Draft

Groundwater Sustainability Plan
Chapter 4– Subbasin Setting

for the

Arroyo Grande Groundwater Subbasin Groundwater Sustainability Agency

Prepared by

9/13/2021

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The grey highlighted sections in the Table of Contents (TOC) indicate that the section has been previously released (Chapters 1 through 3) or will be released in the future (Chapters 5 through 14). The complete list of the anticipated TOC is presented to give the reader context as to how Chapters 4 connects with the complete Groundwater Sustainability Plan.

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LIST OF TERMS USED

Abbreviation	**Definition**
AB	Assembly Bill
ADD	Average Day Demand
AF	Acre Feet
AFY	Acre Feet per Year
AMSL	Above Mean Sea Level
AG AG Subbasin	Arroyo Grande Groundwater AG Subbasin
Basin Plan	Water Quality Control Plan for the Central Coast AG Subbasin
CASGEM	California State Groundwater Elevation Monitoring program
CCR	California Code of Regulations
CCRWQCB	Central Coast Regional Water Quality Control Board
CCGC	Central Coast Groundwater Coalition
CDFM	Cumulative departure from the mean
CDPH	California Department of Public Health
CIMIS	California Irrigation Management Information System
City	City of Arroyo Grande
County	County of San Luis Obispo
CPUC	California Public Utilities Commission
CRWQCB	California Regional Water Quality Control Board
CWC	California Water Code
DDW	Division of Drinking Water
Du/ac	Dwelling Units per Acre
DWR	Department of Water Resources
EPA	Environmental Protection Agency
ET_0	Evapotranspiration
°F	Degrees Fahrenheit
FAR	Floor Area Ratio
FY	Fiscal Year
GAMA	Groundwater Ambient Monitoring and Assessment program
GHG	Greenhouse Gas
GMP	Groundwater Management Plan
GPM	Gallons per Minute
GSA	Groundwater Sustainability Agency
GSC	Groundwater Sustainability Commission
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic Conceptual Model
HCP	Habitat Conservation Plan
IRWMP	San Luis Obispo County Integrated Regional Water Management Plan
kWh	Kilowatt-Hour
LUCE	Land Use and Circulation Element
LUFTs	Leaky Underground Fuel Tanks
MAF	Million Acre Feet
MCL	Maximum Contaminant Level
MG	Million Gallons
MGD	Million Gallons per Day

Abbreviation	Definition
Mg/L	Milligrams per Liter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MWR	Master Water Report
NCCAG	Natural Communities Commonly Associated with Groundwater
NCDC	National Climate Data Center
NCMA	Northern Cities Management Area
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information System
RW	Recycled Water
RWQCB	Regional Water Quality Control Board
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SGMA	Sustainable Groundwater Management Act
SGMP	Sustainable Groundwater Management Planning
SGWP	Sustainable Groundwater Planning
SLOFCWCD	San Luis Obispo Flood Control and Water Conservation District
SMCL	Secondary Maximum Contaminant Level
SOI	Sphere of Influence
SNMP	Salt and Nutrient Management Plan
SSURGO	Soil Survey Geographic Database
SWRCB	California State Water Resources Control Board
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USDA-NRCS	United States Department of Agriculture – Natural Resources Conservation Service
USGS	United States Geological Survey
USFW	United States Fish and Wildlife Service
USTs	Underground Storage Tanks
UWMP	Urban Water Management Plan
UWMP Act	Urban Water Management Planning Act
UWMP Guidebook	Department of Water Resources 2015 Urban Water Management Plan Guidebook
WCS	Water Code Section
WMP	Water Master Plan
WPA	Water Planning Areas
WRF	Water Reclamation Facility
WRCC	Western Regional Climate Center
WRRF	Water Resource Recovery Facility
WSA	Water Supply Assessment
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This section to be completed after GSP is complete.

4 BASIN SETTING (§ 354.14)

This section describes the geologic setting of the AG Subbasin, including the AG Subbasin boundaries, geologic formations and structures, principal aquifer units, geologic cross sections, and hydraulic parameter data. The information presented in this chapter, when considered with the information presented in Chapter 5 (Groundwater Conditions) and Chapter 6 (Water Budget), comprises the basis of the Hydrogeologic Conceptual Model (HCM) of the AG Subbasin. This section draws upon previously published studies. The data and information presented in this section is not intended to be exhaustive but is a summary of the relevant and important aspects of the AG Subbasin hydrogeology that influence groundwater sustainability. More detailed information can be found in the original reports listed in the references section of these chapters. This chapter presents the framework for subsequent sections on groundwater conditions and water budgets.

As part of the GSP process, a numerical groundwater model is being developed for the AG Subbasin and downstream areas in the adjudicated portion of the Santa Maria Subbasin to use as a tool in the GSP and the Habitat Conservation Plan (HCP) development processes (Appendix ZZ). Much of the information comprising the HCM presented in Chapters 4, 5, and 6 of the GSP is applied directly to the development of the groundwater model. Physical data on the geology and hydrogeologic parameters of the AG Subbasin presented in Chapter 4 are used to develop the model structure and parameterization. Data on groundwater conditions and water budget presented in Chapters 5 and 6 are used in model calibration.

Multiple sources and types of data are presented in Chapters 4, 5, and 6. Some of this data, such as rainfall amounts, depth to groundwater, and depth to bedrock, is directly measurable and involves a low degree of uncertainty. Other data, such as aquifer transmissivity, is based on calculations and interpretations of observed data, but is not directly measurable, and so involves a greater amount of uncertainty than direct measurements. And finally, values presented in the water budget are primarily derived from analysis of related data since most groundwater related water budget components are not directly measurable, and so involve more uncertainty than the previously discussed data types.

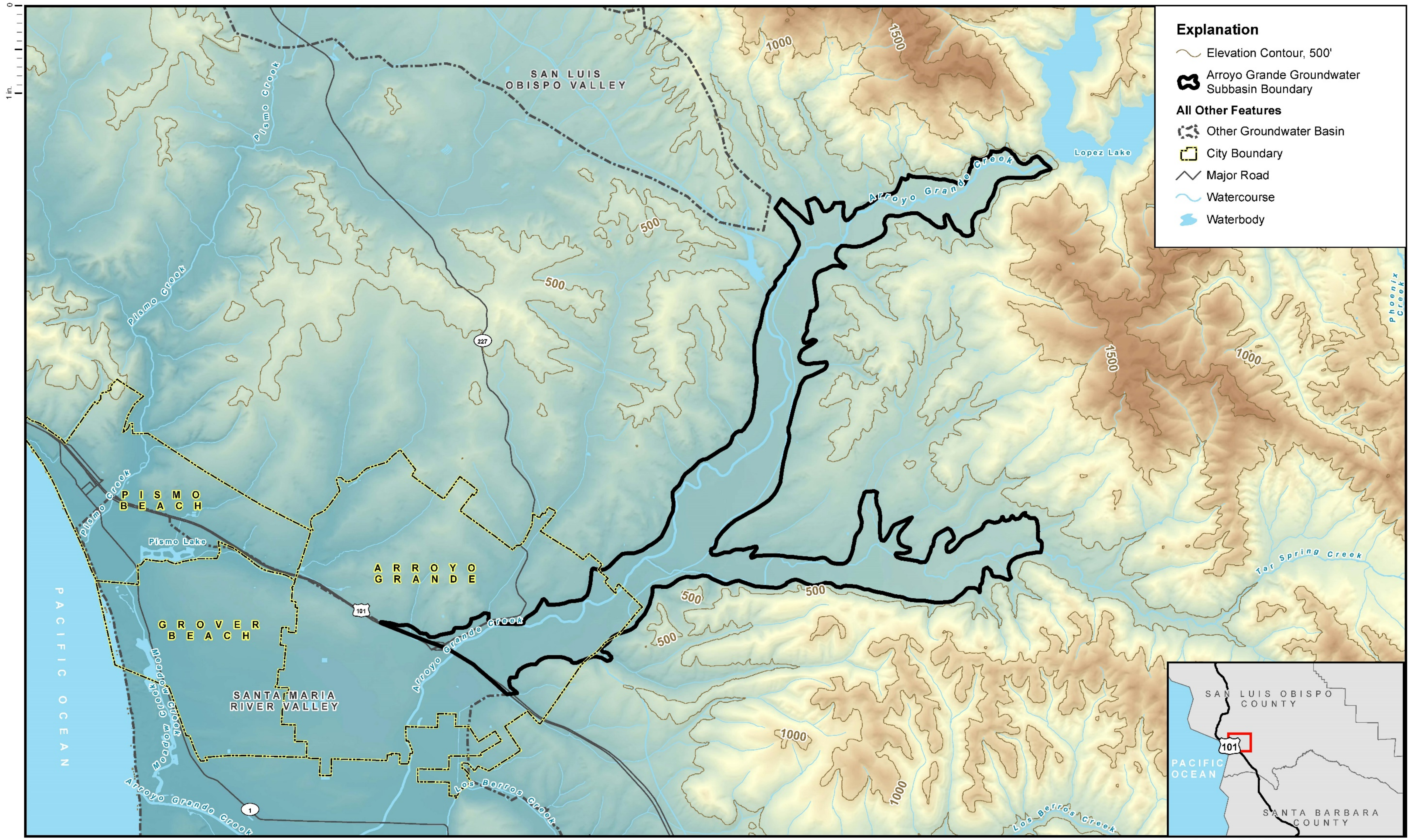
4.1 BASIN TOPOGRAPHY AND BOUNDARIES

The AG Subbasin is approximately seven miles long, oriented in a northeast-southwest direction, extending from Lopez Dam to the boundary of the Adjudicated Area of the Santa Maria Subbasin (approximately coincident with the Wilmar Avenue Fault and Highway 101). The tributary valley of Tar Spring Creek is about three miles long, oriented east-west, and joins Arroyo Grande Creek about three miles upstream of Highway 101 (Figure 4-1 and Figure 4-2). Land surface of AG Subbasin extends from an altitude of about 380 feet AMSL at the base of Lopez Dam to about 100 ft AMSL at the bottom of the AG Subbasin. Tar Spring Creek Valley extends from an altitude of about 360 ft AMSL to 160 ft AMSL at the confluence with Arroyo Grande Creek. Mountain ridges on the north side of the AG Subbasin rise steeply to elevations of over 1500 feet AMSL near Lopez Dam (Figure 4-1).

The primary weather patterns for the AG Subbasin are derived from seasonal patterns of atmospheric conditions that originate over the Pacific Ocean and move inland. As storm fronts move in from the coast, rainfall in the area falls more heavily in the mountains, and the AG Subbasin itself receives less rainfall because of a muted rain shadow effect. Average annual precipitation ranges from under 16 inches at the lower elevations of the AG Subbasin near Highway 101 to about 21 inches in relatively higher elevation areas near Lopez Dam (Figure 4-3). The time series of annual precipitation for the period of record from 1969 to 2020 at the Lopez Dam weather station was presented in Chapter 3, (Figure 3-1). The average rainfall at this location is 21.07 inches. The historical maximum is 45.52 inches, which occurred in 1998. The historical minimum is 7.16 inches, which occurred in 2014.

The AG Subbasin (DWR No. 3-012.02) is a DWR-recognized groundwater subbasin of the adjudicated Santa Maria River Valley Groundwater Basin (previously classified as DWR No. 3-012). The main part of the Santa Maria Subbasinthat is adjudicated and managed is now known as the Santa Maria Subbasin and has been reclassified by DWR (DWR No. 3-12.01). The southwestern extent of the AG Subbasin borders the northernmost of these management areas, the Northern Cities Management Area (NCMA), at the Wilmar Avenue Fault, approximately coincident with Highway 101. The AG Subbasin is adjacent to the southeastern extent of the San Luis Obispo Valley Groundwater Basin (DWR Basin 3-09) in the northern extent of the AG SubbasinSanta Maria AG SubbasinAG Subbasin. However, there is a groundwater divide between the two adjacent basins. Groundwater flow direction in the San Luis Obispo Valley Basin is to the northwest, away from AG Subbasin (GSI, 2018), so the two basins are distinct and there is minimal hydraulic communication between the basins.

The physical definition of the AG Subbasin boundary is the contact of unconsolidated alluvial sediments with the bedrock of the Miocene-aged formations and Franciscan Assemblage. (The geologic units will be described in greater detail Section 4.4.) Figure 4-4 displays a surface defining the bottom boundary of the AG Subbasin, based on the elevation of bedrock surface below the AG Subbasin sediments. The elevations range from about 400 feet AMSL near Lopez Dam to about 40 ft AMSL near the southern boundary of the AG Subbasin. Figure 4-5 displays contours of the thickness of the AG Subbasin sediments, and indicates that a maximum thickness of over 120 feet is present north of the confluence with Tar Spring Creek.



Prepared for:

COUNTY OF SAN LUIS OBISPO

CITY OF ARROYO GRANDE CALIFORNIA

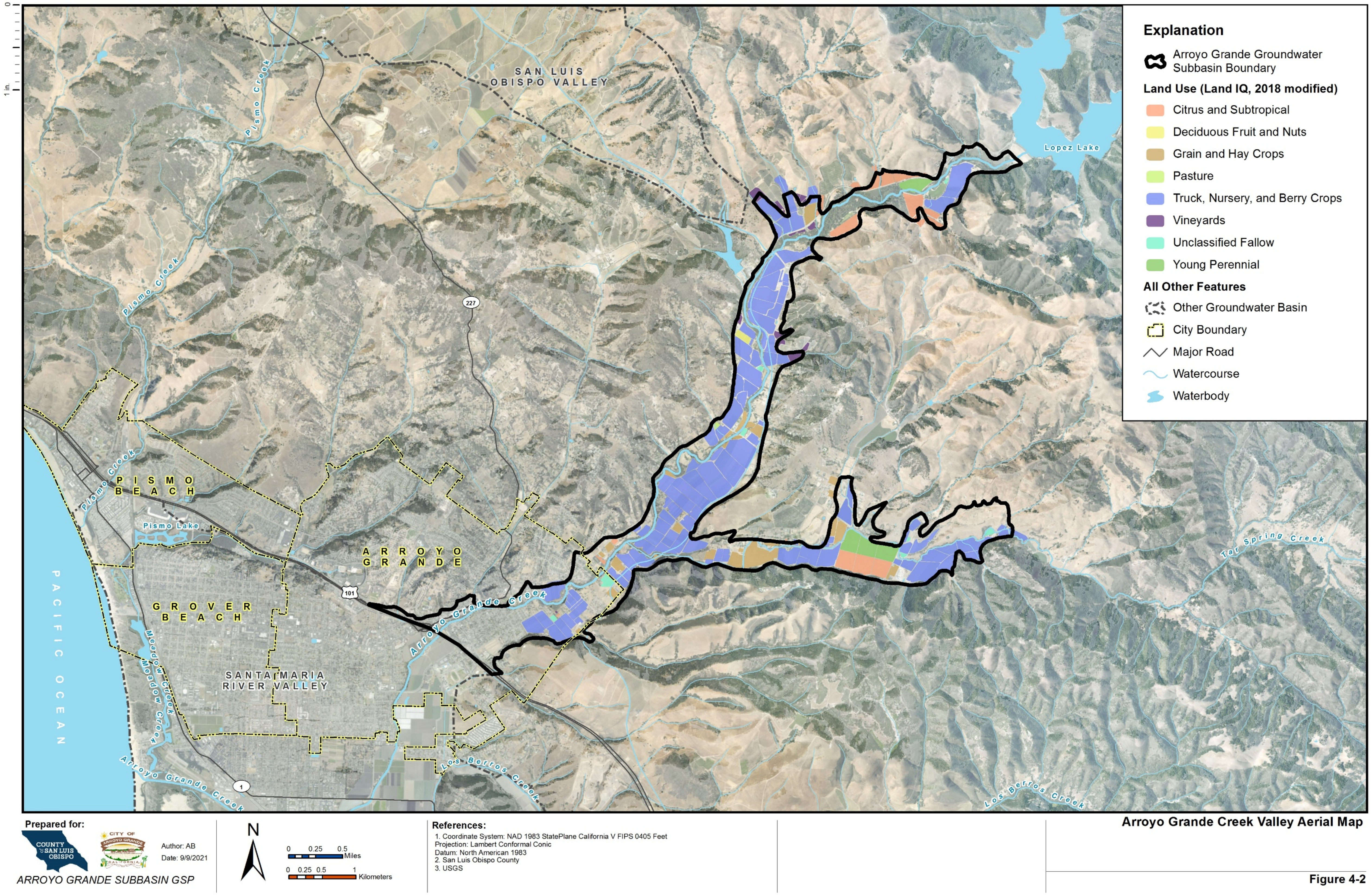
Author: AB
Date: 6/10/2021

ARROYO GRANDE SUBBASIN GSP

References:
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
2. San Luis Obispo County
3. USGS

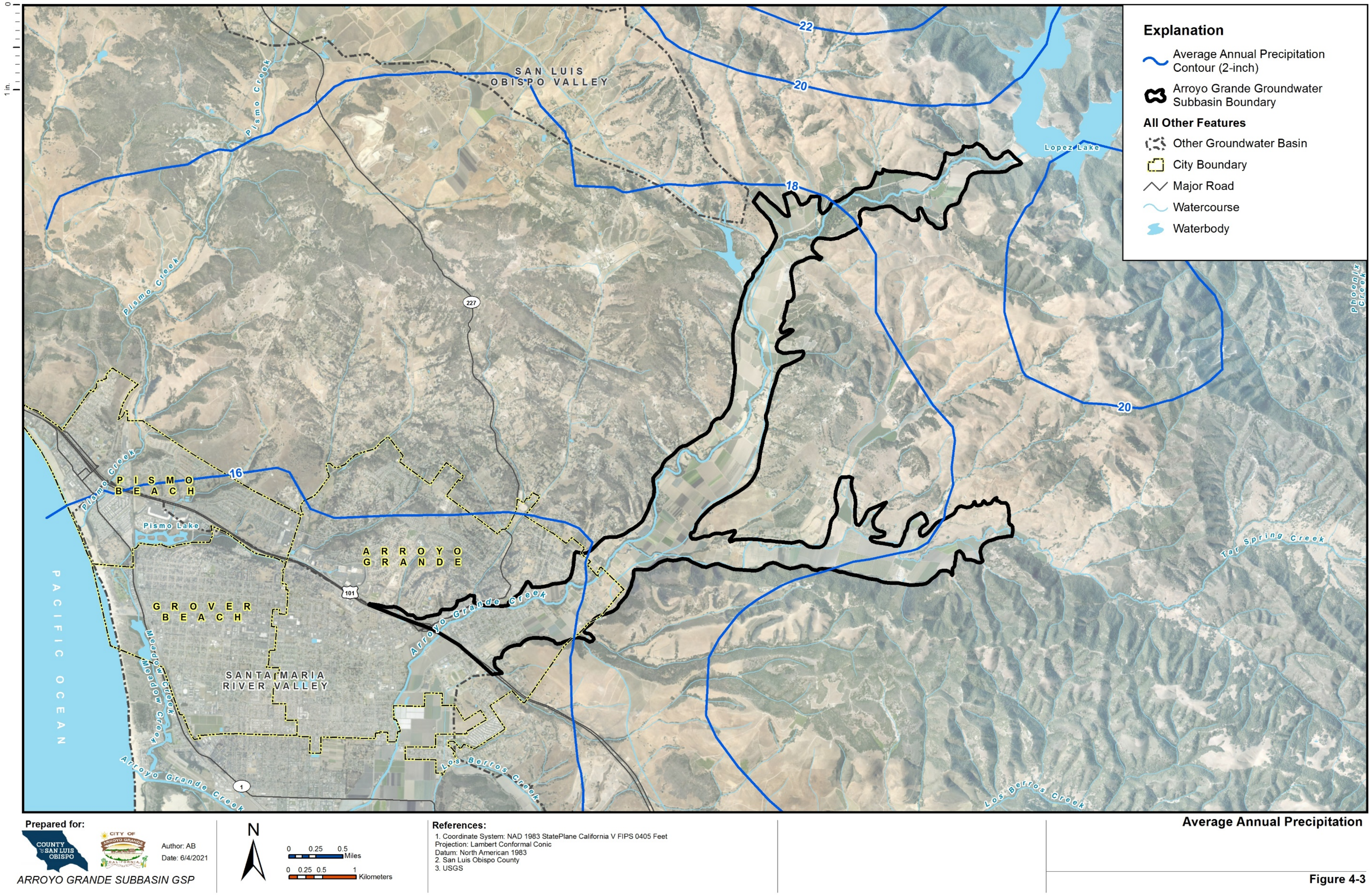
Arroyo Grande Creek Valley Topographic Map

Figure 4-1



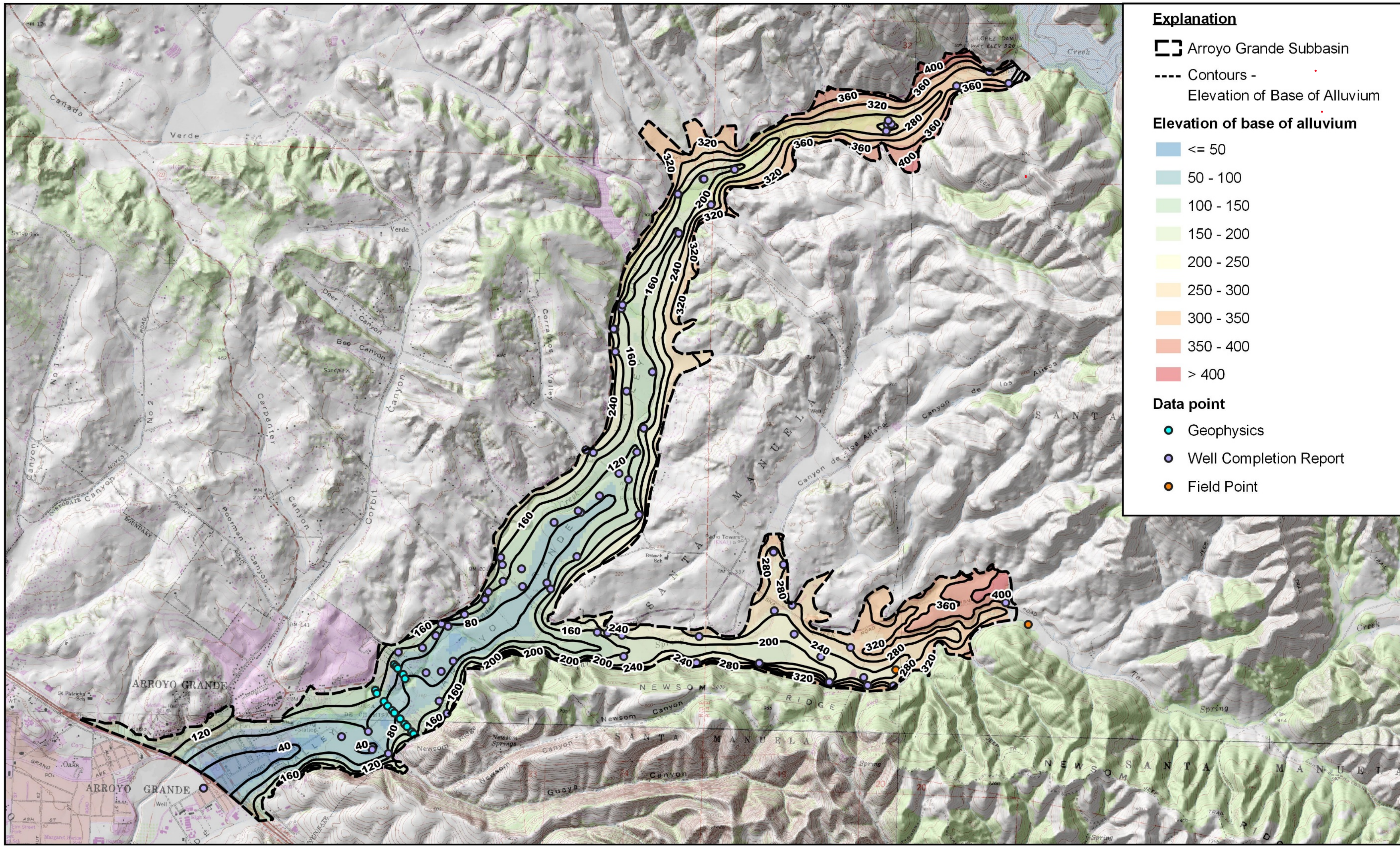
Arroyo Grande Creek Valley Aerial Map

Figure 4-2



Average Annual Precipitation

Figure 4-3



Prepared For:

Author: TK
Date: 09/09/2021

ARROYO GRANDE SUBBASIN GSP

N

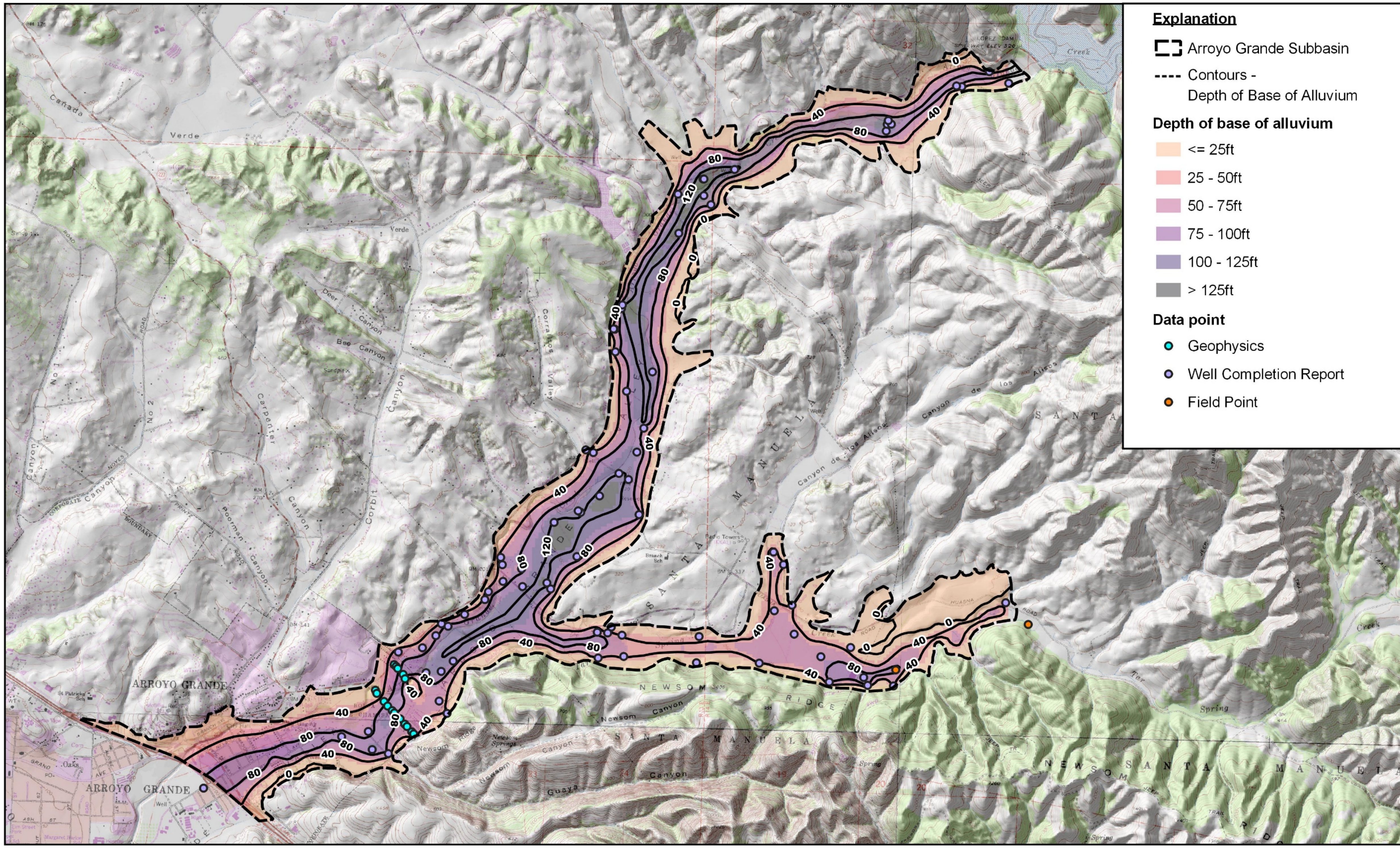
0 0.25 0.5 0.75 mi
0 0.5 1 km

References:
1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Horizontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: USGS 7.5' Topographic Map

Notes:
1.
2.
3.

Base of Alluvium Elevation

Figure 4-4



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Author: TK
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ARROYO GRANDE SUBBASIN GSP

N

0 0.25 0.5 0.75 mi
0 0.5 1 km

References:
1. Coordinate System: State Plane California V FIPS 0405 Feet
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3. Horizontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: USGS 7.5' Topographic Map

Notes:
1.
2.
3.

Base of Alluvium Depth

Figure 4-5

4.2 PRIMARY USERS OF GROUNDWATER

The predominant groundwater use in the AG Subbasin is pumping for agricultural supply s. Approximately 50% of land in the Subbasin is used for agriculture (Figure 4-2). Annual estimates of groundwater extraction are presented in greater detail in Chapter 6 (Water Budget), but agricultural pumping accounts for over 90% of pumping in the subbasin. A variety of crops are grown in the AG Subbasin, as displayed previously in Figure 3-2. Most agricultural production in the AG Subbasin relies on groundwater for irrigation supply, although some have riparian water rights along Arroyo Grande Creek. The City of Arroyo Grande does not have any supply wells located in the AG Subbasin. Most of the City's productive supply wells are located in the NCMA portion of the Santa Maria Subbasin (GSI, 2021). Private domestic residential wells in the AG Subbasin are used for local potable supply. These entities are discussed in more detail in Chapter 3 of this report.

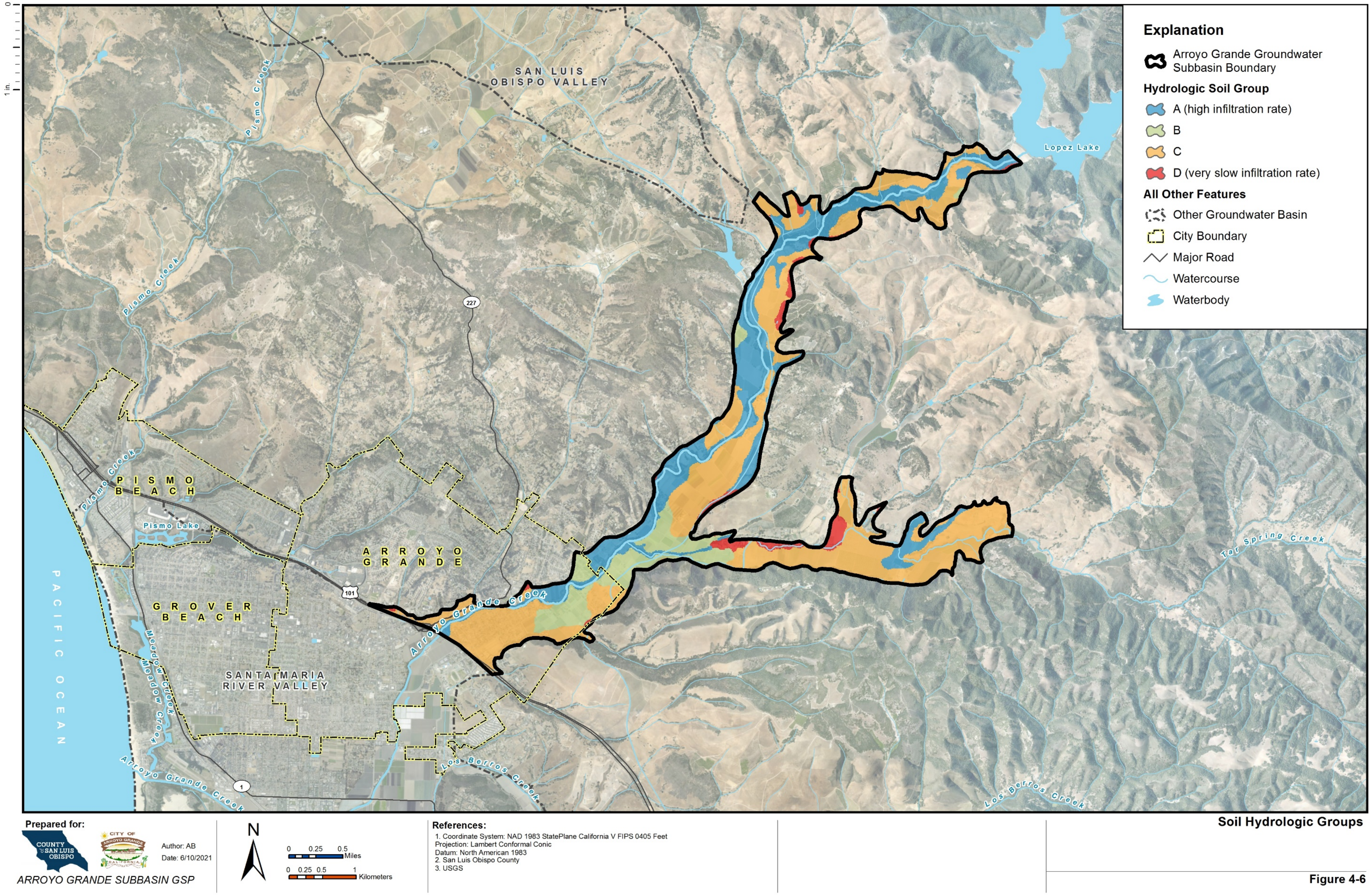
The AG Subbasin is dominated by agricultural land use (Figure 4-2), with historical estimates of agricultural acreage ranging from 1,620 acres in 1975 to 1,920 acres in 1995 (DWR, 2002), although in 2002 the DWR AG Subbasin encompassed 3,860 acres, compared to the currently defined AG Subbasin area of 2,899 acres. Other historical estimates for agricultural acreage in the Arroyo Grande valley range from 1,770 acres in 2009 to 1,867 acres in 2013 (Cleath-Harris Geologists, 2015), but also include acreages outside of the currently defined AG Subbasin. A 2016 estimate of agricultural land use of 1,440 acres within the formal AG Subbasin boundary is provided in Table 3-1 (Chapter 3; total acreage minus native vegetation and urban land use). The main crop type for all years is vegetable crops.

4.3 SOILS INFILTRATION POTENTIAL

Saturated hydraulic conductivity of surficial soils is a good indicator of the soil's infiltration potential. Soil data from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) (USDA-NRCS, 2007) is shown by the four hydrologic groups on Figure 4-6. The soil hydrologic group is an assessment of soil infiltration rates that is determined by the water transmitting properties of the soil, which includes hydraulic conductivity and percentage of clays in the soil relative to sands and gravels. The groups are defined as:

- Group A – High Infiltration Rate: water is transmitted freely through the soil; soils typically less than 10 percent clay and more than 90 percent sand or gravel.
- Group B – Moderate Infiltration Rate: water transmission through the soil is unimpeded; soils typically have between 10 and 20 percent clay and 50 to 90 percent sand.
- Group C – Slow Infiltration Rate: water transmission through the soil is somewhat restricted; soils typically have between 20 and 40 percent clay and less than 50 percent sand.
- Group D – Very Slow Infiltration Rate: water movement through the soil is restricted or very restricted; soils typically have greater than 40 percent clay, less than 50 percent sand.

A higher soil infiltration capacity does not necessarily correlate to higher transmissivity in the underlying aquifer, but it may correlate to greater recharge potential in localized areas. This will be discussed in more detail in Chapter 5.



Soil Hydrologic Groups

Figure 4-6

4.4 REGIONAL GEOLOGY

This section provides a description of the geologic formations and structures in the AG Subbasin. These descriptions are summarized from previously published reports. Figure 4-7 displays a stratigraphic column presenting the significant geologic formations within the AG Subbasin (Chipping, 1987). Figure 4-8 presents a surficial geologic map of the AG Subbasin [(Dibble, Geologic Map of Nipomo Quadrangle, San Luis Obispo County, CA, 2006a), (Dibble, Geologic Map of the Oceano Quadrangle, San Luis Obispo County, CA, 2006b), (Dibble, Geologic Map of the Tar Springs Ridge Quadrangle, San Luis Obispo County, CA, 2006c), (Dibble, Geologic Map of the Arroyo Grande NE Quadrangle, San Luis Obispo County, CA, 2006d)] and surrounding area and displays the locations of lithologic data used for this plan, and the section lines corresponding to cross sections in the following figures. Geologic cross sections are presented in Figure 4-9, Figure 4-10, and Figure 4-11. The geologic cross sections illustrate the relationship of the geologic formations that comprise the AG Subbasin and the geologic formations that underlie and bound the AG Subbasin.

4.4.1 Regional Geologic Structures

The AG Subbasin is cross cut by three regional fault systems; the Wilmar Avenue Fault, the Edna Fault, and the Huasna Fault. The most significant fault from a hydrogeologic standpoint is the Wilmar Avenue Fault. This fault defines the downgradient extent of the AG Subbasin and its boundary with the greater Santa Maria Subbasin. The Wilmar Fault has been interpreted in the past to provide a partial hydrogeologic barrier to groundwater flow from the AG Subbasin to the Santa Maria Subbasin (GSI, 2018). The Edna Fault extends to the northwest where it defines the southern boundary of the San Luis Obispo Groundwater Basin. All the faults are classified as normal faults, where primary displacement motion is vertical rather than lateral.

Fault data displayed in Figure 4-8 were acquired via the USGS Earthquake Hazards Program. The Quaternary fault and fold database from which the shapefiles are derived was published in 2006 and cites a wide variety of published sources. Fault traces within the shapefile represent surficial deformation caused by earthquakes during the Quaternary Period (the last 1.6 million years). The water-bearing sedimentary formations and the non-water-bearing bedrock formations are briefly described below.

4.4.2 Geologic Formations within the AG Subbasin

For the purpose of this plan, the geologic units in the AG Subbasin and vicinity may be considered as two basic groups; the AG Subbasin sediments and the consolidated bedrock formations surrounding and underlying the AG Subbasin. The consolidated bedrock formations range in age and composition from (1) Jurassic-aged serpentine and marine sediments to (2) Tertiary-aged marine and volcanic depositions. Compared to the saturated sediments that comprise the AG Subbasin aquifer, the consolidated bedrock formations are not considered to be significantly water-bearing. Although bedding plane and/or structural fractures in these rocks may yield economically usable amounts of water to wells, they do not represent a significant portion of the pumping in the area.

The delineation of the AG Subbasin boundaries is defined both laterally and vertically by the contacts of theAG Subbasin alluvial sedimentary formations with the consolidated bedrock formations. From a hydrogeologic standpoint, the most important strata in theAG Subbasin are the alluvial deposits associated with Arroyo Grande Creek and Tar Spring Creek that define the vertical and lateral extents of the AG Subbasin. Figure 4-7 presents a stratigraphic column of the significant local geologic units. Figure 4-8 presents a geologic map of the AG Subbasin vicinity (assembled from a mosaic of the Dibblee maps from the Tar Spring Ridge, Oceano, Nipomo, and Arroyo Grande NE quadrangles) showing where the various formations crop out at the surface.

4.4.2.1 Alluvium

The Recent Alluvium is the mapped geologic unit composed of unconsolidated sediments of gravel, sand, silt, and clay, deposited by fluvial processes along the courses of Arroyo Grande Creek, and Tar Spring Creek, and their tributaries. Lenses of sand and gravel are the productive strata within the Recent Alluvium. The Recent Alluvium sediments have no significant lateral continuity across large areas of subsurface within the AG Subbasin and may range from just a few feet to more than 120 feet. Well pumping rates may range from less than 10 gallons per minute (gpm) to more than 500gpm. If adequate thickness of alluvium is not available at a given well location, that well may be screened through the alluvium into the underlying bedrock to increase well yield.

4.4.3 Geologic Formations Surrounding the AG Subbasin

Older geologic formations that underlie the AG Subbasin sediments typically have lower permeability and/or porosity and are generally considered non-water-bearing. In some cases, these older beds may occasionally yield flow adequate for local or domestic needs, but wells drilled into these units are also often dry or produce only small rates of groundwater yield. Generally, the water quality from the bedrock units is poor in comparison to the AG Subbasin sediments. In general, the geologic units underlying the AG Subbasin include Tertiary-age consolidated sedimentary and volcanic beds (Pismo, Monterey, and Obispo Formations), and Cretaceous-age sedimentary and metamorphic rocks (Franciscan Assemblage).

The Pismo Formation bedrock is exposed at the surface in the mountains west of the valley, and in much of the area between Arroyo Grande Valley and Tar Spring Creek Valley. To the southeast of the Arroyo Grande/Tar Creek Spring Valley, the Monterey Formation crops out at the surface. The Edna Fault Zone and the Huasna Fault Zone cross the northern extent of the Arroyo Grande Valley; as a result, faulted and folded rocks of the Monterey Formation and Franciscan Assemblage crop out in the area northeast of the valley.

4.4.3.1 Pismo Formation

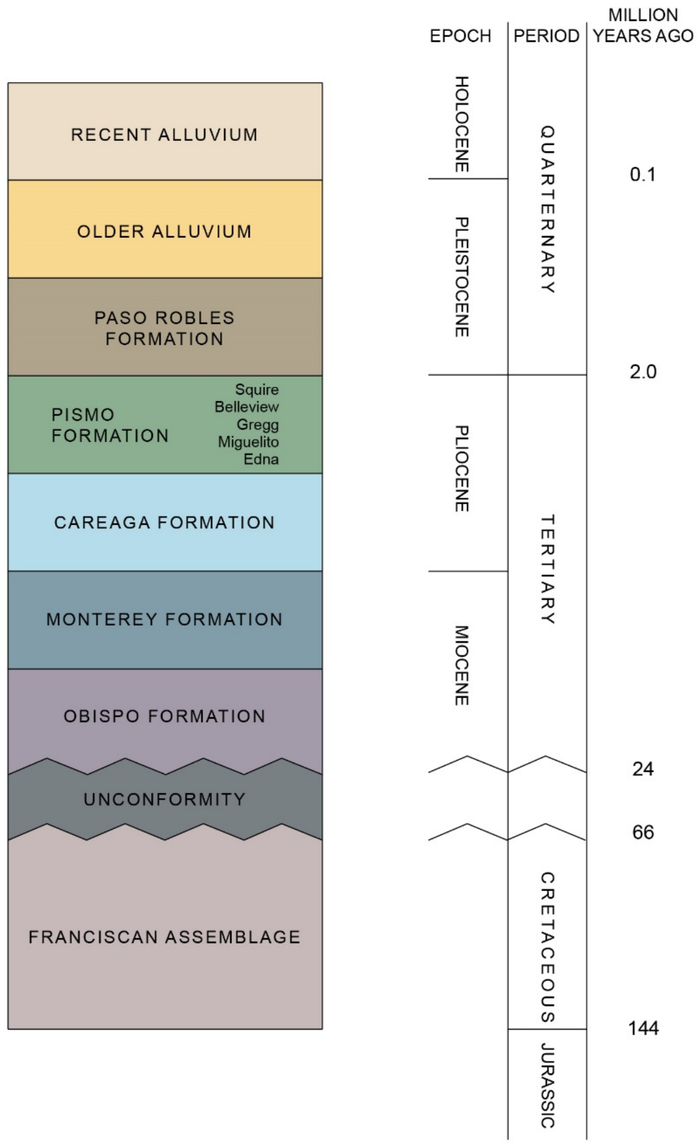
The youngest geologic unit that crops out around the AG Subbasin is the Pismo Formation. The Pismo Formation is a Pliocene-aged sequence of unconsolidated to loosely consolidated marine deposited sedimentary units composed of claystone, siltstone, sandstone, and conglomerate. There are five recognized members of the Pismo Formation, reflecting different depositional environments, and the variations in geology may affect the hydrogeologic characteristics of the strata. From the bottom (oldest) up, these are 1) the Edna Member, which lies unconformably atop the Monterey Formation, and is locally bituminous (hydrocarbon-bearing), 2) the Miguelito Member, primarily composed of thinly bedded grey or brown siltstones and claystones, 3) the Gragg Member, usually described as a medium-grained sandstone, 4) the Bellview Member, composed of interbedded fine-grained sandstones and claystones, and 5) the Squire Member, generally described as a medium- to coarse-grained fossiliferous sandstone of white to grey sands.

4.4.3.2 Monterey Formation

The Monterey Formation is a thinly bedded siliceous shale, with layers of chert in some locations. In other areas of the County outside of the AG Subbasin, the Monterey Formation is the source of significant oil production. While fractures in consolidated rock may yield usable quantities of water to wells, the Monterey Formation is not considered to be an aquifer for the purposes of this GSP. Regionally, the unit thickness is as great as 2,000 feet, and the unit is often highly deformed. Water wells completed in the Monterey Formation are occasionally productive if a sufficient thickness of highly deformed and fractured shale is encountered. More often, however, the Monterey shale produces groundwater to wells in low quantities. Groundwater produced from the Monterey Formation often has high concentrations of Total Dissolved Solids (TDS), hydrogen sulfide, total organic carbon, and manganese.

4.4.3.3 Obispo Formation
The Obispo Formation and associated Tertiary volcanics are composed of materials associated with volcanic activity along tectonic plate margins approximately 20 to 25 million years ago. The Obispo Formation is composed of ash and other material expelled during volcanic eruptions. Although fractures in consolidated volcanic rock may yield small quantities of water to wells, the Obispo Formation is not considered to be an aquifer for the purposes of this GSP.

4.4.3.4 Franciscan Assemblage
The Franciscan Assemblage contains the oldest rocks in the AG Subbasin area, ranging in age from late Jurassic through Cretaceous (150 to 66 million years ago). The rocks include a heterogeneous collection of basalts, which have been altered through high-pressure metamorphosis associated with subduction of the oceanic crust beneath the North American Plate before the creation of the San Andreas Fault. The current assemblage includes ophiolites, which weather to serpentinites and are common in the San Luis and Santa Lucia Ranges. Although fractures may yield small quantities of water to wells, the Franciscan Assemblage is not considered to be an aquifer for the purposes of this GSP.



NOTE:
Adapted from Chipping, 1987.

FIGURE 4-7
Local Stratigraphic Column

Prepared for:

Author: AB
Date: 6/4/2021

ARROYO GRANDE SUBBASIN GSP

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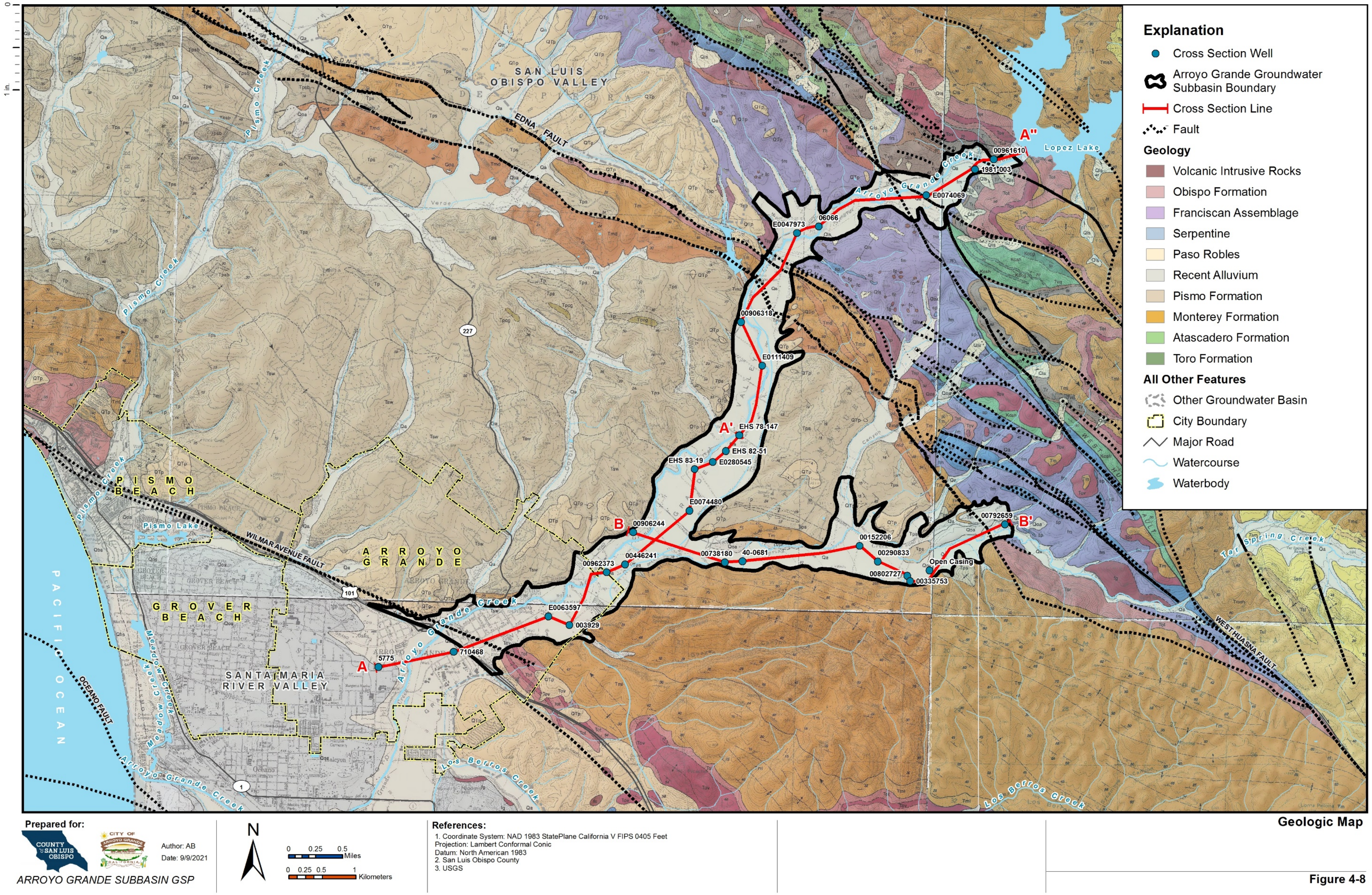


Geologic Map

Figure 4-8

4.5 PRINCIPAL AQUIFERS AND AQUITARDS

Water-bearing sand and gravel beds that may be laterally and vertically discontinuous are generally grouped together into zones that are referred to as aquifers. The aquifers can be vertically separated by fine-grained zones that can impede movement of groundwater between aquifers, referred to as aquitards. The Alluvial Aquifer is the only aquifer formation present in the AG Subbasin. It is a relatively continuous aquifer comprising alluvial sediments that define the extent of the AG Subbasin.

4.5.1 Cross Sections

Three cross sections were prepared for this GSP; two (A-A', A'-A'') are oriented along the longitudinal axis of the Arroyo Grande Creek Valley of the AG Subbasin and one (B-B') is oriented along the longitudinal axis of the Tar Spring Creek Valley (a part of the AG Subbasin) approximately perpendicular to Arroyo Grande Creek (Figure 4-8). All available lithologic data was reviewed during the selection of the section line locations. The cross sections display lithology, interpretations of geologic contacts based on available data, well screen intervals, and interpreted and mapped faults. If the geologic interpretation was not clear from the points on the cross section lines, nearby data from other locations was reviewed to provide broader geologic context. Each geologic cross section is discussed in the following paragraphs. Additionally, previous geophysical data analysis performed by CHG (Cleath-Harris Geologists, 2019) in the AG Subbasin was referenced and incorporated into the cross sections.

- Cross Section A-A' (Figure 4-9) extends approximately 4.5 miles along the Arroyo Grande Creek Valley axis, from just beyond the southwest boundary of the AG Subbasin (coincident with the Wilmar Avenue Fault) at its boundary with the Santa Maria Subbasin to a point about halfway up the Arroyo Grande Creek Valley, approximately coincident with a mapped synclinal axis in the underlying bedrock. Land surface elevation is about 100 feet AMSL at the southwest end of the section line, and slopes gently upward to about 225 feet AMSL at the northeast extent. Recent Alluvium is exposed at the surface for the entire length of this cross section, ranging in thickness from less than 50 feet in the Santa Maria Subbasin portion of the cross section to about 125 feet in most of the AG Subbasin portion of the section. A significant contiguous strata comprised predominantly of clay is present and interpreted to extend from the vicinity of the Wilmar Avenue Fault to the northwest through the entire cross section, ranging in thickness from about 10 to 50 feet. The presence of this clay layer may have implications regarding the understanding of direct percolation of streamflow throughout the AG Subbasin. (Field work is currently under way with the objective of enhancing the understanding of this process in the AG Subbasin.) Southwest of the Wilmar Avenue Fault, the alluvial sediments are directly underlain by the Paso Robles Formation, which overlies Franciscan Assemblage bedrock. Northeast of the Wilmar Avenue Fault, the Alluvium is underlain by bedrock of the Obispo Formation, Monterey Formation, and Pismo Formation, successively. The Wilmar Avenue Fault is not interpreted to displace the Alluvium, nor to create any hydrogeologic barrier to groundwater flow in the Alluvium.
- Cross Section A'-A" (Figure 4-10) extends approximately 4.5 miles along the Arroyo Grande Creek Valley axis, starting at the match line with Cross Section A-A' and extending northwest to Lopez Dam. Land surface elevation ranges from approximately 225 feet AMSL at the southwest extent of the section to about 375 feet AMSL at the base of Lopez Dam. Thickness of the Alluvium is relatively constant in the section, with a maximum thickness of about 150 feet. The contiguous clay strata that are observed in Section A-A' appears to pinch out about two miles downstream of Lopez Dam. The Edna Fault and the Huasna Fault systems are mapped in the area of this section; these faults displace the bedrock formation of the mountains surrounding the AG Subbasin, but are not interpreted to displace the Recent Alluvium. The Alluvium is underlain by the Pismo Formation southwest of the Edna Fault, and by the Franciscan Formation northeast of the Fault.

- Cross section B-B' (Figure 4-11) is oriented approximately east-west and extends approximately 4.5 miles along the Tar Spring Creek Valley axis from its confluence with Arroyo Grande Creek to the upgradient extent of the AG Subbasin. Land surface elevation ranges from approximately 150 feet AMSL at Arroyo Grande Creek to about 350 feet AMSL at the eastern edge of the section. Thickness of the Alluvium ranges from about 50 to 100 feet along Tar Spring Creek. A 10- to 20-foot-thick layer of alluvial strata comprised primarily of clay is observed near land surface in the lithologic data used to generate this section and is interpreted to extend contiguously along the length of Tar Spring Creek. The Edna Fault is mapped in bedrock beneath the alluvium at the eastern extent of the section, emplacing Monterey Formation bedrock west of the fault against Franciscan Group bedrock east of the Fault. These faults displace the bedrock formations but is not interpreted to displace the Recent Alluvium.

4.5.2 Aquifer Characteristics

The relative productivity of an aquifer can be expressed in terms of transmissivity, hydraulic conductivity, or specific capacity. The most robust method is measuring transmissivity using a long-term constant-rate pumping test (frequently 24 hours or more). Water level drawdown data collected during this test can be analyzed and used to calculate aquifer transmissivity. Aquifer transmissivity is the rate of flow under a unit hydraulic gradient through a unit width of aquifer of a saturated thickness and the transmissivity of an aquifer is related to its hydraulic conductivity. Hydraulic conductivity is a measure of a material's capacity to transmit water. Specific capacity is a simple measure of flow rate (gpm) divided by drawdown (feet), routinely measured by well service contractors during well maintenance and reported in units of gpm per foot of drawdown (gpm/ft). A common practice for well drillers in San Luis Obispo County is to conduct air lift tests, wherein compressed air is pumped into the bottom of the well, which displaces groundwater out the top of the well at a rate estimated by the driller. This method provides no drawdown measurement and is dependent on subjective flow estimates made by the driller, but it does provide general information on the comparative productivity of the aquifer in different parts of the AG Subbasin. Information on specific capacity measurements may be affected by poor well construction or degraded well materials, and, therefore, are not necessarily uniquely correlated to aquifer transmissivity. Nevertheless, the following commonly employed empirical relationship allows transmissivity to be estimated from specific capacity measurements.

$$T\ (\text{gpd/ft}) = SC\ (\text{gpm/ft}) * (1{,}500 \text{ to } 2{,}000)$$

Where T = Transmissivity (gpd/ft),
SC = Specific Capacity (gpm/ft),
1,500 – 2,000 = Empirical factor (1,500 used for unconfined, 2,000 for confined aquifer)

Data describing transmissivity, specific capacity, and air lift tests from water wells throughout the AG Subbasin were compiled. The data was obtained from previous regional studies or reports, well completion reports, previous pumping tests, and well service information provided by local stakeholders. All available reports and documents that were made available through data requests, report reviews, etc., were reviewed for technical information, and included in this summary if the data were judged to be sufficient. Figure 4-12 displays the spatial distribution of the available data locations for well tests in the AG Subbasin listed on Table 4-1. Inspection of Figure 4-12 indicates a good spatial coverage of locations, with reasonable data density throughout the AG Subbasin.

Specific yield is a parameter that describes the volume of water that will drain by gravity from a given soil mass to the volume of that soil, expressed as a dimensionless fraction. DWR reported specific yield values for eight Alluvium wells in the Arroyo Grande Valley ranging from 0.09 to 0.21, with a median value of 0.12 (DWR, 2002). These values are typical of unconfined alluvial sediments.

Hydraulic conductivity of the alluvial aquifer in Arroyo Grande is variable. DWR reported a single hydraulic conductivity estimate of 270 ft/day for Arroyo Grande Valley subbasin Alluvium based on aquifer test data, a range of 1.2 to 12 ft/day based on pump efficiency tests, and a range of 22 to 775 ft/day based on lithologic correlation (DWR, 2002). Data reviewed for this GSP and summarized in Table 4-1 indicate a range of hydraulic conductivity values from 8 ft/day to 46 ft/day.

Three constant rate aquifer tests were performed on wells in Arroyo Grande Valley during the preparation of the Basin Boundary Modification Request (GSI, 2018). The locations of the tests are presented as large blue dots on Figure 4-12. Results indicate that one well had a transmissivity of 90,000 gpd/ft, and a corresponding hydraulic conductivity of 252 ft/day; however, it was subsequently determined that this well is partially screened in the underlying Monterey Formation, and the transmissivity apportioned to the alluvial aquifer is estimated to be about 18,000 gpd/ft. The other well test yielded a transmissivity estimate of 15,000 gpd/ft with a corresponding hydraulic conductivity value of 19 ft/day (Table 4-1).

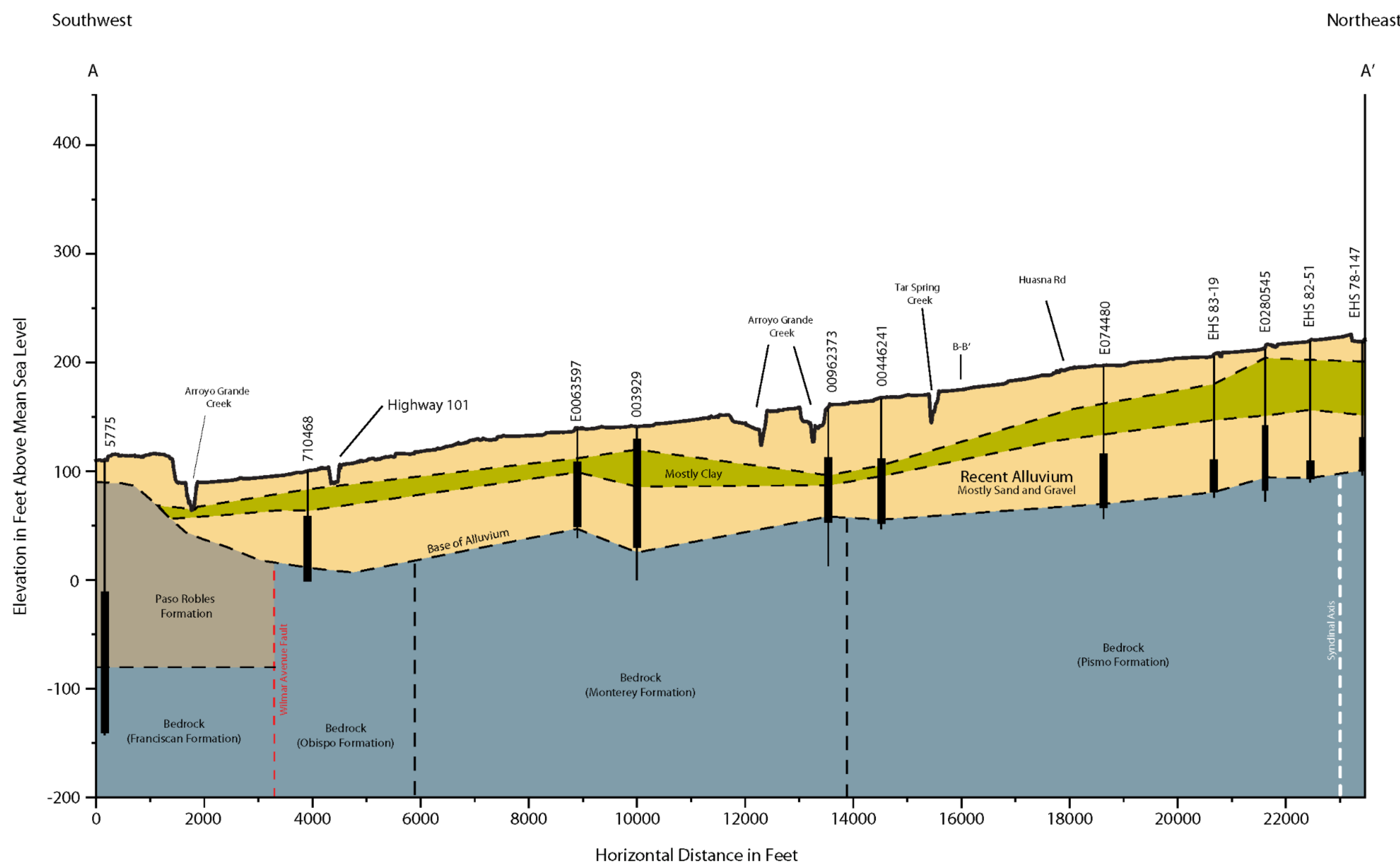
Table 4-1 presents a compilation of all well test data compiled during the preparation of this GSP. This information is used to inform the groundwater model development, and in the technical work supporting preparation of the GSP for the AG Subbasin.

Table 4-1: Well Test Data for Wells within AG Subbasin.

WCR/ID	GPM	Duration (hrs)	SWL (ft)	DD (ft)	SC (gpm/ft)	T (gpd/ft)	K (ft/d)
Aquifer tests (pumping tests with drawdown curves)							
906318	115	24	32	4.5	25.6	24,300	46
Biddle Dom.	65	4		3.3	19.7	15,000	19
Huasna Rd.	440	4		11.2	39.3	18,000	38
Specific capacity tests (pumping tests with final drawdown only)							
802727	201	6	28	32	6.3	6700	15
385342	50	4	30	25	2	1800	8
962373	75	12	38.5	16	4.7	5500	14
Air-lift tests							
156766	30	2		-	-	-	-
337436	300 @ 100ft		33	-	-	-	-
395065	100	4	35	-	-	-	-
448657	10 @ 70ft		30	-	-	-	-
505757	45@35ft / 50@55ft		17	-	-	-	-
738175	50+		39	-	-	-	-
738180	60-100		10	-	-	-	-
739489	500		30	-	-	-	-
906244	20+		34	-	-	-	-
1084102	500+		25	-	-	-	-
1097967	200+		26	-	-	-	-
1979-618	30		15	-	-	-	-
E0063592	30	1	34	-	-	-	-
E0063597	40-50	1	27	-	-	-	-
E0074480	30@80ft/150@130ft		61	-	-	-	-
E0075996	15@28ft/30@100ft		26	-	-	-	-
E0101996	300+@110ft		10	-	-	-	-
E0111409	300@60ft/500@125ft		22	-	-	-	-
E0180027	20	1.5	18	-	-	-	-
E0211771	200+@60ft/300+@140ft		28	-	-	-	-
E0277953	100	1.5	39	-	-	-	-
E0280545	150	4	73	-	-	-	-
2017-003929	400	6	48	-	-	-	-
2018-06066	200	2	27	-	-	-	-
2019-016947	300	4	63	-	-	-	-
961610	500+		30	-	-	-	-
539759	200-300		40	-	-	-	-
539798	30		15	-	-	-	-
580609	25		30	-	-	-	-

4.5.3 Aquitards

An aquitard is a layer of low permeability, usually comprised of fine-grained materials such as clay or silt, which vertically separates adjacent layers of higher permeability formations that may serve as aquifers. As displayed in the cross sections in Figure 4-9, Figure 4-10, and Figure 4-11, there is a contiguous clay layer present in the lower 6 miles of the Arroyo Grande Valley, and a contiguous clay layer present near the surface through most of Tar Spring Creek Valley. These clay layers are part of the Alluvial aquifer, but may function as local aquitards impacting the relative ability of the alluvial aquifer to percolate streamflow or direct percolation of precipitation. The presence of these clay layers is considered in the development of the integrated model.



Prepared For:

Author: JC
Date: 09/10/2021

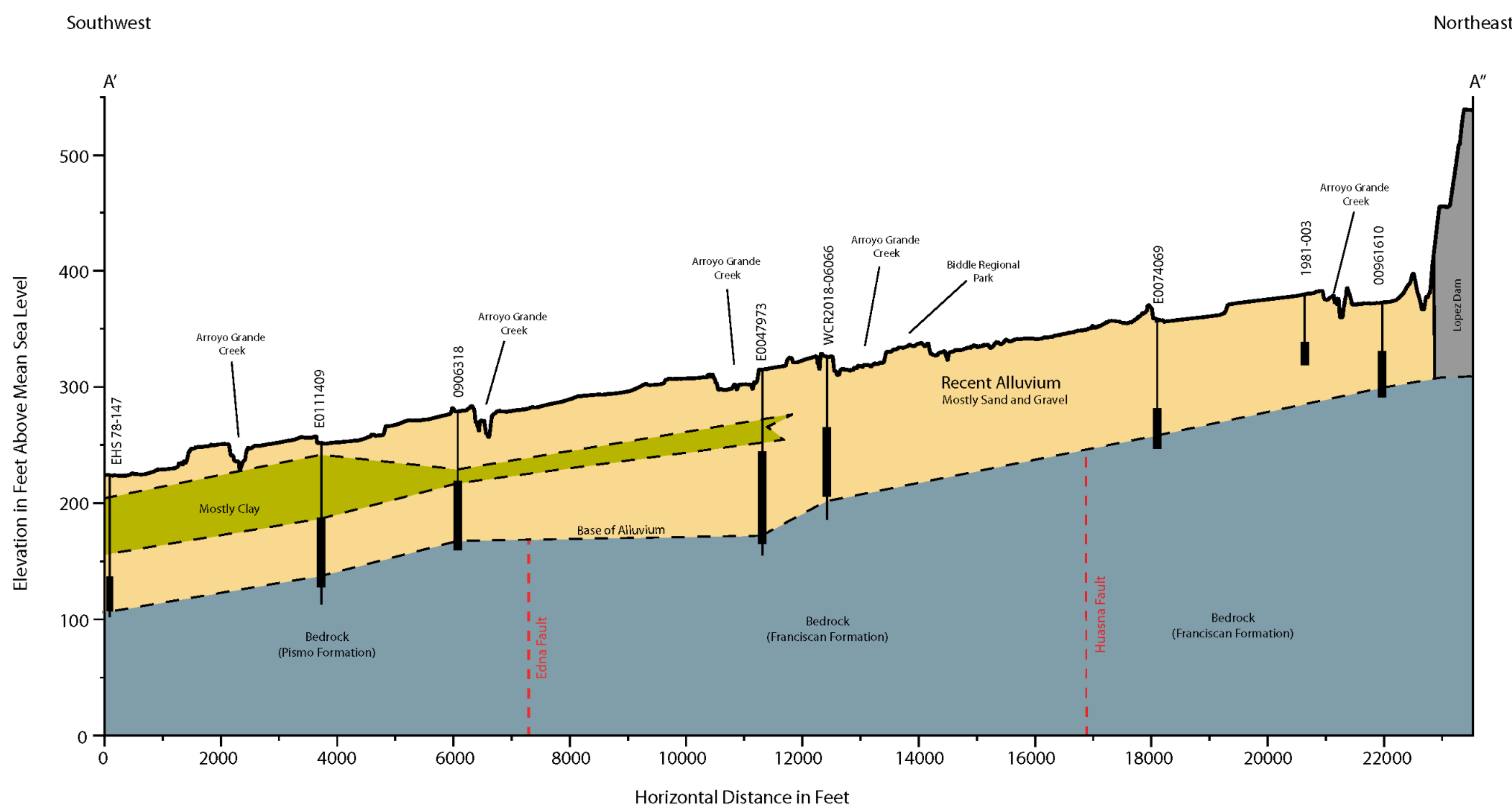
ARROYO GRANDE SUBBASIN GSP

Vertical Exaggeration:
20X

Explanation:
well with perforated interval
approximate geologic contact
fault

Cross Section A-A'

Figure 4-9



Prepared For:

Author: JC
Date: 09/10/2021

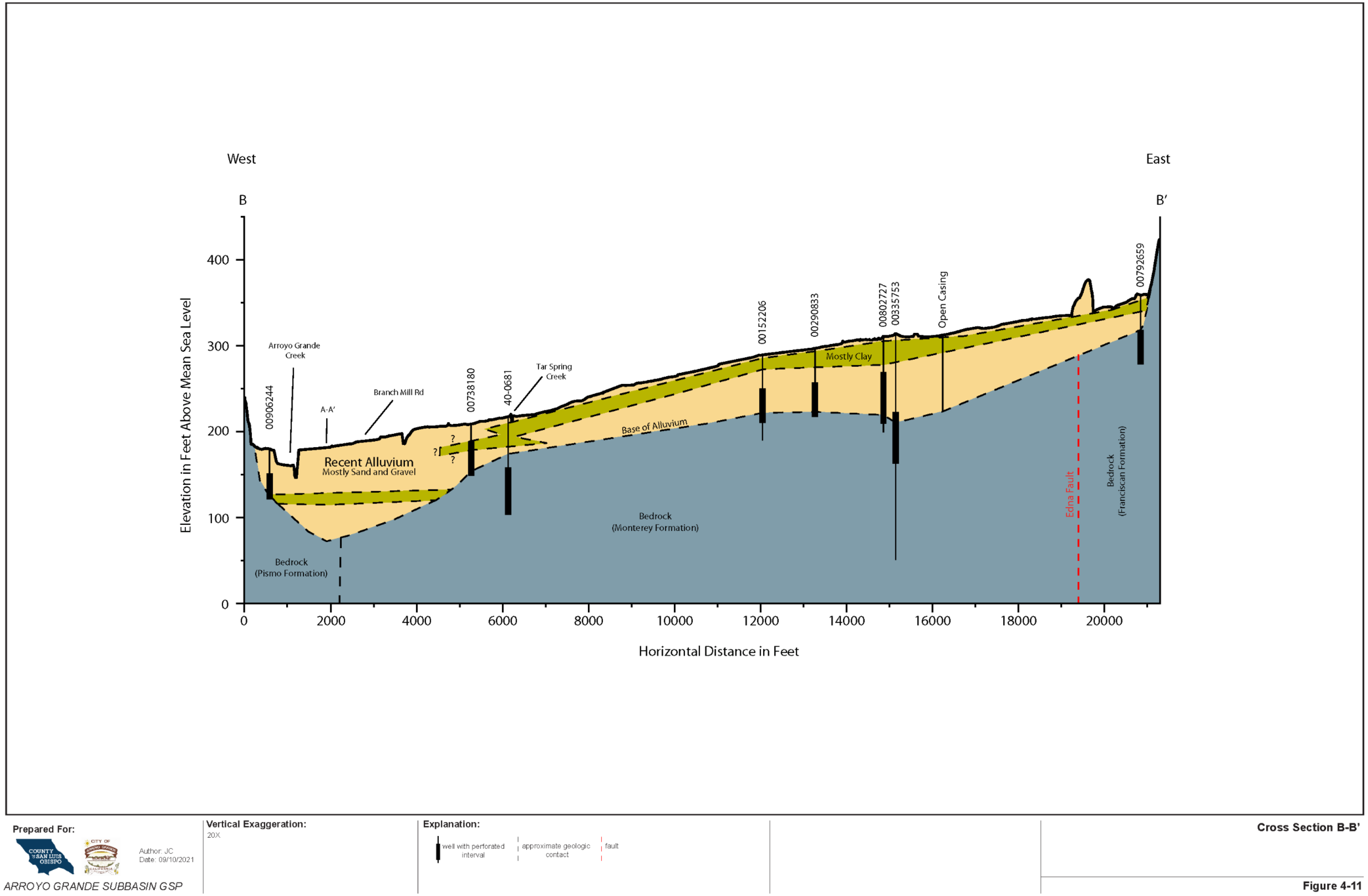
ARROYO GRANDE SUBBASIN GSP

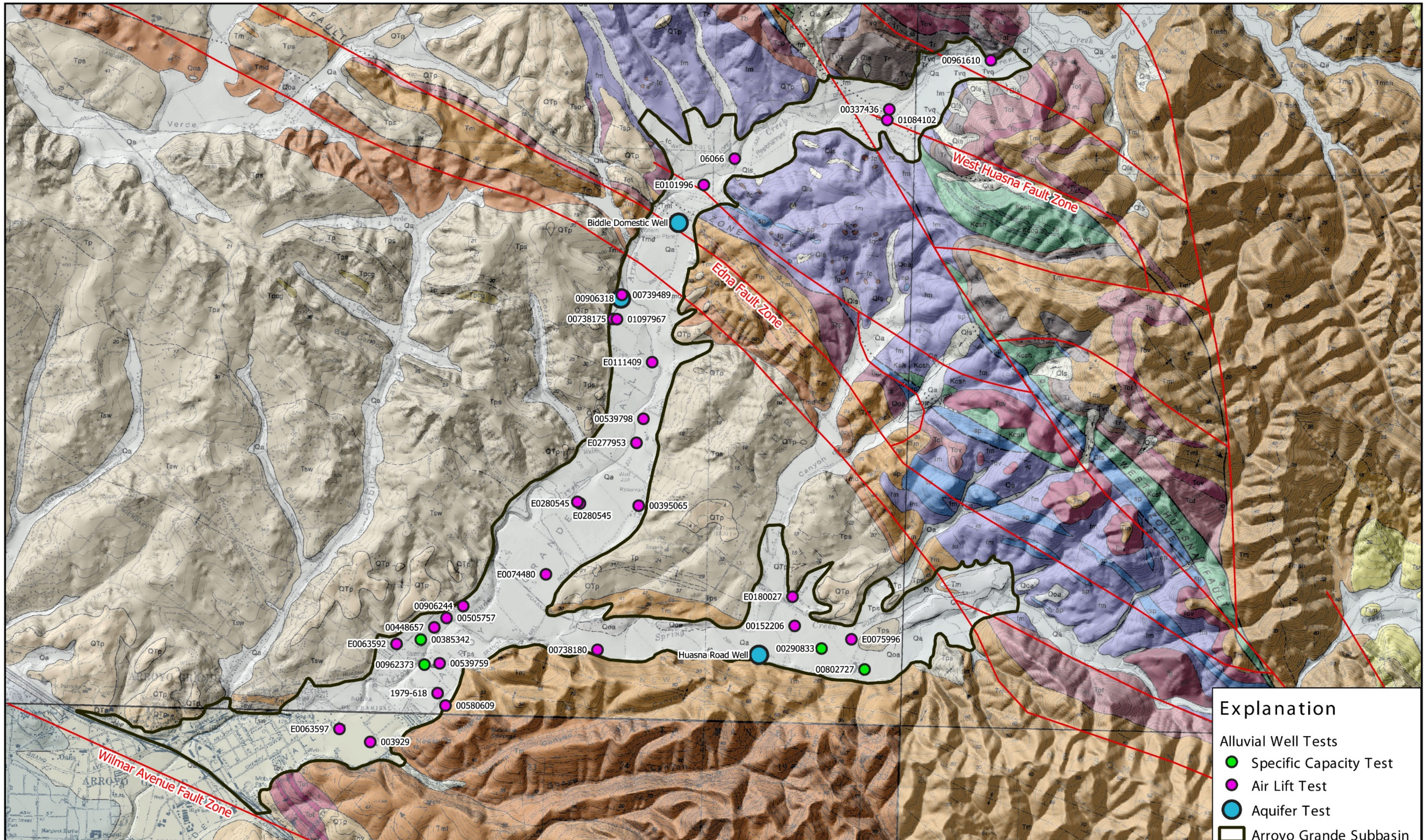
Vertical Exaggeration:
20X

Explanation:
well with perforated interval
approximate geologic contact
fault

Cross Section A'-A"

Figure 4-10


West
East
B
B'
Elevation in Feet Above Mean Sea Level
Horizontal Distance in Feet
0
100
200
300
400
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
Arroyo Grande Creek
A-A'
Branch Mill Rd
Tar Spring Creek
00906244
00738180
40-0681
00152206
00290833
00802727
00335753
Open Casing
00792659
Recent Alluvium
Mostly Sand and Gravel
Mostly Clay
Base of Alluvium
Bedrock
(Pismo Formation)
Bedrock
(Monterey Formation)
Edna Fault
Bedrock
(Franciscan Formation)
Prepared For:
Author: JC
Date: 09/10/2021
ARROYO GRANDE SUBBASIN GSP
Vertical Exaggeration:
20X
Explanation:
well with perforated interval
approximate geologic contact
fault
Cross Section B-B'
Figure 4-11



Prepared For:
ARROYO GRANDE SUBBASIN GSP
Author: JC
Date: 04/30/2021

References:
1. Coordinate System: State Plane California V FIPS 0405 Feet
2. Projection: Lambert Conformal Conic
3. Horizontal Datum: NAD 83
4. Vertical Datum: NAVD 88
5. Basemap: Dibblee, T.W. and Minch, J.A. 2006, Geologic map of the Arroyo Grande NE quadrangle, Tar Spring Ridge quadrangle, Oceano quadrangle, and Nipomo quadrangle, Dibblee Geological Foundation

Notes:
1.
2.
3.

Arroyo Grande Subbasin Well Tests

Figure 4-12

4.6 SURFACE WATER BODIES

Surface water/groundwater interactions represent a significant portion of the water budget of the AG Subbasin aquifer system. In the AG Subbasin, these interactions occur primarily as a function of releases from Lopez Dam to Arroyo Grande Creek, and to a lesser degree in the course of natural flows in Tar Spring Creek.
The watersheds support important habitat for native fish and wildlife, including the federally threatened South-Central California Coast steelhead (*Oncorhynchus mykiss)* (Stillwater, 2014).

Groundwater interaction with streams in the AG Subbasin is not well quantified, but it is recognized as an important component of recharge in the water budget. Where the water table is above the streambed and slopes toward the stream, the stream receives groundwater flow from the aquifer; this is known as a gaining reach (i.e., the stream gains flow as it moves through the reach). Because there is always some amount of flow released to Arroyo Grande Creek to support fish populations in the stream, it is thought that the streamflow in Arroyo Grande Creek is in hydraulic communication with the groundwater in the surrounding aquifer, maintaining groundwater levels in the vicinity of the creek at levels approximately equivalent to the surface water levels in the creek. Some areas may receive inflow from the aquifer, and some reaches may discharge to the aquifer, but along Arroyo Grande Creek they are always in communication. Along Tar Spring Creek, by contrast, where the water table is beneath the streambed and slopes away from the stream, the stream loses water to the aquifer; this is known as a losing reach. During seasonal dry flow conditions, groundwater elevations are deeper than the streambed since no base flow is present in the creek. Therefore, it is generally understood that the streams in the AG Subbasin discharge to the underlying aquifer, at least in the first part of the wet-weather flow season. If there is constant seasonal surface water flow, it is possible that groundwater elevations may rise to the point that they are higher than the stream elevation, and the creek may become a seasonally gaining stream in some reaches. Field work is being conducted to further investigate the surface water/groundwater interaction along Arroyo Grande Creek, and groundwater modeling can help evaluate surface water/groundwater interaction.

The SLO County Flood Control and Water Conservation District (SLOFC&WCD) maintains eight (8) real-time data monitoring stream gages within the Arroyo Grande Creek watershed. Three out of the eight stream gages are located within the Arroyo Grande AG Subbasin that include Rodriguez, Cecchetti, and Arroyo Grande Creek Gages. As summarized in Table 3-6, each stream gage measures stage at 15-minute intervals. Stage-discharge relationships, or rating curves, were developed by Western Hydrologics for the SLOFC&WCD and streamflow data in cubic feet per second (CFS) were calculated for each gage. In addition, the USGS has one stream gage located in the upper watershed of Lopez Canyon. The location of the eight SLOFC&WCD gages and USGS gage are presented in Figure 3-9.

4.7 SUBSIDENCE POTENTIAL

Subsidence is the gradual settling or sinking of the earth's surface due to material movement at depth at a given location. It may be associated with lowered groundwater levels caused by groundwater pumping and is one of the undesired results identified in SGMA. For clarity, this Sustainable Management Criterion references two related concepts:

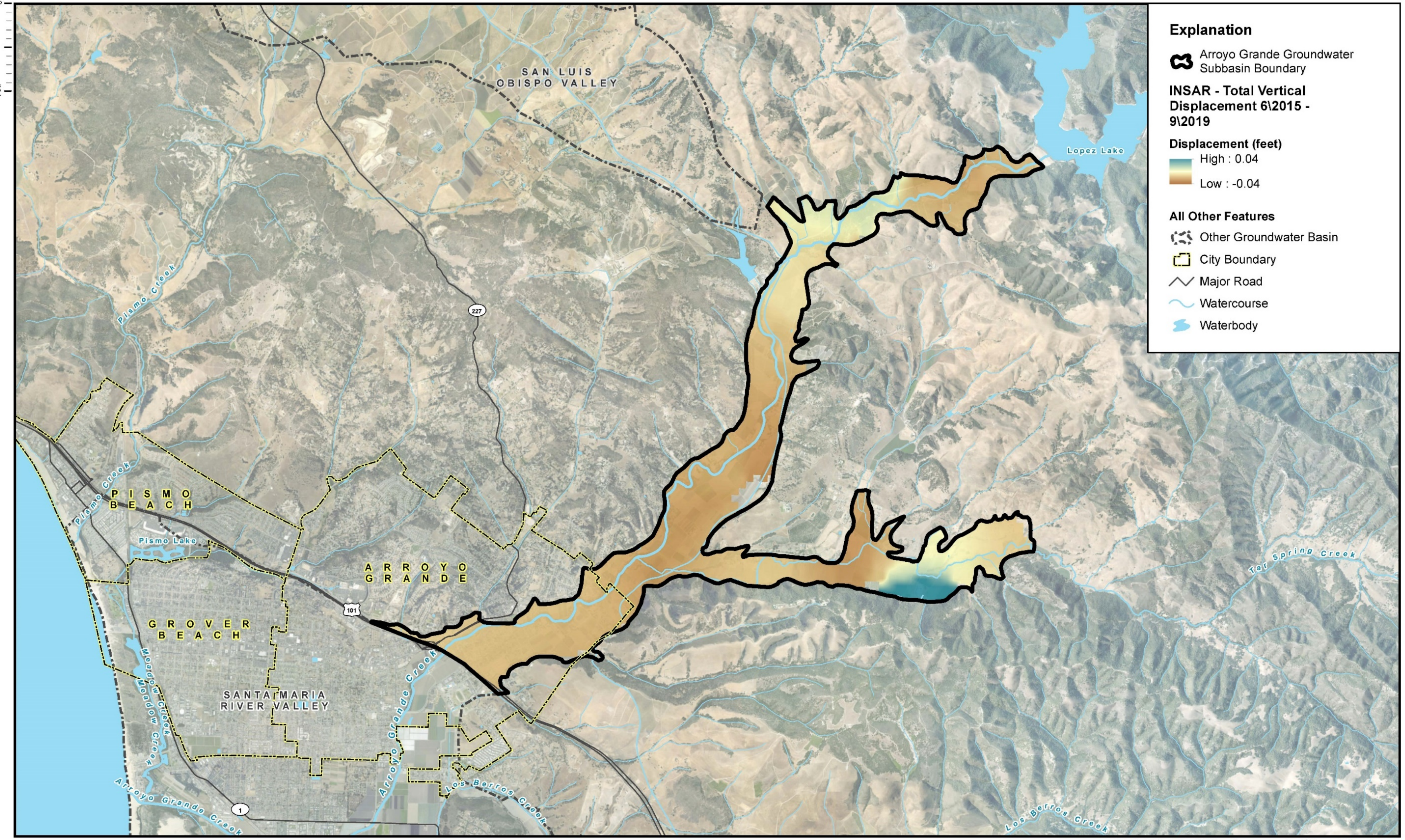
1. Land Subsidence is a gradual settling of the land surface caused by, among other processes, compaction of subsurface materials due to lowering of groundwater elevations from groundwater pumping. Land subsidence from dewatering subsurface clay layers can be an inelastic process, and the potential decline in land surface could be permanent.
2. Land Surface Fluctuation is the periodic or annual measurement of the ground surface elevation. Land surface may rise or fall in any one year. Declining land surface fluctuation may or may not indicate long-term permanent subsidence.

Reduced groundwater levels may allow the dewatering of shallow clay or peat layers if present, causing them to lose the hydrostatic pressure of the groundwater in the pore space, allowing the sediments to compress under the weight of overlying sediments. Subsidence can cause damage to buildings and infrastructure at the surface, resulting in significant economical impacts. If subsidence occurs in agricultural areas without significant buildings or infrastructure present, a small amount of subsidence may have no negative impact. There have been no historical long-term declines of groundwater levels in the AG Subbasin, and no subsidence has been documented in the Arroyo Grande Creek AG Subbasin.

DWR has implemented a satellite-based data collection program referred to as Interferometric Synthetic Aperture Radar (InSAR) capable of measuring small changes in land surface altitude in the state over time. DWR identifies the AG Subbasin as having a low subsidence potential. Inspection of data online in DWR's SGMA data web portal indicates Interpolated Displacement Values clustered around zero, indicating no measurable subsidence in recent years 2015 to 2020. DWR has stated that, on a statewide level, for the total vertical displacement measurements between June 2015 and September 2019, the errors are as follows (NASA-JPL, 2018):

1. The error between InSAR data and continuous GPS data is 16 mm (0.052 feet) with a 95% confidence level.
2. The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 feet with 95% confidence level.

For the purposes of this GSP, the error for InSAR data is considered the sum of errors 1 and 2, combined total error of 0.1 foot. Figure 4-13 presents InSAR total vertical displacement (TVD) data in the AG Subbasin for the period from 2015 to 2019. This figure indicates TVD values ranging from –0.04 to +0.04 over this time period. These values are within the 0.1-foot error range discussed above and corroborate anecdotal information that there have been no negative impacts associated with subsidence in the AG Subbasin.



Prepared for:

Author: AB
Date: 6/10/2021

ARROYO GRANDE SUBBASIN GSP

0 0.25 0.5 Miles
0 0.25 0.5 1 Kilometers

References:
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
2. San Luis Obispo County
3. USGS

Total Vertical Displacement of Land Surface June 2015 to September 2019

Figure 4-13

REFERENCES

Chipping, D. H. (1987). *The Geology of San Luis Obispo County, A Brief Description and Field Guide.*

Cleath-Harris Geologists. (2015). *Arroyo Grande Valley Agricultural Water Use Survey, Lopez Hydrogeological Services Project. Technical Memorandum Prepared for ECORP Consulting.*

Cleath-Harris Geologists. (2019). *Passive Seismic Geophysical Survey for Strother Park Well Siting Study Technical Memorandum .* City of Arroyo Grande.

Dibble, T. (2006a). *Geologic Map of Nipomo Quadrangle, San Luis Obispo County, CA.* Dibble Geology Center Map #DF-208.

Dibble, T. (2006b). *Geologic Map of the Oceano Quadrangle, San Luis Obispo County, CA.* Dibble Geology Center Map #DF-209.

Dibble, T. (2006c). *Geologic Map of the Tar Springs Ridge Quadrangle, San Luis Obispo County, CA.* Dibble Geology Center Map #DF-210.

Dibble, T. (2006d). *Geologic Map of the Arroyo Grande NE Quadrangle, San Luis Obispo County, CA.* Dibble Geology Center Map #DF-211.

DWR. (2002). *Water Resources of the Arroyo Grande Nipomo Mesa Area.* California Department of Water Resources Southern District.

GSI. (2018). *Santa Maria River Valley Groundwater Basin Boundary Modification Request Technical Report.*

GSI. (2021). *Northern Cities Management Area 2020 Annual Monitoring Report Annual Report.*

NASA-JPL. (2018). *Raster Geographic Information System (GIS) Dataset: Vertical Displacement.* National Aeronautics and Space Administration - Jet Propulsion Laboratory.

Stillwater. (2014). *San Luis Obispo County Regional Instream Flow Assessment.* California Coastal San Luis Resource Conservation District.

USDA-NRCS. (2007). *Soil Survey Geographic Database (SSURGO).* U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS).