11 Groundwater Supply Sustainability

11.1 Introduction

The Sustainable Groundwater Management Act (SGMA) defines sustainable groundwater management as "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" {Water Code § 10721(u)}. "Undesirable results" are defined as any chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence and depletions of interconnected surface waters. The recent drought has increased Californians' awareness of groundwater management issues. Zone 7 has been sustainably managing the Livermore Valley's groundwater storage and use for over 40 years. In this section, those groundwater management activities and their results are reviewed with regard to long-term sustainability of the basin's groundwater supply. The sustainability of groundwater quality is discussed in the next section (*Section 12*).

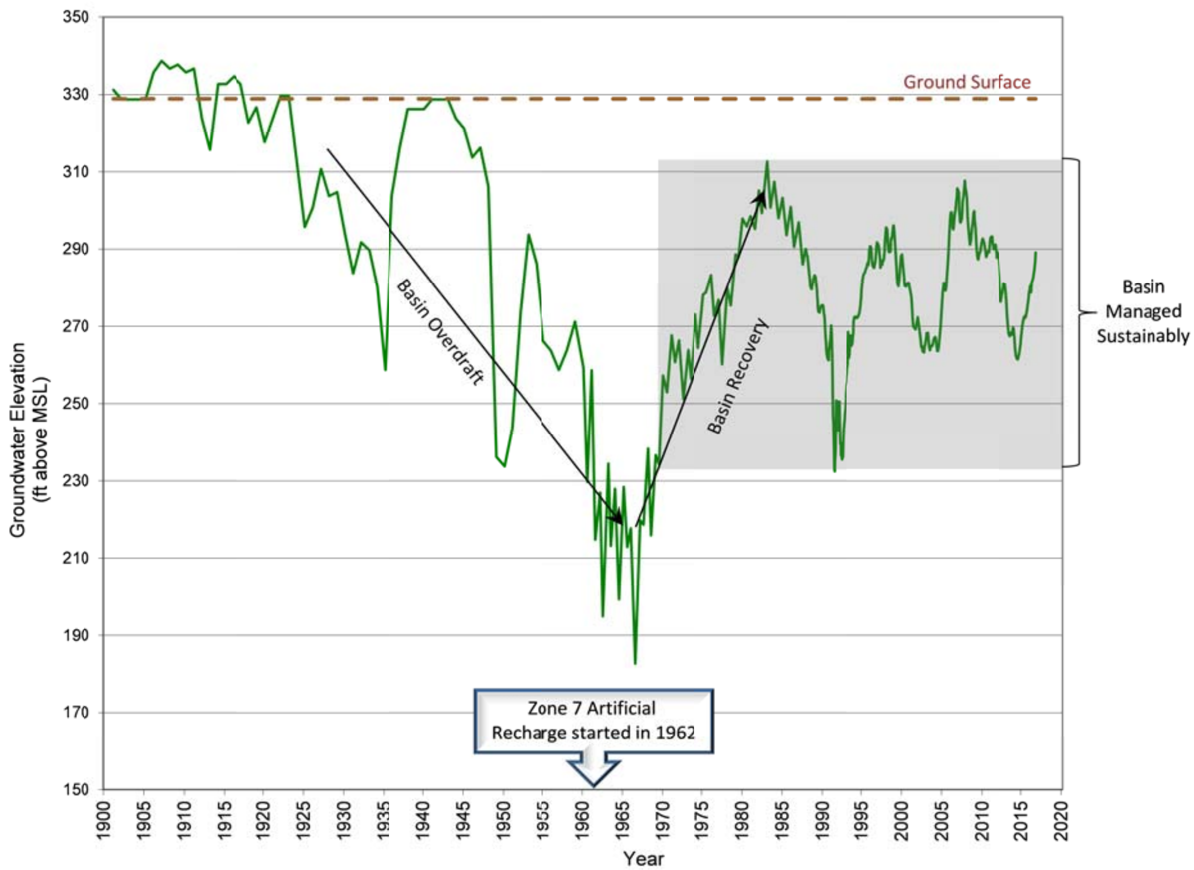
11.2 Historical Water Levels

Originally, much of the groundwater in the Main Basin was under artesian conditions. In the late 1800s, the pre-development groundwater levels in the basin created a gradient, causing groundwater to flow from east to west and naturally exit the basin as surface outflow into the Arroyo de la Laguna. In the early 1900s, mining of aquifer material began and groundwater began to be extracted in appreciable quantities, causing groundwater levels to drop throughout the basin. As a result, groundwater levels dropped below the point where groundwater would naturally outflow into the Arroyo de la Laguna, and continued to drop significantly during the 1940s and 1950s.

Zone 7 was established in 1957 partially to address the groundwater overdraft. The downward trend in groundwater elevation began to reverse in 1962 when Zone 7 began importing water from the State Water Project (SWP) for artificial recharge and later in the 1960s when Zone 7 began capturing and storing local runoff behind the new dam which created Lake Del Valle. The first imports were diverted to an off-stream recharge facility called Las Positas Pit. This facility was operated from 1962 until the late 1970s and again, briefly, in the 1980s. Thus, after experiencing historical groundwater lows in the 1960s, Main Basin water levels stabilized in the late 1960s and started to rise in the early 1970s with the advent of regional groundwater management programs (see *Figure 11-A*). Following a 'very critical dry' year in 1977, groundwater levels continued to recover and peaked in 1983 establishing the modern "basin full" threshold to the "Sustainable Operational Storage Range" (see *Section 5.1.1*).

Since 1983, water levels have been drawn down three separate times in response to periods of limited water importation from the State Water Project; but none of them reached the lower groundwater elevation limit established primarily by 1960's water levels (i.e., Historical Low). Groundwater levels were subsequently recovered following the first two episodes through Zone 7's managed aquifer recharge operations (aka "artificial recharge") and its reduction in groundwater production once surface water treatment plants were constructed (aka "in lieu recharge"). Recovery from the third, and most recent, drawdown episode (2012-2014) began in the 2015 WY and continued in through the 2016 WY with the concerted cutback in Zone 7 groundwater pumping and resumption and increase of its artificial recharge operations.

Figure 11-A: Groundwater Basin Management: Historical Groundwater Elevations at Fairgrounds Key Well



11.3 Sustainable Groundwater Management

11.3.1 Policies and Measures

Zone 7 has been sustainably managing the Livermore Valley Groundwater Basin by adopting and implementing numerous interrelated policies and programs to assess, manage, monitor, and protect the groundwater supply. In 2005, Zone 7 compiled and documented its groundwater management policies, objectives, and programs into its GWMP for the Livermore Valley Groundwater Basin. Since then, Zone 7 has published annual reports that summarize activities, monitoring results, achievement of objectives, the conditions of the basin, and any updates to the policies and objectives first outlined in the GWMP.

Zone 7 has been adaptively managing its groundwater supply with regard to current hydrologic conditions (see *Section 10.2.3*), water demands (*Section 10.2.4*), water quality conditions, and future water supply/demand forecasts. More specifically, Zone 7 maintains the sustainability of the groundwater basin by:

- Monitoring the long-term natural groundwater budget (inflow described in *Section 11.4.2.1* and outflow described in *Section 11.4.2.2*),
- Importing, artificially recharging, and banking surface water to meet future demands (described in *Section 11.4.3.1*),
- Implementing a conjunctive use program that maximizes use of the storage capacity of the groundwater basin (described in *Section 11.4.3.3*),
- Limiting long-term groundwater pumping to sustainably manage the basin (described in *Section 11.4.3.2*),
- Maintaining sustainable long-term groundwater storage volumes, even when total outflows exceed the natural sustainable supply (see *Section 11.4.3.3*),
- Promoting increased and sound recycled water use (*Section 8.2*),
- Administering a well permitting program under the Alameda County General Ordinance Code, Chapter 6.88 (*Section 12.4*),
- Monitoring mining area conditions and coordinating with the surface mining permitting agency (*Section 4*), and
- Identifying and planning for future supply needs and demand impacts (*Section 9*). This is often performed using Zone 7's groundwater model of the basin (*Section 11.5*).

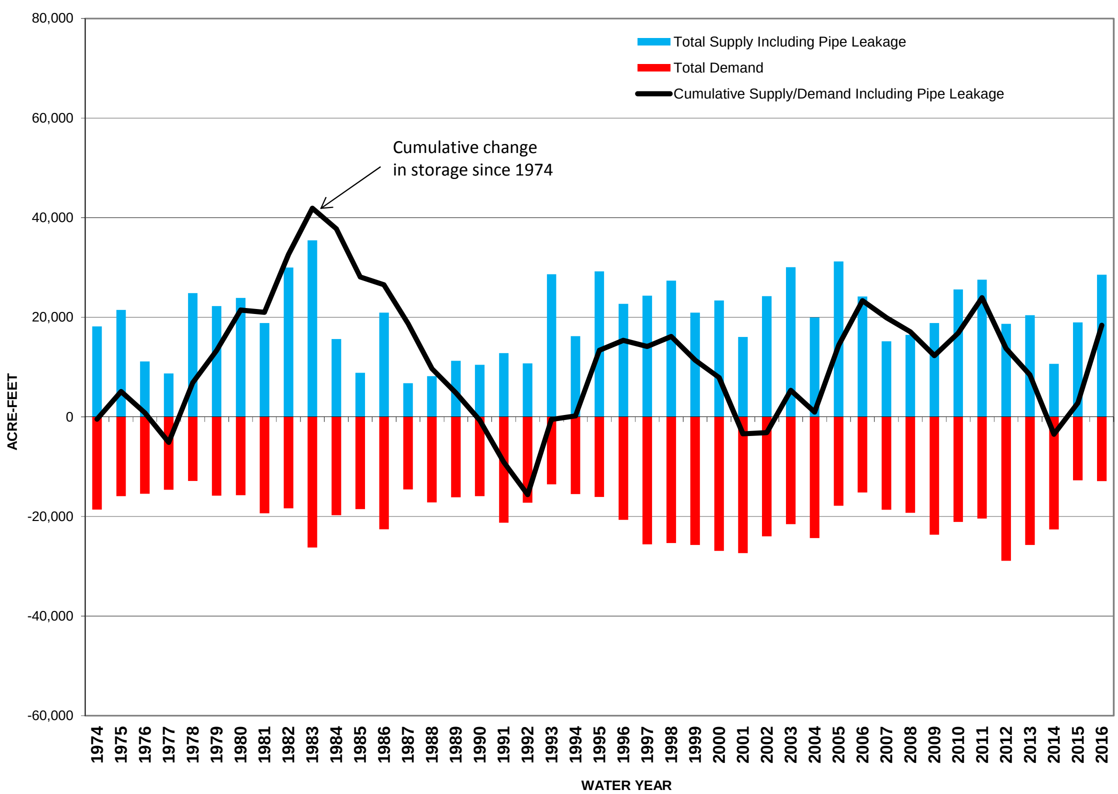
11.3.2 SGMA Compliance

In 2014, the State of California passed the Sustainable Groundwater Management Act (SGMA) to "empower local agencies to adopt groundwater management plans that are tailored to the resources and needs of their communities". The Act designated Zone 7 as the exclusive

Groundwater Sustainability Agency (GSA) for the Livermore Valley Groundwater Basin. In January 2017 Zone 7 submitted a notification letter to DWR of its *Decision to Become the Exclusive Groundwater Sustainability Agency for Livermore Valley Groundwater Basin (DWR Basin 2-10) (Zone 7, 2017).* As part of this effort, Zone 7 entered into a Memorandum of Understanding with other local agencies (e.g., Contra Costa County, City of San Ramon, East Bay Municipal Utilities District) for a small portion of the basin that extends north into Contra Costa County beyond the current Zone 7 Service Area.

SGMA requires that all high- and medium-priority basins be managed under a Groundwater Sustainability Plan (GSP) by 2022. However, an Alternative GSP may be submitted for this purpose if it is "functionally equivalent" to a GSP as specified in Title 23 of the California Code of Regulations and it can be demonstrated that the basin has been managed sustainably for the last ten years or more. Because Zone 7 has been managing the Livermore Valley Groundwater Basin sustainably for more than 40 years, Zone 7 submitted an Alternative GSP (*Zone 7, 2016c*) based on its GWMP to DWR in December 2016 for consideration. DWR has not established a timeline for their approval process of Alternative GSPs, however the submittal is currently posted on the DWR SGMA Portal website (http://sgma.water.ca.gov/portal/) for public review. The Zone 7 GSA notification is posted on the DWR website as well.

Figure 11-B: Groundwater Inflows and Outflows since 1974



In addition to *Figure 11-A* (*Section 11.2*), *Figure 11-B* further portrays the results of more than 40 years of Zone 7's groundwater supply management activities for the Main Basin. As demonstrated by the graph, any given year may have an imbalanced inflow and outflow, but long-term sustainability has been achieved; in this case, for 42 years. The sustainability for each supply and demand component is discussed in the next section (*Section 11.4*).

11.4 Groundwater Budget Components

11.4.1 Introduction

Groundwater inflows and outflows for the basin are divided into two budget categories:

- **Natural Sustainable Yield –** The Main Basin's "natural" sustainable groundwater yield (formerly referred to as the "safe yield") is the amount of water that can be pumped from the groundwater basin on average and replenished by long-term average natural supply (local runoff, precipitation, etc.). "Natural" groundwater inflow consists of recharge that is independent of Zone 7's activities (e.g., rainfall, applied water for irrigation, natural stream recharge, and subsurface inflow). Groundwater pumping by non-Zone 7 entities (by retailers, agriculture, or domestic use), mining area losses (e.g. pond evaporation, mining exports), and subsurface outflow are assigned to this sustainable water supply.

- **Zone 7 Groundwater Pumping and Recharge –** Zone 7's groundwater pumping is offset by the supplies it captures or imports and then recharges into the groundwater basin. Zone 7 generally pumps groundwater in the months and years when imported water supplies are limited (e.g., typically during the summer and "dry" hydrological years), and artificially recharges more water than it pumps when surplus surface water imports are available ("conjunctive use").

11.4.2 Natural Sustainable Yield

11.4.2.1 Natural Groundwater Inflow

The inflow component of the "natural" sustainable groundwater yield consists of the components listed in *Table 11-C*. In 1992, Zone 7 (*Zone 7, 1992*) calculated that the long-term average "natural" groundwater inflow into the Main Basin is estimated to be about 13,400 AF annually. The groundwater inflow for Main and Fringe Basins together is about 18,000 AF. This long-term average (shown as the "sustainable values" in the tables below) was primarily based on local precipitation and natural recharge over a century of hydrologic records and projections of future recharge conditions; however, the actual amount of natural recharge varies from year to year depending on the amount of local precipitation and irrigation during the year. Applied water (irrigation) recharge is also included in the "natural" inflow, because of its steady sustainable contribution to groundwater recharge.

For the 2016 WY, the recharge attributed to the natural groundwater inflow was about 18,426 AF for just the Main Basin, approximately 138% of the average (*Table 11-C*).

Table 11-C: Natural Groundwater Inflow Components

SUPPLY COMPONENT	**2016 WY (AF)**	**Estimated Sustainable Values (AF/Yr)***
Natural Stream Recharge	8,289	5,700
Arroyo Valle Prior Rights	884	900
Rainfall Recharge	6,554	4,300
Applied (Irrigation) Water Recharge	1,699	1,600
Subsurface Groundwater Flow	1,000	900
Subsurface Inflow	*1,000*	*1,000*
Basin Overflow	*0*	*-100*
TOTAL	18,426	13,400

* as calculated in *Zone 7, 1992*

11.4.2.2 Natural Groundwater Outflow/Demand

The Main Basin's outflow/demand components assigned to the natural groundwater inflow are shown in *Table 11-D*. As a routine, Zone 7 monitors each demand component and checks whether it is within the acceptable long-term average:

Table 11-D: Natural Sustainable Demand Components

DEMAND COMPONENT	**2016 WY (AF)**	**Estimated Sustainable Values (AF/Yr)***
Municipal pumping by Retailers	6,972	7,214**
City of Pleasanton	*3,752*	*3,500***
California Water Service	*2,575*	*3,069***
*DSRSD**	*645*	*645***
Other pumping for potable supply	847	1,186
Agricultural pumping	115	400
Mining Area Losses	3,597	4,600***
TOTAL	11,531	13,400

* as calculated in *Zone 7, 1992*
** Retailer Groundwater Pumping Quota (GPQ) for a Calendar Year
*** Remainder of total Sustainable Yield for Demand to equal Natural Supply

As a condition to their water supply contracts with Zone 7, each retailer is permitted to pump their annual independent Groundwater Pumping Quota (GPQ) without paying a recharge fee to Zone 7. The GPQs are generally based on an average historical use, but were pro-rated based on the agreed upon “natural” sustainable yield of the groundwater basin established in a 1967 joint study. Together, the retailers’ GPQ is 7,214 AF annually per calendar year; however, unused GPQ credits are allowed to be carried over to the next year when less than the assigned GPQ is pumped by a retailer in a given year. Such carryovers are limited to 20% of the assigned GPQ. A retailer must pay a “recharge fee” based on Zone 7’s actual artificial recharge operations costs for all groundwater it pumps exceeding the GPQ. This provides a strong contractual incentive to the larger municipal water purveyors to keep their collective groundwater pumping within the “natural” sustainable yield of the basin and to use alternative supplies such as treated water provided by Zone 7 or by recycling water.

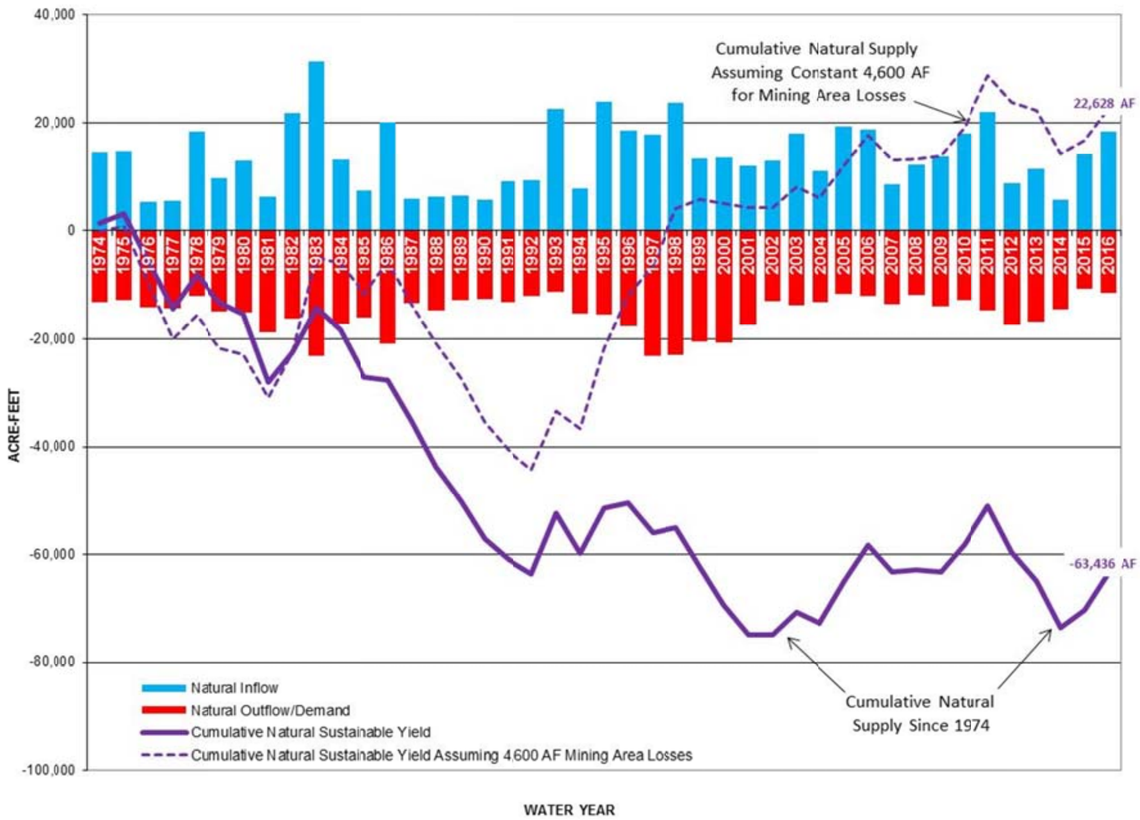
The sustainable yield allotted for other groundwater users (i.e., small public systems, rural domestic wells, agricultural and landscape irrigation (limited), and quarry operations) are also based on long-term averages and/or current use trends. Next to the municipal pumping, the mining area losses (4,600 AF) make up the next largest sustainable allotment assigned to the “natural” supply, with Mining Area evaporation accounting for about 70% of the allocation. Discharges associated with the dewatering of the active quarry pits are only considered groundwater losses if they are discharged to one of the outflowing Arroyos; they are not considered groundwater losses when they are discharged to another pond that recharges the aquifers (*Section 10.2.4.3*).

For the 2016 WY, the estimated total for these assigned demand components was 11,531 AF; or approximately 86% of sustainable yield of the “natural” supply (13,400 AF). As typical, the two largest contributors to the demand component were municipal pumping by the retailers (97% of normal) and the mining area losses (78% of the sustainable yield allotment). *Figure 11-E* below shows graphically the historical annual inflow and outflow totals assigned to the Natural Sustainable Yield.

11.4.2.3 Mining Area Sustainability

The capture and subsequent recharge of Vulcan’s discharges from their quarry dewatering activities in the 2016 WY (*Section 10.2.4.3*) kept the total Mining Use losses (3,597 AF) below the assigned annual sustainable value (4,600 AF/Yr) for the second straight year. Prior to 2015, however, the quarry operations discharged much of the groundwater pumped for their pit dewatering activities to the arroyos where it would subsequently flow out of the basin and result in Mining Use losses in excess of the assigned 4,600 AF/yr, particularly during the periods 1980-1986, 1994-2001 and 2009-2014. As a result of these historic excess Mining Area losses, there is a cumulative 63,400 AF deficit in the net “natural” supply (inflow minus outflow) since 1974 (see *Figure 11-E*). If the Mining Area losses been held at 4,600 AF/Yr from1974 through the present, the cumulative “natural” supply would have been 22,600 AF in surplus at the end of the 2016 WY. Fortunately, the impact of the “natural” supply deficit was mitigated by Zone 7’s surplus artificial recharge (59,507 AF), unallocated incidental 'Pipe Leakage' (22,316 AF) and periodic reductions in pumping by others during the same period (see *Table 10-3*).

Figure 11-E: Long-Term Natural Sustainable Yield

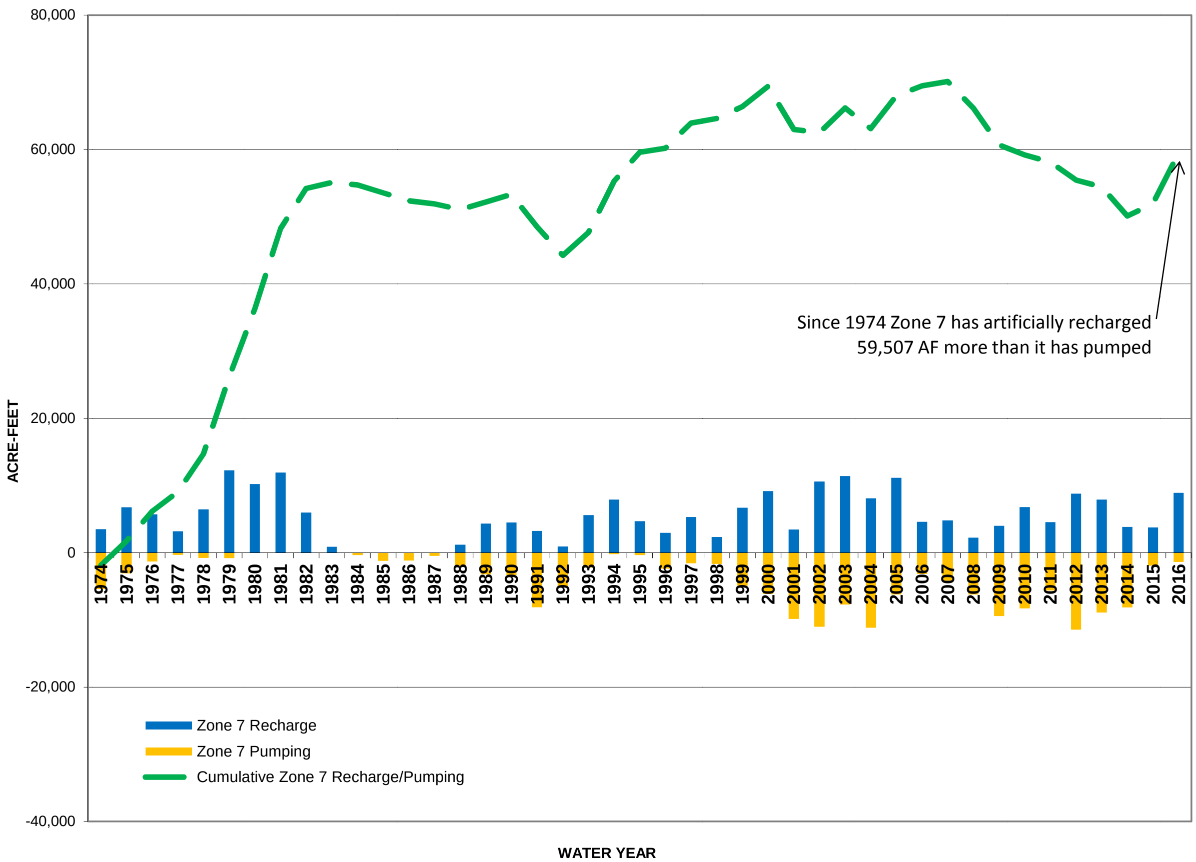


Mining Area losses will likely continue to be less than 4,600 AF/yr in the immediate future as most mining releases are now being captured and re-percolated in various mining area ponds (*Sections 4.3* and *10.2.4.3*). Mining Area dewatering operations may ramp up in the mid-term as several of the active pits are being deepened which may lead to an increase of evaporative losses, depending on the storage of the additional discharges. All dewatering operations are expected to cease altogether when aggregate reserves have been sufficiently depleted and extraction are halted; currently anticipated by 2058.

11.4.3 Zone 7 Supply and Demand

The sustainability of Zone 7's groundwater basin is dependent on its "Artificial Recharge" program. The "Artificial Recharge" operation is in turn dependent on Zone 7's annual SWP allocations, local precipitation captured locally, and water supply operations plans. Typically, Zone 7 will commence Artificial Recharge operations during times of surplus import water availability. Since 1974, Zone 7 has artificially recharged over 59,500 AF more water than it has pumped. The annual put and takes are depicted on *Figure 11-F* below along with the cumulative net results. Additional information on Zone 7's imported water availability, groundwater pumping and "Artificial Recharge" operations are contained in the following sections.

Figure 11-F: Long-Term Zone 7 Recharge/Pumping



11.4.3.1 Imports and Surface Water Supplies

Zone 7 ensures that local groundwater supplies are not depleted by importing approximately 75% of the Valley's water supply (delivered to Zone 7's retailers and agricultural customers) and recharging the Main Basin with surplus surface water when available (artificial recharge). These surplus surface water supplies, which are accounted for by calendar year, come from the following sources:

- **State Water Project (SWP deliveries via the South Bay Aqueduct [SBA])** - As a SWP contractor, Zone 7 imports supplies from the SWP through the SBA. Since1998, Zone 7 has had an annual maximum SWP contract amount of 80,619 AF/yr, referred to as the "Table A Contract Amount." However, actual SWP deliveries are usually allocated in any given calendar year by DWR at a lower level based on numerous factors, including hydrologic conditions. Currently, the long-term reliable yield of the SWP is approximately 60% of the Table A amount (48,370 AF/yr). This should increase if the California Water Fix is implemented by the State.

- **Arroyo Valle Water Rights (Lake Del Valle) –** Zone 7 has temporary water rights for a portion of the natural flows into Lake Del Valle. Accordingly, Zone 7 coordinates releases from the reservoir into the Arroyo Valle to recharge through the streambed and to maintain downstream flows at levels that would have occurred had the reservoir not been constructed. Additional releases of Arroyo Valle water can be made from the lake when such water is available for Zone 7. Maintaining minimum flows is a condition of Zone 7's water rights permit for the Arroyo Valle water and allows Zone 7 to use other portions of Arroyo Valle water for supply to its treatment plants and for supplemental aquifer recharge. Zone 7 is currently pursuing an extension of these rights to this surface water source.

- **Byron-Bethany Irrigation District (BBID)** - Zone 7 has a contract with Byron-Bethany Irrigation District (BBID) for up to 5,000 AF/yr of supplemental water made available to Zone 7 as a transfer of BBID's pre-1914 water rights water when surplus supplies are declared by BBID. When available, it is delivered upon request to Zone 7 through the SBA and can be used to supply Zone 7's artificial recharge program as well as Zone 7's water treatment plants. This water is only available in years when BBID declares that a surplus is available for transfer, and approvals from DWR and the US Bureau of Reclamation are given. Surplus water was not available in the 2016 WY.

- **Kern Groundwater Basin (storage rights only)** - Zone 7 has purchased water storage rights in the Semitropic Water Storage District (78,000 AF) and in the Cawelo Water District (120,000 AF) groundwater basins in Kern County. These rights give Zone 7 the ability to remotely store surplus SWP water when available. When Zone 7 is ready to use the water locally, it can import up to fixed annual amounts of this stored SWP water through an exchange procedure within the SWP system.

- **Yuba Accord –** In 2008, Zone 7 entered into a contract with DWR to purchase additional water under the Lower Yuba River Accord (Yuba Accord). The contract was amended in November 2014 to cover the period from October 2015 through 2020. New pricing would be negotiated at that time. There are four different Components (types) of water available; Zone 7 has the option to purchase Component 1, Component 2 and Component 3 water during drought conditions, and Component 4 water when Yuba County Water Agency has determined that it has water supply available to sell. Zone 7 estimates the average yield from the Yuba Accord to be 850 AF/yr. No Yuba Accord water was available in 2016 CY, thus Zone 7 did not receive any of this alternative supply.

- **Multi-Year Pool –** In 2013, DWR implemented the Multi-Year Water Pool Demonstration Program, intended to facilitate the transfer of water between SWP contractors and to serve as an alternative to the under-used Turnback Pool Program. This program remains a pilot program. Zone 7 participated in the Multi-Year Pool in 2013 2015 and 2016, receiving 819 AF of this supply in 2016.

- **Dry Year Transfer Program –** The State Water Contractors, an organization comprised of contractors of the SWP, facilitates the purchase of water from the Feather River Watershed for transfer to SWP contractors during dry years. This is an optional program, and in 2016, Zone 7 opted out of this program.

Supplemental supply totals, which are based on the Calendar Year (CY) to be consistent with DWR's allocation and accounting of State Project Water, are summarized in *Table 11-G* below:

Table 11-G: Supplemental Sources for the 2016 Calendar Year

Source	**Available in 2016 CY (AF)**	**Used in 2016 CY (AF)**	**Carry-Over to 2017 CY (AF)**
State Water Project	**61,731**	**52,341**	**9,390**
Table A (60% Allocation for 2016)	*48,371*	*41,981*	*6,390*
Article 56	*13,360*	*10,360*	*3,000*
Lake Del Valle (AV Water Rights)	**9,075**	**204**	**8,871**
BBID	**0**	**0**	**0**
Kern Groundwater Basin	**74,389**	**-7,676**	**82,065**
Semitropic	*59,234*	*-4,176*	*63,410*
Cawelo	*15,155*	*-3,500*	*18,655*
Other		**819**	
Kern transfer to San Luis Reservoir		*0*	*0*
Yuba/Multi-Year Pool		*819*	
TOTAL	**145,195**	**45,688**	**100,326**

Other highlights for the 2016 CY include:

- Zone 7's treated surface water made up 94% of regional potable water deliveries in the 2016 CY, well above the annual average of 75%.

- Due to increased SWP water supply, Zone 7 was able to send 12,000 AF to the water banks in Semitropic and Cawelo for a net gain of 8,000 AF.

- Also due to increased SWP water supply, Zone 7 was able to artificially recharge 10,300 AF in 2016 CY.

- Continued conservation by the Valley's residents, businesses and public agencies during the 2016 CY resulted in about 30% reduction in Valley-wide demand from the 2013 CY level.

- 1,333 AF of the 17,813 AF of water received from the Kern Groundwater Basin in the 2016 CY was sent to San Luis Reservoir for carryover to the 2017 CY.

11.4.3.2 Zone 7 Groundwater Pumping

Historically, Zone 7's annual groundwater production has varied with the availability of surface water and the capacity to treat that surface water. While groundwater pumping by the retailers is accounted in the 'Natural Sustainable Yield,' Zone 7's groundwater pumping is a component of its conjunctive use demands (i.e., withdrawals from the artificially-recharged supplies).

Zone 7 operates its supply wells to augment production during demand peaks and whenever a shortage or interruption occurs in its surface water supply or treatment (e.g., during droughts, and SWP and treatment plant outages). However, Zone 7 also pumps groundwater as a salt management strategy. When groundwater is delivered to the Retailers, and distributed to their customers, a certain percent of the water becomes wastewater that is in turn treated and exported from the valley along with its dissolved salts. Likewise, four of Zone 7's supply wells are connected to Zone 7's Mocho Groundwater Demineralization Plant (MGDP), which when operated, removes salts from the produced groundwater and discharges them to the same wastewater export pipeline that discharges treated wastewater to San Francisco Bay (*see Section 12.1.6*). The decision of which well(s) to pump is based on pumping costs, pressure zone demands, delivered aesthetic water quality, groundwater levels, and demineralization facility capacity. Although reduced groundwater pumping may have a positive impact on groundwater storage and delivered water quality, increased groundwater pumping has a beneficial impact on the basin's salt loading because of the salt in the exported wastewater.

For the 2016 WY:

- Zone 7 only pumped 2,002 AF of groundwater (including 645 AF pumped as DSRSD's Groundwater Pumping Quota – *Section 11.4.2.2*), of which 1,939 AF went into production. This represents about 34% of Zone 7's sustainable groundwater demand (5,940 AF)

- Valleywide, groundwater production made up about 24% of the total water produced in the 2016 WY *(Figure 11-1*). Zone 7's groundwater production (1,939 AF) represented only 20% of the total groundwater produced from the basin in the 2016 WY *(Figure 11-1*).

- Zone 7's groundwater production (1,939 AF) was only about 7% of the total treated water production that Zone 7 delivered to its retailers during the 2016 WY (On average, groundwater makes up about 15% of Zone 7's annual treated water deliveries.)

- Despite being in the fifth consecutive "below normal year" (operationally), reduced groundwater pumping contributed to groundwater levels (and storage) beginning to recover from the impacts of the previous four "below normal" to "critically dry years" as determined by the Sacramento Valley Index.

11.4.3.3 Zone 7 Artificial Recharge

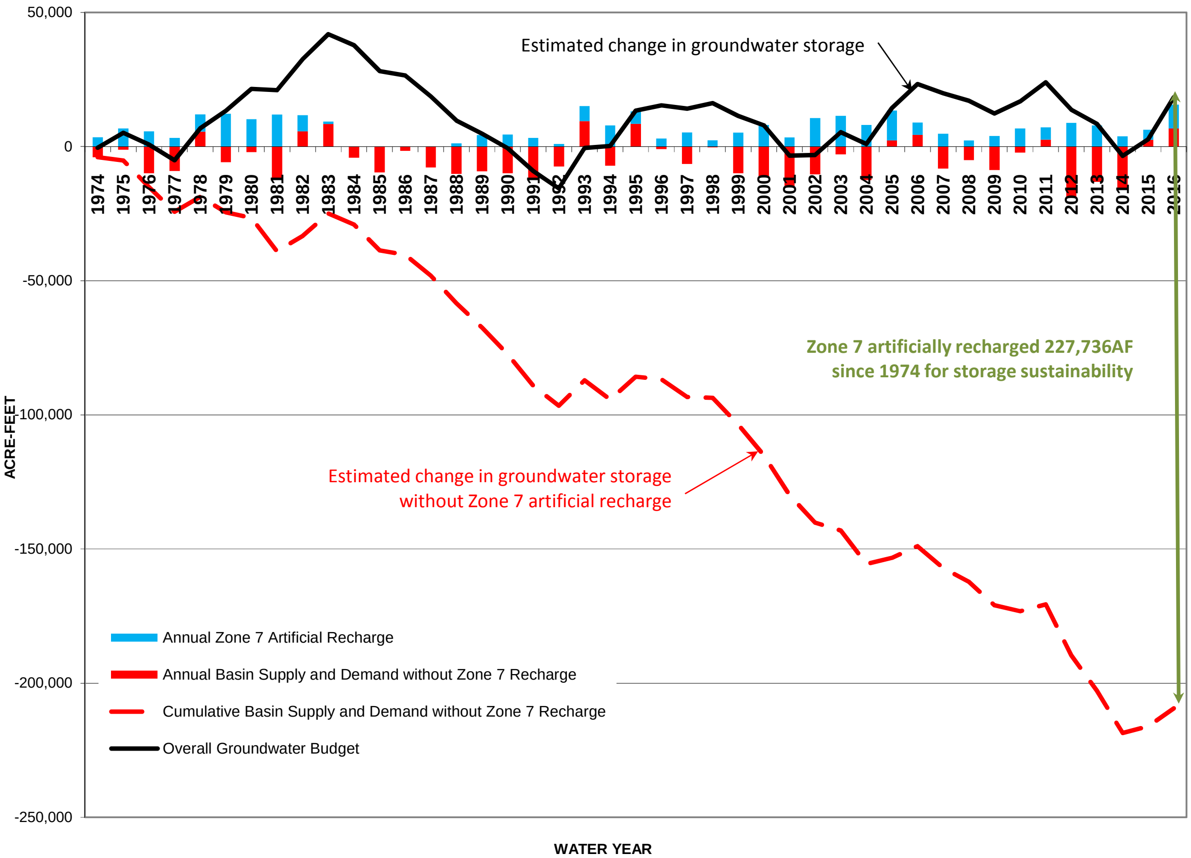
Zone 7 has been importing and recharging SWP water (artificial recharge) since the 1960s to replenish what has been pumped from the groundwater basin. Zone 7 actively embraces a conjunctive use approach to Basin Management by integrating management of local and imported surface water supplies with the management of local conveyance, storage and groundwater recharge features, including; local arroyos (which are also used as flood protection facilities during wet seasons); and two former quarry pits (Lake I and Cope Lake).

A key component of Zone 7's conjunctive use program has been its artificial recharge program, which consists of releases of surface water to dry arroyos to recharge the groundwater basin. The timing and quantity of artificial recharge is typically dependent upon available supply, available recharge capacities, source water quality, and regulatory requirements.

The location and timing of artificial recharge operations can be used as a water quality management tool as well as a temporal water storage activity. When practical to do so, Zone 7 prioritizes its SWP releases for recharge to occur in the spring and summer when TDS of the source water is low. Because each acre-foot that is subsequently pumped from the Basin removes water with higher TDS, this can eventually improve the salinity of the groundwater basin, helping achieve salt management objectives. The salt removal effectiveness of the conjunctive use is related to the difference in the TDS of recharge water and pumped groundwater and the annual volumes involved (see *Section 12.1*)

The historical artificial recharge for the Main Basin has averaged about 5,300 AF per year. Below, *Figure 11-H* shows the long-term importance of Zone 7's artificial recharge program for the sustainability of groundwater in the basin. The graph shows what the long-term groundwater budget would have been had Zone 7 not been recharging the basin since 1974 (the earliest date for which Zone 7 has detailed hydrologic inventory records). The graph also shows that Zone 7 has imported and recharged about 228,000 AF since 2014 which has kept the basin sustainable during that time.

Figure 11-H: Effect of Zone 7's Artificial Recharge



For the 2016 WY, Zone 7's Artificial Recharge Program included the following activities and highlights:

- Zone 7 released 10,662 AF of imported surface water to the local arroyos, of which about 8,910 AF artificially recharged the groundwater basin.
- EBRPD diverted a total of 430 AF into Shadow Cliffs to maintain the lake level for recreational use, which had the ancillary benefit of recharging the basin by the same amount.
- This was the third year of re-capturing and artificially recharging mining use water in Cope Lake and Lake I. This water is not included in the Artificial Recharge total because it is essentially a groundwater-to-groundwater transfer, and not an augmentation of groundwater. However, these lakes, along with Lake H, will be available to store, convey, and artificially recharge imported surface water in the future to augment groundwater supplies.

Looking farther into the future, Zone 7 plans to increase its conjunctive use to keep up with growing demands. Perfection of Zone 7's Arroyo Valle Water Rights (*see Section 3.2.1*) and acquisition of additional former quarries (Lakes A through H) to complete the future "Chain of Lakes" will allow Zone 7's artificial recharge and regional flood protection projects to be fully implemented (see *Section 4.3*).

11.5 Groundwater Model

11.5.1 Model Description

Zone 7 maintains a numerical groundwater model of the basin for predicting the consequences of proposed groundwater basin management actions. The active part of the groundwater model encompasses the Amador, Bernal, Bishop, Camp, Castle, Dublin, and Mocho II Subareas of the Valley. Originally a three-layer model, it was reconstructed in 2014-2015 with contributions from DWR's Local Groundwater Assistance Grant Program to have ten layers in order to improve the simulation of observed water quality stratifications. It has been used in the past for: water supply well planning (*Zone 7, 2003*); salt management planning (*Zone 7, 2004);* groundwater demineralization plant siting (*Zone 7, 2006c*); Zone 7's Water Supply Evaluation (*Zone 7, 2011c*); and most recently, development and evaluation of groundwater pumping alternatives during extended drought periods.

The model was originally created in Visual MODFLOW, but was later converted to run with the Groundwater Vistas graphical user interface (GUI) using the USGS MODFLOW-SURFACT code to perform the modeling calculations. In 2006, Zone 7 and HydroMetrics WRI (HydroMetrics) reevaluated, recalibrated, and revised the model as described in the Annual Report for the Groundwater Management Program – 2005 WY (*Zone 7, 2006d)*. Between 2014 and 2016, Zone 7 staff and HydroMetrics made several additional improvements to the model including revisions necessary to utilize the newer USGS MODFLOW-NWT code. More details on the latest model upgrades are discussed in *Section 11.5.2*, below.

11.5.2 Recent Model Update and Improvements

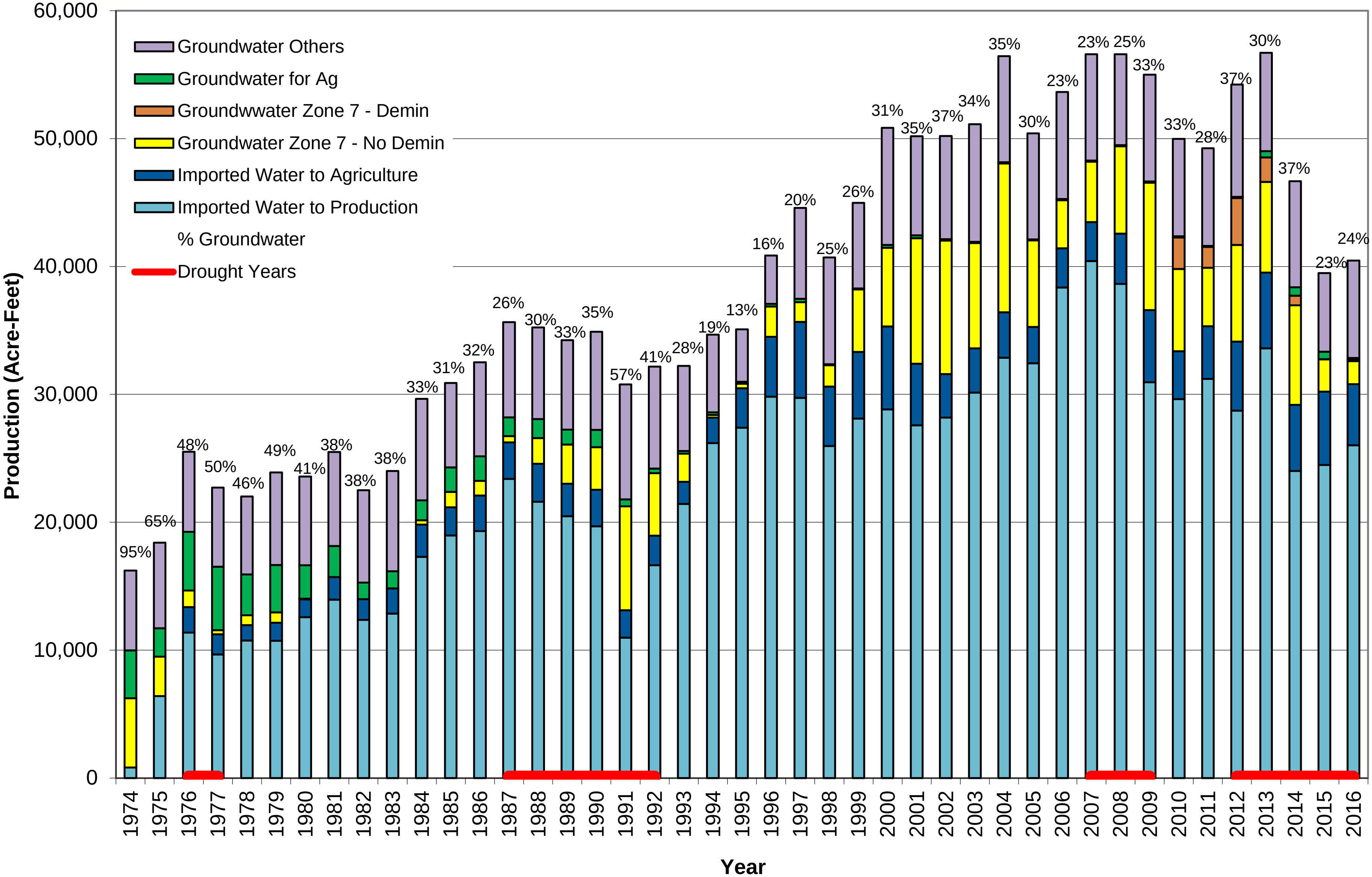
In December 2013, DWR awarded Zone 7 a Proposition 84 Local Groundwater Assistance Program grant of $200,000 to update and improve its groundwater model so that it can better evaluate future groundwater management and salt mitigation strategies. Zone 7 contracted HydroMetrics to complete the bulk of the improvements. The approved scope of work for the project included:

- Converting the model software from MODFLOW-SURFACT to MODFLOW-NWT.
- Adding additional layers to the model that represent hydrostratigraphic boundaries identified in recent geologic studies.

- Incorporating the MODFLOW Streams and Lakes Packages.
- Recalibrating the model using both water elevation and salt concentration datasets, including data collected during the recent drought.
- Running up to three scenarios to test the operation of the model and its ability to optimize Zone 7's maximum pumping capacity under various drought conditions.

During the 2016 WY, the project team completed the model updates and additions, and re-calibrated the model with recent and historic water level and water quality data. At the end of the 2016 WY, the project team was testing the updated model and completing documentation of its new features and calibration. A draft model report was submitted to DWR and made available on Zone 7's website for public review early in the 2017 WY. The final version of the report, which addresses the DWR's and public comments, is expected to be completed in April 2017 and will be included in the next annual report.

FIGURE 11-1
VALLEY WATER PRODUCTION FROM IMPORTED WATER AND GROUNDWATER
1974 TO 2016 WATER YEARS



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