Salinas Valley: 180/400-Foot Aquifer Subbasin Groundwater Sustainability Plan

VOLUME 2

Chapter 5. Groundwater Conditions

Prepared for:

Salinas Valley Basin Groundwater Sustainability Agency

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5 GROUNDWATER CONDITIONS

Commented [AO1]: Data throughout chapter updated to 2019, or 2020 where data is available.

This chapter describes the historical and current groundwater conditions in the 180/400-Foot Aquifer Subbasin in accordance with the GSP Regulations § 354.16. In this GSP, current conditions are any conditions occurring after January 1, 2015. This GSP Update uses 2020 as the representative current year where possible, thus updating the 2017 data in the original GSP. By implication, historical conditions are any conditions occurring prior to January 1, 2015. The chapter focuses on information required by the GSP regulations, and information that is important for developing an effective plan to achieve sustainability. This chapter provides a description of current and historical groundwater conditions at a scale and level of detail appropriate for meeting the GSP sustainability requirements under SGMA.

This chapter is organized to align the groundwater conditions descriptions with the 6 sustainability indicators relevant to this subbasin, including:

1. Chronic lowering of groundwater levels
2. Changes in groundwater storage
3. Seawater intrusion
4. Subsidence
5. Groundwater quality
6. Depletion of interconnected surface waters

In addition, to meet the GSP Regulations § 356.4 assessment requirements for GSP amendments, this chapter includes a section on water use.

5.1 Groundwater Elevations

5.1.1 Data Sources

Commented [AO2]: Simplified section to avoid repetition

The assessment of groundwater elevation conditions is largely based on data collected by MCWRA from 1944 through the present. MCWRA's monitoring programs are described in Chapter 3.

Groundwater elevation data are analyzed and presented with three sets of graphics:

- Maps of groundwater elevation contours show the geographic distribution of groundwater elevations at a specific time. These contours represent the elevation of the groundwater in feet, using the NAVD88 vertical datum. The contour interval is 10 feet, meaning each blue line represents an area where groundwater elevations are either 10 feet higher or 10 feet lower than the next blue line (Figure 5-1 to Figure 5-8).

- Hydrographs of individual wells show the variations in groundwater elevations at individual wells over an extended period of time Figure 5-9).
- Vertical hydraulic gradients in a single location assess the potential for vertical groundwater flow and its direction, as discussed in Section 5.1.4.

5.1.2 Groundwater Elevation Contours and Horizontal Groundwater Gradients

Commented [AO3]: Updated data

MCWRA annually produces groundwater elevation contour maps for the Salinas Valley Groundwater Basin using data from their annual August trough and fall measurement programs. August groundwater elevations are contoured to assess the driving force of seawater intrusion because this is usually when the aquifers are the most stressed. ~~The August measurements represent seasonal low conditions in the Subbasin.~~ MCWRA also contours fall groundwater elevations because these measurements are taken from mid-November to December after the end of the irrigation season and before seasonal recharge from winter precipitation increases groundwater levels. The August measurements represent seasonal low conditions in the Subbasin, and the fall measurements represent the seasonal high. ~~MCWRA does not produce groundwater elevation contour maps in the spring. Therefore, new maps of spring groundwater levels were developed for this GSP. Spring groundwater elevation maps were developed from data collected between January and March for 2019 and 1995. The period from January to March usually reflects seasonal high groundwater levels in the Salinas Valley Groundwater Basin (MCWRA, 2015a). The MCWRA Quarterly Salinas Valley Water Conditions report demonstrates that in 2020, the seasonal high groundwater elevations occurred in January (MCWRA, 2019a).~~ In 1995, data collected in March were more representative of seasonal high groundwater elevations.

The following 8 maps present the Current (2019) and Historical (1995) groundwater elevation contours.

Table 5-1~~5-1~~. Figures Showing Current and Historical Groundwater Elevation Contours

Figure #	Year	Season	Aquifer
Figure 5-1	Current (2019)	~~Spring~~Fall	180-Foot
Figure 5-2	Current (2019)	August Trough	180-Foot
Figure 5-3	Current (2019)	~~Spring~~Fall	400-Foot
Figure 5-4	Current (2019)	August Trough	400-Foot
Figure 5-7	Historical (1995)	~~Spring~~Fall	180-Foot
Figure 5-8	Historical (1995)	August Trough	180-Foot
Figure 5-7	Historical (1995)	~~Spring~~Fall	400-Foot
Figure 5-8	Historical (1995)	August Trough	400-Foot

The groundwater elevation contours only cover the portions of the basin monitored by MCWRA. Contours do not always extend to subbasin margins. Furthermore, MCWRA does not produce groundwater elevation maps of the Deep Aquifers. Insufficient data currently exist to map flow directions and groundwater elevations in the Deep Aquifers. These are data gaps that will be addressed during GSP implementation.

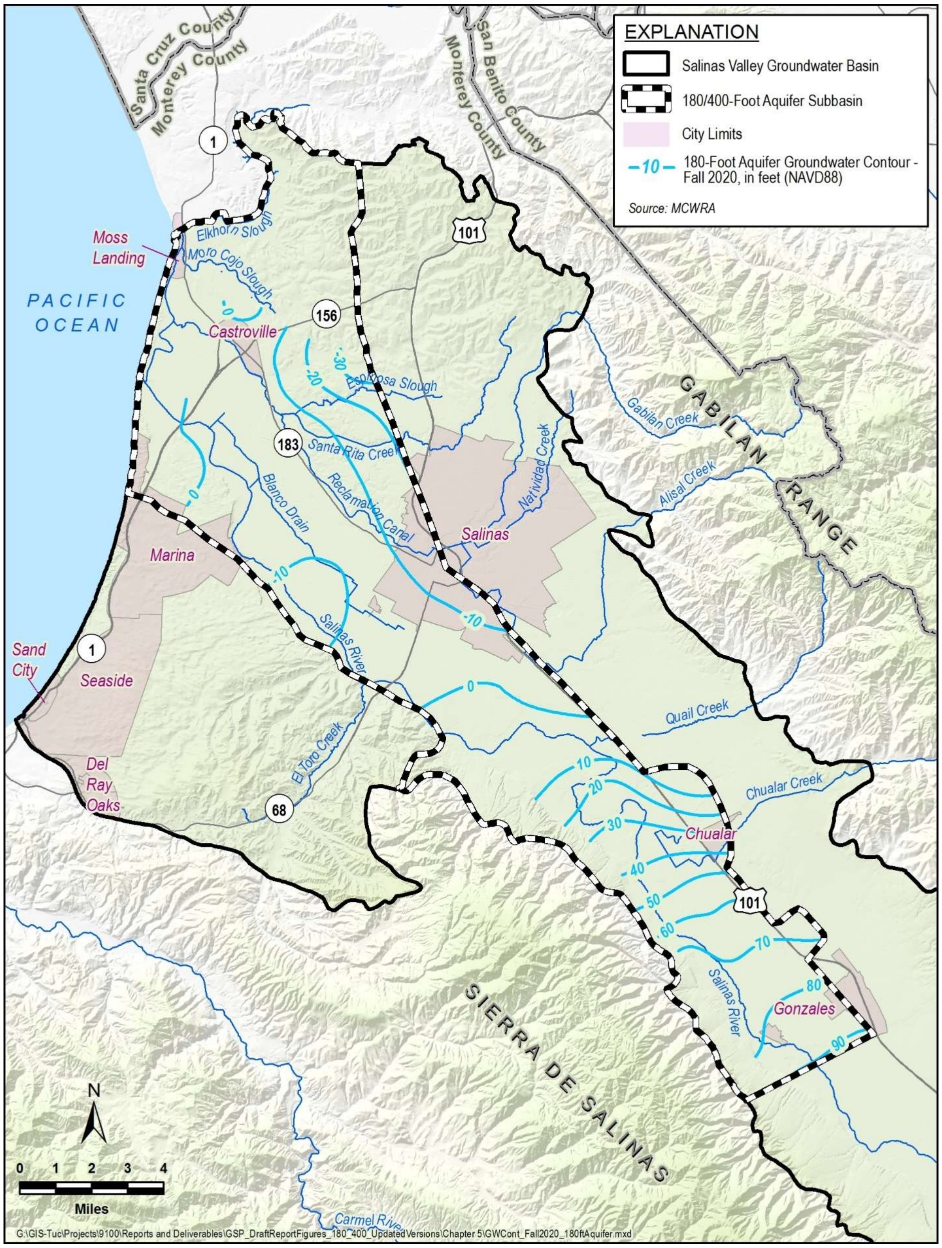


Figure 5-15~~-1~~. ~~Spring~~ Fall 2020 180-Foot Aquifer Groundwater Elevation Contours

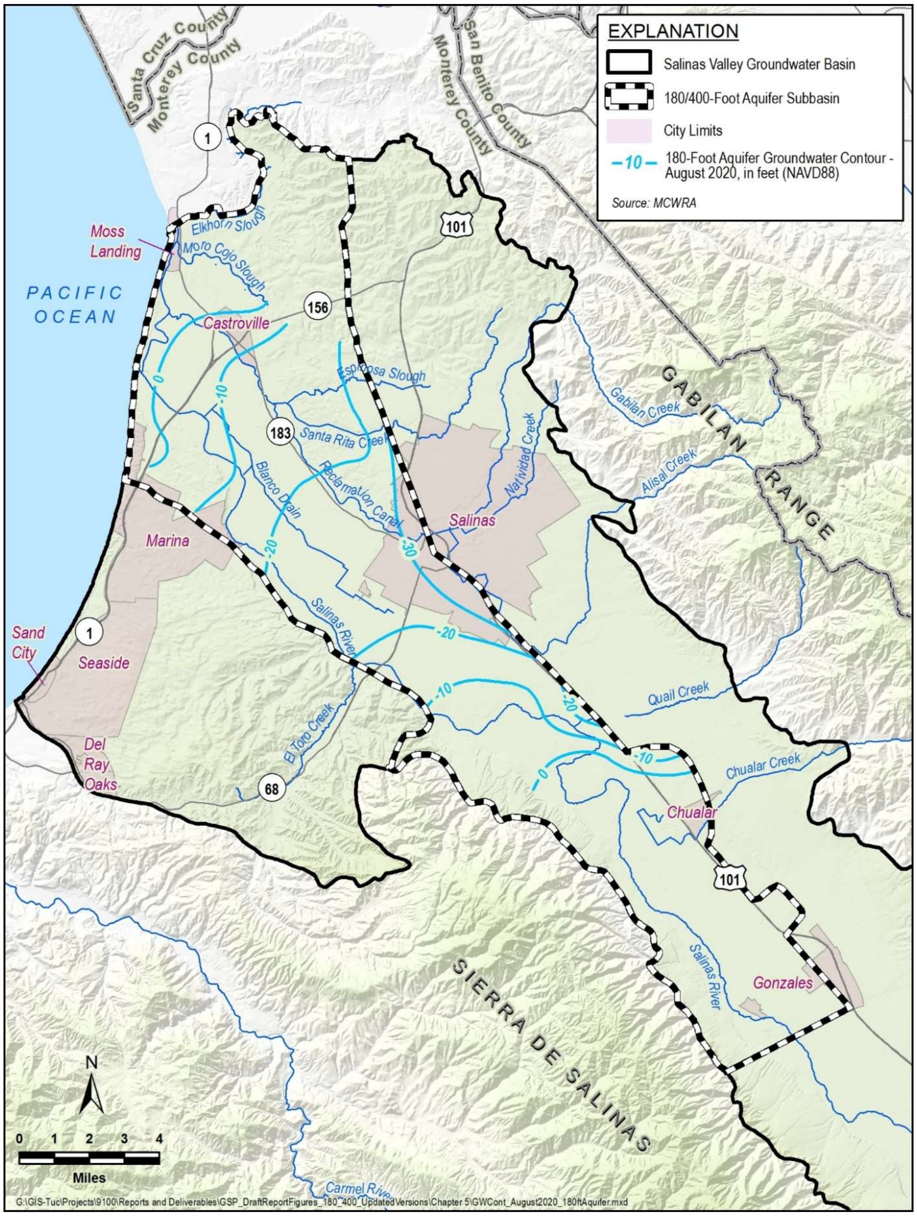


Figure 5-2~~5-2~~. August 2020 180-Foot Aquifer Groundwater Elevation Contours

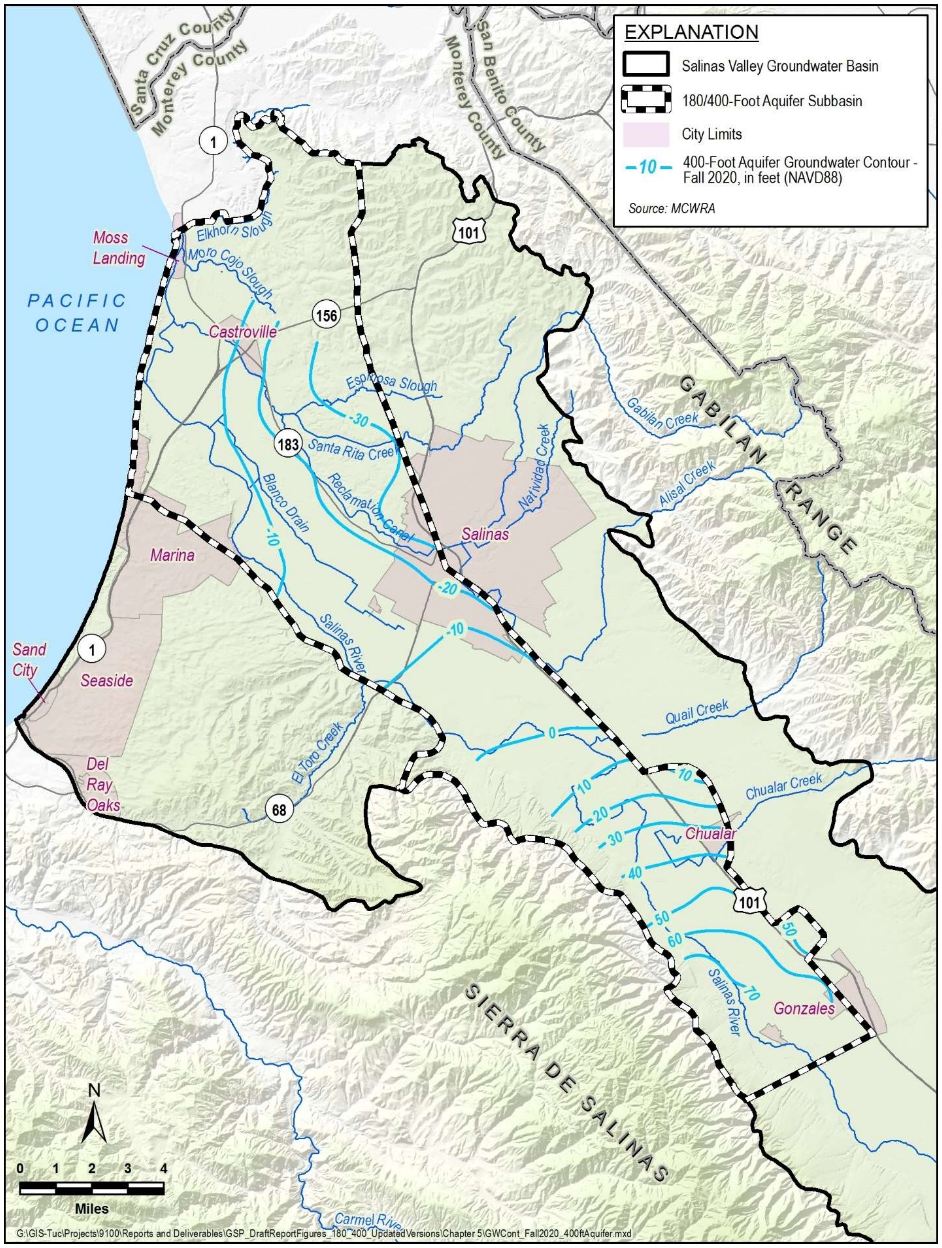


Figure 5-3~~5-3~~. ~~Spring~~Fall 2020 400-Foot Aquifer Groundwater Elevation Contours

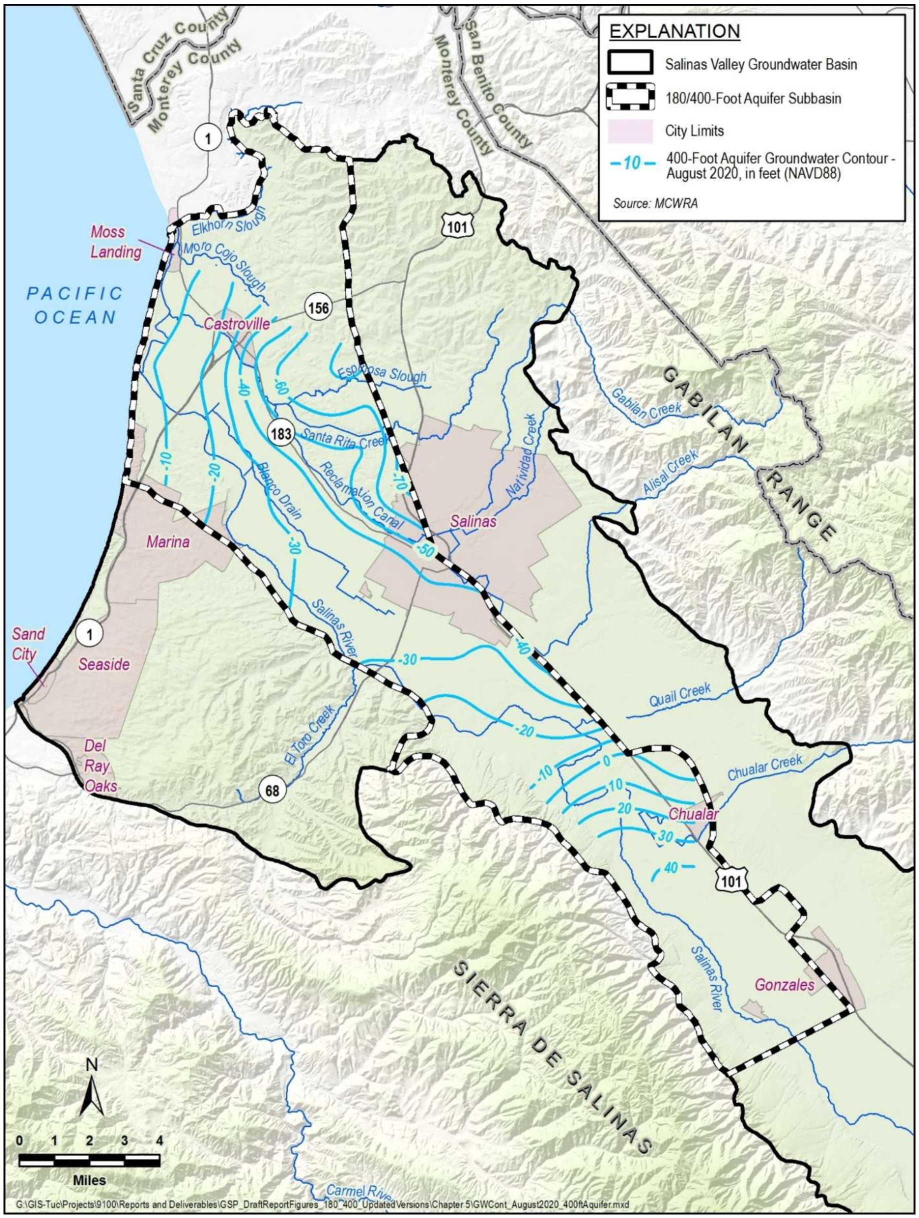


Figure 5-45~~-4~~. August 2020 400-Foot Aquifer Groundwater Elevation Contours

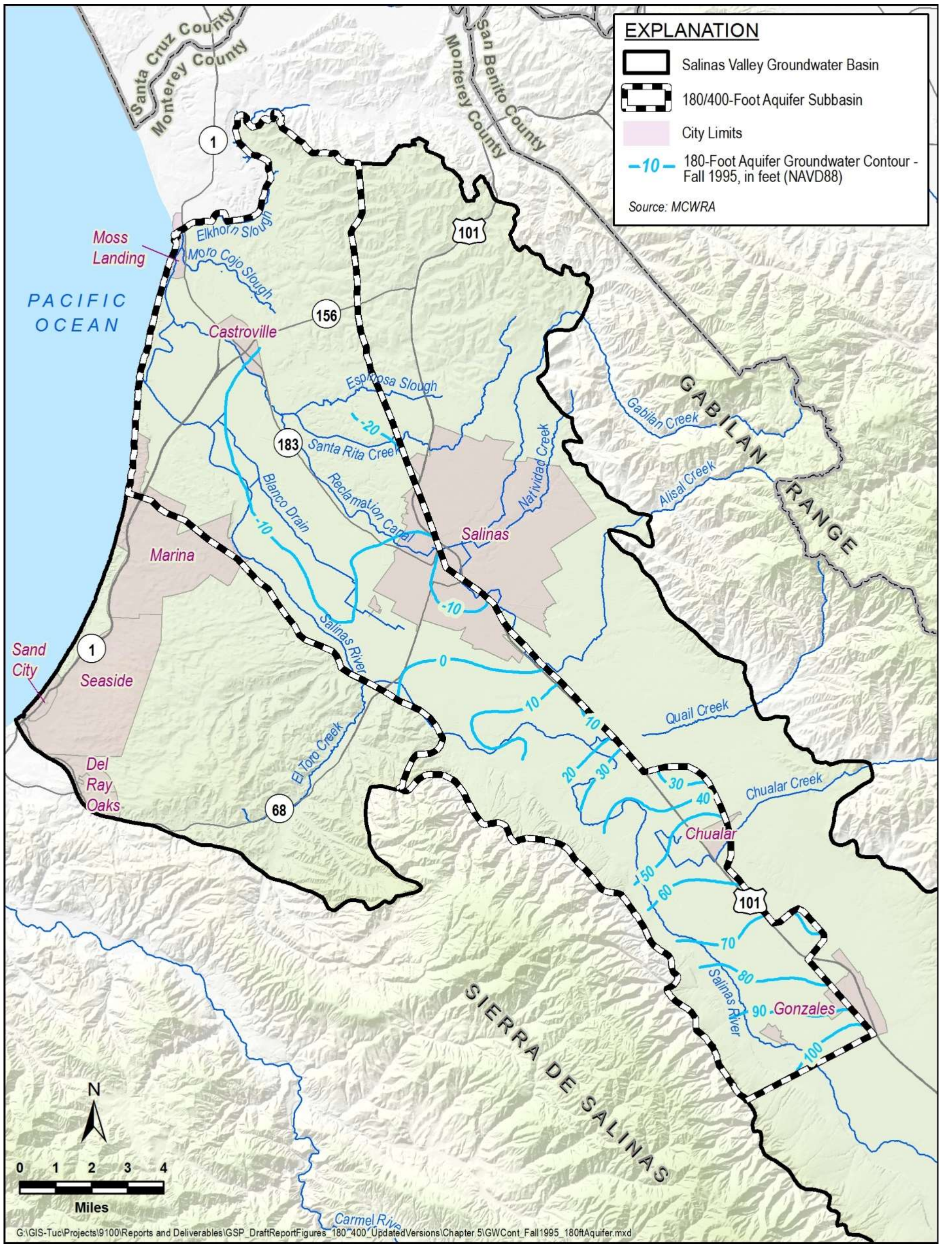
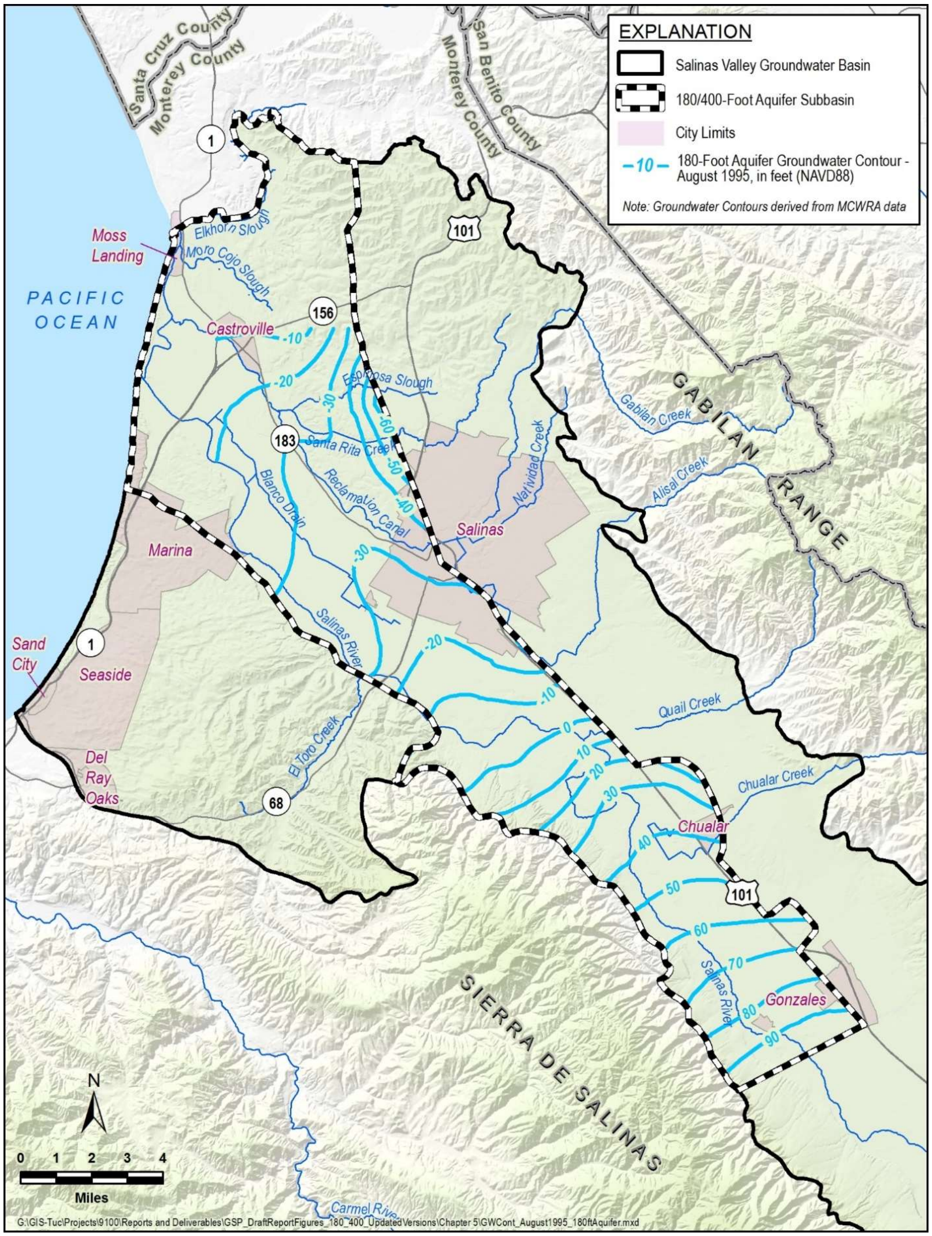
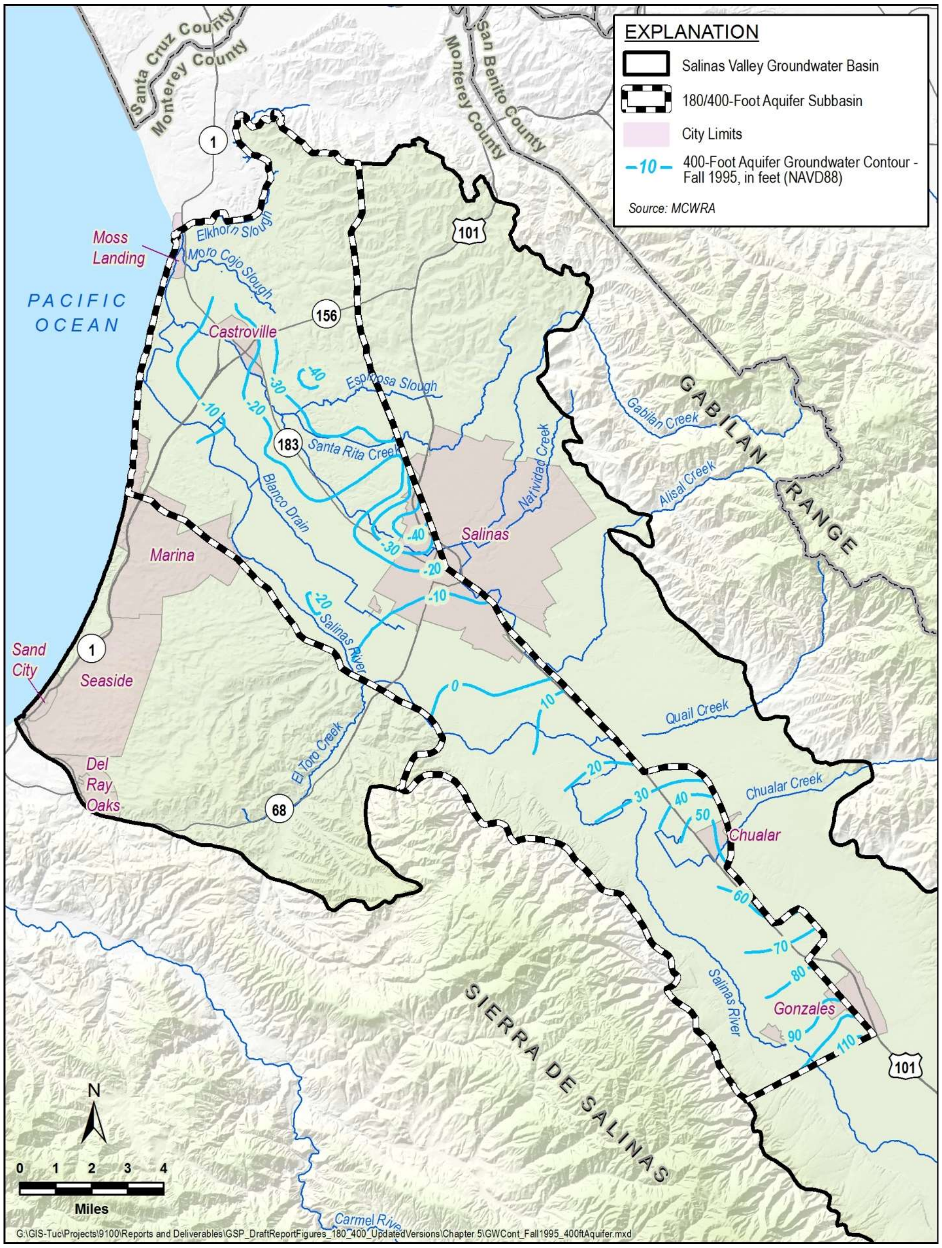


Figure 5-5~~5-5~~. ~~Spring~~Fall 1995 180-Foot Aquifer Groundwater Elevation Contours



Note: Groundwater Contours derived from MCWRA data

Figure 5-6~~5-6~~. August 1995 180-Foot Aquifer Groundwater Elevation Contours



Source: MCWRA

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Figure 5-7~~5-7~~. ~~Spring~~Fall 1995 400-Foot Aquifer Groundwater Elevation Contours

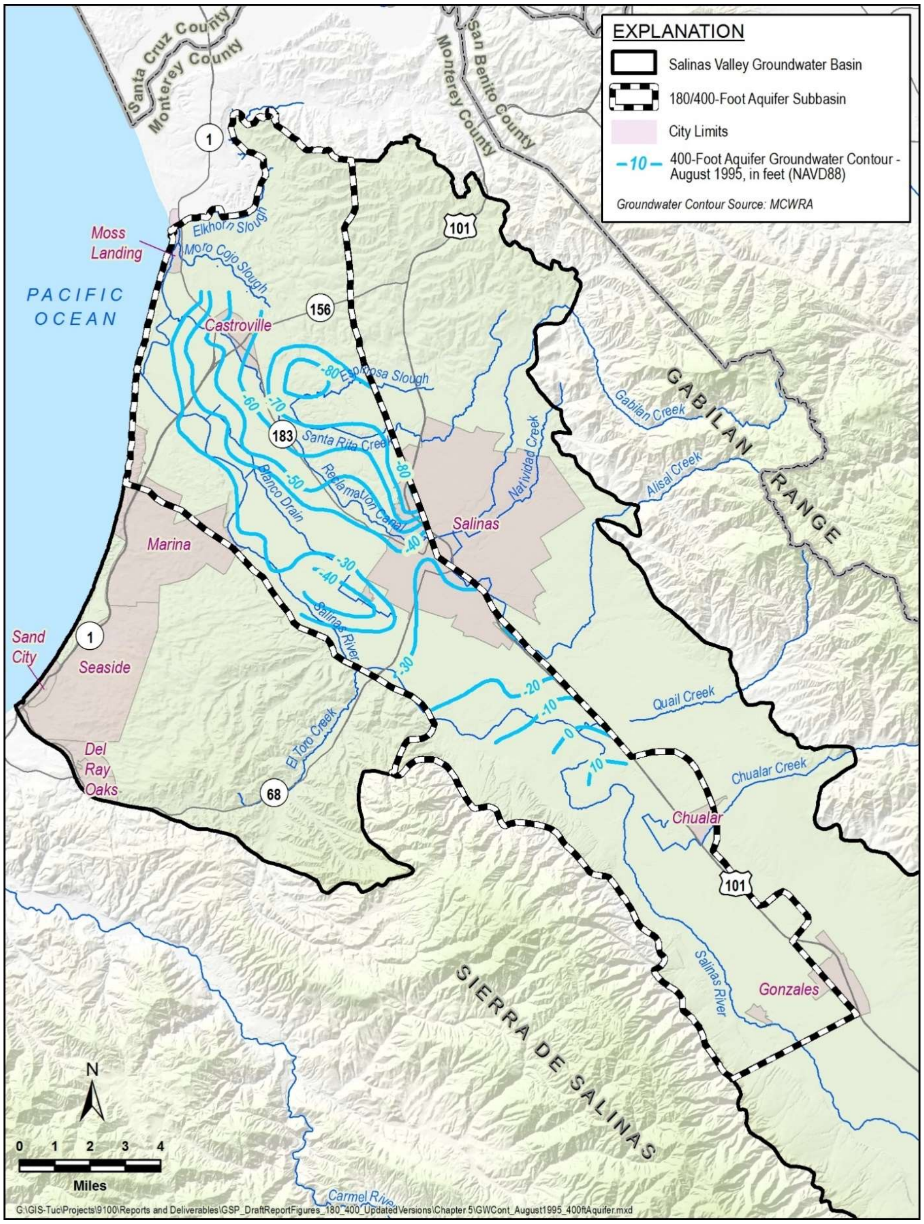


Figure 5-8~~5-8~~. August 1995 400-Foot Aquifer Groundwater Elevation Contours

Groundwater generally flows from the south and from adjacent basins toward the north-northwest, with localized depressions around the pumping centers like those along the boundary with the Eastside Aquifer Subbasin northwest of the City of Salinas. The contours indicate that groundwater flow directions are similar in the 180-Foot and 400-Foot Aquifers. However, based on these contours, groundwater elevations in the 400-Foot Aquifer are generally lower than groundwater elevations in the 180-Foot Aquifer during both 1995 and 2019.

Under current conditions (Figure 5-1 to Figure 5-4), groundwater elevations in the northern half of the Subbasin are below sea level, estimated as zero feet NAVD88, as indicated by the negative values on the contour lines. The lowest groundwater elevations for both the 180-Foot and 400-Foot Aquifers occur northwest of the City of Salinas along the boundary with the Eastside Aquifer Subbasin. In the 180-Foot Aquifer, minimum groundwater elevations are approximately -30 ft NAVD88 during the fall measurements (Figure 5-1) and -40ft NAVD88 during the August measurements (Figure 5-2). In the 400-Foot Aquifer, minimum groundwater elevations are approximately -30 ft NAVD88 during the fall measurements (Figure 5-3) and -80 ft NAVD88 during the August measurements (Figure 5-4). The hydraulic gradients differ throughout the subbasin and are difficult to quantify based on variable groundwater elevations.

Groundwater elevations in the 180/400-Foot Aquifer Subbasin increase to the west toward the boundary with the Monterey Bay. They also increase toward the southern boundary with the Forebay Subbasin Aquifer where groundwater elevations are greater than 90 ft NAVD88 in the 180-Foot Aquifer (Figure 5-1 and Figure 5-2) and greater than 40 ft NAVD88 in the 400-Foot Aquifer (Figure 5-3 and Figure 5-4).

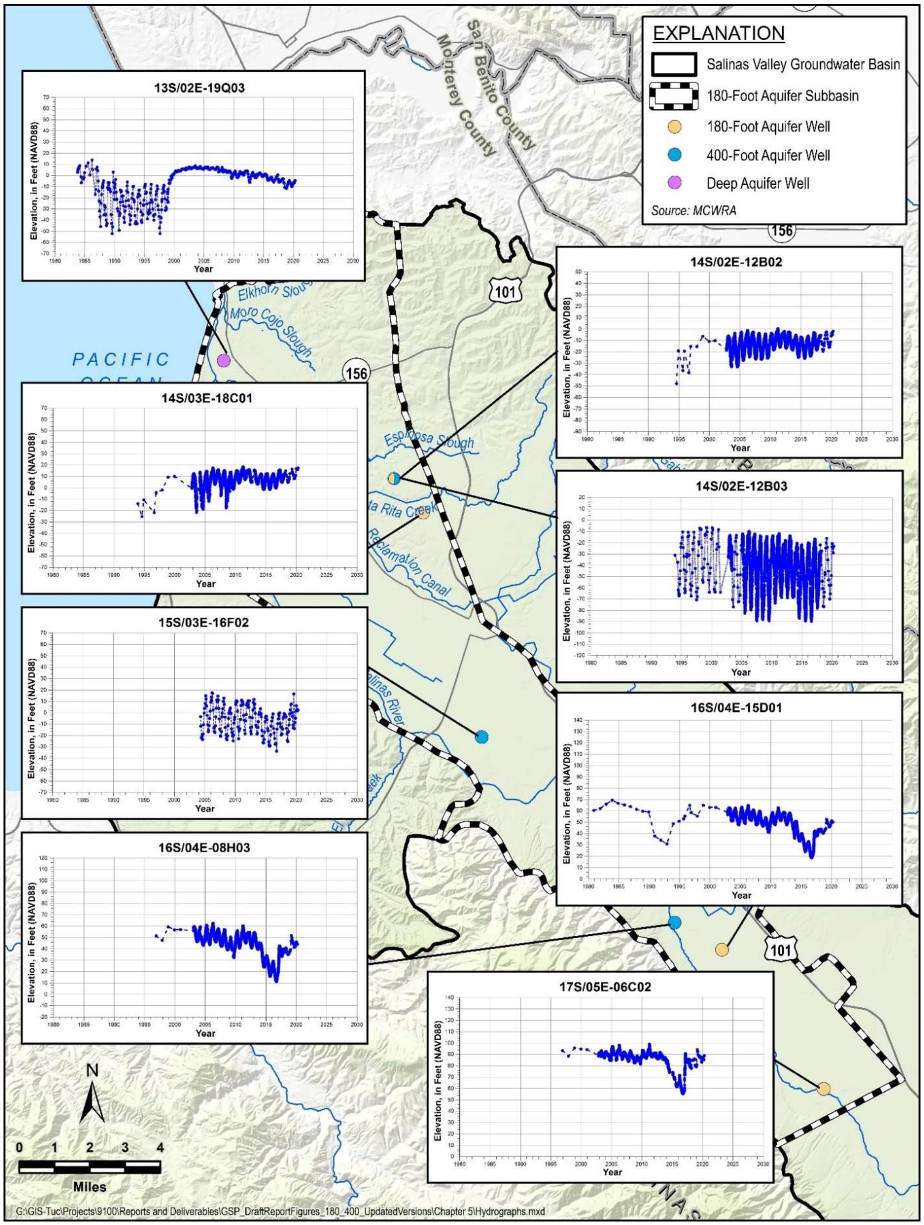
Under the historical conditions of 1995, a similar flow pattern to that of current conditions was present in both the 180-Foot and 400-Foot Aquifers; however, the magnitude of the pumping trough has varied over time. A discussion of historical groundwater elevation changes is presented in Section 5.1.3.

5.1.3 Hydrographs

Commented [AO4]: Example hydrographs included on maps in chapter. Larger hydrographs for all Representative Monitoring Sites are included in appendix

Representative temporal trends in groundwater elevations can be assessed with hydrographs, which plot changes in groundwater elevations over time. Groundwater elevation data from wells within the Subbasin are available from monitoring conducted and reported by MCWRA.

Figure 5-9 depicts the locations and hydrographs of example monitoring wells in the Subbasin. Larger versions of the hydrographs for these wells, as well as all representative monitoring wells, are included in Appendix 5A. The locations of all the representative monitoring wells are shown on Figure 5-10 through Figure 5-12. Chapter 7 provides more information specific to the wells and the monitoring system.



Source: MCWRA

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Figure 5-9~~5-9~~. Map of Example Hydrographs

Figure 5-10~~5-10~~. Locations of 180-Foot Aquifer Wells in the with Hydrographs Included in Appendix 5A

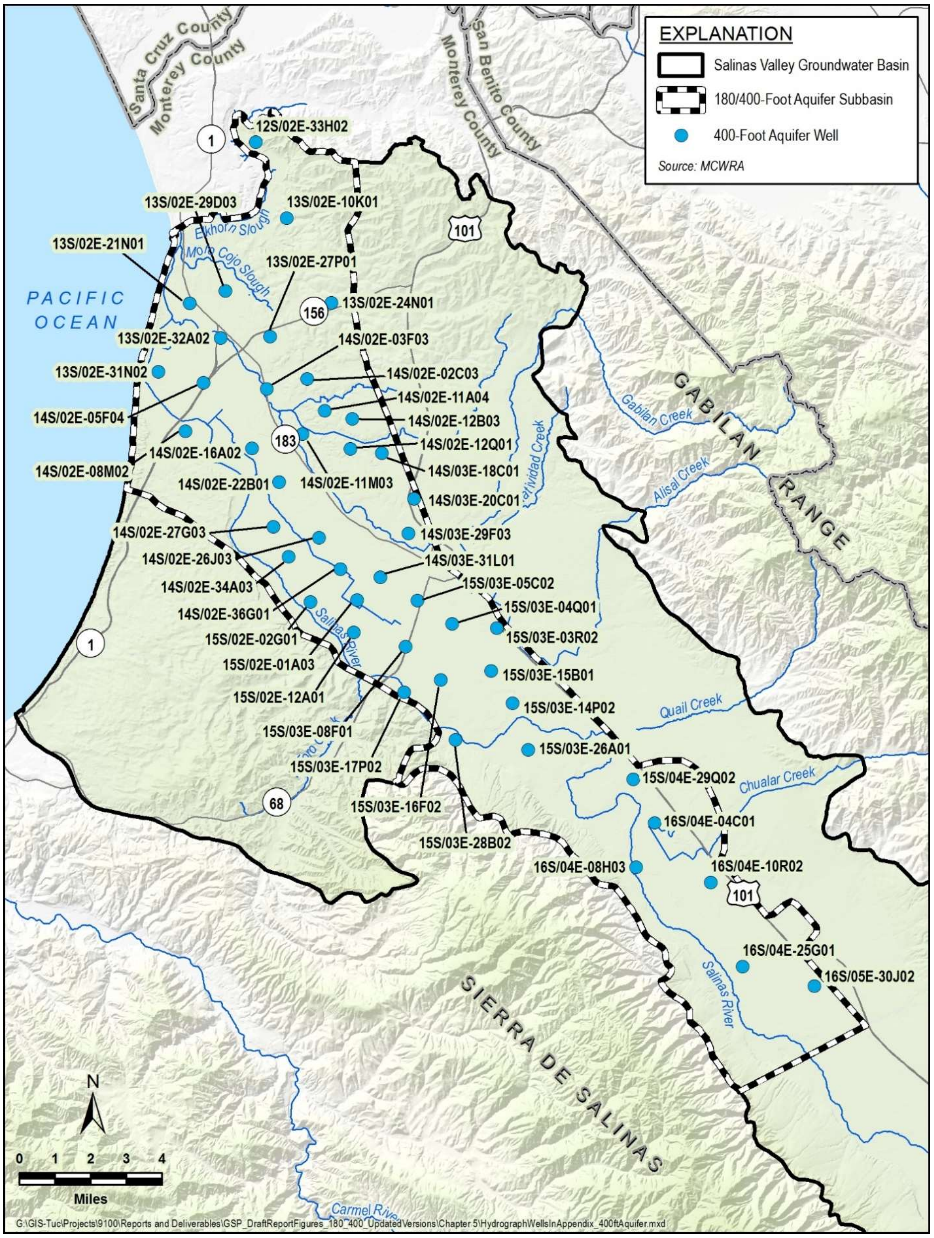

Figure 5-11~~5-11~~. Locations of 400-Foot Aquifer Wells in the with Hydrographs Included in Appendix 5A

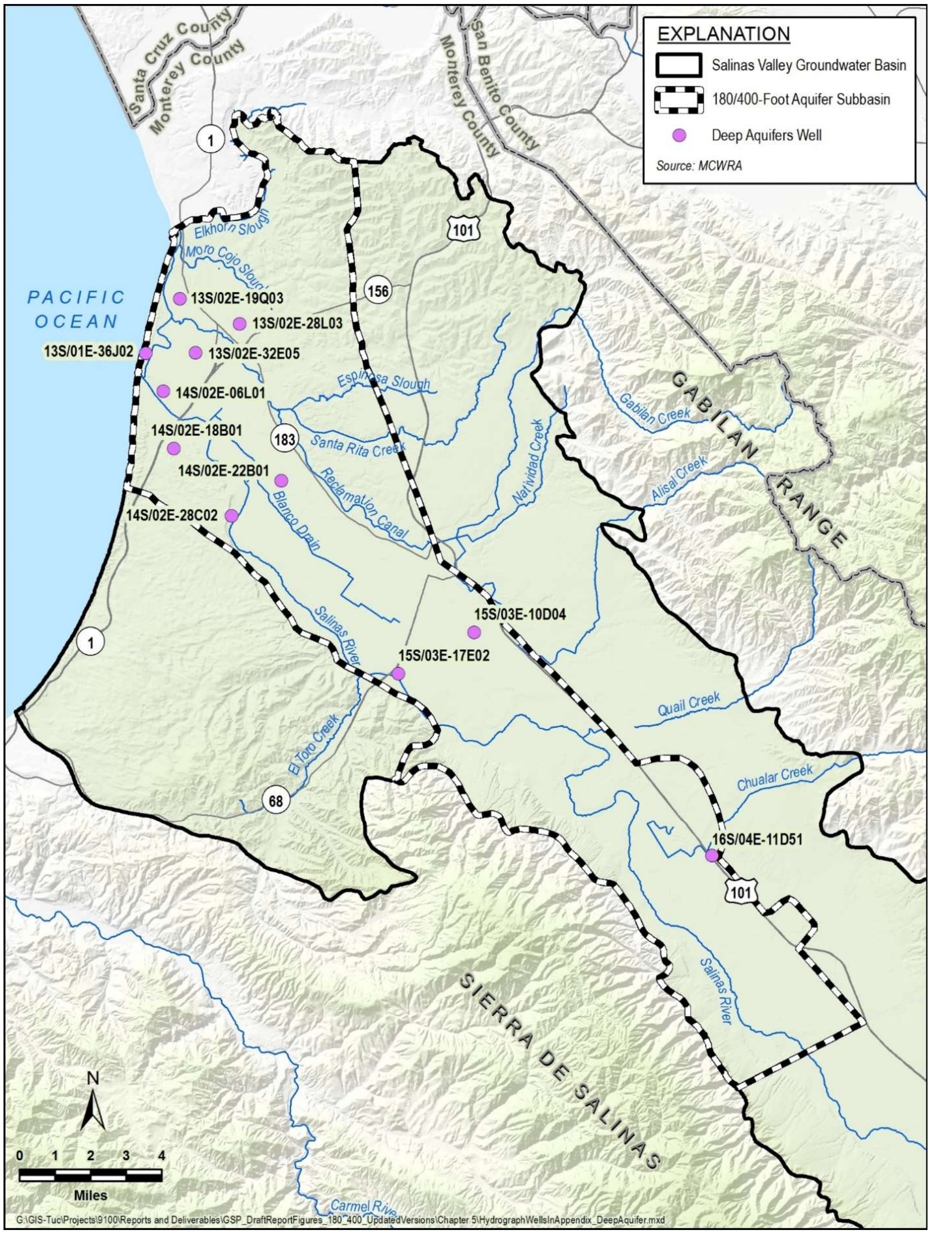

Figure 5-12~~5-12~~. Locations of Deep Aquifers Wells in the with Hydrographs Included in Appendix 5A

Figure 5-14 presents a graph of cumulative groundwater elevation change for the 180/400-Foot Aquifer Subbasin. The graph was initially developed by MCWRA and is based on averaged change in fall groundwater elevations for designated wells in the Pressure subarea each year. The Pressure subarea used by MCWRA for its groundwater elevation change analyses overlaps the 180/400-Foot Subbasin, as well as small parts of the Eastside Aquifer Subbasin and most of the Monterey and Seaside Subbasins, as shown on Figure 5-15. The figure was adapted to reflect the cumulative change in groundwater elevations specific to the 180/400-Foot Aquifer Subbasin.

The cumulative change in groundwater elevation graph is developed by MCWRA and is based on averaged change in Fall groundwater elevations for designated wells in the subarea each year. MCWRA uses Fall groundwater elevations because these measurements are taken after the end of the irrigation season and before seasonal recharge from winter precipitation increases in groundwater levels. The cumulative groundwater elevation change plot is therefore an estimated average hydrograph for wells in the subarea. Although this plot does not reflect the groundwater elevation change at any specific location, it provides a general illustration of how the average groundwater elevation in the subarea changes in response to climatic cycles, groundwater extraction, and water-resources management at the subbasin scale.

The cumulative elevation change graph and the specific hydrographs presented in Appendix 5A show that groundwater elevations in the Subbasin show a long-term decline over time.

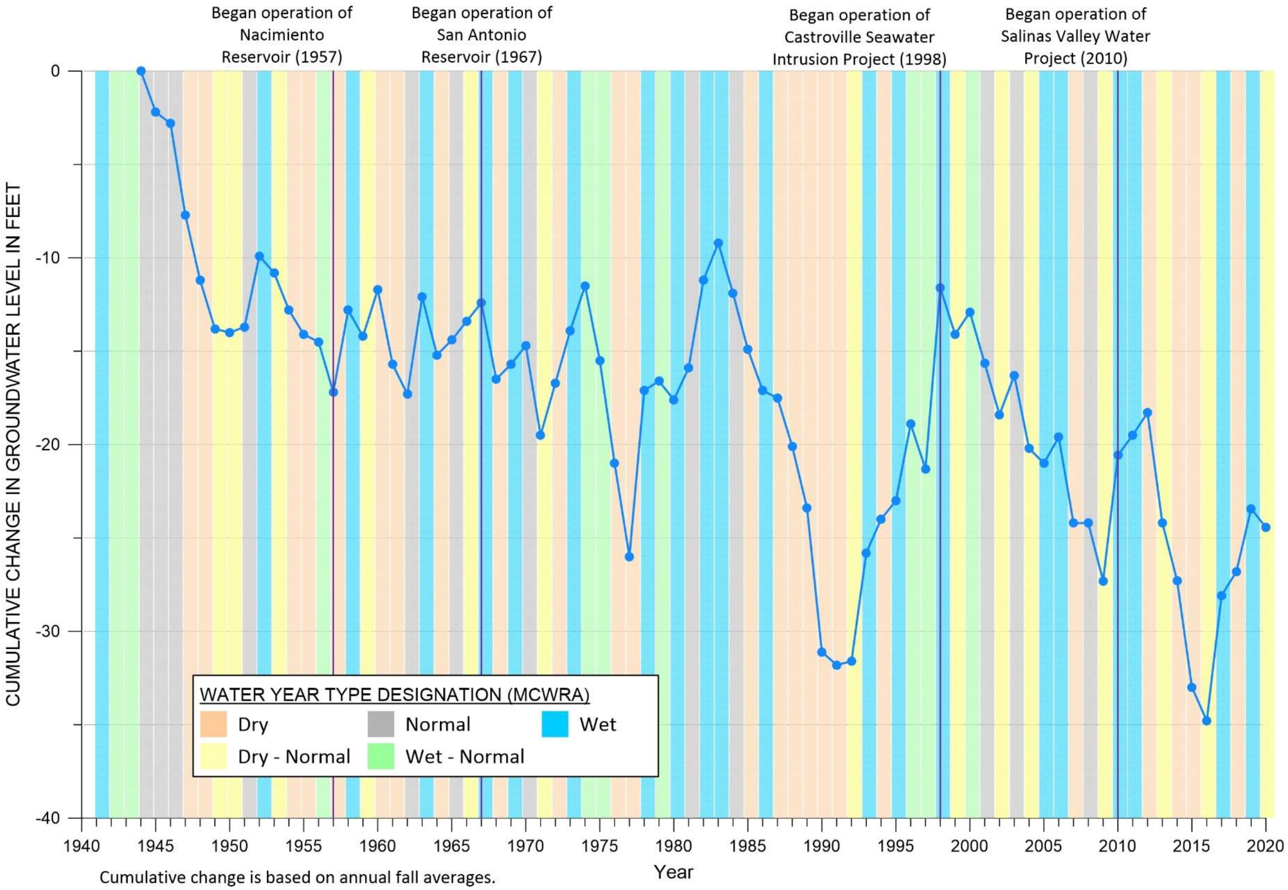

Figure 5-135~~-13~~. Cumulative Groundwater Elevation Change Graph for the 180/400-Foot Aquifer Subbasin (Adapted from MCWRA, 2018a, personal communication)

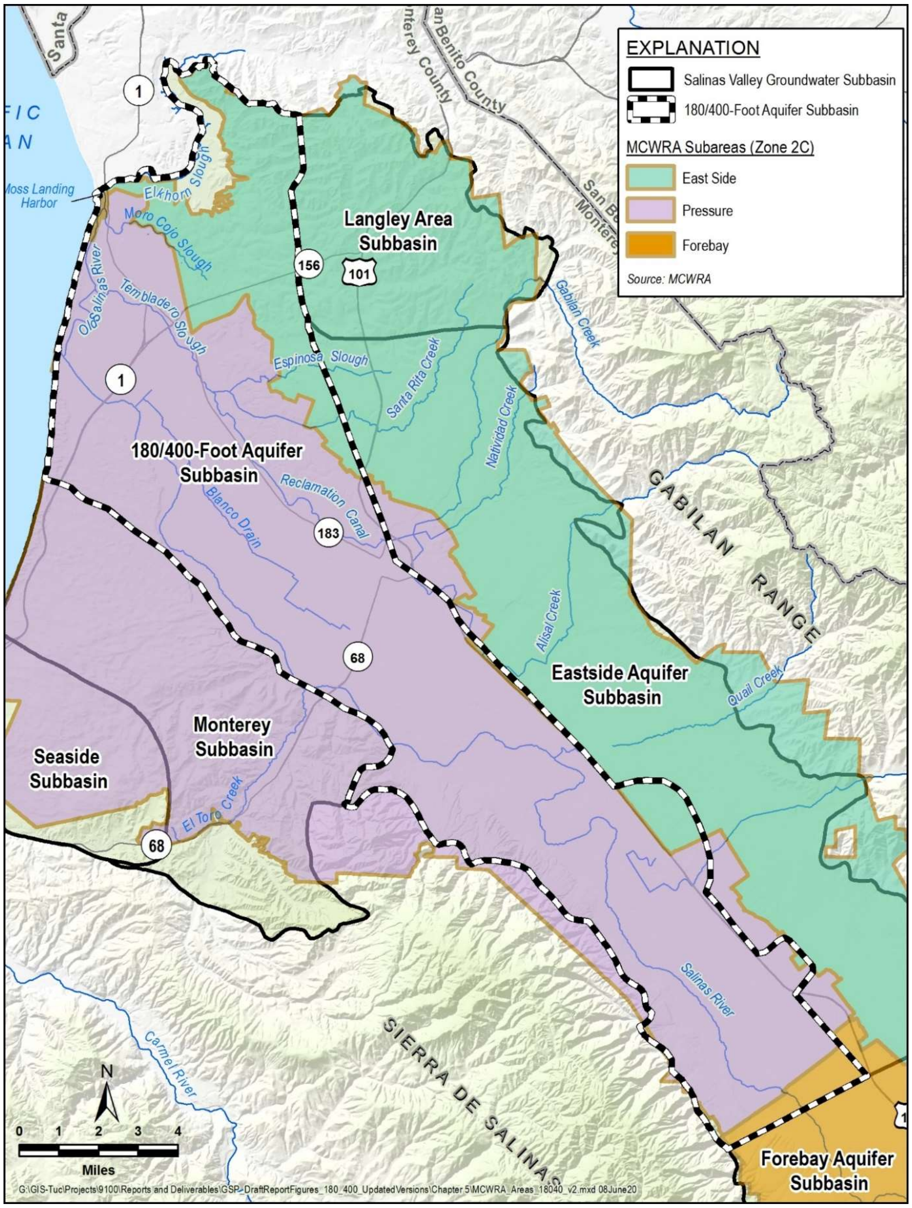

Figure 5-14~~5-14~~. MCWRA Management Subareas

5.1.4 Vertical Groundwater Gradients

In the 180/400-Foot Aquifer Subbasin, the laterally extensive aquitards result in notable vertical hydraulic gradients: in some places groundwater elevations are approximately 20 to 50 feet lower in deeper wells than in shallower wells. Because the downward vertical gradients are caused by pumping, the magnitudes of the vertical gradients in many areas are greater during the irrigation season.

Figure 5-15 illustrates how vertical gradients at representative well pairs vary throughout the Subbasin. Each representative well pair consists of two adjacent wells with different well depths. The hydrographs for each well pair illustrate the difference in groundwater potentiometric elevation between wells of different depths at the same location. The two northernmost well pairs for the 180-Foot and 400-Foot Aquifers demonstrate similar fluctuating patterns between each well pair; however, groundwater elevations for the wells in the 180-Foot Aquifer are generally higher than those in the 400-Foot Aquifer. This likely indicates a lack of connection between the 180-Foot and 400-Foot Aquifers. On the contrary, the southern well pair for the 180-Foot and 400-Foot Aquifers does not demonstrate an appreciable difference in groundwater elevations which probably indicates a connection between the aquifers. There are not enough groundwater elevation records for wells in the Deep Aquifer to make a conclusion about the connection among the 180-Foot, 400-Foot, and Deep Aquifers.

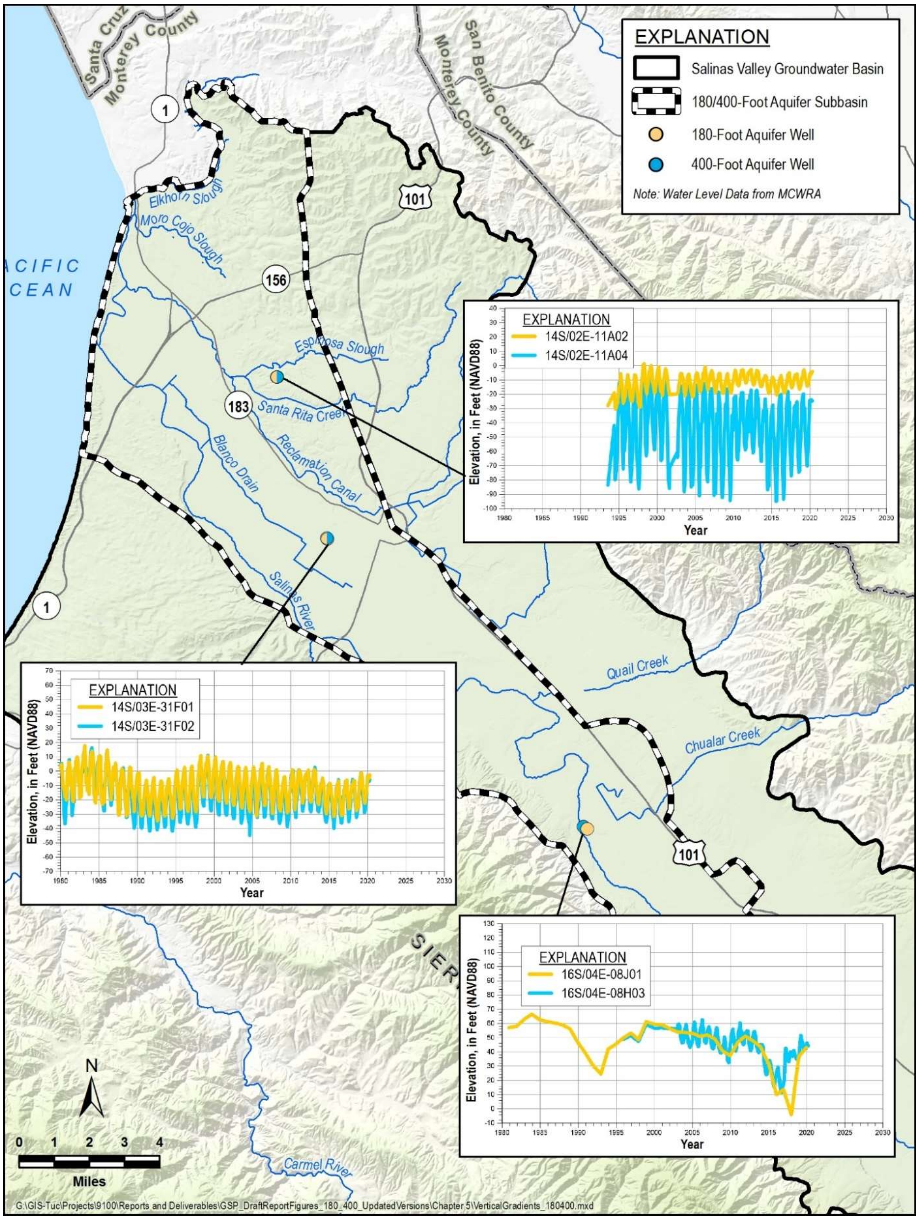

Figure 5-15~~5-15~~. Vertical Gradients

5.2 Change in Groundwater Storage

Commented [AO5]: GSP Update contains revised method of calculation to improved method (storage change due to groundwater level changes plus storage change due to seawater intrusion). Prior method (storage change calculation based on cumulative groundwater level hydrograph) still included, but as a check.

Change in groundwater storage is calculated as the sum of the change in storage due to groundwater elevations outside of the seawater intruded area; and change in storage due to seawater intrusion within the seawater intruded area. This approach calculates the change in usable groundwater in storage rather than a change in total groundwater in storage. ~~-~~This is a common approach that best addresses the intent of SGMA.

Changes in groundwater elevations directly relate to fluctuation of groundwater storage; thus, the change in storage outside of the seawater intruded area is based on the change in groundwater elevations. As seawater intrusion ~~increases~~advances inland, freshwater storage is decreased by the intruding seawater. Therefore, inside the seawater intruded area, the change in storage is the change in volume of seawater in the aquifer. To calculate the total change in storage in the Subbasin, ~~both~~ the change in storage due to groundwater elevations and seawater intrusion need to be summed together.

5.2.1 Data Sources

Change in storage due to changes in groundwater elevation is developed based on MCWRA's fall groundwater elevation measurements. Fall groundwater elevation contour maps are used because these measurements are taken after the peak irrigation season and before winter precipitation increases groundwater levels; therefore, fall groundwater levels are reflective of annual change in storage caused by recharge and withdrawals of groundwater~~to retain consistency with the cumulative change in groundwater elevation graph~~. These groundwater elevation measurements are used to create fall groundwater elevation contour maps; and MCWRA's fall 1995 and fall 2019 contour maps are used to determine the spatial distribution of historical storage changes.

The change in storage from 2019 to 2020 is included in this GSP to describe current conditions. However, current conditions reflect the change in storage over the course of only one year; and annual change in storage fluctuates significantly depending on annual groundwater elevation changes. The historical groundwater elevations used to develop the cumulative change in groundwater elevation graph (Figure 5-13) that is used to estimate change in groundwater storage over time are used to validate the storage change due to groundwater elevations.

Change in storage due to seawater intrusion is based on MCWRA's extent of seawater intrusion maps. MCWRA produces these maps ~~bi~~annually. The maps identify the inferred extent of the 500 mg/L chloride concentrations in both the 180- and 400-Foot Aquifers. The change in storage calculations assume that all groundwater seaward of the 500 mg/L chloride isocontours is unusable.

5.2.2 Change in Groundwater Storage Due to Groundwater Elevation Changes

The calculation of change in storage using groundwater elevation changes for the non-seawater intruded area is based on the following relationship:

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$$\Delta S = \Delta WL \times A \times SC$$

Where: ΔS = Annual change in storage volume in the Subbasin (AF/yr.)

ΔWL= Annual change in average groundwater elevation in the Subbasin (ft/yr.)

SC = Storage coefficient (ft^3/ft^3)

A = Non-seawater intruded land area of Subbasin (acres)~~SC = Storage coefficient (ft^3/ft^3)~~

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This GSP Update calculates change in storage due to groundwater elevations in two ways:

1) ***Aquifer-specific calculation***: aquifer-specific storage coefficients are used to calculate the storage change in the areas of the 180-Foot and 400-Foot Aquifers that are not seawater intruded~~, which are then summed together~~.

2) ***Whole subbasin calculation***: a storage coefficient representing all ~~non-seawater intruded portions of the~~ aquifers and aquitards above the 400-Foot/Deep Aquitard is used together with an area that subtracts the seawater intruded area. This is considered more representative because it accounts for the unconfined conditions in part of the Subbasin and shallow sediments. This whole subbasin calculation is also used for the groundwater storage SMC calculation described in Chapter 8.

Both calculations use the same c~~C~~hange in groundwater storage due to change in groundwater elevations in the Subbasin (ΔWL), but they differ in how they calculate the storage coefficient (SC) and land area (A). ~~is calculated by first subtracting the fall 2019 groundwater elevation contours from the fall 1995 groundwater elevation contours.~~

Annual change in average groundwater elevations (ΔWL): This is calculated by first subtracting the fall 2019 groundwater elevation contours from the fall 1995 groundwater elevation contours. For the 180-Foot Aquifer, Figure 5-5 and Figure 5-16 show the fall 1995 and fall 2019 groundwater elevation contours, respectively. Figure 5-17 shows the estimated change in groundwater storage in the 180-Foot Aquifer calculated by subtracting these two fall groundwater elevation maps. Figure 5-18 shows the estimated change in groundwater storage from fall 2019 to fall 2020 calculated by subtracting the fall 2019 (Figure 5-16) and fall 2020 (Figure 5-1) groundwater elevation contours. Change in storage for the 180-Foot Aquifer was calculated over ~~an~~ non-seawater intruded area of approximately 66,000 acres.

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Similarly, for the 400-Foot Aquifer, Figure 5-7 and Figure 5-19 show the fall 1995 and fall 2019 groundwater elevation contour maps, respectively, and Figure 5-20 shows the associated 400-Foot Aquifer change in groundwater storage from fall 1995 to fall 2019. Figure 5-21 shows the estimated change in groundwater storage from fall 2019 to fall 2020 calculated by subtracting the fall 2019 (Figure 5-19) and fall 2020 (Figure 5-3). Change in storage in the 400-Foot Aquifer was calculated over a non-seawater intruded~~n~~ area of approximately 75,000 acres.

Given the limited data available for the Deep Aquifers, the groundwater level data used for calculating change in storage is predominantly from the 180-Foot and 400-Foot Aquifers, not the Deep Aquifers. Change in storage in the Deep Aquifers will be evaluated in the future as more data and information are collected during GSP implementation.

While subbasin calculations of change in storage are averaged over the entire Subbasin, change in storage maps show geographically how change in storage varies across the Subbasin. Between 1995 and 2019, a loss in groundwater storage has occurred in the southern end of the Subbasin in both the 180-Foot and 400-Foot Aquifers near Chualar. The loss in storage in this area ranges from 0.1 to 0.3 AF per acre over an area of approximately 12,000 acres in the 180-Foot Aquifer and 0.1 to 0.3 AF per acre over an area of approximately 900 acres in the 400-Foot Aquifer. Other noticeable areas with loss of groundwater storage are seen around Gonzales. From 2019 to 2020, storage change mostly remained within 0.1 AF per acre in both the 180-Foot and 400-Foot Aquifers throughout the Subbasin, there was only a small area within 1,000 acres that experienced a los in storage within 0.1 to 0.2 AF per acre.

Storage coefficient (SC): The aquifer-specific calculation ~~The change in storage is calculated by groundwater elevation change is then multiplyi~~ed~~ng a change in groundwater elevation by a storage coefficient. Storage coefficients depend on the hydraulic properties of the aquifer materials and are commonly measured~~ estimated ~~through long-term pumping tests~~, ~~or laboratory tests, or groundwater modeling.~~ uses a specific storage estimates from the SVIHM of ~~0.0000~~8.2x10^{-5} ft^{-1} and ~~0.0000~~2.7x10^{-5} ft^{-1} for the 180-Foot and 400-Foot Aquifers, respectively. The specific storage estimates from the SVIHM are multiplied by the approximate thickness of 150 feet for the 180-Foot Aquifer and 200 feet for the 400-Foot Aquifer; yielding storage coefficients of 0.012 and 0.005 for the 180-Foot and 400-Foot Aquifers, respectively. When the SVIHM is finalized, its specific storage estimates are likely to change. However, these values are reasonable and are the best available data. The final SVIHM's specific storage estimates will be used when they are available.

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For the whole subbasin calculation, ~~As described in Chapter 4, storage coefficients can be calculated by multiplying specific storage and the aquifer thickness. The SVIHM uses a specific storage estimate of 0.000082 ft^{-1} and 0.000027 ft^{-1} for the 180-Foot and 400-Foot Aquifers, respectively. for the 180-Foot and 400-Foot Aquifers in the North Marina Groundwater Model (NMGWM), as estimates that Aquifer specific storage es(),and specific storage in the 400-Foot Aquifer ranges from ()The lower specific storage estimates were typically onshore, and comparable to the SVIHM onshore specific storage values. groundwater changes in The specific~~

~~storage estimates from the SVIHM were multiplied by the approximate thickness of 150 feet for the 180-Foot Aquifer and 200 feet for the 400-Foot Aquifer; yielding storage coefficients of 0.012 and 0.005 for the 180-Foot and 400-Foot Aquifers, respectively. As When the SVIHM is finalized, its specific storage estimates are likely to change. However these values are reasonable and but currently, these are the best available data. The final SVIHM's specific storage estimates will be used when they are available. To remain consistent with the groundwater storage SMC calculation described in Chapter 8the, Tthe aquifer-specific change in storage calculations are supplemented with a Subbasin-wide change in storage calculation. another calculation using a A~~ storage coefficient of 0.078 is used for the entire Subbasin. ~~the whole Subbasin is necessarycalculation. seawater~~This estimate incorporates the 180-Foot, 400-Foot, and Deep Aquifers. More details and background on how the aquifer-specific and whole Subbasin storage coefficients were calculated are provided in Appendix 5B.

Non-seawater intruded land area of Subbasin (A): ~~A generalized storage coefficient for all aquifers in the 180/400-Foot Aquifer Subbasin was estimated at 0.036 in the State of the Basin Report (Brown and Caldwell, 2015). The area of the 180/400-Foot Subbasin is approximately 89,700 acres. Given the limited data available for the Deep Aquifers, the estimates are derived from these groundwater level data used for calculating change in storage is predominantly from the 180-Foot and 400-Foot Aquifers, not the Deep Aquifers. Change in storage in the Deep Aquifers will be evaluated in the future as more data and information are collected during GSP implementation.~~

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~~This calculation of change in storage using groundwater elevation changes isare based on the following relationship:~~

Δ~~$S=\Delta WL\times A\times SC$~~

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~~Where: ΔS = Annual change in storage volume in the Subbasin (AF/yr.)~~

~~ΔWL= Annual change in average groundwater elevation in the Subbasin (ft/yr.)~~

~~A = Land area of Subbasin (acres)~~

~~SC = Storage coefficient (ft3/ft3)~~

For the aquifer-specific calculation, t~~T~~he area used for each individual aquifer calculation differs based on the area covered by annual fall contours and seawater intruded area.

For the whole Subbasin ~~total~~ calculation, the area was estimated by subtracting the total volume of seawater intruded groundwater from the total amount of water that can be held in storage above the bottom of the 400-Foot Aquifer. This volume was then divided by the depth to the bottom of the 400-Foot Aquifer to calculate an area. Calculating area in this manner accounts for the aquitards and shallow sediments, which hold some water and are factored into the whole subbasin storage coefficient of 0.078.

Annual Change in Storage Calculation: ~~Figure 5-5 and Figure 5-16 shows the Ffall 1995 and fFall 2019 groundwater elevation contours for the 180-Foot Aquifer, respectively. Figure 5-17 shows the estimated change in groundwater storage in the 180-Foot Aquifer calculated by subtracting these two fFall groundwater elevation maps. Figure 5-18 shows the estimated change in groundwater storage from fall 2019 to fall 2020 calculated by subtracting the fall 2019 (Figure 5-16) and fall 2020 (Figure 5-1) groundwater elevation contours. Change in storage for the 180-Foot Aquifer was calculated over an area of approximately 6649,000 acres.~~

~~Similarly, Figure 5-7 and Figure 5-18 Figure 5-19 shows the Ffall 1995 and Fall fall 201920 groundwater elevation contour maps for the 400-Foot Aquifer, respectively, and Figure 5-20 Figure 5-19 shows the associated 400-Foot Aquifer change in groundwater storage from Ffall 1995 to Ffall 201920. Figure 5-21 shows the estimated change in groundwater storage from fall 2019 to fall 2020 calculated by subtracting the fall 2019 (Figure 5-19) and fall 2020 (Figure 5-3). Change in storage in the 400-Foot Aquifer was calculated over an area of approximately 7553,000 acres. Figure 5-20 and Figure 5-21 show the fall groundwater contours and the spatial change in storage between 2019 and 2020 for the 180-Foot Aquifer, respectively. Figure 5-22 and Figure 5-23 show the fall groundwater contours and the spatial change in storage between 2019 and 2020 for the 400-Foot Aquifer, respectively.~~

~~Between 1995 and 2019, a loss in groundwater storage has occurred in the southern end of the Subbasin in both the 180-Foot and 400-Foot Aquifers near Chualar. The loss in storage in this area ranges from 0.16 to 0.31 AF per acre over an area of approximately 212,0800 acres in the 180-Foot Aquifer and 0.16 to 0.31 AF per acre over an area of approximately 9002,000 acres in the 400-Foot Aquifer. Other noticeable areas with loss of groundwater storage are seen around Gonzales. From 2019 to 2020, storage change mostly remained within 0.1 AF per acre there was not a major spatial change in storage anywhere in both the 180-Foot and 400-Foot Aquifers throughout the Subbasin, there was only a small area within 1,000 acres that experienced a los in storage within 0.1 to 0.2 AF per acre. In the 400-Foot Aquifer the greatest storage loss between 2019 and 2020 was about 0.6 AF per acre along the eastern boundary within the Salinas city boundaries.~~

A summary of components used for estimating change in groundwater storage due to groundwater elevation changes is shown in Table 5-2. Using the aquifer-specific storage coefficients, average annual groundwater storage loss due to changes in groundwater elevation since 1995 was ~~330~~ 130 AF/yr. in the 180-Foot Aquifer and 40~~230~~ AF/yr. in the 400-Foot Aquifer. Using the estimated ~~whole~~ Subbasin-wide storage coefficient, t~~T~~he total average annual loss in storage due to changes in groundwater elevation ~~fluctuations~~ wa~~i~~s ~~560~~ 770 AF/yr. from 1995 to 2019 and 8,390~~1,930~~ from 2019 to 2020. The total storage change in the individual aquifers do not add up to the ~~total Subbaisn~~Subbasin-wide storage change. This remaining loss in storage in the Subbasin possibly occurs in the Deep Aquifers and in the shallow sediments above the 180-Foot Aquifer, which are not designated as a principal aquifer. -MCWRA does not produce groundwater elevation maps of the Deep Aquifers. Insufficient data currently exist to map groundwater elevations, and thus, groundwater storage changes, in the Deep Aquifers. This is a data gap that will be addressed during GSP implementation.

Table 5-2~~5-2~~. Components Used for Estimating Change in Groundwater Storage Due to Groundwater Elevation Changes

Components	*Aquifer Specific Calculation*				*Whole Subbasin Calculation*	
	1995 to 2019		2019 to 2020		1995 to 2019	2019 to 2020
	180-Foot Aquifer	400-Foot Aquifer	180-Foot Aquifer	400-Foot Aquifer	Subbasin Total	Subbasin Total
Area of ~~C~~contoured p~~p~~ortion of Subbasin minus Seawater Intrusion Area (acres)	65,600~~49,300~~	75,500~~53,220~~	65,600~~49,200~~	75,300~~52,930~~	76,000	76,000
Storage c~~C~~oefficient (ft^3/ft^3)	0.012~~0.036~~	0.005~~0.036~~	0.012~~0.036~~	0.005~~0.036~~	0.078	0.078
Average change in groundwater elevation (feet)	-4.00~~-4.45~~	-2.21~~-2.92~~	-1.89~~-0.49~~	-0.94~~-0.56~~	-3.11	-1.41
Change in groundwater storage (AF)	-3,230~~-7,900~~	-900~~-5,590~~	-1,530~~-870~~	-380~~-1,060~~	-18,410	-8,390
Average annual change in groundwater storage (AF/yr.)	-130~~-330~~	-40~~-230~~	-1,530~~-870~~	-380~~-1,060~~	-770	-8,390
~~t~~Total average annual change in groundwater storage (AF/yr.)	**-170~~560~~**		**-1,910~~1,930~~**		**-770**	**-8,390**

Note: Negative values indicate loss, positive values indicate gain. The change from 1995 to 2019 is included to quantify historical change in storage and to be consistent with the other GSPs in the Salinas Valley. The change in storage from 2019 to 2020 is included in this GSP to describe current conditions and because it is based on one year it is largely dependent on annual groundwater elevation changes.

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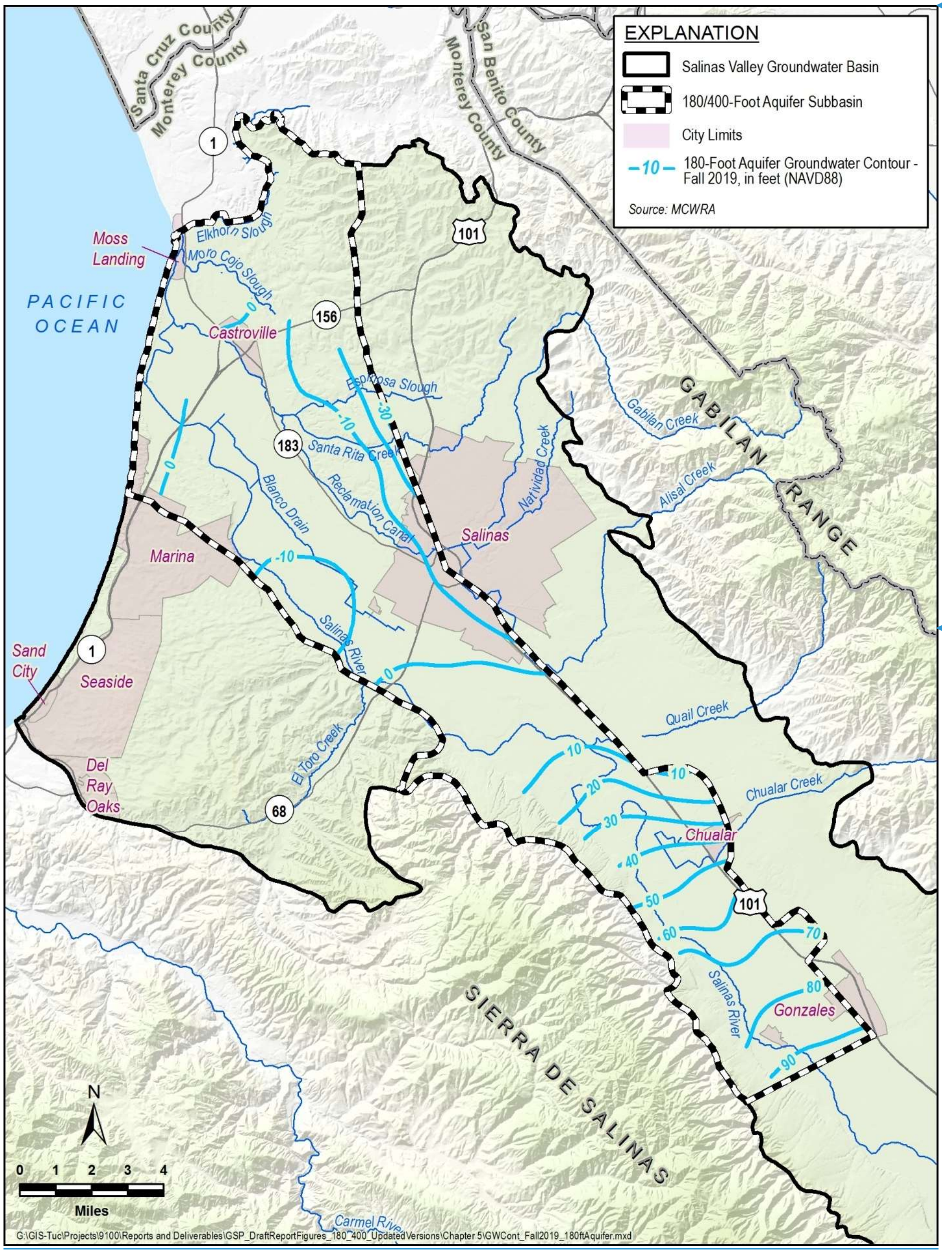

Figure 5-16~~5-16~~. ~~Fall 1995 (left) and~~ Fall 2019 ~~(right)~~ 180-Foot Aquifer Groundwater Elevation Contours

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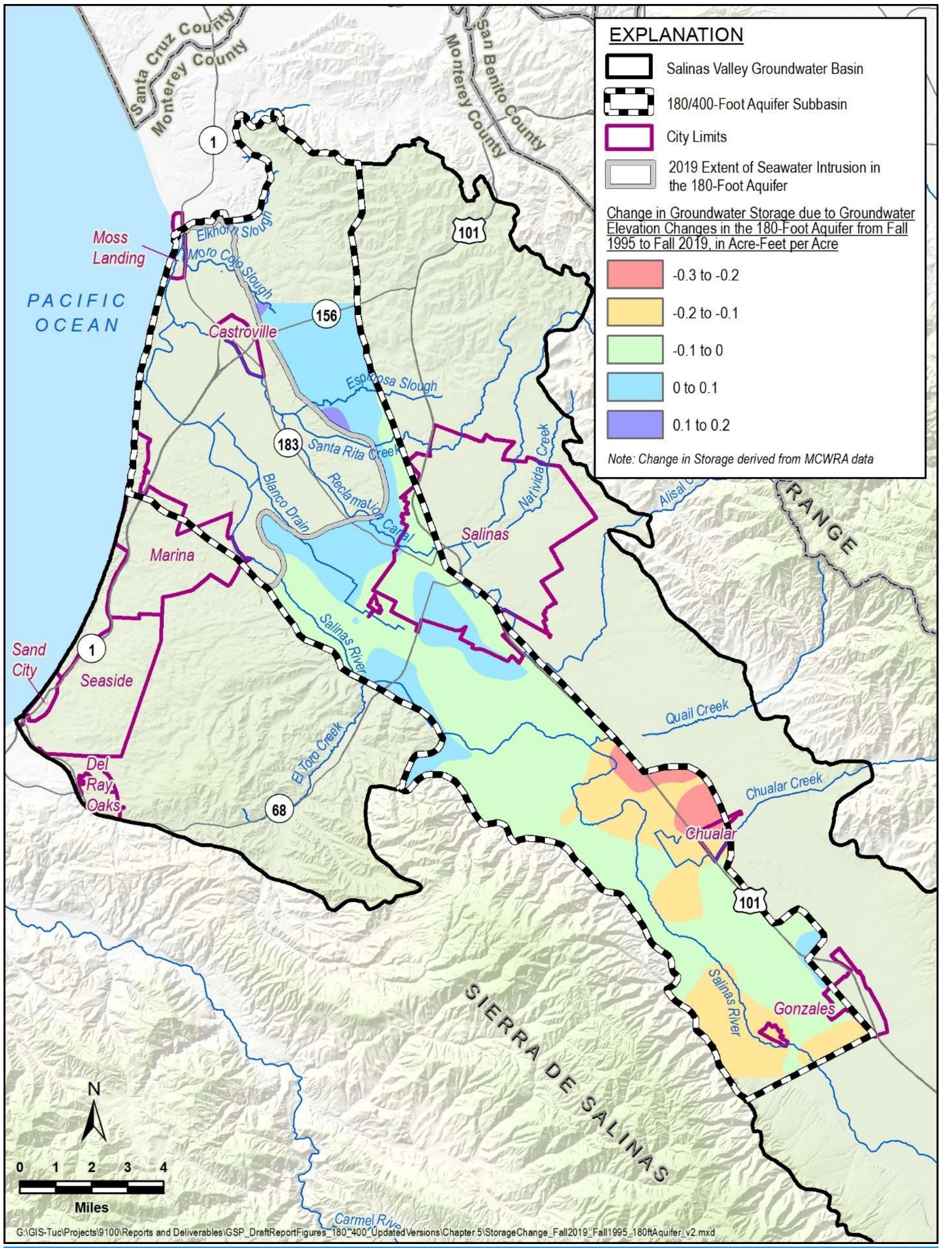

Figure 5-17~~5-17~~. Change in Groundwater Storage in the 180-Foot Aquifer from Fall 1995 to Fall 2019

~~Figure 5-18. Fall 2019 (left) and Fall 2020 (right) 180-Foot Aquifer Groundwater Elevation Contours~~

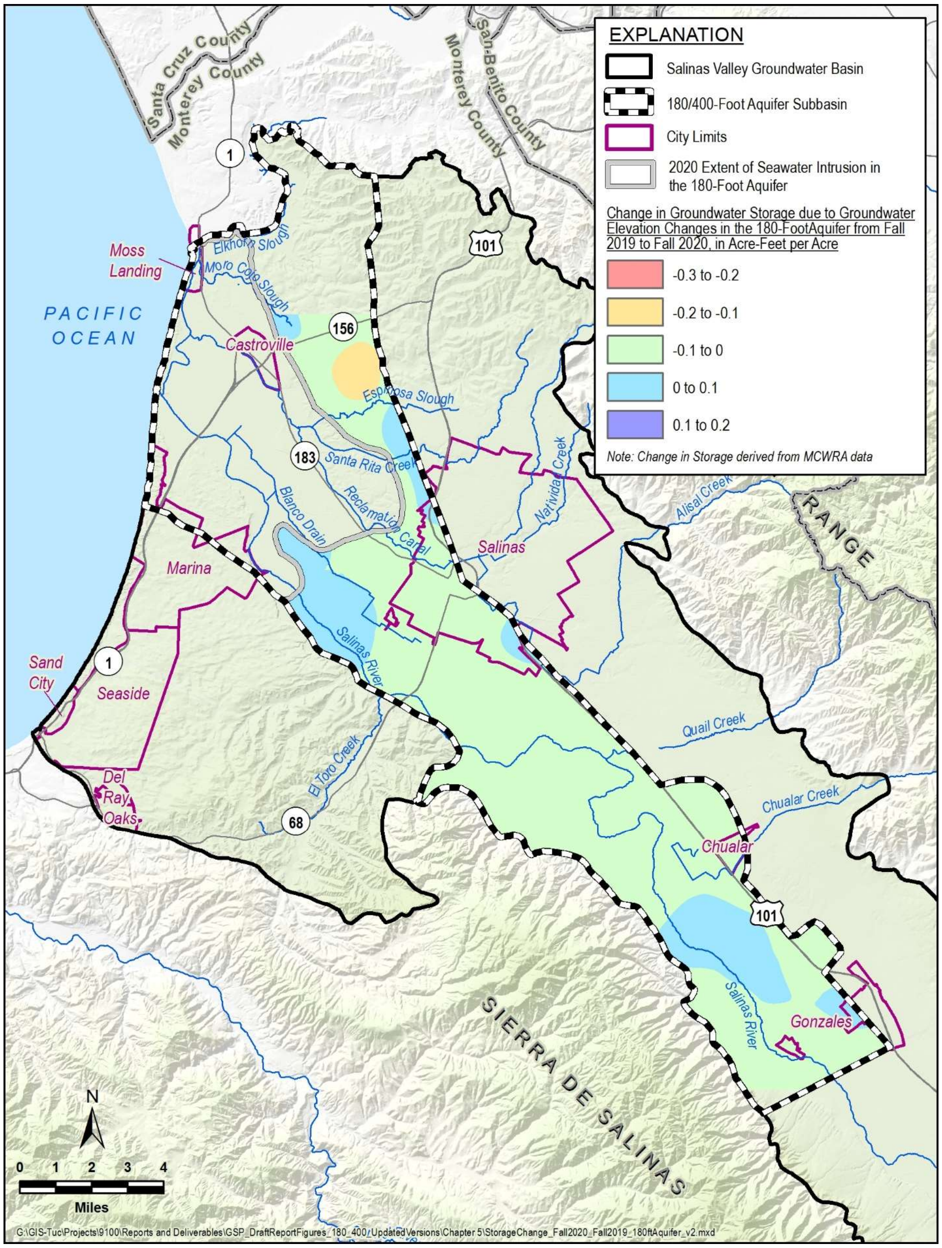

Figure 5-18~~5-19~~. Change in Groundwater Storage in the 180-Foot Aquifer from Fall 2019 to Fall 2020

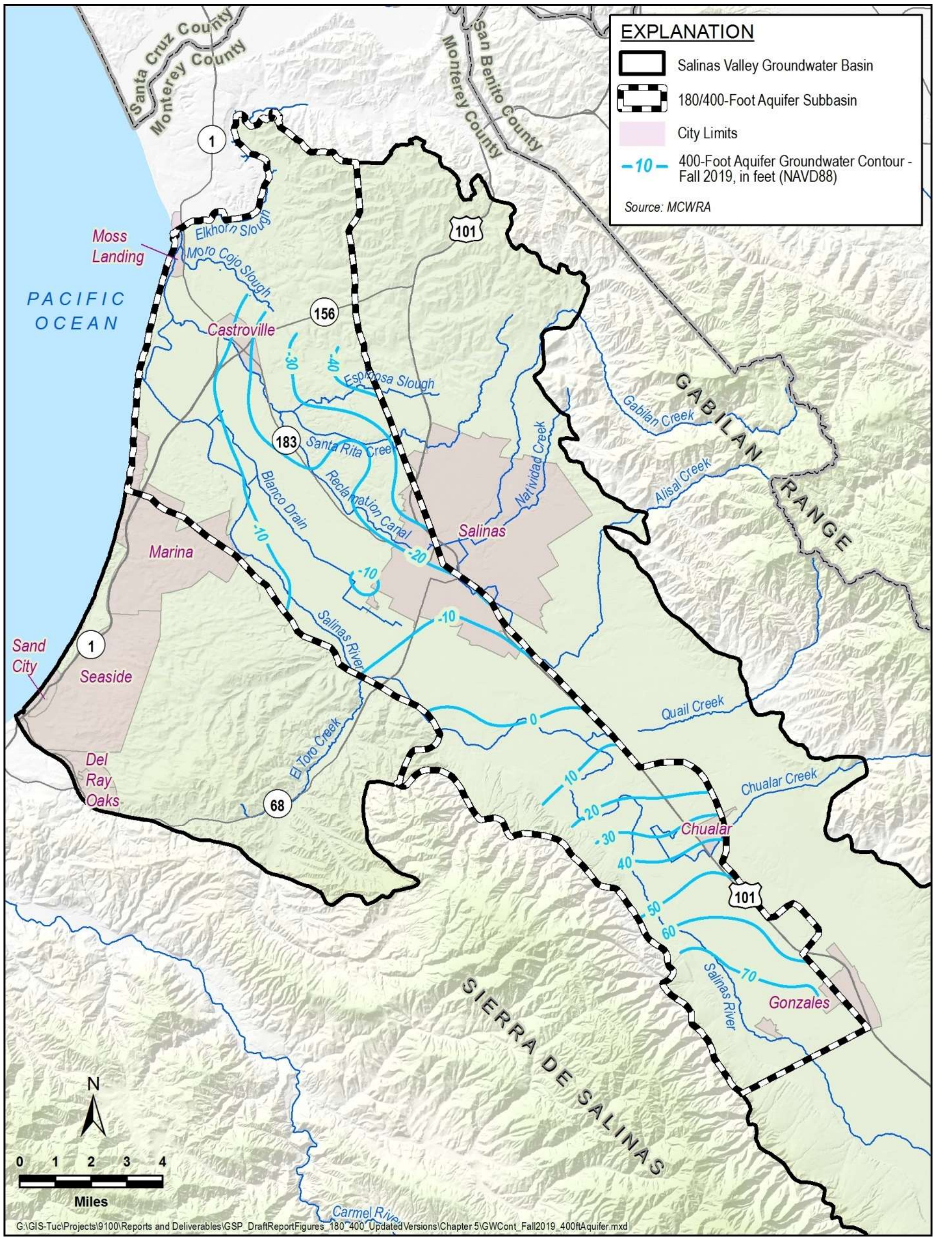

Figure 5-19. ~~Fall 1995 (left) and~~ Fall 2019 ~~(right)~~ 400-Foot Aquifer Groundwater Elevation Contours

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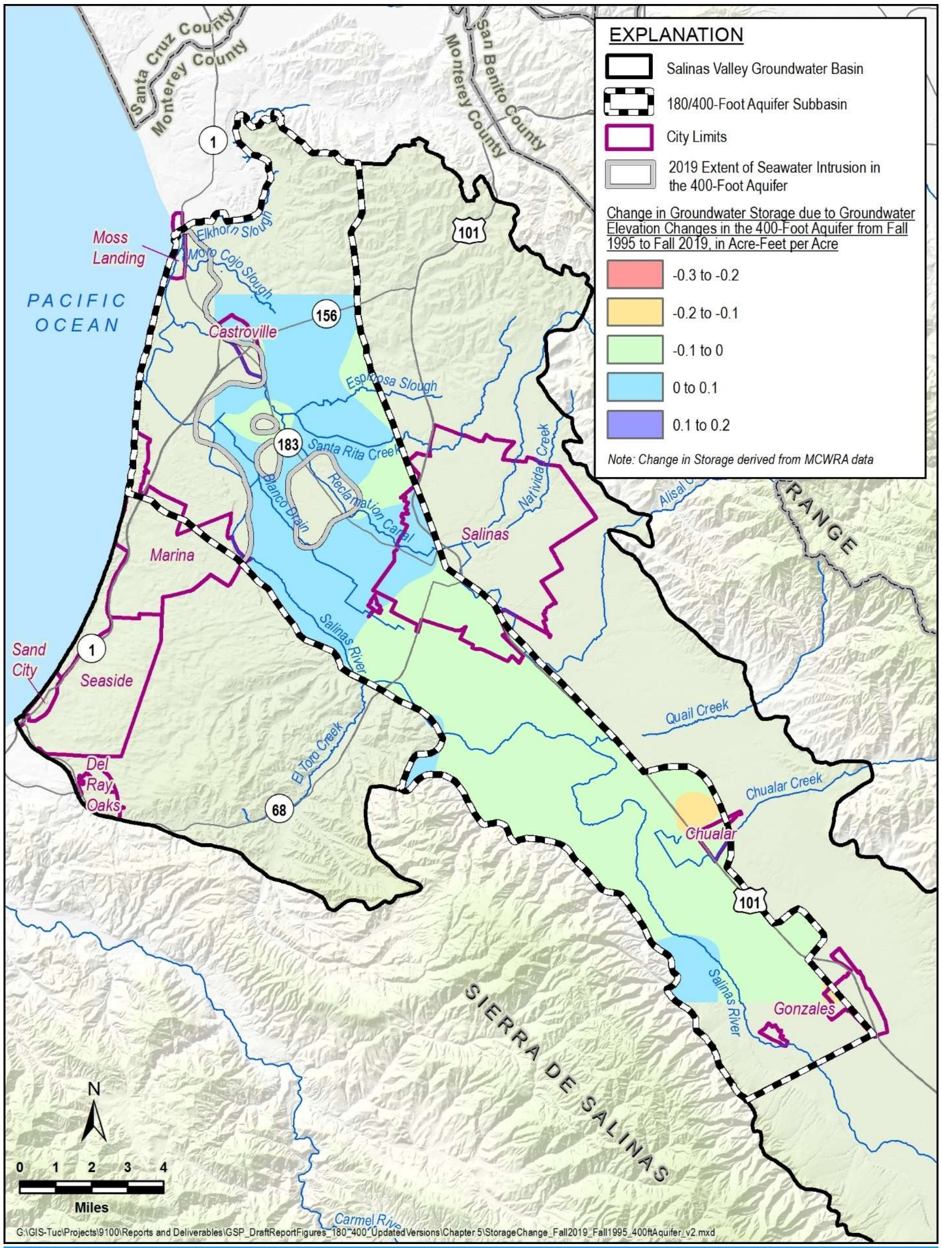


Figure 5-20~~5-21~~. Change in Groundwater Storage in the 400-Foot Aquifer from Fall 1995 to Fall 2019

~~Figure 5-22. Fall 2019 (left) and Fall 2020 (right) 400-Foot Aquifer Groundwater Elevation Contours~~

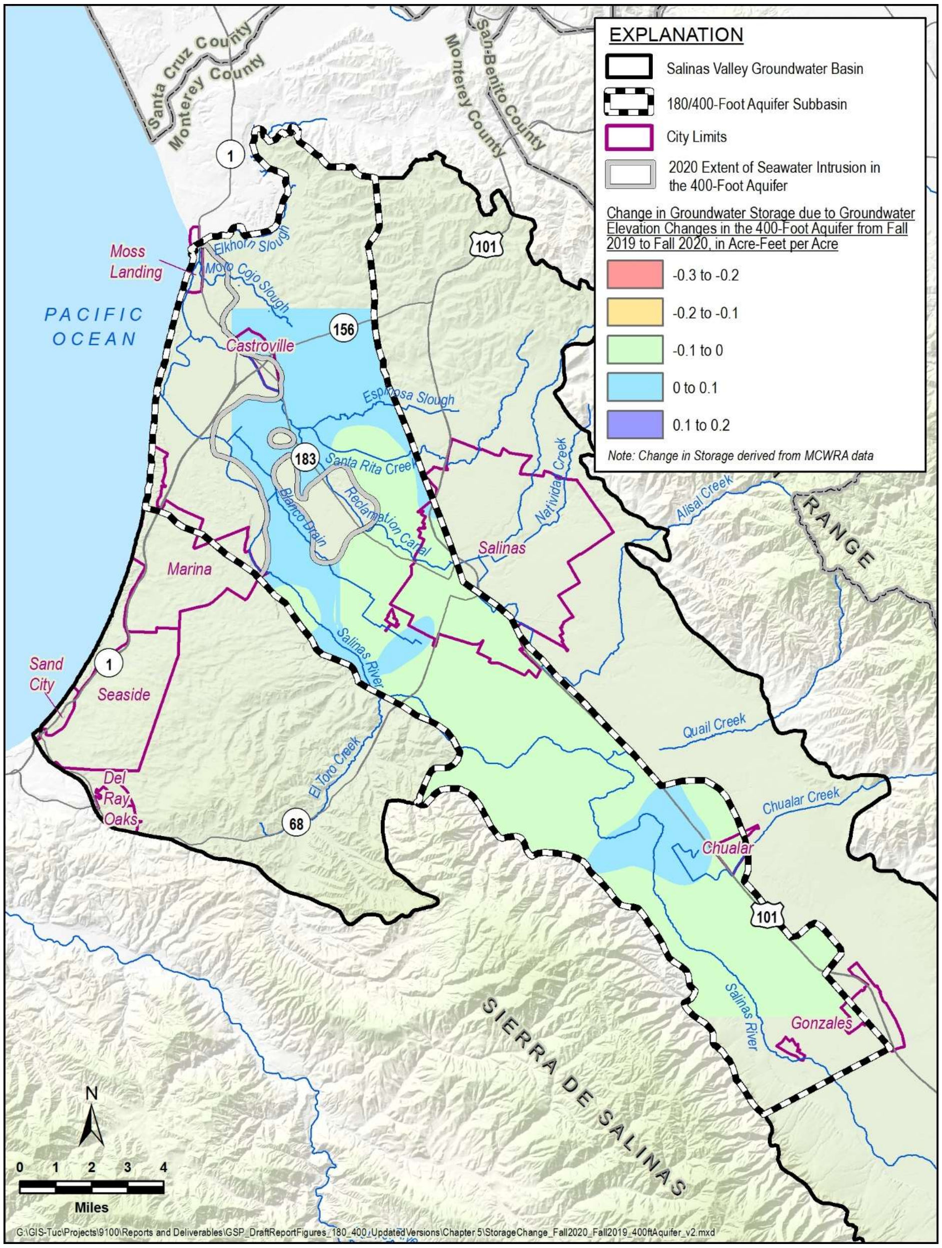


Figure 5-21~~5-23~~. Change in Groundwater Storage in the 400-Foot Aquifer from Fall 2019 to Fall 2020

5.2.3 Change in Groundwater Storage Due to Seawater Intrusion

Groundwater storage losses due to seawater intrusion is estimated based on the change in seawater intrusion area, as mapped by MCWRA. The area of change is multiplied by an assumed aquifer thickness and effective porosity of 0.12, which is used in the SVIHM for the 180-Foot and 400-Foot Aquifers, to estimate the average annual loss of groundwater storage due to seawater intrusion. Average aquifer thickness is approximately 150 feet in the 180-Foot Aquifer and 200 feet in the 400-Foot Aquifer, based on descriptions provided in Chapter 4. Average annual groundwater storage loss due to seawater intrusion in the 180/400-Foot Aquifer Subbasin from 1995 to 2019 is -5,180 AF/yr. in the 180-Foot Aquifer and -7,370 AF/yr. in the 400-Foot Aquifer. From 2019 to 2020, storage losses due to seawater intrusion are -540 AF in the 180-Foot Aquifer and -5,280 AF in the 400-Foot Aquifer. This analysis considers the average historic change in storage due to seawater intrusion to be -12,550 AF/yr., which is the total of the 180-Foot and 400-Foot Aquifers storage changes. This storage loss is in addition to the change in groundwater storage due to changes in groundwater elevations. No seawater intrusion has been reported in the Deep Aquifers, thus, there likely is no change in storage due to seawater intrusion.

Table 5-3. Components Used for Estimating Loss in Groundwater Storage Due to Seawater Intrusion

Component	1995 to 2019		2019 to 2020	
	180-Foot Aquifer	400-Foot Aquifer	180-Foot Aquifer	400-Foot Aquifer
Change in seawater intrusion area (acres)	-6,910	-7,370	-30	-220
Effective porosity	0.12	0.12	0.12	0.12
Approximate aquifer thickness (feet)	150	200	150	200
Loss in groundwater storage (AF)	-124,380	-176,880	-540	-5,280
Average annual loss of storage (AF/yr.)	-5,180	-7,370	-540	-5,280
Total average annual change in storage due to seawater intrusion (AF/yr.)	-12,550		-1,740	

Note: Increases in acreage intruded by seawater are indicated by negative values. Negative values indicate loss, positive values indicate gain. The change from 1995 to 2019 is included to quantify historical change in storage and to be consistent with the other GSPs in the Salinas Valley. The change in storage from 2019 to 2020 is included in this GSP to describe current conditions.

5.2.4 Total Annual Average Change in Groundwater Storage

The total annual average change in groundwater storage is the sum of the changes in groundwater storage due to groundwater elevation changes and seawater intrusion. Table 5-4 summarizes the total average annual loss in storage from 1995 to 2019 and from 2019 to 2020. The total change in storage for the Subbasin in Table 5-4 is likely underestimated because the change in storage for the Deep Aquifers is not included. Groundwater elevations contours for the Deep Aquifers could not be drawn at the time of this GSP Update because of a lack of data. This is a data gap that will be filled during GSP implementation.

Table 5-4. Total Average Annual Change in Groundwater Storage

Component	*Aquifer Specific Calculation*				*Whole Subbasin Calculation*	
	1995 to 2019		2019 to 2020		1995 to 2019	2019 to 2020
	180-Foot Aquifer	**400-Foot Aquifer**	**180-Foot Aquifer**	**400-Foot Aquifer**	**Subbasin Total**	**Subbasin Total**
Annual storage loss due to groundwater elevation decrease (AF/yr.)	-130	-40	-1,530	-380	-770	-8,390
Annual loss due to seawater intrusion (AF/yr.)	-5,180	-7,370	-540	-5,280	-12,550	-5,820
Total annual loss of storage (AF/yr.)	**-5,310**	**-7,410**	**-2,070**	**-5,660**	**-13,320**	**-14,210**

Note: Negative values indicate loss, positive values indicate gain. The change from 1995 to 2019 is included to quantify historical change in storage and to be consistent with the other GSPs in the Salinas Valley. The change in storage from 2019 to 2020 is included in this GSP to describe current conditions and because it is based on one year it is largely dependent on annual groundwater elevation changes.

To verify the change in storage calculation from declining groundwater levels in Section 5.2.2, the change in storage was also calculated using Figure 5-22. The orange line on Figure 5-22 shows estimated cumulative change in groundwater storage in the 180/400-Foot Aquifer Subbasin from 1944 through 2020. This graph is based on MCWRA's cumulative change in groundwater elevation data (Figure 5-13). The groundwater storage changes are calculated by multiplying the annual groundwater elevation change by an assumed storage coefficient of 0.078~~36~~ and size of the Subbasin. The black line on Figure 5-22 is the best fit linear rate of groundwater storage decline between 1995 and 2019. This black line shows that the average annual loss between 1995 and 2019 was 1,~~200~~ 900 AF/yr. ~~for the part of the Subbasin that is not seawater intruded, which for this calculation was assumed to be two-thirds of~~in the Subbasin. This estimate does not exactly match what it presented in Table 5-4; however, the two estimates are similar enough for the purposes of verifying the calculation in Section 5.2.2. Figure 5-24 includes limited data for the Deep Aquifers, as more data becomes available for the Deep Aquifers the chart will be refined accordingly.

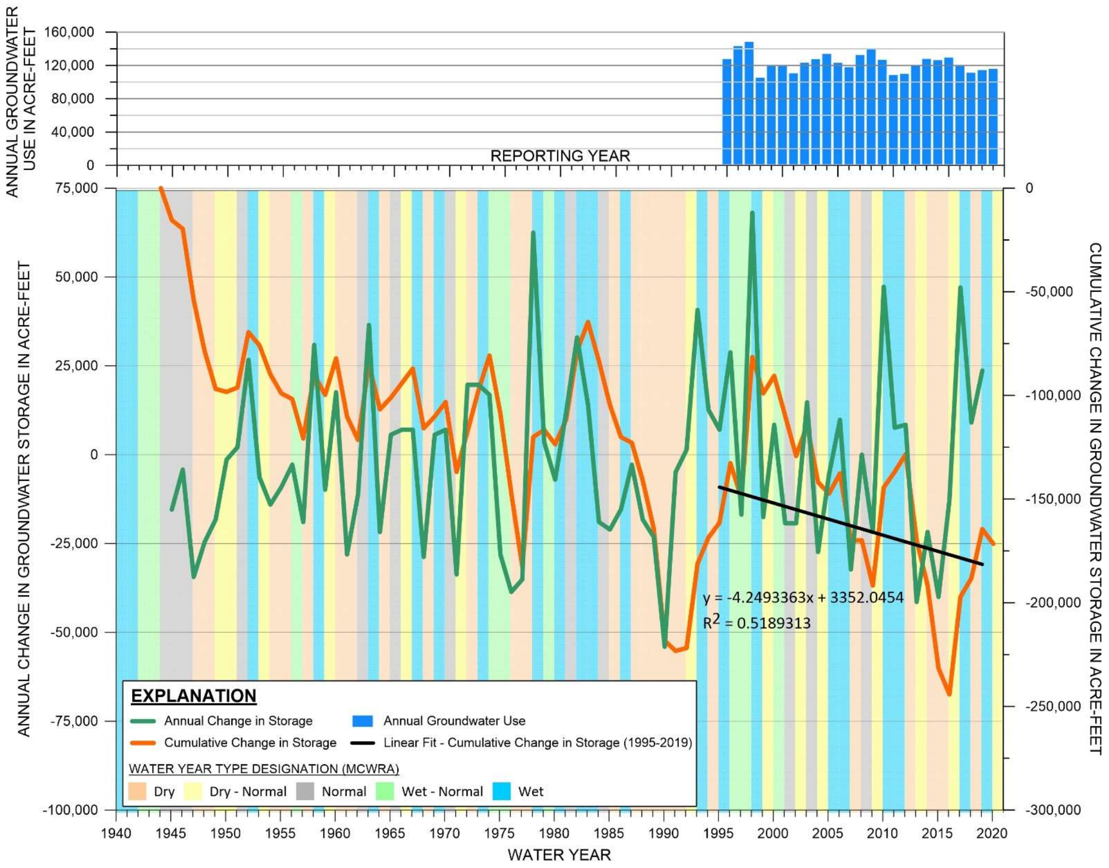


Figure 5-22. Annual and Cumulative Change in Groundwater Storage and Total Annual Groundwater Extraction in the 180/400-Foot Aquifer Subbasin, Based on Groundwater Elevations (adapted from MCWRA, 2018a, personal communication)

Commented [AO6]: Figure included to meet regulations, and 1995-2020 best-fit line added

5.3 Seawater Intrusion

Commented [AO7]: Data updated

The 180-Foot and 400-Foot Aquifers have been subject to seawater intrusion for more than 70 years, as demonstrated by increased salt concentrations in wells near the Monterey Bay coastline. The negative impact of seawater intrusion on local water resources and the agricultural economy has been the primary motivation for many studies dating back to 1946 (DWR, 1946). MCWRA and others have implemented a series of engineering and management projects including well construction moratoriums, developing the CSIP system, and implementing the Salinas Valley Water Project (SVWP), among other actions to halt seawater intrusion. Although those actions have managed to slow the advance of intrusion and reduce its impacts, seawater intrusion remains an ongoing threat.

5.3.1 Data Sources

The extent and advance of seawater intrusion are monitored and reported by MCWRA. Monitoring seawater intrusion has been ongoing since the Agency formed in 1947, and currently includes a network of 156~~1~~ dedicated monitoring and production wells in the Salinas Valley Groundwater Basin that are sampled twice annually in June and August. Most of the wells MCWRA monitors are located in the 180/400-Foot Aquifer Subbasin. The water samples are analyzed for general minerals; and the analytical results are used by MCWRA to analyze and report the following:

- Maps and graphs of historical chloride and specific conductivity trends
- Stiff diagrams and Piper diagrams
- Plots of chloride concentration vs. Na/Cl molar ratio trends

MCWRA publishes estimates of the extent of seawater intrusion every year. SVBGSA uses the ~~The~~ MCWRA maps to define the extent of seawater intrusion as the location of the 500 mg/L chloride concentration isocontour. This chloride concentration is significantly lower than the 19,000 mg/L chloride concentration typical of seawater; however, it represents a concentration that may begin to impact beneficial uses. The 500 mg/L threshold is considered the Upper Limit Secondary Maximum Contaminant Level (SMCL) for chloride as defined by the EPA and is approximately ten times the concentration of naturally occurring groundwater in the Subbasin. SVBGSA and MCWDGSA are collaborating closely on the development and implementation of their GSPs for the 180/400 and Monterey Subbasins. MCWDGSA uses an isocontour derived based on a combination of TDS and chloride measurements and geophysical data. There are notable data gaps in the MCWRA seawater intrusion isocontour maps for the Monterey Subbasin, MCWDGSA chose these other data to more accurately map seawater intrusion in the Monterey Subbasin. During implementation, SVBGSA, MCWDGSA, and MCWRA will align the separate data sets with enhanced data-sharing and collaboration.

5.3.2 Seawater Intrusion Maps and Cross Section

~~Figure 5-25~~ Figure 5-23 and ~~Figure 5-26~~ Figure 5-24 show the MCWRA mapped extents of current and historical seawater intrusion in the 180/400-Foot Subbasin in the 180-Foot and 400-Foot Aquifers, respectively. In each of the two figures, the maximum extent of the shaded contours represents the extent of groundwater with chloride exceeding 500 mg/L during the 2020 monitoring period. The historical progression of the 500 mg/L extent is also illustrated on these figures through the colored overlays that represent the extent of seawater intrusion observed during selected years.

~~Figure 5-25~~ Figure 5-23 and ~~Figure 5-26~~ Figure 5-24 also show the mapped August 2020 groundwater elevations for the 180-Foot and 400-Foot Aquifer and the adjacent Eastside Aquifer Subbasin. These maps show the groundwater elevations that are persistently below sea levels that, when paired with a pathway, enable seawater intrusion. The groundwater elevation contours show that groundwater travels toward the depression at the northern end of the Eastside Aquifer Subbasin in both the Shallow and Deep Zones of the Eastside Aquifer that are generally equivalent to the 180-Foot and 400-foot Aquifers, respectively, in the 180/400-Foot Aquifer Subbasin.

A cross-section showing the vertical distribution of seawater intrusion is shown on ~~Figure 5-27~~Figure 5-25. The hydrostratigraphy shown on this cross section is adapted from the *Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley* (Kennedy-Jenks, 2004). The location of the cross-section is also shown on ~~Figure 5-27~~ Figure 5-25 as line A-A'. The superposition of the seawater intrusion on the existing hydrostratigraphic cross-section was based on the 2020 500mg/L contour from MCWRA and recent groundwater quality data in the GSP database. The entire saturated thickness of the aquifer was assumed to be seawater intruded if any well in the aquifer indicated seawater intrusion.

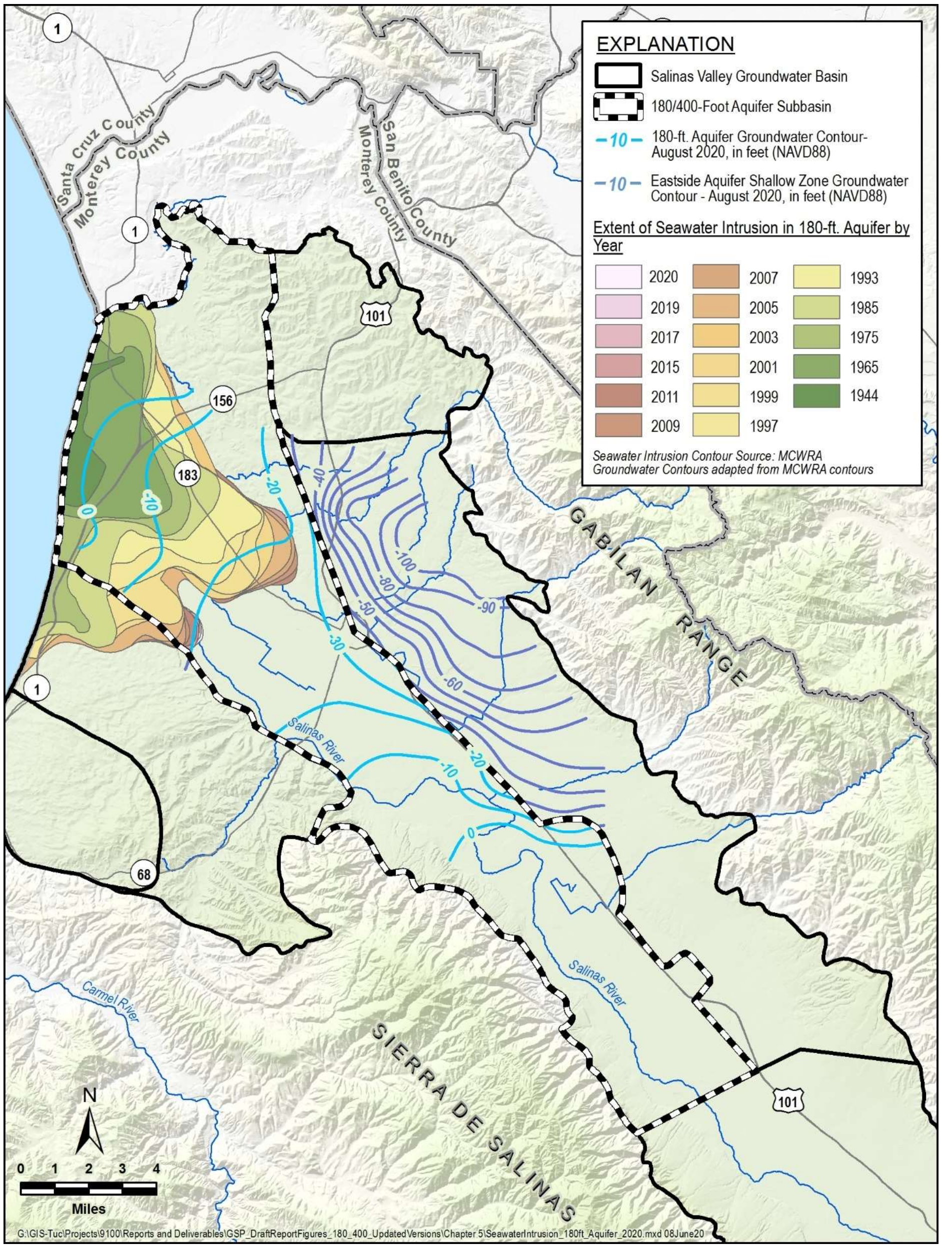


Figure 5-23~~5-25~~. Seawater Intrusion in the 180-Foot Aquifer

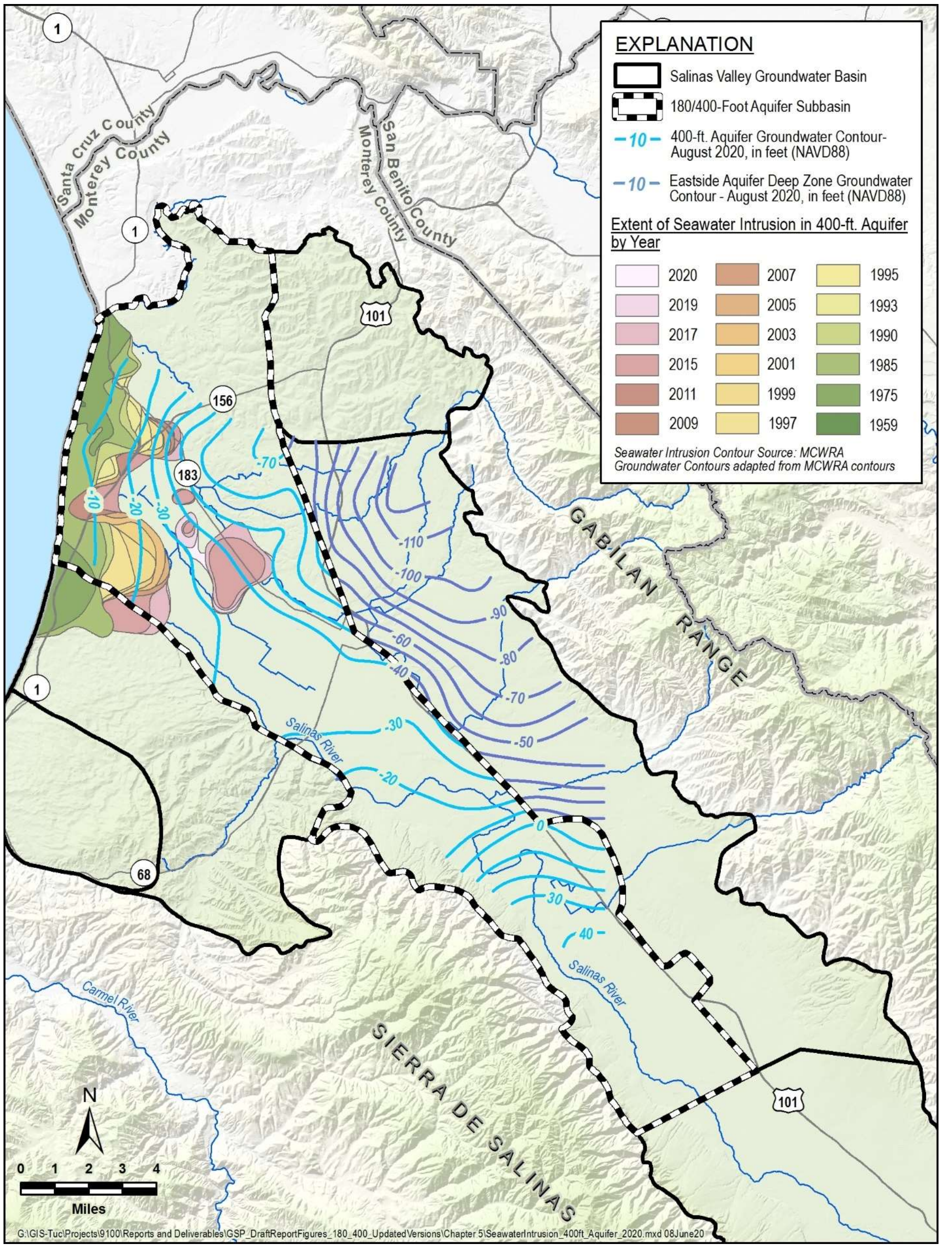


Figure 5-24~~5-26~~. Seawater Intrusion in the 400-Foot Aquifer

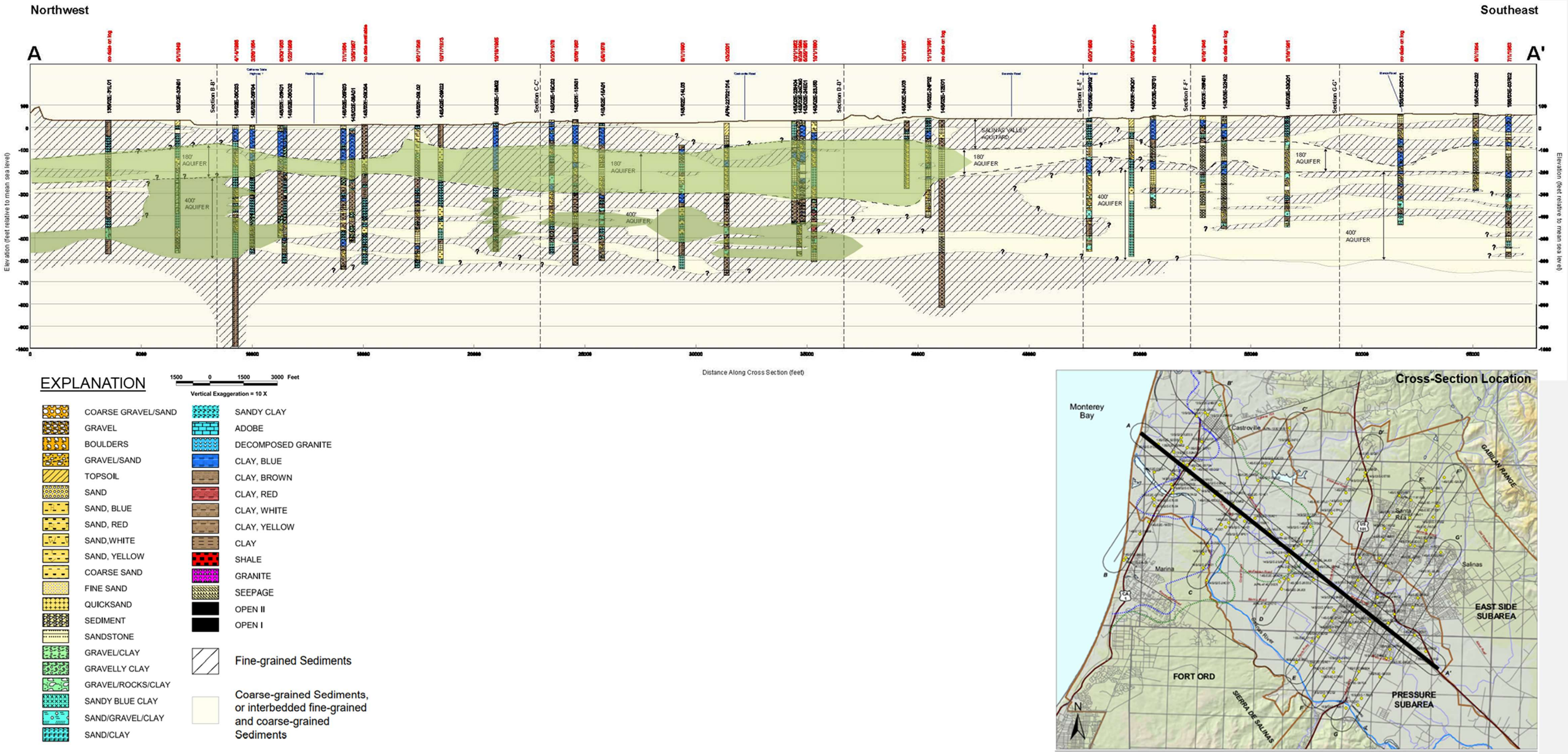


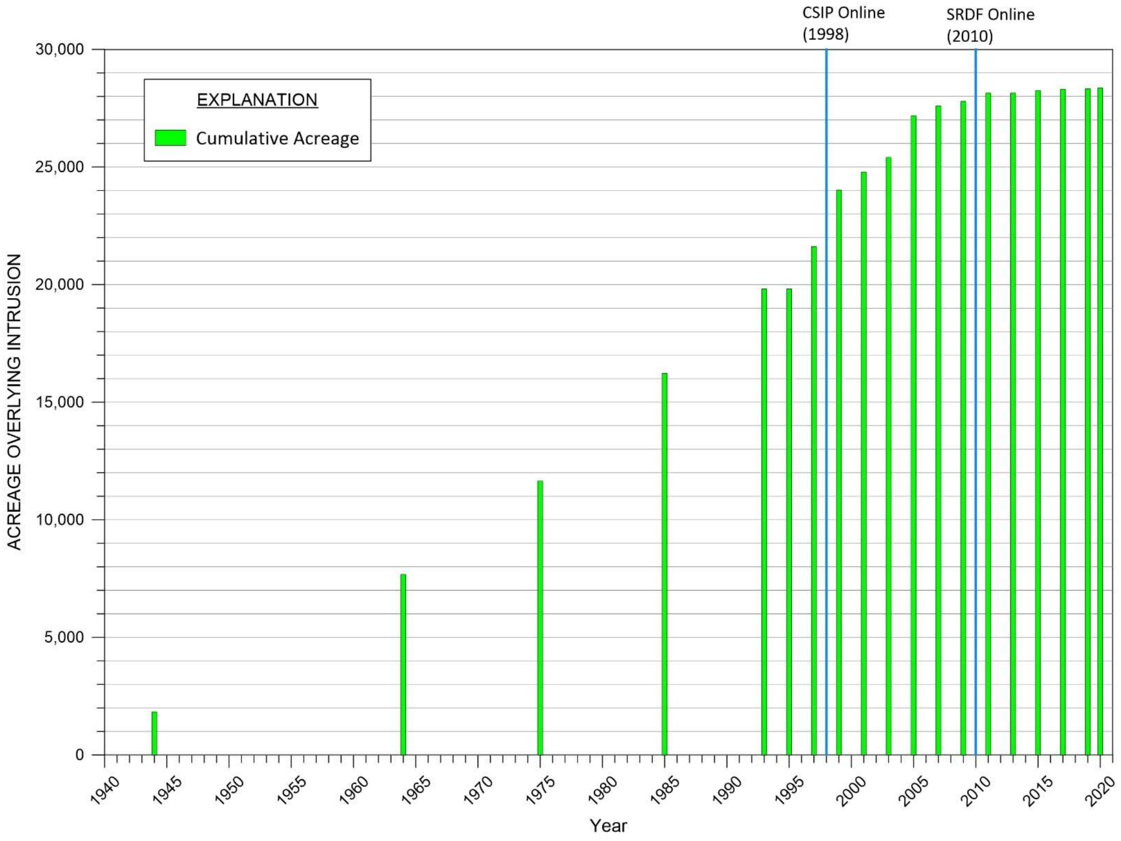
Figure 5-25~~5-27~~. Cross-Section of Estimated Depth of Seawater Intrusion Based on Mapped 2020 Intrusion (Adapted from Kennedy-Jenks, 2004)

5.3.3 Seawater Intrusion Rates

~~Figure 5-28~~ Figure 5-26 and ~~Figure 5-29~~ Figure 5-27 show time series graphs of the total acreage that overlies groundwater with chloride concentration greater than 500 mg/L. Figure 5-28 shows the time series of acreage overlying seawater intrusion in the 180-Foot Aquifer. In 2020 85% of this seawater intruded area was in the 180/400-Foot Aquifer Subbasin and the remainder was in the adjacent Monterey Subbasin. ~~Figure 5-29~~ Figure 5-27 shows the time series of acreage overlying seawater intrusion in the 400-Foot Aquifer. In 2020, 83% of this seawater intruded area was in the 180/400-Foot Aquifer Subbasin and the remainder was in the adjacent Monterey Subbasin.

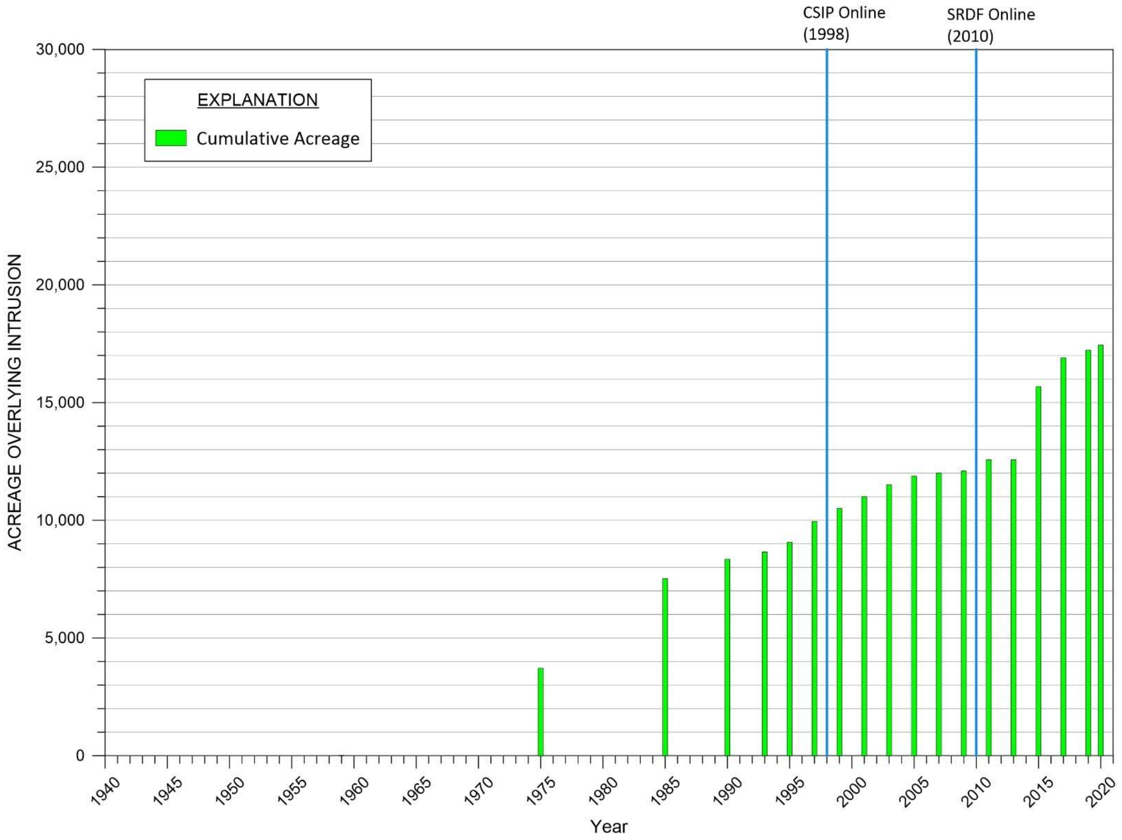
As shown on ~~Figure 5-28~~Figure 5-26, seawater intrusion into the 180-Foot Aquifer covered approximately 20,000 acres in 1995 and had expanded to approximately 28,000 acres by 2009. Since then, the rate of expansion has decreased, with an overlying area of approximately 28,300 in 2017 and 28,400 acres in 2020. ~~Figure 5-29~~ Figure 5-27 shows that the area overlying seawater intrusion into the 400-Foot Aquifer is not as extensive as that in the 180-Foot Aquifer. The 400-Foot Aquifer had an overlying area of approximately 12,000 acres in 2009. However, between 2011 and 2015, the 400-Foot Aquifer experienced a significant increase in the area of seawater intrusion, from approximately 12,600 acres to approximately 15,700 acres. The acreage overlying seawater intrusion increased to about 16,900 acres in 2017 and to about 17,400 in 2020. This apparent rapid increase in this area is likely the result of localized downward migration of high chloride groundwater from the 180-Foot Aquifer to the 400-Foot Aquifer.

The process of downward migration between aquifers may be in part attributed to wells that are screened across both aquifers, discontinuous aquitards, or improperly abandoned wells, which can cause the isolated patches of seawater intrusion in the 400-Foot Aquifer. For example, the middle patch that greatly expanded from 2017 to 2019, is associated with a leaky well that connects the 180-Foot and 400-Foot Aquifers. This well was destroyed in November 2019. Regardless of the specific pathways, the presence of vertical downward hydraulic gradients from the 180-Foot Aquifer to the 400-Foot Aquifer presents a risk that eventually the intruded area of the 400-Foot Aquifer will be as large as that of the 180-Foot Aquifer.



Source: Special Joint Meeting of MCWRA BOD and Monterey County BOS

Figure 5-26~~5-28~~. Acreage Overlying Seawater Intrusion in the 180-Foot Aquifer (created with data from MCWRA)



Source: Special Joint Meeting of MCWRA BOD and Monterey County BOS

Figure 5-27~~5-29~~. Acreage Overlying Seawater Intrusion in the 400-Foot Aquifer

(created with data from MCWRA)

Seawater intrusion has not been reported in the Deep Aquifers.

The volume of seawater flowing into the Subbasin every year does not strictly correspond to the acreages overlying the seawater-intruded area that are shown on ~~Figure 5-28~~ Figure 5-26 and ~~Figure 5-29~~Figure 5-27. As the seawater intrusion front approaches pumping depressions, the front will slow down and stop at the lowest point in the pumping depression. When the seawater intrusion front stops at a pumping depression, no more acreage will be added every year. However, seawater will continue to flow in from the ocean towards the pumping depression.

The State of the Salinas River Groundwater Basin report estimated that approximately 11,000 acre-feet of seawater flows into the Pressure subarea every year. Previous estimates have ranged between 14,000 and 18,000 AF/yr. of seawater intrusion (Brown and Caldwell, 2015~~6~~). These seawater inflow estimates include portions of the Monterey Subbasin. The length of coastline subject to seawater intrusion is approximately 75% in the 180/400-Foot Aquifer Subbasin and therefore this GSP estimates the flow into the 180/400-Foot Aquifer Subbasin is between 8,250 and 13,500 AF/yr.

5.4 Groundwater Quality Distribution and Trends

Commented [AO8]: Data updated

The SVBGSA does not have regulatory authority over groundwater quality and is not charged with improving groundwater quality in the Salinas Valley Groundwater Basin. Projects and actions implemented by the SVBGSA are not required to improve groundwater quality; however, they must not further degrade it.

5.4.1 Data Sources

Groundwater quality samples have been collected and analyzed in the Subbasin for various studies and programs. Groundwater quality samples have also been collected on a regular basis for compliance with regulatory programs. Groundwater quality data for this GSP were collected from:

- The Northern Counties Groundwater Characterization report (CCGC, 2015)
- The USGS' Groundwater Ambient Monitoring and Assessment Program (GAMA) reports (Kulongoski and Belitz, 2005; Burton and Wright, 2018)
- State Water Resources Control Board's GeoTracker Data Management System (SWRCB, ~~2020a~~2021a)
- State Water Resources Control Board's GAMA Groundwater Information System (SWRCB, ~~2020b~~2021b)
- The California Department of Toxic Substances Control's EnviroStor data management system (DTSC, 2021~~0~~)

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5.4.2 Point Sources of Groundwater Contaminants

Clean-up and monitoring of point source pollutants may be under the responsibility of either the Central Coast Regional Water Quality Control Board (CCRWQCB) or the Department of Toxic Substances Control (DTSC). The locations of these clean-up sites are visible in SWRCB's GeoTracker database map, publicly available at: https://geotracker.waterboards.ca.gov/. The GeoTracker database is linked to the DTSC's EnviroStor data management system that is used to track clean-up, permitting, and investigation efforts. Table 5-5 and ~~Figure 5-30~~ Figure 5-28 provide a summary of the active clean-up sites within the Subbasin. Table 5-5 does not include sites that have leaking underground storage tanks, which are not overseen by DTSC or the CCRWQCB.

Table 5-5~~5-5~~. Active Cleanup Sites

Label	Site Name	Site Type	Status	Constituents of Concern (COCs)	Address	City
1	Dynegy Moss Landing	Corrective Action	Active	metals, petroleum, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs)	Highway 1 & Dolan Road	Moss Landing
2	Moss Landing Power Plant	Cleanup Program Site	Open - Verification Monitoring	metals/heavy metals, petroleum/fuels/oils, polynuclear aromatic hydrocarbons, volatile organic compounds (VOCs)	Highway 1 & Dolan Road	Moss Landing
3	National Refractories (Former)	Cleanup Program Site	Open - Remediation	chromium, trichloroethylene (TCE)	7697 California Highway 1	Moss Landing
4	Union Pacific Railroad - Salinas Yard	Cleanup Program Site	Open - Verification Monitoring	petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), naphthalene, VOCs, metals	Rico and West Lakes Streets	Salinas
5	Toro Petroleum-Agt	Cleanup Program Site	Open - Verification Monitoring	benzene, petroleum hydrocarbons	308 West Market Street	Salinas
6	Pacific Gas & Electric (PG&E), Salinas Manufactured Gas Plant (MPG)	Voluntary Cleanup	Active	cyanide, metals, contaminated soil, hydrocarbon mixtures	2 Bridge Street	Salinas
7	Borina Foundation	Cleanup Program Site	Open - Remediation contaminated soil was excavated in 2013. Soil vapor extraction remedy is operating to treat soil gas	halogenated volatile organic compounds (VOCs) in soil and soil gas	110-124 Abbott Street	Salinas
8	Crop Production Services, Inc. - Salinas	Cleanup Program Site	Open - Remediation Pump and treat system in place	nitrate, pesticides in shallow aquifer	1143 Terven Avenue	Salinas
9	Pure-Etch Co	Corrective Action	Active - dual phase extraction remedy implemented	benzene, ethylbenzene, petroleum hydrocarbon-gas, toluene, xylenes	1031 Industrial Street	Salinas
10	NH3 Service Company	Cleanup Program Site	Open - Verification Monitoring Pump and treat system in place	nitrate	945 Johnson Avenue	Salinas

Label	Site Name	Site Type	Status	Constituents of Concern (COCs)	Address	City
11	Firestone Tire (Salinas Plant)	National Priorities List	Delisted	1,2-dichloroethylene (DCE), tetrachloroethylene (PCE)	340 El Camino Real South	Salinas

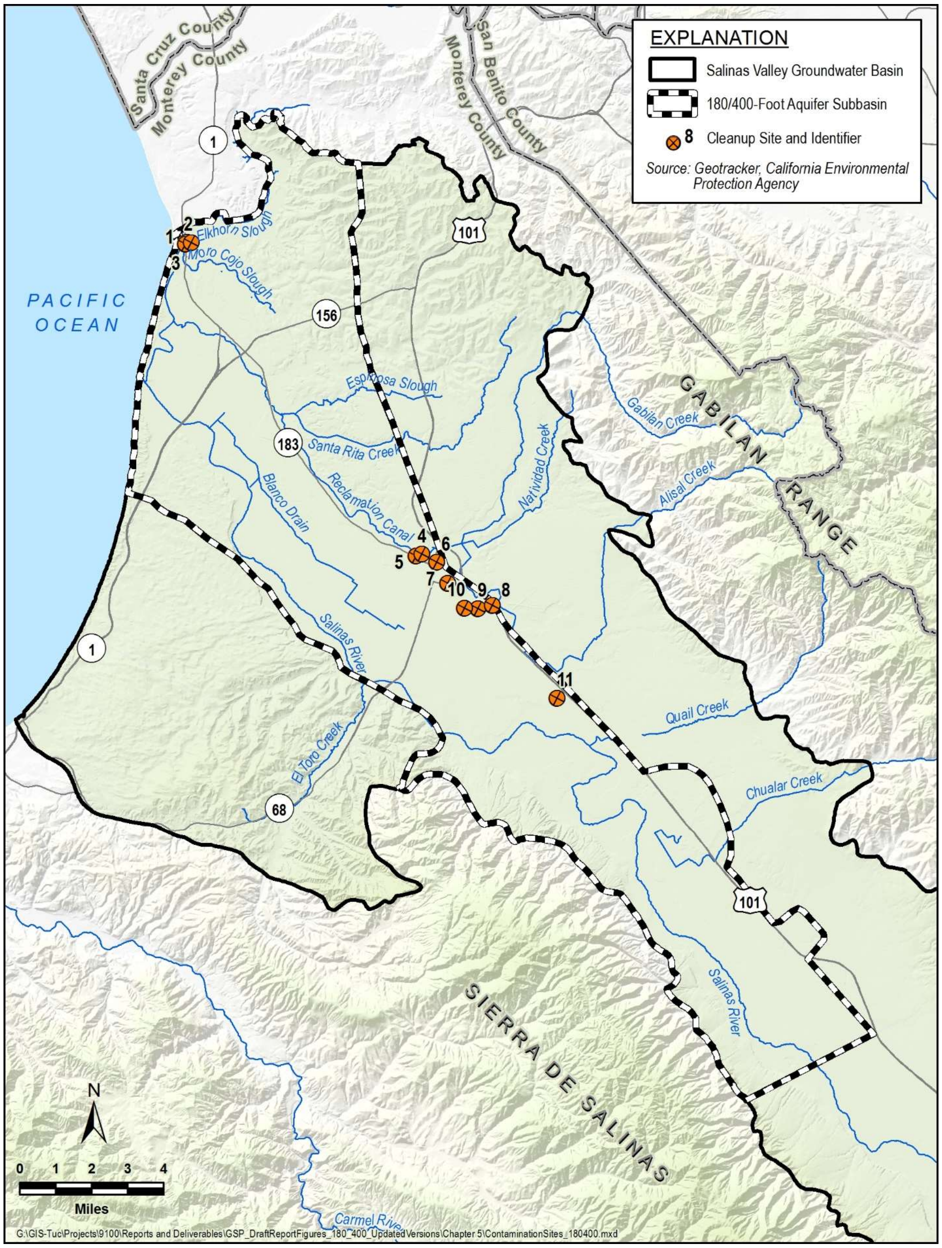


Figure 5-28~~5-30~~. Active Cleanup Sites

5.4.3 Distribution and Concentrations of Diffuse or Natural Groundwater Constituents

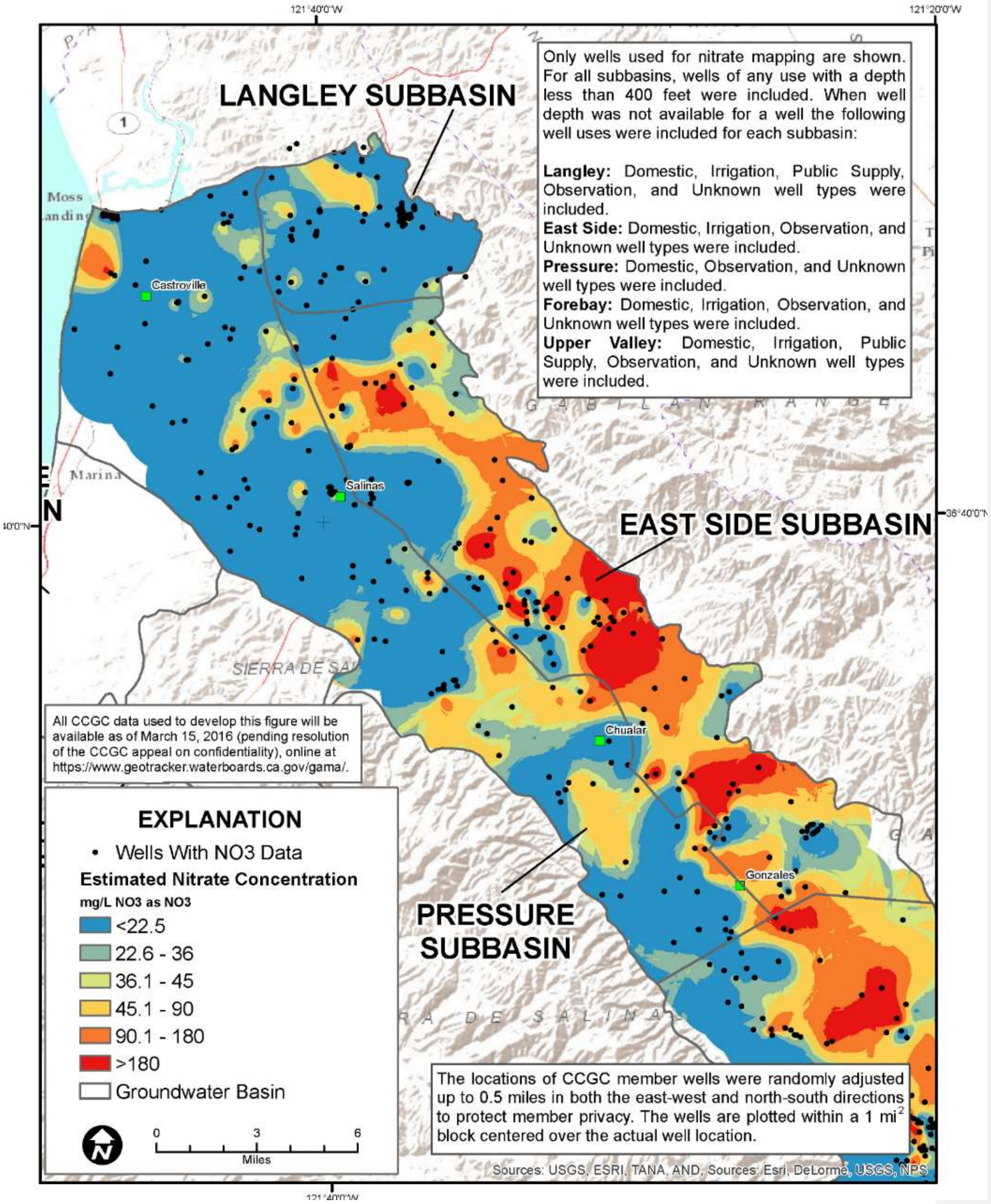
In addition to the point sources described above, the CCRWQCB monitors and regulates activities and discharges that can contribute to non-point pollutants, which are constituents that are released to groundwater over large areas. In the Subbasin, the most prevalent non-point water quality concern is nitrate. The current distribution of nitrate was extensively monitored and evaluated by the CCGC and documented in a report submitted to the CCRWQCB (CCGC, 2015).

~~Figure 5-31~~ Figure 5-29 shows a map of nitrate distribution in the Subbasin prepared by CCGC. The orange and red areas illustrate the portions of the Subbasin where groundwater has nitrate concentrations above the drinking water MCL of 45 mg/L NO_3.

~~Figure 5-32~~ Figure 5-30 shows maps of measured nitrate concentration from six decades of monitoring for the entire Salinas Valley Groundwater Basin. These maps, prepared by MCWRA, indicate that elevated nitrate concentrations in groundwater were locally present in the 1960s, but significantly increased in 1970s and 1980s. Extensive distribution of nitrate concentrations above the drinking water MCL, as shown on ~~Figure 5-31~~Figure 5-29, has been present in the 180/400-Foot Aquifer Subbasin for 20 to 30 years.

A May 2018 staff report to the CCRWQCB included a summary of nitrate concentrations throughout the Central Coast Region, including the Salinas Valley Groundwater Basin. The staff report includes data from 2008 to 2018, collected at 2,235 wells in the Salinas Valley Groundwater Basin, during Agricultural Orders 2.0 and 3.0 sampling events. The report states that 26% of on-farm domestic wells in the 180/400-Foot Aquifer Subbasin exceeded the drinking water MCL, with a mean concentration of 52.7 mg/L NO_3. In addition, 21% of irrigation supply wells in the Subbasin exceeded this MCL with a mean concentration of 29.7 mg/L NO_3 (CCRWQCB, 2018).

Some constituents of concern can be concentrated at various aquifer depths. Nitrate is a surficial constituent derived from such sources as fertilizer, livestock, and septic systems. Because the sources are all near the surface, nitrate is usually highest near ground surface, and decreases with depth. Raising groundwater levels may mobilize additional nitrate. By contrast, arsenic concentrations usually increase with depth, and lowering groundwater levels may mobilize additional arsenic. The distribution and concentrations of constituents of concern can be further complicated by location and rate of groundwater pumping. The extent to which pumping affects groundwater quality depends on aquifer properties, distance to contamination, constituent characteristics and transport rate, and the time at which contaminants entered the subsurface.



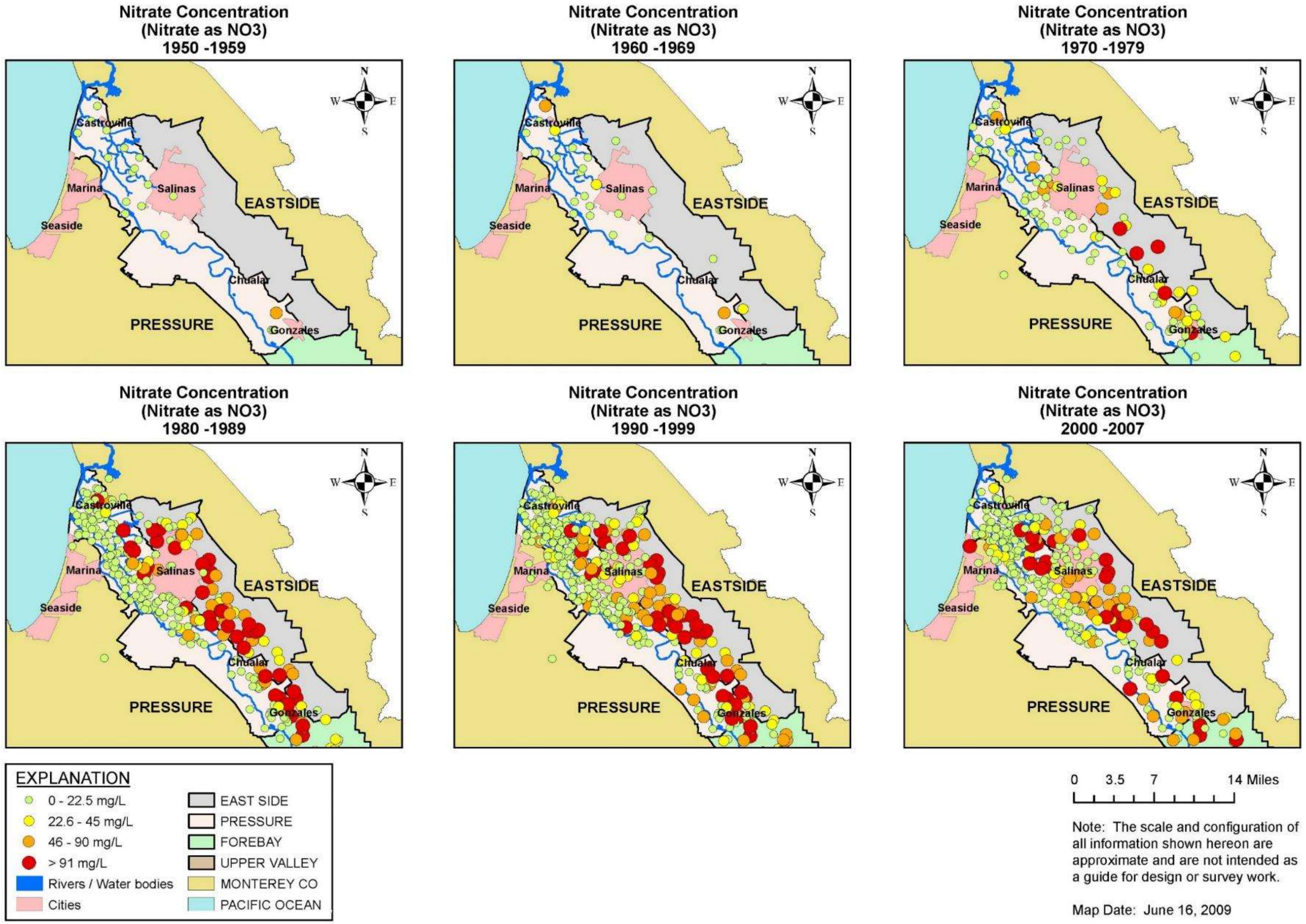
Only wells used for nitrate mapping are shown. For all subbasins, wells of any use with a depth less than 400 feet were included. When well depth was not available for a well the following well uses were included for each subbasin:

Langley: Domestic, Irrigation, Public Supply, Observation, and Unknown well types were included.
East Side: Domestic, Irrigation, Observation, and Unknown well types were included.
Pressure: Domestic, Observation, and Unknown well types were included.
Forebay: Domestic, Irrigation, Observation, and Unknown well types were included.
Upper Valley: Domestic, Irrigation, Public Supply, Observation, and Unknown well types were included.

All CCGC data used to develop this figure will be available as of March 15, 2016 (pending resolution of the CCGC appeal on confidentiality), online at https://www.geotracker.waterboards.ca.gov/gama/.

The locations of CCGC member wells were randomly adjusted up to 0.5 miles in both the east-west and north-south directions to protect member privacy. The wells are plotted within a 1 mi^2 block centered over the actual well location.

Figure 5-29~~5-31~~. Estimated Nitrate Concentrations
(from CCGC, 2015)



Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for design or survey work.

Map Date: June 16, 2009

Figure 5-30~~5-32~~. Nitrate Concentrations, 1950 to 2007
(modified from MCWRA data)

Additional groundwater quality conditions in the Basin are summarized in two USGS water quality studies in the Salinas Valley. The USGS 2005 GAMA study characterized deeper groundwater resources used for public water supply (Kulongoski and Belitz, 2005). The USGS 2018 GAMA study focused on domestic well water quality (Burton and Wright, 2018). The source data used in these two studies and additional publicly available water quality data can be accessed through the SWRCB GAMA groundwater information system at: https://gamagroundwater.waterboards.ca.gov/gama/datadownload.

The GAMA groundwater information system includes groundwater quality data for public water system supply wells from the SWRCB Division of Drinking Water (DDW), and on-farm domestic wells and irrigation supply wells from CCRWQCB's Irrigated Lands Regulatory Program (ILRP). This GSP relies on established thresholds for constituents of concern (COC): Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs) established by the State's Title 22 drinking water standards for public water system supply wells and on-farm domestic wells, and COC levels that may lead to reduced crop production for irrigation supply wells, as outlined in the CCRWQCB's Basin Plan (CCRWQCB, 2019).

Table 5-6 reports the constituents of concern in the 180/400-Foot Aquifer Subbasin based on GAMA groundwater information system data up to 2020. The number of wells that exceed the regulatory standard for any given COC is based on the latest sample for each well in the monitoring network. Not all wells have been sampled for all COC. Therefore, the percentage of wells with exceedances is the number of wells that exceed the regulatory standard divided by the total number of wells that have ever been sampled for that COC. Additionally, Table 5-6 does not report all of the constituents that are monitored under Title 22 or the Basin Plan; it only includes the constituents that exceed a regulatory standard. The total list of constituents sampled in the water quality monitoring network are listed in Table 8-4. Maps with the locations of wells that exceeded the regulatory standard for any of the COC listed in Table 5-6 from 2013 to 2019 are provided in Appendix ~~5B~~5C.

Table 5-6~~5-6~~. Water Quality Constituents of Concern and Exccedances

	Regulatory Exceedance Standard		Number of Wells Sampled for COC	Number of Wells Exceeding Regulatory Standard from latest sample	
DDW Wells (Data from April 1974 to December 2020)					
Aluminum	1000	UG/L	100	1	1%
Arsenic	10	UG/L	102	2	2%
Di(2-ethylhexyl) phthalate	4	UG/L	86	2	2%
Benzo(a)Pyrene	0.2	MG/L	86	2	2%
Chloride	500	MG/L	97	3	3%
1,2 Dibromo-3-chloropropane	0.2	UG/L	81	9	11%
Dinoseb	7	UG/L	100	2	2%

Commented [AO9]: Analysis added based on GAMA groundwater information system data up to 2020

Constituent of Concern	Regulatory Exceedance Standard	Standard Units	Number of Wells Sampled for COC	Number of Wells Exceeding Regulatory Standard from latest sample	Percentage of Wells with Exceedances
Fluoride	2	MG/L	103	1	1%
Iron	300	UG/L	96	6	6%
Hexachlorobenzene	1	UG/L	67	2	3%
Heptachlor	0.01	UG/L	65	2	3%
Manganese	50	UG/L	95	5	5%
Methyl-tert-butyl ether (MTBE)	13	UG/L	101	3	3%
Nitrate (as nitrogen)	10	MG/L	139	12	9%
Tetrachloroethene	5	UG/L	150	1	1%
Specific Conductance	1600	UMHOS/CM	103	4	4%
Selenium	20	UG/L	101	2	2%
1,2,4-Trichlorobenzene	4	UG/L	102	1	1%
1,2,3-Trichloropropane	0.005	UG/L	107	13	12%
Total Dissolved Solids	1000	MG/L	98	7	7%
Vinyl Chloride	0.5	UG/L	150	34	23%
On-Farm Domestic ILRP Wells (Data from August 2012 to December 2020)					
Chloride	500	MG/L	181	9	5%
Iron	300	UG/L	41	11	27%
Manganese	50	UG/L	41	3	7%
Nitrite	1	MG/L	99	1	1%
Nitrate (as nitrogen)	10	MG/L	191	49	26%
Nitrate + Nitrite (sum as nitrogen)	10	MG/L	70	14	20%
Specific Conductance	1600	UMHOS/CM	207	44	21%
Sulfate	500	MG/L	181	3	2%
Total Dissolved Solids	1000	MG/L	154	44	30%
ILRP Irrigation Wells (Data from September 2012 to December 2020)					
Chloride	350	MG/L	324	28	9%
Iron	5000	UG/L	98	2	2%
Manganese	200	UG/L	98	1	1%

5.4.4 Groundwater Quality Summary

Based on the water quality information for the DDW and ILRP wells from GAMA groundwater information system, the following are the COC for drinking water supply wells in the Subbasin and that have exceedances in the Subbasin:

- 1,2 dibromo-3-chloropropane
- 1,2,3-trichloropropane
- 1,2,4-trichlorobenzene
- aluminum
- arsenic
- benzo(a)pyrene
- chloride
- di(2-ethylhexyl) phthalate
- dinoseb
- fluoride
- heptachlor
- hexachlorobenzene
- iron
- manganese
- methyl-tert-butyl ether (MTBE)
- nitrate (as nitrogen)
- nitrate + nitrite (sum as nitrogen)
- nitrite
- selenium
- specific conductance
- sulfate
- tetrachloroethene
- total dissolved solids
- vinyl chloride

The COC for agricultural supply wells that occur in the Subbasin and are known to cause reductions in crop production when irrigation water includes them in concentrations above agricultural water quality objectives include:

- chloride
- iron
- manganese

The COC for active cleanup sites listed in Table 5-5 are not part of the monitoring network described in Chapter 7. However, the status of these constituents at these sites will continue to be monitored by the DTSC or the CCRWQCB. Furthermore, the COC at these sites that have a regulatory standard under Title 22 for drinking water wells, or the Basin Plan for irrigation supply wells will be monitored in the DDW and ILRP wells that are part of the monitoring network.

This GSP relies on data from existing monitoring programs to measure changes in groundwater quality. Therefore, the GSA is dependent on the monitoring density and frequency of the DDW and ILRP. The monitoring system is further defined in Chapter 7.

5.5 Subsidence

Commented [AO10]: Data updated

Land subsidence is the lowering of the ground surface elevation. This is often caused by pumping below thick clay layers. Land subsidence can be elastic or inelastic. Elastic subsidence is called elastic because the small, lowering and rising of the ground surface is reversible. Inelastic subsidence is generally irreversible and is the focus of this GSP.

5.5.1 Data Sources

To estimate subsidence, DWR has made Interferometric Synthetic Aperture Radar (InSAR) satellite data available on their SGMA Data Viewer web map: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub. These are the only data used for estimating subsidence in this GSP.

5.5.2 Subsidence Mapping

~~Figure 5-33~~ Figure 5-31 presents a map showing the average annual InSAR subsidence data in the 180/400-Foot Aquifer Subbasin between June 2015 and June 2020 (DWR, 2020a~~e~~). The yellow area on the map is the area with measured average annual changes in ground elevation of between -0.1 and 0.1 foot. As discussed in Section 8.9.2.1, because of measurement error in this methodology, any measured ground level changes between -0.1 and 0.1 foot are considered an area of no subsidence. The white areas on the map are areas with no available data. The map shows that no measurable subsidence has been recorded anywhere in the Subbasin.

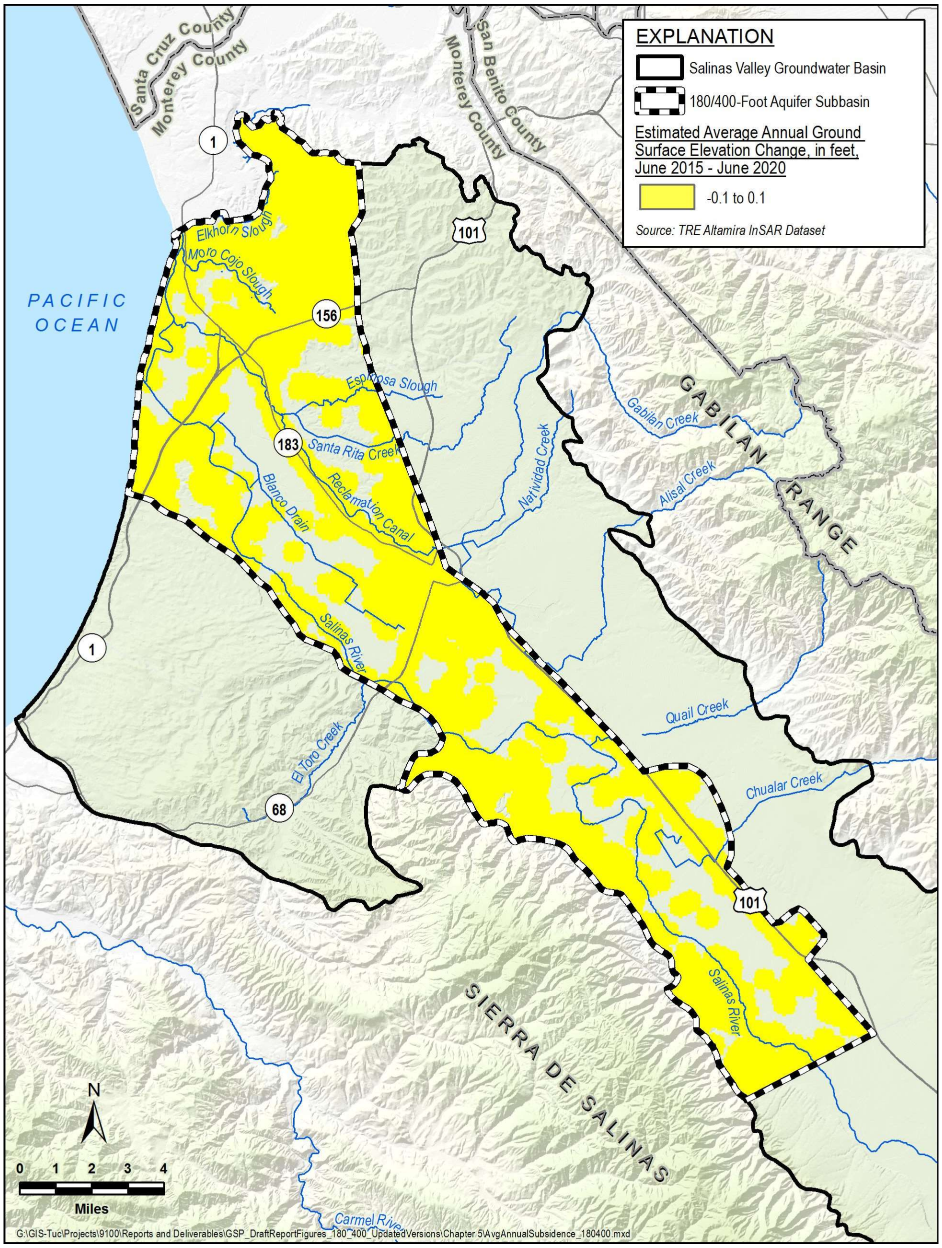


Figure 5-31~~5-33~~. Estimated Average Annual InSAR Subsidence in Subbasin

5.6 Interconnected Surface Water

Commented [AO11]: Updated since Salinas Valley Integrated Hydrologic Model became available for analysis of locations and rate of interconnection between surface water and groundwater

ISW is surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completed. If groundwater elevations are higher than the water level in the stream, the stream is said to be a gaining stream because it gains water from the surrounding groundwater. If the groundwater elevation is lower than the water level in the stream, it is termed a losing stream because it loses water to the surrounding groundwater. If the groundwater elevation is below the streambed elevation, the stream and groundwater are disconnected. SGMA does not require that disconnected stream reaches be analyzed or managed. These concepts are illustrated on ~~Figure 5-34~~Figure 5-32.

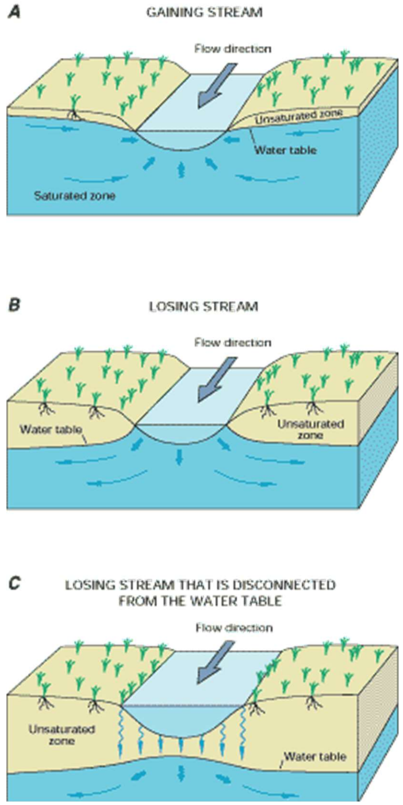


Figure 5-32~~5-34~~. Conceptual Representation of Interconnected Surface Water (Winter, et al., 1999)

5.6.1 Data Sources

The preliminary SVIHM is used to map the potential locations of ISW, as described in Chapter 4 and shown on Figure 4-11. There is no data that verifies the location and extent of surface water connection to groundwater, nor the extent to which groundwater extraction depletes surface water. Therefore, this section describes the hydraulic principles that establish the relationship between surface water and groundwater, upon which the current conditions and monitoring network are based.

5.6.2 Evaluation of Surface Water and Groundwater Interconnection

Groundwater extraction can alter flows between surface water and groundwater. Flow changes related to interconnected surface and groundwater could be due to reductions in groundwater discharge to surface water, or increases in surface water recharge to groundwater. These two changes together constitute the change in the amount of surface water depletion.

Depletion of ISW is estimated by evaluating the change in the modeled stream leakage with and without pumping (i.e., water flowing from the stream into the groundwater system). A model simulation without any groundwater pumping in the model (i.e., SVIHM with no pumping) was compared to the model simulation with groundwater pumping (i.e., SVIHM with pumping). The difference in stream depletion between the 2 models is the depletion caused by the groundwater pumping. This comparison was undertaken for the entire area of the Salinas Valley included in the model and also for the Subbasin. The stream depletion differences are only estimated for the interconnected segments identified on Figure 4-11. The Salinas Valley Aquitard extends across much of the Subbasin and inhibits hydraulic connection between the stream and the underlying principal aquifers where groundwater pumping occurs. This analysis assumes that ISW in the Subbasin occurs along stream reaches located outside the mapped extent of the Aquitard shown on Figure 4-12. The methodology for quantifying stream depletion is described in detail by Barlow and Leake (2012).

This analysis uses the “peak” conservation release period from June to September that reflects when most conservation releases are made, not the full April to October MCWRA conservation release period when releases can be made. Depletion of interconnected sections of the surface water bodies is estimated separately for the peak conservation release period of June through September, and the non-peak conservation release period of October through May. Table 5-7 shows the estimated annual average depletion of ISW due to groundwater pumping along the stream segments in the Subbasin shown on Figure 4-11.

Table 5-7~~5-7~~. Average SVIHM Simulated Depletion of Interconnected Surface Waters (AF/yr.)

Peak Conservation Release Period	Non Peak Conservation Release Period
2,600	5,800

Note: provisional data subject to change[1].

[1] These data (model and/or model results) are preliminary or provisional and are subject to revision. This model and model results are being provided to meet the need for timely best science. The model has not received final approval by the U.S. Geological Survey (USGS). No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the model and related material nor shall the fact of release constitute any such warranty. The model is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the model.

5.7 Water Use

5.7.1 Data Sources

As mentioned in Chapter 3, water use in the 180/400-Foot Aquifer Subbasin consists of groundwater extraction, surface water, and recycled water. Agricultural and urban groundwater extraction data is collected by MCWRA through GEMS for wells with discharge pipes with an internal diameter greater than 3 inches within Zones 2, 2A, and 2B. Domestic pumping, including water systems small enough to not require reporting to the State, is estimated by multiplying the estimated number of domestic users by a water use factor. The initial water use factor used is 0.39 AF/yr./dwelling unit. Surface water diversions from the Salinas River collected by eWRIMS and SRDF make up the surface water supplies in the Subbasin. SVRP provides most of the recycled water in the Subbasin.

5.7.2 Water Use

5.7.2.1 Groundwater Use

Table 5-8 provides groundwater extraction by water use sector for the 180/400-Foot Aquifer Subbasin from 2017 to 2020. 2017 was considered current conditions in the GSP and this GSP Update uses 2020 to define current conditions. Agricultural pumping is reported by MCWRA for the period November 1 through October 31, whereas urban pumping is reported on a calendar-year basis. These reporting periods and submittal deadlines for the GEMS data is defined by Monterey County Ordinance No. 3717 and 3718. Rural domestic pumping is estimated on a calendar year basis.

Urban use data from MCWRA aggregates municipal wells, small public water systems, and industrial wells. On average, ~~A~~agricultural use accounted for 90% of groundwater extraction from 2017 to 2020~~in 2019~~; urban and industrial use accounted for 10%. MCWRA's Groundwater Reporting Program allows three different reporting methods: water flowmeter, electrical meter, or hour meter. From 2017 to 2020, 83% of extractions on average were

Commented [AO12]: New section added to meet regulations for amendments

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Table 5-8~~5-8~~. 2017 to 2020 Groundwater Use (AF/yr.)

	2017	2018	2019	2020
Rural Domestic	200	200	200	200
Urban (includes industrial)	11,000	12,600	12,100	12,300
Agricultural	101,600	103,200	105,100	106,500
Managed Wetlands	0	0	0	0
Managed Recharge	0	0	0	0
Natural Vegetation	0	0	0	0
Total	**112,800**	**116,000**	**117,400**	**119,000**

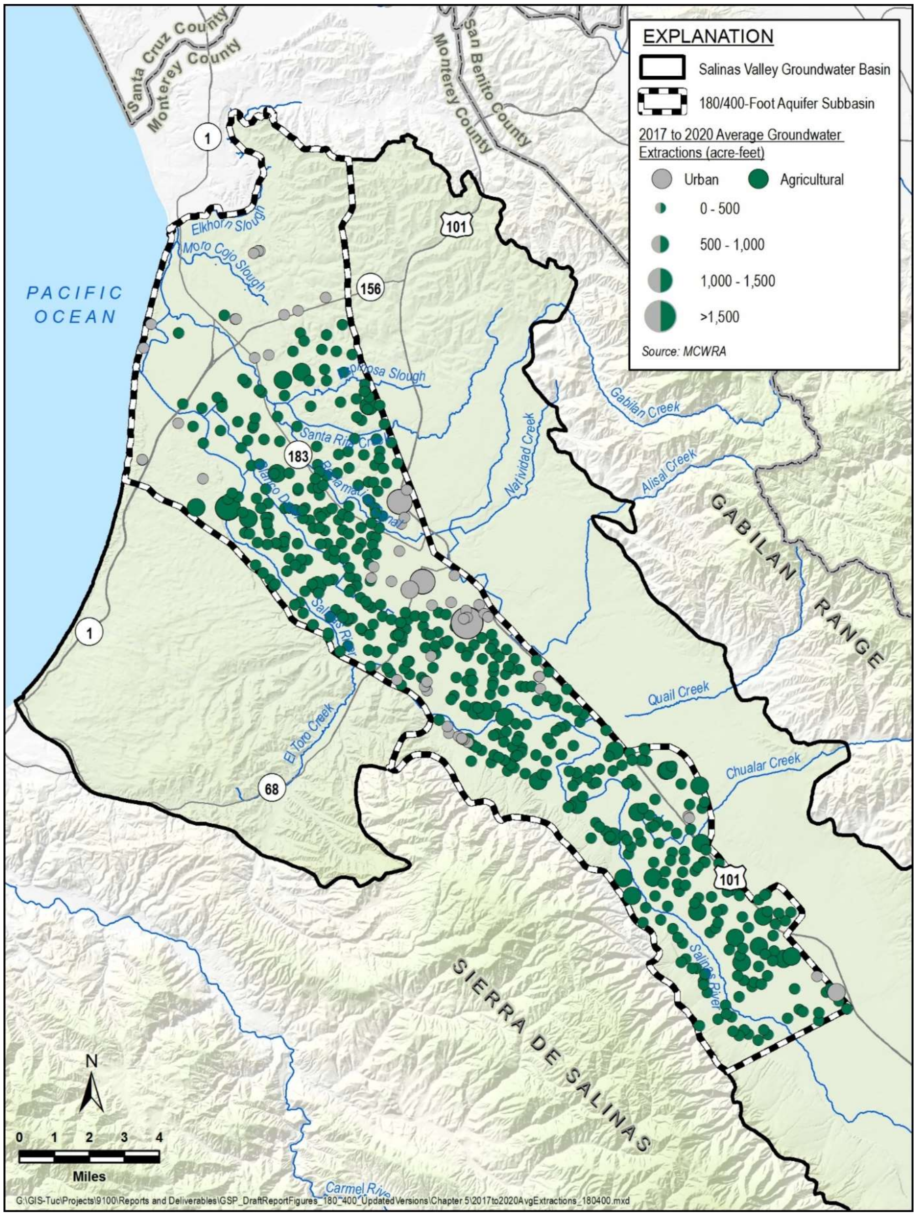

Figure 5-33~~5-35~~. General Location and Volume of Groundwater Extractions in the 180/400-Foot Aquifer Subbasin

5.7.2.2 Surface Water Supply

Annual Salinas River diversion data are obtained from the SWRCB's eWRIMS website (SWRCB, 2021c). These data are combined with annual SRDF diversions to calculate the total surface water use in the 180/400-Foot Aquifer Subbasin. This accounting is done for convenience only and is not meant to imply that any or all of the reported diversions are classified as surface water. All surface water is used for irrigation.

Table 5-9~~5-9~~. 2017 to 2020 Surface Water Use

Surface Water Diversions	2017	2018	2019	2020
SRDF	4,200	5,300	7,600	6,700
eWRIMS	7,800	7,800	7,100	7,800
Total	**11,900**	**13,100**	**14,700**	**14,500**

5.7.2.3 Recycled Water Supply

In addition to groundwater and surface water, a third water source type in the 180/400-Foot Aquifer Subbasin is recycled water. Monterey One Water treats and delivers this Salinas Valley Reclamation Plant (SVRP) recycled water to the coastal farmland surrounding Castroville through the CSIP system. Recycled water deliveries are summarized in Table 5-10.

Table 5-10~~5-10~~. 2017 to 2020 Recycled Water Use

	2017	2018	2019	2020
SVRP-Recycled	10,300	13,600	8,500	12,500

5.7.2.4 Total Water Use

Total water use is the sum of groundwater extractions, surface water use, and recycled water use and is summarized in Table 5-11 and ~~Figure 5-36~~Figure 5-34.

Many growers and residents have noted that some irrigation water use is reported both to the SWRCB's eWRIMS as Salinas River diversions and to the MCWRA as groundwater pumping. Comparing surface water diversion data to groundwater pumping data is complicated by the fact that diversions and pumping are reported on different schedules. An initial analysis was undertaken by matching unique locations and monthly diversion amounts summed by the GEMS reporting year (November 1 to October 31) to reported annual pumping data from 2017 to 2020. The initial analysis suggests an average 2,200 AF/yr. of water was reported to both MCWRA and the SWRCB. Further review indicated that the eWRIMS diversions do not include the Salinas River diversions at the SRDF. To avoid double counting, 2,200 AF of groundwater pumping are deducted from agricultural groundwater use to account for the potential double reporting.

Table 5-11~~5-11~~. 2017 to 2020 Total Water Use by Water Source Type and Water Use Sector

Water Use Sector	**2017**			**2018**			**2019**			**2020**		
												Recycled Water
Rural Domestic	200	0	0	200	0	0	200	0	0	200	0	0
Urban	11,000	0	0	12,600	0	0	12,100	0	0	12,300	0	0
Agricultural	99,400	11,900	10,300	101,000	13,100	13,600	102,900	14,700	8,500	104,300	14500	12500
SUBTOTALS	110,600	11,900	10,300	113,800	13,100	13,600	115,200	14,700	8,500	116,800	14500	12500
TOTAL	**132,800**			**140,500**			**138,400**			**143,800**		

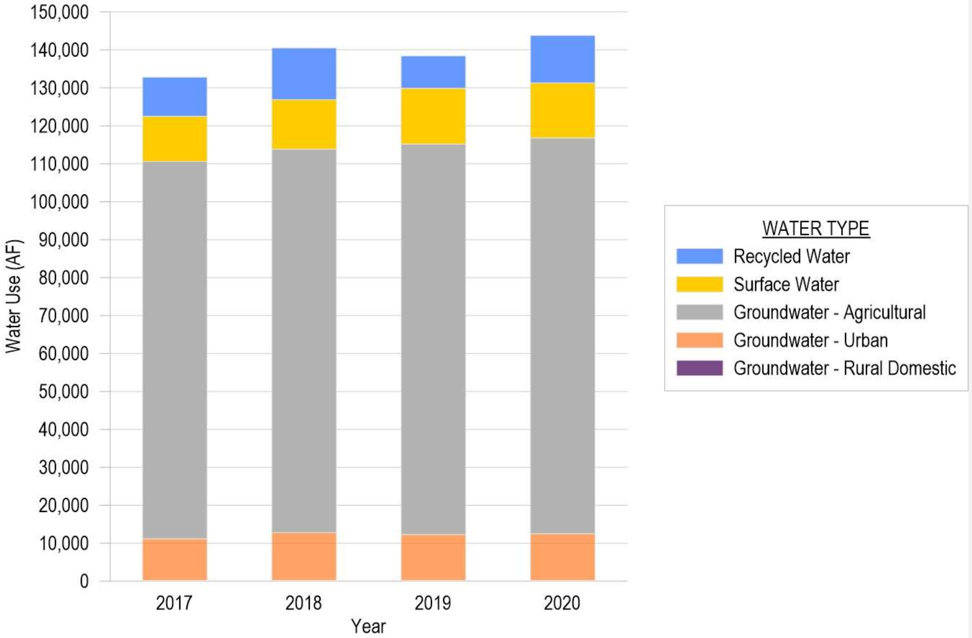

Figure 5-34~~5-36~~. 2017 to 2020 Total Water Use by Water Source Type and Water Use Sector