. Table 7-1, Table 7-2, and Figure 7-1 show projected water demands and populations under alternative future scenarios. Scenario A exhibits the highest demand because population growth is assumed to occur at the high end of the simulation range (1.1% per year), while rate increases are assumed to be no greater than inflation (i.e., zero in real terms), which removes a significant source of downward pressure on demand from the calculus. On the other end of the spectrum is Scenario E, which assumes population growth will be at the lower end of the simulation range (0.52% per year), while all the downward pressures on water demand, such as increasing housing density, rate increases, and conservation, remain operational over time. The other scenarios (B through D) that incorporate the key assumptions in various combinations remain clustered between Scenarios A and E. Only Scenario E predicts a slightly lowering demand over time. All others either indicate rising demand (Scenario A) or somewhat minimal increase over time (Scenarios B through D).

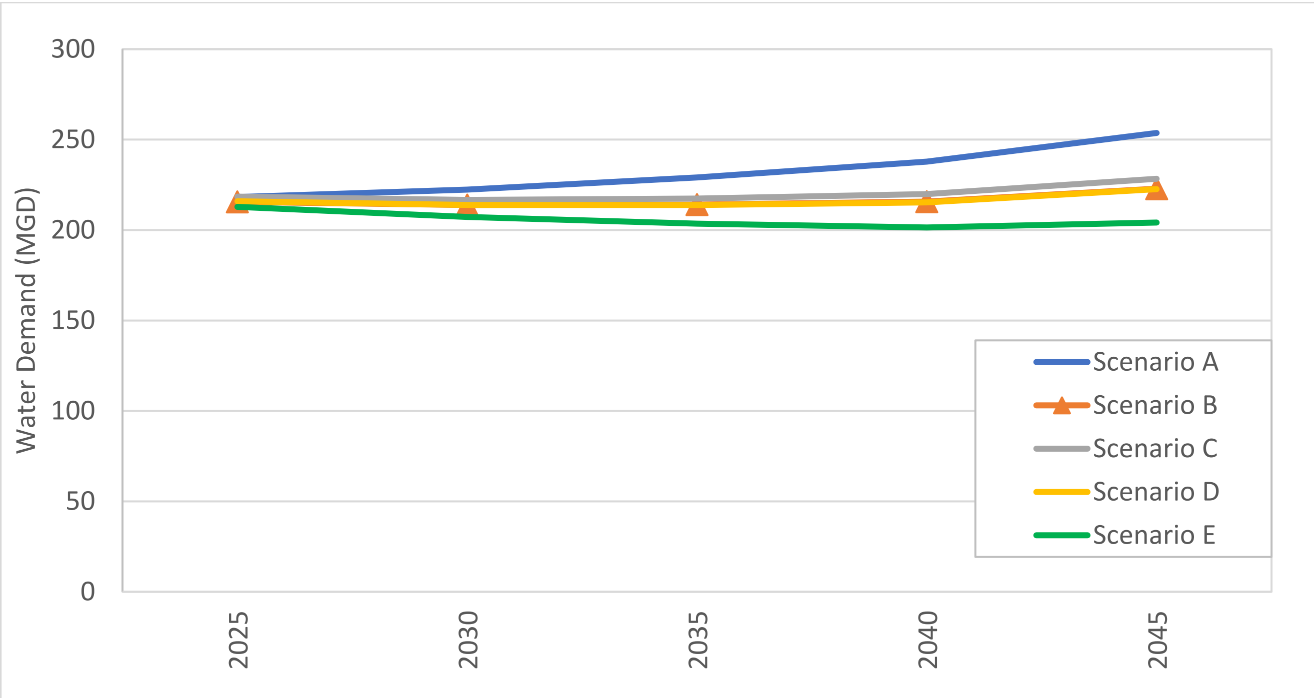
Table 7-1. Future BAWSCA Region-Wide Water Demands (in MGD) Under Scenarios A Through E

Year	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
2025	218	216	218	216	213
2030	222	214	217	214	207
2035	229	214	217	214	204
2040	238	216	220	215	201
2045	254	223	228	223	204

Table 7-2. Future BAWSCA Region-Wide Population Under Scenarios A Through E

Year	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
2025	1,974,169	1,949,292	1,974,169	1,949,292	1,919,754
2030	2,073,412	2,023,826	2,073,412	2,023,826	1,966,197
2035	2,188,305	2,107,557	2,188,305	2,107,557	2,016,617
2040	2,304,144	2,191,015	2,304,144	2,191,015	2,066,227
2045	2,456,565	2,302,236	2,456,565	2,302,236	2,133,051

Figure 7-1. Future BAWSCA Region-Wide Water Demands as Projected Under Scenarios A Through E



Notes:

1. *Specific values for the figure above are shown in Table 7-1.*
2. *Scenario B and Scenario D have similar values causing the lines to overlap in the figure. As a result, Scenario B has been given symbol markers to help illustrate its value path.*

Of the various demand drivers, population growth remains the most important source of upward pressure. For example, Scenario A's projected demand in 2045 is 254 MGD assuming population growth is realized at the higher end of the simulated range (1.1% per year) while conservation continues to reduce per capita demand by 0.5% per year. Modifying the assumed population growth rate in Scenario A to the lower end of the simulated range (0.52% per year) while holding all other inputs the same would cause projected demand in 2045 to decline to 220 MGD (or a reduction of 34 MGD) in this altered Scenario A. Layering additional upward (climate change) and downward (rising housing density, rate increases, additional conservation) pressures on water demand, as done in Scenario E, leads to a projected demand in 2045 of 204 MGD, or a further reduction of 16 MGD. Population growth, therefore, remains one of the key drivers of uncertainty in these projected demands.

According to the 2020 study released by the National Aeronautics and Space Administration (NASA), the current warming pattern is on the same trajectory as the climate change assumptions related to RCP4.5. This was seen through comparisons with observed temperature increases.[30] The models that were used in the *Fourth Climate Change Assessment* can be evaluated by comparing their approximately 20-year predictions with what occurred. In Figure 7-2, the multi-model ensemble and the average of all the models are plotted alongside the NASA Goddard Institute for Space Studies (GISS) Surface Temperature Index (GISTEMP)[31,32] to illustrate the

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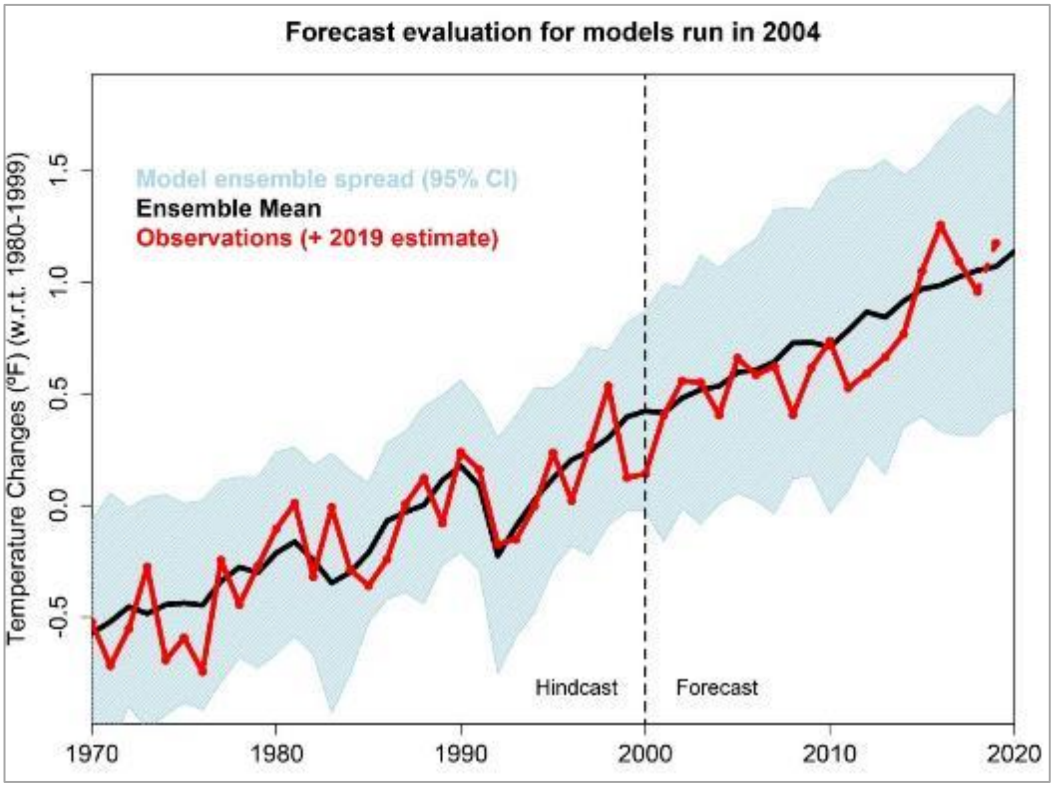
[30] NASA. (2020). NASA's Jet Propulsion Laboratory web page, Study Confirms Climate Models are Getting Future Warming Projections Right, written by Alan Buis, accessed August 2022. https://climate.nasa.gov/news/2943/study-confirms-climate-models-are-getting-future-warming-projections-right/

[31] GISTEMP Team, 2022: GISS Surface Temperature Analysis (GISTEMP), version 4. NASA Goddard Institute for Space Studies. Dataset accessed online August 2022. https://data.giss.nasa.gov/gistemp/.

[32] Lenssen, N., G. Schmidt, J. Hansen, M. Menne, A. Persin, R. Ruedy, and D. Zyss, 2019: Improvements in the GISTEMP uncertainty model. J. Geophys. Res. Atmos., 124, no. 12, 6307-6326, doi:10.1029/2018JD029522.

temperature increase. Climate drivers were known for the "hindcast" period (before 2000) and forecasted for the period beyond. The temperatures are plotted with respect to a 1980–1999 baseline.

Figure 7-2. NASA Temperature Change Observations



Source: NASA. (2020). NASA's Jet Propulsion Laboratory web page, Study Confirms Climate Models are Getting Future Warming Projections Right, written by Alan Buis.

A desirable feature of scenario analyses is that it is possible to track which alternative future scenario appears to be unfolding with the passage of time because many of the key drivers can be tracked. In other words, the key drivers can also be viewed as "signposts." For example, population growth, housing density changes, and rate escalation can all be tracked on an annual basis by BAWSCA staff to evaluate which alternative future scenario appears to be emerging.

Demand forecasts presented in this report do not consider (i.e., are unconstrained by) future supply conditions. If climate change causes supply conditions to significantly worsen and no cost-effective sources of alternative water are forthcoming, demand will have to match future supply conditions through regulations and mandates that impose cutbacks on residents and businesses. That is yet another "signpost" that can be tracked to evaluate the impact of emerging supply constraints on water demand.

New California state regulations from AB 1668 and SB 606 are expected to be released in late 2022, some of which are expected to be related to conservation program activity tracking. Using this, BAWSCA agencies could show evidence of achieved conservation by tracking the rate of landscape transformation. If such evidence could be collected on an annual or bi-annual basis, it would provide early indicators of whether conservation is proceeding at an aggressive rate or a more normal rate.

8 FINDINGS AND RECOMMENDATIONS

The goal of the 2022 Demand Study Update was to refresh the 2020 Demand Study to reflect new data that became available since its completion and to better understand and quantify uncertainty associated with demand estimates and the variables that influence water demands. BAWSCA will use the results of the 2022 Demand Study Update to support implementation of its Long-Term Reliable Water Supply Strategy and to help support decisions as to which new conservation measures to incorporate in BAWSCA's Regional Water Conservation Program.

8.1 Findings

In comparison to the 2020 Demand Study, by 2045 the 2022 Demand Study Update demonstrated that the cumulative total water demand projections for BAWSCA agencies will increase by an additional 2% for demands with active and passive conservation. This increase from the demand projected in the 2020 Demand Study is modest. Key reasons for the demand increase could be that overall BAWSCA regionwide population projections are anticipated to increase by 2045 compared to the previous 2020 Demand Study. Additionally, there are more agencies planning to increase their recycled water since there were more agencies that increased their recycled water projections, as more recycled water projects are being developed. Per this study, recycled water increased by approximately 2% in 2045 when compared to the 2020 Demand Study. Other factors impacting the increase in demand in 2045 include job projections, conservation, and planned future land uses.

The sensitivity analysis from this 2022 Demand Study Update estimates the effect of key variables on water demand projections used to quantify uncertainty. As illustrated, in Figure 7-1, the range of scenarios varied by up to 50 MGD by 2045. These findings can assist regional and agency-level water use forecasts and potential refinements to BAWSCA agencies' water use efficiency programs as the agencies continue to strive to optimize available water supplies. Furthermore, BAWSCA can compare results from this analysis to actual conditions and water use in the future to validate the accuracy of a variable's impact on water demand.

As observed in the sensitivity analysis, of the various demand drivers, population growth remains the most important source of upward pressure and should be closely observed in the future when analyzing water demand projections. Since the first Regional Demand Study published in 2004, BAWSCA population projections have closely aligned with actual population in the BAWSCA service area. This consistent, close alignment has increased confidence in BAWSCA's projected water demands but should be consistently updated to adjust for future shifts in population patterns.

Another significant near-term change to continue to assess is the effects of the California state laws, AB 1668 and SB 606, passed in May 2018. These laws require each urban retail water supplier to calculate and report an urban water use objective no later than January 1, 2024, then every year thereafter, and to compare its actual urban water use to the objective. The urban water use objectives will be calculated using individual efficiency standards set by the state for indoor residential water use, outdoor residential water use, dedicated irrigation, and water loss. In addition, urban water suppliers may be required to implement specific performance measures for commercial, industrial, and institutional water use. When more information on the state standards becomes available, BAWSCA and the member agencies may need to review demand projections and conservation targets to prepare for compliance with urban water use objectives. BAWSCA recognizes that actual water conservation implementation is needed to achieve the identified water-savings goals in support of member agencies meeting their future water use objectives.

8.2 Recommendations

Recommendations to assist with future BAWSCA demand forecasting and planning efforts:

- Continue to track COVID-19 pandemic impacts on employment and total water production. Revisit water demands as appropriate to incorporate recent events into planning efforts.

- Compare observed population growth and climate conditions with the results of this study to be able to anticipate if demands are being contained within the projected demand model.
- Continue to track how and why demands could shift in the future including representation of the key drivers of demand, namely temperature, efficiency improvements, and population growth. This would allow for a more explicit treatment of uncertainty and a continued understanding of how and when climate, population, and customer water use are driving demand.
- Use updated water demand numbers to support implementation of BAWSCA's Long-Term Reliable Water Supply Strategy and to help make decisions on SFPUC's Alternative Water Supply plan.
- Engage in the state processes to establish the requirements associated with implementing the AB 1668 and SB 606 legislation.
- Support BAWSCA agencies in taking steps to differentiate between residential and non-residential dedicated irrigation use in their billing systems to support compliance with the state requirements and improve future per capita water use forecasting.
- Continue collaborating with member agencies to evaluate regional implementation of identified conservation programs which have high water-savings potential and agency interest.

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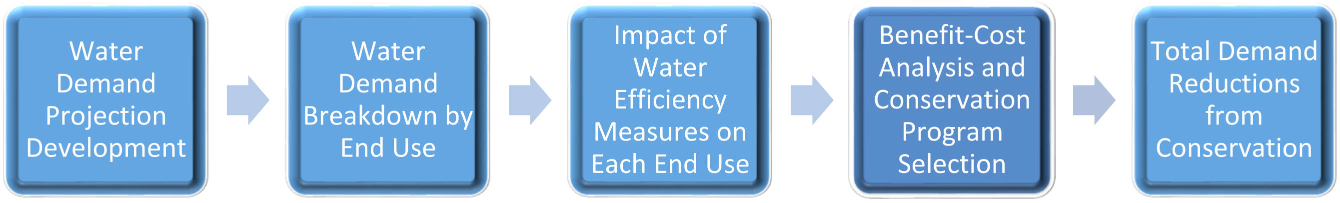
APPENDIX A – DSS MODEL OVERVIEW



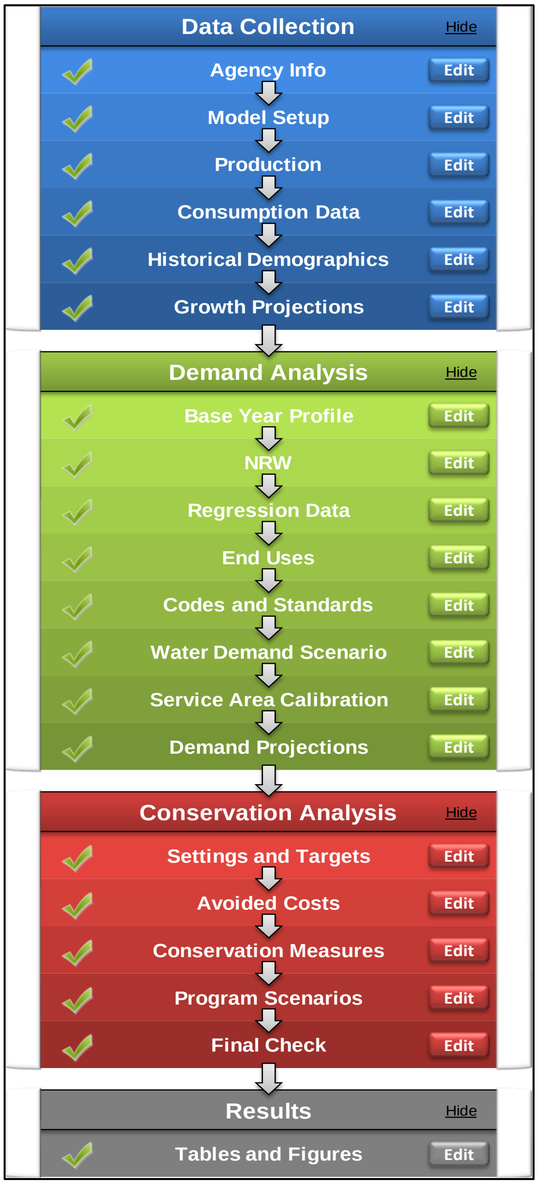


Figure A-1. DSS Model Main Worksheet

DSS Model Overview: The Least Cost Planning Decision Support System Model (DSS Model) is used to prepare long-range, detailed demand projections. The purpose of the extra detail is to enable a more accurate assessment of the impact of water efficiency programs on demand and to provide a rigorous and defensible modeling approach necessary for projects subject to regulatory or environmental review.

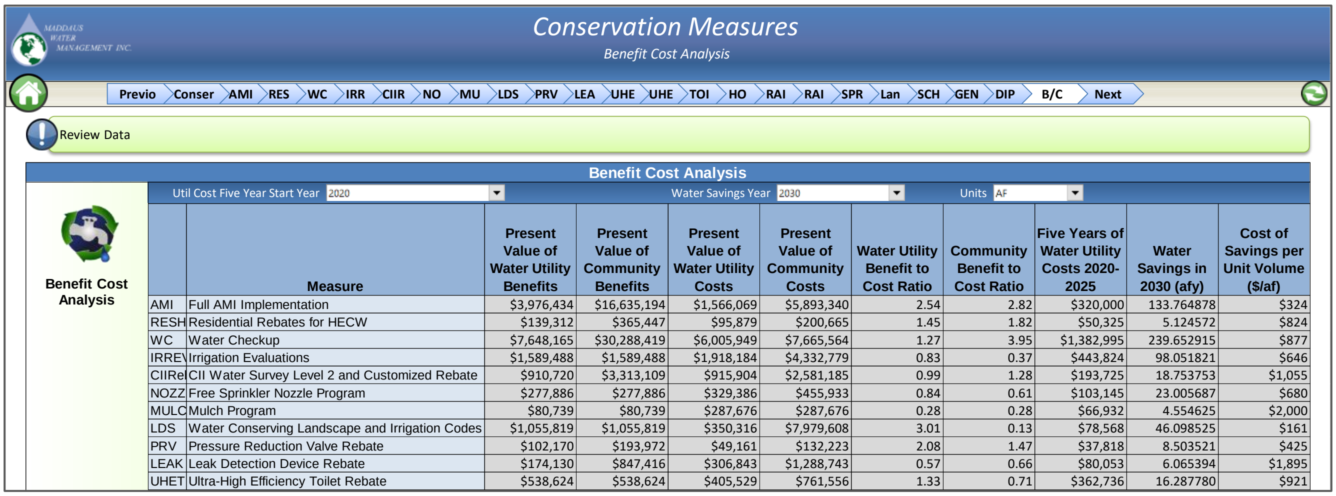
Originally developed in 1999 and continuously updated, the DSS Model is an "end-use" model that breaks down total water production (water demand in the service area) to specific water end uses, such as plumbing fixtures and appliances. The model uses a bottom-up approach that allows for multiple criteria to be considered when estimating future demands, such as the effects of natural fixture replacement, plumbing codes, and conservation efforts. The DSS Model may also use a top-down approach with a utility-prepared water demand forecast.

Demand Forecast Development and Model Calibration: To forecast urban water demands using the DSS Model, customer demand data is obtained from the water agency being modeled. Demand data is reconciled with available demographic data to characterize water usage for each customer category in terms of number of users per account and per capita water use. Data is further analyzed to approximate the split of indoor and outdoor water usage in each customer category. The indoor/outdoor water usage is further divided into typical end uses for each customer category. Published data on average per capita indoor water use and average per capita end use is combined with the number of water users to calibrate the volume of water allocated to specific end uses in each customer category. In other words, the DSS Model checks that the social norms from end studies on water use behavior (e.g., flushes per person per day) are not exceeded or drop below reasonable use limits.

Passive Water Savings Calculations: The DSS Model is used to forecast service area water fixture use. Specific end-use type, average water use, and lifetime are compiled for each fixture. Additionally, state and national plumbing codes and appliance standards are modeled by customer category. These fixtures and plumbing codes can be added to, edited, or deleted by the user. This process yields two demand forecasts, one with plumbing codes and one without plumbing codes. Plumbing code measures are independent of any water use efficiency program and are based on customers following applicable current local, state, and federal laws, building codes, and ordinances.

Active Conservation Measure Analysis Using Benefit-Cost Analysis: The DSS Model evaluates active conservation measures using benefit-cost analysis with the present value of the cost of water saved ($/Million Gallons or $/Acre-Feet). Benefits are based on savings in water and wastewater facility operations and maintenance (O&M) and any deferred capital expenditures. The figures on the previous page illustrate the processes for forecasting conservation water savings, including the impacts of fixture replacement due to existing plumbing codes and standards.

Figure A-2. Benefit-Cost Analysis Summary Example



	Measure	Present Value of Water Utility Benefits	Present Value of Community Benefits	Present Value of Water Utility Costs	Present Value of Community Costs	Water Utility Benefit to Cost Ratio	Community Benefit to Cost Ratio	Five Years of Water Utility Costs 2020-2025	Water Savings in 2030 (afy)	Cost of Savings per Unit Volume ($/af)
AMI	Full AMI Implementation	$3,976,434	$16,635,194	$1,566,069	$5,893,340	2.54	2.82	$320,000	133.764878	$324
RESH	Residential Rebates for HECW	$139,312	$365,447	$95,879	$200,665	1.45	1.82	$50,325	5.124572	$824
WC	Water Checkup	$7,648,165	$30,288,419	$6,005,949	$7,665,564	1.27	3.95	$1,382,995	239.652915	$877
IRREV	Irrigation Evaluations	$1,589,488	$1,589,488	$1,918,184	$4,332,779	0.83	0.37	$443,824	98.051821	$646
CIIRe	CII Water Survey Level 2 and Customized Rebate	$910,720	$3,313,109	$915,904	$2,581,185	0.99	1.28	$193,725	18.753753	$1,055
NOZZ	Free Sprinkler Nozzle Program	$277,886	$277,886	$329,386	$455,933	0.84	0.61	$103,145	23.005687	$680
MULC	Mulch Program	$80,739	$80,739	$287,676	$287,676	0.28	0.28	$66,932	4.554625	$2,000
LDS	Water Conserving Landscape and Irrigation Codes	$1,055,819	$1,055,819	$350,316	$7,979,608	3.01	0.13	$78,568	46.098525	$161
PRV	Pressure Reduction Valve Rebate	$102,170	$193,972	$49,161	$132,223	2.08	1.47	$37,818	8.503521	$425
LEAK	Leak Detection Device Rebate	$174,130	$847,416	$306,843	$1,288,743	0.57	0.66	$80,053	6.065394	$1,895
UHET	Ultra-High Efficiency Toilet Rebate	$538,624	$538,624	$405,529	$761,556	1.33	0.71	$362,736	16.287780	$921

Model Use and Validation: The DSS Model has been used for over 20 years for practical applications of conservation planning in over 400 service areas representing 80 million people, including extensive efforts nationally and internationally in Australia, New Zealand, and Canada. The DSS Model has been used in 23 U.S. states.

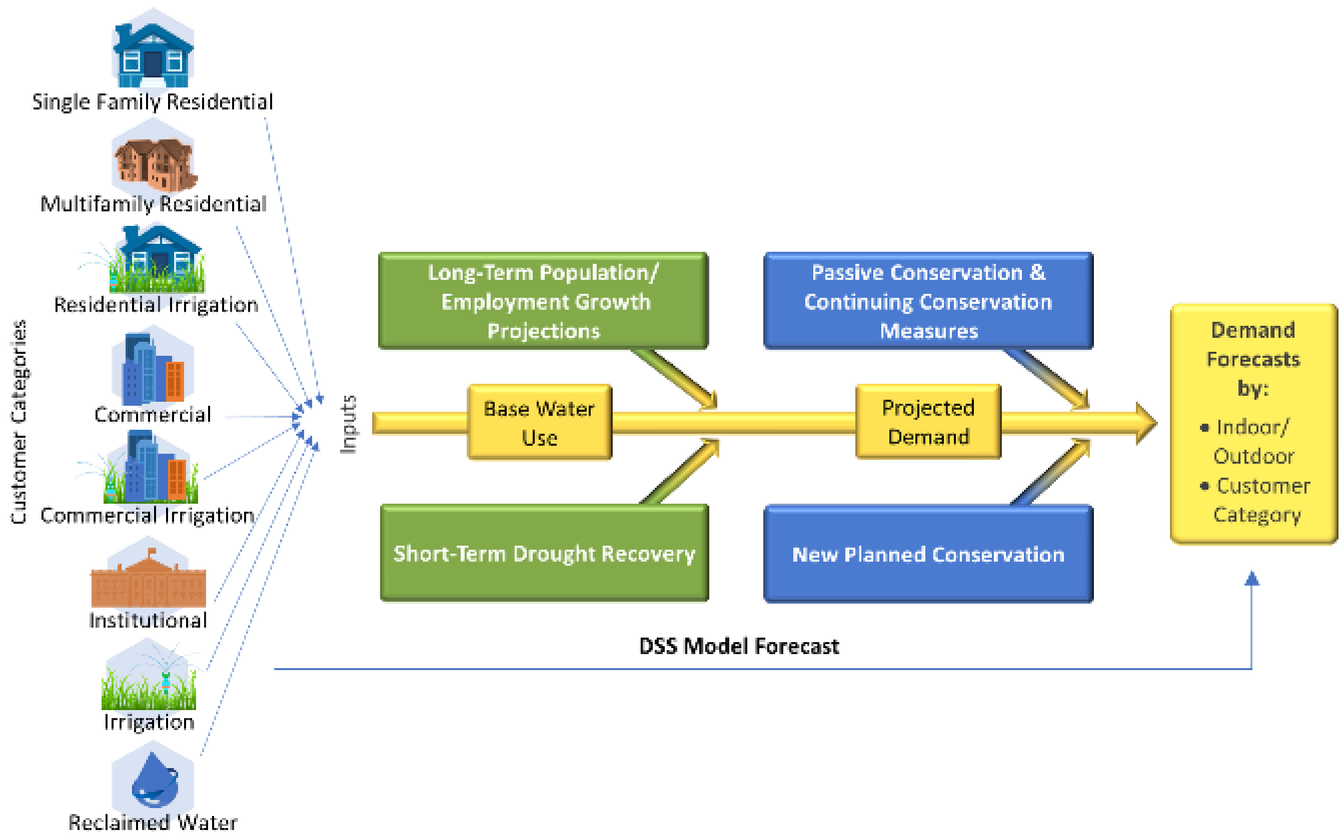
The California Water Efficiency Partnership, or CalWEP (formerly the California Urban Water Conservation Council), has peer reviewed and endorsed the model since 2006. It is offered to all CalWEP members for use to estimate water demand, plumbing code, and conservation program savings.

The DSS Model uses one of the following: 1) a statistical approach to forecast demands (e.g., an econometric model); 2) a forecasted increase in population and employment; 3) predicted future demands; or 4) a demand projection entered into the model from an outside source. Baseline demand is developed based on an increase in residential population.

A.1 DSS Model Methodology

For the long-term projections (2019–2045), the DSS Model was used to generate demand forecasts for each BAWSCA member agency. The DSS Model also included a conservation component that quantified savings from passive conservation (e.g., plumbing codes) and active conservation programs. The DSS Model's conservation component covers the entire forecast period of 2019–2045. Quantification of savings from active conservation programs is covered in Section 5 in Tables 5-6 and 5-7. Only the DSS Model's estimates of savings from plumbing codes were provided to enable each agency to evaluate what its future demand likely would be absent any active conservation programs from 2020 to 2045.

Figure A-3. BAWSCA Demand and Conservation DSS Model Flow Diagram



As illustrated in Figure A-3, the first step for forecasting water demands using the DSS Model was to gather customer category billing data (e.g., Single Family Residential, Multifamily Residential, Commercial, Institutional, etc.) from each BAWSCA member agency. The next step was to calibrate the model by comparing water use data with available demographic data to characterize water usage for each customer category in terms of number of users per account and per capita water use. During the model calibration process, data was further analyzed to approximate the indoor/outdoor split by customer category. The indoor/outdoor water usage was further divided into typical end uses for each customer category. Published data on average per capita indoor water use and average per capita end use were combined with the number of water users to calibrate the volume of water allocated to specific end uses in each customer category. In other words, the DSS Model reflects social norms from end-use studies on water use behavior (e.g., flushes per person per day).

Following the model calibration, the future population and employment projections were incorporated. Each BAWSCA member agency selected its own projection forecasts. These growth projections were used to develop a projected demand for 2019–2045.

APPENDIX B – ECONOMETRIC MODEL DESCRIPTION AND SENSITIVITY ANALYSIS METHODOLOGY

This appendix describes the Econometric Modeling process, framework, and results.

B.1 Econometric Model Overview

Until the late 2000s, BAWSCA relied on projections of population and jobs to predict future water demand as a baseline that was adjusted to account for potential conservation programs. Residential demand was forecasted by multiplying per household water use by projected population growth, and Commercial, Institutional, and Industrial (CII) demand was forecasted by multiplying per job water use by projected job growth. Then, these estimates were converted from baseline demand projections to net demand projections by subtracting likely savings from various passive and active conservation programs.

While the simplicity of this methodology is appealing and easy to understand, it is not capable of capturing the impacts of abnormal weather, recessions, and droughts on water demand. For this reason, starting in 2014, BAWSCA switched to an approach that uses econometric modeling to generate short-term demand forecasts along with the traditional population- and jobs-based approach for long-term forecasts. The econometric model's purpose is both to select the elements of the equation and to estimate each independent variable's coefficient.

Assuming historical relationships remain valid, econometric analysis of historical data can help answer questions about changing demand patterns (i.e., extent of demand rebound as drought impacts recede and/or as economic and weather conditions normalize). BAWSCA's econometric demand model estimates the relationship between water demand and its key drivers, such as price, economic conditions, and weather (Equation 1). This earlier framework was refined for the 2022 Demand Study Update by incorporating the additional feature of housing density. In BAWSCA's first econometric modeling effort, the impact of changing housing mix appeared negligible. However, over time, the impact of increasing multifamily housing on the region's future growth became more clearly discernible and, thus, is now incorporated in the econometric demand model to evaluate housing mix in alternative scenarios.

Based on the earlier framework, now incorporating a measure for changing housing mix, the following best-fit equation has been developed:

$$Ln(monthly\ GPCD) = \alpha + \beta trend + \Omega(multifamily\ share\ of\ housing\ stock) + \theta Ln(unemployment\ rate) + \delta Ln(marginal\ price) + \vartheta temperature\ deviation + \psi rainfall\ deviation + \pi monthly\ indicators + \phi drought\ restriction\ indicators + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..Eq.1$$

Where,

Monthly production is measured in gallons per capita per day (GPCD)

α is a scaling constant

Trend is a variable that takes on a value of 0 in the first year, 1 in the second year, and so on

Multifamily share of housing stock equals multifamily dwelling units divided by total dwelling units in the service area

Unemployment rate is captured as a percent (e.g., 7%)

Marginal price for single family customers is measured in dollars per hundred cubic feet (ccf) deflated by the consumer price index

Temperature deviation is measured in degrees Fahrenheit (average maximum daily temperature in a given month minus average for the same month between 1995 and 2006)

Rainfall deviation is measured in total inches (total rainfall in a given month minus average total rainfall for the same month between 1995 and 2006)

Monthly indicators are binary 0-1 variables, taking on a value of 1 for a given month in question, 0 otherwise

Drought restriction indicator variables are used for affected months during the 2014–2017 period

ε denotes random statistical error

Sources for the data are indicated below:

- Each variable on the right-hand side of the equation (independent variable) is preceded by a coefficient (e.g., β, etc.) that measures the strength of the impact of an independent variable on monthly demand. The variable on the left-hand side of the equation is also known as the dependent variable. A positive coefficient implies that increases in an independent variable will cause an increase in the dependent variable; a negative coefficient implies the opposite.
- Continuous variables, such as the marginal price and the unemployment rate, are logarithmically transformed so that their respective coefficients can be given a proportional interpretation. For example, the coefficient of logarithmically transformed marginal price becomes the price elasticity. The trend variable captures changes in GPCD over time not accounted for by price, unemployment rate, or weather. The multifamily share of housing stock captures the extent of downward pressure that increasing multifamily share has placed on water demand over time.

BAWSCA's basic model specification (Equation 1) includes several features:

- First, agency-specific production data is modeled at a monthly, not annual, level. Estimating monthly level models allows for the impact of weather to vary by time of year. Prior research strongly indicates that abnormal temperature and abnormal rainfall do not have the same effect in January as, say, in May.[33] Working with monthly production data allows one to incorporate time-varying weather effects.
- Second, temperature and rainfall enter the model as deviations from their respective monthly averages, capturing directly how demand reacts to weather as it deviates from the average. Normal seasonality in monthly demand (i.e., July demand being much higher than January demand) is captured by the monthly indicator variables, and temperature and rainfall information is obtained from the closest NOAA stations throughout the San Francisco Bay Area.
- Third, cyclical economic conditions are captured by the unemployment rate obtained from the Bureau of Labor Statistics (BLS). This metric is available at a granular level and is useful for capturing economic cycles impacting water demand.

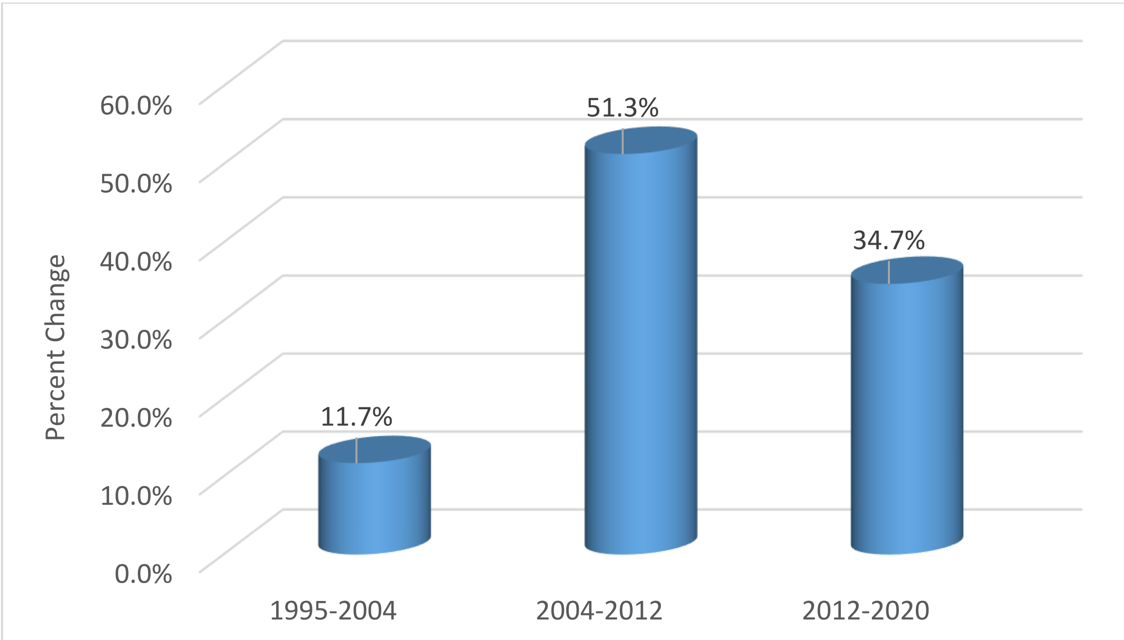
Finally, the model also includes a measure of the marginal price of water in real terms (i.e., price deflated by the consumer price index published by the BLS). Marginal price of water faced by the average single family customer in each agency is used to depict price variation over time. By and large, CII and single family price trends appear similar. Figure B-1 shows price escalation faced by single family customers in the BAWSCA service area overall, calculated as a weighted average of each BAWSCA member agency's price data. The price and unemployment rate information is available at a water supplier level (the latter by town or city) so that these metrics can be tailored to each member agency's service area. In other words, each BAWSCA member agency has its own marginal price and unemployment rate metric, including a weather metric from the closest NOAA station.

For this analysis, the multifamily share of total housing stock was obtained from historical annual housing data published by the DOF. The city-specific data was tailored to each member agency. This data about the relative shares of single family and multifamily housing follow census definitions and may not always correspond with how billing systems classify customers. Some agencies do not even have a classification for multifamily

[33] Bamezai, A. (2011). *GPCD Weather Normalization Methodology*, final report submitted to the California Urban Water Conservation Council.

customers, instead lumping them into the CII category. To bring consistency across agencies, census-based housing data was used both for estimating the impact of changing housing mix on water demand and for crafting alternative future housing mix scenarios.

Figure B-1. BAWSCA Region-Wide Historical Trends in Single Family Real Price of Water



Note: The pricing increases in the above graph represent the BAWSCA member agency share for funding the $4.6 billion Water System Improvement Program.

B.2 Model Results

To generate parameters for quantifying water demand under alternative future scenarios, a monthly GPCD model was developed for all BAWSCA agencies combined; this type of "rolled-up" region-wide model is known as a time-series, cross-sectional model. This region-wide model incorporates agency-level fixed effects and population weighting to account for different agency sizes.

Agency-level fixed effects capture the impact of specific agency characteristics that do not vary much over time, such as average household income and lot size, leading to a much more robust model specification than one without these fixed effects. In other words, the model implicitly captures the resulting impact of income, lot size, and other unobservable time-invariant differences across agencies in terms of GPCD.

In addition to fixed effects, normal seasonality in water use is varied across agencies. The impact of weather deviations from normal weather is varied by season and across agencies by interacting these deviation variables with an agency's transformed seasonal peaking factor.[34] A greater summer-winter differential indicates a greater prevalence of weather-sensitive end uses, making the impact of non-normal weather correspondingly greater. The feasibility of using peaking factors to scale the impact of non-normal weather across agencies was demonstrated by the previously cited study completed for the California Urban Water Conservation Council (Bamezai, 2011). Those concepts have been applied here as well.

For BAWSCA region-wide demand, using parameters generated by this BAWSCA region-wide model is preferable over individual agency models. Individual agency models do not consistently yield statistically significant

[34] Peaking factor is calculated by dividing maximum monthly summer demand by minimum winter monthly demand in any given year, then averaging these ratios across all years included during the baseline period. Transformed peaking factor is calculated as 1-(1/Peaking Factor).

parameters for one or more variables (e.g., coefficient of price or multifamily share of total dwelling units) because of scarce or inaccurate data. In such instances, evaluating alternative future scenarios for a given member agency becomes difficult. Thus, to evaluate the impact of alternative price escalation scenarios or housing mix scenarios, relevant parameters are drawn from the estimated BAWSCA region-wide model. On the other hand, the impact of passive and active conservation programs is agency-specific and is drawn from the DSS Models developed during the 2020 Demand Study. In other words, the conservation analyses are not inferred from the econometric model; however, the result of the econometric model informs the design of conservation saving levels, as discussed later.

During the 2020 Demand Study, an important goal of the econometric modeling was to forecast what water demand would have been in 2018 had the drought of 2014–2017 not occurred. The gap between actual 2018 demand and model-predicted demand was used to provide an estimate of potential rise in demand over the next several years. This exercise involved developing both individual agency models, a BAWSCA region-wide model, and the water demand balance by end-use within the DSS Model to predict expected demand in 2025. In this 2022 Demand Study Update, the estimate of 2025 per capita demand remains the same as was developed earlier. The alternative future scenarios evaluate the impact of scenario assumptions post-2025.

The BAWSCA region-wide model estimated for the 2022 Demand Study Update uses monthly data between 1995 and 2013 even though agency data is available through 2020. Data untainted by large perturbations (such as the drought of 2014–2017 which substantially altered water use patterns post-2013) are preferable for generating key parameters for the sensitivity analysis. The estimated pre-drought, pre-pandemic region-wide model (Table B-1) has three columns:

1. Estimated coefficient
2. Band of uncertainty surrounding this coefficient (referred to as standard error)
3. t-statistic – This parameter is an independent variable's ratio of the coefficient over its standard error. A t-statistic higher than 1.96 or lower than -1.96 indicates a statistically significant relationship at 5% level of significance between the dependent and independent variable; a t-statistic between -1.96 and 1.96 indicates that the data is not able to conclusively demonstrate a relationship. The latter finding may reflect the lack of any relationship, data errors, or other problems (e.g., two or more independent variables being highly correlated with one another). The model's correlation coefficient (i.e., R-Squared [R^2] value) indicates the explanatory power of a statistical model and is shown at the end of Table B-1. R^2 can vary between zero and a maximum of 1, with higher numbers indicating greater explanatory power.

The coefficients in Table B-1 have the following interpretations:

- The annual trend coefficient being negative and statistically significant implies that between 1995 and 2013, per capita demand dropped by 0.42% per year after accounting for all other factors included in the model. This corresponds quite well with the DSS Model results, which suggest that passive and active conservation programs can be expected to reduce per capita demand by roughly 0.5% per year across the BAWSCA region, although estimates vary somewhat across agencies.
- The coefficient of the multifamily share of total dwelling units being negative and statistically significant implies that per capita urban water demand drops as multifamily housing share increases. This is as expected. The coefficient's magnitude suggests that if the multifamily share of total housing increases by, say, 10%, per capita demand can be expected to drop by roughly 7.4% ($e^{(-0.767*0.1)}$-1). This finding is used for simulating the impact of alternative housing mix scenarios.
- A statistically significant price elasticity of -0.161 indicates that a 10% real increase in the marginal price of water can be expected to reduce demand by 1.6%. BAWSCA's region-wide estimate of price elasticity compares well with the published literature on this topic. This parameter is used for simulating the impact of alternative rate escalation scenarios.

- A 10% increase in the unemployment rate is likely to depress water demand by 0.47%, a statistically significant effect, but one weaker than price. This parameter is not included in the quantification of alternative future scenarios since this is a control for short-term cyclical effects embedded in the historical data. Long-term economic conditions are implicitly captured by expected growth rates in population and jobs, with strong economic conditions supporting robust jobs and population growth, and vice versa.
- All weather coefficients are significant and behave in expected ways. For an agency with a peaking factor of 2, or a transformed peaking factor (TPF) of 0.5 (a typical agency peaking factor), an extra inch of rainfall per month during the spring reduces monthly demand by about 7.5%, while the same extra inch during the winter only depresses monthly demand by 0.8%.
- On the temperature dimension, for an agency with a peaking factor of 2 or a TPF of 0.5 (a typical agency peaking factor), if daily maximum temperature is 1 degree Fahrenheit higher on average in a given month, monthly water demand is likely to increase by 1.3% during the spring, 0.4% during the summer, and 1.1% during late fall and winter. Lower than average temperatures would have the opposite effect. The temperature parameters are used to evaluate future increases in demand due to climate change. Climate models do not indicate large changes in average rainfall in the future, although year-to-year variability is expected to increase. Estimated rainfall parameters in the econometric demand model do not get used in quantification of alternative future scenarios, although they could be if climate models begin to predict significant change in average rainfall in the future. The monthly dummy variables also exhibit the expected pattern with July showing the largest coefficient, indicating that demand is greatest in July. The coefficient reaches a minimum during January because January is the omitted (or reference) month and the remaining monthly dummy coefficients are positive indicating per capita demand was greater in all months relative to January. However, the difference between December and February per capita demand relative to January is statistically insignificant

Table B-1. BAWSCA Region-Wide Pre-Drought, Pre-Pandemic Regression Model Results

Dependent Variable: Ln(Monthly GPCD)

Independent Variable	Coefficient	Standard Error	t-statistic
Trend	-0.004	0.0006	-6.8
Multifamily Share of Housing Stock	-0.767	0.131	-5.8
Ln (Marginal Price)	-0.161	0.012	-13.4
Ln (Unemployment Rate)	-0.047	0.005	-8.6
Temperature Deviation (Apr-Jun) x TPF[1]	0.026	0.003	9.6
Temperature Deviation (Jul-Oct) x TPF	0.009	0.003	3.0
Temperature Deviation (Nov-Mar) x TPF	0.022	0.002	9.1
Rain Deviation (Apr-Jun) x TPF	-0.153	0.009	-16.4
Rain Deviation (Jul-Oct) x TPF	-0.047	0.011	-4.2
Rain Deviation (Nov-Mar) x TPF	-0.017	0.002	-7.9
February Indicator	0.016	0.041	0.4
March Indicator	0.103	0.041	2.5
April Indicator	0.268	0.041	6.6
May Indicator	0.476	0.041	11.7
June Indicator	0.644	0.041	15.9
July Indicator	0.692	0.041	17.0
August Indicator	0.682	0.041	16.8
September Indicator	0.612	0.041	15.1
October Indicator	0.435	0.041	10.7
November Indicator	0.168	0.041	4.1
December Indicator	0.030	0.041	0.8
Constant	5.219	0.061	85.8
Agency-Specific Fixed Effects[2]	Included		
Agency Interactions with Monthly Dummies[2]	Included		
Coefficient of Correlation (R-Squared)	0.93		

[1] TPF denotes transformed peaking factor.

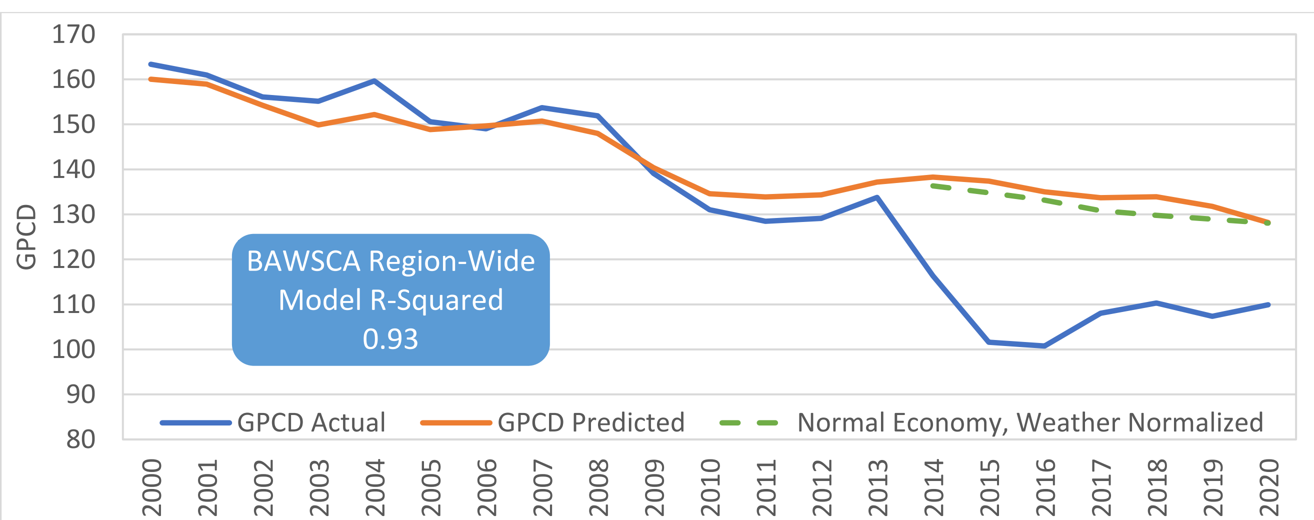
[2] For the sake of brevity, the large number of coefficients associated with the agency-specific fixed effects, agency-specific trend terms, and agency interactions with monthly dummies are not shown.

Figure B-2 shows how the model prediction compares with BAWSCA's region-wide GPCD trend during the pre-drought period since that is the period from which the model has been estimated. The resulting R^2 value of 0.93 shows that there is a high correlation between actual and predicted values. The model quite accurately captures the downturn in demand experienced during the Great Recession of 2008–2010 and subsequent recovery until 2013. Beyond 2013, the model begins to diverge from observed demand because of the drought of 2014–2017, which is why these years are not used for estimating the key parameters needed for simulating demand under the proposed alternative future scenarios. These key parameters include the impact of price increases, the year-over-year decline (downward trend) in water demand not accounted for by price, and the impact of changing housing mix.

The first two of the three key parameters mentioned above, the impact of price increases and year-over-year decline in water demand not accounted for by price, are interdependent drivers of water demand because they move in the same direction over time. For example, the trend coefficient could be interpreted as the impact of non-price drivers (active and passive conservation) on water demand and the coefficient of the price variable as the impact of price increases on demand. However, this separation is rarely flawless in practice. It is possible that the price variable also is picking up the effect of non-price variables (such as changing landscape tastes, reduction in lot size, etc.) that remain unaccounted for in the model. Calculating the joint impact of these two drivers offers one way to assess how per capita demand has reacted to price and non-price effects taken together, conceptually a more reliable metric. For example, the trend variable indicates per capita demand has dropped at a rate of 0.42% per year between 1995 and 2013. During this time, the marginal price of water in real dollars increased by 3.3% per year, as discussed earlier, which at the estimated elasticity of -0.161 translates into roughly 0.53% decline in per capita demand per year. The combined impact of price and non-price factors is a 0.95% decline in per capita demand per year between 1995 and 2013. It is useful to keep this joint estimate in mind while selecting parameters for the alternative futures presented earlier. For example, Scenario E assumes that aggressive conservation will drive per capita demand down by 0.625% per year, while marginal price increases of 2.3% can be expected to add additional downward pressure of 0.37% (2.3*-0.161) in per capita demand per year for a total effect of roughly 1.0% decline per year. This is slightly more aggressive than the historical estimate of 0.95% decline per year, but still defensibly close.

These demand reductions are layered upon other sources of savings, such as a housing stock steadily shifting in favor of more multifamily housing. Given that multifamily housing already has lower outdoor use, it becomes difficult to see where greater conservation savings will come from. Thus, the risk of double counting savings increases if scenarios are conjured in a way where projected savings from price and non-price effects appear excessive compared to the historical experience.

Figure B-2. BAWSCA Region-Wide Econometric Model Fit



APPENDIX C – KEY ASSUMPTIONS FOR THE DSS MODEL

This section presents the methodology used to determine passive water savings, information regarding national and state plumbing codes, and key inputs and assumptions used in the DSS Model including fixture replacement and estimates.

C.1 National Plumbing Code

The Energy Policy Act of 1992, as amended in 2005, mandates that only fixtures meeting the following standards can be installed in new buildings:

- Toilet – 1.6 gal/flush maximum
- Urinals – 1.0 gal/flush maximum
- Showerhead – 2.5 gal/min at 80 pounds per square inch (psi)
- Residential faucets – 2.2 gal/min at 60 psi
- Public restroom faucets – 0.5 gal/min at 60 psi
- Dishwashing pre-rinse spray valves – 1.6 gal/min at 60 psi

Replacement of fixtures in existing buildings is also governed by the Federal Energy Policy Act, which mandates that only devices with the specified level of efficiency (as shown above) can be sold as of 2006. The net result of the plumbing code is that new buildings will have more efficient fixtures and old inefficient fixtures will slowly be replaced with new, more efficient models. The national plumbing code is an important piece of legislation and must be carefully taken into consideration when analyzing the overall water efficiency of a service area.

In addition to the plumbing code, the U.S. Department of Energy regulates appliances, such as residential clothes washers, further reducing indoor water demands. Regulations to make these appliances more energy efficient have driven manufactures to dramatically reduce the amount of water these machines use. Generally, front loading washing machines use 30 to 50% less water than conventional models (which are still available).

In this analysis, the DSS Model forecasts a gradual transition to high efficiency clothes washers (using 12 gallons or less) so that by the year 2025 that will be the only type of machine available for purchase. In addition to the industry becoming more efficient, rebate programs for washers have been successful in encouraging customers to buy more water efficient models. Given that machines last about 10 years, eventually all machines on the market will be the more water efficient models. Energy Star washing machines have a water factor of 6.0 or less – the equivalent of using 3.1 cubic feet (or 23.2 gallons) of water per load. The maximum water factor for residential clothes washers under current federal standards is 6.5. The water factor equals the number of gallons used per cycle per cubic foot of capacity. Prior to the year 2000, the water factor for a typical new residential clothes washer was around 12. In March 2015, the federal standard reduced the maximum water factor for top- and front-loading machines to 8.4 and 4.7, respectively. In 2018, the maximum water factor for top-loading machines was further reduced to 6.5. For commercial washers, the maximum water factors were reduced in 2010 to 8.5 and 5.5 for top- and front-loading machines, respectively. Beginning in 2015, the maximum water factor for Energy Star certified washers was 3.7 for front-loading and 4.3 for top-loading machines. In 2011, the U.S. Environmental Protection Agency estimated that Energy Star washers comprised more that 60% of the residential market and 30% of the commercial market (Energy Star, 2011). A new Energy Star compliant washer uses about two-thirds less water per cycle than washers manufactured in the 1990s.

C.2 State Plumbing Code

This section describes California state codes applicable to each member agency service area water use.

California State Law – AB 715

Plumbing codes for toilets, urinals, showerheads, and faucets were initially adopted by California in 1991, mandating the sale and use of ultra-low flush toilets using 1.6 gallons per flush (gpf), urinals using 1 gpf, and low-flow showerheads and faucets. AB 715 led to an update to California Code of Regulations Title 20 (see below) mandating that all toilets and urinals sold and installed in California as of January 1, 2014 must be high efficiency versions having flush ratings that do not exceed 1.28 gpf (toilets) and 0.5 gpf (urinals).

California State Laws – SB 407 and SB 837

SB 407 addresses plumbing fixture retrofits on resale or remodel. The DSS Model carefully considers the overlap with SB 407, the plumbing code (natural replacement), CALGreen, AB 715 and rebate programs (such as toilet rebates). SB 407 (enacted in 2009) requires that properties built prior to 1994 be fully retrofitted with water conserving fixtures by the year 2017 for single family residential houses and 2019 for multifamily and commercial properties. SB 407 program length is variable and continues until all the older high flush toilets have been replaced in the service area. The number of accounts with high flow fixtures is tracked to make sure that the situation of replacing more high flow fixtures than actually exist does not occur. Additionally, SB 407 conditions issuance of building permits for major improvements and renovations upon retrofit of non-compliant plumbing fixtures. SB 837 (enacted in 2011) requires that sellers of real estate property disclose on their Real Estate Transfer Disclosure Statement whether their property complies with these requirements. Both laws are intended to accelerate the replacement of older, low efficiency plumbing fixtures, and ensure that only high efficiency fixtures are installed in new residential and commercial buildings.

2019 CALGreen and 2015 CA Code of Regulations Title 20 Appliance Efficiency Regulations

Fixture characteristics in the DSS Model are tracked in new accounts, which are subject to the requirements of the 2019 California Green Building Code and 2015 California Code of Regulations Title 20 Appliance Efficiency Regulations adopted by the California Energy Commission (CEC) on September 1, 2015. The CEC 2015 appliance efficiency standards apply to the following new appliances, if they are sold in California: showerheads, lavatory faucets, kitchen faucets, metering faucets, replacement aerators, wash fountains, tub spout diverters, public lavatory faucets, commercial pre-rinse spray valves, urinals, and toilets. The DSS Model accounts for passive savings due to the effects these standards have on showerheads, faucets, aerators, urinals, and toilets.

- Showerheads – July 2016: 2.0 gallons per minute (gpm); July 2018: 1.8 gpm
- Wall Mounted Urinals – January 2016: 0.125 gpf (pint)
- Lavatory Faucets and Aerator – July 2016: 1.2 gpm at 60 psi
- Kitchen Faucets and Aerator – July 2016: 1.8 gpm with optional temporary flow of 2.2 gpm at 60 psi
- Public Lavatory Faucets – July 2016: 0.5 gpm at 60 psi

In summary, the controlling law for **toilets** is Assembly Bill 715. This bill requires high efficiency toilets (1.28 gpf) to be exclusively sold in California beginning January 1, 2014. The controlling law for wall-mounted urinals is the 2015 CEC efficiency regulations requiring that ultra-high efficiency pint **urinals** (0.125 gpf) be exclusively sold in California beginning January 1, 2016. This is an efficiency progression for urinals from AB 715's requirement of high efficiency (0.5 gpf) urinals starting in 2014.

Standards for **residential clothes washers** fall under the regulations of the U.S. Department of Energy. In 2018, the maximum water factor for standard top-loading machines was reduced to 6.5.

<u>Showerhead</u> flow rates are regulated under the 2015 California Code of Regulations Title 20 Appliance Efficiency Regulations adopted by the CEC, which requires the exclusive sale in California of 2.0 gpm showerheads at 80 psi as of July 1, 2016 and 1.8 gpm showerheads at 80 psi as of July 1, 2018. The WaterSense specification applies to showerheads that have a maximum flow rate of 2.0 gpm or less. This represents a 20% reduction in showerhead flow rate over the current federal standard of 2.5 gpm, as specified by the Energy Policy Act of 1992.

<u>Faucet</u> flow rates have likewise been recently regulated by the 2015 CEC Title 20 regulations. This standard requires that the residential faucets and aerators manufactured on or after July 1, 2016 be exclusively sold in California at 1.2 gpm at 60 psi; and public lavatory and kitchen faucets/aerators sold or offered for sale on or after July 1, 2016 be 0.5 gpm at 60 psi and 1.8 gpm at 60 psi (with optional temporary flow of 2.2 gpm), respectively. Previously, all faucets had been regulated by the 2019 California Building Code Title 24 at 2.2 gpm at 60 psi.

C.3 Key Baseline Potable Demand Inputs, Passive Savings Assumptions, and Resources

The following tables present the key assumptions and references that are used in the DSS Model in determining projected demands with passive savings. The assumptions having the most dramatic effect on future demands are the natural replacement rate of fixtures; how residential or commercial future use is projected; and the percent of estimated real water losses.

Table C-1. List of Key Assumptions

Parameter	Model Input Value, Assumptions, and Key References
Model Start Year for Analysis	2019
Model End Year	2045
Non-Revenue Water	Based on individual billing
Population Projection Source	Provided by and verified by individual agencies
Employment Projection Source	Provided by and verified by individual agencies
Number of Water Accounts for Start Year	Provided by and verified by individual agencies
Avoided Cost of Water $/MG	Provided by and verified by individual agencies

Table C-2. Key Assumptions Resources

Parameter	Resource
Residential End Uses	Key Reference: CA DWR Report "California Single Family Water Use Efficiency Study," (DeOreo, 2011 – Page 28, Figure 3: Comparison of household end-uses) and AWWA Research Foundation (AWWARF) Report "Residential End Uses of Water, Version 2 - 4309" (DeOreo, 2016). Table 2-A. Water Consumption by Water-Using Plumbing Products and Appliances - 1980-2012. PERC Phase 1 Report. Plumbing Efficiency Research Coalition. 2013. http://www.map-testing.com/content/info/menu/perc.html Model Input Values are found in the "End Uses" section of the DSS Model on the "Breakdown" worksheet.
Non-Residential End Uses, percent	Key Reference: AWWARF Report "Commercial and Institutional End Uses of Water" (Dziegielewski, 2000 – Appendix D: Details of Commercial and Industrial Assumptions, by End Use). Santa Clara Valley Water District Water Use Efficiency Unit. "SCVWD CII Water Use and Baseline Study." February 2008. Model Input Values are found in the "End Uses" section of the DSS Model on the "Breakdown" worksheet.
Efficiency Residential Fixture Current Installation Rates	U.S. Census, Housing age by type of dwelling plus natural replacement plus rebate program (if any). Key Reference: GMP Research, Inc. (2019). 2019 U.S. WaterSense Market Penetration Industry Report Key Reference: Consortium for Efficient Energy (www.cee1.org). Model Input Values are found in the "Codes and Standards" green section of the DSS Model by customer category fixtures.
Water Savings for Fixtures, gal/capita/day	Key Reference: AWWARF Report "Residential End Uses of Water, Version 2 - 4309" (DeOreo, 2016). Key Reference: CA DWR Report "California Single Family Water Use Efficiency Study" (DeOreo, 2011 – Page 28, Figure 3: Comparison of household end-uses). BAWSCA supplied data on costs and savings; professional judgment was made where no published data was available. Key Reference: California Energy Commission, Staff Analysis of Toilets, Urinals and Faucets, CEC-400-2014-007-SD, Docket Number 14-AAER-1, 2014. Model Input Values are found in the "Codes and Standards" green section on the "Fixtures" worksheet of the DSS Model.
Non-Residential Fixture Efficiency Current Installation Rates	Key Reference: 2010 U.S. Census, Housing age by type of dwelling plus natural replacement plus rebate program (if any). Assume commercial establishments built at same rate as housing, plus natural replacement. California Energy Commission, Staff Analysis of Toilets, Urinals and Faucets, CEC-400-2014-007-SD, Docket Number 14-AAER-1, 2014. Santa Clara Valley Water District Water Use Efficiency Unit. "SCVWD CII Water Use and Baseline Study." February 2008. Model Input Values are found in the "Codes and Standards" green section of the DSS Model by customer category fixtures.

Parameter	Resource
Residential Frequency of Use Data, Toilets, Showers, Faucets, Washers, Uses/user/day	Key Reference: AWWARF Report "Residential End Uses of Water, Version 2 - 4309" (DeOreo, 2016). Summary values can be found in the full report: http://www.waterrf.org/Pages/Projects.aspx?PID=4309 Key Reference: California Energy Commission, Staff Analysis of Toilets, Urinals and Faucets, CEC-400-2014-007-SD, Docket Number 14-AAER-1, 2014. Key Reference: Alliance for Water Efficiency, The Status of Legislation, Regulation, Codes & Standards on Indoor Plumbing Water Efficiency, January 2016. Model Input Values are found in the "Codes and Standards" green section on the "Fixtures" worksheet of the DSS Model and confirmed in each "Service Area Calibration End Use" worksheet by customer category.
Non-Residential Frequency of Use Data, Toilets, Urinals, and Faucets, Uses/user/day	Key References: Estimated based on AWWARF Report "Commercial and Institutional End Uses of Water" (Dziegielewski, 2000 – Appendix D: Details of Commercial and Industrial Assumptions, by End Use). Key Reference: California Energy Commission, Staff Analysis of Toilets, Urinals and Faucets, CEC-400-2014-007-SD, Docket Number 14-AAER-1, 2014. Fixture uses over a 5-day work week are prorated to 7 days. Non-residential 0.5gpm faucet standards per Table 2-A. Water Consumption by Water-Using Plumbing Products and Appliances - 1980-2012. PERC Phase 1 Report. Plumbing Efficiency Research Coalition, 2012. http://www.map-testing.com/content/info/menu/perc.html Model Input Values are found in the "Codes and Standards" green section on the "Fixtures" worksheet of the DSS Model and confirmed in each "Service Area Calibration End Use" worksheet by customer category.
Natural Replacement Rate of Fixtures (percent per year)	Residential Toilets 2%-4%
	Non-Residential Toilets 2%-3%
	Residential Showers 4% (corresponds to 25-year life of a new fixture)
	Residential Clothes Washers 10% (based on 10-year washer life). Key References: "Residential End Uses of Water" (DeOreo, 2016) and "Bern Clothes Washer Study, Final Report" (Oak Ridge National Laboratory, 1998).
	Residential Faucets 10% and Non-Residential Faucets 6.7% (every 15 years). CEC uses an average life of 10 years for faucet accessories (aerators). A similar assumption can be made for public lavatories, though no hard data exists and since CII fixtures are typically replaced less frequently than residential, 15 years is assumed. CEC, Analysis of Standards Proposal for Residential Faucets and Faucet Accessories, a report prepared under CEC's Codes and Standards Enhancement Initiative, Docket #12-AAER-2C, August 2013.
	Model Input Value is found in the "Codes and Standards" green section on the "Fixtures" worksheet of the DSS Model.
Residential Future Water Use	Increases Based on Population Growth and Demographic Forecast
Non-Residential Future Water Use	Increases Based on Employment Growth and Demographic Forecast

Fixture Estimates

Determining the current level of efficient fixtures in a service area while evaluating the passive savings in the DSS Model is part of the standard process and is called "initial fixture proportions." As described earlier in Section 2.2, MWM reconciled water efficient fixtures and devices installed within the BAWSCA service area and estimated the number of outstanding inefficient fixtures.

MWM used the DSS Model to perform a saturation analysis for toilets, urinals, showerheads, faucets, and clothes washers. The process included a review of age of buildings from census data, number of rebates per device, and assumed natural replacement rates. MWM presumed the fixtures that were nearing saturation and worth analysis would include residential toilets and residential clothes washers as both have been included in recommended conservation practices for over two decades.

In 2014, the Water Research Foundation updated its 1999 Residential End Uses of Water Study (DeOreo, 2016). Water utilities, industry regulators, and government planning agencies consider it the industry benchmark for single family home indoor water use. This Demand Study incorporates recent study results which reflect the change to the profile of water use in residential homes including adoption of more water efficient fixtures over the past 20 years (1999–2019). Residential End Uses of Water Study results were combined with BAWSCA historical rebate and billing data to enhance and verify assumptions made for all customer accounts, including saturation levels on the above-mentioned plumbing fixtures.

The DSS Model presents the estimated current and projected proportions of these fixtures by efficiency level within each member agency service area. These proportions were calculated by:

- Using standards in place at the time of building construction;
- Taking the initial proportions of homes by age (corresponding to fixture efficiency levels);
- Adding the net change due to natural replacement; and
- Adding the change due to rebate measure minus the "free rider effect."[35]

Further adjustments were made to initial proportions to account for the reduction in fixture use due to lower occupancy and based on field observations. The projected fixture proportions do **not** include any future active conservation measures implemented by member agencies. More information about the development of initial and projected fixture proportions can be found in the DSS Model "Codes and Standards" section.

The DSS Model is capable of modeling multiple types of fixtures, including fixtures with different designs. For example, currently toilets can be purchased that flush at a rate of 0.8 gpf, 1.0 gpf or 1.28 gpf. The 1.6 gpf and higher toilets still exist but can no longer be purchased in California. Therefore, they cannot be used for replacement or new installation of a toilet. So, the DSS Model utilizes fixture replacement rates to determine what type of fixture should be used for a new construction installation or replacement. The replacement of the fixtures is listed as a percentage within the DSS Model. A value of 100% would indicate that all the toilets installed would be of one particular flush volume. A value of 75% means three out of every four toilets installed would be of that particular flush volume. All the Fixture Model information and assumptions were carefully reviewed and accepted by BAWSCA staff.

The DSS Model provides inputs and analysis of the number, type, and replacement rates of fixtures for each customer category (e.g., single family toilets, commercial toilets, residential clothes washing machines). For example, the DSS Model incorporates the effects of the 1992 Federal Energy Policy Act and AB 715 on toilet fixtures. A DSS model feature determines the "saturation" of 1.6 gpf toilets as the 1992 Federal Energy Policy Act was in effect from 1992 to 2014 for 1.6 gpf toilet replacements. AB 715 now applies for the replacement of

[35] It is important to note that in water conservation program management the "free rider effect" occurs when a customer applies for and receives a rebate on a targeted high efficiency fixture they would have purchased even without a rebate. In this case, the rebate was not the incentive for their purchase but a "bonus." Rebate measures are designed to target those customers needing financial incentive to install the more efficient fixture.

toilets at 1.28 gpf. Further consideration and adjustments were made to replacement rates to account for the reduction in fixture use and wear due to lower occupancy and based on field observations.

C.4 Present Value Analysis and the Utility and Community Perspective

Present value analysis using present day dollars and a real discount rate of 3% is used to discount costs and benefits to the base year. From this analysis, benefit-cost ratios of each measure are computed. When measures are put together in programs, the model is set up to avoid double counting savings from multiple measures that act on the same end use of water. For example, multiple measures in a program may target toilet replacements. The model includes assumptions to apportion water savings between the multiple measures.

Economic analysis can be performed from several different perspectives, based on which party is affected. For planning water use efficiency programs for utilities, perspectives most commonly used for benefit-cost analyses are the “utility” perspective and the “community” perspective. The “utility” benefit-cost analysis is based on the benefits and costs to the water provider. The “community” benefit-cost analysis includes the utility benefit and costs together with account owner/customer benefits and costs. These include customer energy and other capital or operating cost benefits plus costs of implementing the measure, beyond what the utility pays.

The utility perspective offers two advantages. First, it considers only the program costs that will be directly borne by the utility. This enables the utility to fairly compare potential investments for saving versus supplying increased quantities of water. Second, revenue shifts are treated as transfer payments, which means program participants will have lower water bills and non-participants will have slightly higher water bills so that the utility’s revenue needs continue to be met. Therefore, the analysis is not complicated with uncertainties associated with long-term rate projections and retail rate design assumptions. It should be noted that there is a significant difference between the utility’s savings from the avoided cost of procurement and delivery of water and the reduction in retail revenue that results from reduced water sales due to water use efficiency. This budget impact occurs slowly and can be accounted for in water rate planning. Because it is the water provider’s role in developing a water use efficiency plan that is vital in this study, the utility perspective was primarily used to evaluate elements of this report.

The community perspective is defined to include the utility and the customer costs and benefits. Costs incurred by customers striving to save water while participating in water use efficiency programs are considered, as well as benefits received in terms of reduced energy bills (from water heating costs) and wastewater savings, among others. Water bill savings are not a customer benefit in aggregate for reasons described previously. Other factors external to the utility, such as environmental effects, are often difficult to quantify or are not necessarily under the control of the utility. They are therefore frequently excluded from economic analyses, including this one.

C.5 Present Value Parameters

The time value of money is explicitly considered. Typically, the costs to save water occur early in the planning period whereas the benefits usually extend to the end of the planning period. For this reason, a planning period of 10 years or longer is used because costs and benefits that occur beyond 10 years have little influence on the total present value of costs and benefits. The value of all future costs and benefits is discounted to the first year in the DSS Model (the base year), at the real interest rate of 3.01%. The DSS Model calculates this real interest rate, adjusting the current nominal interest rate (assumed to be approximately 6.1%) by the assumed rate of inflation (3.0%). The formula to calculate the real interest rate is: (nominal interest rate – assumed rate of inflation)/ (1 + assumed rate of inflation). Cash flows discounted in this manner are herein referred to as “Present Value” sums.

C.6 Assumptions About Measure Costs

The assumptions and inputs used in the DSS Model to evaluate each water conservation measure can be found in the 2020 Demand Study report. Assumptions regarding the following variables were made for each measure:

- **Targeted Water User Group End Use –** Water user group (e.g., single family residential) and end use (e.g., indoor or outdoor water use)
- **Utility Unit Cost –** Cost of rebates, incentives, and contractors hired by BAWSCA and BAWSCA member agencies to implement measures
- **Retail Customer Unit Cost –** Cost for implementing measures that is paid by retail customers (i.e., remainder of a measure's cost that is not covered by a rebate or incentive)
- **Utility Administration and Marketing Cost –** The cost to the utility for staff time, general expenses, and overhead needed to implement and administer the measure, including consultant contract administration, marketing, and participant tracking. The unit costs vary greatly according to the type of customer and implementation method. For example, a measure might cost a different amount for a single family account than a multifamily account. Rebate program costs are different than costs to develop and enforce an ordinance requirement or a direct installation program. Typically, water utilities incur increased costs with achieving higher market saturation, such as more surveys per year. The model calculates the annual costs based on the number of participants each year.

Costs are determined for each of the measures based on industry knowledge, past experience, and data provided by BAWSCA, Valley Water, SFPUC, and the member agencies. Costs may include incentive costs, usually determined on a per-participant basis; fixed costs, such as marketing; variable costs, such as costs to staff the measures and obtain and maintain equipment; and a one-time set-up cost. The set-up cost is for measure design by staff or consultants, any required pilot testing, and preparation of materials used to market the measure. Measure costs are estimated each year through 2045. Costs are spread over the time period depending on the length of the implementation period for the measure and estimated voluntary customer participation levels.

Lost revenue from reduced water sales is not included as a cost because the water use conservation measures evaluated herein usually take effect over a long span of time that is sufficient to enable timely rate adjustments, if necessary, to meet fixed cost obligations and savings on variable costs such as energy and chemicals.

C.7 Assumptions about Measure Savings

Data necessary to forecast water savings of measures include specific data on water use, demographics, market penetration, and unit water savings. Savings normally develop at a measured and predetermined pace, reaching full maturity after full market penetration is achieved. This may occur three to seven years after the start of implementation, depending upon the implementation schedule. For every water use efficiency activity or replacement with more efficient devices, there is a useful life. The useful life is called the "Measure Life" and is defined to be how long water use conservation measures stay in place and continue to save water. It is assumed that measures implemented because of codes, standards, or ordinances (e.g., toilets) would be "permanent" and not revert to an old inefficient level of water use if the device needed to be replaced. However, some measures that are primarily behavior-based, such as residential surveys, are assumed to need to be repeated on an ongoing basis to retain the water savings (e.g., homeowners move away, and the new homeowners may have less efficient water using practices). Surveys typically have a measure life on the order of five years.

C.8 Assumptions about Avoided Costs

The estimated avoided cost of water was provided by BAWSCA staff and can be found in each BAWSCA member agency's specific DSS Model. The avoided cost of water or water production operational cost is $7.75/ccf as per information from BAWSCA on April 2, 2020 based on FY 2030-31 rates from SFPUC's Wholesale Rate Projections for the 10-year horizon. Given that there are no projections beyond the 2031 mark, the 2031 data value was selected.