SALINAS VALLEY GROUNDWATER USAGE:

AN ANALYSIS OF 25 YEARS OF GROUNDWATER EXTRACTION REPORTING

Monterey County
Water Resources Agency

Special Report Series 21-01

November 2021

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Monterey County Water Resources Agency

Mission Statement
Manage water resources sustainably while minimizing impacts from flooding for present and future generations.

Vision Statement
Be recognized throughout the region as a leader in water resource management through demonstrated knowledge, integrity, and the quality of our actions.

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1. Introduction

1.1. Objective

The Monterey County Water Resources Agency (MCWRA or Agency) has collected groundwater extraction and water conservation information through the Groundwater Extraction Management System program since 1993. This Special Report analyzes the groundwater usage throughout the GEMS program area within the Salinas Valley over the last 25 years. The focus is to show trends in the amount of groundwater extracted and used over time, water and crop type use changes, and water conservation practices.

1.2. Background

1.2.1. GEMS Program

"Even though at times water may seem to be abundant, water that is usable to satisfy human need for residential, agricultural, commercial, industrial, and other purposes is diminishing in both quantity and quality. The natural replenishment and the artificial recharge taking place in Monterey County groundwater basins do not adequately restore the groundwater supply. The evaluation of actual water use figures will facilitate the determination of the management practices needed to curtail the threat to the public health, safety, and welfare created by an inadequate water supply" (MCWRA Ordinance No. 3660).

The Groundwater Extraction Management System (GEMS) is the Agency's groundwater extraction and water conservation data collection program. One purpose of the GEMS program is to provide the Agency with the most accurate water use information available to effectively manage groundwater resources in the basin. The Agency has been collecting groundwater extraction information since Report Year[1] 1993, Agricultural Water Conservation Plans since 1995, and Urban Water Conservation Plans since 1996. Data collected through the GEMS program are required by a series of MCWRA ordinances, which are outlined below. Copies of these ordinances are included in Appendices A-C.

<u>MCWRA Ordinance 3717 and 3718- Groundwater Extractions</u>
Adopted in October 1993, Ordinance 3717 requires groundwater extractors within Zones 2, 2A, and 2B (Figure 1) to report annual water use information from groundwater wells with a discharge pipe having an internal diameter greater than three inches to the Agency. In addition, Ordinance 3717 requires the installation of flowmeters on all wells and sets the due date for reports by February 15th of each year. Ordinance 3718, adopted in October 1993, amended Ordinance 3717 by adding standards for granting variances to the time limits requiring flowmeters on groundwater wells.

[1] The GEMS Reporting Year is November-October for agricultural wells, and January-December for urban wells

MCWRA Ordinance 3851- Agricultural Water Conservation Plans

Ordinance 3851 requires all agricultural growers farming property in Zones 2, 2A, and 2B to file plans showing water conservation measures implemented in the previous and upcoming years. Ordinance 3851 was adopted in December 1995 and requires reports to be submitted to the Agency by February 15th of each year.

MCWRA Ordinance 3886- Urban Water Conservation Plans

Created as an urban counterpart to Ordinance 3851, Ordinance 3886 requires all cities and urban water purveyors in Zones 2, 2A, and 2B to file plans showing water conservation measures implemented in the previous and upcoming years. Ordinance 3886 was adopted in September 1996 and requires reports to be submitted to the Agency by February 15th of each year.

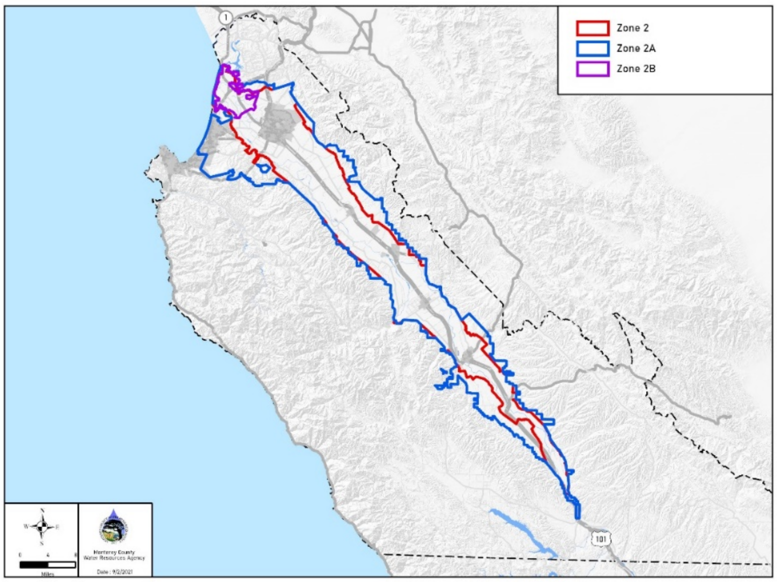
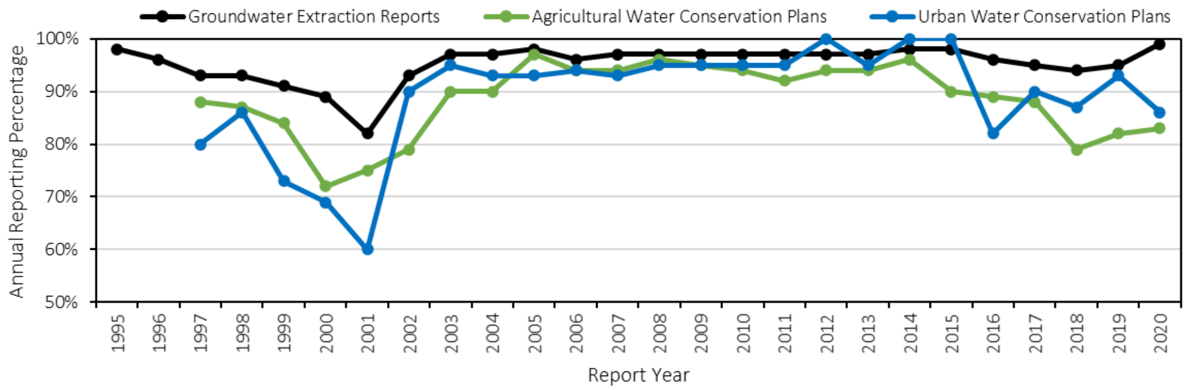


Figure 1. GEMS Reporting Boundary: MCWRA Zones 2, 2A and 2B

There are currently three methods for reporting groundwater extraction information: flowmeter method, electric meter method, and hour meter method. The monthly and annual volume of water extracted is calculated from monthly meter readings submitted to the Agency by the well owner/operator.

All data collected through the GEMS program is self-reported by agricultural and urban entities. Every year, Agency staff performs several outreach efforts to well owners and operators to maintain a high reporting compliance. Reporting compliance varies year to year, but on average, the Agency has received 95% of groundwater extraction reports, 88% of Agricultural Water Conservation Plans, and 89% of Urban Water Conservation Plans (Figure 2). The Agency maintains a strict quality assurance process in the entry, compilation, and standardization of data received. While the Agency makes every effort to ensure the accuracy of the data collected and presented in annual summary reports and in this review, changes to historical data may have occurred due to submittals received after due dates or after the generation of summary reports.



Data collected through the GEMS program each reporting year is summarized and released in an Annual Summary Report. These reports summarize information from the water conservation plans and extractions within the four main subareas in the GEMS reporting boundary. Sections 1.2.4-1.2.7 include an overview of the four subareas, their geographic extent, and a brief hydrogeologic review. It is worth noting that the GEMS subareas are not the same as the Salinas Valley subbasin boundaries defined in CA Bulletin 118.

1.2.2. Zones 2 and 2A

The GEMS reporting boundary consists of MCWRA Zones 2, 2A and 2B (Figure 1). Zones 2 and 2A were assessment zones used to fund the operation and maintenance of Nacimiento and San Antonio Dams and Reservoirs. In 2003, Zone 2C was created to fund the Salinas Valley Water Project and reservoir operations and eliminated the existing Zone 2 and 2A standby and availability charges. However, the GEMS ordinances were adopted prior to 2003 and were never revised to extend the reporting boundary to Zone 2C.

1.2.3. Zone 2B and CSIP

MCWRA initiated the Monterey County Water Recycling Projects to provide a replacement water supply for the approximately 12,000 acres of farmland in the Castroville Seawater Intrusion Project (CSIP) service area to help address seawater intrusion in the coastal region. The assessment zone, Zone 2B, which is coincident with the CSIP service area, was created to fund the project (Figure 3).

CSIP initially received a mix of reclaimed water from the Salinas Valley Reclamation Project (SVRP), supplemented by groundwater extractions from MCWRA owned CSIP-Supplemental wells. A third water source to CSIP was introduced in 2010 when the Salinas River Diversion Facility (SRDF) went online. The SRDF was one component of the Salinas Valley Water

Project (SVWP), along with the modification of the Nacimiento spillway and reoperation of the reservoirs.

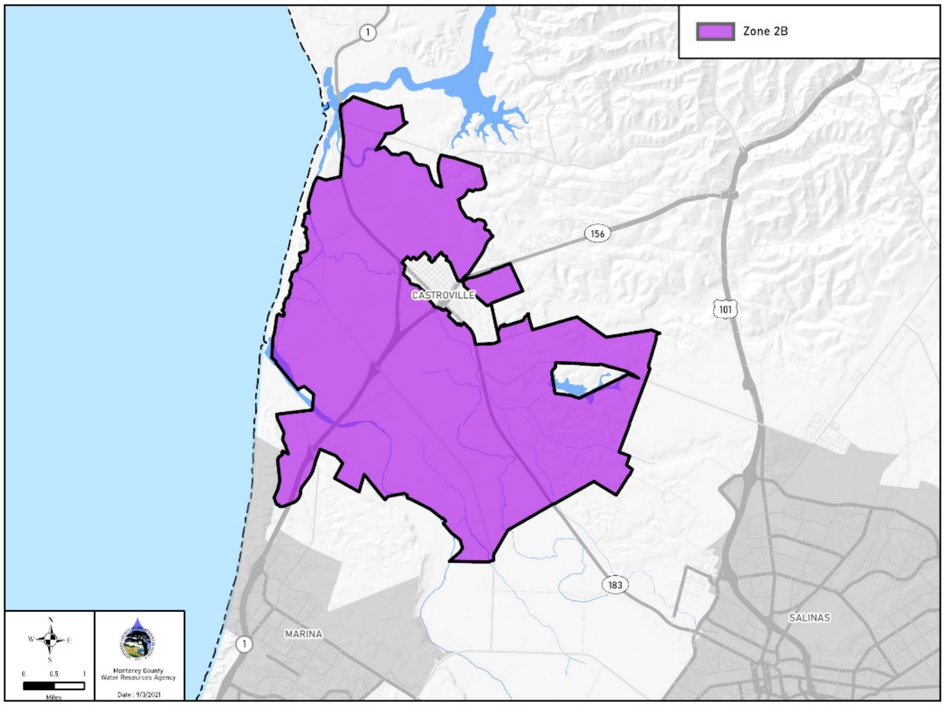


Figure 3. MCWRA Zone 2B

1.2.4. Pressure Subarea

Overall, the Pressure subarea covers 181 square miles (Figure 4). The subarea is bordered by the East Side Subarea to the northeast, roughly along Highway 101, and the Forebay Subarea to the south, beginning around Gonzales. Monterey Bay defines the northwest boundary. The Pressure Subarea roughly covers a similar extent as the 180/400-Foot Aquifer, Monterey, and Seaside subbasins, as defined by CA Bulletin 118.

The Pressure Subarea has three primary aquifer units: the 180-Foot Aquifer, the 400-Foot Aquifer, and the Deep Aquifers. Clay or clay and sand aquitards separate the aquifers. The series of aquifers and aquitards results from the sea level rising and falling over the past few million years, resulting in alternating periods of estuarine and fluvial deposits (Kennedy/Jenks, 2004). Additionally, there is a fourth aquifer unit, the Shallow Aquifer, which is located near the ground surface but is laterally discontinuous and is limited in both the quantity and quality of water available. Recharge to the 180-Foot and 400-Foot Aquifers predominately comes from underflow from recharge occurring in the Forebay Subarea (DWR, 2004; Harding ESE, 2001). However, isotope data from Deep Aquifers wells indicates that groundwater was recharged 25,000 to 30,000 years before present and may not be actively recharging (Hanson, R.T., et al., 2002).

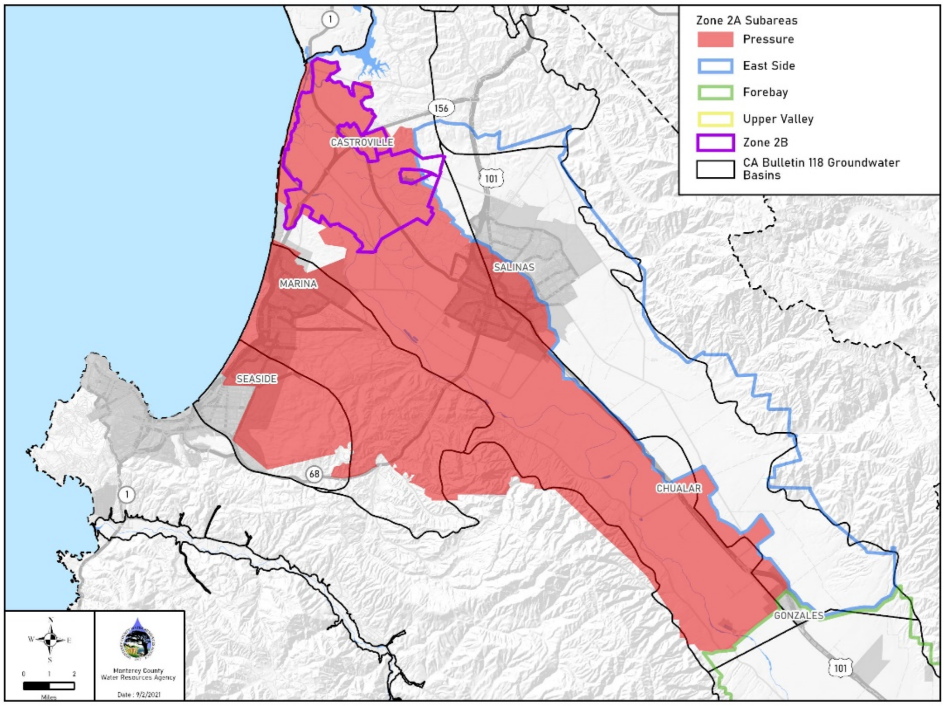


Figure 4. Zone 2A Pressure Subarea

The Pressure Subarea aquifers are in direct hydrologic connection with Monterey Bay. Groundwater elevations in these aquifers have historically been drawn below sea level from over pumping, creating a landward groundwater gradient which led to regional seawater intrusion in the 180-Foot and 400-Foot Aquifers. Additionally, a downward vertical gradient between the two aquifers, combined with gaps in the aquitard and damaged or improperly constructed wells, has led to inter-aquifer seawater intrusion from the overlying 180-Foot Aquifer into the 400-Foot Aquifer (MCWRA, 2017). In 2020, the extent of seawater intrusion in the 180-Foot Aquifer was 28,358 acres and 18,403 acres in the 400-Foot Aquifer (or 44.3 and 28.7 square miles, respectively).

1.2.5. East Side Subarea

The East Side Subarea, shown in Figure 5, covers 100 square miles. The Gabilan Range borders the subarea along the northeast edge, the Pressure Subarea along the southwest edge, and the Forebay Subarea to the south, beginning around Gonzales. The East Side Subarea covers a similar extent as the East Side Subbasin defined by CA Bulletin 118.

Several alluvial fans built up by streams draining the Gabilan Range resulted in thin, discontinuous, poorly bedded sequences of clays, sands, silts, and gravels in the East Side Subarea (MCFCWCD, 1960; Kennedy/Jenks, 2004). While the fluvially generated aquifers in the Pressure Subarea are not seen in the East Side Subarea, sediments in both subareas can be correlated by stratigraphically equivalent zones (Kennedy/Jenks, 2004). The transition zone between the Pressure and East Side Subareas shifts from predominately fluvial to alluvial fan deposits (Kennedy/Jenks, 2004). The flow of groundwater, which preferentially moves along geologic pathways allowing for the easier movement of water, is restricted (but not absent) across this transition zone due to the discontinuous and layered nature of sediments through the boundary. As a result, groundwater recharge predominately occurs through percolation of streams draining the Gabilan Range (Kennedy/Jenks, 2004).

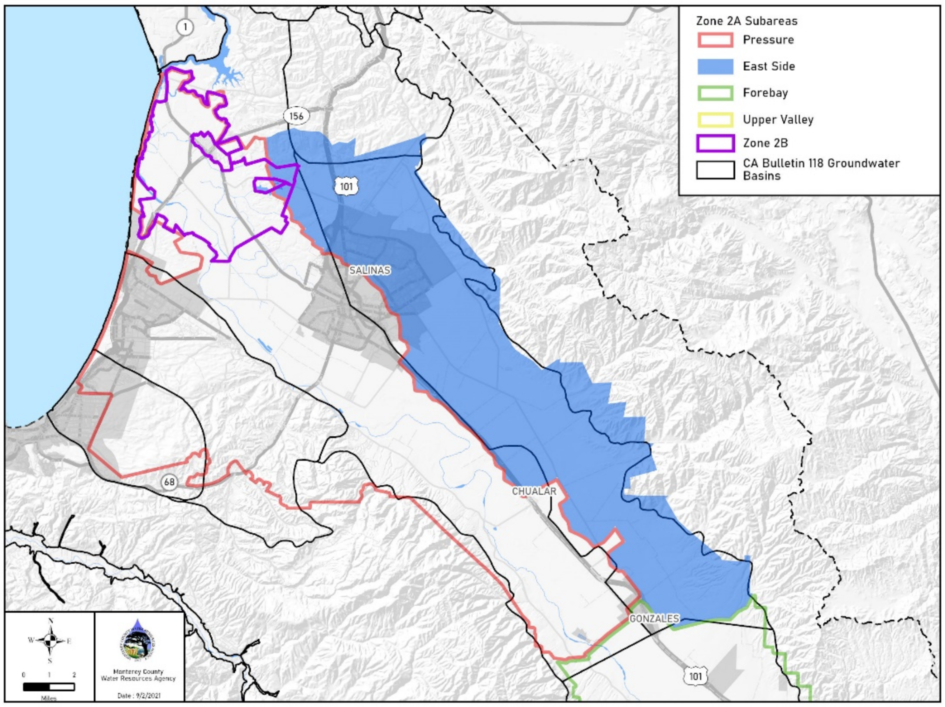


Figure 5. Zone 2A East Side Subarea

1.2.6. Forebay Subarea

The Forebay subarea covers 122 square miles overall (Figure 6). The subarea is bordered by the Pressure and East Side Subareas to the northwest, beginning around Gonzales, and the Upper Valley Subarea to the southeast, just south of Greenfield. The Gabilan Range borders the Forebay along the northeast edge and the Sierra de Salinas makes up the border to the southwest. The Arroyo Seco River, whose watershed is in the Sierra de Salinas, drains into the Salinas River in the Forebay.

The Forebay Subarea consists of fluvial and marine deposits of the Salinas Valley and alluvial fan deposits from the Arroyo Seco River. The fluvial and marine sediments in the Forebay are stratigraphically equivalent to those seen in the Pressure Subarea; however, the confining unit and Salinas Valley aquitard do not extend into the Forebay (MCWRA, 2006).

Groundwater in the Forebay Subarea is unconfined and predominately exists in sand and gravel lenses that are interbedded with finer material (DWR, 2004). The alluvial fan deposits from the Arroyo Seco River, referred to as the Arroyo Seco Cone, are coarser than the fluvial and marine deposits of the Salinas Valley. Groundwater recharge in the Forebay Subarea predominately comes from infiltration from the Salinas and Arroyo Seco Rivers.

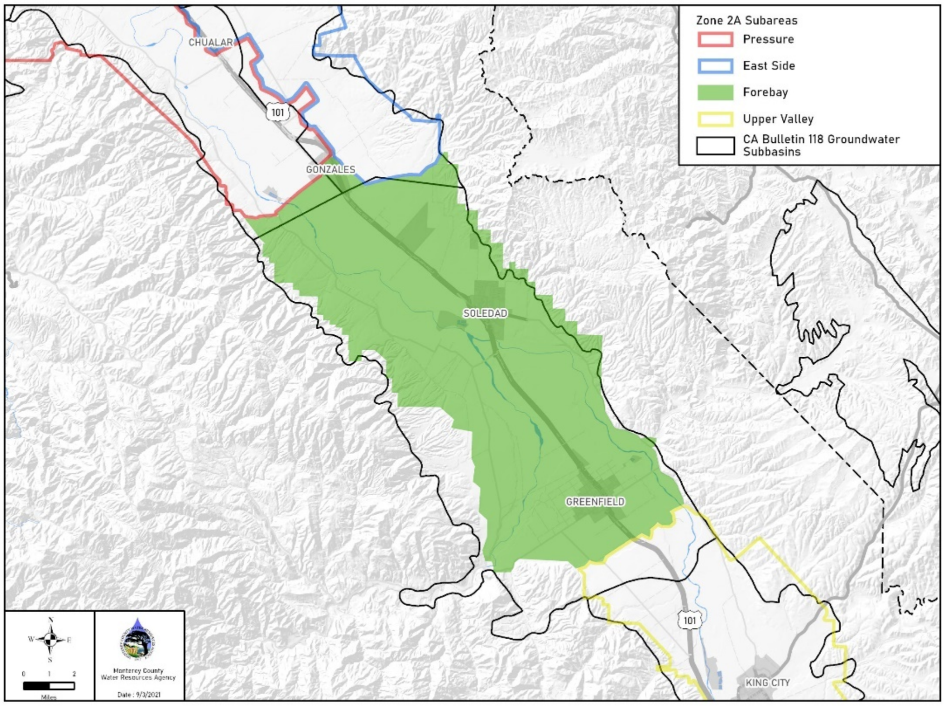


Figure 6. Zone 2A Forebay Subarea

1.2.7. Upper Valley Subarea

The Upper Valley Subarea, shown in Figure 7, covers 152 square miles. The Subarea is bordered by the Forebay Subarea to the north, beginning just south of Greenfield, and extends a few miles south of San Ardo. The Gabilan and Sierra de Salinas ranges border the Subarea along the northeast and southwest edges, respectively. The Upper Valley Subarea covers a much smaller area than the CA Bulletin 118 Upper Valley Subbasin. These were similar in extent in previous CA Bulletin 118 updates, but a jurisdictional boundary revision in 2018 extended the Upper Valley Subbasin to include Hames Valley and portions up to the Monterey and San Luis Obispo County line.

Aquifer units in the Upper Valley are unconfined and consist of unconsolidated gravels and sands from river and alluvial fan deposits (DWR, 2004; MCWRA, 2006). Recharge to the Upper Valley sediments occurs predominately from infiltration from the Salinas River.

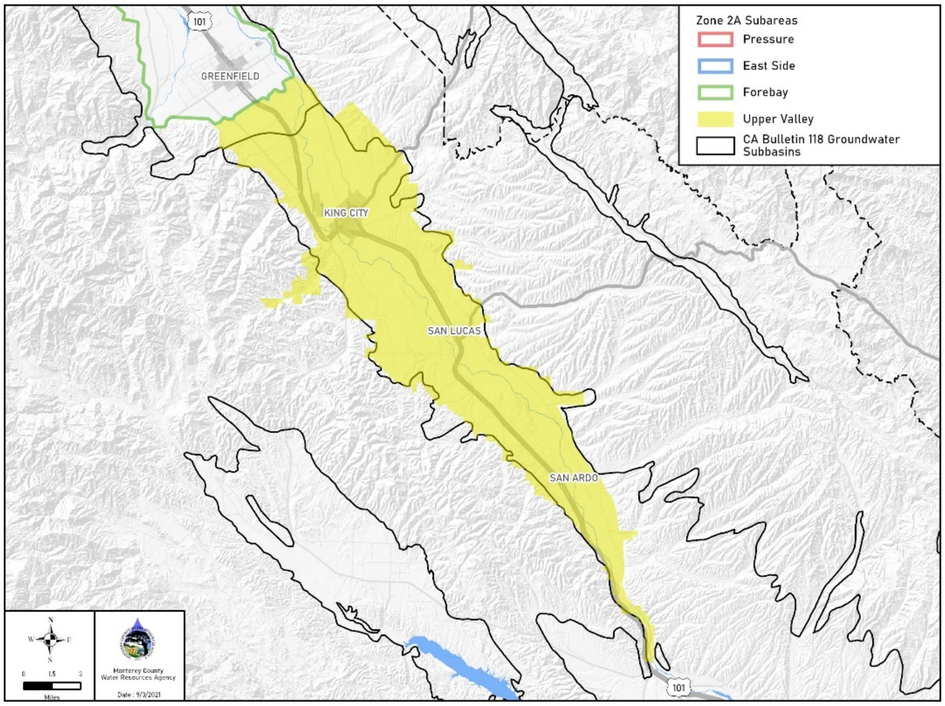


Figure 7. Zone 2A Upper Valley Subarea

1.2.8. Area of Impact

The Area of Impact was first defined in the 2017 report *Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin* (2017 Recommendations Report). The 2017 Recommendations Report was published by the Agency in response to a request by the Board of Supervisors of the County of Monterey, Board of Supervisors to the Monterey County Water Resources Agency, and Water Resources Agency Board of Directors (Joint Boards) to present recommendations that, if implemented, would slow or halt the further advancement of seawater intrusion.

After the 2017 *Recommendations* Report was released, the Joint Boards directed staff to convene a 90-Day Working Group focused on developing an interim urgency ordinance to address the issues in the report. The 90-Day Working Group's recommendations were presented to the Joint Boards on April 24, 2018, at which point Staff was directed to return to the Monterey County Board of Supervisors with an ordinance for a temporary moratorium on drilling new wells in the 180-Foot and 400-Foot within a redefined Area of Impact, shown in Figure 8, and a temporary moratorium on drilling of new wells in the Deep Aquifers[2].

[2] The temporary ordinance included exceptions for replacement wells, domestic wells, and municipal supply wells.

Monterey County Ordinance 5302 was adopted May 22, 2018 and was extended by Ordinance 5303 on June 26, 2018. Ordinance 5303 expired on May 21, 2020.

The Area of Impact encompassed the portion of the 180/400-Foot Aquifer and Monterey Subbasins in which chloride concentrations in the 180-Foot or 400-Foot Aquifers were 250 mg/L or greater, based on data from 2015. The 250 mg/L metric was used to delineate portions of the groundwater basin considered vulnerable due to the presence of pathways and conduits in which seawater intrusion could advance.

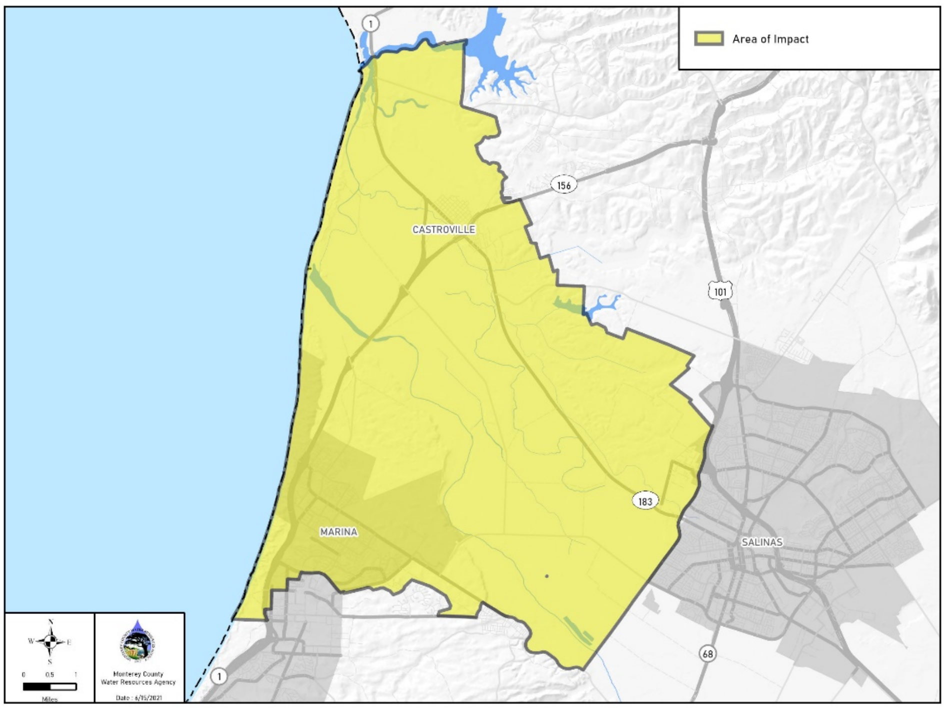


Figure 8. Area of Impact as defined by Ordinance 5302

1.2.9. Methods in this Report

Trends over time are discussed throughout this report. All trends were determined using a linear interpolation over the entire time series, with rates calculated from slope of the interpolation.

2. Groundwater Extractions (1995-2020)

From 1995 to 2020, annual extractions for all subareas averaged 495,000 acre-feet per year (AFY). Total annual extractions ranged from 441,050 AF (1998) to 598,100 AF (1997). On average, the Pressure Subarea reported 24% of total annual extractions, the East Side Subarea reported 20% of total annual extractions, the Forebay Subarea reported 29% of total annual extractions, and the Upper Valley Subarea reported 27% of total annual extractions (Figure 9).

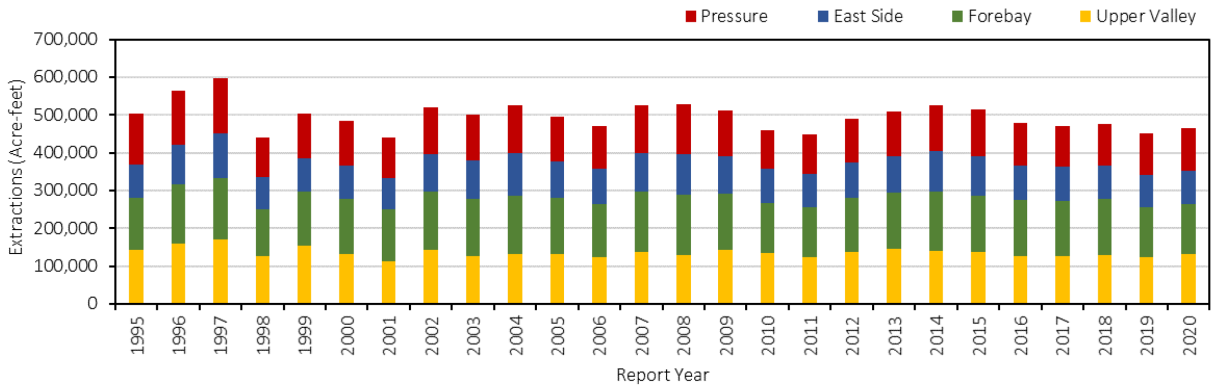


Figure 9. Annual Groundwater Extractions, by Subarea

On an average annual basis, agricultural extractions make up 91% of total extractions (450,850 AFY) and urban extractions account for 9% (43,920 AFY) (Figure 10). Even with varying annual extraction totals, this percentage has remained relatively constant over the period of record. The highest annual agricultural extraction total was 551,900 AF (1997) and the highest annual urban extraction total was 53,000 AF (2004).

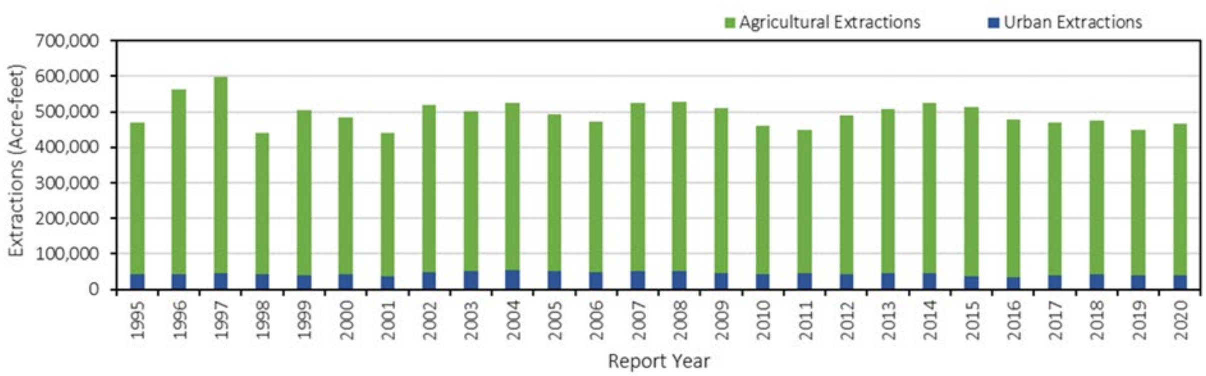


Figure 10. Annual Groundwater Extractions, by type

Variability in annual extractions is seen throughout the period of record. There is a slight negative correlation between the annual amount of groundwater extracted and annual precipitation at the Salinas Airport station (Figure 11). Wetter periods, such as 1998 or 2010-2012, roughly correlate with years with lower reported annual extractions. Drier periods, such as 2007-2009 or 2013-2015, roughly correlate with years with higher annual extractions reported. This correlation is apparent when comparing agricultural extractions to annual precipitation, but not with urban extractions.

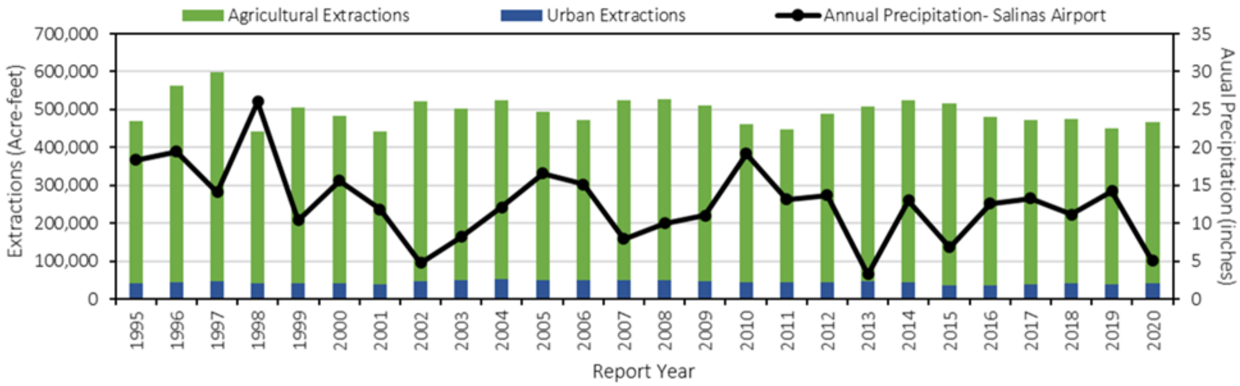


Figure 11. Annual Groundwater Extractions versus Annual Precipitation at the Salinas Airport Station

2.1. Urban Extractions

Urban extractions include those made for single or multi-family residential, commercial, industrial, or governmental usage. Urban extractions don't include most private domestic extractions since only wells with an internal discharge pipe diameter of three inches or greater must report to the GEMS program. Between 1995 and 2020, average annual urban extractions were 43,920 AFY (Figure 12). Though there is some variability over the period of record, there is no notable correlation between annual urban extractions and annual precipitation totals.

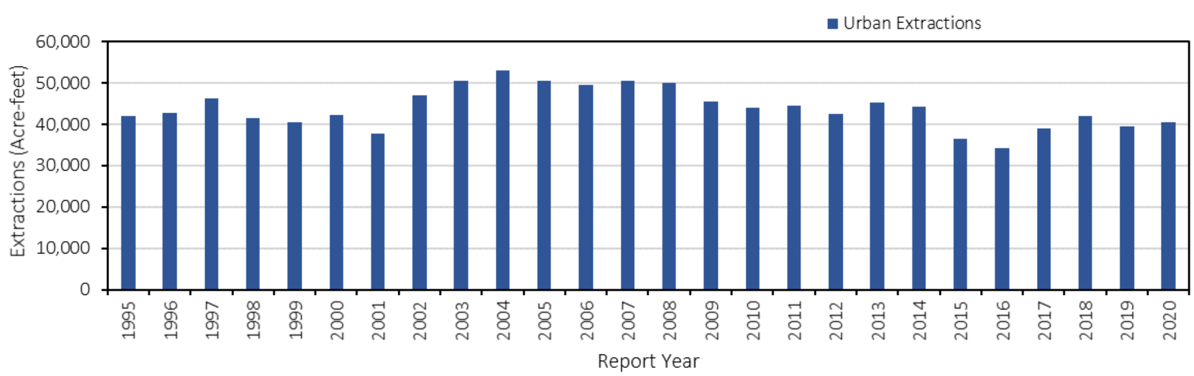


Figure 12. Urban Extractions between 1995 and 2020

Figure 13 shows the distribution of urban groundwater extractions by cities or other areas (OA) in the GEMS reporting area. Over the period of record, Salinas has accounted for 46% of overall urban extractions, followed by other users in the Pressure Subarea (9.6%), then Marina (9.2%). Most cities or areas have remained stable or seen a slight decrease in annual extractions over the period of record, except OA-East Side. Time series data for individual cities or other areas can be found in Appendix D.

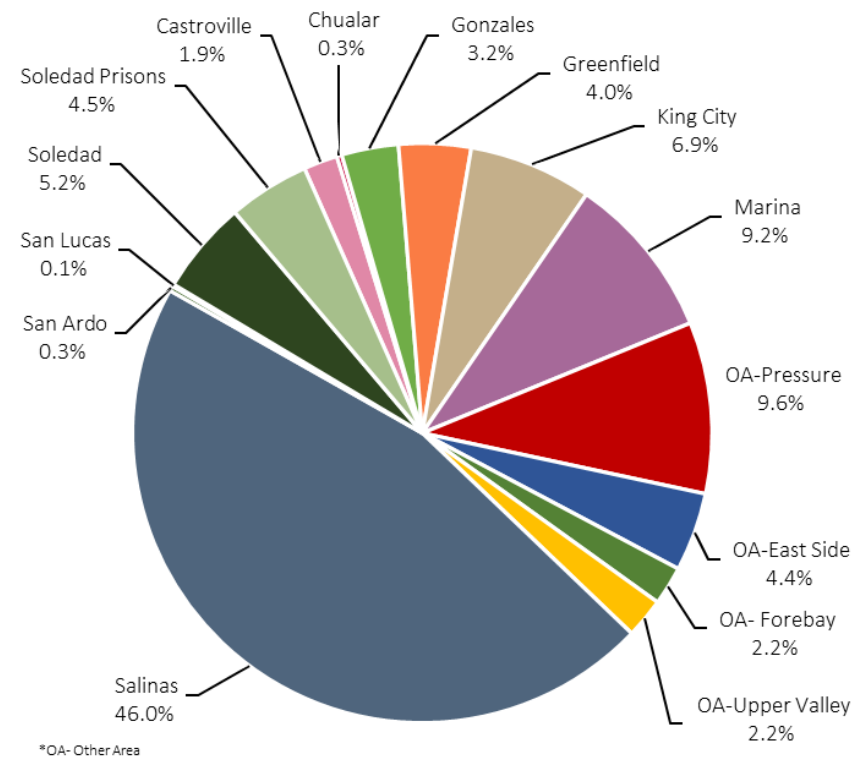


Figure 13. Average Distribution of Urban Extractions, by City or Other Areas

2.2. Pressure Subarea

Groundwater extractions from the Pressure Subarea are shown in Figure 14. Average annual extractions in the Pressure Subarea were 118,850 AFY. Agricultural extractions averaged 98,930 AFY (83% of total) and urban extractions averaged 19,920 AFY (17% of total). Over the period of record, both agricultural and urban extractions decreased an average of 370 AFY.

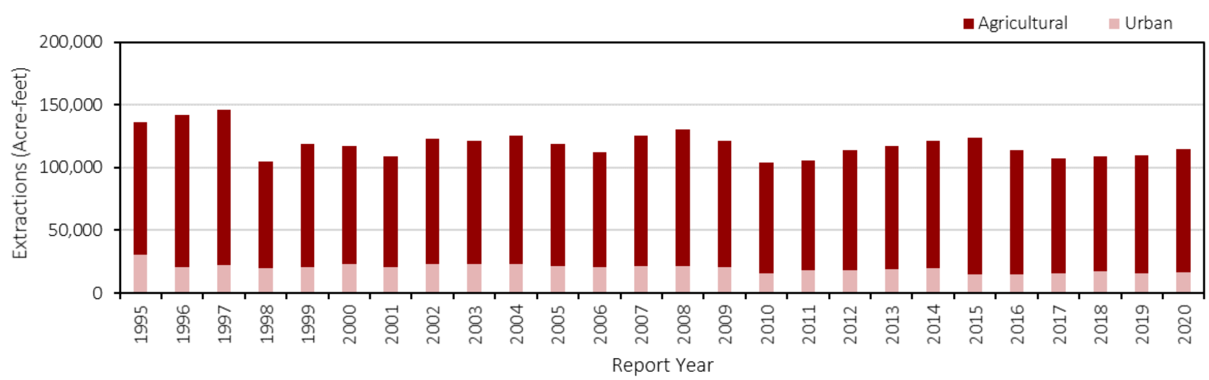


Figure 14. Groundwater Extractions from the Pressure Subarea, by type

For the period of record, an average of 48% of total Pressure Subarea extractions were from the 400-Foot Aquifer, 23% were from wells with unknown construction, 22% from wells in the 180-Foot Aquifer, 4% from Deep Aquifers wells, and 4% from Dual-Screened wells (Figure 15). “Dual-Screened” consists of wells screened in both the 180-Foot and 400-Foot Aquifers. “Pressure Unknown” consists of wells with unknown construction information. Trends in extractions from each of these aquifers are discussed more in the following sections.

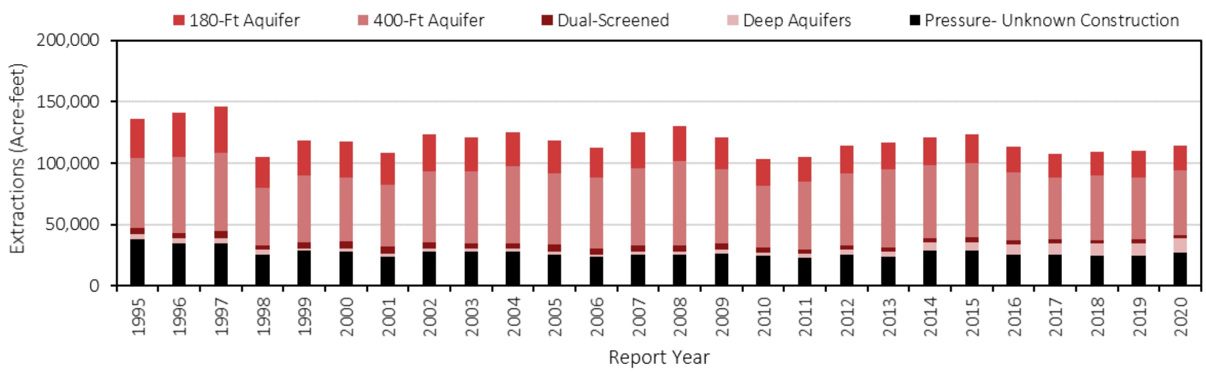


Figure 15. Groundwater Extractions from the Pressure Subarea, by Aquifer

2.2.1. 180-Foot Aquifer Extractions

Between 1995 and 2020, there has been a decreasing trend in the total extractions from the 180-Foot Aquifer, averaging 550 AFY (Figure 16). On average, agricultural usage accounted for ninety-seven percent of extractions from the 180-Foot Aquifer.

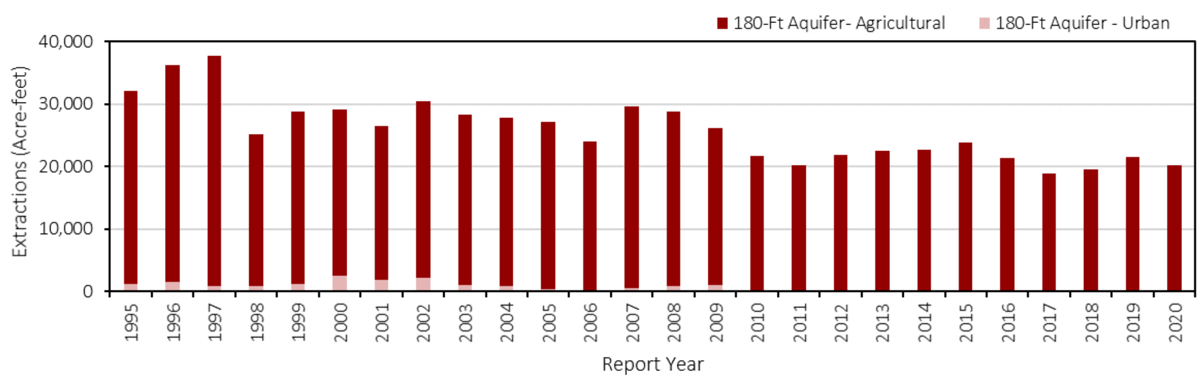


Figure 16. Groundwater Extractions from the 180-Ft Aquifer, by Type

2.2.2. 400-Foot Aquifer Extractions

Figure 17 breaks down groundwater extractions from the 400-Foot Aquifer into agricultural and urban use. On average, agricultural usage accounted for 79% of extractions, and urban usage 21%. Agricultural extractions from the 400-Foot Aquifer have slowly increased over the period of record by an average of 100 AFY. Urban extractions remained constant between 1995 and 2014, decreased in 2015, and remained stable from 2015-2020.

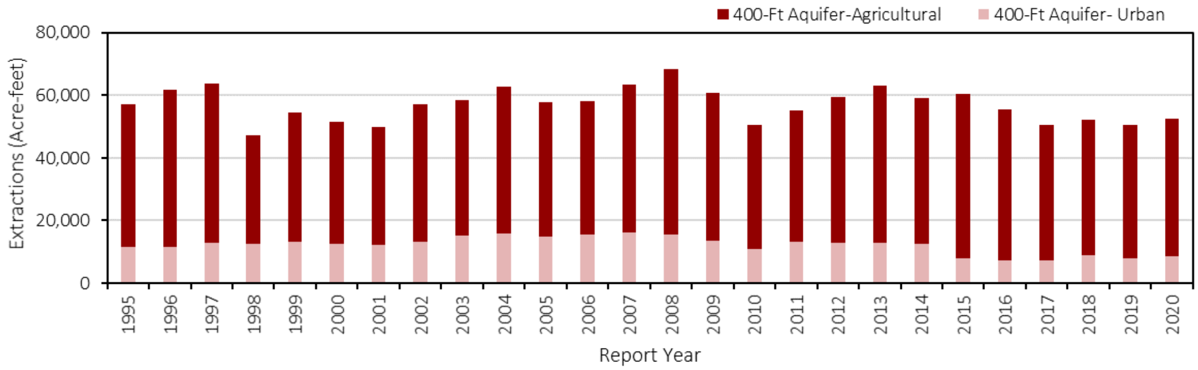


Figure 17. Groundwater Extractions from the 400-Ft Aquifer, by Type

2.2.3. Dual Screened Well Extractions

Agricultural extractions from wells dual-screened in the 180-Foot and 400-Foot Aquifers have remained constant over the period of record (Figure 18). However, urban extractions have decreased at 100 AFY, on average.

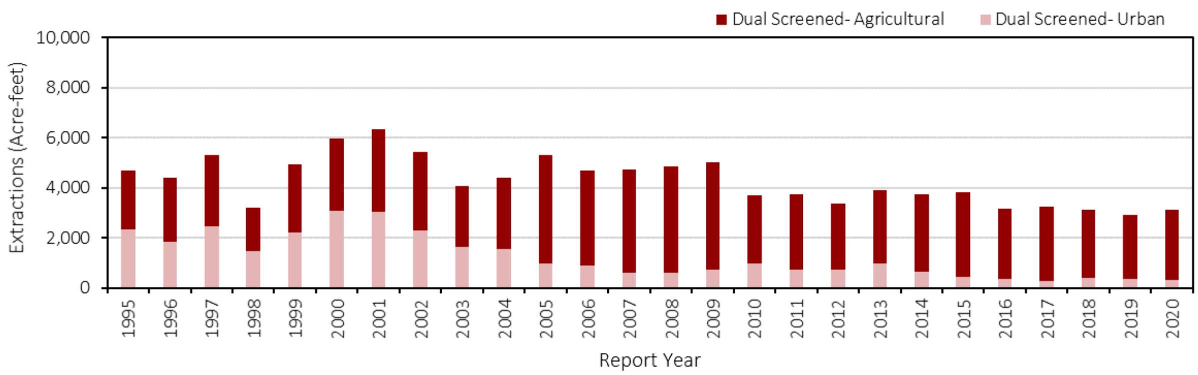


Figure 18. Groundwater Extractions from Dual-Screened wells, by Type

2.2.4. Deep Aquifers Extractions

Extractions from the Deep Aquifers of the Pressure Subarea can be seen in Figure 19. The only agricultural extractions reported from 1995-1998 were occurring within Zone 2B. These ceased after 1998 following the start-up of the CSIP project. Zero agricultural extractions were reported from the Deep Aquifers until 2007, when new wells drilled outside of Zone 2B began reporting extractions. Since 2007, agricultural extractions from the Deep Aquifers have been increasing by over 500 AFY on average. Urban extractions from the Deep Aquifers remained constant from 1995 to 2013, doubled in 2014, and remained steady since then.

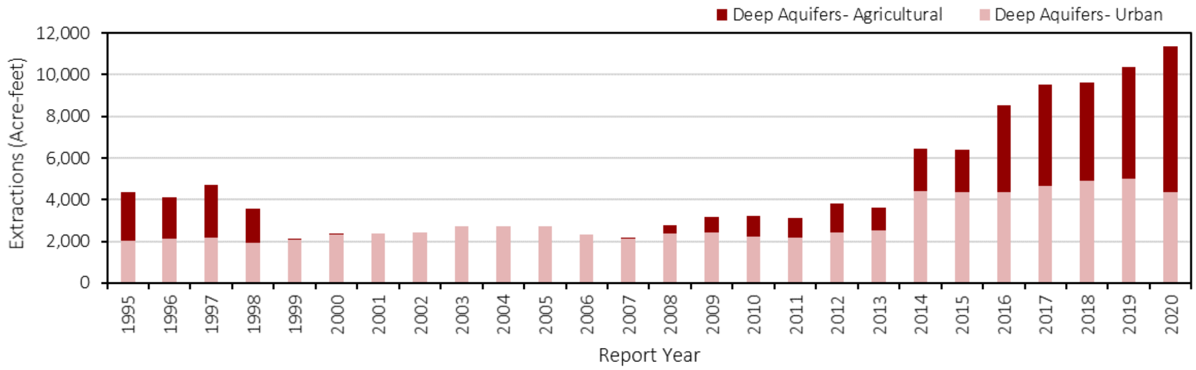


Figure 19. Groundwater Extraction from the Deep Aquifers, by Type

2.3. East Side Subarea

Between 1995 and 2020, total extractions from the East Side Subarea averaged 96,390 AFY (Figure 20). Agricultural extractions averaged 83,370 AFY (86% of total) and urban extractions averaged 13,020 AFY (14% of total). East Side extractions show a slightly decreasing trend over the period of record, a net result of agricultural extractions reducing by 380 AFY and urban extractions increasing by 165 AFY on average.

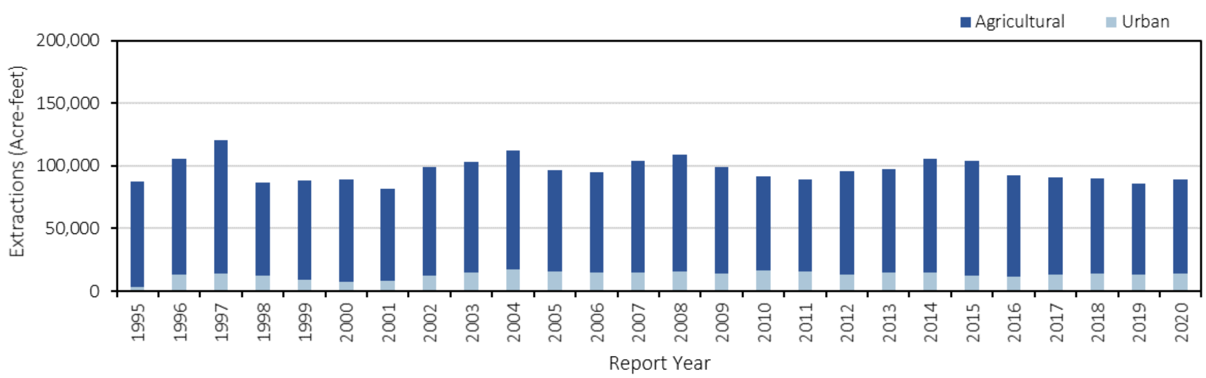


Figure 20. Groundwater Extractions from the East Side Subarea, by type

2.4. Forebay Subarea

The average annual groundwater extraction total from the Forebay Subarea from 1995-2020 was 145,490 AFY (Figure 21). Agricultural extractions were 138,480 AFY on average (95% of total), and urban extractions were 7,010 AFY on average (5% of total). Overall, there has been a slight decrease in annual extractions over the period of record, with urban extractions remaining constant and agricultural extractions decreasing at an average rate of 260 AFY.

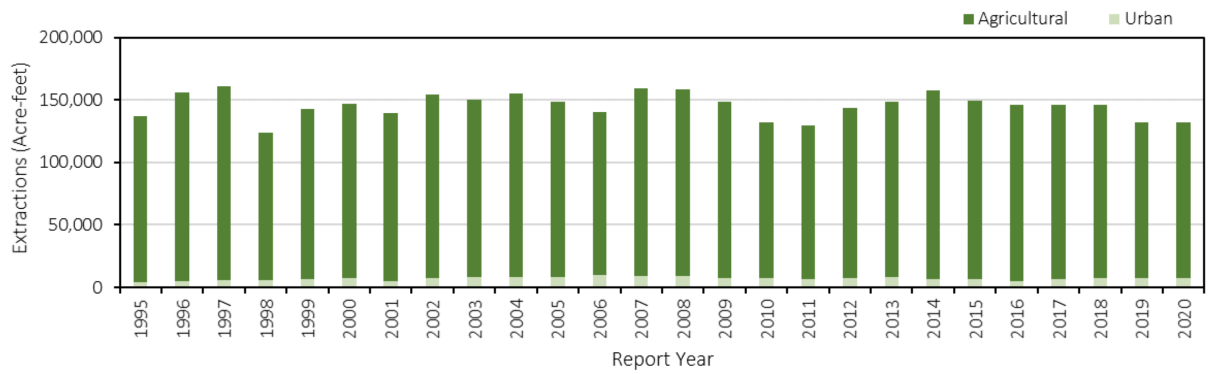


Figure 21. Groundwater Extractions from the Forebay Subarea, by type

2.5. Upper Valley Subarea

Total annual extractions from the Upper Valley between 1995 and 2020 averaged 135,410 AFY (Figure 22). Of this, 97% was agricultural reported extractions (131,440 AFY on average), and 3% was urban reported (3,970 AFY on average). Overall, Upper Valley extractions have decreased at a rate of 640 AFY over the period of record. This reduction was seen in both agricultural and urban extractions, decreasing at 600 and 40 AFY on average, respectively.

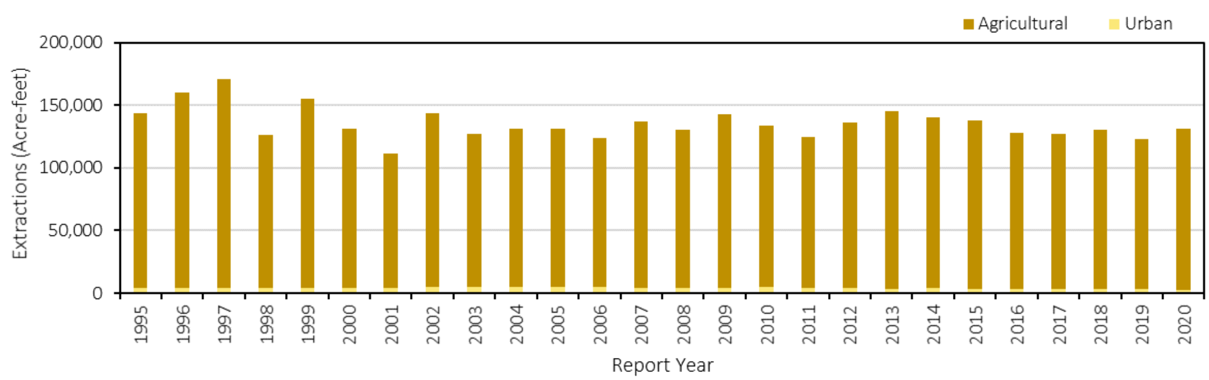


Figure 22. Groundwater Extraction from the Upper Valley Subarea, by type

3. CSIP Water Usage (Zone 2B)

3.1. Castroville Seawater Intrusion Project

The Castroville Seawater Intrusion Project (CSIP) has been delivering recycled water to growers near Castroville since 1998 to reduce groundwater pumping near the coast and slow the advancement of seawater intrusion in the coastal aquifers. On average, 20,040 AFY was delivered to the CSIP distribution system between 1999 and 2020, with different proportions of recycled, river and supplemental groundwater extractions (Figure 23). 1998 is not included in the average because it was the first year of the project and was not a full year of operation. The amount of delivered water has been slowly increasing at a rate of 190 AFY on average. There is seasonal variability in the amount of water supplied to CSIP, with a moderate negative correlation in the amount of CSIP delivered water and annual precipitation at the Salinas Airport station, similar to the correlation between valley-wide groundwater extractions and precipitation.

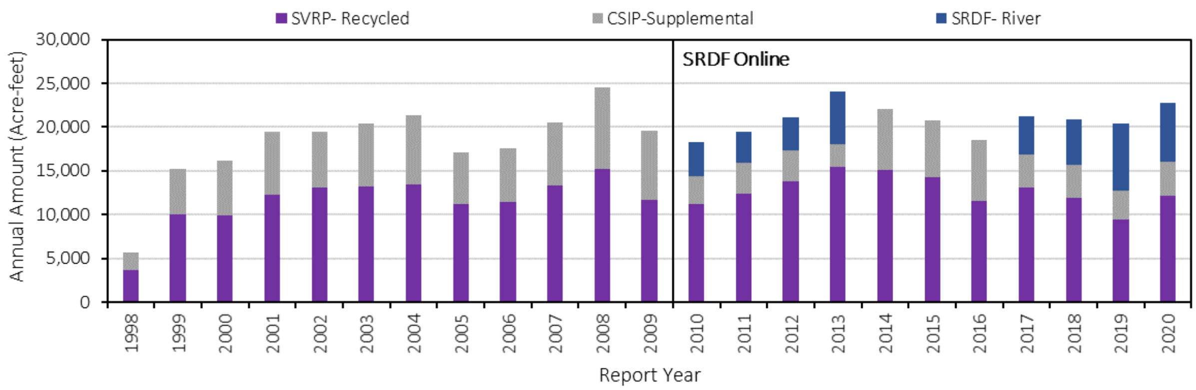


Figure 23. CSIP Delivered Water, by Source

3.2. SVRP Treated Water

Between 1998 and 2020, the SVRP provided an average of 12,140 AFY to the CSIP system (63% of the delivered project water). There is no noticeable trend in the amount of SVRP treated water delivered between 1998 and 2020. Still, seasonal variability is seen and can be correlated with annual precipitation totals at the Salinas Airport.

3.3. SRDF Diverted Water

The SRDF came online in 2010, delivering a third water source to growers in the CSIP area. Between 2014 and 2016, the SRDF was non-operational due to a lack of reservoir releases that resulted from the 2012-2016 drought. In years when the SRDF was operational, 5,100 AFY (24% of the delivered project water) was diverted from the river. This additional water source allowed for a 44% reduction of extractions from CSIP supplemental wells, which helps slow the advancement of seawater intrusion in the coastal aquifers.

3.4. CSIP-Supplemental Well Extractions

Extractions from CSIP supplemental wells makes up one of the three sources of water to CSIP. The amount of extraction from CSIP supplemental wells is highly dependent on SRDF operations, though pumping from the supplemental wells is sometimes conducted for CSIP operations purposes, such as to maintain pressure in the system. Groundwater extractions from CSIP supplemental wells averaged 6,600 AFY in years when the SRDF was not online, compared to 3,450 AFY in years when the SRDF was operational. This difference equated to a 44% reduction in groundwater extractions in years when the SRDF was available to deliver water.

3.5. Additional Groundwater Extractions in Zone 2B

MCWRA Ordinance No. 3790 *"…provides for the management of all groundwater wells within the Castroville Seawater Intrusion Project area, known as Zone 2B, following completion and start-up of the Castroville Seawater Intrusion Project. It prohibits and otherwise restricts pumping from groundwater wells in Zone 2B, and it provides for the classification of the various wells…"* among other actions. Classification of a well as a "standby well" allows for well owners to maintain their wells following the start-up of CSIP and operate these wells under certain circumstances *"…as an additional assurance that an adequate water supply will be available at all times."*

Groundwater extractions from private wells are still occurring within Zone 2B. Figure 24 shows the additional pumping in Zone 2B, compared to the other water sources within the CSIP distribution system. On average, private wells in Zone 2B extracted 1,600 AFY from 1998 to 2020. However, extractions have ranged from 3,510 AF (1998) to 700 AF (2020). Since 1998, as many as 46 individual wells reported extractions in Zone 2B; though this declined to only 11 individual wells that reported extractions in 2020.

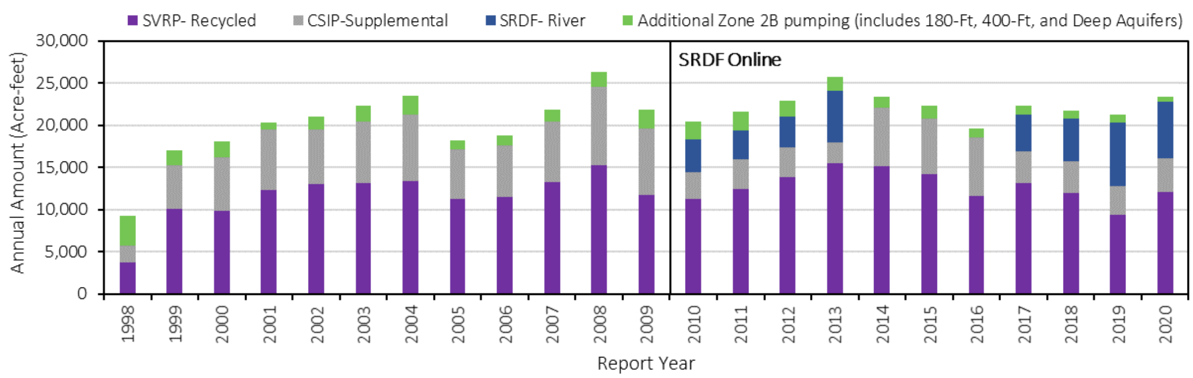


Figure 24. Zone 2B Water Usage, by Source

Extractions from individual (non-supplemental) wells in Zone 2B come primarily from the 400-Foot or East Side Deep Aquifers (83%), with 15% extracted from the Deep Aquifers of the Pressure Subarea, and 2% from 180-Foot Aquifer wells (Figure 25). One well has insufficient construction information to associate it with a specific aquifer unit, but for Figure 25 is grouped with extractions from the 400-Foot Aquifer. There are no dual-screened wells reporting extractions in Zone 2B. The large amount of private extractions over the first few years of the project is due to the phasing in of turnouts before all growers started using CSIP system water.

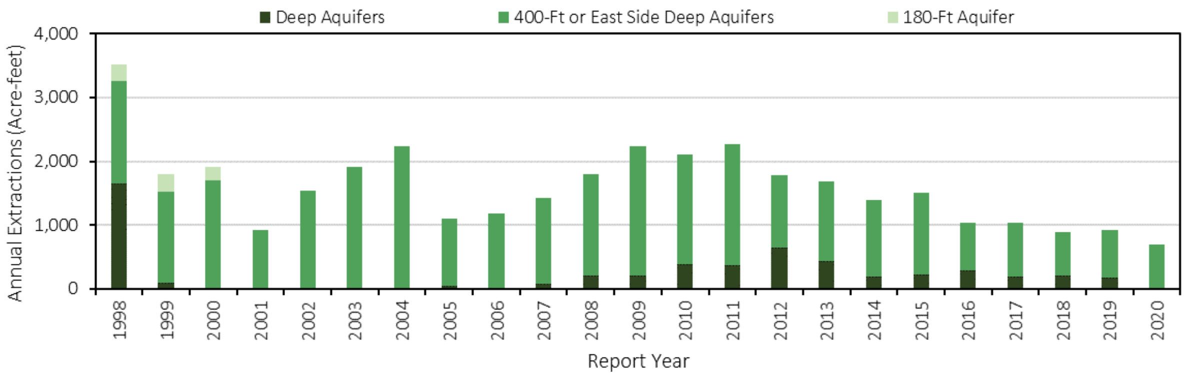


Figure 25. Additional Zone 2B Extraction, by Aquifer

As discussed in the *Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin: 2020 Update* (2020 *Recommendations* Report), proposed CSIP project efficiencies, such as scheduling water delivery, could eliminate the need for groundwater extractions from private wells within the Zone 2B Boundary.

4. Extractions in the Area of Impact

As discussed in Section 1.2.8, the Area of Impact encompasses the area in which chloride concentrations in the 180-Foot or 400-Foot Aquifers were 250 mg/L or greater, based on data from 2015. This area is considered vulnerable due to pathways, conduits, and a vertical downward gradient that could allow seawater intrusion to migrate from the 180-Foot Aquifer into the 400-Foot Aquifer.

Groundwater extractions in the Area of Impact have averaged 32,680 AFY between 1995 and 2020. Figure 26 shows the breakdown of extractions by aquifer unit. On average, 53% of extractions were reported from the 400-Foot Aquifer, followed by 13% from wells with unknown construction and 11% from wells screened in the Deep Aquifers. Since 2015, there has been a decline in overall extractions from the Area of Impact at a rate of 1,610 AFY. Most of this decline was seen in 400-Foot Aquifer extractions; however, extractions from wells in the East Side, 180-Foot Aquifer, dual-screened wells, and wells with unknown construction also decreased. The one exception is extractions from the Deep Aquifers, which since 2015 have increased at a rate of 1,020 AFY on average. By 2020, Area of Impact extractions from the Deep Aquifers exceeded those from the 400-Foot Aquifer.

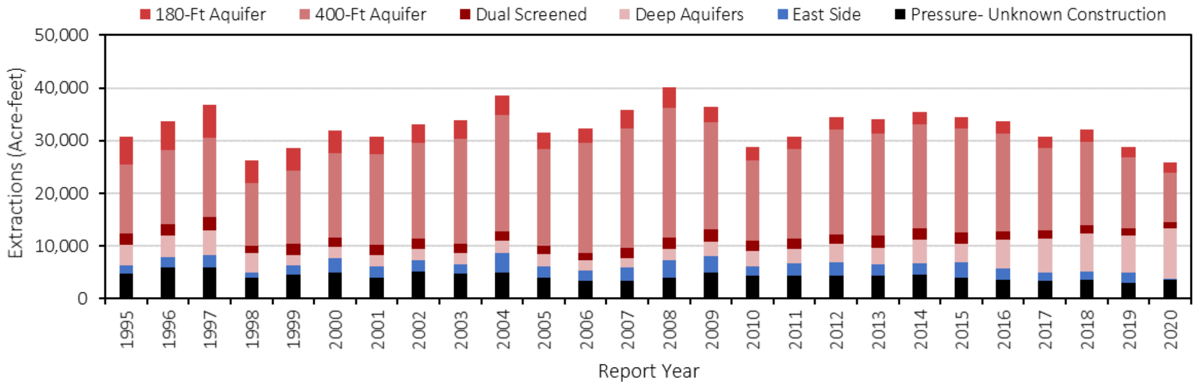


Figure 26. Groundwater Extractions in the Area of Impact, by Aquifer

5. Water and Land Use

Data collected in the Water and Land Use Forms (WLUF) pertain to the amount of water applied to the net acreage of individual crop types over the last year. These forms provide valuable information to compare water use, land use, and water usage per crop type for the major crop types and across the four subareas.

Crop type categories include vegetables, berries, grapes, trees, field crops (e.g., beans and grains), forage crops (e.g., alfalfa and pasture), nursery, and other (e.g., sod, flower bulbs, cactus, dust control, frost prevention, etc.). In 2019, cannabis was added as a crop type for the first time. Before 1999, some companies reported net acres in the water and land use form, and others crop acres. In 1999, Staff made efforts to standardize the information reported and have companies only report the net acres grown. As a result, the following section only discusses water and land use data from report year 1999 onward.

Valley-wide, an average of 157,200 net acres of crops have been grown over the period of record; this net acreage has increased at a rate of 2,150 acres/year on average. The increase in net acres has been seen in all subareas, with the most significant growth seen in the Upper Valley subarea (660 acres/year, on average), followed by the Forebay (650 acres/year), Pressure (550 acres/year), and East Side subarea (290 acres/year) (Figure 27).

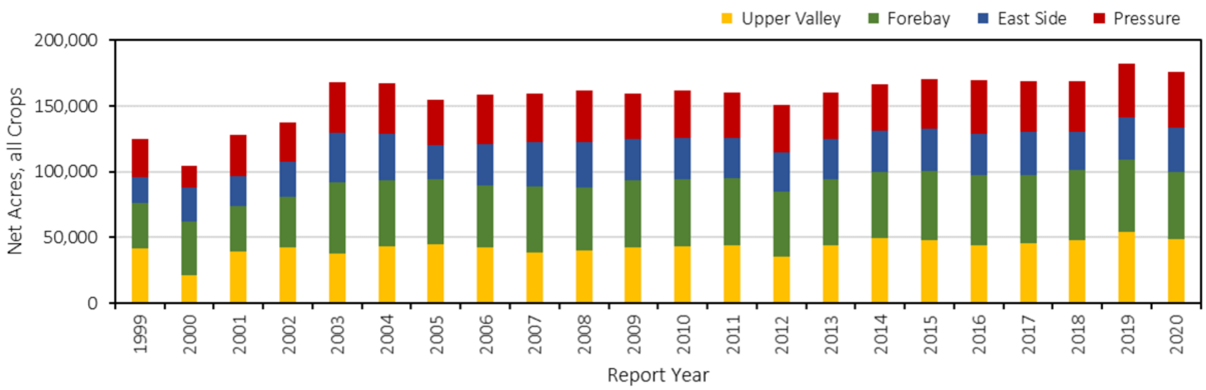


Figure 27. Net Acres of all Crops reported in the Water and Land Use Forms, by Subarea

Along with the increase in net acres grown, an increase in water use has also been observed. Reported water usage on the WLUF has averaged 411,300 AFY and ranged from 279,300 to 463,770 AFY. Not all agricultural extractions are required to complete a WLUF, which is why there is a difference between agricultural water extracted and the amount reported in this section.

The amount of water used per net acre grown can be considered water efficiency, reported as acre-feet/acre (AF/acre). Water efficiency can vary by crop type, subarea, and year; over the period of record, these values have ranged from 0.1 AF/acre to over 15 AF/acre.

Agricultural water efficiency across the entire GEMS reporting area has improved over the period of record (Figure 28). Specifically, the Forebay and Upper Valley subareas saw the most significant improvement, with total water usage decreasing at a rate of 0.025 AF/acre/year on average. Water efficiency in the Pressure and East Side subareas has remained relatively constant over the period of record. Some annual variability in water efficiency is seen year to year. Similar to annual extractions, there is a weak negative correlation between water efficiency and annual precipitation, with drier periods generally reporting a higher AF/acre used and wetter periods a lower AF/acre.

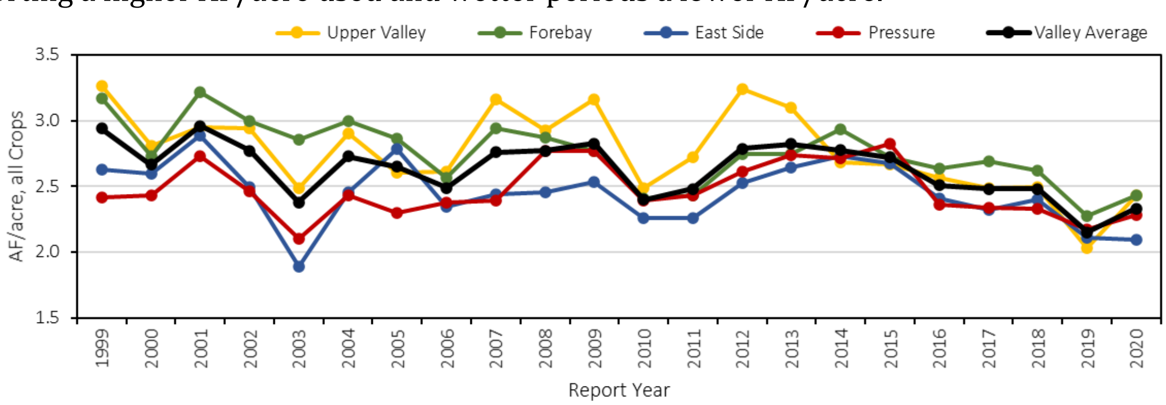


Figure 28. Water Efficiency (AF/acre) for all crop types, by Subarea

5.1. Water and Land Use in the Pressure Subarea

The average reported water and land use in the Pressure Subarea for all crop types was 87,500 AF and 35,480 acres over the period of record (Figure 29). The primary crop types grown in the Pressure Subarea have been vegetables (90% of total acres on average), followed by berries (5%) and grapes (4%). The crop types using the majority of water by volume have been vegetables (92%), followed by berries (5%), and grapes (1%). The largest increase in net acres is attributed to vegetables, at an average rate of 390 acres/year, followed by berries at 110 acres/year. The reported net acres of grapes have remained fairly constant over the period of record.

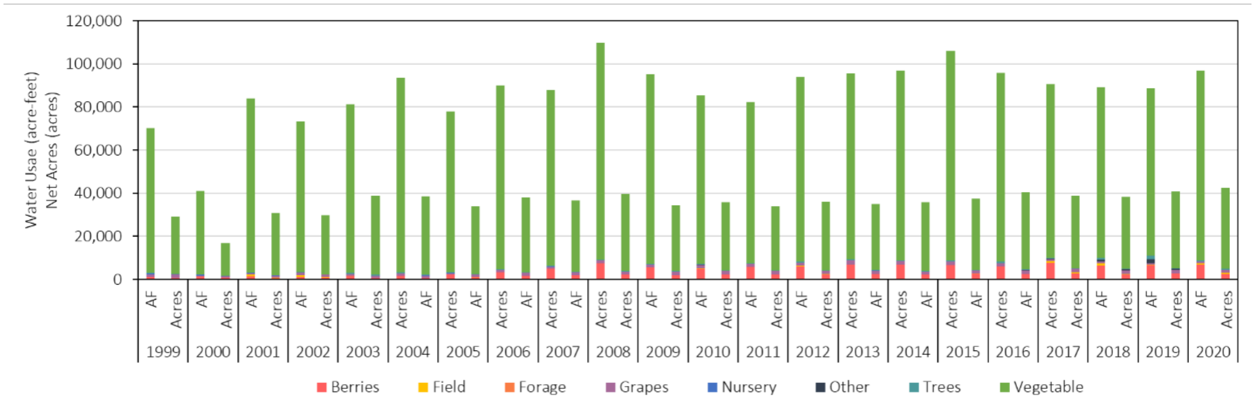


Figure 29. Water and Land Use in the Pressure Subarea, by Crop Type

Water efficiency for vegetables and grapes has remained constant over the period of record. However, water efficiency for berries has decreased, with an average increase of 0.035 AF/acre/year seen over the period of record (Figure 30).

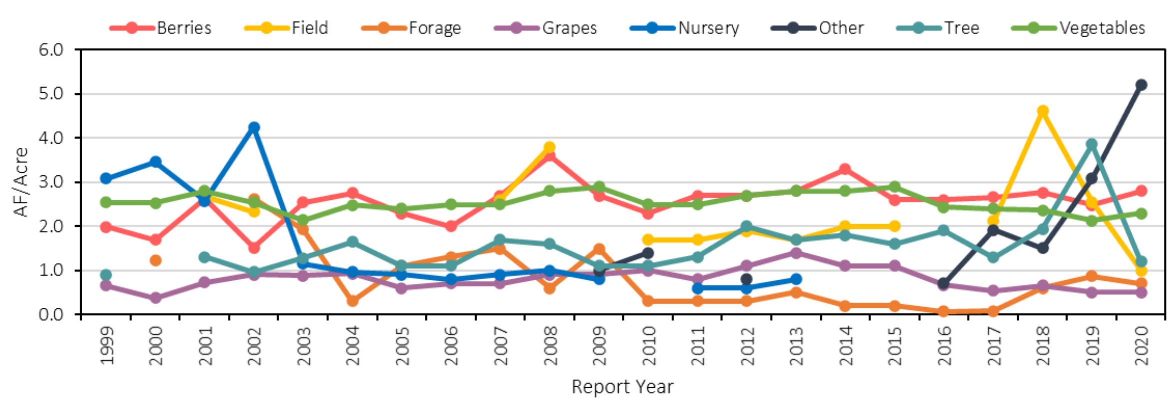


Figure 30. Water Efficiency (AF/acre) in the Pressure Subarea, by Crop Type

5.2. Water and Land Use in the East Side Subarea

The East Side Subarea reported an average land use of 25,810 acres and an average water use of 62,760 AF over the period of record. The primary crop types grown in the East Side have been vegetables (82% of total acres on average), followed by berries (11%) and grapes (3%). Vegetables have used the majority of the water by volume (79%), followed by berries (11%), and grapes (7%). The breakdown of water and land use in the East Side Subarea by crop type is shown in Figure 31. The net acreage of vegetables grown has stayed constant over the period of record. Berries saw an increase in net acreage produced between 1999 and 2013, but in recent years have seen a decrease in the acreage grown.

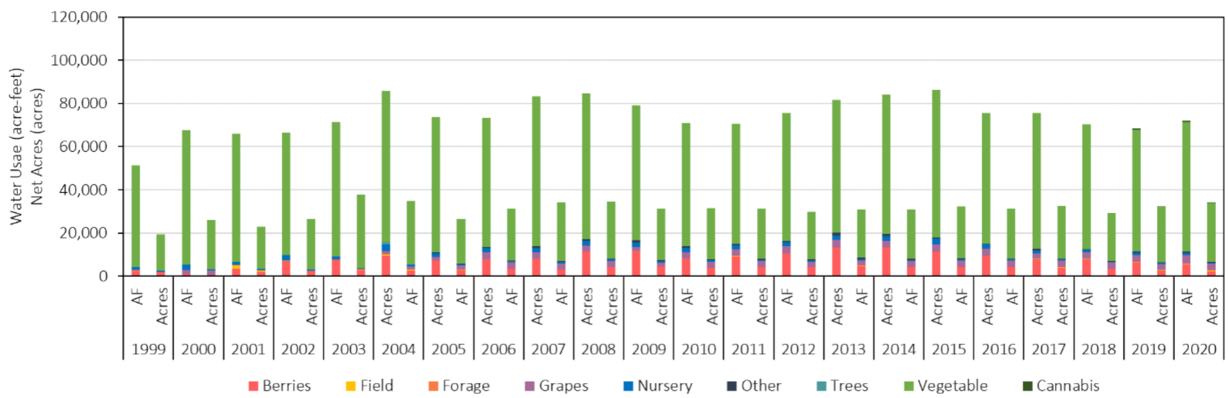


Figure 31. Water and Land Use in the East Side Subarea, by Crop Type

Water efficiency for vegetables and berries has remained relatively constant in the East Side over the period of record, averaging 2.5 and 2.4 AF/acre, respectively (Figure 32). Cannabis was added as a separate crop type in 2019; before that, cannabis data would have been included with Nursery crop types.

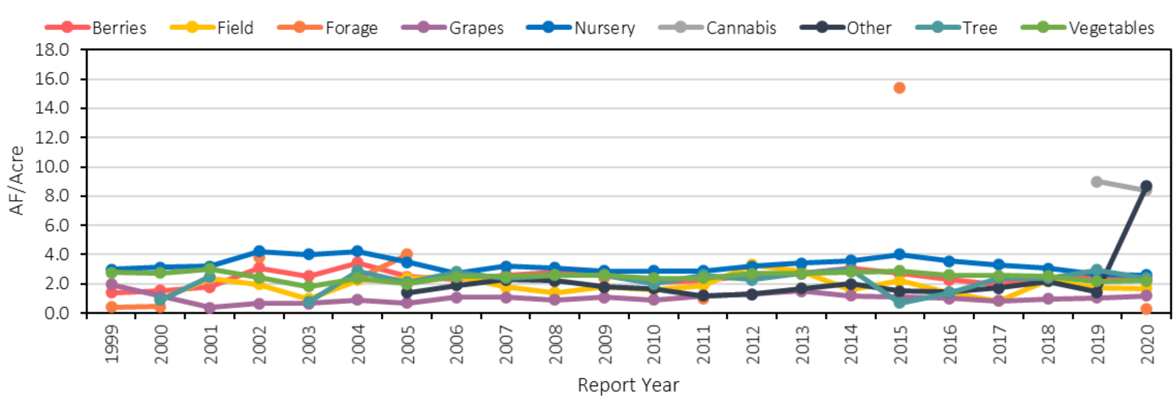


Figure 32. Water Efficiency (AF/acre) in the East Side Subarea, by Crop Type

5.3. Water and Land Use in the Forebay Subarea

The average reported water and land use in the Forebay Subarea for all crop types was 132,830 AF and 48,540 acres over the period of record. The primary crop types grown in the Forebay have been vegetables (65% of total acres on average), followed by grapes (31%) and tree crops (2%). The majority of the water has been used for vegetables (82%), followed by grapes (15%), and then tree crops (1%). The breakdown of water and land use in the Forebay Subarea by crop type can be seen in Figure 33. Both vegetables and grapes have seen an increase in net acres over the period of record, at an average rate of 265 and 390 acres/year, respectively.

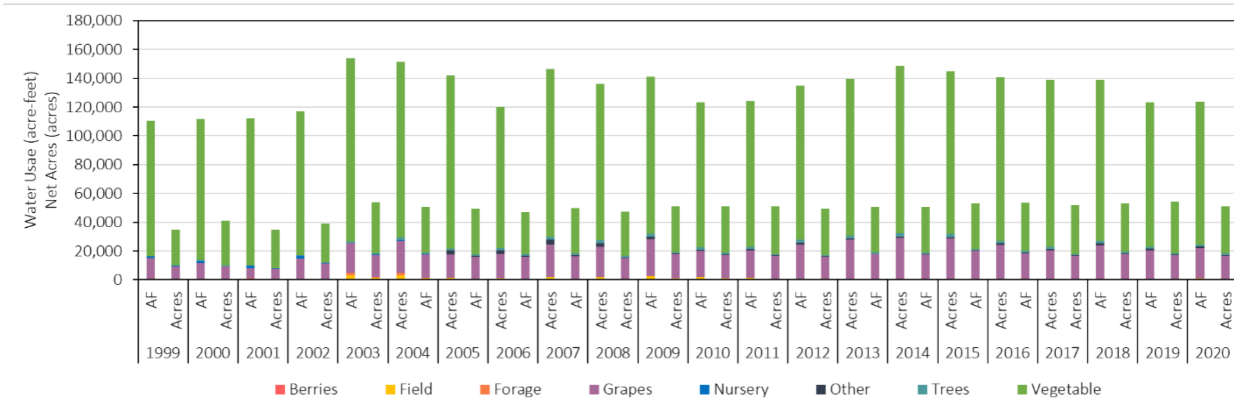


Figure 33. Water and Land Use in the Forebay Subarea, by Crop Type

Water efficiency for vegetables has improved over the period of record, with water usage decreasing at a rate of 0.025 AF/acre/year on average. However, water efficiency for grapes and all other crop types has remained similar over the period of record (Figure 34).

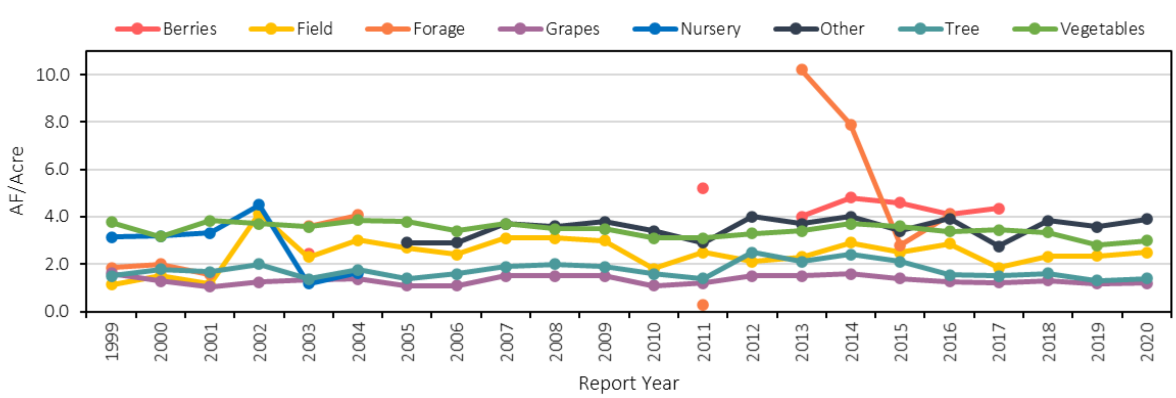


Figure 34. Water Efficiency (AF/acre) in the Forebay Subarea, by Crop Type

5.4. Water and Land Use in the Upper Valley Subarea

The Upper Valley reported an average land use of 42,670 acres and water use of 116,820 AFY over the period of record. The primary crop types grown have been vegetables (57% of total acres on average), followed by grapes (40%) and field crops (2%). Vegetables have accounted for the majority of water usage (76%), followed by grapes (22%), and field crops (2%). The breakdown of water and land use in the Upper Valley Subarea by crop type can be seen in Figure 35. The net acreage of vegetables grown has increased over the period of record, at an average rate of 480 acres/year. Grapes have also seen an increase in net acres grown, at a rate of 195 acres/year on average.

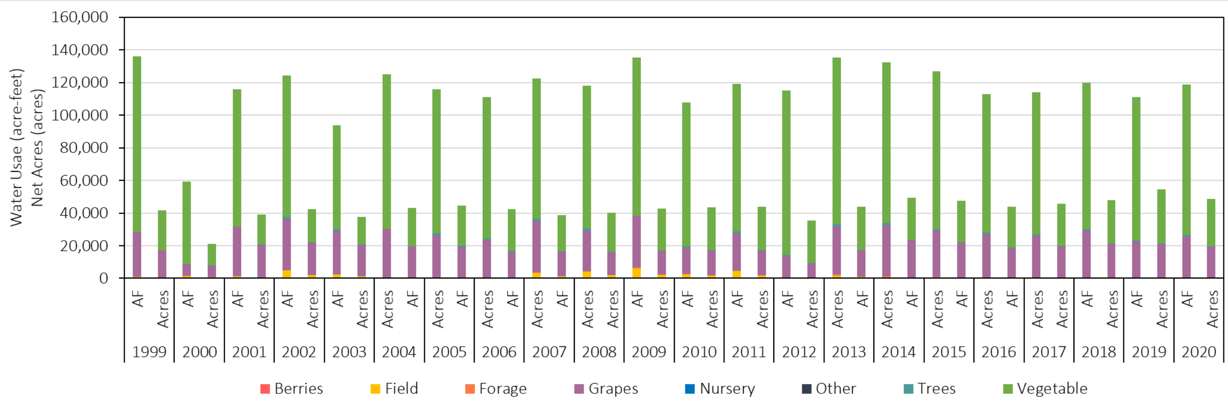


Figure 35. Water and Land Use in the Upper Valley Subarea, by Crop Type

Water efficiency for vegetables and forage has improved over the period of record, with water usage decreasing at an average rate of 0.05 AF/acre/year. Water efficiency for forage crops has also improved over the last decade, with water usage decreasing by 0.23 AF/acre/year. However, water efficiency for grapes and all other crop types has remained similar over the period of record (Figure 36).

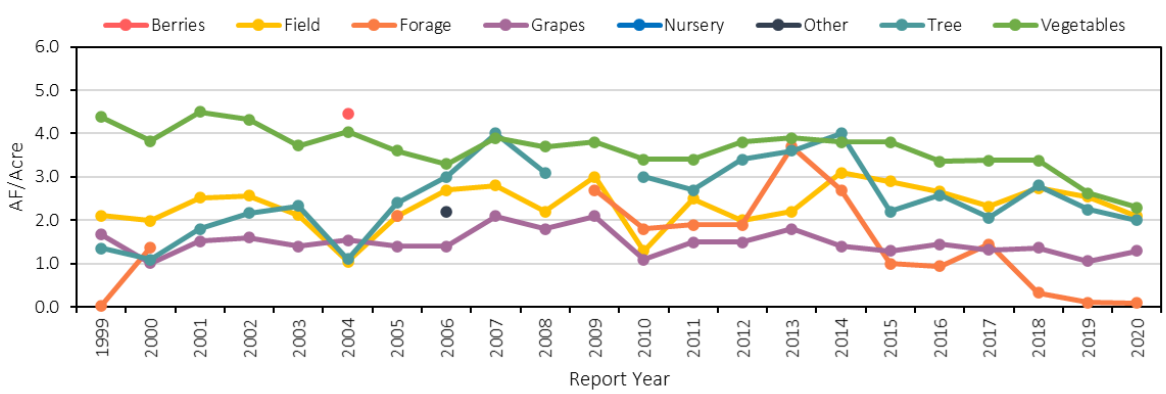


Figure 36. Water Efficiency (AF/acre) in the Upper Valley Subarea, by Crop Type

6. Water Conservation

6.1. Agricultural Water Conservation

"The conservation of agricultural water is an economically and environmentally feasible way to reduce water demand, help prevent overdraft, and to help curtail the presently existing threat to the groundwater basin" (MCWRA Ordinance No. 3851).

Agricultural water conservation plans (AWCP) describe how growers are reducing water usage by detailing the conservation measures implemented each year and irrigation methods utilized for various crop types. As discussed in Section 4, improvements in water efficiency have been seen throughout the duration of the GEMS program, which may be attributed to changes in irrigation methods or implementing best management practices.

AWCPs are not subarea specific, and this section will describe practices implemented by growers across the GEMS reporting area.

6.1.1. Irrigation Methods Over Time

The first portion of the AWCP asks growers about the types of irrigation methods implemented by acres of crop type in the upcoming year. Figure 37 shows the net acreage for each irrigation method, stacked on top of one another. On average, drip irrigation has been the predominant irrigation method (55% of total net acres), followed by the sprinkler & furrow method (23%) and hand-move sprinklers (14%).

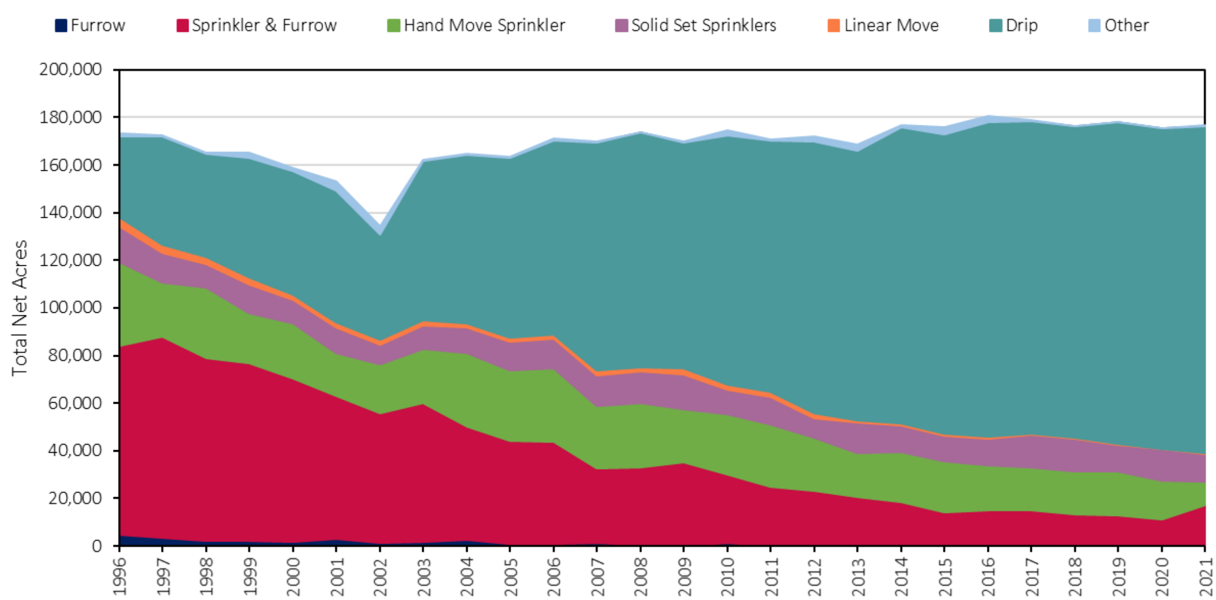


Figure 37. Irrigation Methods over Time, all Crop Types (1996-2021)

Shifts in the predominant irrigation methods have been seen over the period of record. Since 1996, there has been a 300% increase in the net acres irrigated using drip irrigation, increasing from 33,000 to 137,000 acres. This increase was seen across several crop types, with the largest increases in vegetables, followed by grapes and berries. The most significant decline has been in the sprinkler & furrow method, decreasing from 84,000 to 11,000 net acres. Vegetables are the main crop irrigated using the sprinkler & furrow method (98% of net acres on average), followed by field crops (2%). Additional figures showing irrigation methods for individual crop types over time are included in Appendix F.

6.1.2. Best Management Practices

The second portion of the AWCP asks growers what best management practices they plan to implement in the upcoming year and the total acreage to which each approach is being applied. Over the period of record, the use of automatic time clock on pumps and/or pressure switches on boosters has been the broadest applied practice (85% of reported irrigated acres), followed by the use of water flowmeters (82% of reported irrigated acres). The top ten best management practices, by average acreage over the period of record, are shown in Figure 38. Additional figures for all best management practices are included in Appendix F.

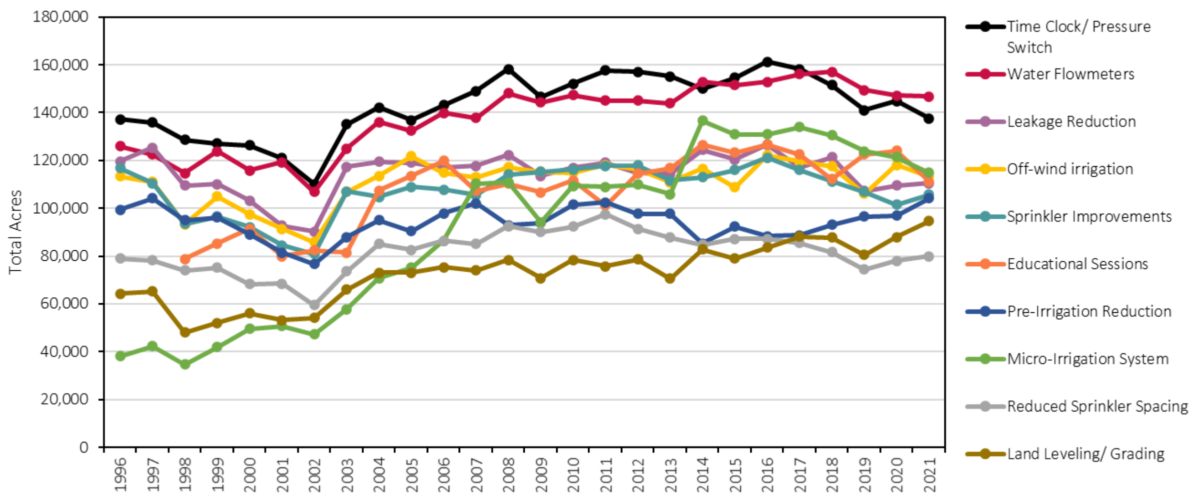


Figure 38. Top Ten Best Management Practice, by average acreage over the period of record

The use of micro-irrigation systems, which includes drip tape, or the addition of pressure compensating emitters or micro-sprayers, has seen more than a three-fold increase over the period of record. In 1996, only 38,000 acres (22% of reported irrigated acres) had micro-irrigations installed; by 2014, this rose to 136,600 acres (77% of reported irrigated acres). Other practices such as land leveling and grading, the use of transplants, and the development of conservation programs have also seen increases over the period of record. Conversely, some practices have seen a decline in use over the period of record, including surge flow irrigation, tailwater reuse, tailwater return systems, and summer fallowing of land.

6.2. Urban Water Conservation

As discussed in Section 1.2, urban water purveyors must submit an UWCP describing the best management practices applied in the previous year and those they plan to implement in the upcoming year. The following sections summarize information collected in the UWCPs for small water systems, which serve 15-199 customer connections, and large water systems, which serve 200 or more customer connections.

6.2.1. Water Usage per Connection Class

Urban water purveyors must submit the number of connections by class type and water delivered to each class type. Connection classes include single-family residential, multi-family residential, commercial/institutional (e.g., retail, offices, schools, hospitals, hotels), industrial, landscape irrigation (e.g., parks, cemeteries), and other uses (e.g., fire suppression, line flushing, construction or temporary meters, etc.).

Over the period of record, single-family residential connections had the lowest AF/connection on average (0.384 AF/connection), and industrial connections had the highest (11.478 AF/connection), not including agricultural irrigation. Industrial water usage per connection saw an increase of 0.78 AF/connection/year, on average. Single-family residential, multi-family residential, and landscape irrigation connection classes have seen a slight decrease in water usage per connection over the period of record, while commercial/institutional usage has stayed stable (Figure 39).

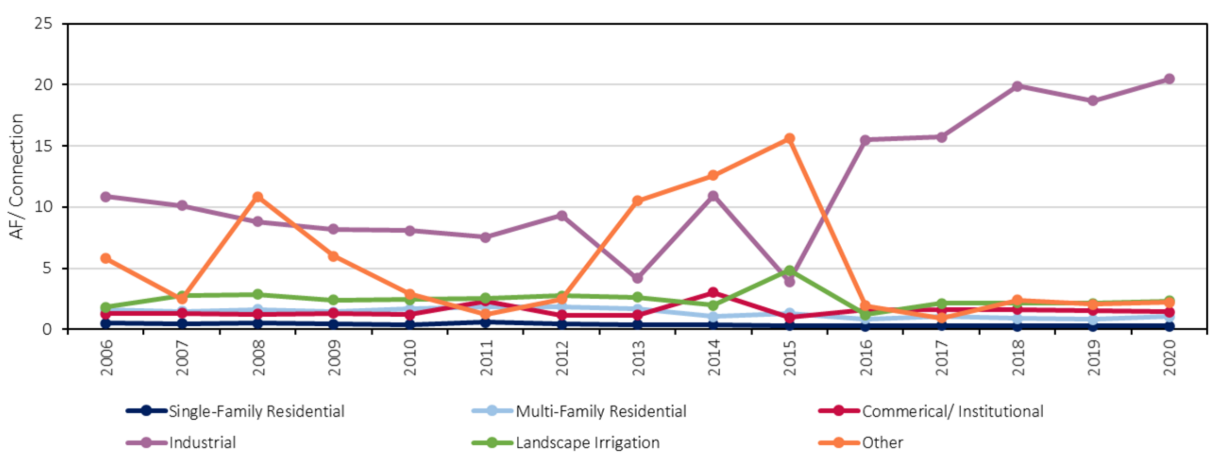


Figure 39. Large Water Systems AF/Connection, by Connection Class

Figure 40 shows the AF/connection for agricultural irrigation connections served by large water systems. The 2016 annual summary report first included this category as a separate connection class. Before that, information on the amount of water delivered to agricultural irrigation was collected, but not the number of connections. As such, AF/connection for agricultural irrigation is only available from 2016 onwards. Between 2016 and 2020, water systems delivered 76.433 AF/connection to this connection class on average.

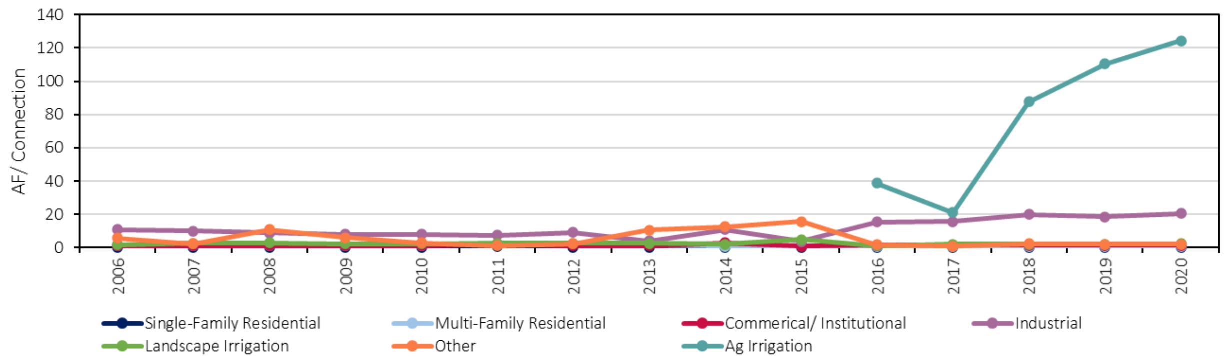


Figure 40. Large Water Systems AF/Connection for the Agricultural Irrigation Connection Class

Over the period of record, multi-family residential connections had the lowest AF/connection on average (0.552 AF/connection), followed closely by single-family residential (0.566 AF/connection) (Figure 41). Industrial connections had the highest AF/connection on average (19.050 AF/connection). The significant increase in 2016 in the industrial connection class was due to a change in the number of connections reported, but not in the overall water usage. Single-family residential, multi-family residential, and commercial/institutional classes have seen a slight decrease in water usage per connection over the period of record, while landscape irrigation and other connection types have seen an increase in recent years.

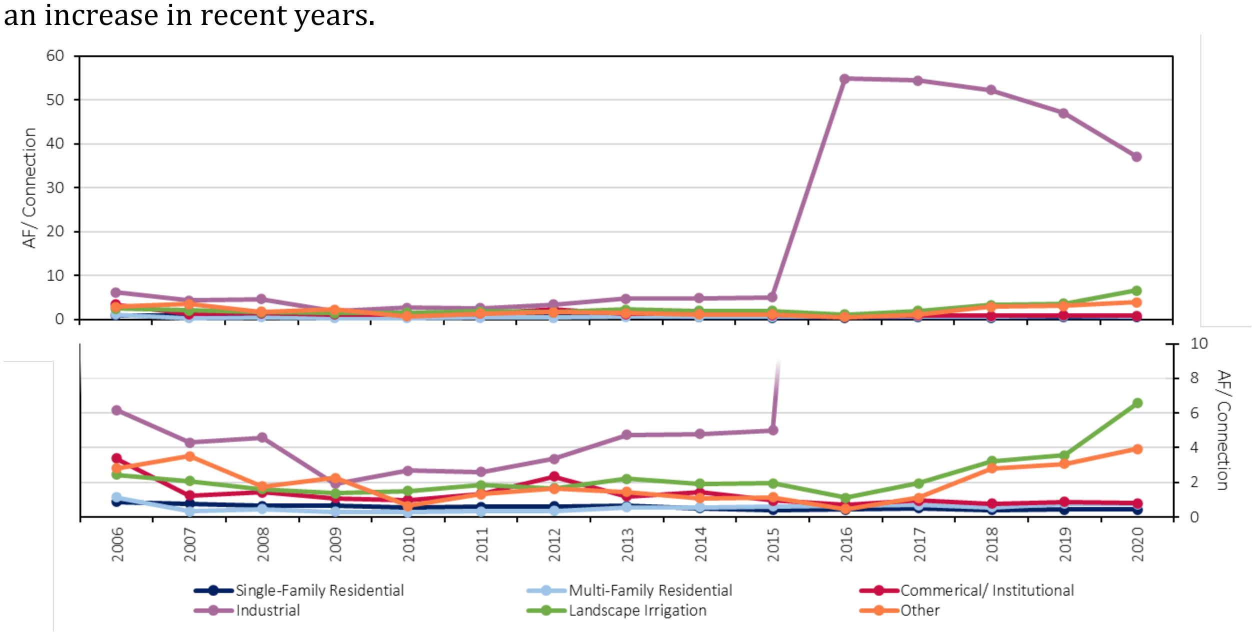


Figure 41. Small Water Systems AF/Connection, by Connection Class

6.2.2. Best Management Practices

Best management practices in the UWCP include, but aren't limited to, those related to public information programs, metering water usage, audits, incentive programs, and water conservation for various connection types. Between 1996 and 2020, the broadest applied practice for large and small water systems has been advising customers when a leak is apparent on the customer's side of the water meter (97% of large water systems, by service area acreage, and 87% of small water systems)—followed by requiring all new connections to be metered and billed by volume of use (96% of large water systems, 85% of small water systems).

The top ten best management practices, by average percentage applied over the period of record, are in Table 1 and Table 2 for large and small water systems, respectively. Additional tables for all best management practices and year-to-year percentages are included in Appendix G.

Table 1. Top Ten Best Management Practices, Large Water Systems

97%	Advise customers when it appears possible that leaks exist on customer's side of water meter
96%	Implement requirements that all new connections be metered and billed by volume of use
87%	Provide individual historical water use information on water bills
87%	Support of legislation prohibiting sale of toilets using more than 1.6 gpf
86%	Coordinate with other entities in regional efforts to promote water conservation practices
86%	Provide guidelines, information, and/or incentives for installation of more efficient landscapes and water saving practices
86%	Provide conservation information in bill inserts
85%	Perform distribution system leak detection and repair whenever the audit reveals that it would be cost-effective
82%	Enforcement and support of water conserving plumbing fixture standards, including gradual requirement for High Efficiency Toilets (HET) in all new construction
77%	Offer free interior and exterior water audits to identify water conservation opportunities

Table 2. Top Ten Best Management Practices, Small Water Systems

87%	Advise customers when it appears possible that leaks exist on customer's side of water meter
85%	Implement requirements that all new connections be metered and billed by volume of use
82%	Support of legislation prohibiting sale of toilets using more than 1.6 gallons per flush (gpf)
73%	Perform distribution system leak detection and repair whenever the audit reveals that it would be cost-effective
69%	Establish a program to retrofit any existing unmetered connections and bill by volume of use
68%	Provide individual historical water use information on water bills

Table 2 continued…	
68%	Provide guidelines, information, and/or incentives for installation of more efficient landscapes and water saving practices
62%	Enact and enforce measure prohibiting water waste as specified in Monterey County Water Resources Agency Ordinance No. 3932 or as subsequently amended, and encourage the efficient use of water
59%	Coordinate with other entities in regional efforts to promote water conservation practices
56%	Provide conservation information in bill inserts

7. Summary

Data collected and summarized from the 25-years of GEMS reporting has shown the following:

1. Between 1995 and 2020, annual groundwater extractions have been 495,000 AFY on average. Agricultural extractions have historically made up 91% of total groundwater extractions, while urban extractions account for the remaining 9%.

2. Over the period of record, groundwater extractions have exhibited annual variability. There is a weak correlation between annual groundwater extractions and annual precipitation seen each year, with wetter periods correlated to years with lower groundwater extractions and drier periods associated with higher groundwater extractions reported. Notably, agricultural extractions exhibited this correlation, but urban extractions did not.

3. Water deliveries to CSIP have averaged 20,040 AFY between 1999 and 2020. In years when the SRDF was online, CSIP supplemental wells pumped 44% less groundwater. Additional groundwater extractions from private wells within Zone 2B are still occurring; however, extractions from these wells decreased by 80% over the project's history.

4. Information collected from the Water and Land Use forms shows that vegetables have accounted for 71% of total acreage reported and 82% of water usage, followed by grapes (23% of total acreage, 12% of water usage) and berries (3% of total acreage, 3% of water usage). However, the distribution of predominant crop types and water efficiency for each varies by subarea.

5. The net acreage of crops grown throughout the valley has increased over the period of record, resulting in increased water usage. However, water efficiency, or the amount of water applied per acre of a crop, has on average improved. The Forebay

and Upper Valley subareas saw the most significant improvements, mainly in water applied to vegetable crops.

6. The predominant irrigation methods utilized have changed over the period of record, including a 300% increase in acreage irrigated by drip irrigation and a decline in the sprinkler & furrow, furrow, and linear move methods.

7. Agricultural and Urban Water Conservation Plans have provided information on the implementation of best management practices. For agricultural entities, top practices have included the use of time clocks or pressure switches, followed by water flowmeters on wells. For urban entities, top practices have included advising customers when a leak is possible on the customer's side of the water meter and implementing requirements that all new connections be metered and billed by volume of use.

8. Urban water usage data shows that industrial connections reported the highest AF/connection on average for large and small water systems. This doesn't include the agricultural irrigation connection class, which has reported higher AF/connection usage than the industrial connection class, but wasn't introduced in the annual summary reports until 2016.

8. References

Department of Water Resources. (2004). *Bulletin 118 Interim Update 2004; Salinas Valley Groundwater Basin, 180/400 Foot Aquifer Subbasin*.

Department of Water Resources. (2004). *Bulletin 118 Interim Update 2004; Salinas Valley Groundwater Basin, Forebay Aquifer Subbasin*.

Department of Water Resources. (2004). *Bulletin 118 Interim Update 2004; Salinas Valley Groundwater Basin, Upper Valley Aquifer Subbasin*.

Hanson, R.T., et al. (2002). *Geohydrology of a deep-aquifer system monitoring-well site at Marina, Monterey County, California*. https://pubs.usgs.gov/wri/wri024003/pdf/wrir024003.pdf

Harding ESE. (2001). *Hydrogeologic Investigation of the Salinas Valley Basin in the Vicinity of Fort Ord and Marina, Salinas Valley, California*. 12 April. 166p.

Kennedy/Jenks. (2004). *Hydrostratigraphic Analysis of the Northern Salinas Valley*. 14 May, 113p.

Monterey County Water Resources Agency. (1993). *Ordinance No. 3660: An Ordinance of the Monterey County Water Resources Agency Amending Ordinances No. 3406 and No. 3428 and Adopting New Requirements for Water Suppliers within Zones 2,2A and 2B to Register Groundwater Extraction Facilities.*

Monterey County Water Resources Agency. (1994). *Ordinance No. 3790: An Ordinance of the Monterey County Water Resources Agency Establishing Regulations for the*

Classification, Operation, Maintenance and Destruction of Groundwater Wells in MCWRA Zone 2B, to Protect the Salinas Valley Groundwater Basin Against Further Seawater Intrusion.

Monterey County Water Resources Agency. (1995). *Ordinance No. 3851: An Ordinance Requiring the Filing of Agricultural Water Conservation Plans.*

Monterey County Water Resources Agency. (2006). *Monterey County Groundwater Management Plan.*

Monterey County Water Resources Agency. (2017). *Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin*. https://www.co.monterey.ca.us/home/showdocument?id=57396

Monterey County Water Resources Agency. (2020). *Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin: 2020*