Santa Barbara County Groundwater Characterization Project: Santa Ynez River Valley Groundwater Basin

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Arroyo Grande
Oceano
Nipomo
Sisquoc River
Santa Barbara
Santa Maria
SANTA MARIA VALLEY
101
Orcutt
US-101-S
Vandenberg Air Force Base
Lompoc Terrace
Lompoc Upland
Lompoc Plain
Lompoc
PURISIMA HILLS
US-101-N
Santa Rita
Buellton
Solvang
Santa Ynez
154
Santa Ynez
Cachuma Recreation Area
SAN RAFAEL RANGE
SANTA YNEZ MOUNTAINS
2142 ft
1722 ft
5108 ft
4901
Gaviota State Park
Goleta
US-101
Isla Vista
Legend
County Boundaries
Santa Ynez River Valley (3-015) Groundwater Sub-basins
0
2.5
5
10
15
20
Miles
N
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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Datum

Horizontal coordinate information is referenced to the World Geodetic System 1984 (WGS 1984).
Vertical coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Abbreviations and Acronyms

BGS: below ground surface
CCWB: Central Coast Regional Water Quality Control Board
CDPH: California Department of Public Health
GAMA: Groundwater Ambient Monitoring Assessment
GAP: groundwater assessment program
LAMP: local agency management plan
MCL: Maximum Contaminant Level
MGD: Million Gallons per Day
NADA: Nondetects and data analysis
NWIS: National Water Information System
OWTS: onsite wastewater treatment system
SMCL: Secondary MCL
SYRV: Santa Ynez River Valley groundwater basin
SYRWCD ID1: Santa Ynez River Water Conservation District
TDS: Total Dissolved Solids
USGS: United States Geologic Survey
WWTP: wastewater treatment plant

Definitions

Aesthetic benchmark: secondary water quality benchmark for drinking water related to unpleasant taste, odor, color, or technical effects (corrosion or sedimentation).

Alluvial Deposit: Sand, silt, clay, gravel, or other material deposited by flowing water e.g. riverbed, floodplain, delta.

Anthropogenic: originating in human activity

Aquifer: body of permeable rock that can contain or transmit groundwater

Exceedance: groundwater concentration greater than the drinking water standard e.g. primary maximum contaminant level, secondary maximum contaminant level.

Groundwater Basin: an area underlain by permeable materials capable of furnishing a significant supply of groundwater to wells or storing a significant amount of water.

Groundwater Loading: Localized contribution of water containing pollutants such as nitrate, to underlying groundwater at concentrations greater than naturally occurring.

Groundwater recharge: deep drainage or percolation where water moves downward from the ground surface to the underlying aquifer.

Leaching: drain away from soil, action of percolation liquid (septic wastewater, rain, irrigation)

Maximum Contaminant Level (MCL): Standards set by the United States Environmental Protection Agency (USEPA) for drinking water quality. An MCL is the legal threshold limit on the amount of a substance that is allowed in public water systems under the Safe Drinking Water Act.

Notification Level (NL): Health-based advisory levels established by the Division of Drinking Water (DDW) for chemicals in drinking water that lack maximum contaminant levels (MCLs). When chemicals are found at concentrations greater than their notification levels, certain requirements and recommendations apply.

Secondary Maximum Contaminant Level (SMCL): Established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL and are not enforced by the USEPA.

Subbasin: structural geologic feature where a larger basin is divided into a series of smaller basins.

Unsaturated Zone – The portion of the subsurface above the water table. The soil and rock in this zone contains air and water in the pore spaces.

Well Screen (Screen depth): “a well screen is a filtering device that serves as the intake portion of wells constructed in unconsolidated or semi-consolidated aquifer. The screen permits water to enter the well from the saturated aquifer, prevents sediment from entering the well, and serves structurally to support the aquifer material.” (Driscoll, 1986)

Executive Summary

This report includes a summary of available groundwater quality information for the Santa Ynez River Valley (SYRV) groundwater basin, identifies areas where domestic wells may be at risk of pollution, and evaluates the risk and impacts of onsite wastewater treatment systems (OWTS) to the basin. The data gathering, compilation, statistical analysis, and reporting of data presented in this report was prepared by an intern funded by the non-profit organization Heal the Ocean and the technical analysis was overseen by technical staff from the Central Coast Regional Water Quality Control Board (Central Coast Water Board). The technical interpretations of the data were based on best professional judgment with the presumption that the data was accurate.

To identify areas where groundwater may be vulnerable to pollution from OWTS, a geographical information system (GIS) based risk model is presented in this report that combines OWTS density with various hydrogeological parameters that affect groundwater pollution potential. Results of this work indicate the highest OWTS density and highest OWTS risk occur near the towns of Los Olivos, Santa Ynez, and Janin Acres. While these areas had previously already been identified as areas of concern for OWTS pollution, the maps presented in this report allow for a quick comparison of the density and risk in these areas relative to other parts of the basin. In addition, the risk model provides new information that indicates that the Lompoc Plain and the foothills northeast of Los Olivos may also be at risk from OWTS pollution.

The characterization of groundwater quality is based on existing data collected from wells in the SYRV basin. In the SYRV, arsenic and hexavalent chromium have impaired water quality in at least two of the five subbasins. In the Lompoc Terrace subbasin, arsenic impairment is widespread in the wells that were analyzed for arsenic. The risk to drinking water is predominantly limited to municipal supply wells as there are very few domestic wells in that subbasin. In the Santa Ynez subbasin, nearly 50 percent of the wells sampled exceed the human health drinking water standard for hexavalent chromium and there are many domestic wells within a one square mile radius of those wells that have elevated hexavalent chromium, suggesting that domestic well users may be at risk of drinking water above the drinking water standard for hexavalent chromium. There are far fewer wells that have been sampled for hexavalent chromium in each of the other four subbasins and as such, there may also be hexavalent chromium impaired wells in those subbasins.

In the last chapter of this report, a risk-based analysis of impacts from OWTS on groundwater quality within the Santa Ynez subbasin is included. This basin was chosen for additional detailed analysis of water quality impacts because this subbasin has been previously recognized as an area of concern due to the high density of OWTS in the basin. This analysis focused on nitrate concentration as an indicator of OWTS impairment because OWTS impacts on nitrate concentration are widely documented, nitrate concentration data is widely available, and many wells have long historical records of nitrate concentration data. However, there are a variety of other land use practices that can contribute nitrate to groundwater, including the agricultural activity that is prevalent within the Santa Ynez subbasin. Therefore, this report includes a compilation of the available data and an analysis of the source and impact of nitrate from a variety of different sources. This analysis should be regarded as a first-order assessment which will guide more targeted future investigations and additional subsequent sampling or modeling to identify sources of nitrate and other impacts of OWTS in specific areas of concern.

Our detailed investigation of OWTS impacts in the Santa Ynez subbasin indicate that, although nitrate concentrations throughout the subbasin are generally low, OWTS is likely causing some localized impairments with respect to nitrate in groundwater. In areas that have either high OWTS density or high risk of OWTS impairment, there is typically elevated and/or increasing nitrate concentrations. However, there are also decreasing and/or low nitrate concentrations in high density or high OWTS risk areas. The seeming lack of consistency in nitrate concentrations in high density/high risk OWTS impairment areas is partially a function of the depth of the well screen from which the nitrate groundwater data is collected. Wells with deeper perforated intervals (i.e., wells that extract groundwater from deeper portions of the aquifer) are likely pumping older water that has less communication with the land surface above or the deeper intervals may be isolated from the impacted shallow groundwater due to natural, low permeability geologic layers. Analysis of nitrate concentrations from wells that had both construction information and concentration data revealed the shallow wells generally have higher concentrations of nitrate compared to the deeper wells. Due to the lack of depth-discrete vertical groundwater quality information and the fact that other land use and hydrogeological factors are also affecting nitrate concentrations, it is challenging to confidently identify a specific nitrate source for specific wells, especially deeper, larger pumping wells.

The analysis used in this report included statistical models to understand how multiple land uses and hydrogeological variables simultaneously impact groundwater nitrate concentrations. The statistical models both indicate that OWTS density is significantly positively correlated with nitrate concentration. The results of the statistical model indicate that for an area with an OWTS density of 425 OWTS per square mile (unit/mi^2) (such as near the Town of Santa Ynez or the Janin Acres subdivision), OWTS are expected to contribute between 5 and 7 milligrams per liter (mg/L) of nitrate as nitrogen (nitrate as N). When accounting for the other statistically significant predictors of nitrate concentration (such as recharge rates, proximity to agricultural lands, or, depth to groundwater) the predicted resultant nitrate concentration is even higher. It should be noted that, although the results of the statistical models are highly significant ($p<<0.05$), the correlation coefficients are small ($R^2 = 0.27$ and 0.35), which indicates the models only account for a small portion of the variability in nitrate concentration. It is also important to recognize that in small areas (~1/4 mi^2) around the town of Los Olivos, lot sizes are as small as 1/10 of an acre and there are 300 or more OWTS in a ¼ mi^2 area. In this area, OWTS impacts to shallow groundwater may be far greater than predicted by the statistical model.

Future investigations of OWTS impacts should focus on sampling for unique identifiers of OWTS effluent, such as nitrogen (N) and oxygen (O) isotopes of nitrate, pharmaceutical compounds, or organic compounds such as caffeine, artificial sweeteners, or nicotine. Monitoring wells with shallower and shorter wells screens would be helpful for isolating sampling depth and helping to more confidently identify a pollutant source. Finally, numerical groundwater modeling may also be a useful tool for simulating loading of wastewater from OWTS to groundwater.

Santa Barbara County Groundwater Characterization Project: Santa Ynez River Valley Groundwater Basin

1. Introduction

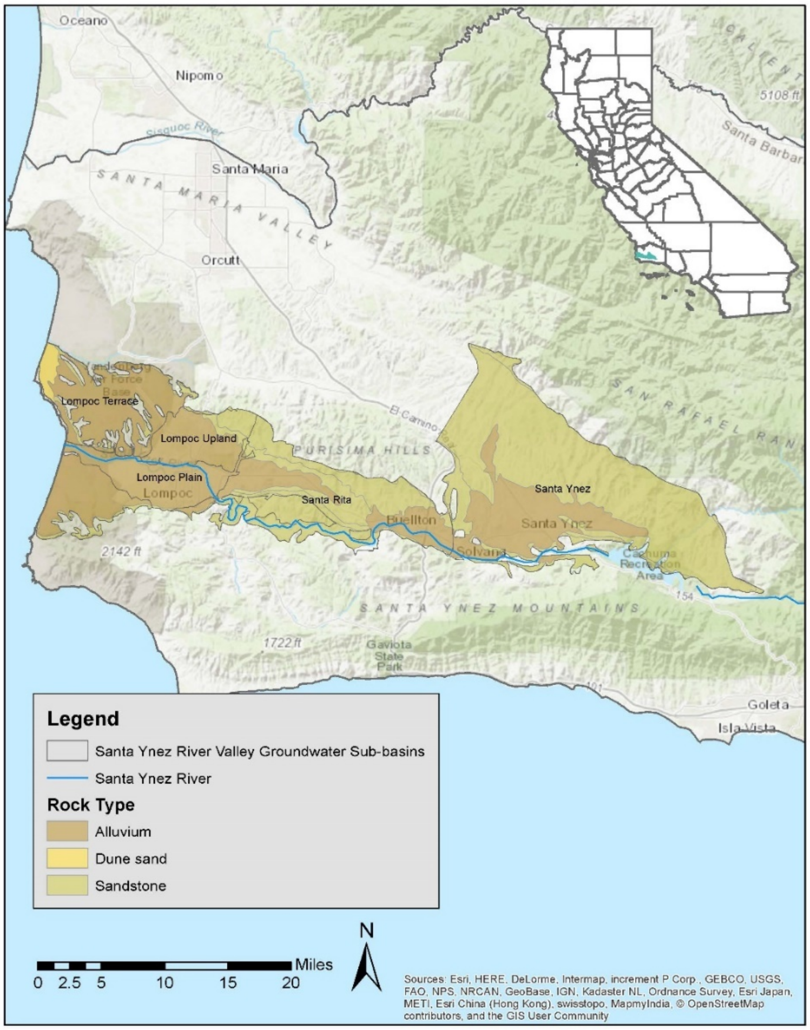
In rural areas not served by municipal wastewater treatment facilities, wastewater is disposed where it is created via onsite wastewater treatment systems (OWTS). Often, these rural areas also supply drinking water from private domestic wells or small drinking water systems (wells serving 5 – 14 service connections). The co-occurrence of OWTS and water supply wells in rural areas poses a threat to human health as effluent from OWTS can pollute nearby drinking water supply wells. The first chapter of this report includes a map of OWTS densities in the SYRV basin and describes the potential risk posed by OWTS to groundwater. Chapter 2 provides an overview of water quality for select chemical constituents in each of the five subbasins that make up the greater SYRV basin. A comparison of the available water quality data to drinking water standards provides context for which to compare water quality among the subbasins. The third chapter of this report includes an evaluation of existing groundwater quality data in the Santa Ynez subbasin to understand whether groundwater may already be polluted by OWTS. The Santa Ynez subbasin is chosen for this additional in-depth analysis because of both the high density of OWTS that occur in some parts of the subbasin and due to the reliance on groundwater for drinking water supply. Additionally, a substantial number of wells within the Santa Ynez subbasin are privately-owned domestic wells and are unregulated with respect to drinking water quality standards. As such, users of these privately-owned wells may be at risk of unknowingly drinking groundwater polluted by OWTS. This report builds on previous studies of OWTS impacts in the basin (Hantzsche, 2003) by adding additional data and providing a more current assessment of water quality conditions. This report does not attempt to evaluate the impact of a single OWTS, but rather the cumulative impacts of all OWTS in a particular area. The evaluation of impacts to water quality to ensure protection of drinking water sources as summarized in this report is consistent with the objectives of the following Central Coast Water Board resolutions:

- Human Right to Water as a Core Value and Directing Its Implementation in Central Coast Water Board Programs and Activities (Res. No. R3-2017-0004),
- Central Coast Groundwater Assessment Program (GAP) Program (Res. No. R3-2012-0024),
- Santa Barbara County Local Agency Management Program (LAMP) (Res. No. R3-2015-0037).

The objectives of this report are the following: (1) conduct a risk assessment of groundwater pollution by OWTS for the entire basin, (2) assess and characterize groundwater quality for each of the five subbasins, (3) further evaluate the impacts of OWTS on groundwater quality within the Santa Ynez subbasin, and (4) identify domestic wells with potential impacts that exceed drinking water standards.

I. Study Area

The SYRV groundwater basin is located in the Santa Barbara County South Coast Ranges, extending from the Cachuma Reservoir along the Santa Ynez River to the Pacific Ocean at the westernmost border. Within the greater SYRV basin, five subbasins are delineated by variations in aquifer materials and hydrogeologic properties. The five groundwater subbasin boundaries are shown in Figure 1, as defined by the Department of Water Resources Bulletin 118 and as described in the Water Quality Control Plan for the Central Coast Basin (Basin Plan).[1] Table 1 lists sources of recharge to groundwater, surficial geologic formations and thickness, and primary water-bearing formations and thickness. The geological and hydrogeological characteristics of each of the five subbasins is further described in Chapter 2.



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 1. Santa Ynez River Valley Groundwater subbasin boundaries.

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[1] https://www.waterboards.ca.gov/centralcoast/publications_forms/publications/basin_plan/docs2017/2017_basin_plan_r3_complete.pdf

Table 1. Santa Ynez River Valley Groundwater subbasin Descriptions (Bright 1992, Hamlin, 1985, & Miller, 1976).

Subbasin	Sources of Recharge	Surficial Geologic Formation and thickness	Primary Geologic Formation and thickness
Santa Ynez	Precipitation, underflow from Santa Ynez River and streams, domestic wastewater from septic systems, percolation from wastewater ponds, irrigation	Terrace and alluvial deposits (0-150 feet)	Paso Robles Formation (0-700 feet)
Santa Rita	Precipitation, underflow from Santa Ynez River and streams, irrigation, percolation from wastewater ponds	Terrace and alluvial deposits (0-150 feet)	Paso Robles Formation (0-700 feet) Careaga Sand (450- 1,000 feet) Orcutt Sand (<200 feet)
Lompoc Plain	Precipitation, underflow from Lompoc Upland subbasin, irrigation, City of Lompoc municipal wastewater discharge, and percolation from wastewater ponds at Mission Hills	Upper Alluvium (0- 150 feet) Alluvium (0- 90 feet)	Terrace deposits (0-50 feet)
Lompoc Upland	Precipitation from northern mountain ranges, irrigation, and military wastewater	Terrace and alluvial deposits (0-150 feet)	Orcutt Sand (0-300 feet) Paso Robles Formation (0-350 feet) Careaga Sand (0-450 feet)
Lompoc Terrace	Precipitation, military wastewater, sea water intrusion	Terrace deposits (0-150 feet)	Orcutt Sand (0-300 feet) Careaga San (0-500 feet)

2. OWTS Risk Assessment

I. Introduction

In order to identify areas that may be especially vulnerable to pollution from OWTS and to prioritize subbasins for further investigation, the location and density of OWTS in the SYRV groundwater basin were mapped and a model was created that could provide a risk rating of potential OWTS groundwater pollution. The model results represent *potential* cumulative impacts to the uppermost portion of the aquifer due to OWTS for a given area. Results are meant to be a screening-level tool that helps prioritize areas for more detailed analysis of site conditions and water quality data. The model is GIS-based and was developed by overlaying different geospatial layers representing factors that influence the potential for groundwater pollution. This risk model is based on the U.S. Environmental Protection Agency's (USEPA) DRASTIC system, which is an approach for identifying areas that are of greatest risk for groundwater pollution (Aller, 1985). DRASTIC is an acronym for hydrogeologic factors that affect groundwater pollution susceptibility. The factors that make up DRASTIC are as follows:

D – depth to water
R – recharge
A – aquifer media
S – soil media
T – topography (slope)
I – impact of the unsaturated (vadose) zone
C – hydraulic conductivity of the aquifer

Each of the above factors is assigned a rating and a weight that is based on the relative contribution to the risk. Guidelines for appropriate ratings and weights are included in the original DRASTIC publication. The ratings and weights for each factor are multiplied together then summed with the product of each other factor's weight and rating using the equation:

$$\text{Pollution potential} = D_r{*}D_w + R_r{*}R_w + A_r{*}A_w + S_r{*}S_w + T_r{*}T_w + I_r{*}I_w + C_r{*}C_w$$

Where the subscript:

r = the parameter rating
w = the parameter weight

This study utilized the DRASTIC approach by creating geospatial layers for each of the above parameters then overlaying the layers to create a pollution potential map. There have been a variety of investigations that utilized and improved upon DRASTIC; these improvements were incorporated into this study and are described below. For this study, three important modifications were made to the DRASTIC approach. First, aquifer hydraulic conductivity was not incorporated in this assessment due to the lack of data for all of the aquifer locations within the SYRV basin. However, the parameters that are chosen to be included in these types of models are flexible, as long as all parts of the study area receive the same number of model inputs (i.e., consistently applied). Second, OWTS density was added as an additional risk factor to this model so that pollution potential maps could be created specific to risks posed by OWTS. Third, the weight of the some of the parameters was reduced from that described in the original

DRASTIC publication in order to account for data scarcity for a particular parameter. Reducing the weight is an approach for accounting for the uncertainty associated with a data-poor parameter and results in the parameter having a lower impact on the final risk model. The data used for each of the parameters is described briefly below and the risk values and weights for each parameter are shown in Table 6 of Appendix A. The final model results were mapped to 100 x 100 meter cell sizes.

II. OWTS Risk Assessment Methods

OWTS Density

OWTS density is the most important factor affecting the potential for OWTS systems to impact groundwater quality. A single OWTS system is expected to only pose a small risk to the environment because the discharging effluent can effectively be diluted by the receiving groundwater prior to the effluent reaching a receptor of concern. However, as the number of OWTS per unit area increases, the potential cumulative impacts of those OWTS increases as well.

The USEPA has designated areas with an OWTS density greater than 40 unit/mi^2 as areas of potential groundwater pollution. A 1977 study by the USEPA identified three density ranges (Yates, 1985):

- Less than 10 units/mi^2 as low density
- 10 to 40 units/mi^2 as medium density
- Greater than 40 units/mi^2 as high density

In order to calculate OWTS density, the locations of OWTS in the SYRV basin were first mapped. A Santa Barbara County Department of Environmental Health database of OTWS systems was used to map many of the systems in the basin. However, because the county's database doesn't have information for every parcel, presence and location of OWTS not included in the county database were estimated for some areas. This estimation was accomplished using Santa Barbara County Assessor Parcel Number (APN) databases and information on the location of municipal sewer services. In essence, it was assumed that parcels not served by municipal sewers had an OWTS. Parcels with land use designations that suggested the presence of an OWTS were unlikely (e.g. pasture/graze, beaches/dune, etc.) were not included.

To calculate OWTS density, the GIS ArcMap tool *point density* was used with a circular search radius of 0.56 mi ($\pi * 0.56^2 \approx 1$ mi^2). This density was mapped to a raster layer with 100 x 100 meter resolution. The calculated densities were then used to assign risk ratings based on the USEPA guidelines described above. The OWTS density raster layer was separated into eight classes:

- 0 OWTS units/mi^2
- 1 – 10 OWTS units/mi^2
- 11 – 40 OWTS units/mi^2
- 41 – 100 OWTS units/mi^2
- 100 - 200 OWTS units/mi^2
- 200 - 300 OWTS units/mi^2

- 300 - 400 OWTS units/mi^2
- >400 OWTS units/mi^2

The risk ratings assigned to density ranges above are shown in Table 6 of Appendix A and a map of OWTS density in the SYRV basin is shown in Figure 2.

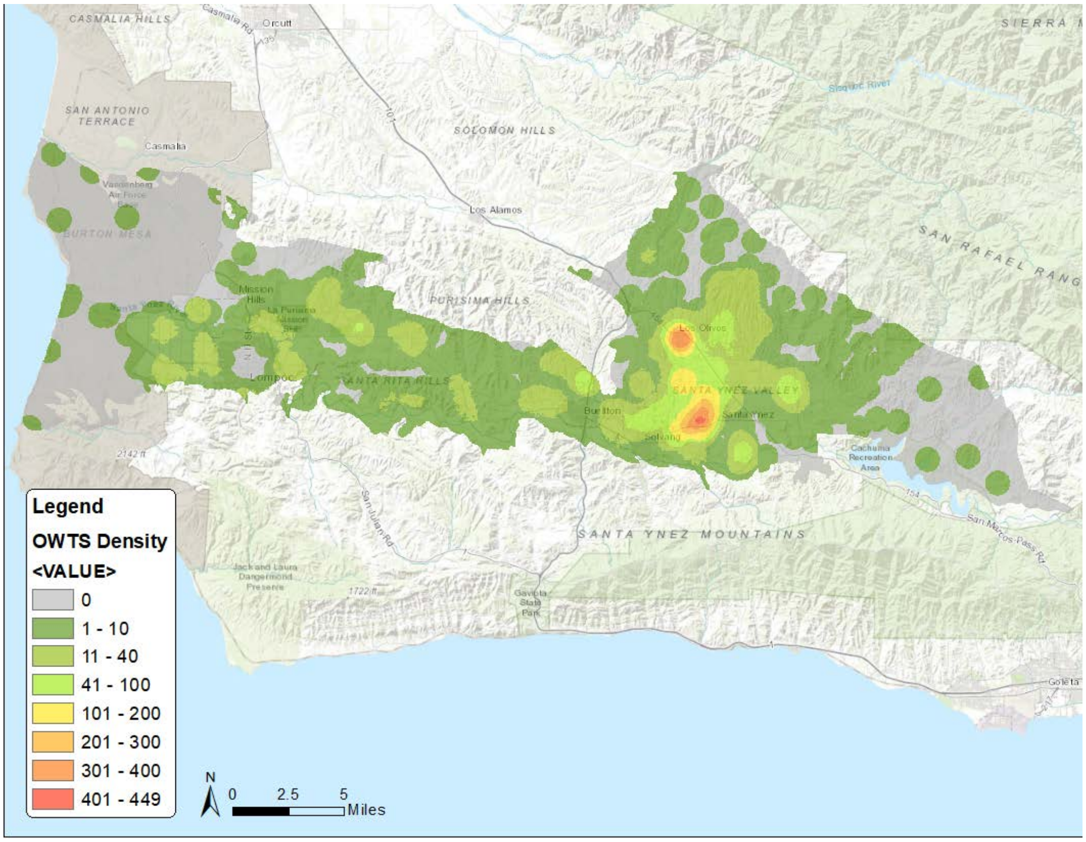

Figure 2. OWTS density in the Santa Ynez River Valley groundwater basin.

Depth to Groundwater

Groundwater depths were measured by the California Department of Water Resources (DWR) in Spring of 2018 and the data was downloaded from the DWR's Groundwater Information Center Interactive Map Application (https://gis.water.ca.gov/app/gicima/). DWR has 54 wells with groundwater elevations spread throughout the SYRV basin. These discrete points were interpolated to a continuous surface using ordinary kriging and a gaussian semivariogram model. To improve the krigged surface results, 16 additional data points representing groundwater depths of 0 feet below ground surface (bgs) were added at locations where the groundwater surface and land surface are known to intersect, such as the Santa Ynez River and the coastline.

Recharge

For the purposes of this study, recharge only includes precipitation-driven recharge and ignores recharge from irrigation return flows, surface water bodies such as the Santa Ynez river, or other sources. The basis for excluding these additional recharge sources in this risk model is that the risk posed by recharge is represented by the ability to drive wastewater discharging from an OWTS leachfield through the unsaturated zone to the groundwater table. With the case of OWTS, the leachfields associated with these systems typically aren't located in a river or stream channel or in the middle of an irrigated agricultural field and as such, these types of recharge aren't relevant to the risk model. The primary means by which OTWS effluent will be discharged to groundwater is via precipitation-driven recharge percolating through the unsaturated zone.

Recharge data calculated by the U.S. Geological Survey's 2014 California Basin Characterization Model Downscaled Climate and Hydrology - 30 Year Summaries (Flint & Flint, 2014) was used in this model. The recharge dataset produced by this report represents the average recharge based on monthly precipitation data collected over a 30 year period between 1981 and 2010. The raster dataset of recharge rates was developed at 270 meter spatial resolution. This report did not include an evaluation of the potential future impacts from climate change on recharge.

Aquifer Media

The geologic units and hydrogeologic properties of the five subbasins that comprise the greater SYRV basin are described by Upson and Thomasson (1951), Miller (1976), Hamlin (1985), DWR Bulletin 118 (2003), and by the Santa Barbara County Water Agency (SBCWA, 2012, 2014). Aquifer media information and descriptions were evaluated to assign a risk rating to each of the five subbasins. The original DRASTIC publication has nine classes of aquifer media to choose from and all of the subbasins within the larger SYRV basin fall under either the *Massive Sandstone* or *Sand and Gravel* categories from DRASTIC. Within these categories, there is a range of ratings that could be applied; for this study, the rating was chosen after discussion with geologists at the Central Coast Water Board who had overseen geologic investigations in these basins. A single risk rating was applied to the entire area delineated by a particular subbasin. The reasoning for this is that the five subbasins are delineated primarily by differences in lithology of the water-bearing formations. At coarse resolution, each subbasin is comprised of relatively homogenous material. Typically, the DRASTIC recommends a weighting factor of three for the aquifer media parameter. However, given that the aquifer media was mapped at a relatively coarse scale (subbasin scale) the weight was reduced to two to account for spatial uncertainty.

Soil Media

Soil media risk ratings were assigned using the Natural Resources Conservation District's SSURGO soil survey database (NRCS, 2014). This database contains geospatial information on soil types and soil properties. There are a variety of different SSURGO soil properties databases that could potentially be used but for this study the soil property *Drainage Class* was used as the measure of risk that OWTS poses to groundwater. The choice to use *Drainage Class* was based on the recommendation of Ruper et al. (1999) that investigated the effectiveness of the different SSURGO soil classes for predicting groundwater pollution in a DRASTIC-type risk assessment.

Topography (slope)

Slope can be an important parameter because effluent discharging from leachfields on flatter slopes has a greater chance of percolating to groundwater, while steeper slopes are more conducive to surface runoff. Percent slope was determined using a 10 meter Digital Elevation Model (USGS, 2013).

Impact of Unsaturated Zone

Within the DRASTIC framework, the impact of the unsaturated zone is a function of the types of geologic materials present. For this study, surficial geologic materials were assumed to provide a good approximation of the material that comprises the unsaturated zone. Surficial geology (and by proxy, geologic material making up the unsaturated zone) was identified using a U.S. Geological Survey digital geologic map (Ludington et al., 2005). This map was compiled from an existing digital state map at a scale of 1:750,000. DRASTIC recommends a weighting of five for the Impact of the Unsaturated Zone. However, given the coarse scale of the geologic map and the scarcity of information regarding the composition of the unsaturated zone in the SYRV basin, the weight of this parameter was reduced to three to offset the uncertainty.

III. OWTS Risk Assessment Results and Discussion

The highest OWTS densities and highest risk of OWTS groundwater pollution occur in a north-south transect between the town of Los Olivos and the Janin Acres subdivision (Figure 2 andFigure 3). The OWTS density map shows that the highest densities occur near the towns of Los Olivos, Santa Ynez, and Janin Acres subdivision. Although much of the town of Santa Ynez has been connected to sewers, high OWTS densities still exist outside of the sewered areas. The map of OWTS groundwater pollution risk highlights the Janin acres subdivision as the highest risk area in the entire SYRV basin. The combination of high OWTS density and relatively shallow depth to groundwater are the primary factors driving this high risk score in Janin Acres. In the risk map there are some areas that are not assigned a risk score, this is because either there were no identified OWTS within a one square mile area or one of the data inputs to the risk model was missing (typically soil media). The risk map also highlights other areas of high potential risk of groundwater pollution, such as along the Santa Ynez River and in the Lompoc Plain. Although OWTS densities are generally low in these areas, groundwater is shallow and therefore a low density of OWTS can still pose a risk. However, it is important to acknowledge that groundwater near the banks of the Santa Ynez River are shallow but groundwater beneath the banks is being nearly constantly recharged and diluted by Santa Ynez River water and as a result, groundwater quality near the river is typically good. In the Lompoc Plain, where groundwater is shallow but dilution by the Santa Ynez River is less prevalent, groundwater quality can be poor, particularly for nitrate. Although intensive commercial agriculture that occurs in the Lompoc Plain is almost certainly a source of nitrate in groundwater, these results suggests that OWTS in the Lompoc Plain may also be contributing to the nitrate problem in that area.

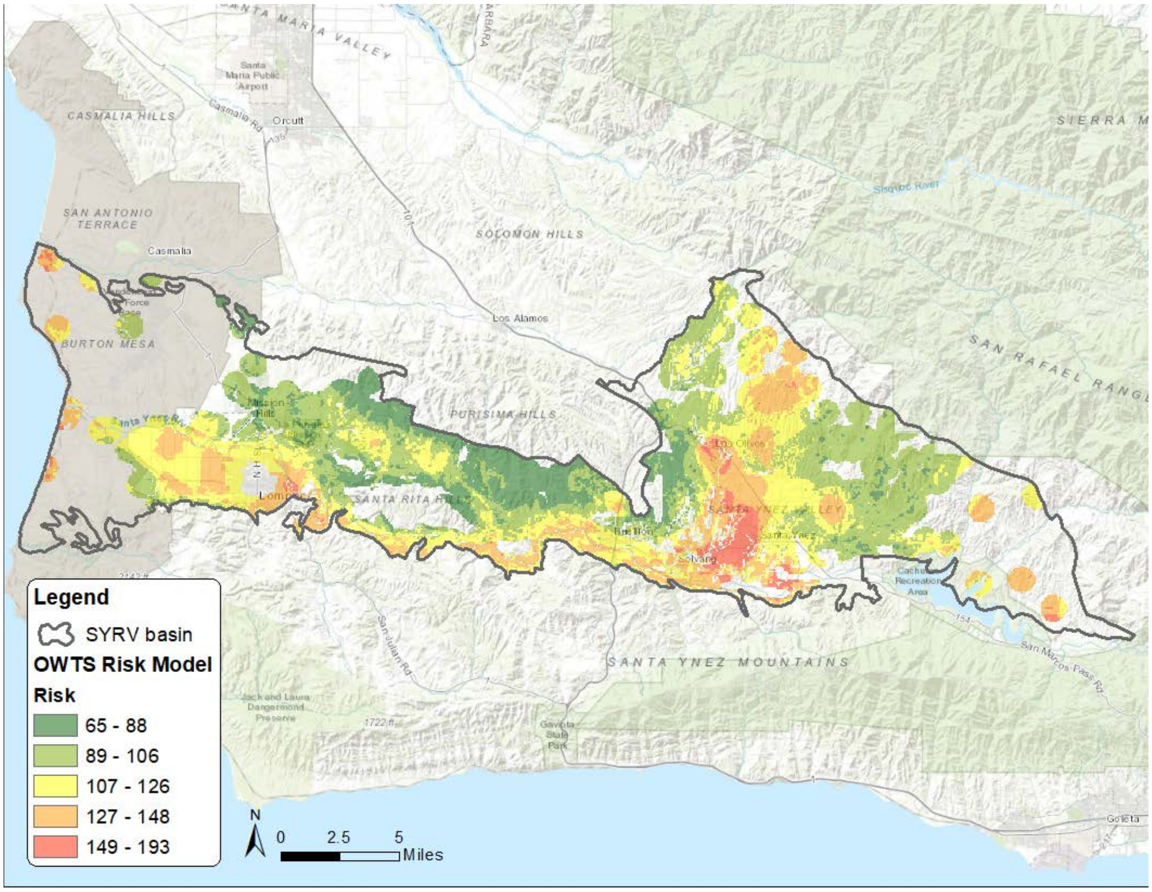

Figure 3. Risk of groundwater pollution by OWTS in the Santa Ynez River Valley groundwater basin.

3. Groundwater Quality Overview

I. Groundwater Quality Overview Introduction

This Chapter includes results from a general statistical analysis of available groundwater quality data from the five subbasins within the SYRV basin. The intent of this analysis is to generally identify the pollutants of potential concern in each subbasin, the general depth where groundwater is impacted, how concentrations in individual wells are changing over time, which wells are considered impaired by a particular pollutant, and the location and number of domestic wells that may be at risk of impairment by a particular pollutant. Data for this analysis was compiled from the State Water Board’s GeoTracker GAMA webpage and from laboratory sheets and supporting documents for wells associated with Central Coast Water Board Waste Discharge Requirement (WDR) permitted facilities. In total, this analyses includes a review of approximately 16,400 groundwater samples from 2,091 wells in the SYRV groundwater basin.

II. Groundwater Quality Overview Methods

Pollutants of Concern, Benchmarks, and Objectives

Pollutants of concern were identified by first documenting prevalent land use practices that might be expected to impair groundwater quality then determining what pollutants might be expected to be loaded to groundwater from the various practices. Drinking water standards are established for public water systems by the USEPA and State Water Board Division of Drinking Water (DDW). Additionally, groundwater quality objectives are listed for regional groundwater basins and subbasins in Table 3-6 of the Water Quality Control Plan for the Central Coast Basin (Basin Plan). These Basin Plan groundwater quality objectives establish median concentrations to preserve local groundwater quality and beneficial uses and can be lower than the drinking water standards. Beneficial uses are specific uses of groundwater and surface water that are a benefit to the people of the State and are identified in the Basin Plan (e.g., domestic and municipal use, agricultural, recreational, aquatic habitats, etc.). The analysis was primarily focused on pollutants with water quality data that exceeded the detection limit and those pollutants of concern for drinking water purposes. For example, waterborne pathogens pose a severe threat to human health but there is little data available on pathogen occurrence in groundwater in the SYRV basin and as such pathogens were not a focus of this analysis.

Based on the prioritization described above, seven inorganic pollutants of concern were identified. These included arsenic, hexavalent chromium, iron, manganese, nitrate, sulfate, and total dissolved solids (TDS). Table 2 lists the pollutants selected with their respective drinking water standards including the Maximum Contaminant Level (MCL) and/or Secondary Maximum Contaminant Level (SMCL), Notification Level (NL), and also the potential sources of these pollutants. Table 3 lists pollutants with median groundwater quality objectives per subbasin in the Santa Ynez River Valley (CCWB, 2017). Throughout this report, nitrate will be reported as nitrate as nitrogen (MCL = 10 mg/L).

Table 2. Pollutants of concern and respective benchmarks for drinking water.

Pollutant	MCL[2]	SMCL[3]	NL[4]	Units[5]	Potential Sources
Arsenic	10	-	-	µg/L	Erosion of natural deposits, runoff from orchards, glass and electronic productions wastes
Hexavalent Chromium[6]	10	-	1	µg/L	Discharge from electroplating factories, leather tanneries, wood preservations, chemical synthesis, refractory productions, and textile manufacturing facilities; erosion of natural deposits
Iron	-	300	-	µg/L	Leaching from natural deposits; industrial waste, mining waste
Manganese	-	50	500	µg/L	Erosion of natural deposits
Nitrate as N	10	-	-	mg/L	Runoff & leaching from fertilizer use, sewage; erosion of natural deposits
Sulfate	-	500	-	mg/L	Runoff/leaching from natural deposits; industrial wastes
TDS	-	1,000	-	mg/L	Runoff/leaching from natural deposits, agricultural practices

Table 3. Groundwater quality objectives from the Basin Plan for Central Coast groundwater subbasins in the Santa Ynez River Valley.

Subbasin name	Total Dissolved Solids (mg/L)	Sulfate (mg/L)	Nitrogen (mg/L as N)
Santa Ynez	600	10	1
Santa Rita	1,500	700	1
Lompoc Plain	1,250	500	2
Lompoc Upland	600	100	2
Lompoc Terrace	750	100	1

Groundwater Data

Groundwater quality data were retrieved and compiled from two sources: (1) GeoTracker GAMA and (2) Central Coast Water Quality Control Board WDR groundwater monitoring reports. The following sections discusses each data source.

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[2] Regulatory, health-based DDW and USEPA maximum contaminant levels (MCL)

[3] Non-regulatory, non-health based DDW and USEPA secondary maximum contaminant levels (SMCL).

[4] Non-regulatory, health-based DDW notification levels (NL).

[5] µg/L = micrograms per liter; mg/L = milligrams per liter

[6] In May 2017, the MCL for hexavalent chromium was invalidated by the Superior Court of Sacramento County. However, this report uses the previous MCL of 10 micrograms per liter (µg/L) for analysis as a precaution to future validation.

GeoTracker GAMA

The State Water Board's GeoTracker GAMA website was used to acquire groundwater pollutant concentration data and/or well construction data from public water systems[7], Central Coast Water Board monitoring wells (including irrigated land operations), and United States Geologic Survey National Water Information System wells. Table 4 lists the number of wells available from each dataset within the Santa Ynez River Valley.

Table 4. Number of wells from each GeoTracker GAMA dataset in the Santa Ynez River Valley.

Dataset	Number of wells
Irrigated Agriculture	294
Public Water System	115
Water Board Monitoring Wells	1,076
USGS NWIS	606
TOTAL	2,091

Central Coast Water Board Waste Discharge Requirement (WDR) facilities documents

The Central Coast Water Board regulates all waste discharges to land through the Waste Discharge Requirement (WDR) program. WDR regulated facilities include wastewater treatment plants (WWTP), wineries, and other facilities where wastewater is treated and subsequently discharged to land through various pathways including percolation ponds, septic systems, and irrigation. Groundwater monitoring data from 30 wells associated with WDR facilities are reported to the Central Coast Water Board on a quarterly, semiannual, or annual basis to document any potential impacts of their wastewater discharge to underlying groundwater. Though this data has been recorded and monitored, the information is not currently linked to the GeoTracker GAMA groundwater data management system. Therefore, the Heal the Ocean intern compiled groundwater data from laboratory sheets, monitoring reports, and technical reports, and incorporated these WDR groundwater monitoring data to the groundwater characterization project. The WDR groundwater monitoring dataset was compiled with the GeoTracker GAMA groundwater dataset in order to analyze groundwater quality for the five subbasins. Well construction data were also compiled to evaluate the depth where the water quality concentration data was collected.

Well Construction Data

Well construction data helps identify the vertical location (i.e., depth) that a groundwater sample was collected from within an aquifer. This information is important because groundwater chemical composition often exhibits substantial variability with depth. In addition, private domestic wells are typically drilled to shallower depths and so distinguishing between shallow and deep groundwater quality can provide insight into domestic well water quality. Throughout

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[7] A public water system is a system that provides water for human consumption to 15 or more connections or regularly serves 25 or more people daily for at least 60 days out of the year.

this report, water quality data is separated into two arbitrarily assigned depths; 200 feet or less below ground surface (bgs) and greater than 200 feet bgs. The choice to use 200 feet as the separation between the shallower and deeper aquifer is arbitrary but is used as a means to separate water quality data as a function of depth.

Well construction data compiled from Department of Water Resources well completion reports were retrieved from GeoTracker GAMA. This data includes total well depth, screened intervals, depth to groundwater, and intended well use. Groundwater quality data were matched with well completion reports using well information including the location within the Public Land Survey System grid, well owner, and well name.

Assessment of Groundwater Quality, Impairment, and Trends

Groundwater Quality Assessment

To conduct a general analysis of groundwater quality, standard statistical analyses were utilized to evaluate pollutant concentrations by groundwater subbasin and an arbitrarily identified aquifer depth (less than 200 feet bgs and greater than 200 feet bgs) within the Santa Ynez River Valley. A significant proportion of groundwater pollutant concentrations were below laboratory detection levels and reported as non-detects or censored[8] values. In order to accommodate for censored data, summary statistics were calculated using the Regression on Order statistic (ROS function in R) from the NADA package in the R Statistical Computing Software[9]. This function considers censored values in the dataset to prevent analysis bias and skewed results. Results from statistical analyses are summarized by pollutant, subbasin, and aquifer depth in Table 10 through Table 12.

Well Impairment

The 303(d) Listing Policy[10] is a State policy for establishing a standardized approach for developing a list of impaired water bodies as required by section 303(d) of the federal Clean Water Act. The approach identified in the Listing Policy was used here to identify wells that are considered impaired. Briefly, the Listing Policy defines waterbody impairment using a binomial distribution where the number of exceedances relative to the total number of samples determines the respective impairment. The policy provides guidance for interpreting data using a weight of evidence approach as described in further detail below. This method was considered to be the most appropriate approach for individual wells as opposed to an entire groundwater basin or subbasin.

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[8] Censored data is data in which the true value of a measurement is only partially known. For water quality data, censored data is a sample whose concentration is below the laboratory detection limit and therefore has a true concentration somewhere between 0 and the detection limit.

[9] R is a free software environment for statistical computing and graphics developed by the Department of Statistics of the University of Auckland in Auckland, New Zealand, https://www.r-project.org/

[10] 303(d) Listing Policy: https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2015/020315_8_amendment_clean_version.pdf

Weight-of-Evidence Approach

Groundwater quality data were analyzed using a weight-of-evidence approach. This approach is used to evaluate whether the evidence is in favor of or against designating an individual well as impaired. All data and information are evaluated using the following decision rules:

1) For a particular chemical constituent, evaluate the number of exceedances relative to the sample size to determine if a water segment needs to be placed on the 303(d) list, or in this case, whether a well is determined to be polluted. The exceedance proportion for conventional pollutants (iron, manganese, nitrate, sulfate, and TDS) is shown in Table 8; the proportions for toxicants (arsenic, hexavalent chromium) are shown Table 9.
2) Determine the exceedance proportion for a well.
3) If the number of measured exceedances supports rejection of the null hypothesis as presented in Table 8 and Table 9 (Appendix A), then the well is determined to be impaired.

Trends in Pollutant Concentration over Time

In order to understand how groundwater quality is changing through time in a single well a statistical trend analysis was conducted. These types of tests can determine if a groundwater chemical constituent exhibits statistically significant changes in concentration through time and provides an estimate of the rate of change. The utility of this approach is that it removes the person-to-person subjectivity associated with interpreting time-series data; the statistical test determines if the change is statistically significant and how quickly change is occurring. To do this analysis, the *cenken*[11] function in the NADA package of the R Statistical Computing Software was utilized to evaluate trends. *Cenken* is similar to the widely used Mann-Kendall test of monotonic trend, except that *cenken* incorporates censored data in a statistically defensible manner. The statistical test requires a minimum of five samples and no more than 80 percent censored values. Typically, wells that meet these criteria are municipal production wells that have long term water quality sampling records. These wells are often screened deeper than domestic wells and are typically located in more densely populated urban areas. Therefore, the results of the trend analysis included in this report is biased towards deeper groundwater located in more densely populated areas. Results from the trend analysis are summarized in Table 15 through Table 18.

Identifying Domestic Wells with Potential Pollution

After identifying impaired wells and wells with increasing trends, an analysis was conducted to identify nearby domestic wells within the same Public Land Survey System section (1 mi^2) that may also be at risk for potential pollution. Where data were available, well location and well screen depth were used to identify whether the domestic wells were screened at similar depths as the impaired wells. This approach allowed for a better understanding whether domestic water supply wells may be at risk of pollution. In addition, this analysis provides information to Water Board programs that sample domestic wells (e.g., Groundwater Assessment and Protection

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[11] The *cenken* function is included in the *NADA* package for the R Statistical Computing Language: https://cran.r-project.org/web/packages/NADA/NADA.pdf

Program (GAP)) about the likelihood that domestic wells in a particular area that may be impacted by a pollutant.

III. Groundwater Quality Overview Results and Discussion

Analysis of groundwater data collected within the SYRV basin included 16,400 groundwater samples from 2,901 different wells sampled between May 5, 1924 and February 8, 2018. The median number of samples per well was eight. Groundwater data were divided by well depth with approximately 641 wells less than 200 feet bgs and 244 wells greater than 200 feet bgs. The following sections include a summary of the seven pollutants of concern, grouped by the five groundwater subbasins. Summary data for each pollutant for each subbasin are shown in Tables 10 through 18 in Appendix A and box-and-whisker plots are shown in Figures 13 through 19 in Appendix B. Maps displaying individual well locations, median concentrations, significant trends, impaired wells, and the number of domestic wells at risk are shown in Figures 20 through 34 of Appendix C.

Lompoc Plain Subbasin

The Lompoc Plain subbasin is composed of alluvial and terrace deposits of Holocene age overlying the Paso Robles Formation of Pliocene to Pleistocene age. Alluvial and terrace deposits are stratified of fine and coarse sands, silt, clay, and gravel layers. The Paso Robles formation is composed of fine to coarse sand, silt, and clay of alluvial origin (Bright et al., 1992). Sources of groundwater recharge include underflow from the Lompoc Upland subbasin, underflow from the Santa Ynez River, irrigation, precipitation, City of Lompoc municipal wastewater discharge, and percolation from wastewater ponds at the Mission Hills Wastewater treatment plant.

Approximately 385 wells were analyzed in the Lompoc Plain subbasin. Of those wells, 229 wells are less than 200 feet bgs, 19 are greater than 200 feet bgs, and 137 wells have unknown depth. Mean well depth is 131 feet bgs. The median number of samples per well for this subbasin is six samples. The Lompoc Plain subbasin boundary is outlined in the map below based on USGS groundwater reports (Bright et al.,1992) (Figure 4).

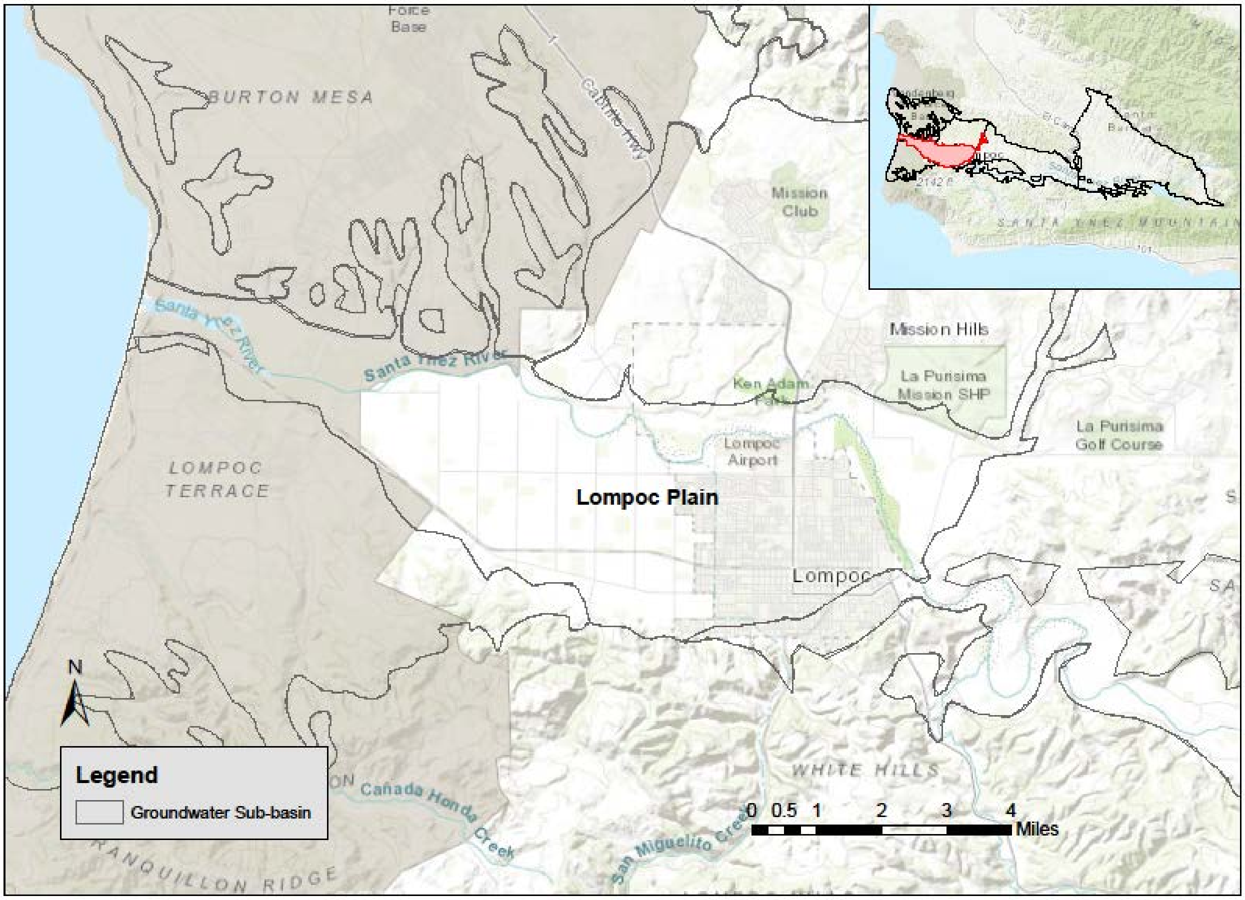

Figure 4. Lompoc Plain groundwater subbasin boundary.

Results: Concentration Summary[12], Exceedance/Impairment[13], Trends[14], and Potential Pollution Sources

Arsenic

- Fifty wells with 448 samples have a median arsenic concentration of 4 µg/L. Analysis of wells grouped by depth indicate higher concentrations in the shallow aquifer wells with a median concentration of 7 µg/L.

- The maximum arsenic concentration was sampled from a well greater than 200 feet bgs at 44 µg/L. Approximately 26% of wells and 18% of samples exceed the primary MCL of 10 µg/L. Arsenic impairment is listed for 18% of the total wells and 10% of wells sampled for arsenic that are screened less than 200 feet bgs.

- Significant increasing arsenic trends were found in five (36%) of the 14 wells that met trend analysis criteria. These wells are increasing in arsenic between 0.13 and 0.58 µg/L per year. One well that is less than 200 feet bgs had a significant decreasing trend.

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[12] Full concentration summary table is found in Tables 10 through 13.

[13] Full impairment summary table is found in Table 14.

[14] Full trend summary table is found in Tables 15 through 18.

Figure 20 displays arsenic concentrations over time for each individual well with increasing arsenic trends.

- Wells exceeding the primary MCL for arsenic are located in three localized areas. The first area contains five shallow public supply wells at the north-eastern part of the basin within the city of Lompoc. The second area contains one monitoring well located at the southern border of the subbasin at a depth that is less than 200 feet bgs. The third area contains a cluster of monitoring wells that are less than 200 feet bgs at the western border of the subbasin (Figure 27).

- The arsenic impaired wells are located within one square mile of approximately 13 domestic wells. Average well depths range from 113 to 177 feet bgs. At least 77% of the domestic wells (10 wells) are at risk of arsenic pollution based on proximity to known arsenic impaired wells with well screens depths less than 200 feet bgs.

Hexavalent Chromium

- Seventeen wells with 46 samples have hexavalent chromium concentrations less than the laboratory detection limit of 0.01 µg/L.

- No well sample concentrations are greater than 10 µg/L.

- No trends were found for hexavalent chromium in the Lompoc Plain subbasin.

- With no exceedances or trends, no additional evaluation of significant sources of hexavalent chromium to the Lompoc Plain were evaluated.

- No wells were impaired for hexavalent chromium in the Lompoc Plain Subbasin and no domestic wells were determined to be at risk.

Iron

- Two hundred twenty-two wells with 1,538 samples have a median iron concentration of 270 µg/L. Analysis of wells grouped by depth indicate higher concentrations in wells that are less than 200 feet bgs with a median iron concentration of 710 µg/L.

- The maximum iron concentration was sampled from a well less than 200 feet bgs at 70,000 µg/L. Approximately 52% of wells and 49% of samples exceed the secondary MCL of 300 µg/L. Iron impairment is listed for 48% of the total wells and 26% of wells sampled for iron that are less than 200 feet bgs.

- Significant decreasing iron trends were found for 18 of the 34 wells (27%) that met the trend analysis criteria (Figure 22). Additionally, increasing trends were found for 16 wells (24%). The number of wells that are less than 200 feet bgs with increasing trends (10%) were greater than decreasing trends (4%).

- The wells exceeding the secondary MCL are distributed across the subbasin in no distinct clusters (Figure 29). The majority of wells in exceedance are part of the USGS NWIS dataset and a few Central Coast Water Board permitted facility monitoring wells screened in shallow wells. Consequences related to high iron concentrations are metallic taste and staining of plumbing fixtures. The public supply wells providing drinking water all had concentrations within the secondary standard of 300 µg/L.

Manganese

- One hundred thirteen wells with 1,241 samples had a median manganese concentration of 540 µg/L. Analysis of wells grouped by depth indicate higher concentrations in the wells that are less than 200 feet bgs with a median manganese concentration of 710 µg/L.

- The maximum manganese concentration was sampled from a well less than 200 feet bgs at 25,000 µg/L. Approximately 96% of wells and 79% of samples exceed the secondary MCL of 50 µg/L. Manganese impairment is listed for 91% of the total wells and 44% for manganese for wells that are less than 200 feet bgs (Figure 30).

- Significant decreasing manganese trends were found in 22 of the 63 wells (35%) that met the trend analysis criteria (Figure 23). Wells in both the less than and greater than 200 feet bgs aquifer depths had decreasing trends.

- The wells exceeding the secondary MCL for manganese are distributed across the Lompoc Plain subbasin. High concentrations are present in wells along the Santa Ynez River. Sources of manganese appear to be of natural geologic origin based on the distribution of the elevated concentrations detected.

Nitrate

- Three hundred ten wells with 2,744 samples have a median nitrate concentration of 0.14 mg/L nitrate as nitrogen. Analysis of wells grouped by depth indicate higher concentrations in the wells that are less than 200 feet bgs with a median nitrate concentration of 0.32 mg/L.

- The maximum nitrate concentration was sampled from a well less than 200 feet bgs at 104 mg/L. Approximately 7% of wells and 4% of samples exceed the primary MCL. Nitrate impairment is listed for 7% of the total wells and 4% of the well that are less than 200 feet bgs.

- Significant increasing nitrate trends were found for 15 of the 68 wells (22%) that met the trend analysis criteria. All wells with increasing trends are less than 200 feet bgs and are part of the USGS NWIS dataset (Figure 24).

- The nitrate impaired wells are located within one square mile of approximately 47 domestic wells. Average well depths range from 60 to 300 feet bgs. All impaired wells are screened wells less than 200 feet bgs. Therefore, at least 53% of domestic wells (25 wells) are at risk of nitrate pollution based on proximity to impaired wells with screens at depths less than 200 feet bgs.

Sulfate

- Four hundred seven wells with 2,868 samples have a median sulfate concentration of 416 mg/L. Analysis of wells grouped by depth indicate higher concentrations in wells that are less than 200 feet bgs with a median sulfate concentration of 405 mg/L.

- The maximum sulfate concentration was sampled from a well less than 200 feet bgs at 4,080 mg/L. Approximately 45% of wells and 31% of samples exceed the secondary MCL of 500 mg/L (Figure 32). Sulfate impairment is listed for 14% of the total wells and 7% of the wells sampled for sulfate that are less than 200 feet bgs.

- Significant decreasing sulfate concentrations were found for 22 of the 109 wells (20%) that met the trend analysis criteria. Approximately 10% of wells that are less than 200 feet bgs had increasing trends.

  The groundwater quality objective for sulfate in the Lompoc Plain is 500 mg/L (same as the secondary MCL). The wells exceeding the groundwater quality objective and SMCL are distributed throughout the subbasin.

Total Dissolved Solids (TDS)

- Four hundred two wells with 3,965 samples have a median TDS concentration of 1,190 mg/L. Analysis of wells grouped by depth indicate higher concentrations in the wells that are less than 200 feet bgs with a median TDS concentration of 1,400 mg/L.

- The maximum TDS concentration was sampled from a well that is less than 200 feet bgs at 24,000 mg/L. Approximately 86% of wells and 61% of samples exceed the secondary MCL of 1,000 mg/L (Figure 33). Total dissolved solids impairment is listed for 35% of wells and 21% of wells sampled for TDS that are less than 200 feet bgs.

- Significant increasing trends were found for 22 of 102 wells (22%) that met the trend analysis criteria (Figure 26). More wells exhibited increasing trends than decreasing trends.

- The groundwater quality objective for TDS in the Lompoc Plain is 1,250 mg/L (secondary MCL is 1,000 mg/L). The wells exceeding the groundwater quality objective and secondary MCL are distributed throughout the subbasin. Elevated concentrations are likely from both natural and anthropogenic sources.

Lompoc Terrace Subbasin

The Lompoc Terrace subbasin is composed of terrace deposits of Pleistocene age overlying the Orcutt Sand formation of Pleistocene age and Careaga Sand formations of Pliocene age. Terrace deposits are stratified with gravel and sands, and silt and clay zones. The Orcutt Sand formation is composed of coarse sand, silt, and clay of fluvial origin. The Careaga Sand formation is composed of medium to coarse sand (Bright et al., 1992). Sources of groundwater recharge include underflow from the Santa Ynez River, discharge of treated wastewater, and precipitation.

Approximately 475 total wells were analyzed in the Lompoc Plain subbasin with 87 wells greater than 200 feet bgs, 268 less than 200 feet bgs, and 120 wells with unknown depths. Mean well depth is 67 feet bgs. The median number of samples per well is 12 for this subbasin. The Lompoc Terrace subbasin boundary is outlined in the map below based on USGS geologic reports (Bright et al.,1992) (Figure 5).

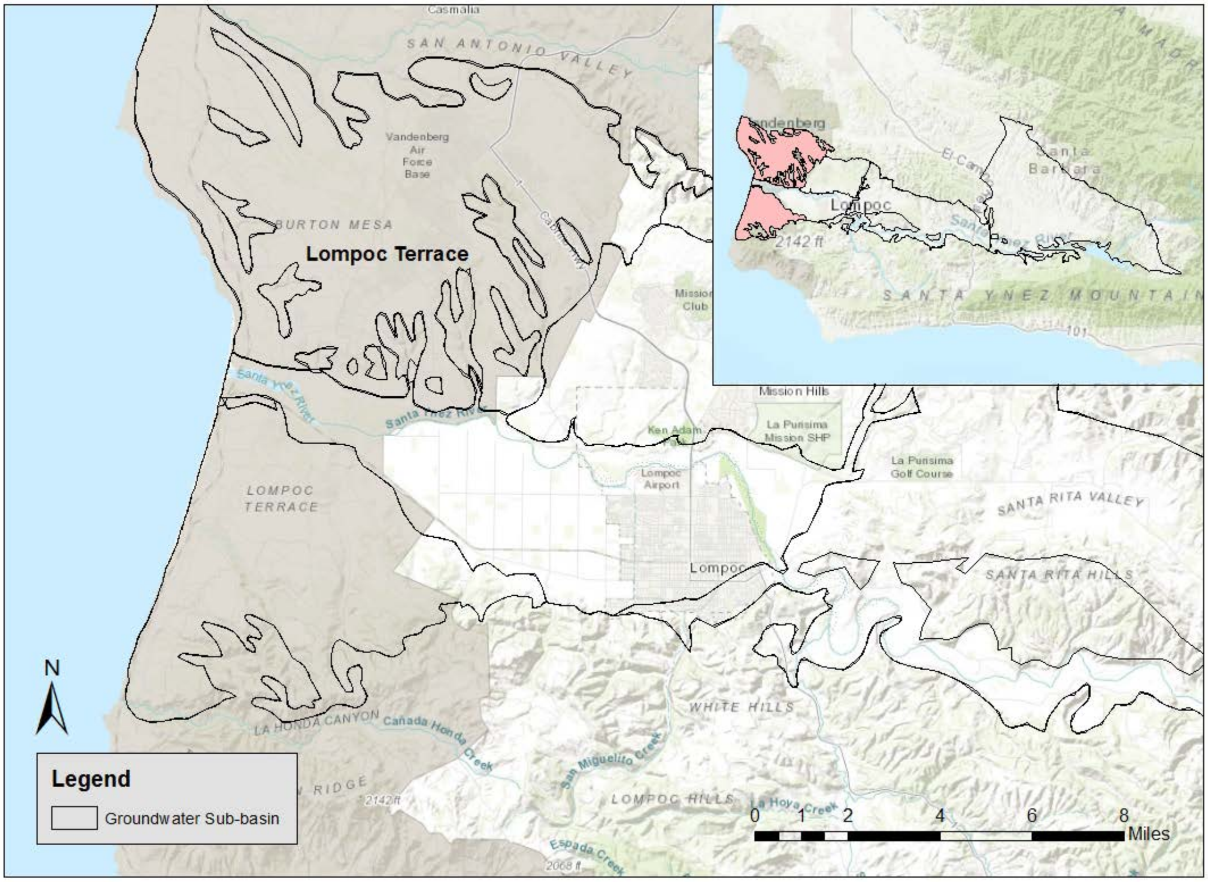

Figure 5. Lompoc Terrace Groundwater Subbasin Boundary.

Results: Concentration Summary, Exceedance/Impairment, Trends, and Potential Pollution Sources

Arsenic

- Two hundred ninety-eight wells with 1,771 samples have a median arsenic concentration of 3.04 µg/L. Analysis of wells grouped by depth indicate a higher median arsenic concentration in the wells that are less than 200 feet bgs at 5 µg/L.

- The maximum arsenic concentration was 2,550 µg/L for a well with an unknown well depth. Approximately 42% of wells and 31% of samples exceed the primary MCL at 10 µg/L (Figure 27). Arsenic impairment is listed for 42% of wells and 30% for wells that are less than 200 feet bgs.

- Significant arsenic trends were found in 19 of the 79 wells (24%) that met trend criteria (Figure 20). Of the 19 wells, 12 have decreasing trends and two of the 12 wells are less than 200 feet bgs. The remaining seven wells have increasing trends and three of the seven wells are less than 200 feet bgs.

- The wells exceeding the primary MCL for arsenic are located in four localized areas within the subbasin. The first area contains 100 shallow monitoring wells that are all located near the Vandenberg Airforce Base with at least one arsenic sample greater than 10 µg/L. Two localized areas contain six shallow monitoring wells on the south-western edge of the subbasin. The remaining localized area is in an area where three shallow monitoring wells are located on the north-western edge of the subbasin. Within the Lompoc Terrace, the majority of well trends are detected in monitoring wells associated with the Central Coast Water Board Department of Defense Cleanup Projects on the Vandenberg Airforce Base.

- There are no domestic wells located within one square mile of an arsenic impaired well. Therefore, arsenic impacts to domestic water supply were not further evaluated for the Lompoc Terrace subbasin.

Hexavalent Chromium

- Thirty-two wells with 146 samples have a median hexavalent chromium concentration of 6.29 µg/L. Well construction information was not available for these wells.

- The maximum hexavalent chromium concentration was sampled from a well that is less than 200 feet bgs at 2,900 µg/L. Approximately 25% of wells and 38% of samples exceed 10 µg/L (Figure 28). Hexavalent chromium impairment is listed for 25% of wells and 19% of wells less than 200 feet bgs.

- Significant hexavalent chromium trends were found in three of the nine wells (33%) that met the trend criteria (Figure 21). Of the three wells, all have decreasing trends and unknown screen depths.

- High hexavalent chromium concentrations were within two localized areas. The first area was identified at three shallow monitoring wells on Vandenberg Airforce Base on the northern portion of the Lompoc Terrace subbasin. The second area was identified at two monitoring wells screened at depth greater than 200 feet bgs. These two wells are located on the southern portion of the Lompoc Terrace subbasin.

- There are no domestic wells located within one square mile of hexavalent chromium identified impaired wells. Therefore, hexavalent chromium impacts to domestic water supply were not evaluated further within the Lompoc Terrace subbasin.

Iron

- Three hundred sixty-one wells with 1,860 samples have a median iron concentration of 192 µg/L. Analysis of wells grouped by depth indicate higher iron concentrations in the wells that are less than 200 feet bgs with a median iron concentration of 324 µg/L.

- The maximum iron concentration was sampled from a well that is less than 200 feet bgs at 343,000 µg/L. Approximately 63% of wells and 45% of samples exceed the secondary MCL at 300 µg/L. Iron impairment is listed for 52% of wells and 35% of wells that are less than 200 feet bgs (Figure 29).

- Significant iron trends were found for 31 of the 91 wells (34%) that met the trend criteria. Of the 31 wells, 11 have decreasing trends (12%) and two of those wells are less than 200 feet bgs (Figure 22). The remaining 20 wells (22%) have increasing trends and five of those wells are less than 200 feet bgs.

- The wells exceeding the secondary MCL for iron are distributed across the subbasin in no distinct clusters. The majority of wells in exceedance are part of the Central Coast Water Board regulated facilities with monitoring wells and USGS NWIS datasets. The wells are mostly screened less than 200 feet bgs.

Manganese

- Three hundred thirty-one wells with 2,089 samples have a median manganese concentration of 102 µg/L. Analysis of wells grouped by depth indicate higher concentrations in wells less than 200 feet bgs with a median manganese concentration of 127 µg/L.

- The maximum manganese concentration was sampled from a well that is less than 200 feet bgs at 41,600 µg/L. Approximately 75% of wells and 63% of samples exceed the secondary MCL of 50 µg/L (Figure 30). Manganese impairment is listed for 73% of wells and 51% of wells that are less than 200 feet bgs.

- Significant manganese trends were found for 26 of the 102 wells (25%) that met the trend criteria (Figure 23). Of the 26 wells, 18 (18%) have decreasing trends and eight of those wells are less than 200 feet bgs. The remaining eight wells (8%) have increasing trends for wells that are less than 200 feet bgs.

- The wells exceeding the secondary MCL for manganese are distributed in two localized areas within the Lompoc Terrace subbasin. Both localized areas are identified by shallow monitoring wells associated with the Central Coast Water Board Department of Defense cleanup sites at the Vandenberg Airforce base. One localized area is within the northern portion of the subbasin. The other localized area is located on the south-western portion of the subbasin.

Nitrate

- One hundred ninety-four wells with 1,299 samples have a median nitrate concentration of 0.11 mg/L. Analysis of wells grouped by depth indicate higher concentrations in the wells that are greater than 200 feet bgs with a median nitrate concentration of 0.29 mg/L.

- The maximum nitrate concentration was sampled from a well that is less than 200 feet bgs at 80.4 mg/L. Approximately 9% of wells and 7% of samples exceed the primary MCL (Figure 31). Nitrate impairment is listed for 9% of shallow aquifer wells.

- Significant nitrate trends were found for 18 of the 77 wells (23%) that met the trend criteria. Of the 18 wells, 14 (18%) have decreasing trends in wells less than 200 feet bgs(Figure 24). The remaining four wells (5%) have increasing trends including three wells less than 200 feet bgs and one well greater than 200 feet bgs.

- The wells exceeding the primary MCL for nitrate are located in one localized area on the northern portion of the Lompoc Terrace subbasin.

- There are no domestic wells located within one square mile of a nitrate impaired well. Therefore, nitrate impacts to domestic water supply within the Lompoc Terrace subbasin were not evaluated.

Sulfate

- Two hundred seventy-one wells with 1,784 samples have a median sulfate concentration at 101 mg/L. Analysis of wells grouped by depth indicate higher median sulfate concentrations in wells that are greater than 200 feet bgs.

- The maximum sulfate concentration was sampled at 5,650 mg/L, though well depth is unknown. One well that is less than 200 feet bgs had sulfate concentrations as high as 4,080 mg/L. Approximately 14% of wells and 9% of samples exceed the secondary MCL at 500 mg/L (Figure 32). Sulfate impairment is listed for 7% of wells and 5% of wells that are less than 200 feet bgs.

- Significant sulfate trends were found for 39 of the 126 wells (31%) that met the trend criteria. Of the 39 wells, 26 (21%) have decreasing trends and two known depths screened in wells less than 200 feet bgs (Figure 25). The remaining 13 wells (10%) have increasing trends and two known depths screened in wells less than 200 feet bgs.

  The groundwater quality objectives for sulfate in the Lompoc Terrace subbasin is 100 mg/L and the secondary MCL is 500 mg/L. The wells exceeding the groundwater quality objective and secondary MCL are located in three localized areas. The first localized area is identified by Central Coast Water Board Department of Defense regulated monitoring wells associated with Vandenberg Airforce Base cleanup sites. The other two localized areas are located on the western subbasin border by the Pacific Ocean.

Total Dissolved Solids

- Seventy-six wells with 468 samples have a median TDS concentration of 758.5 mg/L. Analysis of wells grouped by depth indicate a higher concentration in wells less than 200 feet bgs with a median TDS concentration of 1,110 mg/L.

- The maximum TDS concentration was sampled at 161,000 mg/L, though well depth is unknown. One well less than 200 feet bgs had TDS concentrations as high as 9,040 mg/L. Approximately 63% of wells and 35% of samples exceed the secondary MCL at 1,000 mg/L (Figure 33). TDS impairment is listed for 21% of wells and 13% of wells that are less than 200 feet bgs.

- Significant TDS trends were found for two of the 17 wells (12%) that met the trend criteria (Figure 26). Of the two wells, both have decreasing trends and one well is less than 200 feet bgs.

- The groundwater quality objective for TDS in the Lompoc Terrace subbasin is 750 mg/L and the secondary MCL is 1,000 mg/L. The wells exceeding the groundwater quality objective and secondary MCL are distributed in several localized areas throughout the subbasin.

Lompoc Upland Subbasin

The Lompoc Upland subbasin is composed of alluvial and terrace deposits overlying the Orcutt Sand, Paso Robles, and Careaga Sand formations. Terrace deposits are stratified with gravel and sands, and silt and clay zones. The Orcutt Sand and Paso Robles formations are composed of coarse sand, silt, and clay of fluvial origin. The Careaga Sand formation is composed of medium to coarse sand (Bright et al., 1992). Sources of groundwater recharge include precipitation, and irrigation.

Groundwater data from approximately 46 total wells were analyzed in the Lompoc Upland subbasin boundaries. Of the total wells, 16 are greater than 200 feet bgs, 13 are less than 200 feet bgs, and 17 well depths are unknown. Mean well depth is 291 feet bgs. The median number of samples per well is 16 for this subbasin. The following sections summarize results including concentrations, exceedance/impairment, trends, and potential pollution sources for each of the seven pollutants of concern. The Lompoc Upland subbasin boundary is outlined in the map below based on USGS geologic reports (Bright et al.,1992) (Figure 6).

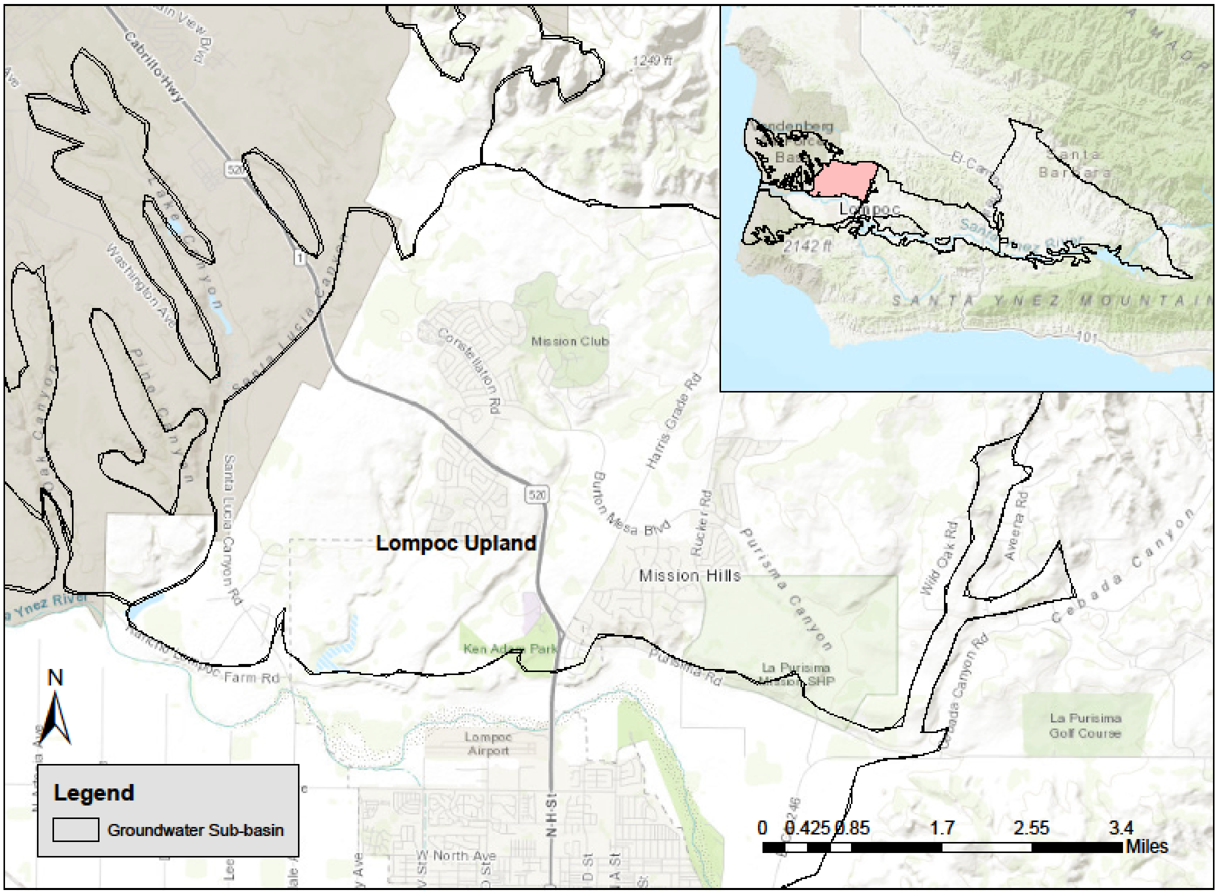

Figure 6. Lompoc Upland groundwater subbasin boundary.

Results: Concentration Summary, Exceedance/Impairment, Trends, and Potential Pollution Sources

Arsenic

- Twenty-one wells with 103 samples have a median arsenic concentration of 3 µg/L. Analysis of groundwater data grouped by depth indicate higher arsenic concentrations in wells greater than 200 feet bgs with a median at 3.3 µg/L.

- The maximum arsenic concentration was sampled from a well that is greater than 200 feet bgs at 50 µg/L. Approximately 43% of wells and 10% of samples exceed the primary MCL of 10 µg/L (Figure 27). Arsenic impairment is listed for 43% of wells and 14% of wells greater than 200 feet bgs.

- Significant arsenic trends were found in one of seven wells (14%) that met the trend criteria (Figure 20). The one well has decreasing trends and is screened in a well less than 200 feet bgs.

- The well exceeding the primary MCL for arsenic is located near the community of Mission Hills. Trends indicate arsenic concentrations are decreasing in this area.

- The arsenic impaired wells are located within one square mile of approximately nine domestic wells. Average well depths range from 280 to 853 feet bgs. With well impairment in wells greater than 200 feet bgs, all nine domestic wells are at risk of arsenic pollution based on close proximity to wells with known impairment and screening depths greater than 200 feet bgs.

Hexavalent Chromium

- Seven wells with 14 samples have over 80% of hexavalent chromium concentrations below laboratory detection levels (LDL), therefore the median value is less than the LDL of 0.01 µg/L.

- The maximum hexavalent chromium concentration was sampled from a well that is greater than 200 feet bgs at 1.3 µg/L. No wells or samples within the Lompoc Upland subbasin boundary are in exceedance of 10 µg/L.

- No trends were found for hexavalent chromium in the Lompoc Upland subbasin.

- With no exceedances or trends, there appears to be no significant sources of hexavalent chromium in the Lompoc Upland subbasin.

- With no known impairment within the Lompoc Upland subbasin, no further evaluation of domestic wells at risk of hexavalent chromium pollution was conducted.

Iron

- Thirty wells with 635 samples have over 80% of iron concentrations below LDL, therefore the median value is less that the LDL of 1 µg/L. Analysis of groundwater data grouped by well depth indicate a higher median concentration in wells greater than 200 feet bgs, with a median of 120 µg/L.

- The maximum iron concentration was sampled from a well greater than 200 feet bgs at 4,400 µg/L. Approximately 47% of wells and 11% of samples exceed the secondary MCL of 300 µg/L (Figure 29). Iron impairment is listed for 40% of wells and 13% of wells greater than 200 feet bgs.

- Significant iron trends were found in five of the 16 wells (31%) that met the trend criteria. Of the five wells, three (19%) have decreasing trends and unknown well depths (Figure 22). The remaining two wells have increasing trends and unknown well depths.

- The wells exceeding the secondary MCL are clustered near the town of Mission Hills.

Manganese

- Twenty-six wells with 616 samples have a median manganese concentration of 47 µg/L. Analysis of groundwater data grouped by well depth indicated higher concentrations in wells greater than 200 feet bgs with a median value of 75 µg/L.

- The maximum manganese concentration was sampled from a well less than 200 feet bgs at 1,300 µg/L. Approximately 81% of wells and 47% of samples exceed the secondary MCL of 50 µg/L (Figure 30). Manganese impairment is listed for 73% of wells including 12% of wells less than 200 feet bgs and 15% of wells greater than 200 feet bgs.

- Significant manganese trends were found in three of the 16 wells (19%) that met the trend criteria. Of the three wells, two (13%) have decreasing trends in wells greater than 200 feet bgs (Figure 23). The remaining one well (6%) has an increasing trend in a well that is less than 200 feet bgs.

- Wells exceeding the secondary MCL for manganese are located in two clusters of public supply wells that are greater than 200 feet bgs.

Nitrate

- Thirty wells with 266 samples have a median nitrate concentration of 0.16 mg/L nitrate. Analysis of groundwater data grouped by well depth indicates higher concentrations in wells less than 200 feet bgs with a median value of 1.2 mg/L.

- The maximum nitrate concentration was sampled at 6.2 mg/L, though the well depth is unknown. One well that is greater than 200 feet bgs had concentrations as high as 5.87 mg/L. No wells or samples within the Lompoc Upland subbasin boundary are in exceedance of the primary MCL of 10 mg/L.

- Significant nitrate trends were found in four of the seven wells (57%) that met the trend criteria (Figure 24). The four wells have increasing trends and one well has a known depth screened that is greater than 200 feet bgs.

- With no known impairment within the Lompoc Upland subbasin, no further evaluation of domestic wells was conducted.

Sulfate

- Forty-two wells with 185 samples have a median sulfate concentration of 110 mg/L. Analysis of groundwater data grouped by well depth indicate higher concentrations in wells greater than 200 feet bgs with a median value of 111 mg/L.

- The maximum sulfate concentration was sampled at 1,720 mg/L, though the well depth is unknown. Approximately 2% of wells and 1% of samples exceed the secondary MCL of 500 mg/L. No wells are listed with sulfate impairment.

- Significant sulfate trends were found in one of the 17 wells (6%) that met the trend criteria (Figure 25). The well has decreasing trends and unknown depth.

Total Dissolved Solids

- Forty-four wells with 308 samples have a median TDS concentration of 560 mg/L. Analysis of groundwater data grouped by well depth indicate higher concentrations in wells less than 200 feet bgs with a median value of 653.5 mg/L.

- The maximum TDS concentration was sampled at 3,730 mg/L, though the well depth is unknown. Wells less than 200 feet bgs had higher maximum concentration than wells less than 200 feet bgs with a maximum TDS concentration of 1,670 mg/L. Approximately 7% of wells and 2% of samples exceed the secondary MCL of 1,000 mg/L (Figure 33). Total dissolved solids impairment is listed for 2% of wells less than 200 feet bgs.

- Significant TDS trends were found in three of the 24 wells (13%) that met the trend criteria (Figure 26). Of the three wells, all have increasing trends and two are in wells that are greater than 200 feet bgs.

Santa Rita Subbasin

The Santa Rita subbasin is composed of alluvial and terrace deposits overlying the Paso Robles, Careaga Sand, and Orcutt Sand formations. Alluvial and terrace deposits are stratified of fine and coarse sands, silt, clay, and gravel layers. The Orcutt Sand and Paso Robles formations are composed of coarse sand, silt, and clay of fluvial origin. The Careaga Sand formation is composed of medium to coarse sand (Bright et al., 1992). Sources of groundwater recharge include underflow from the Santa Ynez River, irrigation, discharges from agricultural operations, percolation from wastewater ponds at the Buellton wastewater treatment plant, and leaching from OWTS.

Groundwater data from approximately 238 total wells were analyzed within the Santa Rita subbasin boundaries. Of the total wells, 38 are greater than 200 feet bgs, 51 are less than 200 feet bgs, and 149 well depths are unknown. Mean well depth is 288 feet bgs. The median number of samples per well is 5 for this subbasin. The Santa Rita subbasin boundary is outlined in the map below based on USGS geologic reports (Hamlin, 1985) (Figure 7)

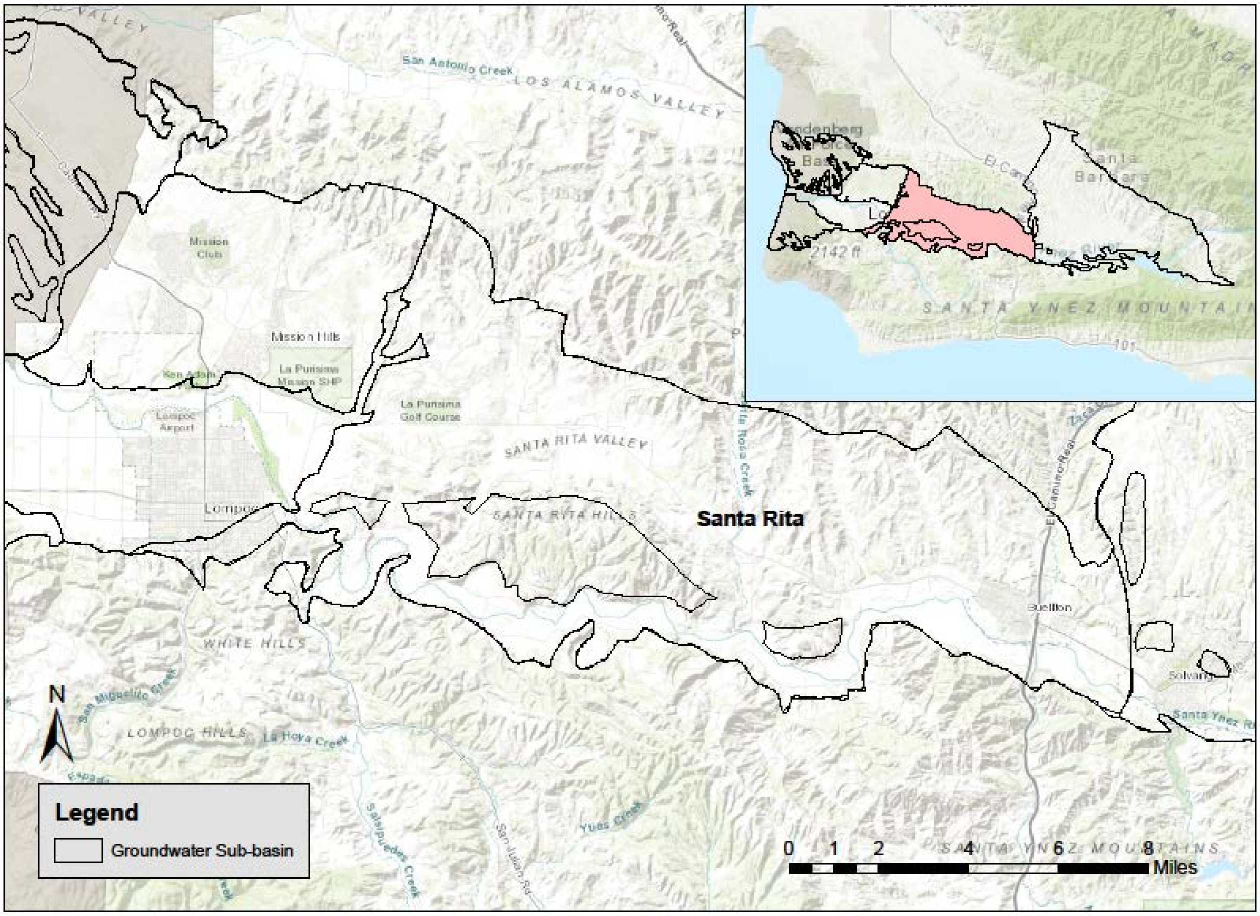

Figure 7. Santa Rita groundwater subbasin boundary.

Results: Concentration Summary, Exceedance/Impairment, Trends, and Potential Pollution Sources

Arsenic

- Nineteen wells and 118 samples have a median arsenic concentration of 2.7 µg/L. Analysis of groundwater data grouped by well depth indicated higher arsenic concentrations in wells greater than 200 feet bgs with a median concentration of 3.6 µg/L.

- The maximum arsenic concentration was sampled from a well less than 200 feet bgs at 53 µg/L. Approximately 21% of wells and 12% of samples exceed the primary MCL of 10 µg/L (Figure 27). Arsenic impairment is listed for 5% of wells less than 200 feet bgs.

- Significant arsenic trends were found for one well (13%) of the eight that met the trend criteria (Figure 20). The results indicate decreasing trend in the well, which is less than 200 feet bgs.

- The wells exceeding the primary MCL for arsenic are located on the eastern edge of the subbasin near the City of Buellton. The wells are public supply wells and used for drinking water. One well with a decreasing trend is located within the city of Buellton.

- The arsenic impaired wells are located within one square mile of approximately twenty domestic wells. Average well depths range from 64 to 452 feet bgs. At least six of the domestic wells appear to be at risk of potential arsenic pollution based on close proximity to known arsenic impaired wells that are less than 200 feet bgs.

Hexavalent Chromium

- Eleven wells and 18 samples have over 80% of hexavalent chromium concentrations less than laboratory detection levels (LDL). Therefore, the median value is less than the LDL of 0.01 µg/L.

- The maximum hexavalent chromium was sampled from a well that is greater than 200 feet bgs at 1.9 µg/L. No wells were in exceedance of 10 µg/L.

- No trends were found for hexavalent chromium in the Santa Rita subbasin.

- With no exceedances or trends, there appears to be no significant sources of hexavalent chromium in the Santa Rita subbasin.

- With no known impairment within the Santa Rita subbasin, no further evaluation of domestic wells for hexavalent chromium pollution was conducted.

Iron

- Seventy-four wells and 182 samples have a median iron concentration of 29.9 µg/L. Analysis of groundwater data grouped by well depth indicate similar concentrations in wells greater than 200 feet bgs with a median value of 30 µg/L.

- The maximum iron concentration was sampled from a well that is less than 200 feet bgs at 26,000 µg/L. Approximately 24% of wells and 15% of samples exceed the secondary MCL of 300 µg/L (Figure 29). Iron impairment is listed for 22% of wells and 5% of wells less than 200 feet bgs.

- Significant iron trends were found in three wells (50%) of the six that met the trend criteria (Figure 22). Of the three wells, all have increasing trends and unknown well depths.

- Wells with high iron concentrations are distributed throughout the subbasin. One exceedance trend was identified in agricultural wells located along the Santa Ynez River corridor. Additional wells in exceedance are located within the City of Buellton and the western portion of the subbasin near the City of Lompoc. Well depths indicate higher concentrations in wells less than 200 feet bgs.

Manganese

- Thirty-four wells and 351 samples have a median manganese concentration less than laboratory detection levels of 20 µg/L (US EPA, 2004). Analysis of groundwater data grouped by well depth indicate higher concentrations in wells less than 200 feet bgs, with a median value of 200 µg/L in the shallower wells.

- The maximum manganese concentration was sampled from a well greater than 200 feet bgs at 720 µg/L. Approximately 56% of wells and 23% of samples exceed the secondary MCL of 50 µg/L (Figure 30). Manganese impairment is listed for 50% of wells including 15% in the wells less than 200 feet bgs and 9% in wells greater than 200 feet bgs.

- A significant manganese trend was found in one well (10%) of the ten that met the trend criteria (Figure 23). The one well has a decreasing trend and is less than 200 feet bgs.

Nitrate

- One hundred seventy-two wells and 875 samples have a median nitrate concentration of 1.92 mg/L. Analysis of groundwater data grouped by well depth indicate higher concentration in wells less than 200 feet bgs with a median value of 5.9 mg/L.

- The maximum nitrate concentration was sampled from a well less than 200 feet bgs at 27 mg/L. Approximately 7% of wells and 16% of samples exceed the primary MCL of 10 mg/L (Figure 31). Nitrate impairment is listed for 7% of wells including 3% in wells less than 200 feet bgs.

- Significant nitrate trends were found in five wells (26%) of the 19 that met the trend criteria. Of the five wells, four (15%) have decreasing trends, with two of the four wells less than 200 feet bgs, and the other two greater than 200 feet bgs (Figure 24). One well has an increasing trend and is greater than 200 feet bgs.

- Wells exceeding the primary MCL for nitrate are distributed across the subbasin.

- The nitrate impaired wells are located within one square mile of approximately 54 domestic wells. Average well depths range from 72 to 399 feet bgs. At least 65% of the wells (35 domestic wells) appear to be at risk of nitrate pollution based on close proximity to known impaired wells and screening depths less than 200 feet bgs.

Sulfate

- One hundred ninety-five wells and 669 samples have a median sulfate concentration of 260 mg/L. Analysis of groundwater data grouped by well depth indicate higher concentration in wells less than 200 feet bgs with a median sulfate concentration of 270 mg/L.

- The maximum sulfate was sampled from a well less than 200 feet bgs at 2,420 mg/L. Approximately 22% of wells and 14% of samples exceed the secondary MCL of 500 mg/L (Figure 32). Sulfate impairment is listed for 2% of wells including 1% of wells less than 200 feet bgs.

- Significant sulfate trends were found in five wells (29%) of the 17 that met the trend criteria. Of the five wells, one (6%) has decreasing trends in a well greater than 200 feet bgs (Figure 25). The remaining four wells (24%) have increasing trends with unknown well depths.

- The groundwater quality objective for sulfate in the Santa Rita subbasin is 700 mg/L. The wells exceeding the groundwater quality objective and secondary MCL are located along the Santa Ynez River.

Total Dissolved Solids

- One hundred ninety-seven wells and 795 samples have a median TDS concentration of 920 mg/L. Analysis of groundwater data grouped by well depth indicate higher concentrations in wells less than 200 feet bgs with a median TDS concentration of 990 mg/L in these shallow wells.

- The maximum TDS was sampled from a well less than 200 feet bgs at 5,120 mg/L. Approximately 50% of wells and 37% of samples exceed the secondary MCL of 1,000 mg/L (Figure 33). Total dissolved solids impairment is listed for 7% of wells, with approximately half of these wells less than 200 feet bgs.

- No significant TDS trends were found.

- The groundwater quality objective for TDS in the Santa Rita subbasin is 1,500 mg/L. The wells exceeding the groundwater quality objective and secondary MCL are located along the Santa Ynez River.

Santa Ynez Subbasin

The Santa Ynez subbasin is composed of alluvial and terrace deposits overlying the Paso Robles formation. Alluvial and terrace deposits are stratified with fine and coarse sands, silt, clay, and gravel layers. The Paso Robles formation is composed of coarse sand, silt, and clay of alluvial origin. Sources of groundwater recharge include underflow from the Santa Ynez River and other tributary creeks, irrigation return flow, percolation from agricultural discharge, leaching from domestic OWTS, percolation from wastewater ponds at the Solvang wastewater treatment plant, and precipitation.

Groundwater data from approximately 277 total wells were analyzed in the Santa Ynez subbasin boundaries. Of the total wells, 84 are greater than 200 feet bgs, 80 are less than 200 feet bgs, and 113 well depths are unknown. Mean well depth is 287 feet bgs. The median number of samples per well is 8 for this subbasin. The Santa Ynez subbasin boundary is outlined in the map below based on USGS geologic reports (Hamlin, 1985) (Figure 8).

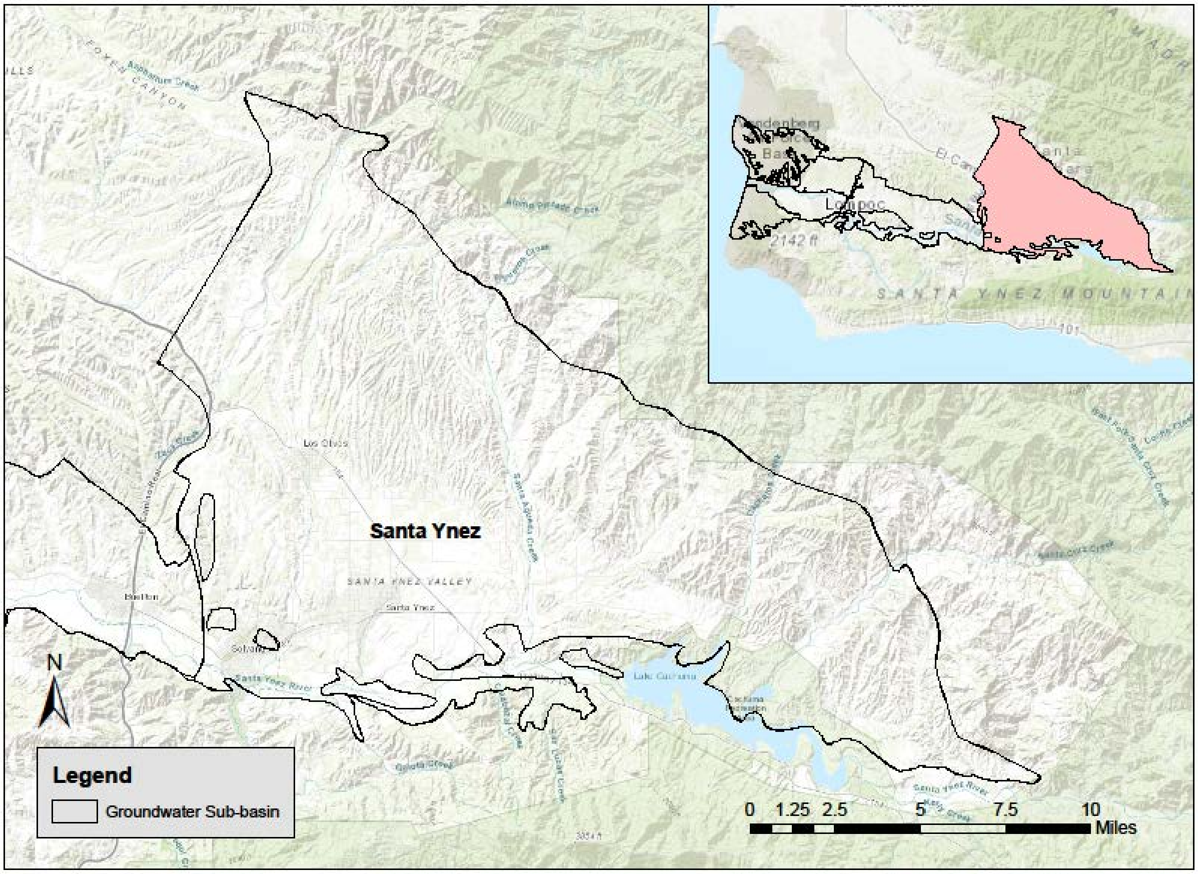

Figure 8. Santa Ynez groundwater subbasin boundary.

Results: Concentration Summary, Exceedance/Impairment, Trends, and Potential Pollution Sources

Arsenic

- Seventy-three wells with 259 samples have a median arsenic concentration less than LDL of 0.9 µg/L.

- The maximum arsenic concentration of 30 µg/L was sampled from a well that is less than 200 feet bgs. Approximately 7% of wells and 2% of samples exceed the primary MCL of 10 µg/L (Figure 27).

- Significant arsenic trends were found in one well (7%) of the 14 that met the trend criteria (Figure 20). This well is greater than 200 feet bgs and concentrations are decreasing.

- One well with arsenic impairment is located near the Ballard Canyon Landfill cleanup site. The well is used for monitoring and is screened in the shallow aquifer. Only one sample was taken from this well, therefore trends are unknown. Only one significant trend is within the subbasin indicating decreasing concentrations.

- No wells were documented with arsenic impairment; therefore, no further evaluation of domestic wells at risk for arsenic pollution was conducted.

Hexavalent Chromium

- Forty-five wells with 180 samples have a median hexavalent chromium concentration of 9.1 µg/L. Analysis of groundwater data grouped by well depth indicate higher concentration in wells less than 200 feet bgs with a median value of 12 µg/L.

- The maximum hexavalent chromium concentration was 43 µg/L, though the well depth is unknown. Maximum concentrations from groundwater data with known well depths is 36 µg/L (Figure 28). Approximately 40% of wells and 41% of samples exceed the previous primary MCL of 10 µg/L. Hexavalent chromium impairment is listed for 29% of wells, with 4% in wells less than 200 feet bgs, 11% in wells greater than 200 feet bgs, and the remaining wells with unknown depths.

- Significant hexavalent chromium trends were found in three wells (23%) of the 13 that met the trend criteria. Of the three wells, two are decreasing and one is increasing (Figure 21). The well with increasing concentration in a well less than 200 feet bgs.

- The wells exceeding the primary MCL of 10 µg/L, are located on the northeastern portion of the basin. Wells that are greater than 200 feet bgs and located in the Uplands Area east of Los Olivos and all have elevated hexavalent chromium concentrations and decreasing trends. Wells less than 200 feet bgs and located within the town of Santa Ynez had increasing trends.

- The hexavalent chromium impaired wells are located within one square mile of approximately 169 domestic wells. Average well depths range from 172 to 836 feet bgs. At least 4% of wells less than 200 feet bgs (7 domestic wells) and 38% of wells greater than 200 feet bgs (65 domestic wells) are at risk of hexavalent chromium pollution based on close proximity to known impaired wells and depths.

Iron

- One hundred fiftysix wells with 917 samples have a median iron concentration of 20 µg/L. Analysis of groundwater data grouped by well depth indicated higher concentrations in wells greater than 200 feet bgs with a median value at 38 µg/L.

- The maximum iron concentration was 32,400 µg/L, though the well depth is unknown. Maximum concentrations from groundwater data with known depths are 20,500 µg/L for the wells greater than 200 feet bgs and 20,700 µg/L for wells less than 200 feet bgs. Approximately 29% of wells and 23% of samples exceed the secondary MCL of 300 µg/L (Figure 29). Iron impairment is listed for 13% of wells including 7% of wells less than 200 feet bgs and 3% of wells greater than 200 feet bgs.

- Significant iron trends were found in 14 wells (35%) of the 40 that met the trend criteria. Of the 14 wells, ten (25%) have decreasing trends and unknown well depths (Figure 22).

The remaining four wells (10%) have increasing trends, with two of the four wells less than 200 feet bgs.

- Wells exceeding the secondary MCL for iron are distributed across the Santa Ynez subbasin at less than and greater than 200 feet bgs.

Manganese

- Ninety-four wells with 816 samples have a median manganese concentration of 27.5 µg/L. This value is the same as the median concentration for wells less than 200 feet bgs. The wells that are greater than 200 feet bngs have a higher median concentration of 49 µg/L.

- The maximum manganese concentration was sampled from a well greater than 200 feet bgs at 11,600 µg/L. Approximately 31% of wells and 40% of samples exceed the secondary MCL of 50 µg/L (Figure 30). Manganese impairment is listed for 29% of wells including 17% of wells less than 200 feet bgs and 9% of wells greater than 200 feet bgs.

- Significant manganese trends were found in 13 wells (42%) of the 31 that met the trend criteria. Of the 13 wells, nine have decreasing trends and one known well depth less than 200 feet bgs (Figure 23). The remaining four wells have increasing trends with one known well depth greater than 200 feet bgs.

Nitrate

- Median nitrate concentration measured in 214 wells was 0.86 mg/L. Analysis of groundwater data grouped by well depth indicate higher concentrations in wells greater than 200 feet bgs with a median value of 0.9 mg/L.

- Approximately 3% of wells and 1% of samples exceed the primary MCL of 10 mg/L (Figure 31). Nitrate impairment is listed for 2% of the wells less than 200 feet bgs.

- The maximum nitrate concentration was measured in a well operated by Rancho Marcelino Water and Services (Water System No. CA4200531-010) in 2011 with a concentration of 13.78 mg/L. However, concentrations in that well have steadily decreased since that time and since 2015 the most recent eight measurements have all been less than 2 mg/L.

- Wells exceeding the primary MCL for nitrate are located within three localized areas near the towns of Santa Ynez and Ballard. Historically, high nitrate concentrations were sampled from shallow domestic wells in Los Olivos, though these wells have not been sampled since 1980. Of the wells in exceedance, one had a significant increasing trend and two have decreasing trends (Figure 24).

- Trend analysis results reveal significant nitrate trends in 28 wells of the 75 that met the trend criteria. Of the 28 wells, 13 have decreasing trends with four of the 13 wells greater than 200 feet bgs and nine of the 13 wells less than 200 feet bgs (Figure 24). There are 16 wells that have increasing trends, with four of the 16 wells greater than 200 feet bgs, three wells less than 200 feet bgs, and the remaining wells with increasing trends have unknown depths.

- The nitrate impaired wells are located within one square mile of approximately 90 domestic wells. Average well depths range from 172 to 411 feet bgs. All impaired wells are less than 200 feet bgs. Therefore at least 21% of domestic wells (19 wells) are at risk of nitrate pollution based on proximity to impaired wells and screening depths less than 200 feet bgs.

Sulfate

- Two hundred fifty wells and 1,371 samples have a median sulfate concentration of 170 mg/L. Analysis of groundwater data grouped by well depth indicate higher concentrations in wells less than 200 feet bgs with a median value of 235 mg/L.

- The maximum sulfate concentration was sampled from a well less than 200 feet bgs at 2,680 mg/L. Approximately 4% of wells and 5% of samples exceed the secondary MCL of 500 mg/L (Figure 32). Sulfate impairment is listed for 2% of wells less than 200 feet bgs.

- Significant sulfate trends were found for 22 (34%) of the 65 wells that met the trend criteria. Of the 22 wells, eight have decreasing trends with three wells less than 200 feet bgs (Figure 25). The remaining 14 wells have increasing trends with one well less than 200 feet bgs.

Total Dissolved Solids

- Two hundred fifty-two wells and 1,535 samples have a median TDS concentration of 680 mg/L. Analysis of groundwater data grouped by well depth indicated higher concentrations in wells less than 200 feet bgs with a median value of 830 mg/L.

- The maximum TDS concentration was sampled from a well less than 200 feet bgs at 3,400 mg/L. Approximately 12% of wells and 15% of samples exceed the secondary MCL of 1,000 mg/L (Figure 33). Total dissolved solids impairment is listed for 7% of wells.

- Significant TDS trends were found for six of the 68 wells that met the trend criteria. Of the six wells, three have decreasing trends with one well greater than 200 feet bgs and two less than 200 feet bgs (Figure 26). The remaining three wells have increasing trends with one known well depth greater than 200 feet bgs.

- The groundwater quality objective for TDS in the Santa Ynez subbasin is 600 mg/L. The wells exceeding the groundwater quality objective and secondary MCL are distributed throughout the subbasin with higher concentrations in the direction of groundwater flow towards the southwest. Sources of TDS are likely from anthropogenic activity.

IV. Domestic Wells at Risk

Domestic wells at risk are assessed based on the geographic locations and screening depths of known impaired wells. This section presents results for domestic wells at risk of arsenic, hexavalent chromium, and nitrate pollution.

Arsenic

A total of 25 domestic wells were documented in the Santa Ynez River Valley with a potential for arsenic pollution. These wells are within one square mile of known arsenic impaired wells and are screened at similar depths.

Hexavalent Chromium

A total of 72 domestic wells were documented in the Santa Ynez subbasin with a potential for hexavalent chromium pollution. These wells are within one square mile of known hexavalent chromium impaired wells and are screened at similar depths. No other subbasins were evaluated for risks of hexavalent chromium pollution to domestic water supply due to the lack of identifiable impaired wells.

Nitrate

A total of 49 domestic wells were documented in the Santa Ynez River Valley with potential nitrate pollution. These wells are within one square mile of known nitrate impaired wells and are screened in wells less than 200 feet bgs. These wells are located in the Santa Ynez, Santa Rita, and Lompoc Plain subbasins.

4. OWTS Impacts in the Santa Ynez Subbasin

I. OWTS Impacts Introduction

This section summarizes impacts from OWTS on groundwater in the Santa Ynez subbasin. In this analysis, nitrate is used as the sole water quality indicator for OWTS impacts. However, it must be acknowledged that there are a variety of different potential land use-based sources of nitrate in groundwater in addition to OWTS, including agricultural and livestock operations and naturally occurring sources. Nitrate is used in this analysis because nitrate concentration data is widely available, many wells have long historical records of nitrate concentration, and OWTS impacts on nitrate concentration are widely documented. However, because nitrate is a non-unique indicator of OWTS pollution, the work described in this chapter focuses on discerning nitrate derived from OWTS from other sources. In most cases, it will be difficult to definitively quantify the amount of nitrate loaded to groundwater from various sources using concentration and land use data alone. This analysis should be regarded as a first-order assessment which will guide more targeted future investigations and additional subsequent targeted sampling and/or modeling.

II. OWTS Impacts Methods

i. Land Use and Water Quality Evaluation

Land use data, OWTS risk model results, and groundwater nitrate concentrations were used to identify potential sources of nitrate. Land use data included OWTS density, the location of facilities with waste discharge requirement (WDR) permits from the Central Coast Water Board, and the location and type of agricultural lands. Information on agricultural land use was acquired from the Department of Water Resources’ 2014 Crop Mapping shapefile (Kimmelshue, 2014). Nitrate concentration data were downloaded from GeoTracker GAMA. The analysis of groundwater nitrate data included both recent data (from the last ten years) and historical data. The recent data provides information on the current state of nitrate impairment while the historical data provides information on the rate of nitrate concentration change and the rate of water quality degradation.

ii. Statistical Model

A statistical model was constructed to evaluate how hydrogeological variables and different land use practices, including OWTS, might impact groundwater nitrate concentrations. This statistical model was necessary due to the lack of a strong relationship or correlation between groundwater nitrate concentrations and any *single* land use or hydrogeological variable. The lack of a clear relationship is probably because there are multiple factors working together simultaneously that affect groundwater nitrate concentration, such as a variety of land use practices or hydrogeological variables. To assess the impact of a variety of factors on groundwater nitrate concentrations, multiple regression with backwards elimination was conducted whereby the effect of all predictor variables on nitrate concentration were evaluated, then insignificant variables were eliminated one-by-one in a stepwise manner until the final regression equation consisted of only statistically significant predictors. In the statistical model described in this report, mean nitrate concentration measured in a well between 2008 and 2018 was used as the dependent variable and predictor variables included the density of septic systems, proximity to agricultural land, recharge rate, depth to the top of the well screen, depth to groundwater, soil type, and slope. Non-significant variables were eliminated based on the Aikake Information Criteria (AIC) score of the variable; the variable with the lowest AIC score in each iteration was removed, then the regression re-calculated. All statistical analysis was conducted using the R Statistical Programming Language.

Agricultural lands were identified from the Department of Water Resources’ 2014 Crop Mapping shapefiles. Not all agricultural lands identified in the DWR maps were utilized in the analysis, only those which typically apply nitrogen fertilizer. These include vegetable, nursery, berry, young perennial, citrus, and other subtropical crops, deciduous fruits and nuts, vineyards, and pasture lands. The other parameters utilized in the statistical model are described Section 1 on the OWTS risk model. It is worthwhile to again mention that, as explained in Chapter 1, recharge only include precipitation-driven recharge and excludes recharge from the Santa Ynez River channel.

III. OWTS Impacts results and Discussion

Nitrate Concentrations and Land Use

The relatively recent nitrate data collected from wells in the Santa Ynez subbasin shows that concentrations are generally low, except for a few wells located in high OWTS density and high OWTS risk areas. The map in Figure 9 shows the median nitrate concentration measured in a well between 2008 and 2018. Also plotted on the map are OWTS density and different crop types identified from the DWR maps. Agricultural production occurs near or upgradient from many of the highest density OWTS areas and can't be excluded as a possible source of groundwater nitrate. One observation from this map is that there are a substantial number of wells with nitrate concentrations less than 4 mg/L, which suggests that groundwater quality is fairly good in most parts of the basin. This suggests that OWTS density or other potential sources of nitrate appear to have little impact on groundwater nitrate concentrations. For example, in areas where the OWTS density is greater than 100 units/mi^2, such as near the town of Los Olivos, there are more wells whose median concentration is less than 4 mg/L relative to wells whose concentration is greater than 6 mg/L. Another observation is that in the subbasin, of the three wells with the highest median concentrations, two of these wells are in areas where the OWTS density is 100 units/mi^2 or less, suggesting that factors other than OWTS density are contributing to the observed increase in concentration. However, this map is a two-dimensional representation of a three-dimensional phenomenon because depth of the well screen and depth to groundwater are not taken into account. Well construction information is not available for most of the wells in the highest density septic areas, thereby limiting the evaluation of impacts in this area. However, in the highest density septic areas near Janin Acres (outlined by yellow, orange, and red shading), three of the four highest concentration wells have well construction information. These three wells all have perforations beginning at relatively shallow depths (74, 120, and 130 feet bgs) and the well with the highest median concentration also has the shallowest perforated depth. This suggests that shallow groundwater may be especially impacted and any analysis of groundwater nitrate concentration and OWTS impacts must take the depth to the well screen and depth to groundwater into account, when that data is available. It is also relevant to note that the well with the highest median groundwater concentration falls into the area with the highest OWTS risk score from Chapter 1, suggesting that the risk model may be providing reliable risk information for the upper parts of the aquifer.

There are two wells shown on the map that have concentrations greater than 8 mg/L but are located in areas where OWTS density is 40 units/mi^2 or less. One of these wells is a monitoring well for the Santa Ynez landfill and nitrate concentrations in that well may be associated with discharges from the landfill. The other well with a high median concentration is operated by the Meadowlark Ranches Mutual Water Company and is located between Meadowlark Ranches and the Santa Ynez River (Well ID CA4200612-006). Perforations in this well begin at 25 feet bgs. Although the OWTS density in this area is relatively low (61 unit/mi^2), the groundwater being pumped from this well is shallow and vulnerable to OWTS pollution even at low OWTS density. It is possible the relatively low density OWTS associated with Meadowlark Ranches is contributing to the nitrate impacts observed in this well. It is also possible that OWTS effluent from the community of Santa Ynez, that discharged prior to sewer connections, has traveled approximately two miles downgradient to impact this well. However, agricultural lands, located 1,200 feet crossgradient and 4,500 feet upgradient, can't be discounted as a potential source of nitrate either. It is important to note that Meadowlark Ranches Mutual Water Company operates another well 2,500 feet to the east that has a median concentration of only 0.1 mg/L, perforated interval also at 25 feet bgs, and is located in an area where OWTS density is 33 units/mi^2. The most likely reason for the low concentrations in this nearby shallow well is that the well is located within the Santa Ynez River channel and is constantly being recharged by dilute Santa Ynez River water (i.e., low nitrate water). By contrast, the high concentration well is located 2,500 feet upgradient from the Santa Ynez River and likely doesn't experience as much dilution. Overall, these results indicate that there are a variety of factors controlling nitrate concentration variability within the Santa Ynez subbasin, including OWTS density, proximity to agricultural lands, depth to groundwater or well perforations, recharge rates, proximity to the Santa Ynez River, and other site-specific factors.

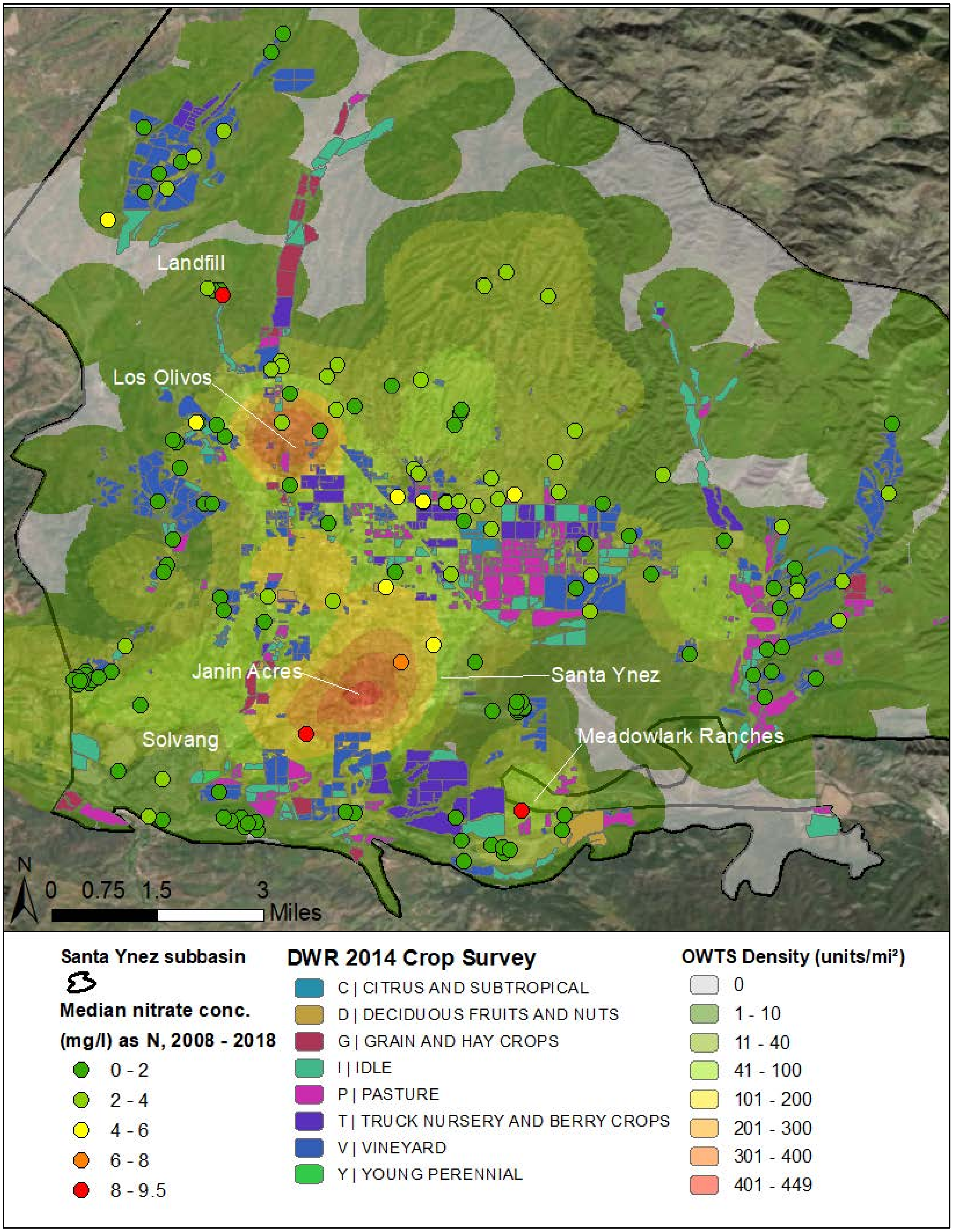

Figure 9. Map of OWTS density, crops from DWR's 2014 crop survey, and mean nitrate concentration measured in wells between 2008 and 2018 in the Santa Ynez subbasin.

Nitrate Concentration Trend Analysis

To evaluate how groundwater nitrate concentrations are changing through time, and to determine if groundwater quality in the basin is degrading, a trend analysis was conducted. Figure 10 shows the location of wells with statistically significant trends in nitrate concentration through time. The color of the bubble indicates whether the concentration is increasing or decreasing while the size of the bubble indicates the median nitrate concentration. Scatter plots for each of the wells shown on the map are shown in Figure 11 and additional information on each of the wells is shown in Table 7. In the areas where OWTS density is greater than 100 units/mi^2 (yellow, orange, and red shading in Figure 10), there are two wells with increasing concentrations and two wells with decreasing concentrations. Well 6 has a statistically significant increase in concentration, though the scatter plot for that well shows that the concentrations are generally less than 2.5 mg/L and the most recent measurement is near the detection limit (Figure 11). Thus, although this well has an increasing trend, the concentration and rate of change does not suggest that the well is at risk of impairment. This well has a perforated interval length of 520 feet (no depth information exists). This indicates that at the bottom of the screen, the well is pumping water that is at least 520 feet deep. The high-quality water observed in this well is likely a result of the long screen length which integrates water from a large depth range and potentially dilutes the contribution from a more polluted upper zone.

There are four wells with increasing concentrations (Wells 8 – 11) in the sewered portion of the Santa Ynez Community Services District (Santa Ynez CSD). Information on screened interval depths shows that Well 8 is much shallower than Well 11 and this well is experiencing higher concentrations and a faster rate of degradation relative to Well 11. This again highlights the importance of depth when considering groundwater quality. The concentrations measured in Well 9 are all from the 1960's through 1980's, prior to installation of the sewer in Santa Ynez. Concentrations in this well were fairly low but were slowly increasing, possibly from OWTS discharges. The other three wells with recent nitrate concentrations measurements are all showing increasing concentrations. This is despite the fact that they are all located within a sewered area. In fact, nitrate concentrations in Well 8 have increased at a faster rate in the last ten years (Figure 11, 0.07 mg/L/year over the well lifetime versus 0.29 mg/L/year since 2008). It would seem that connecting parcels to the sewer would result in decreasing nitrate concentrations in these wells, however, that is not what is observed in the data. One possible explanation for the continued increase in concentration is that nitrate from upgradient (north of the sewered area) may be impacting these wells. The nitrate upgradient from the sewered area could be from OWTS, agriculture, or a combination of sources. Another explanation is that residual OWTS nitrate from before the sewer installed is still moving through the vadose zone, causing the increase in concentration. With the data available, it is difficult to confidently determine the cause of the continued impairment in Wells 8, 10, and 11. Whatever the cause, it is clear that water quality in these wells is degrading and the wells are located in areas where the OWTS density and the OWTS risk model predict impairment.

Wells 12 and 15 are both within area where the OWTS density is greater than 100 units/mi^2 and both have decreasing concentrations trends. Despite the decreasing trends, their median concentrations are at or near the MCL. These high concentrations may be partially a function of the relatively shallow depth of the top of screen, Well 12's perforations begin at 120 feet deep and Well 15 at 75 feet. It is unclear what is causing these wells to decrease in concentration. However, the high OWTS density where these wells are located, combined with the relatively shallow depths of the screened interval, are almost certainly contributing to the high median nitrate concentrations. The OWTS risk model rates the area where Well 15 is located as one of the highest risk areas for OWTS impairment in the entire SYRV basin, further suggesting that OWTS is the primary cause of impairment in this well.

The analysis presented in this report of nitrate concentrations and changes in concentration in the Santa Ynez subbasin indicates that OWTS is likely causing impairment in at least a few wells. However, with the existing data, other land use practices can't be ruled out as possible sources of nitrate. In addition, there is evidence that wells in areas of high OWTS risk and/or high OWTS density that yield relatively unimpaired groundwater, thus complicating the evaluation of OWTS impacts to groundwater. The main reason for the difficulty in assigning a nitrate source is that the wells available for analysis are not necessarily sampling the groundwater in a manner that is ideal for understanding land use impacts on water quality. The production wells which most often have long nitrate concentration records, typically also have deep and/or long well screens. As a result, these wells integrate water and pollutants from a large three-dimensional area. In addition, because groundwater age typically varies with depth, wells with long screens also integrate pollutants from a large time range. As such, the samples from these wells don't reflect a point in space and time, but are a mixture of chemical constituents that reflect a four-dimensional integration of space and time. Therefore, a single sample from a large municipal production well can be composed of pollutants contributed by a variety of broadly spaced land uses that occurred over a broad time horizon, thus making it difficult to confidently assign a specific practice to the observed chemical composition. Finally, there are likely multiple confounding land use and hydrogeological factors that are affecting concentration of nitrate in groundwater and these factors need to be assessed simultaneously to effectively describe groundwater nitrate concentration variability.

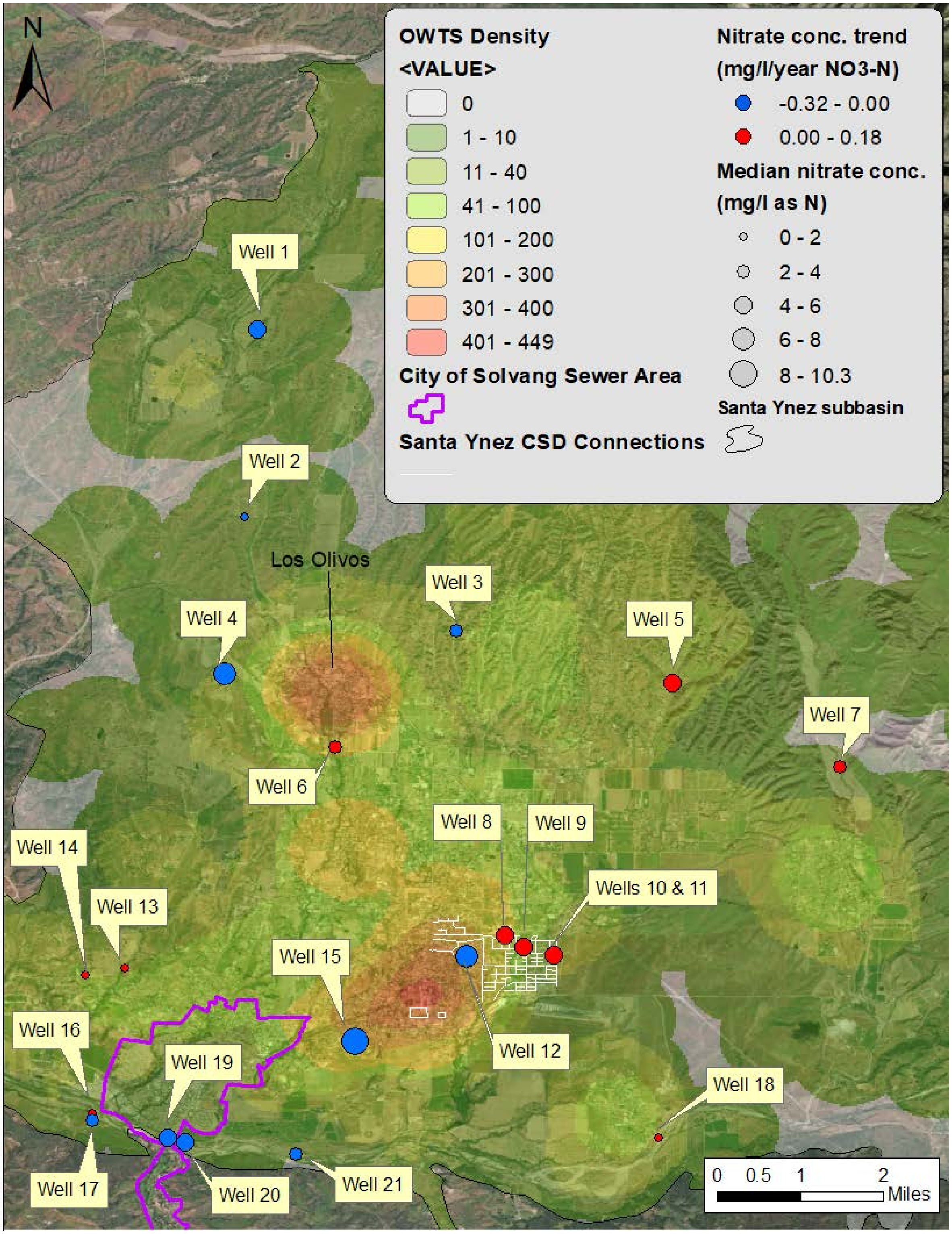

Figure 10. Map of wells with statistically significant trends in concentration through time. *Bubble color indicates the slope of the trend line (either increasing or decreasing concentration through time) and the size of the bubble indicates the well median concentration. Wells are numbered in increasing order from north to south. Plots of each well are shown in Figure 11 and additional information on each well can be found in Table 7. OWTS density is shown for reference*

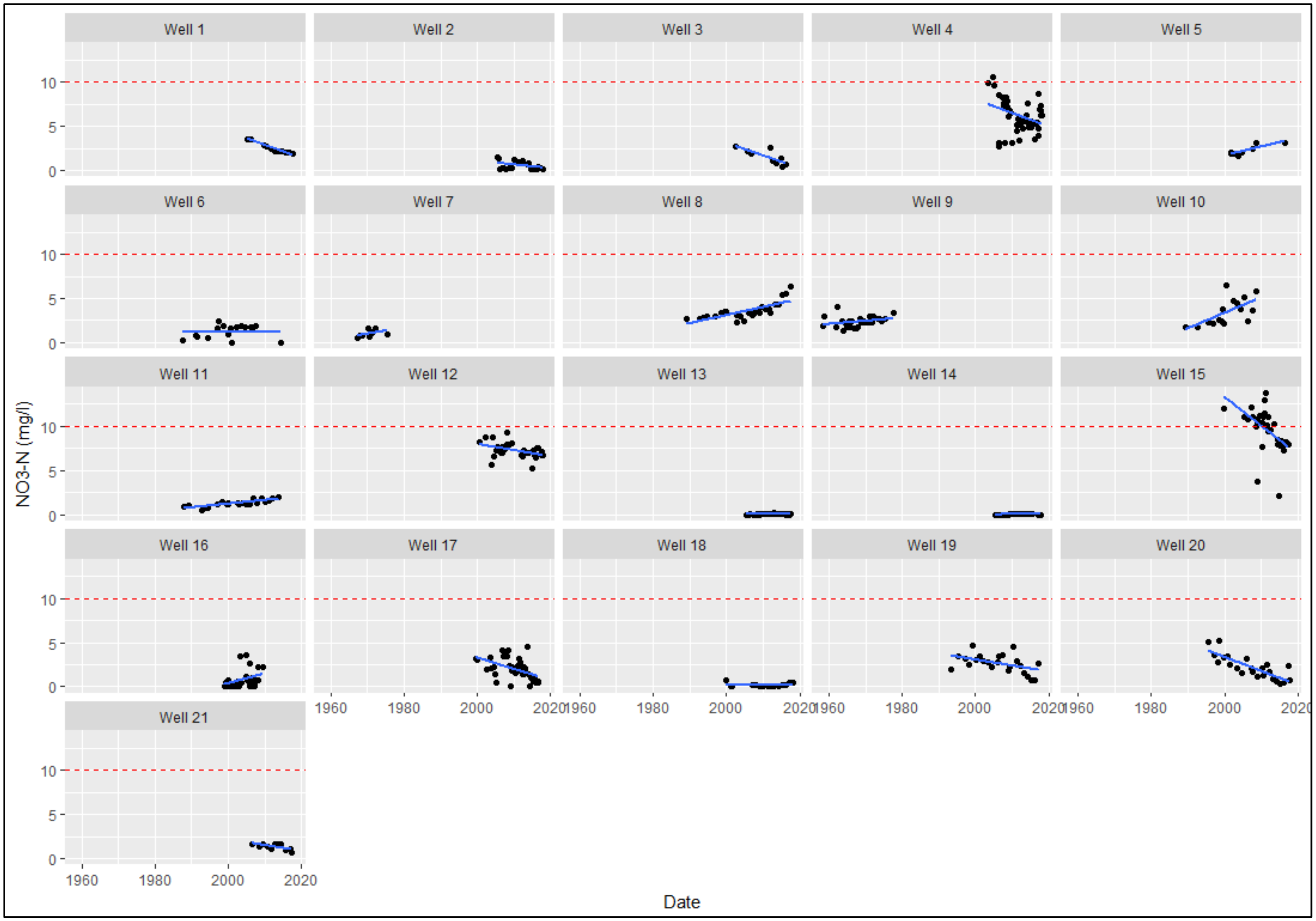

Figure 11. Scatter plots for all wells within the Santa Ynez subbasin with statistically significant trends in nitrate concentration through time. *Black dots are individual nitrate concentration measurements, blue line is the regression line. Well numbers correspond to the numbers in Figure 10 and Table 7.*

OWTS Impacts Statistical Model

To understand how varying land uses and multiple hydrogeological parameters may be simultaneously affecting groundwater nitrate concentrations, a multiple regression model was evaluated. This model evaluates correlations (or lack thereof) between the nitrate concentration measured in wells and a variety of land use (e.g. OWTS density, proximity to agricultural lands) and hydrogeological parameters (recharge, depth to groundwater, etc.). For example, it is anticipated that wells located in areas of high OWTS density would have higher nitrate concentrations. However, we also know that there are other factors that affect nitrate concentration other than only OWTS density. The regression model attempts to evaluate the correlation between *all* the variables (predictor variables) that simultaneously might affect nitrate concentration.

The regression analysis was conducted for the entire SYRV groundwater basin and also for just the Santa Ynez subbasin. The regression model for the entire basin was not statistically significant, indicating that for the entire SYRV basin, there is low confidence that the land use and hydrogeological factors included in the model are correlated with measured nitrate concentrations. However, results for the Santa Ynez subbasin were highly significant ($p = 2*10^{-8}$) and the significant predictor variables of groundwater nitrate concentration were OWTS density and recharge rate, both of which were positively correlated with nitrate concentration. However, the R-squared and adjusted R-squared values of 0.35 and 0.33, respectively, indicate that the regression model accounts for a small portion of the variability in nitrate concentrations in the Santa Ynez subbasin (Figure 12) and there are likely other factors that were not included in the model that affect nitrate concentration. The coefficients for OWTS density and recharge were both positive and similar in magnitude (OWTS – 0.018; recharge – 0.022) indicating that both of these variables are correlated with increasing nitrate concentrations and the magnitude of the effect is similar for both variables. The relatively large coefficient for recharge may be a result of the high recharge rates and moderate nitrate concentrations in the foothills northeast of highway 154. Proximity to agricultural lands was not a statistically significant predictor of nitrate concentration. The regression equation and results of the regression analysis are shown in Table 5, and a plot of the modeled versus measured concentrations is shown in Figure 12.

Because the depth to the top of the well screen was not a statistically significant predictor of nitrate concentration for this dataset, the regression analysis was re-run without including depth to the top of the well screen. By excluding the depth to the top of the well screen as a variable, additional data could be included from a greater number of wells that did not have well construction information ($n = 175$ versus $n = 92$). This second regression analysis was again highly significant ($p = 2*10^{-11}$) in the Santa Ynez subbasin but the correlation coefficients ($R^2 = 0.27$; adj. $R^2 = 0.25$) were also small, indicating that the model explains a small portion of the variability in nitrate concentration (Figure 12). However, this second regression model yielded a greater number of statistically significant predictor variables (Table 5). These predictor variables were all positively correlated with predicted nitrate concentration and included the density of OWTS, proximity to agricultural lands, recharge rate, and depth to groundwater. The coefficients associated with septic density and recharge were again similar in magnitude, indicating that these two variables' predicted impact on nitrate concentration was similar in magnitude. The coefficients for groundwater depth and proximity to agricultural lands were one and two orders of magnitude smaller than septic density or recharge, respectively, indicating that depth to groundwater and proximity to agricultural lands had a much smaller effect on modeled nitrate concentration.

The positive correlation between depth to groundwater and nitrate concentration is not immediately intuitive. In general, a decreasing potential for groundwater pollution with increasing depth to groundwater is expected. However, because the Santa Ynez River is a major source of recharge, groundwater near the river is both shallow and low in concentration due to dilution. North of the river, depth to groundwater increase quickly but dilution potential decreases quickly. As a result, in the Santa Ynez subbasin, as depth to groundwater increases, dilution potential decreases, and nitrate concentrations are higher.

Another result of the regression model that is not immediately intuitive is the correlation between proximity (distance) to agricultural lands and predicted nitrate concentration. An inverse relationship might be expected because as distance from a well to agricultural lands decreases, nitrate concentrations should increase. The positive correlation between distance to agricultural lands and nitrate concentration is anticipated because urban areas, where septic density is highest, tend to be further from agricultural lands. As a result, the model predicts that the further a well is from agricultural lands (and by corollary, the closer the well is to urban/high septic density areas), the higher the nitrate concentration will be. This relationship will probably not hold true for all groundwater basins but in the Santa Ynez subbasin, where industrial-type (i.e., irrigated food crops) farming is less prevalent, this relationship seems plausible.

The results of both regression analyses (with and without screened interval depths) indicate that OWTS density is a statistically significant predictor variable and has a positive correlation with groundwater nitrate concentrations. If the screened interval depth is included into the regression analysis, OWTS is predicted to increase groundwater nitrate concentration by 0.018 mg/L for each additional OWTS per square mile. If the top of the screened interval is excluded as an explanatory variable (and increase the sample size) the OWTS impact on nitrate concentration decreases slightly to 0.012 mg/L per additional OWTS per square mile. For reference, the regression equations predict that in an area where OWTS is 425 units/mi^2 (such as near the Janin Acres subdivision or the town of Santa Ynez), OWTS is predicted to increase the groundwater nitrate concentration by approximately 5 – 7.5 mg/L. It is important to note the regression model predicts that recharge rates also will have a substantial impact on nitrate concentrations. An important implication of this result is that within the Santa Ynez subbasin, areas with high recharge rates and a high density of septic systems are the most susceptible to groundwater pollution.

Table 5. Results of regression analysis. Only statistically significant predictor variables are included in the regression equation. The upper regression equation was from the analysis that included wells with information regarding the depth of the top of the screened interval (n = 92). The lower equation excluded screened interval depth as a predictor but had a greater number of samples (n = 175). P-values are for the regression model, not the individual predictor variables.

Method	**Regression Equation**	**n**	**p**	**R^2**
With screened interval depth	[NO_3-N (mg/L)] = -1.20 + 0.018 OTWS + 0.022 recharge rate	92	$2*10^{-8}$	0.35
Without screened interval depth	[NO_3-N (mg/L)] = -0.97 + 0.012 OTWS+ 0.0002 ag. prox. + 0.013 recharge + 0.007 GW depth	175	$2*10^{-11}$	0.28

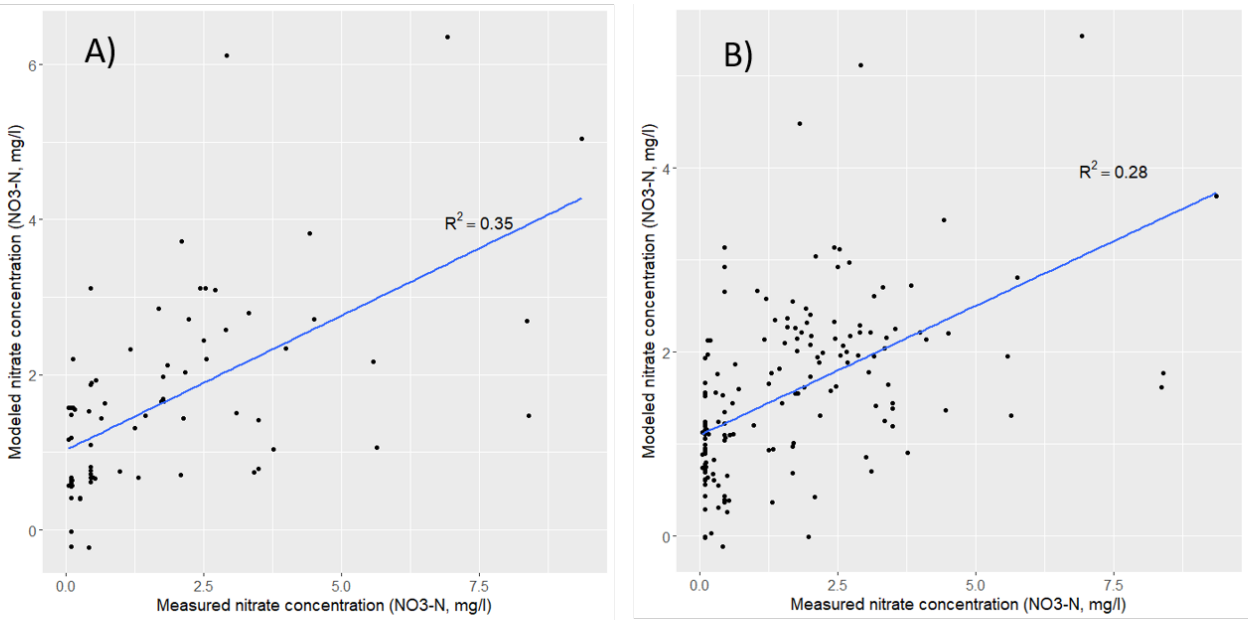

Figure 12. Results of regression analysis. *Observed nitrate concentration values are plotted along the horizontal axis and modeled nitrate concentration values are plotted along the vertical axis. A) Regression analysis using depth to the top of a wells screen as a predictor variable. B) Regression results when excluding the well screen depth as a predictor variable.*

Conclusions

Identifying land use practices that are causing water quality impairment is critical for water resource regulation and land use planning. Identification of these areas can help guide enforcement of current regulation and the development and rationale for future investigation or regulation. This report identifies pollutants of concern, impaired wells, and areas where domestic wells may be at risk of pollution. In addition, OWTS density was mapped and OWTS risk through the greater SYRV basin was quantified, followed by further examination of the risk posed by OWTS in the Santa Ynez subbasin.

The overview of pollutants in each of the five subbasins revealed that arsenic and hexavalent chromium both exceed the drinking water standards in a substantial number of wells. For arsenic, impairment is widespread throughout the Lompoc Terrace subbasin. Arsenic occurs naturally as a trace component in many rocks and sediments. Whether the arsenic is released from these geologic sources into groundwater depends on the chemical form of the arsenic, the geochemical conditions in the aquifer, and the biogeochemical processes that occur. Most of the arsenic detections in water supply are typically associated with natural conditions but industrial sources are also potential causes for arsenic discharges. There are a few domestic wells in that basin that could be at risk. Arsenic concentrations in municipal wells within the City of Lompoc exhibit statistically significant increases in concentration through time and further investigation as to the cause of this increase may be warranted. This report only includes a summary of a statistical analysis of the data and an evaluation of sources of arsenic was not performed.

For hexavalent chromium, the Santa Ynez subbasin appears to be the most impaired. Within this subbasin, 12 of the 24 wells sampled had median concentrations that exceeded the previously established hexavalent chromium drinking water standard of 10 µg/L and many of the impaired wells are located near areas with a high density of domestic wells. Additionally, the number of wells sampled for hexavalent chromium in the other basins is much lower than in the Santa Ynez basin, which suggests that there may be hexavalent chromium impairment in the other basins that the public is unaware of. Hexavalent chromium can occur naturally in the environment or from industrial discharges. This report only includes a summary of a statistical analysis of the data, an evaluation of the sources of chromium was not performed.

The results from the evaluation of nitrate pollution has revealed that the Lompoc Plain subbasin generally has the most samples exceeding the MCL for nitrate and this subbasin has the most wells that are impaired. Shallow groundwater, widespread intensive agriculture, moderate OWTS density, and limited recharge from the Santa Ynez river all probably contribute to the nitrate problem in the Lompoc Plain subbasin. However, the median well concentration in the Lompoc Plain subbasin is similar in magnitude to the other subbasins (Figure 17). The Lompoc Plain subbasin stands out by having a greater number of wells with median concentrations in excess of the MCL.

A basin-wide analysis of OWTS density and OWTS risk was conducted. This analysis showed that the highest OWTS density areas were located in the Santa Ynez subbasin, near the towns of Los Olivos, Santa Ynez, and the Janin Acres subdivision. This is not necessarily new information, as these areas have been previously identified as OWTS problem areas (Hantzsche, 2003). However, the risk-based analysis described in this report provides a map of OWTS densities throughout the SYRV basin and allows for a quick comparison of densities for different areas in the basin. The OWTS risk analysis revealed that the highest OWTS risk in the entire SYRV basin occurs near the Janin Acres subdivision. This high risk score is largely a factor of the high density and shallow depth to groundwater in the area. The risk analysis also showed that the Lompoc Plain subbasin and the foothills northeast of Los Olivos are also at risk from OWTS. Although OWTS densities in both areas are low to moderate, the shallow depth to groundwater creates conditions where lower OWTS density can cause pollution and a risk to drinking water.

The OWTS impacts in the Santa Ynez subbasin indicate that OWTS is likely causing some impairment with respect to groundwater nitrate concentrations. In areas that are either high OWTS density or high risk of OWTS impairment, high and/or increasing nitrate concentrations are observed. However, there are also decreasing and/or low nitrate concentrations in high density or high OWTS risk areas. The seeming lack of consistency in nitrate concentrations in high density/high risk areas is partially a function of the depth of the well screen. Wells with deeper perforated intervals are likely pumping older water that has less communication with the land surface above and as a result, has lower nitrate concentrations. For the wells that have both construction information and concentration data, higher concentrations in shallower wells is generally observed. However, in the Santa Ynez subbasin, many supply wells are located within the Santa Ynez River channel. These wells are often shallow but have high quality water due to the near-constant recharge and dilution from the surface water from the Santa Ynez River channel. As such, the shallow groundwater is not always more polluted than deeper groundwater in the Santa Ynez basin. One other confounding factor is that municipal supply wells are often abandoned once nitrate concentrations exceed the MCL. Once the well is abandoned, the nitrate concentration data is no longer easily accessible. As such, there is a sampling bias towards wells that are not impaired because unimpaired wells have easily accessible data. While this bias is difficult to quantify or correct for, it is important to acknowledge.

The statistical models both indicate that OWTS density is significantly positively correlated with nitrate concentration. The results of the statistical model indicate that for an area with an OWTS density of 425 unit/mi^2, such as Janin Acres or Los Olivos, OWTS are expected to contribute between 5 and 7.5 mg/L of nitrate. When accounting for the other significant predictors of nitrate concentration, the predicted resultant nitrate concentration is even higher. Although the statistical models explain a relatively small amount of the nitrate variability, they are useful in identifying the multiple factors that may be impacting nitrate concentrations. For example, the results reveal that precipitation-driven recharge is a significant predictor and has a similar magnitude of impact on nitrate concentration as OWTS density. This result suggests that land use planners and regulators may want to carefully consider recharge rates when creating regulations regarding OWTS density.

While this analysis focused on the impacts of OWTS on nitrate concentrations, OWTS can also contribute pathogens, which can pose a far greater risk to human health. Although pathogens typically die off quickly after discharge from an OWTS, wells that have shallow screens may be vulnerable to pollution from pathogens due to the short travel times between the OWTS leachfield and the well. Further investigation of OWTS impacts in the Santa Ynez subbasin may want to include sampling for pathogens in wells that may be highest risk. In addition, future investigations should focus on sampling for chemical constituents that can uniquely identify wastewater. Nitrogen and oxygen isotopes of nitrate, pharmaceutical compounds, and organic compounds such as caffeine, artificial sweeteners, or nicotine have all been used to identify septic wastewater in groundwater systems (Bishop et al., 2015; Katz and Griffin, 2007; Seiler et al., 1999; Kendall, 1998). Additionally, purpose-built groundwater monitoring wells with a discrete vertical sampling horizon and low pumping rates would allow for the collection of samples that can provide information on a narrower spatial and temporal range and allow for better characterization of potential pollutant sources such as OWTS. Finally, numerical groundwater modeling may prove valuable in helping to simulate the cumulative waste loading occurring in an area of high OWTS density.

The high density of OWTS in the Santa Ynez subbasin has concerned water resource managers and regulators and land use planners for at least two decades. The density alone strongly suggests that there will be impacts to groundwater quality. The risk and statistical models both indicate that OWTS impacts are likely occurring in the Santa Ynez subbasin. The groundwater quality data is difficult to interpret due to seeming inconsistency in concentrations measured between closely located wells. However, wells within the highest risk and/or highest density areas typically exhibit high concentrations and/or increasing trends, particularly when accounting for the depth of the well screen.

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Appendix A: Tables

Table 6. Ratings and weights for the different parameters used in the OWTS risk model.

Septic Density **weight - 6** **OWTS/mi^2**	**Groundwater Depth** **weight - 5** **Depth (feet)**	**Recharge** **weight - 4** **Inches**	**Aquifer material** **weight - 2** **Subbasin**	**Soil media** **weight - 2** **Drainage Class**	**Topography** **weight - 1** **Slope (%)**	**Vadose Zone** **weight - 3** **Surface Geology**	**Risk Rating**
1 - 10	100+	0 - 2		very poor	18+		**1**
	75 - 100			poorly drained			**2**
11 - 40	50 - 75	2 - 4			12 - 18		**3**
				somewhat poorly drained		Serpentinite + peridotite	**4**
	30 - 50			moderately well drained	6 - 12		**5**
		4 - 7	Santa Ynez; Santa Rita; Lompoc Upland; Lompoc Terrace	well drained		Sandstone + mudstone	**6**
41 - 100	15 - 30						**7**
		7 - 10	Lompoc Plain	somewhat excessive		alluvium + terrace; sandstone + conglomerate	**8**
	5 - 10	10+			2 - 6	dune sand	**9**
101 - 450	<5			excessively drained	0 - 2		**10**

Table 7. Select information on wells in the Santa Ynez subbasin with statistically significant changes in concentration through time.

Well numbers correspond to the well numbers in Figure 10 and Figure 11. Depth to groundwater was determined by kriging point measurements of groundwater elevation collected in spring of 2018 and as such, is an approximate depth.

Well Number	Well ID	Latitude	Longitude	Mean NO_3-N (mg/L)	Median NO_3-N (mg/L)	Slope of trend (mg/L/year)	Well Type	Well depth (ft)	Depth to top of screen (ft)	Screen length (ft)	*Depth to GW (ft)
Well 1	4200936-001	34.7265	-120.128388	2.67	2.48	-0.149	MUNICIPAL				60
Well 2	L10004697449 MW8	34.6938232	-120.1306204	0.6	0.37	-0.065	MONITORING	406	383	20	76
Well 3	4200837-004	34.67412	-120.093948	1.52	1.27	-0.158	MUNICIPAL	745	395	340	99
Well 4	4200800-001	34.666556	-120.134194	6.15	5.65	-0.153	MUNICIPAL		523	16	99
Well 5	4200807-009	34.664976	-120.056252	2.29	2.08	0.096	MUNICIPAL	730	360	260	145
Well 6	4210020-011	34.653758	-120.114842	1.31	1.58	0.026	MUNICIPAL			520	99
Well 7	USGS-343901120013401	34.6502642	-120.0270882	1.04	0.95	0.145					169
Well 8	4210020-018	34.620953	-120.085337	3.6	3.39	0.080	MUNICIPAL		130	310	107
Well 9	USGS-343708120045201	34.6188757	-120.0820903	2.38	2.37	0.055					107
Well 10	4210020-005	34.617513	-120.076757	3.48	3.07	0.184					114
Well 11	4210020-006	34.617424	-120.076848	1.31	1.27	0.041	MUNICIPAL		305	47	114
Well 12	4200616-004	34.617306	-120.091952	7.26	7.23	-0.058	MUNICIPAL		120	280	107
Well 13	L10004435913 LARNER	34.615403	-120.1515683	0.09	0.07	0.011	MONITORING	400	245	70	60
Well 14	L10004435913 MW13	34.6140538	-120.1584037	0.09	0.06	0.017	MONITORING	290	269	20	60
Well 15	4200531-010	34.602653	-120.11152	9.58	10.3	-0.321	MUNICIPAL		75	40	76
Well 16	WDR100034624 Well 1 downgrade	34.590051	-120.1571864	0.84	0.54	0.077	MONITORING				37
Well 17	WDR100034624 Well 3 Upgrade	34.588721	-120.1572883	1.94	1.9	-0.185	MONITORING				37
Well 18	4200612-007	34.58578	-120.058542	0.22	0.11	0.020	MUNICIPAL		25	35	76
Well 19	4210013-005	34.585659	-120.144046	2.63	2.71	-0.078	MUNICIPAL		25	20	45
Well 20	4210013-007	34.585032	-120.141094	2.19	2.08	-0.153	MUNICIPAL		30	20	52
Well 21	4210020-026	34.582853	-120.121702	1.36	1.45	-0.070	MUNICIPAL	1205	940	190	52

Table 8. The minimum number of measured exceedances needed to place a water segment on the section 303(d) list for conventional or other pollutants.
(Adapted from the Listing Policy,303(d) listing policy Table 3.2) [15]

<table>
<tr><td colspan="2"><i>Null Hypothesis: Actual exceedance proportion < 10 percent.</i>
<i>Alternate Hypothesis: Actual proportion > 25 percent.</i>
<i>The minimum effect size is 15 percent.</i>
*Application of the binomial test requires a minimum sample size of 26. The number of exceedances required using the binomial test at a sample size of 26 is extended to smaller sample sizes.</td></tr>
<tr><th>Sample Size</th><th>List if the number of exceedances equal or is greater than</th></tr>
<tr><td>5 – 30</td><td>5*</td></tr>
<tr><td>31 – 36</td><td>6</td></tr>
<tr><td>37 – 42</td><td>7</td></tr>
<tr><td>43 – 48</td><td>8</td></tr>
<tr><td>49 – 54</td><td>9</td></tr>
<tr><td>55 – 60</td><td>10</td></tr>
<tr><td>61 – 66</td><td>11</td></tr>
<tr><td>67 – 72</td><td>12</td></tr>
<tr><td>73 – 78</td><td>13</td></tr>
<tr><td>79 – 84</td><td>14</td></tr>
<tr><td>85 – 91</td><td>15</td></tr>
<tr><td>92 – 97</td><td>16</td></tr>
<tr><td>98 – 103</td><td>17</td></tr>
</table>

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[15] *Application of the binomial test requires a minimum sample size of 26. The number of exceedances required using the binomial test at a sample size of 26 is extended to smaller sample sizes.
For sample sizes greater than 121, the minimum number of measured exceedances is established where α and $\beta < 0.2$ and where $|\alpha - \beta|$ is minimized.

α = Excel® Function BINOMDIST(n-k, n, 1 – 0.10, TRUE)
β = Excel® Function BINOMDIST(k-1, n, 0.25, TRUE)

where n = the number of samples,
k = minimum number of measured exceedances to place a water segment on section 303(d) list, 0.10 = acceptable exceedance proportion, and 0.25 = unacceptable exceedance proportion.

Expanded tables up to 20,000 samples can be found on the State Water Board website located at: www.waterboards.ca.gov/water_issues/programs/tmdl/docs/303d_binomial_tables.xls

Table 9. the minimum number of measured exceedances needed to place a water segment on the section 303(d) list for toxicants. *Adapted from the Listing Policy,303(d) listing policy Table 3.1.*

Null Hypothesis: Actual exceedance proportion ≤ 3 percent.

Alternate Hypothesis: Actual exceedance proportion > 18 percent.

The minimum effect size is 15%

**Application of the binomial test requires a minimum sample size of 16. The number of exceedances required using the binomial test at a sample size of 16 is extended to smaller sample sizes.*

Sample Size	**List if the number of exceedances are equal to or greater than**
2-24	2*
25-36	3
37-47	4
48-59	5
60-71	6
72-82	7
83-94	8
95-106	9
107-117	10
118-129	11
130-141	12
142-152	13
153-164	14
165-176	15

Summary Tables

Tables 10 - 13. Mean Summary Tables by pollutant, subbasin, and aquifer.
Table 14. Impairment Summary Tables by pollutant, subbasin, and aquifer.
Tables 15 - 18. Well Trend Summary Table by pollutant, subbasin, and aquifer.

Table 10. Concentration summaries for arsenic and hexavalent chromium by subbasin and depth. *Well % exceedance indicates the number of wells whose median concentration exceeds the relevant standard. Sample % exceedance indicates the number of samples that exceed the relevant standard.*

Pollutant	Subbasin	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed	Sample % Exceed
Arsenic, µg/L	**Lompoc Plain**	**0**	**44**	**5.68**	**4**	**5.96**	**1**	**9**	**162**	**448**	**50**	**26%**	**18%**
	> 200 feet bgs	0	44	8.78	2	14.37	NA	10	4	9	4	25%	11%
	< 200 feet bgs	0	23	9.12	7	5.9	5	15	12	138	18	17%	30%
	Lompoc Terrace	**0**	**2550**	**55.8**	**3.04**	**208.39**	**NA**	**13**	**845**	**1771**	**298**	**42%**	**31%**
	> 200 feet bgs	0	27.3	7.51	NA	6.2	NA	9.68	12	21	3	1%	24%
	< 200 feet bgs	0	353	17.81	5	43.95	NA	12.9	428	911	153	22%	31%
	Lompoc Upland	**0**	**50**	**3.56**	**3**	**4.22**	**5**	**5**	**39**	**103**	**21**	**38%**	**10%**
	> 200 feet bgs	0	50	4.57	3.3	4.32	2.1	5.7	29	67	7	24%	10%
	< 200 feet bgs	0	11	2.91	2	2.96	0	4	7	32	10	5%	3%
	Santa Rita	**0**	**53**	**4.4**	**2.7**	**6.39**	**NA**	**3.9**	**53**	**118**	**19**	**21%**	**12%**
	> 200 feet bgs	0	20	6.02	3.6	5.55	2.1	9.1	13	55	7	5%	18%
	< 200 feet bgs	0	53	2.9	NA	7.06	NA	2.8	35	55	7	11%	5%
	Santa Ynez	**0**	**30**	**2.42**	**NA**	**1.47**	**NA**	**3**	**162**	**259**	**73**	**7%**	**2%**
	> 200 feet bgs	0	10	2.46	1.6	1.28	NA	3	47	89	28	0%	0%
	< 200 feet bgs	0	30	2.56	NA	1.57	NA	2.5	84	121	30	3%	2%
Hexavalent Chromium, µg/L	**Lompoc Plain**	**0**	**1**	**NA**	**NA**	**NA**	**NA**	**NA**	**42**	**46**	**17**	**0%**	**0%**
	> 200 feet bgs	0	0	NA	NA	NA	NA	NA	4	4	1	0%	0%
	< 200 feet bgs	0	1	NA	NA	NA	NA	NA	22	24	0	0%	0%
	Lompoc Terrace	**0**	**2,900**	**118.3**	**6.29**	**451.13**	**NA**	**16**	**46**	**146**	**32**	**25%**	**38%**
	> 200 feet bgs	0	-	-	-	-	-	-	-	-	-	-	-
	< 200 feet bgs	0	2,900	276.95	NA	762.32	NA	NA	31	49	20	20%	29%
	Lompoc Upland	**0**	**1.3**	**NA**	**NA**	**NA**	**NA**	**NA**	**12**	**14**	**7**	**0%**	**0%**
	> 200 feet bgs	0	1.3	NA	NA	NA	NA	NA	12	14	7	0%	0%
	< 200 feet bgs	0	-	-	-	-	-	-	-	-	-	-	0%

Pollutant	Subbasin	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed	Sample % Exceed
	Santa Rita	**0**	**1.9**	**NA**	**NA**	**NA**	**NA**	**NA**	**16**	**18**	**11**	**0%**	**0%**
	> 200 feet bgs	0	1.9	NA	NA	NA	NA	NA	11	13	6	0%	0%
	< 200 feet bgs	0	0	NA	NA	NA	NA	NA	5	5	5	0%	0%
	Santa Ynez	**0**	**43**	**9.83**	**9.1**	**8.82**	**1**	**16**	**44**	**180**	**45**	**40%**	**41%**
	> 200 feet bgs	0	36	9.58	8.9	8.25	1.6	8.9	24	124	21	27%	38%
	< 200 feet bgs	0	36	10.64	12	9.63	NA	NA	16	45	20	9%	51%

Table 11. Concentrations summaries for iron and manganese by subbasin and depth. *Well % exceedance indicates the number of wells whose median concentration exceeds the relevant standard. Sample % exceedance indicates the number of samples that exceed the relevant standard.*

Pollutant	Subbasin/ Aquifer	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed	Sample % Exceed
Iron, µg/L	**Lompoc Plain**	**0**	**70,000**	**1,449**	**270**	**3,001.54**	**20**	**2,100**	**245**	**1,538**	**222**	**52%**	**49%**
	> 200 feet bgs	0	4,590	400.17	94.6	900.62	22	267	8	96	11	4%	18%
	< 200 feet bgs	0	70,000	1,676.76	710	3,111.47	30	2,240	56	1,067	156	37%	58%
	Lompoc Terrace	**0**	**343,000**	**5,818**	**192**	**19,708.25**	**NA**	**2,390**	**476**	**1,860**	**361**	**63%**	**45%**
	> 200 feet bgs	0	47,100	2,106.17	50	7,022.51	10	380	2	99	11	1%	25%
	< 200 feet bgs	0	343,000	7,761.33	324	23,971.32	NA	5,140	255	996	196	36%	51%
	Lompoc Upland	**0**	**4,400**	**129.3**	**NA**	**274.08**	**NA**	**200**	**346**	**635**	**30**	**47%**	**11%**
	> 200 feet bgs	0	4,400	176.4	120	293.97	NA	235	192	421	13	27%	14%
	< 200 feet bgs	0	1,600	118.24	20	290.6	5	60	16	74	12	17%	11%
	Santa Rita	**0**	**26,000**	**361.7**	**29.9**	**2,004.37**	**NA**	**130**	**76**	**182**	**74**	**24%**	**15%**
	> 200 feet bgs	0	4,000	241.58	30	597.29	NA	144	24	76	27	8%	17%
	< 200 feet bgs	0	26,000	469.69	10	2,862.42	NA	75	47	86	37	11%	9%
	Santa Ynez	**0**	**32,400**	**776.9**	**20**	**2,721.14**	**NA**	**250**	**420**	**917**	**156**	**29%**	**23%**
	> 200 feet bgs	0	20,500	1,150.19	38	2,887.13	NA	650	126	307	62	10%	32%
	< 200 feet bgs	0	20700	438.09	20	1772.31	NA	160	227	484	63	14%	18%
Manganese, µg/L	**Lompoc Plain**	**0**	**25000**	**694.6**	**540**	**953.99**	**145**	**920**	**106**	**1241**	**113**	**96%**	**79%**
	> 200 feet bgs	0	887	190.35	84.7	208.46	32	331	5	89	10	8%	67%
	< 200 feet bgs	0	25000	910.41	710	1077.69	478	1120	4	823	80	68%	95%
	Lompoc Terrace	**0**	**41600**	**520.2**	**102**	**1780.21**	**21**	**357**	**185**	**2089**	**331**	**75%**	**63%**
	> 200 feet bgs	0	1660	143.15	40	330.22	7	61.2	9	50	5	1%	34%

Pollutant	Subbasin/ Aquifer	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed	Sample % Exceed
	< 200 feet bgs	0	41600	675.33	127	2241.03	23.4	447	101	1238	173	41%	67%
	Lompoc Upland	**0**	**1300**	**59.31**	**47**	**78.96**	**NA**	**90**	**205**	**616**	**26**	**81%**	**47%**
	> 200 feet bgs	0	420	75.94	75	55.16	36	98	59	416	12	46%	65%
	< 200 feet bgs	0	1,300	79.87	27	178.52	1	90	14	60	10	58%	33%
	Santa Rita	**0**	**720**	**52.99**	**NA**	**107.35**	**NA**	**36**	**213**	**351**	**34**	**56%**	**23%**
	> 200 feet bgs	0	720	79.52	6.8	138.36	NA	120	22	70	16	21%	40%
	< 200 feet bgs	0	490	175.53	200	135.3	21	270	13	58	11	21%	69%
	Santa Ynez	**0**	**11,600**	**118.9**	**27.5**	**485.06**	**NA**	**91**	**271**	**816**	**94**	**31%**	**40%**
	> 200 feet bgs	0	11,600	178.26	49	763.91	0.9	130	72	269	32	14%	49%
	< 200 feet bgs	0	3,250	99.42	27.5	265.69	3.1	82.5	132	449	44	32%	40%

Table 12. Concentration summaries for nitrate and sulfate by subbasin and depth. *Well % exceedance indicates the number of wells whose median concentration exceeds the relevant standard. Sample % exceedance indicates the number of samples that exceed the relevant standard.*

Pollutant	Subbasin	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed	Sample % Exceed
Nitrate as nitrogen, mg/L	**Lompoc Plain**	**0**	**104**	**1.98**	**0.14**	**7.17**	**NA**	**1.13**	**936**	**2,744**	**310**	**7%**	**4%**
	> 200 feet bgs	0	27.11	3.87	0.04	7.84	NA	0.45	37	81	12	0%	20%
	< 200 feet bgs	0	104	2.24	0.32	7.92	0	1.36	427	1,820	158	3%	4%
	Lompoc Terrace	**0**	**80.4**	**2.73**	**0.11**	**7.6**	**NA**	**1.8**	**339**	**1,299**	**194**	**9%**	**7%**
	> 200 feet bgs	0	7.45	0.82	0.29	1.46	0.11	0.84	1	122	12	0%	0%
	< 200 feet bgs	0	80.4	3.53	0.12	8.75	NA	3.89	207	812	115	7%	9%
	Lompoc Upland	**0**	**6.2**	**0.76**	**0.16**	**1.14**	**NA**	**1.3**	**121**	**266**	**30**	**0%**	**0%**
	> 200 feet bgs	0	5.87	0.63	NA	1.12	NA	0.99	109	194	13	0%	0%
	< 200 feet bgs	0.02	1.6	0.92	1.2	0.64	0.56	1.5	0	9	4	0%	0%
	Santa Rita	**0**	**27**	**4.84**	**1.92**	**6.34**	**0**	**7.23**	**204**	**875**	**172**	**7%**	**16%**
	> 200 feet bgs	0	19.43	2.81	1.7	3.47	0.34	4.52	44	188	20	2%	4%
	< 200 feet bgs	0	27	7.57	5.9	7.46	0.68	13	72	430	30	2%	29%
	Santa Ynez	**0**	**13.78**	**1.68**	**0.86**	**2.3**	**NA**	**2.48**	**597**	**2,020**	**214**	**3%**	**1%**
	> 200 feet bgs	0	10.62	1.51	0.9	1.87	0.05	2.48	154	627	57	0%	0%
	< 200 feet bgs	0	13.78	1.87	0.1	2.93	NA	2.71	384	887	67	1%	3%
Sulfate, mg/L	**Lompoc Plain**	**0**	**4,080**	**528.3**	**416**	**475.44**	**338**	**573**	**9**	**2,868**	**407**	**45%**	**31%**
	> 200 feet bgs	0	980	237.82	220	147.41	153	310	1	97	12	1%	4%

Pollutant	Subbasin	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed	Sample % Exceed
	< 200 feet bgs	0	4,080	591.85	405	607.2	296	670	1	1,564	222	26%	36%
	Lompoc Terrace	**0**	**5,650**	**268.2**	**101**	**635.74**	**38.5**	**262**	**29**	**1,784**	**271**	**14%**	**9%**
	> 200 feet bgs	0	490	97.45	107	62.09	47.5	129	0	115	12	0%	0%
	< 200 feet bgs	0	4,080	261.18	102	598.14	34.1	272	21	1,077	164	7%	8%
	Lompoc Upland	**8.6**	**1,720**	**127.9**	**110**	**136.32**	**69**	**152**	**0**	**185**	**42**	**2%**	**1%**
	> 200 feet bgs	15	345	128.89	111.5	68.03	85.5	160	0	108	16	0%	0%
	< 200 feet bgs	8.6	270	106.98	100	58.44	64	150	0	64	14	0%	0%
	Santa Rita	**2**	**2,420**	**301.4**	**260**	**254.71**	**150**	**360**	**0**	**669**	**195**	**22%**	**14%**
	> 200 feet bgs	2	890	108.26	48	133.58	31	140	0	113	33	1%	2%
	< 200 feet bgs	10	2,420	345.61	270	262.38	210	340	0	355	56	9%	15%
	Santa Ynez	**0**	**2,680**	**186.9**	**170**	**173.04**	**58**	**270**	**1**	**1,371**	**250**	**4%**	**5%**
	> 200 feet bgs	0.36	750	147.85	110	136.01	42	210	0	436	82	1%	3%
	< 200 feet bgs	1.9	2,680	248.72	235	210.23	130	300	0	577	73	2%	8%

Table 13. Mean concentrations summary for TDS by subbasin and depth. *Well % exceedance indicates the number of wells whose median concentration exceeds the relevant standard. Sample % exceedance indicates the number of samples that exceed the relevant standard.*

Pollutant	Subbasin	Min.	Max.	Mean	Med.	SD	25%	75%	ND	Samples	Wells	Well % Exceed	Sample % Exceed
TDS, mg/L	**Lompoc Plain**	**0**	**24,000**	**1,609**	**1,190**	**1,474.27**	**860**	**1,880**	**11**	**3,965**	**402**	**86%**	**61%**
	> 200 feet bgs	0	5560	1,581.32	996	1,425.4	800	1,120	1	157	12	2%	45%
	< 200 feet bgs	0	24000	1,843.29	1,400	1,750.05	986	2,050	1	2,453	221	49%	72%
	Lompoc Terrace	**220**	**16,100**	**1,233**	**758.5**	**1,762.08**	**544**	**1,200**	**0**	**468**	**76**	**63%**	**35%**
	> 200 feet bgs	249	6,480	711.29	684	478.46	513	762	0	189	12	8%	6%
	< 200 feet bgs	230	9,040	1,399.28	1,110	1418.07	649	1,370	0	208	43	42%	56%
	Lompoc Upland	**228**	**3,730**	**597.6**	**560**	**261.36**	**490**	**665**	**0**	**308**	**44**	**7%**	**2%**
	> 200 feet bgs	245	990	587.21	560	147.62	489	711	0	130	16	0%	0%
	< 200 feet bgs	228	1,670	663.46	653.5	295.72	472	758	0	72	14	2%	7%
	Santa Rita	**100**	**5,120**	**1,030**	**920**	**539.83**	**736**	**1,180**	**0**	**795**	**197**	**50%**	**37%**
	> 200 feet bgs	178	1,840	671.94	700	304	405	837	0	165	34	3%	10%
	< 200 feet bgs	100	5,120	1,176.57	990	564.8	830	1,300	0	413	55	20%	44%
	Santa Ynez	**193**	**3,400**	**320.5**	**680**	**320.5**	**499**	**913**	**0**	**1,535**	**252**	**12%**	**15%**
	> 200 feet bgs	220	1,900	706.32	562.1	327.58	476	840	0	488	82	3%	18%
	< 200 feet bgs	260	3,400	836.93	830	347.77	621	990	0	614	73	8%	20%

Table 14. Summary of impaired wells by pollutant, subbasin, and depth. *The method used for determining impairment is described in Section 3.*

Pollutant	Subbasin	Impaired Wells	Impaired Wells <200 feet bgs	Impaired Wells >200 feet bgs
Arsenic	Lompoc Plain	9	5	0
	Lompoc Terrace	127	90	1
	Lompoc Upland	9	0	2
	Santa Rita	1	1	0
	Santa Ynez	0	0	0
Hexavalent Chromium	Lompoc Plain	0	0	0
	Lompoc Terrace	8	6	2
	Lompoc Upland	0	0	0
	Santa Rita	0	0	0
	Santa Ynez	13	2	5
Iron	Lompoc Plain	106	57	0
	Lompoc Terrace	186	125	7
	Lompoc Upland	12	1	4
	Santa Rita	16	2	4
	Santa Ynez	20	11	4
Manganese	Lompoc Plain	103	50	0
	Lompoc Terrace	242	170	7
	Lompoc Upland	19	3	4
	Santa Rita	17	3	5
	Santa Ynez	27	16	8
Nitrate	Lompoc Plain	23	12	0
	Lompoc Terrace	18	17	0
	Lompoc Upland	0	0	0
	Santa Rita	12	5	0
	Santa Ynez	4	2	0
Sulfate	Lompoc Plain	56	27	2
	Lompoc Terrace	18	13	0
	Lompoc Upland	0	0	0
	Santa Rita	4	1	0
	Santa Ynez	5	5	0
TDS	Lompoc Plain	139	84	2
	Lompoc Terrace	16	10	2
	Lompoc Upland	1	1	0

Pollutant	Subbasin	Impaired Wells	Impaired Wells <200 feet bgs	Impaired Wells >200 feet bgs
	Santa Rita	14	5	0
	Santa Ynez	17	12	3

Table 15. Trend analysis well summary results for arsenic and hexavalent chromium by subbasin and depth.

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
Arsenic	**Lompoc Plain**	**14**	**6**	**0**	**6**	**0%**	**43%**
	> 200 feet bgs	0	0	0	0	0%	0%
	< 200 feet bgs	9	5	0	5	0%	36%
	Lompoc Terrace	79	19	13	6	16%	8%
	> 200 feet bgs	2	1	1	2	1%	3%
	< 200 feet bgs	52	12	8	4	10%	5%
	Lompoc Upland	**7**	**0**	**0**	**0**	**0%**	**0%**
	> 200 feet bgs	5	0	0	0	0%	0%
	< 200 feet bgs	3	0	0	0	0%	0%
	Santa Rita	**8**	**1**	**1**	**0**	**13%**	**0%**
	> 200 feet bgs	4	1	1	0	13%	0%
	< 200 feet bgs	4	0	0	0	0%	0%
	Santa Ynez	**14**	**0**	**0**	**0**	**0%**	**0%**
	> 200 feet bgs	6	0	0	0	0%	0%
	< 200 feet bgs	8	0	0	0	0%	0%
Hexavalent Chromium	**Lompoc Plain**	**0**	**0**	**0**	**0**	**0%**	**0%**
	> 200 feet bgs	0	0	0	0	0%	0%
	< 200 feet bgs	0	0	0	0	0%	0%
	Lompoc Terrace	**9**	**3**	**3**	**0**	**33%**	**0%**
	> 200 feet bgs	0	0	0	0	0%	0%
	< 200 feet bgs	3	1	1	0	11%	0%
	Lompoc Upland	**0**	**0**	**0**	**0**	**0%**	**0%**
	> 200 feet bgs	0	0	0	0	0%	0%
	< 200 feet bgs	0	0	0	0	0%	0%
	Santa Rita	**1**	**0**	**0**	**0**	**0%**	**0%**
	> 200 feet bgs	1	0	0	0	0%	0%

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
	< 200 feet bgs	0	0	0	0	0%	0%
	Santa Ynez	**13**	**2**	**2**	**0**	**15%**	**0%**
	> 200 feet bgs	10	2	2	0	15%	0%
	< 200 feet bgs	3	0	0	0	0%	0%

Table 16. Trend analysis well summary results for iron and manganese by subbasin and depth.

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
Iron	**Lompoc Plain**	**67**	**34**	**10**	**24**	**15%**	**36%**
	> 200 feet bgs	8	2	0	2	0%	3%
	< 200 feet bgs	51	30	9	21	13%	31%
	Lompoc Terrace	**79**	**32**	**12**	**20**	**15%**	**25%**
	> 200 feet bgs	6	1	1	0	1%	0%
	< 200 feet bgs	51	20	6	14	8%	18%
	Lompoc Upland	**16**	**4**	**2**	**2**	**13%**	**13%**
	> 200 feet bgs	6	2	1	1	6%	6%
	< 200 feet bgs	10	2	1	1	6%	6%
	Santa Rita	**6**	**3**	**0**	**3**	**0%**	**50%**
	> 200 feet bgs	4	2	0	2	0%	33%
	< 200 feet bgs	1	0	0	0	0%	0%
	Santa Ynez	**40**	**10**	**10**	**0**	**25%**	**0%**
	> 200 feet bgs	14	3	3	0	8%	0%
	< 200 feet bgs	22	5	5	0	13%	0%
Manganese	**Lompoc Plain**	**62**	**28**	**22**	**6**	**35%**	**10%**
	> 200 feet bgs	8	4	3	1	5%	2%
	< 200 feet bgs	45	23	18	5	29%	8%
	Lompoc Terrace	**95**	**24**	**18**	**6**	**19%**	**6%**
	> 200 feet bgs	4	1	1	0	1%	0%
	< 200 feet bgs	65	17	13	4	14%	4%
	Lompoc Upland	**18**	**3**	**2**	**1**	**11%**	**6%**

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
	> 200 feet bgs	8	1	1	0	6%	0%
	< 200 feet bgs	10	2	1	1	6%	6%
	Santa Rita	**10**	**1**	**1**	**0**	**10%**	**0%**
	> 200 feet bgs	5	0	0	0	0%	0%
	< 200 feet bgs	3	1	1	0	10%	0%
	Santa Ynez	**31**	**13**	**9**	**4**	**29%**	**13%**
	> 200 feet bgs	11	4	3	1	10%	3%
	< 200 feet bgs	18	8	5	3	16%	10%

Table 17. Trend analysis well summary results for nitrate and sulfate by subbasin and depth.

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
Nitrate	**Lompoc Plain**	**59**	**23**	**8**	**16**	**14%**	**27%**
	> 200 feet bgs	2	0	0	0	0%	0%
	< 200 feet bgs	49	18	6	13	10%	22%
	Lompoc Terrace	**77**	**12**	**7**	**5**	**9%**	**6%**
	> 200 feet bgs	5	2	0	3	0%	4%
	< 200 feet bgs	47	8	5	2	6%	3%
	Lompoc Upland	**7**	**3**	**0**	**3**	**0%**	**43%**
	> 200 feet bgs	3	0	0	2	0%	29%
	< 200 feet bgs	0	2	0	0	0%	0%
	Santa Rita	**19**	**6**	**4**	**2**	**21%**	**11%**
	> 200 feet bgs	7	3	3	2	16%	11%
	< 200 feet bgs	11	3	1	0	5%	0%
	Santa Ynez	**75**	**28**	**10**	**18**	**13%**	**24%**
	> 200 feet bgs	30	15	4	5	5%	7%
	< 200 feet bgs	34	9	4	11	5%	15%
Sulfate	**Lompoc Plain**	**99**	**39**	**20**	**19**	**20%**	**19%**
	> 200 feet bgs	8	4	3	1	3%	1%
	< 200 feet bgs	77	29	12	17	12%	17%

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
	Lompoc Terrace	**124**	**39**	**26**	**13**	**21%**	**10%**
	> 200 feet bgs	5	1	1	0	1%	0%
	< 200 feet bgs	81	23	14	9	11%	7%
	Lompoc Upland	**17**	**1**	**1**	**0**	**6%**	**0%**
	> 200 feet bgs	7	0	0	0	0%	0%
	< 200 feet bgs	10	1	1	0	6%	0%
	Santa Rita	**17**	**5**	**1**	**4**	**6%**	**24%**
	> 200 feet bgs	6	2	0	2	0%	12%
	< 200 feet bgs	9	3	1	2	6%	12%
	Santa Ynez	**65**	**21**	**7**	**14**	**11%**	**22%**
	> 200 feet bgs	24	6	2	4	3%	6%
	< 200 feet bgs	32	12	4	8	6%	12%

Table 18. Trend analysis well summary results for TDS by subbasin and depth.

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
TDS	**Lompoc Plain**	**99**	**48**	**25**	**23**	**25%**	**23%**
	> 200 feet bgs	8	4	0	4	0%	4%
	< 200 feet bgs	74	38	21	17	21%	17%
	Lompoc Terrace	**15**	**6**	**5**	**1**	**33%**	**7%**
	> 200 feet bgs	5	3	3	0	20%	0%
	< 200 feet bgs	9	3	2	1	13%	7%
	Lompoc Upland	**24**	**2**	**0**	**2**	**0%**	**8%**
	> 200 feet bgs	9	1	0	1	0%	4%
	< 200 feet bgs	10	0	0	0	0%	0%
	Santa Rita	**20**	**5**	**1**	**4**	**5%**	**20%**
	> 200 feet bgs	8	1	0	1	0%	5%
	< 200 feet bgs	9	4	1	3	5%	15%
	Santa Ynez	**68**	**17**	**3**	**14**	**4%**	**21%**
	> 200 feet bgs	27	5	1	4	1%	6%

Pollutant	Subbasin	Wells that meet statistical criteria	Wells with significant trends	Wells with significant decreasing trends	Wells with significant increasing trends	Percentage of wells with decreasing trends (%)	Percentage of wells with increasing trends (%)
	< 200 feet bgs	30	11	2	9	3%	13%

Appendix B: Figures

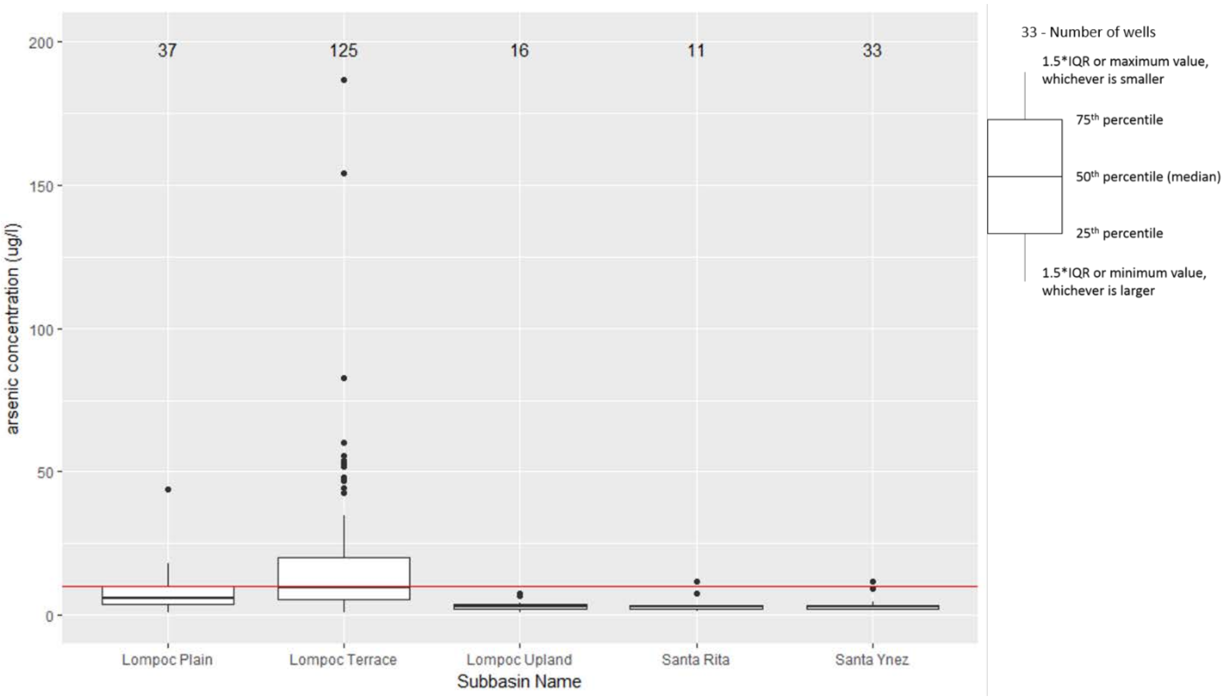

Figure 13. Box-and-whisker plots of the median arsenic concentration measured in wells for each subbasin. *For display purposes, plot excludes one arsenic sample from the Lompoc Terrace subbasin with a concentration of 808 µg/L. Red horizontal line indicates the water quality reference standard. IQR stands for interquartile range, or the range in concentrations from the 25th to 75th percentile.*

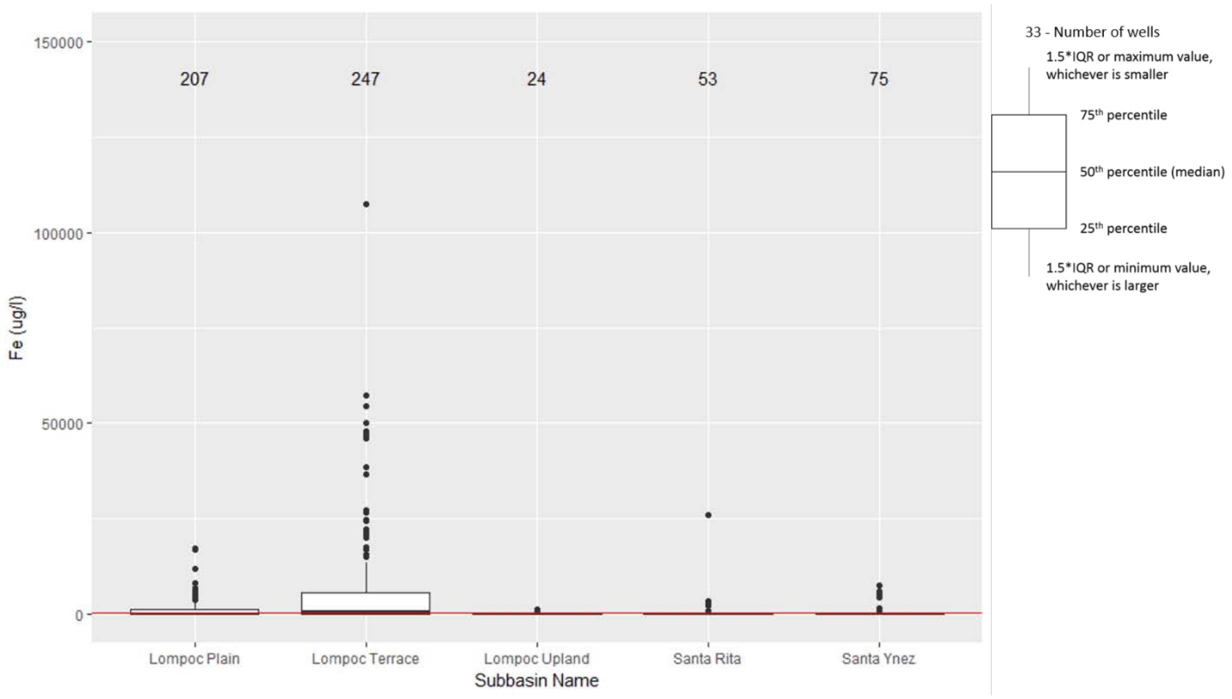

Figure 14. Box-and-whisker plots of the median iron concentration measured in wells for each subbasin. *For display purposes, plot excludes one iron sample from the Lompoc Terrace subbasin with a concentration of 333,000 µg/L. Red horizontal line indicates the water quality reference standard. IQR stands for interquartile range, or the range in concentrations from the 25th to 75th percentile.*

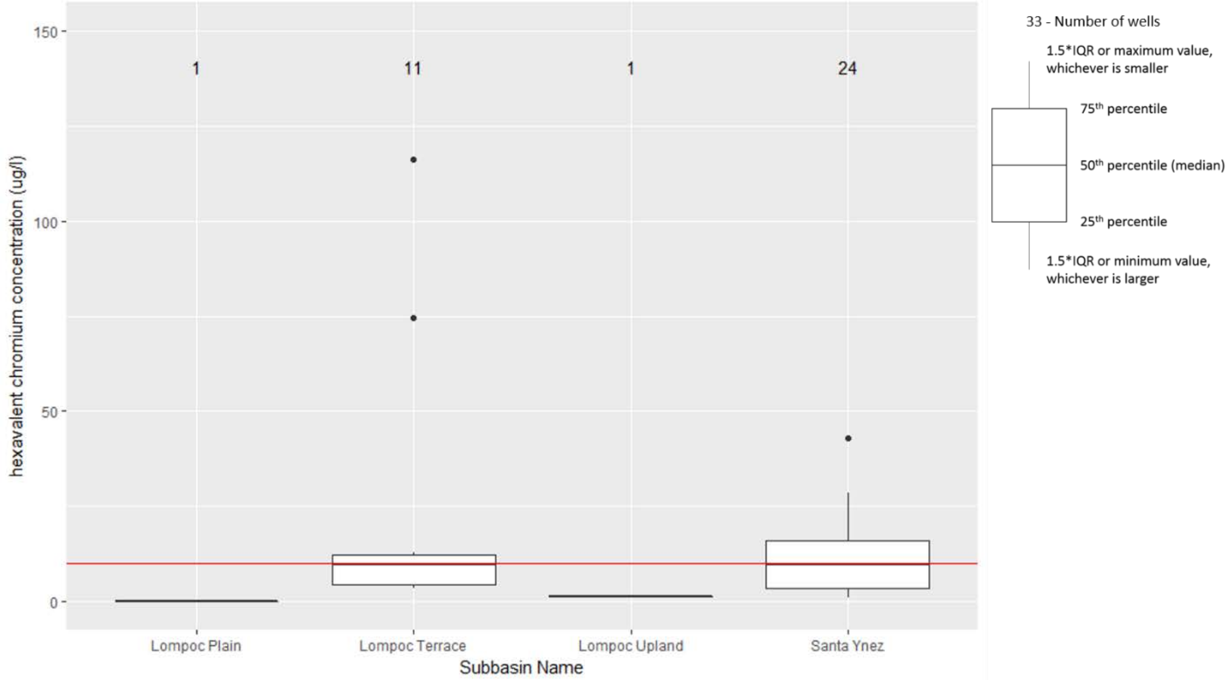

Figure 15. Box-and-whisker plots of the median hexavalent chromium concentration measured in wells for each subbasin. *For display purposes, plot excludes one arsenic sample from the Lompoc Terrace subbasin with a concentration of 1,900 µg/L. Red horizontal line indicates the water quality reference standard. IQR stands for interquartile range, or the range in concentrations from the 25th to 75th percentile.*

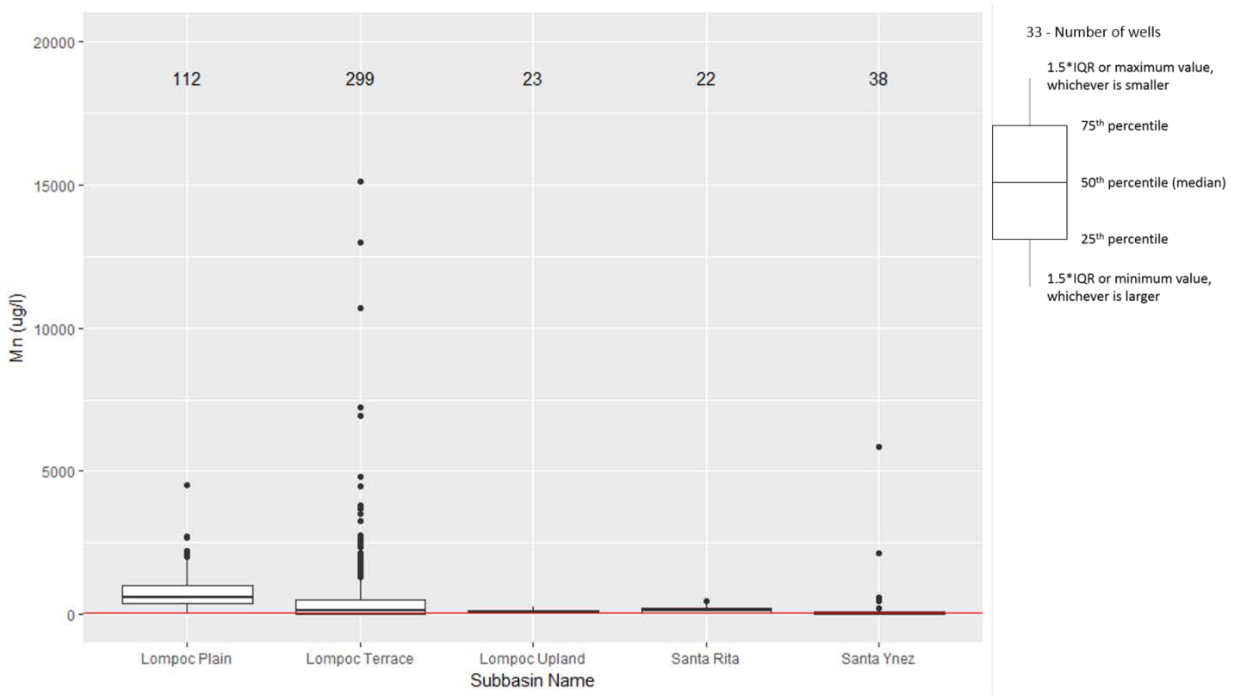

Figure 16. Box-and-whisker plots of the median manganese concentration measured in wells for each subbasin. *For display purposes, plot excludes one arsenic sample from the Lompoc Terrace subbasin with a concentration of 41,600 µg/L. Red horizontal line indicates the water quality reference standard. IQR stands for interquartile range, or the range in concentrations from the 25th to 75th percentile.*

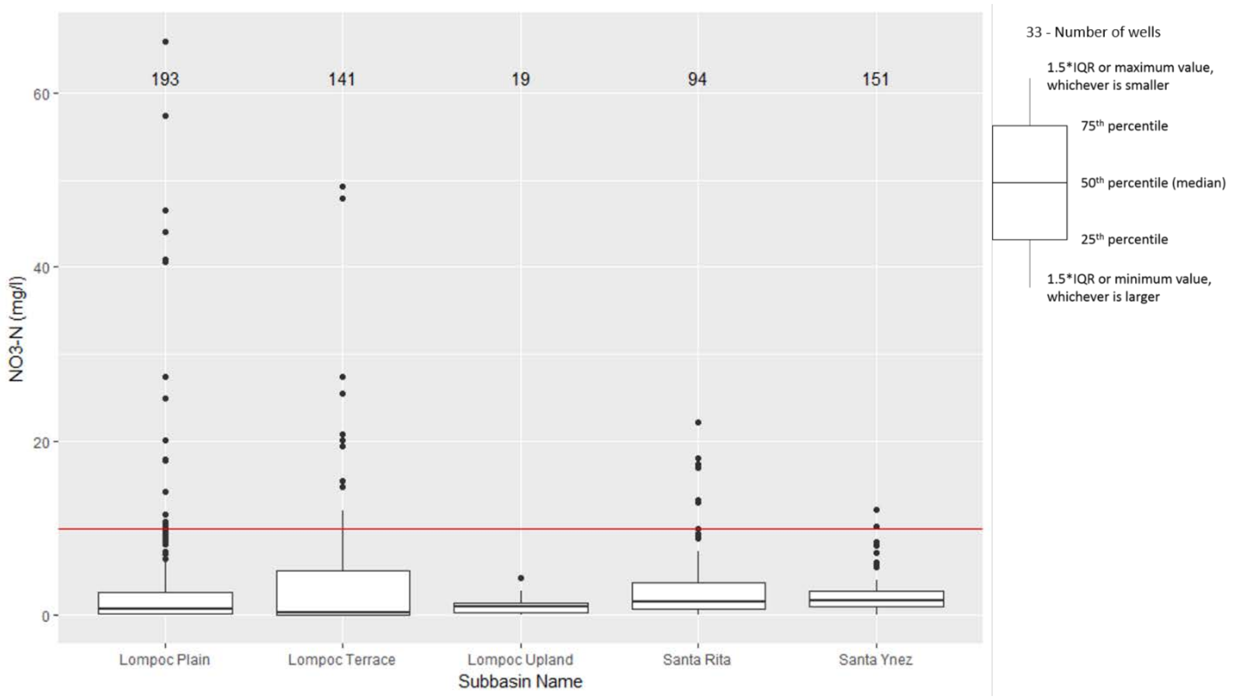

Figure 17. Box-and-whisker plots of the median nitrate concentration measured in wells for each subbasin. *Red horizontal line indicates the water quality reference standard. IQR stands for interquartile range, or the range in concentrations from the 25th to 75th percentile.*

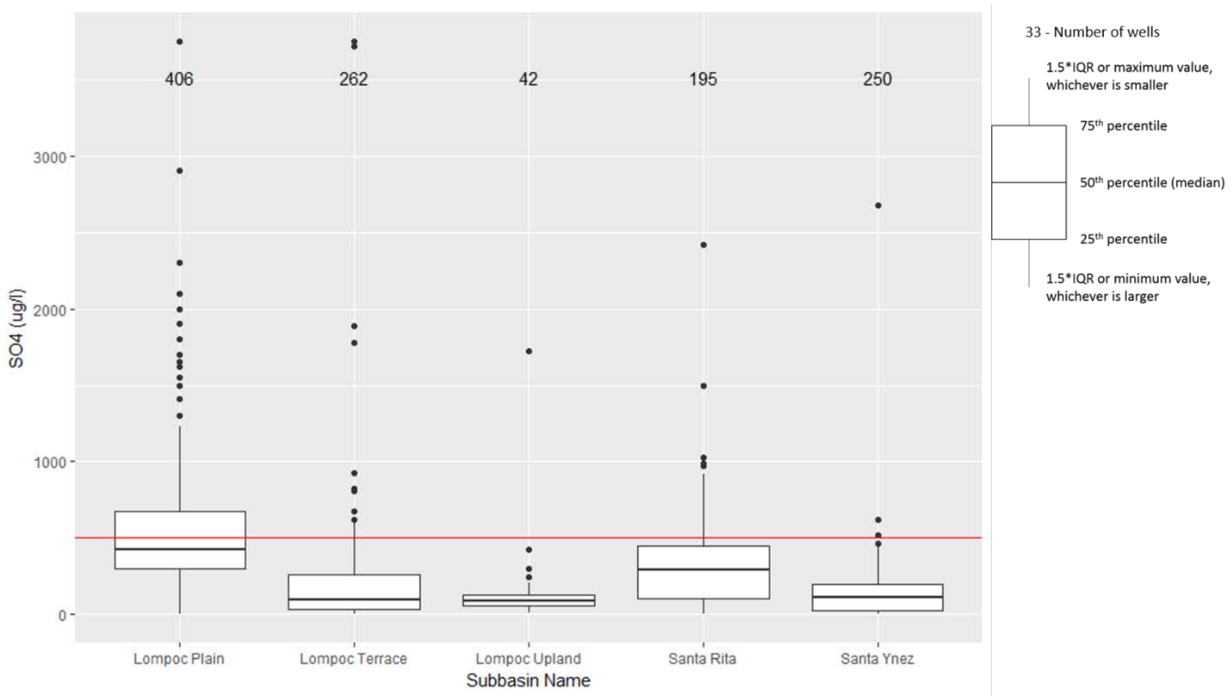

Figure 18. Box-and-whisker plots of the median sulfate concentration measured in wells for each subbasin. *Red horizontal line indicates the water quality reference standard. IQR stands for interquartile range, or the range in concentrations from the 25th to 75th percentile.*

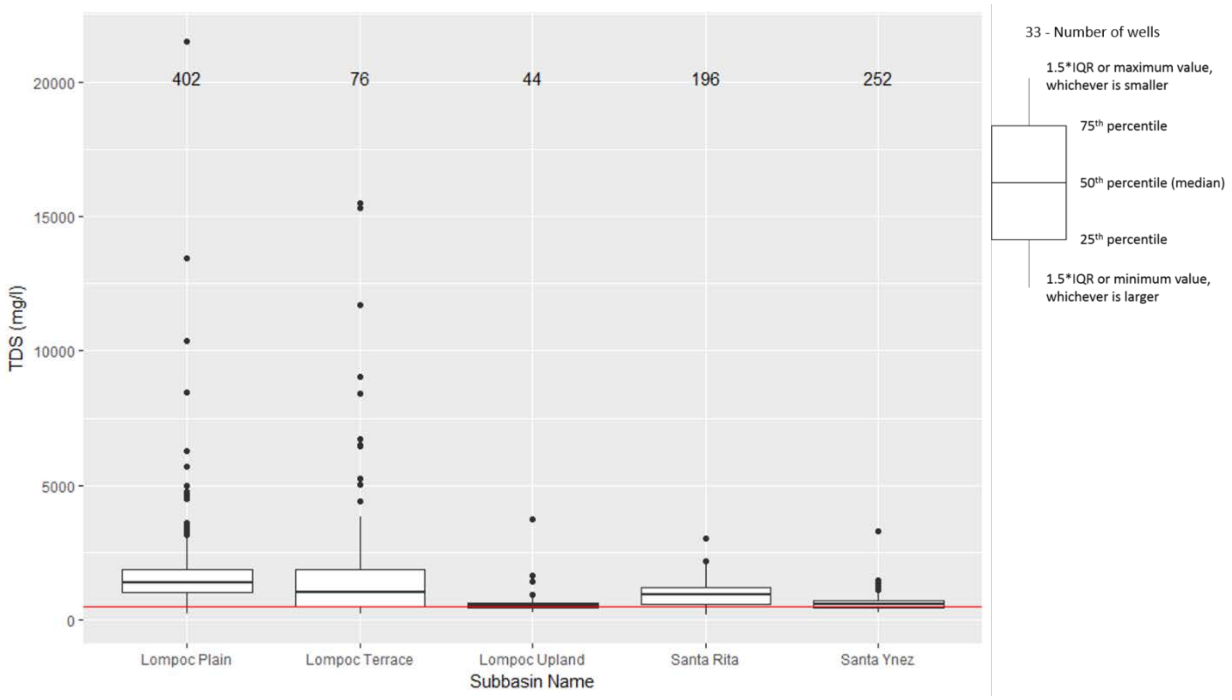

Figure 19. Box-and-whisker plots of the total dissolved solids concentration measured in wells for each subbasin. *Red horizontal line indicates the water quality reference standard. IQR stands for interquartile range, or the range in concentrations from the 25th to 75th percentile.*

Appendix C: Maps

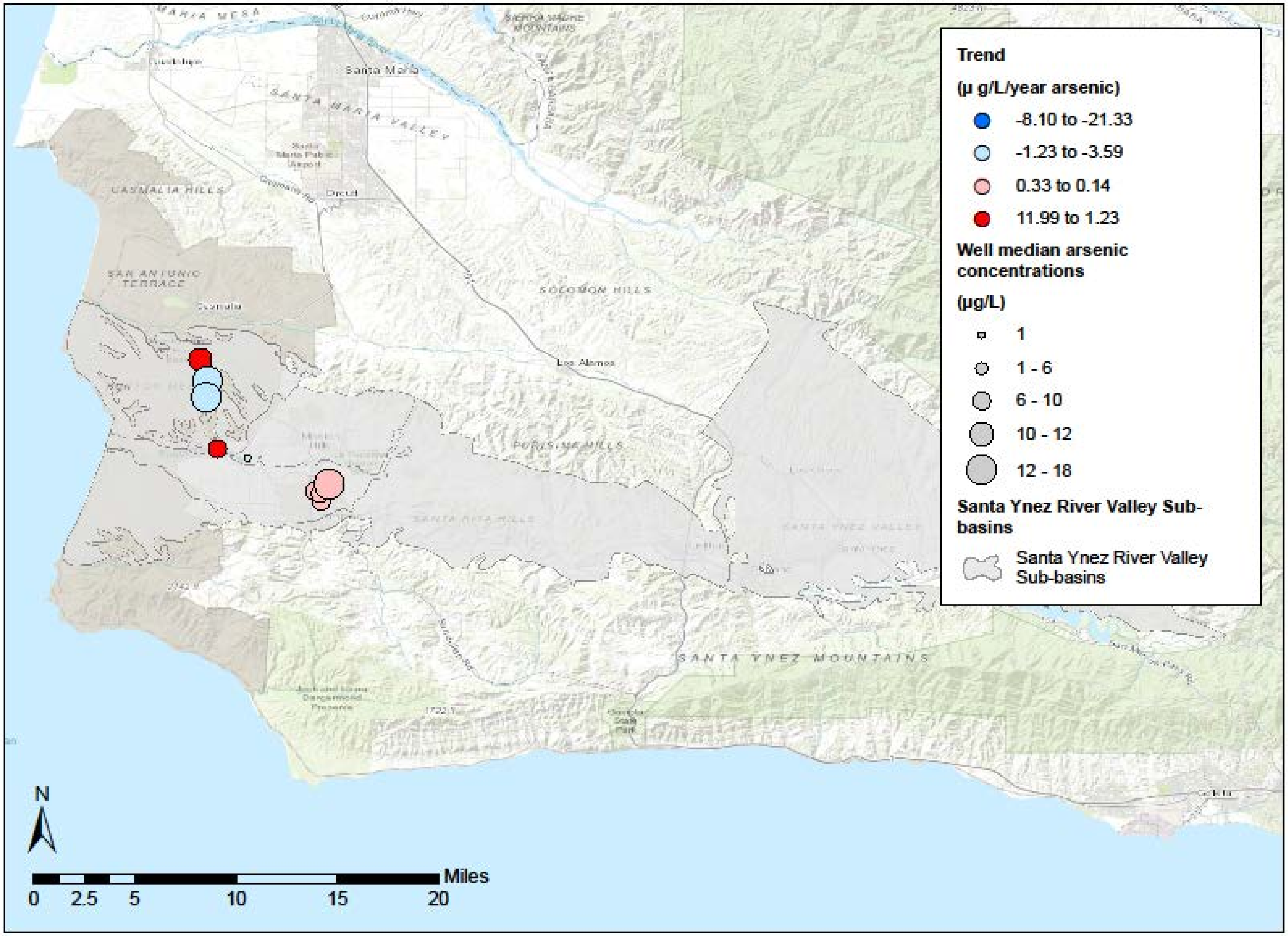

Figure 20. Arsenic trend map.

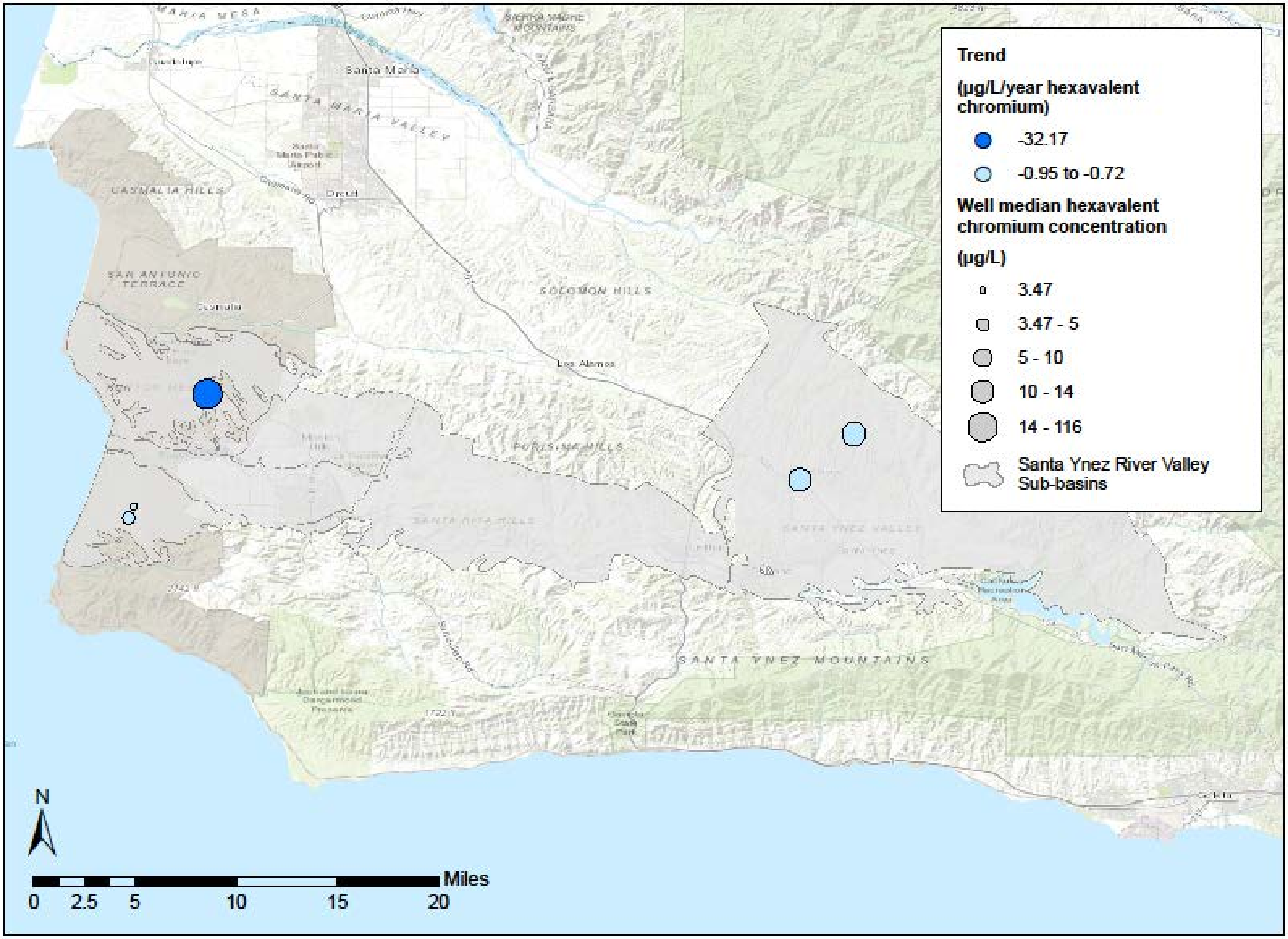

Figure 21. Hexavalent chromium trend map.

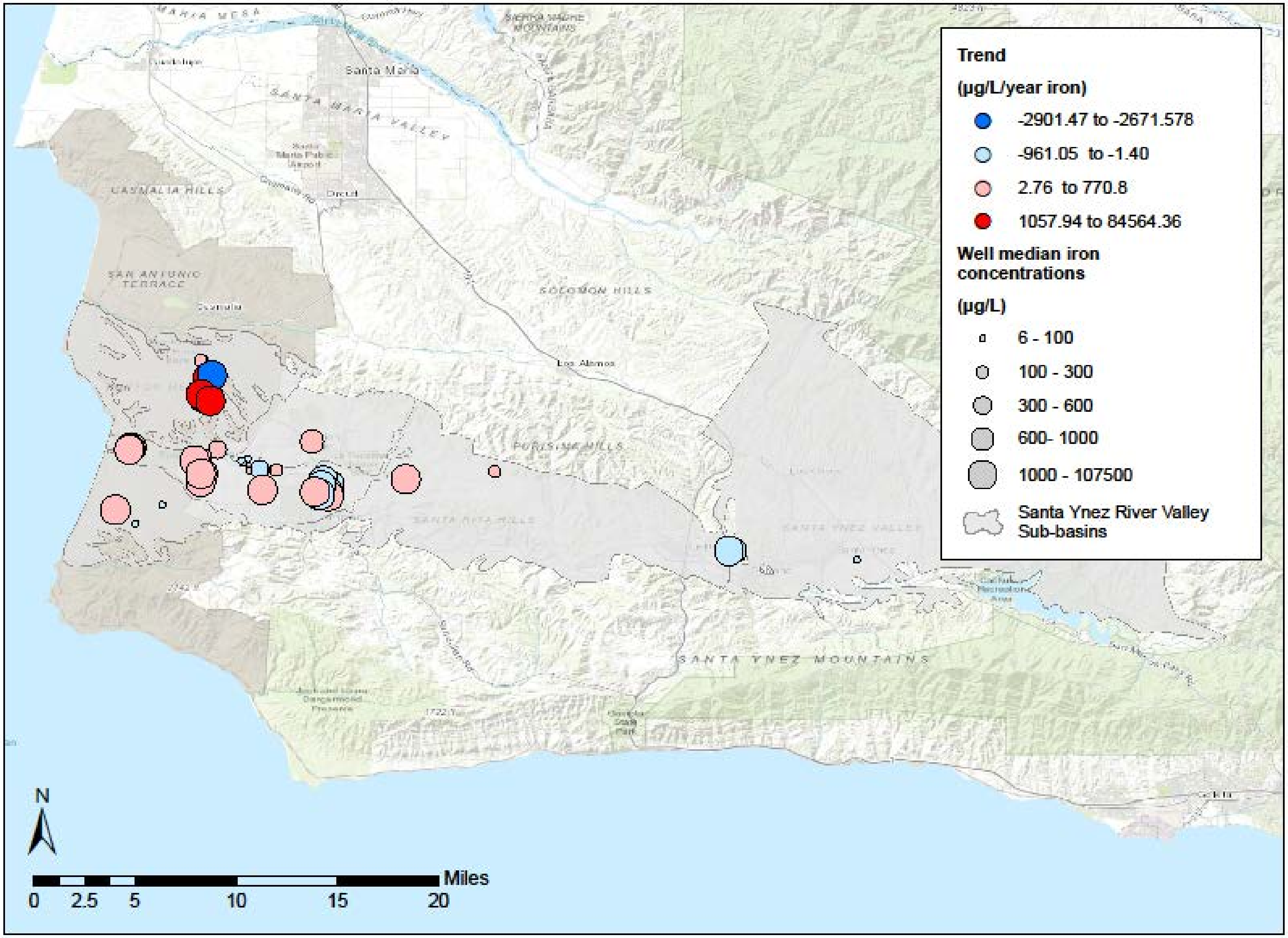

Figure 22. Iron trend map.

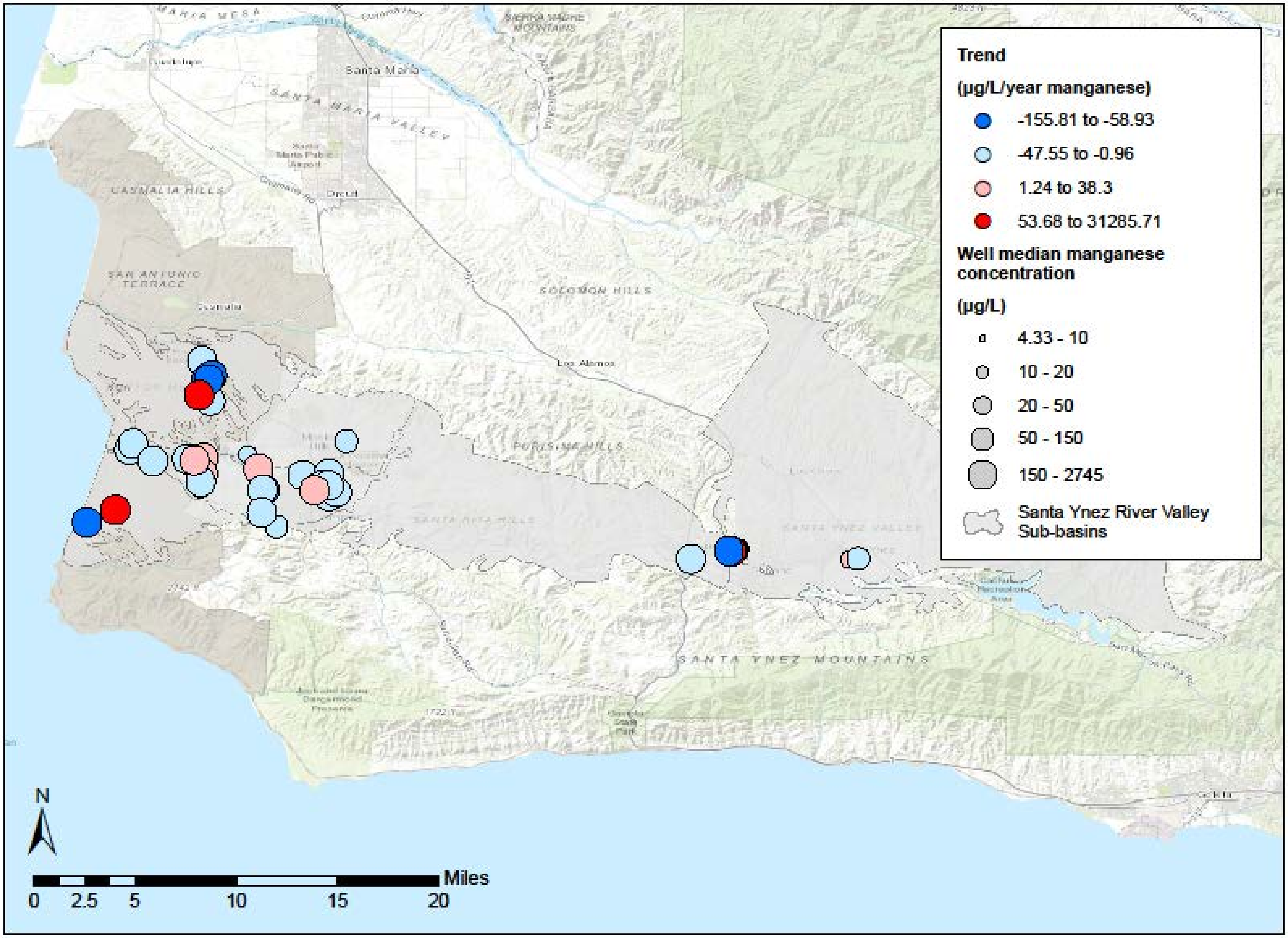

Figure 23. Manganese trend map.

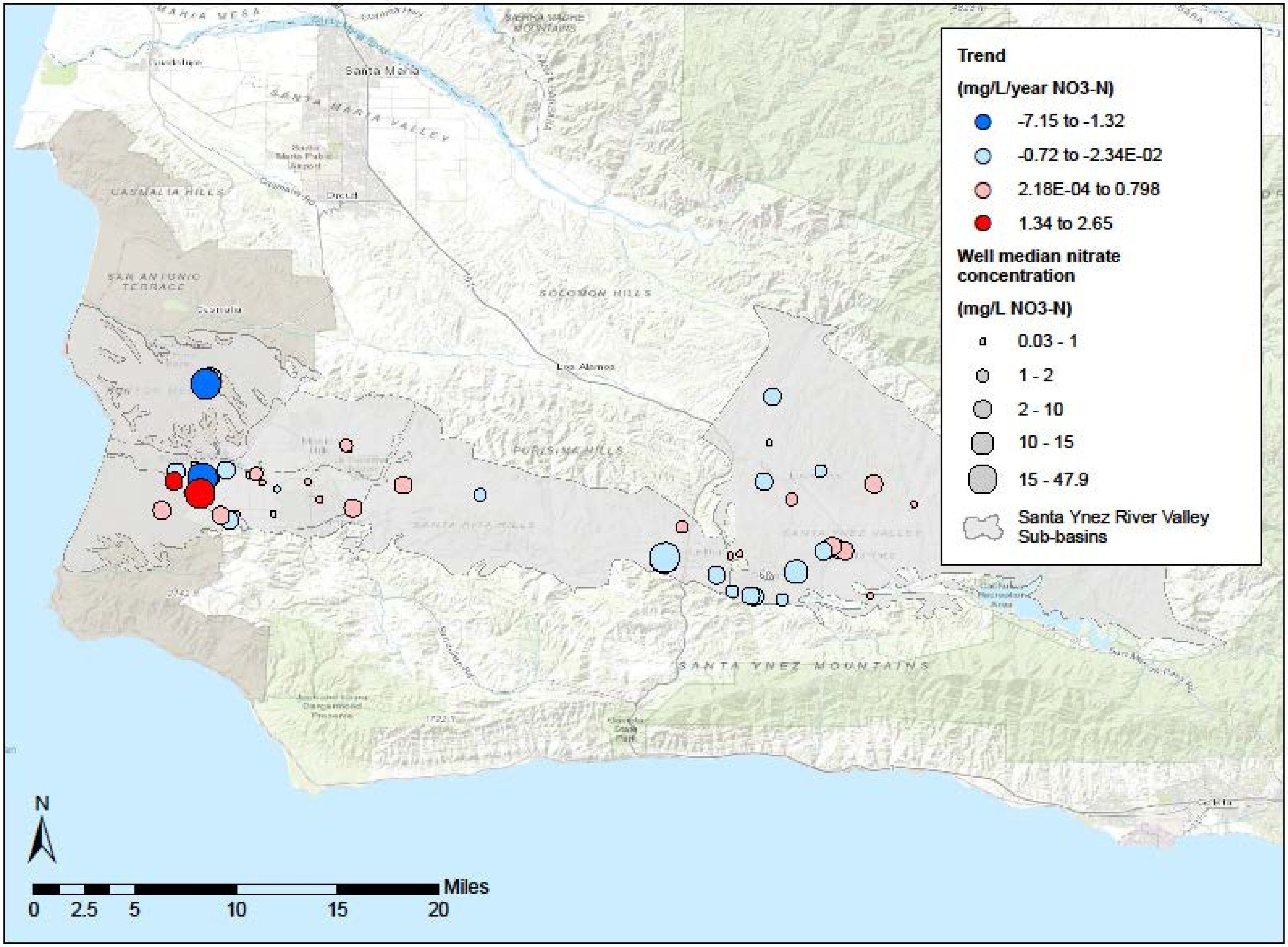

Figure 24. Nitrate trend map.

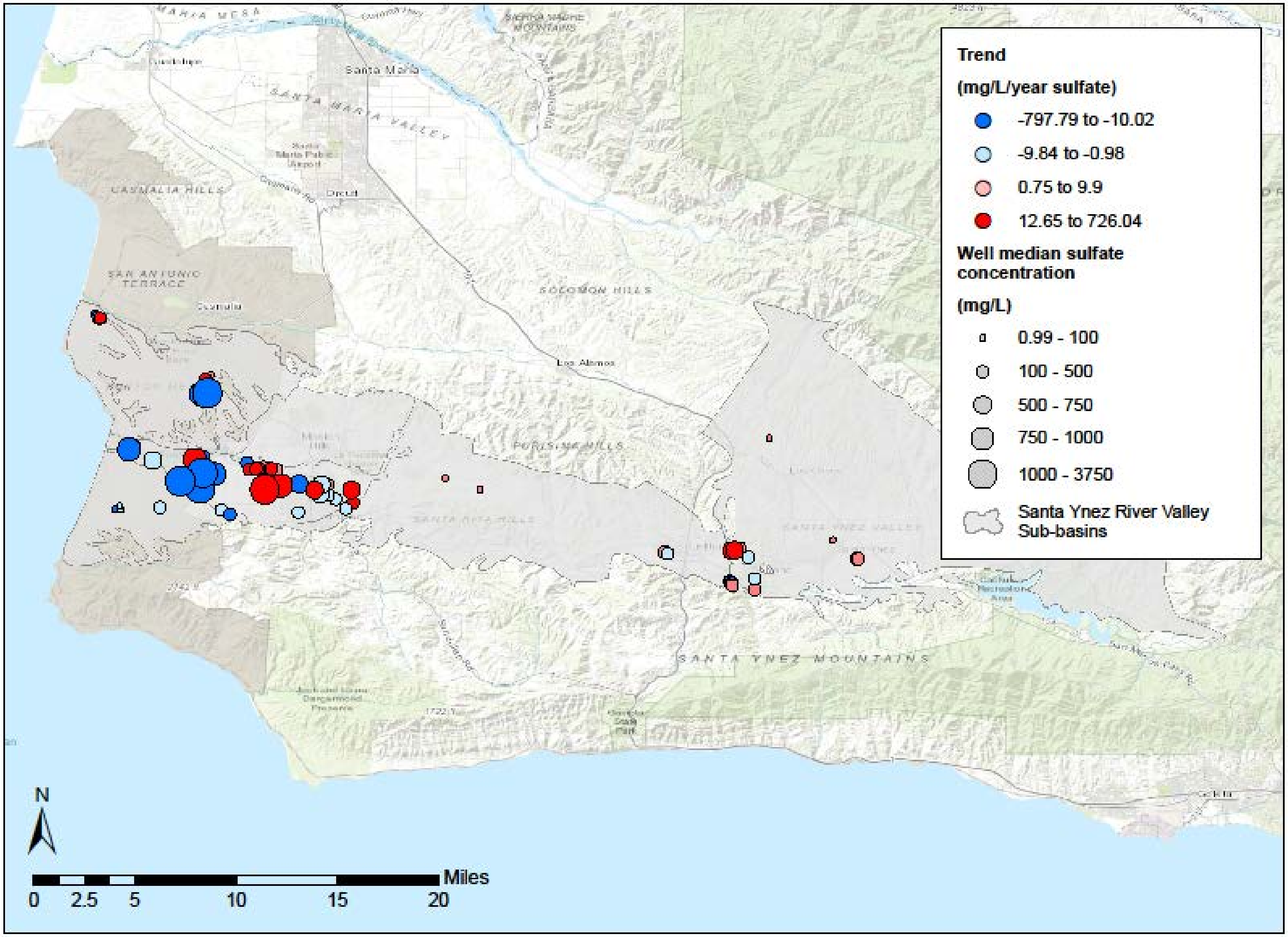

Figure 25. Sulfate trend map.

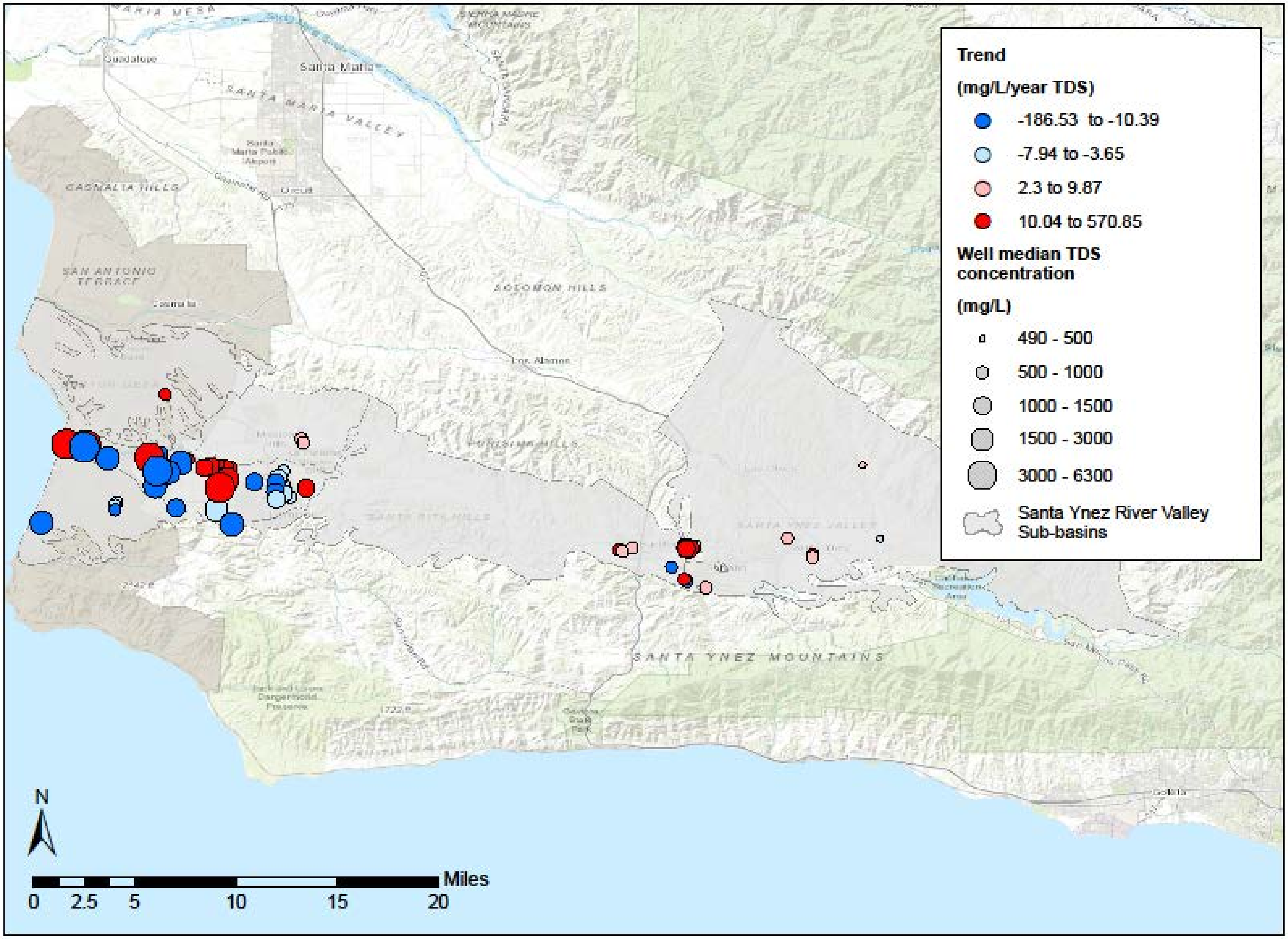

Figure 26. TDS trend map.

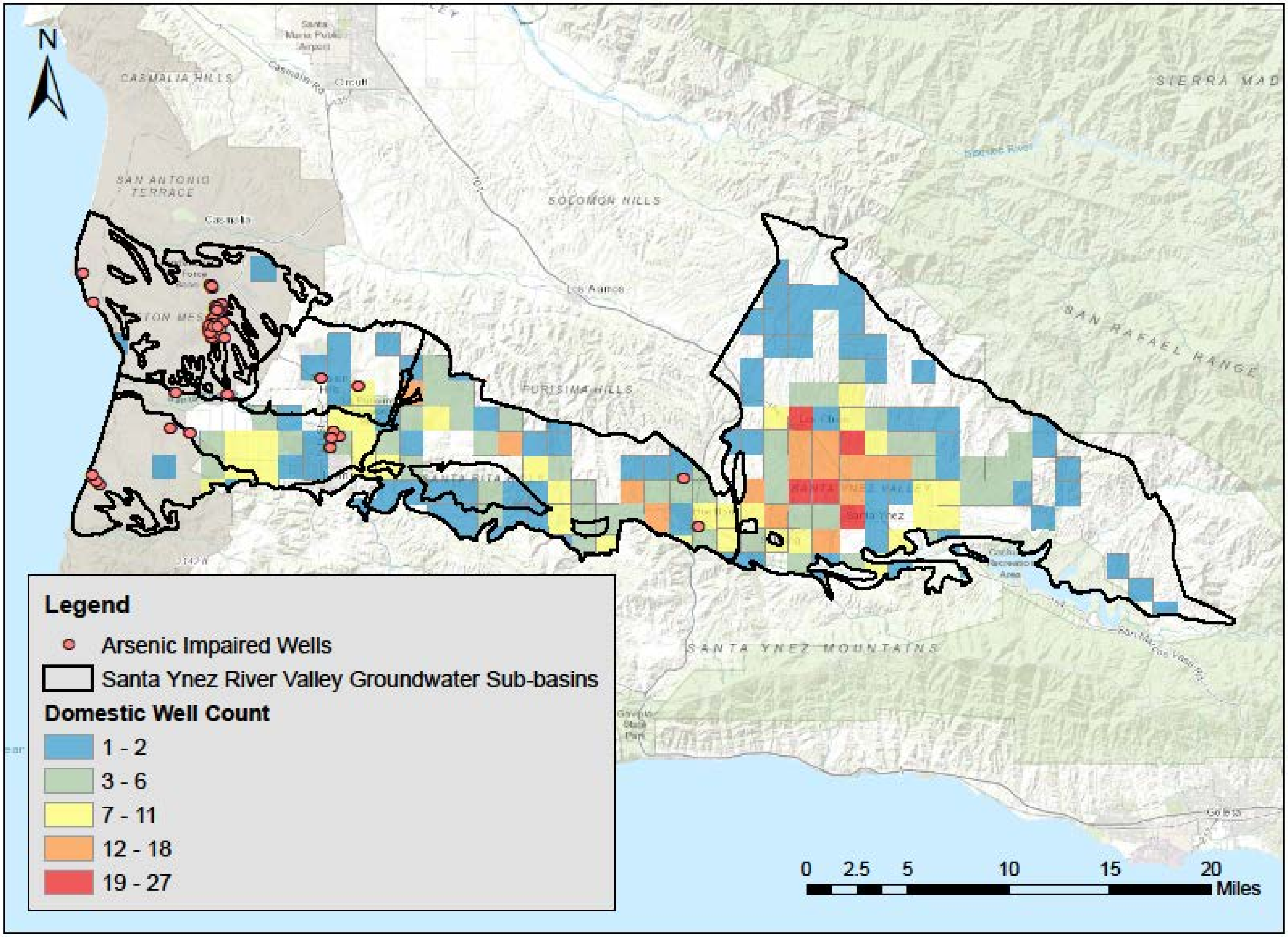

Figure 27. Arsenic impaired well map.

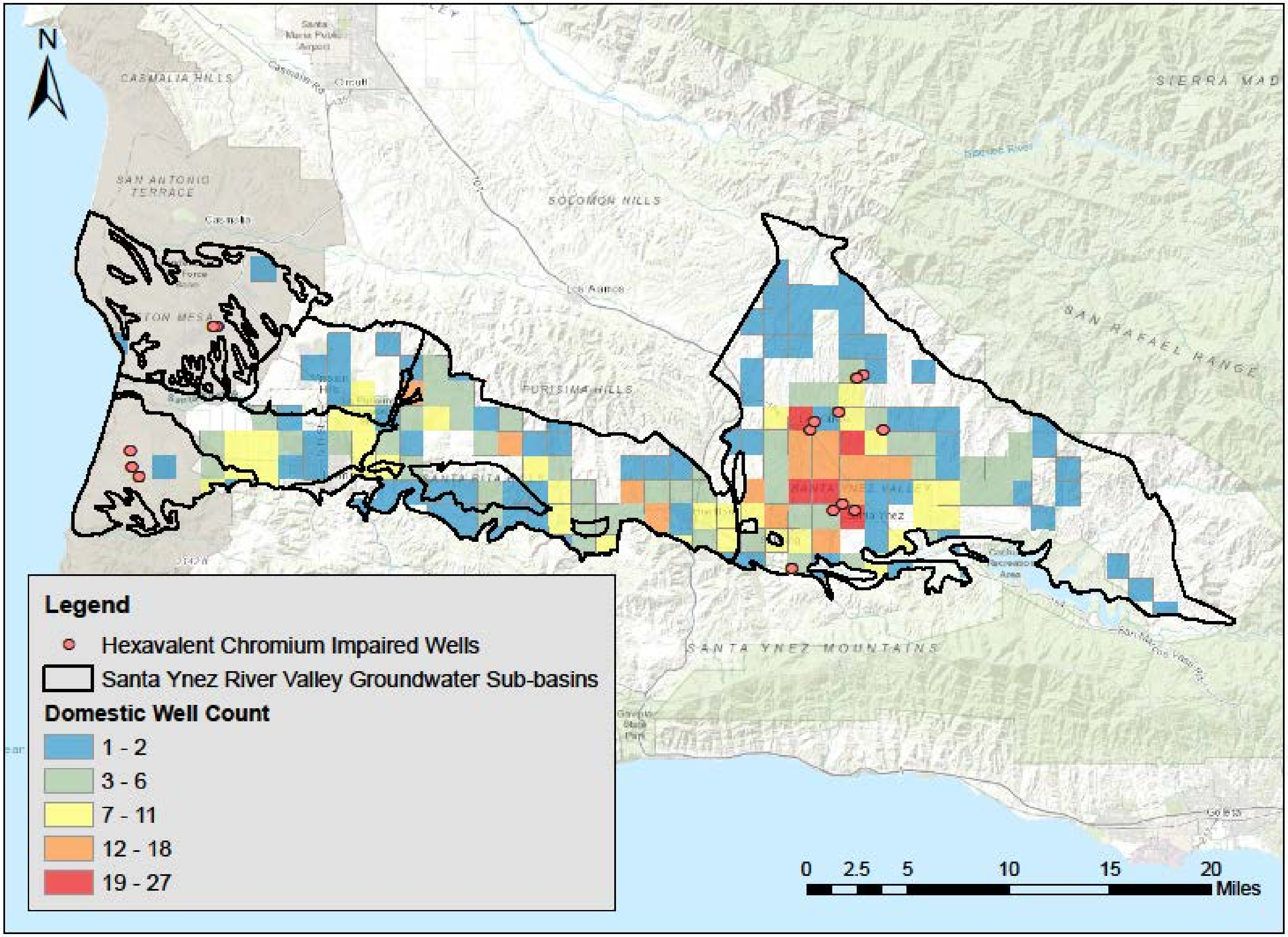

Figure 28. Hexavalent chromium impaired well map.

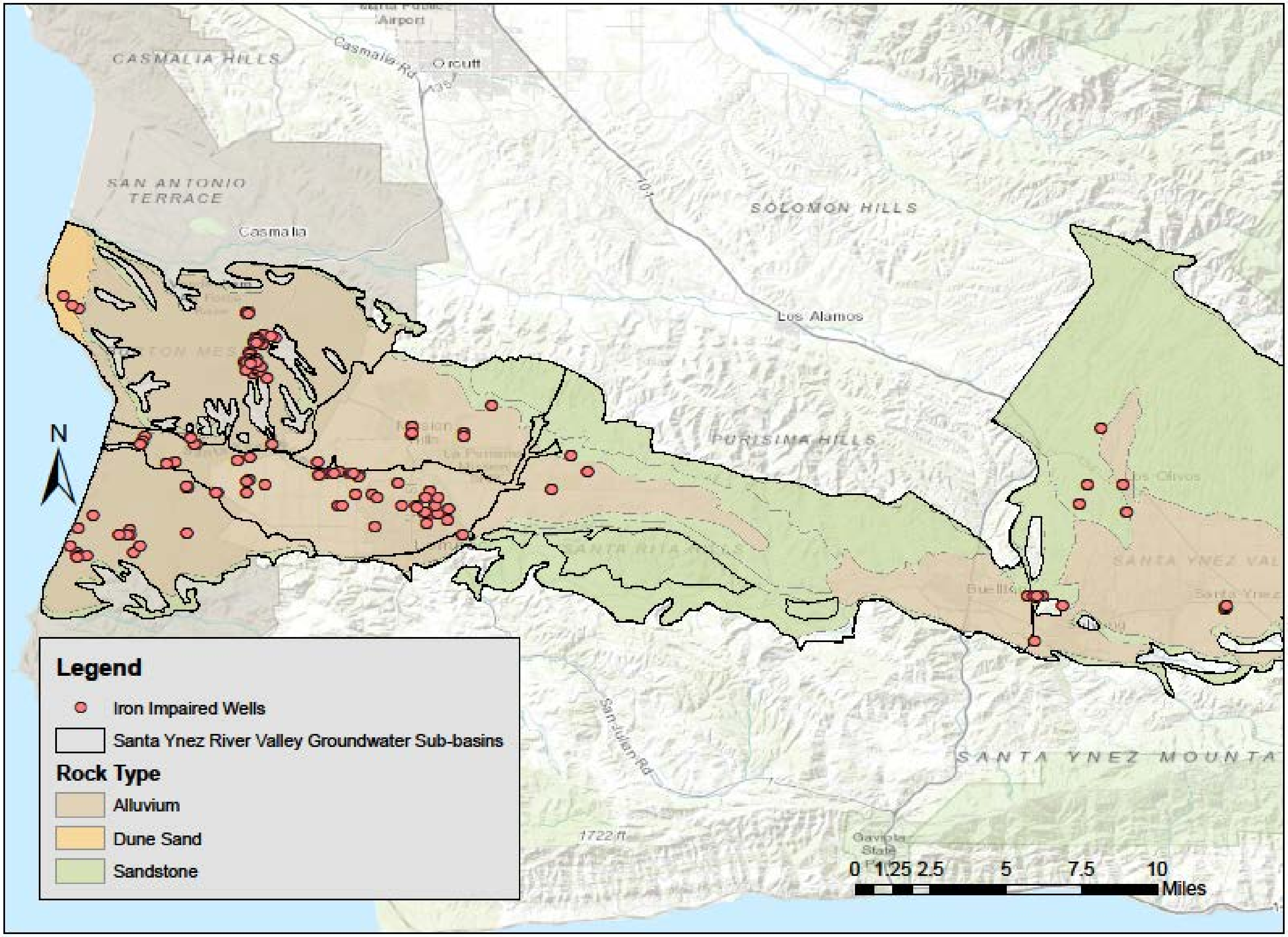

Figure 29. Iron impaired well map.

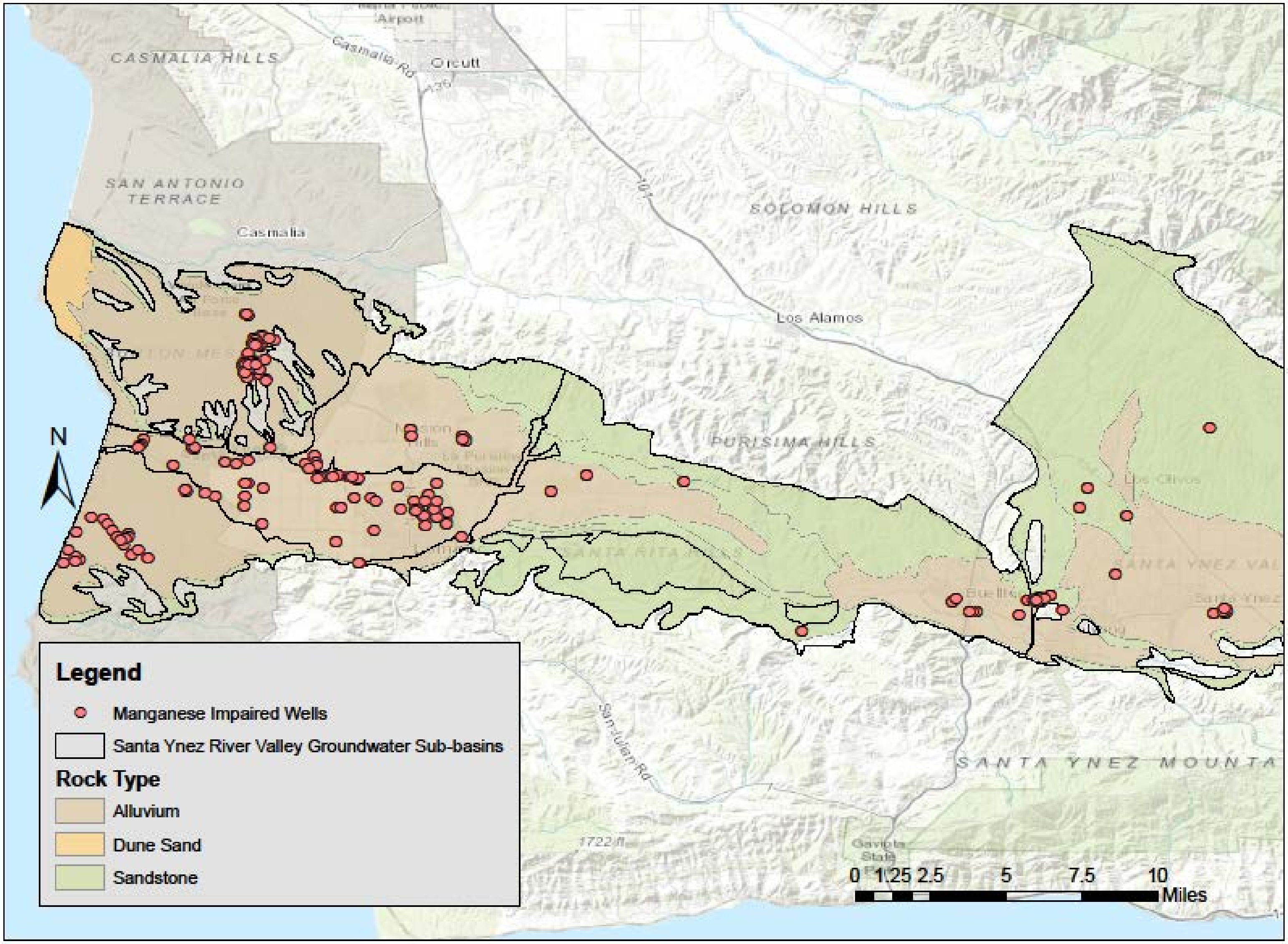

Figure 30. Manganese impaired well map.

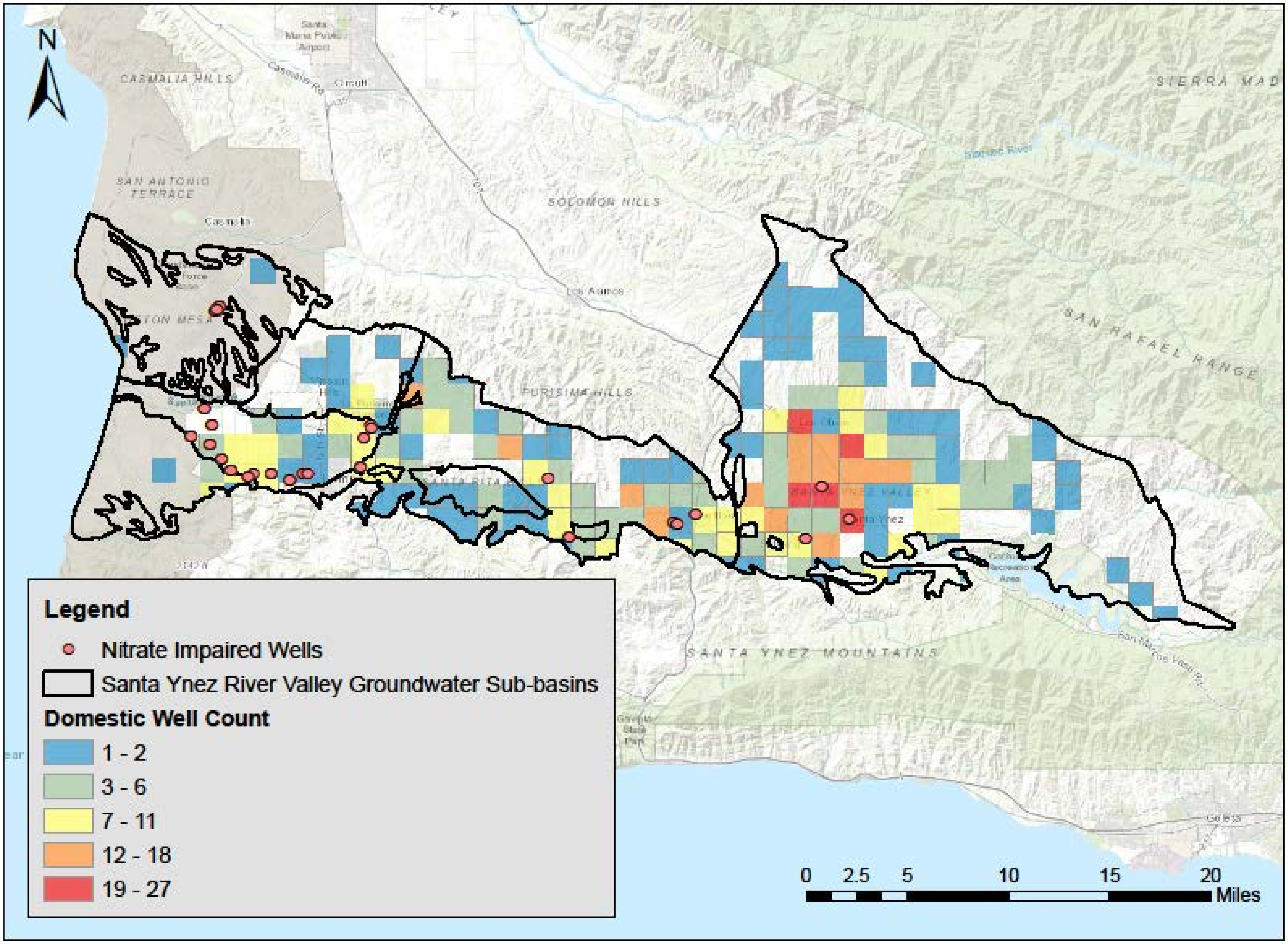

Figure 31. Nitrate impaired well map.

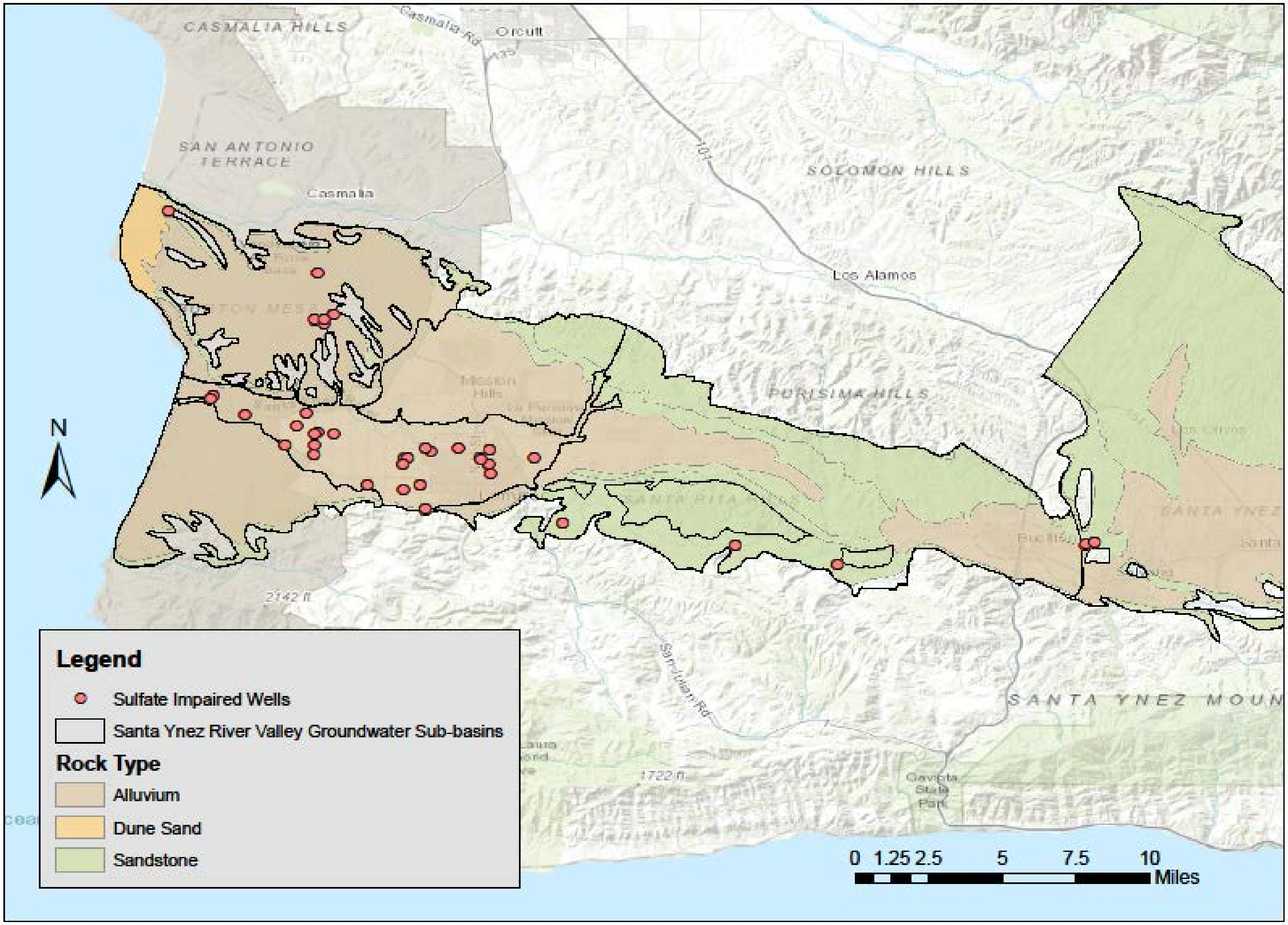

Figure 32. Sulfate impaired well map.

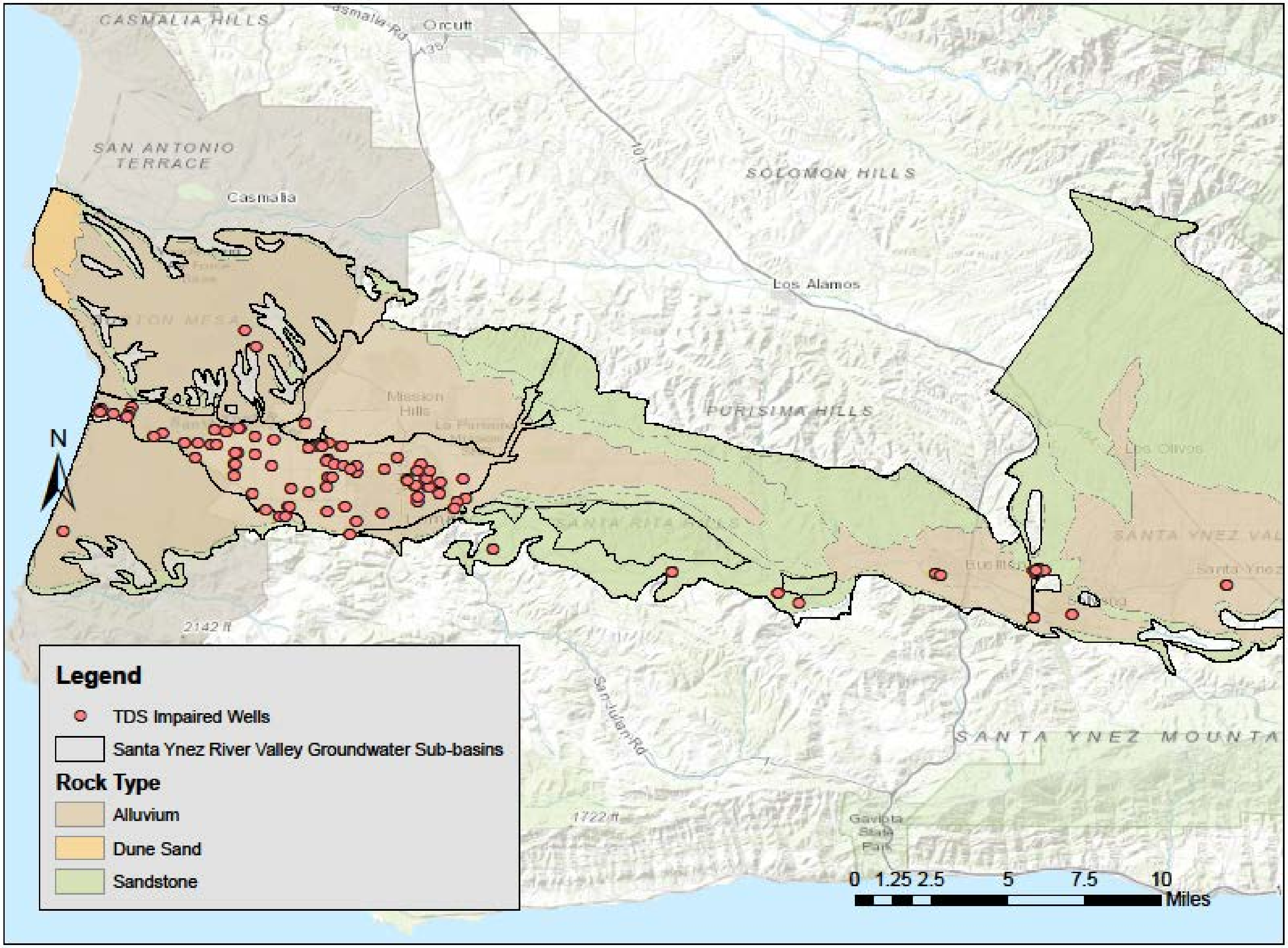

Figure 33. TDS impaired well map.

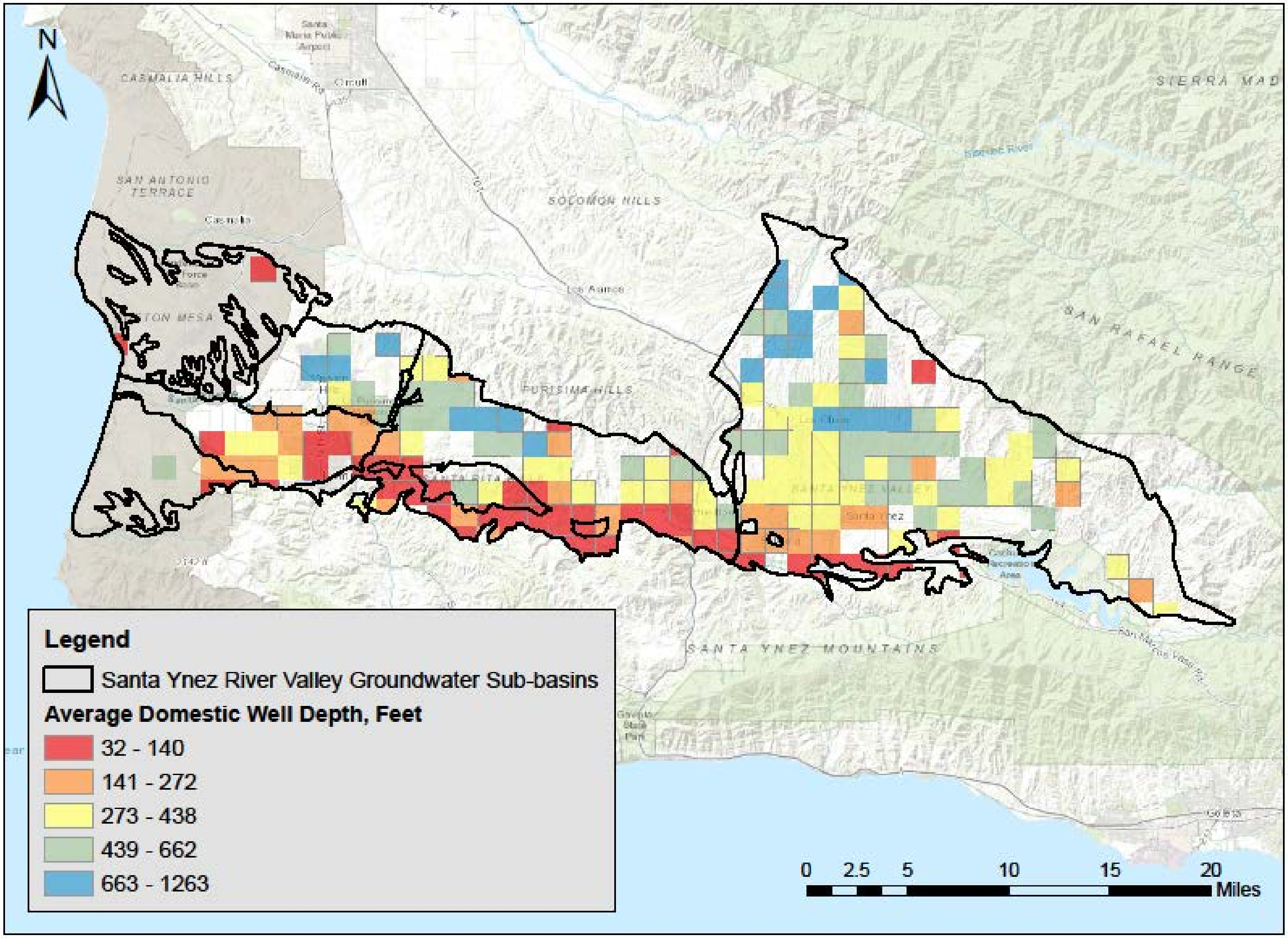

Figure 34. Average domestic well depth map.