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Shandon-San Juan Water District and
Estrella-El Pomar-Creston Water District

Paso Robles Subbasin Stormwater Capture and Recharge Feasibility Study

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TECHNICAL MEMORANDUM

Paso Robles Subbasin Stormwater Capture and Recharge Feasibility Study

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Date: December 30, 2020

Introduction

Stormwater capture and recharge is an approach used elsewhere in the State for augmenting natural recharge to a groundwater basin and thus improving groundwater levels. The concept involves building diversion structures (or canals) to divert storm flows from a stream above a certain allowed volume, capture those flows by diverting to nearby fields or undeveloped areas, and inundating the fields to allow for passive infiltration. This technical memorandum presents screening level feasibility study results for locating sites where stormwater (flood) flow can be captured and used to recharge aquifers within the Paso Robles Area Subbasin of the Salinas Valley Groundwater Basin (Paso Robles Subbasin or Subbasin). This study identifies areas with favorable soil, topography, and aquifer characteristics and estimates the stormwater amount from the tributary watersheds contributing to the surface flows in the Salinas and Estrella rivers and San Juan and Huer Huero creeks within the Paso Robles Subbasin, as shown on Figure 1. The Paso Robles Subbasin, as defined in the Groundwater Sustainability Plan (GSP), is the study area for this scope of work. Of particular interest are areas where the recharge water would migrate directly into the underlying Paso Robles Formation aquifer, the principal aquifer serving most irrigation demands in the basin. The feasibility study was conducted in accordance with the authorized scope of work prepared for the Shandon-San Juan Water District (SSJWD) and Estrella-El Pomar-Creston Water District (EPCWD). The scope proposed for the study, including this technical memorandum, comprises two main tasks, namely:

- Task 1 - Identify optimum target areas for stormwater recharge
- Task 2 - Quantify availability of stormwater for capture

To locate potential target areas with optimum recharge conditions for Task 1, the comparative distribution modeling method was used. A comparative distribution model takes into consideration the spatial distribution of multiple components that have an impact on recharge potential and creates a gridded weighted average index map of these components to elucidate preferred recharge areas within the study area.

In order to quantify the available stormwater for potential capture in Task 2, the modeled surface flows from the calibrated HSPF watershed model[1] used for the GSP were extracted for the study area tributary watersheds. The Paso Robles Subbasin HSPF watershed model is one of the components of the GSP model as described in the GSP (Montgomery, 2020a).

Comparative Distribution Modeling of Recharge Potential

Successful artificial recharge of surface water depends on a high rate of transmission through the soil profile into the unconfined aquifer below. The receiving aquifer should be permeable enough to allow for the infiltrating recharged water to move laterally away from the recharge site without causing excessive mounding, which would limit subsequent recharge. Because the majority of groundwater users pump from the Paso Robles Formation that underlies alluvium, it is also important to identify potential recharge areas that allow for direct communication with the deeper aquifer, thus providing maximum benefit to basin groundwater users. This is especially pertinent for stormwater that is only available within a narrow time frame during the rainy season. Additionally, the bulk of stormwater are available for recharge during an occasional wet year only. Comparative distribution modeling is used to determine areas that meet the conditions described above and are therefore best suited to receive stormwater recharge.

The comparative distribution modeling method (i.e., building models that combine the distributions of different components that affect recharge) was used to create a Recharge Potential Index Map for the study area. The distributed components used to construct a Recharge Potential Index Map include topography, saturated soil hydraulic properties, and aquifer hydraulic properties. Subsequent to the construction of the Recharge Potential Index Map, groundwater elevations and land use factors that could have a negative impact on recharge were also considered to refine the selection of the most promising recharge target areas.

An overview of key spatially distributed information and considerations used for the delineation of recharge target areas are as follows:

Recharge Potential Index Map:

- Topography
- Surficial soil hydraulic properties
- Aquifer hydraulic properties

Additional Land Use Considerations:

- Surficial geology
- Groundwater occurrence and depth
- Proximity to a 100-year flood zone area
- Proximity to water treatment plants
- Proximity to septic tanks
- Proximity to wells

[1] The Hydrological Simulation Program – FORTRAN model was developed by the U.S. Environmental Protection Agency (EPA) in the 1980s. More information on the HSPF watershed model is available at the EPA website: https://19january2017snapshot.epa.gov/sites/production/files/2016-08/documents/flyer_webinar_9-hspf.pdf (accessed May 1, 2020).

- Agricultural crop coverages

Construction of Recharge Potential Index Map

A spatially comparative gridded Recharge Potential Index Map for the study area was built inside a geographic information system (GIS) environment that shows the distribution of potentially promising recharge areas. The individual factors are summarized in the following sections.

Topography

Topography or slope affects the ability to recharge natural and/or captured stormwater. A shallow slope is more conducive to recharge. Relatively level topography is better suited to hold water, allow infiltration to occur over larger areas, and minimize engineering needs to contain the recharge water. The slope percentages for the study area were calculated from the U.S. Geological Survey (USGS) 10-meter Digital Elevation Model (DEM).

Ranges in slope percent were used to categorize soils into seven slope classes with rankings as shown in Table 1.

Table 1 - Topographic Slope Recharge Potential Index Map Rankings

% Slope	Recharge Ranking	
0 – 5	10	Very high
5 – 10	8	High
10 – 15	6	Medium high
15 – 20	4	Medium
20 – 25	3	Medium low
25 – 30	2	Low
30 – 70	1	Very low

The distribution of topographic slope percentages with the corresponding recharge rankings from Table 1 are shown in Figure 2.

Soil Vertical Hydraulic Conductivity

The surficial saturated soil hydraulic conductivities (or permeability) are indicators of infiltration or recharge rate. Greater saturated soil hydraulic conductivities are conducive to greater recharge. For this study, the National Resource Conservation Service (NRCS) Gridded National Soil Survey Geographic Database (gNATSGO) was used to determine the study area’s saturated soil hydraulic conductivities.

Ranges in saturated soil hydraulic conductivities were used to categorize soils into six infiltration classes with rankings as shown in Table 2.

Table 2 – Saturated Soil Hydraulic Conductivity Recharge Potential Index Map Rankings		
Soil Hydraulic Conductivity (inches/hour)	**Recharge Ranking**	
>4	10	Very high
3 – 4	8	High
Unknown	7	Medium high
2 – 3	6	Medium
1 – 2	4	Medium low
<1	2	Low

The distribution of mean saturated hydraulic conductivity with the corresponding recharge rankings shown in Table 2 are shown in Figure 3.

Aquifer Hydraulic Conductivity

The horizontal aquifer hydraulic conductivities are indicators of the degree that infiltrated recharged water can laterally move away from the recharge site, thus reducing mounding and allowing for greater volumes to be recharged and to migrate into aquifer production zones. Greater horizontal aquifer hydraulic conductivities are conducive to greater recharge. For this study, the modeled hydraulic conductivity values of the groundwater component of the GSP model were used to estimate horizontal aquifer hydraulic conductivity (Geoscience, 2015).

Ranges in horizontal aquifer hydraulic conductivities were used to categorize soils into six classes with rankings as shown in Table 3.

Table 3 – Aquifer Hydraulic Conductivity Recharge Potential Index Map Rankings		
Aquifer Hydraulic Conductivity (ft/day)	**Recharge Ranking**	
> 20	10	Very high
15 – 20	9	High
10 – 15	7	Medium
5 – 10	5	Medium low
2 – 5	3	Low
0 – 2	1	Very low

The distribution of horizontal aquifer hydraulic conductivity with the corresponding recharge rankings shown in Table 3 are shown in Figure 4.

Paso Robles Basin Recharge Index Map

A final Recharge Potential Index Map was developed as a weighted average of the ranked distribution maps of slope, soil hydraulic conductivity, and aquifer horizontal hydraulic conductivity (Figures 2, 3, and 4). Using a general approach derived from similar studies (Todd, 2018; Sesser et al., 2011; Muir and Johnson, 1979; Aller et al., 1987), the following weights were assigned:

- Slope Distribution– 20 percent
- Saturated Soil Hydraulic Conductivity Distribution – 50 percent
- Aquifer Horizontal Hydraulic Conductivity Distribution – 30 percent

The final Recharge Potential Index Map values were calculated using the weighted average percentages (Figure 5). Index values are ranked from 1 (low potential index) to 10 (high potential index); higher index values are represented by the darker map colors, indicating the preferred recharge locations. In general, the higher-scoring (preferred) recharge areas occur in the river and stream valleys with shallow slopes and higher soil hydraulic conductivities, and are in the more upstream regions of the watershed where higher aquifer hydraulic conductivities occur.

Additional Considerations for Potential Stormwater Recharge Target Areas

Favorable physical recharge conditions are not the only considerations for selecting potential recharge target areas. Geology, groundwater occurrence, and anthropogenic land uses must also be evaluated.

Surficial Geology and Lithology

The Paso Robles Subbasin GSP provides a detailed description of geologic control of hydrologic conditions in the Paso Robles Subbasin (Montgomery, 2020). The sediments of both the alluvial aquifer and Paso Robles Formation aquifer are from erosion of the surrounding mountains. These erosional sediments are generally coarser near the source mountain and finer towards the center of the basin. The alluvium overlying the Paso Robles Formation occurs beneath the flood plains of the rivers and creeks and is typically no more than 100 feet thick. The Paso Robles Formation ranges from 700 to 1,200 feet in thickness throughout most of the study area and generally has lower permeability than the overlying alluvium.

In the floodplain areas, groundwater elevations tend to be higher in the alluvium than in the Paso Robles Formation, which induces downward flow from the alluvium to the Paso Robles Formation (Fugro, 2005). It has been observed that, in the Shandon area along the San Juan Creek, lithological well log data show limited fine-grained sediments (fines; silt and clays) compared with well logs in the Estrella area (unpublished report by GSI for Shandon Water Users). Similarly, lithological well logs show that the Creston area has less fines than the Estrella area. The lithological data suggest that recharged water will migrate more quickly from the alluvium into the Paso Robles Formation in the upstream areas of the San Juan Creek and Huer Huero Creek, because these areas have less fines and greater permeability. In the alluvium of the Estrella River floodplains, recharged water will percolate more slowly and have less of an immediate impact on water levels than in the Paso Robles Formation due to greater presence of fines.

San Luis Obispo County conducted an aerial geophysical survey (SkyTEM) of a large portion of the basin. That study provides important information about subsurface conditions (geology down to 800 feet) that could be beneficial to this project. The results of that study were not available for this stormwater capture and recharge feasibility project; however, review of early results indicate that it could be very beneficial. The results of the SkyTEM survey are expected to be released early 2021.

Groundwater Occurrence and Potential for Mounding

In general, groundwater in the Paso Robles Subbasin consists of a shallow alluvial aquifer and the deeper Paso Robles Formation aquifer. Groundwater generally flows from southeast to northwest across the subbasin. Depth to water is an important consideration as it can limit artificial recharge. If depth to groundwater is too shallow, it facilitates groundwater mounding under the recharge site, which will impede infiltration of water. On the other hand, groundwater elevations that are excessively deep will have increased travel time to the water table and can significantly delay the benefits of recharge with a slow response in water level increases. The depths to groundwater in this feasibility study are described for the selected target recharge areas for both wet and dry conditions. The determination of how the depth to groundwater may affect potential recharge, however, has not been evaluated quantitatively for this screening level study. This would require a more detailed investigation and further local testing of selected target areas.

Land Use Factors

Anthropogenic land uses were superimposed on the Recharge Potential Index Map to select the recharge target areas that avoid potential negative impacts from certain land use features. The following land use conditions were considered:

- Proximity to 100-year flood zone areas (closer areas are preferred)
- Proximity to wastewater treatment plant effluent percolation ponds (potential for mounding)
- Proximity to septic tank locations (potential for contamination)
- Proximity to wells (potential to capture recharge water without benefiting aquifer)
- Agricultural crop coverages (some crop types cannot handle inundation)

The Federal Emergency Management Authority (FEMA) delineated 100-year flood zone areas in the basin that are susceptible to flooding and will likely not be developed due to zoning laws (Figure 6). The 100-year flood zone areas are located within preferred areas of the Recharge Potential Index Map along the alluvial channels of the rivers and streams that receive stormwater runoff that can be diverted without large engineering efforts. Therefore, target areas within the 100-year flood zone are considered to be beneficial.

Existing or proposed wastewater treatment facilities add treated water to the streamflow, thereby artificially recharging the nearby groundwater and potentially creating high groundwater conditions that can impede recharge. Based on the GSP model, depth to water is about 10 feet (ft) below ground surface (bgs) near existing wastewater treatment plants and is therefore not considered to be beneficial for additional stormwater recharge.

Septic tank discharges are undesirable for artificial recharge projects and should be avoided to protect the water quality. Physical addresses outside municipalities are assumed to have a septic system as shown on Figure 6. Areas with high distribution of septic tanks were avoided in selecting recharge target areas.

Location of active nearby groundwater wells were taken into account for the selection of the recharge target areas. Both active private and public well locations were assumed to have a negative effect on increasing aquifer storage from stormwater recharge. Due to the confidentiality of the well locations, none are shown in the figures; however, the quantity of wells inside the selected recharge target areas are considered in this analysis.

Aquifer recharge from agricultural land is a potential option, as indicated for State of California by the Soil Agricultural Groundwater Banking Index (SAGBI) map (O'Geen et al., 2015). The SAGBI is a comparative distribution model, similar to this feasibility study, showing distributed factors pertaining to the aquifer recharge potential from agricultural crop areas on a statewide scale. This study shows that vineyards have much greater tolerance for saturated conditions compared with most other crops.[2] Hence, nearby vineyards

[2] Vineyards can tolerate saturated conditions for approximately 2 to 4 weeks (O'Geen et al., 2015).

are considered to be potentially beneficial for artificial recharge and were considered in the selection of target recharge areas (see Figure 7).

Average Stormwater Available for Capture and Recharge

For cost-effective artificial recharge, a local source of water, such as stormwater, is preferred. The results of the existing HSPF watershed model, which is a component of the Paso Robles Basin GSP model, were used to assess and quantify stormwater availability.

Simulated HSPF Surface Water and Streambed Percolation in Sub-Watersheds

The GSP model consists of three parts; the HSPF watershed model, a soil-water balance model, and a groundwater model. This three-part model is calibrated to gaged streamflow and groundwater elevations measured in wells to within industry standards and provides a reasonable approach to quantify streamflow and diversion potential for this feasibility study. The accuracy of modeled quantities from the GSP model varies spatially and temporally within the model domain and, as such, the quantified results used in this study should be viewed in a relative rather than an absolute sense.

Results from the existing updated HSPF watershed model (Montgomery, 2020b) were exported at a sub-watershed scale for the available model period from 2001 through 2016. The sub-watershed scale of the HSPF model is shown in Figure 8, along with the model reaches along which the surface water inflows and outflows and streambed percolations are quantified. Modeled streamflow and streambed percolation are important parameters because they indicate locations along the river and stream valleys that either have good recharge potential and/or have available capturable stormwater.

The HSPF watershed model results were used to estimate potential diversion volumes at the sub-watershed scale for the target areas. The State Water Resources Control Board will permit diversion of stormflows that are 20 percent of the 90 percent exceedance flows, which occur, on average, 10 percent of the time. The estimated diversion estimates are based the USGS daily statistics for the Salinas River near Paso Robles, at USGS gage 111475000. USGS used the period of record from 1944 through 2019 to calculate the average daily flow percentiles for the Salinas River near Paso Robles. These statistics were applied to the observed daily Salinas River flows and, if these flows exceeded the USGS calculated 90 percent flow, then 20 percent of that exceedance is calculated as the diversion potential. The diversion potential as a percent of the total flow was calculated from 2001 through 2016 to coincide with the period of record of the HSPF watershed model on a monthly basis to match the monthly output of the model. The calculated monthly diversion percentages from the Salinas River were then applied to the HSPF model flow results, as an estimate of the diversion potential at the sub-watershed scale (see Figure 8).

Streambed percolation is estimated by the HSPF watershed model within each of the reaches of the sub-watersheds. Streambed percolation, at the sub-watershed scale, is an indication of a relative recharge rate along the river valleys. The HSPF watershed model streambed recharge rates are derived from the Green-Ampt infiltration equation (Green, et al., 1911) for a Hydrologic Soil Group as defined by the NRCS and possibly further refined through model calibration. In addition to the modeled HSPF model streambed percolation, estimated recharge rates from the NRCS Hydrologic Soil Groups are calculated. Based on the NRCS Soil Survey Hydrologic Soil Group and estimated soil water properties by Rawls et al. (1982) the following infiltration rate table was used for this study to estimate infiltration rates in the target areas.

Table 4 – NRCS Soils Data Infiltration Rates

Soil Texture Class	NRCS Hydrologic Soil Group	Infiltration Rate (Inches/Hour)
Sand	A	8.27
Loamy Sand	A	2.41
Sandy Loam	B	1.02
Loam	B	0.52
Silt Loam	C	0.27
Sandy Clay Loam	C	0.17

Identification of Target Areas for Potential Stormwater Recharge

To select potential recharge target areas and incorporate all the considerations described in previous sections, information was compiled into a GIS environment overlaying a current areal image of the Paso Robles Subbasin to ensure that no impervious structures would interfere with the potential recharge. The selection of target areas considered the topography, soil and aquifer conditions, and land use environments that have the most beneficial effect on the potential artificial recharge of stormwater.

GSI selected five preliminary target areas that meet the range of conditions for recharge and available stormflow (Target Areas 1 through 5). Two of the selected target areas are along the Estrella River, two more along the San Juan Creek and one near the Huer Huero Creek (see Figure 9). Other locations could be considered if there is local knowledge indicating stormwater recharge could be feasible. The estimated average annual quantities of surface water flow, diversion potential, streambed percolation, and depth to groundwater all were derived from either the HSPF watershed model or MODFLOW groundwater model parts of the GSP model. A soil infiltration rate was also estimated from the dominant NRCS Hydrologic Soil Group present in the target areas. The dominant Hydrologic Soil Group in all target areas is A, loamy sand, with a published infiltration rate of 2.41 inches per hour. A loamy sand consists of approximately 80 percent sand with 20 percent fines, such as silt and clay.

To determine the average, wet, and dry conditions in the limited period of record of the HSPF model (2001 through 2016), observed annual streamflow data from 1941 through 2019 of the USGS Salinas River gage near Paso Robles was used. The annual average flow from 1941 through 2019 in the Salinas River is 97.7 cubic feet per second (cfs), which is close to the 2001 annual flow of 98.4 cfs. Similarly, flows in the lowest quartile (or less than the 25 percentile flows of 10 cfs) were considered as dry conditions, and flows in the highest quartile (or greater than the 75 percentile flows of 135 cfs) were considered as wet conditions. From this Salinas River flow analysis, it was determined that annual HSPF model results for water years 2001, 2005, and 2014 are representative of average, wet, and dry hydrologic conditions, respectively.

Target Area 1. Alongside the Estrella River, recharge Target Area 1 has the most estimated stormwater available compared with other target areas, as it is the most downstream location with the largest contributing watershed area (Figure 9). Target Area 1 has on average, for water years 2001 through 2016, an estimated surface water flow of 16,150 acre-feet per year (AFY), diversion potential of 1,890 AFY, streambed percolation of 160 AFY, and a depth to water of 40 ft bgs in 2005 (wet conditions) and 50 ft bgs in 2014 (dry conditions) (see Figures 9 and 10). The target area's approximate average potential recharge index is 6.5 (see Figure 5).

The target areas consist of NRCS Hydrologic Soil Group A with an estimated recharge rate 2.41 inches per hour (see Table 4) or 4.8 acre-ft/day per acre. The estimated annual potential diversions from 2001 through 2016 are shown in Figure 11, where most of the divertible flow is available during very wet years and no divertible flows are available in dry years. The HSPF modeled annual average diversion potentials are 280 AFY, 20,500 AFY, and 0 AFY for average (2001), wet (2005) and dry (2014) hydrologic years, respectively. In Target Area 1 there are no active non-confidential private or public wells. Stormwater recharge in this area probably has the least benefit to the overall groundwater basin because it is downgradient of the areas that are affected by chronic lowering of groundwater levels.

Target Area 2. Target Area 2 is upstream and to the east of Target Area 1 and has an estimated surface water flow of 15,360 AFY, diversion potential of 1,800 AFY, streambed percolation of 530 AFY, and a depth to water of 15 ft bgs in 2005 (wet conditions) and 25 ft bgs in 2014 (dry conditions) (see Figures 9 and 10). The target area's approximate average potential recharge index is 6.5 (see Figure 5). The target area consists of the NRCS Hydrologic Soil Group A with an estimated recharge rate 2.41 inches per hour (see Table 4) or 4.8 acre-ft/day per acre. The estimated annual potential diversions from 2001 through 2016 are shown in Figure 12, where most of the divertible flow is available during very wet years and no divertible flows are available in dry years. The HSPF modeled annual average diversion potentials are 250 AFY, 19,800 AFY, and 0 AFY for average (2001), wet (2005), and dry (2014) hydrologic years, respectively. In Target Area 2 there are no active non-confidential private or public wells. Again, this area is downgradient and does not substantially benefit the majority of the basin.

Target Area 3. Along the San Juan Creek, Target Area 3 has significantly less surface water flows compared with the more downstream Target Areas 1 and 2; however, as expected due to coarser aquifer material, Target Area 3 has greater streambed recharge. Target Area 3 has on average, for water year 2001 through 2016, an estimated surface water flow of 5,030 AFY, diversion potential of 590 AFY, streambed percolation of 1,160 AFY, and a depth to water of 60 ft bgs in 2005 (wet conditions) and 70 ft bgs in 2014 (dry conditions) (see Figures 9 and 13). The target area's approximate average potential recharge index is 7.5 (see Figure 5). The target area consists of NRCS Hydrologic Soil Group A with an estimated recharge rate 2.41 inches per hour (see Table 4) or 4.8 acre-ft/day per acre. The estimated annual potential diversions from 2001 through 2016 are shown in Figure 14, where most of the divertible flow is available during very wet years and no divertible flows are available in dry years. The HSPF modeled annual average diversion potentials are 15 AFY, 6,800 AFY, and 0 AFY for average (2001), wet (2005) and dry (2014) hydrologic years, respectively. In Target Area 3 there are no active non-confidential private or public wells. Recharge in this part of the basin would benefit a larger portion of the basin because it is located upgradient of the areas that are affected by chronic lowering of groundwater levels and because more water would move into the Paso Robles Formation.

Target Area 4. Target Area 4, also along the San Juan Creek, has on average for water year 2001 through 2016, an estimated surface water flow of 4,950 AFY, diversion potential of 580 AFY, streambed percolation of 580 AFY, and a depth to water of 100 ft bgs in 2005 (wet conditions) and 120 ft bgs in 2014 (dry conditions) (see Figures 9 and 13). The target area's approximate average potential recharge index is 7.0 (see Figure 5). The target area consists of NRCS Hydrologic Soil Group A with an estimated recharge rate 2.41 inches per hour (see Table 4) or 4.8 acre-ft/day per acre. The estimated annual potential diversions from 2001 through 2016 are shown in Figure 15, where most of the divertible flow is available during very wet years and no divertible flows are available in dry years. The HSPF modeled annual average diversion potentials are 0 AFY, 6,200 AFY, and 0 AFY for average (2001), wet (2005) and dry (2014) hydrologic years, respectively. Inside Target Area 4 there is one active private non-confidential well. Recharge in this part of the basin would benefit a larger portion of the basin because it is located upgradient of the areas that are affected by chronic lowering of groundwater levels and because more water would move into the Paso Robles Formation.

Target Area 5. Target Area 5, in the upstream reaches of the Huer Huero Creek, has the best physical conditions to recharge stormwater. Because of this recharge potential, the natural flows occurring in Huer Huero Creek are already being recharged, leaving negligible additional naturally available stormwater. Although Target Area 5 is ideal for artificial recharge, the water source must be imported due to lack of natural flows. Target Area 5 has on average, for water year 2001 through 2016, an estimated surface water flow of 1,030 AFY, diversion potential of 60 AFY, streambed percolation of 1,220 AFY, and a depth to water of 70 ft bgs in 2005 (wet conditions) and 90 ft bgs in 2014 (dry conditions) (see Figures 9 and 16). The target area consists of NRCS Hydrologic Soil Group A with an estimated recharge rate 2.41 inches per hour (see Table 4) or 4.8 acre-ft/day per acre. The estimated annual potential diversions from 2001 through 2016 are shown in Figure 17, where most of the divertible flow is available during very wet years and no divertible flows are available in dry years. The HSPF modeled annual average diversion potential are 0 AFY, 630 AFY, and 0 AFY for average (2001), wet (2005), and dry (2014) hydrologic years, respectively. Inside Target Area 5 there is one active confidential private well and one active non-confidential public well. Recharge in this part of the basin would benefit a larger portion of the basin because it is located upgradient of the areas that are affected by chronic lowering of groundwater levels and because more water would move into the Paso Robles Formation. However, there is an insufficient quantity of natural stormwater flow. This area would be ideal for recharge if an imported source of water were available.

Conclusions

Based on comparative distribution modeling to determine the optimum recharge locations, considering land use, and quantifying the available stormwater in the Paso Robles Subbasin using the GSP model, the following conclusions can be drawn:

- The comparative distribution modeling of topographic slope, soil, and aquifer hydraulic conductivities, in general, delineates that the optimum recharge areas are located near river and creek drainages and toward the higher elevations in the eastern part of the basin, due to greater aquifer hydraulic conductivity.
- Based on the calibrated surface/groundwater GSP model results, capturable stormwater volumes increase in the downstream direction of the San Juan Creek and Estrella River, as the contributing watershed areas become larger. However, stormwater recharge at downgradient locations offer the least benefit to the rest of the basin.
- The areas along the more upstream locations of Huer Huero Creek have the best physical recharge properties in the Paso Robles Subbasin but with limited stormwater flows, since most of the existing surface water percolates into permeable soils connected to the underlying Alluvial Aquifer. It is therefore better suited for recharge of imported water.
- All of the five selected recharge target areas have soils classified as NRCS Hydrologic Soil Group A. NRCS A- soils are the most conducive soils for recharge with an estimated approximate infiltration rate of 2.41 inches/hour or 4.8 acre-ft/day per acre.
- Target Area 1 and 2 have the most available stormwater but lesser physical capacity to percolate water compared to the other target areas.
- Target Areas 3 and 4 have lesser available stormwater but have greater physical capacity to percolate water compared to Areas 1 and 2. The inverse is true compared to Target Area 5.

- Target Area 5 has very little available stormwater flow but has the greater physical capacity to percolate water compared to the other target areas.
- Stormwater is only available during wet periods and the return frequencies of these hydrologic conditions are on the scale of many years, during which no divertible storm water would be available for artificial recharge. While it may be feasible to capture and divert storm water, the cost of improvements and monitoring relative to the benefit of the recharge water to the basin is questionable and will have to be determined with additional evaluations.

Recommended Next Steps

This screening level feasibility study evaluated the five most promising recharge target areas in the Paso Robles Subbasin based on readily available regional data in the study area. Unfortunately, the analysis indicates that the capturable flows are only available for 2 or 3 years out of every 10-15 years and the quantities of flow that could be diverted are likely not large enough to make the cost versus benefit favorable. Rather than proceed with the original planned Phase 2 scope of work, a modified Phase 2 scope of work is suggested that will focus efforts and funds on developing one or more favorable sites where land owners are willing to participate in this program.

Site Specific Project Development

Task 3 – Identify Alternative Recharge Locations

The purpose of this task is to identify new locations where stormwater recharge would directly benefit the area of severe water level decline identified by the County of San Luis Obispo Department of Planning and Building and areas within the Shandon-San Juan Water District. Potential areas that have been suggested previously include parcels along the Estrella River west of Shandon and parcels along San Juan Creek. Based on present knowledge of hydrogeological conditions, recharge on parcels located along San Juan Creek would be less likely to benefit the area of severe decline observed to the west within a reasonable timeframe because of limited connectivity; however, recharge in the San Juan Creek area would infiltrate relatively quickly and may help maintain water levels in that area.

In this task, the results of the SkyTEM geophysical study (to be released by the County in early 2021) will be used to further identify favorable areas that lack significant clay layers and that have connectivity with the deeper Paso Robles Formation in the area of severe decline. These data will be integrated with the Phase 1 GIS recharge criteria layers to identify parcels that have the highest potential for recharging the largest amount of water into the area of severe decline.

Task 4 – Site Specific Project Investigation

The purpose of this task is to obtain site specific information about infiltration rates and potential recharge volumes at the preferred locations identified in Task 3. This would better define the project, quantify the actual recharge potential, and determine what approach is needed to capture the stormwater at a specific location. Subtasks include:

- Work with landowners identified in Task 3 to map out where the project(s) would be sited.
- Assess river morphology to determine the best method for diverting stormwater into an area to be flooded.
- Develop contractor cost estimates once a site is selected.
- Drill a borehole and collect soil samples to assess the depth to the Paso Robles Formation and presence of clay layers that may impede downward movement of recharge water.

- Perform soil textural analysis using test pits and submit samples to a soils lab for measurement of grain size distribution and permeability.
- Perform infiltration testing in test pits to measure near surface infiltration rates.
- Perform a surface geophysical survey to identify the most suitable areas for recharge and estimate infiltration characteristics.

Task 5- Permitting and Regulatory Requirements

This task includes review of applicable County and State of California permitting and approval requirements pertaining to siting and operating stormwater capture and recharge projects. These approvals and permits may include land use approval from the County, stream diversion permit from the State Water Resources Control Board (SWRCB) or the Department of Water Resources (DWR), CEQA environmental review, and grading and building permits from the County.

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FIGURES

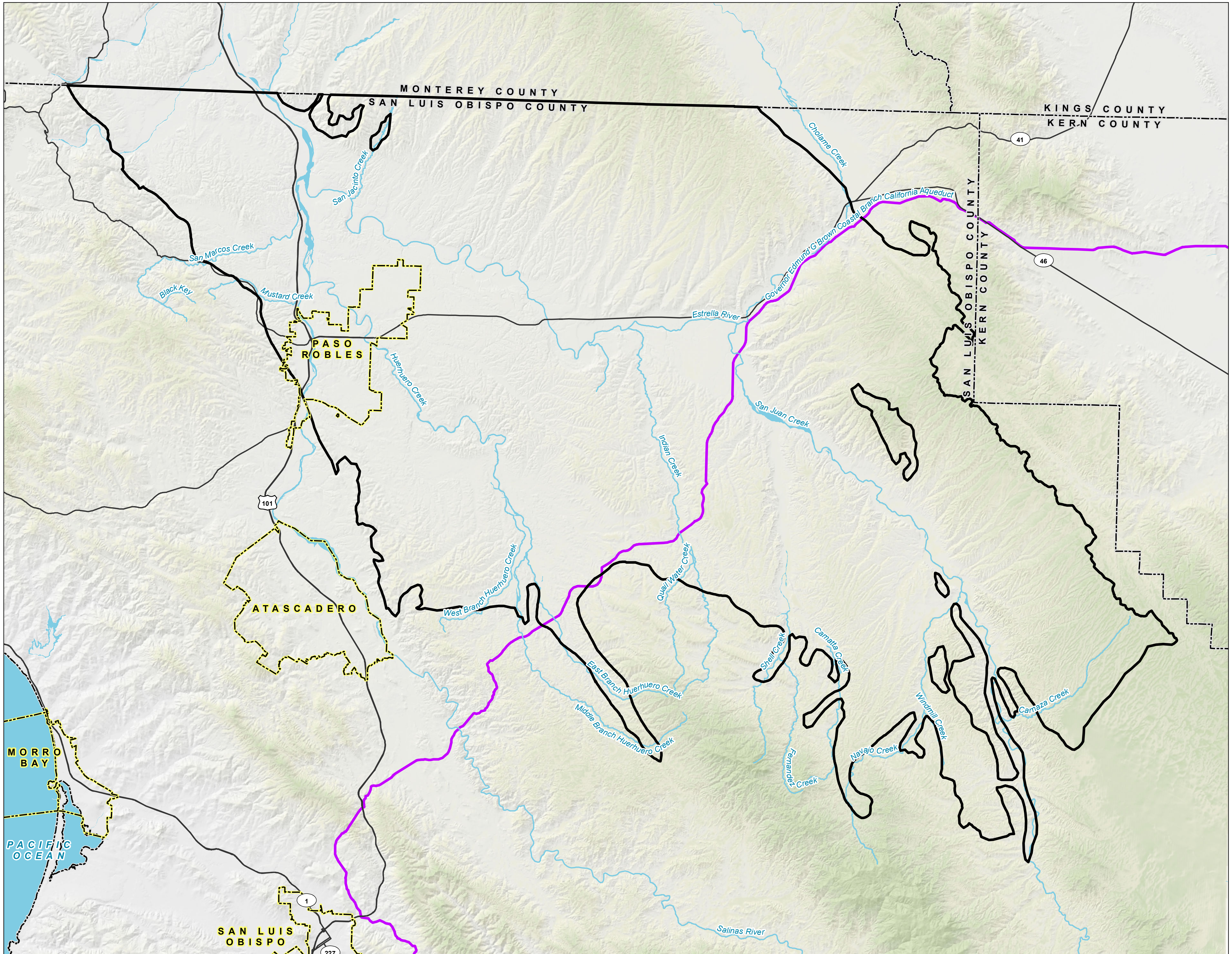

FIGURE 1
Study Area
Paso Robles Subbasin

LEGEND
- Major Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary
- County Boundary

N

0 2 4 6
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

GSI Water Solutions, Inc.

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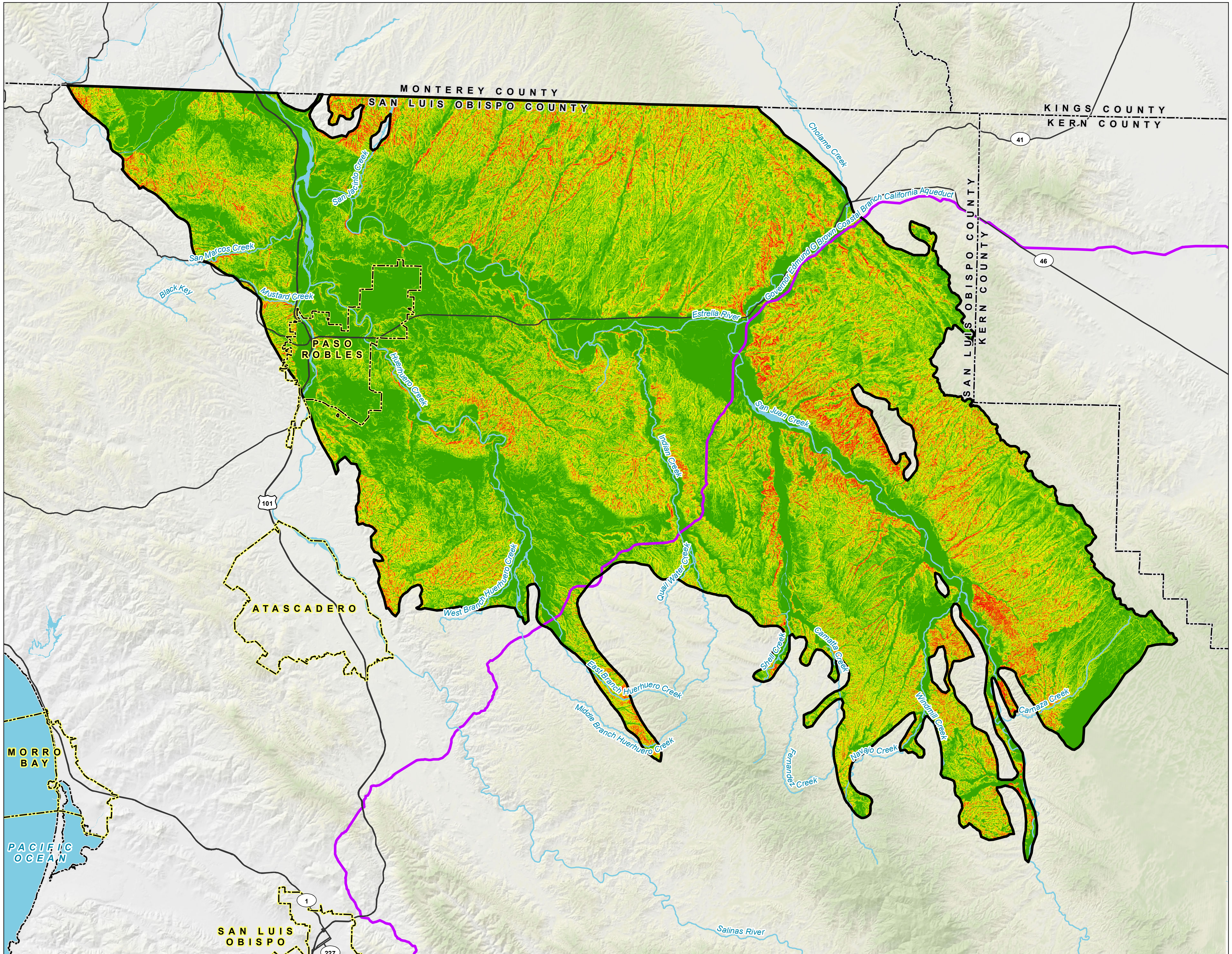
FIGURE 2

Topographic Slope Recharge Potential Index Ranking

Paso Robles Subbasin



LEGEND

Topographic Slope Recharge Potential Index Ranking

- 1: Very Low
- 2: Low
- 3: Medium Low
- 4: Medium
- 6: Medium High
- 8: High
- 10: Very High

All Other Features

- Major Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary
- County Boundary

N

0 2 4 6
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

GSI Water Solutions, Inc.

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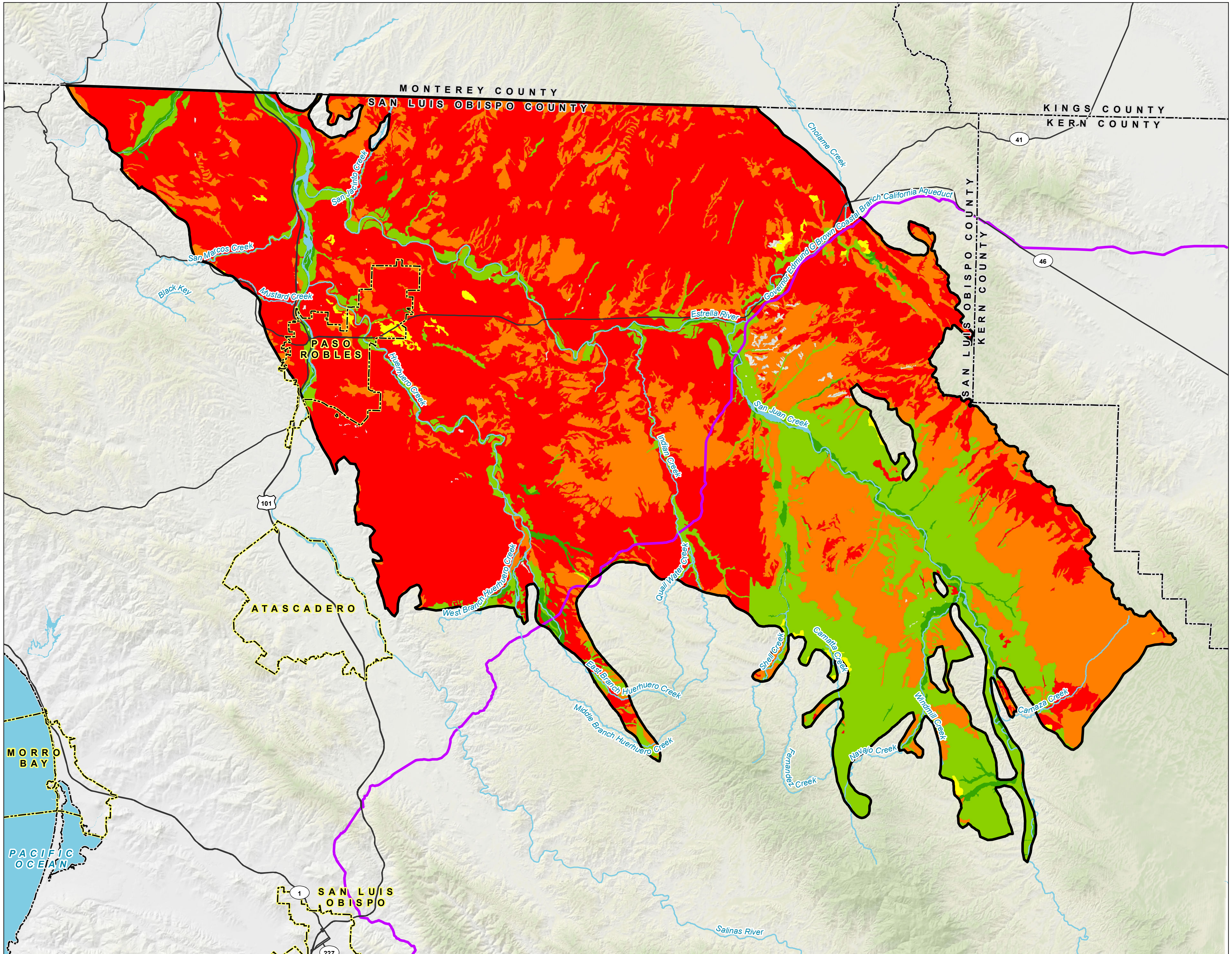

FIGURE 3

Saturated Soil Hydraulic Conductivity Recharge Potential Index Ranking

Paso Robles Subbasin

LEGEND

Saturated Soil Hydraulic Conductivity Recharge Potential Index Ranking

- 2: Low
- 4: Medium Low
- 6: Medium
- 8: High
- 10: Very High

All Other Features

- Major Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary

N

0 2 4 6
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

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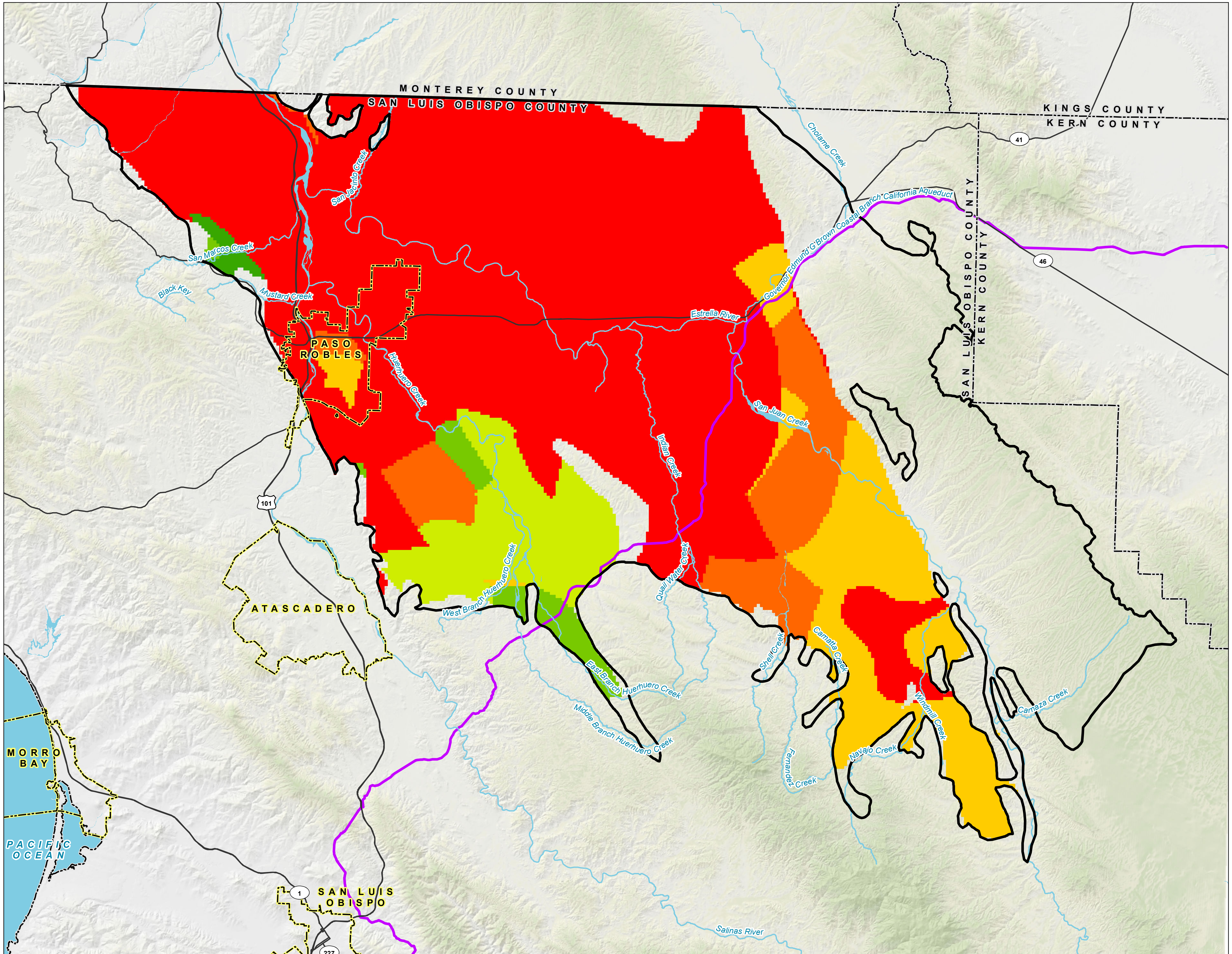

FIGURE 4

Aquifer Hydraulic Conductivity Recharge Potential Index Ranking

Paso Robles Subbasin

LEGEND

Aquifer Hydraulic Conductivity Recharge Potential Index Ranking

- 1: Very Low
- 3: Low
- 5: Medium Low
- 7: Medium
- 9: High
- 10: Very High

All Other Features

- Major Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary
- County Boundary

N

0 2 4 6
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

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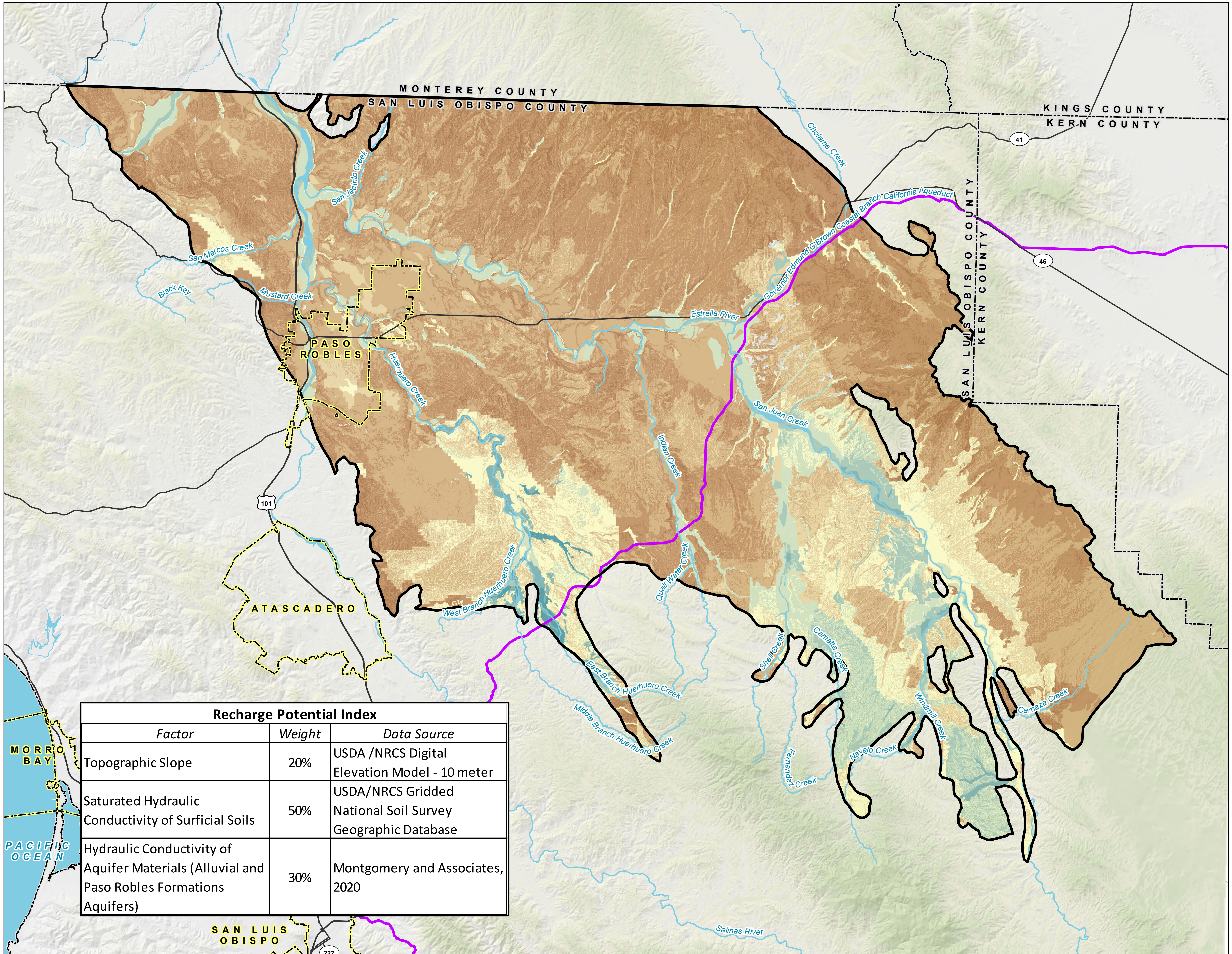
FIGURE 5

Recharge Potential Index Map

Paso Robles Subbasin



Recharge Potential Index		
Factor	*Weight*	*Data Source*
Topographic Slope	20%	USDA /NRCS Digital Elevation Model - 10 meter
Saturated Hydraulic Conductivity of Surficial Soils	50%	USDA/NRCS Gridded National Soil Survey Geographic Database
Hydraulic Conductivity of Aquifer Materials (Alluvial and Paso Robles Formations Aquifers)	30%	Montgomery and Associates, 2020

LEGEND

Recharge Potential Index

- 0 - 2 (Low)
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10 (High)

All Other Features

- Major Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary
- County Boundary

N

0 2 4 6
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

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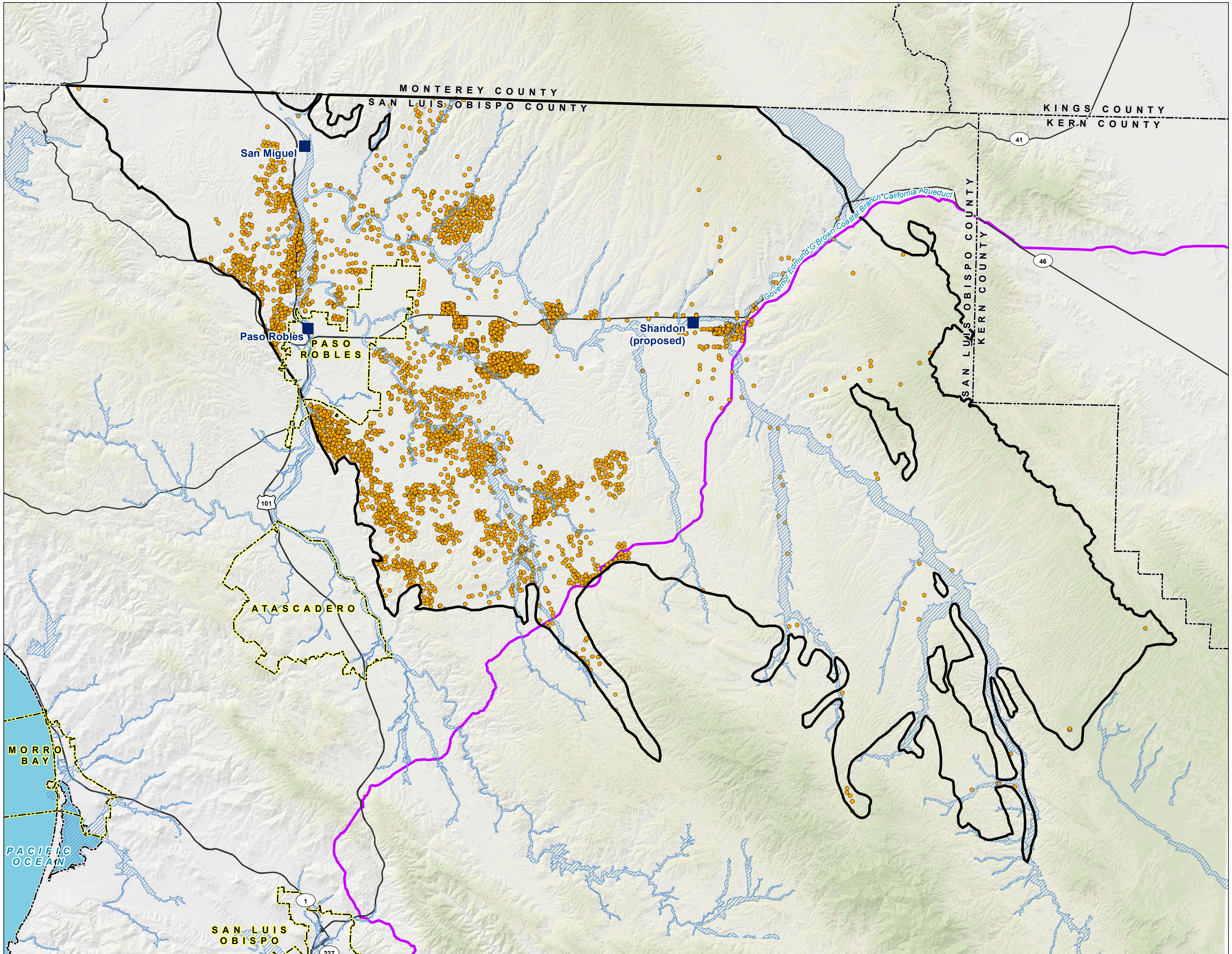
Document Path: Y:\0757_Shandon San Juan\Source Figures\004 - Flood Water Capture Recharge Study\Figure5_Recharge_Potential_Index.mxd

FIGURE 6

Key Physical Land Use Features

Paso Robles Subbasin



LEGEND

- Assumed Septic Tank Location (any address location outside of San Miguel or Paso Robles Service Area)
- Wastewater Treatment Facility
- 100-year Flood Zone
- Coastal Branch California Aqueduct

All Other Features

- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary
- County Boundary

N

0 2 4 6
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

GSI Water Solutions, Inc.

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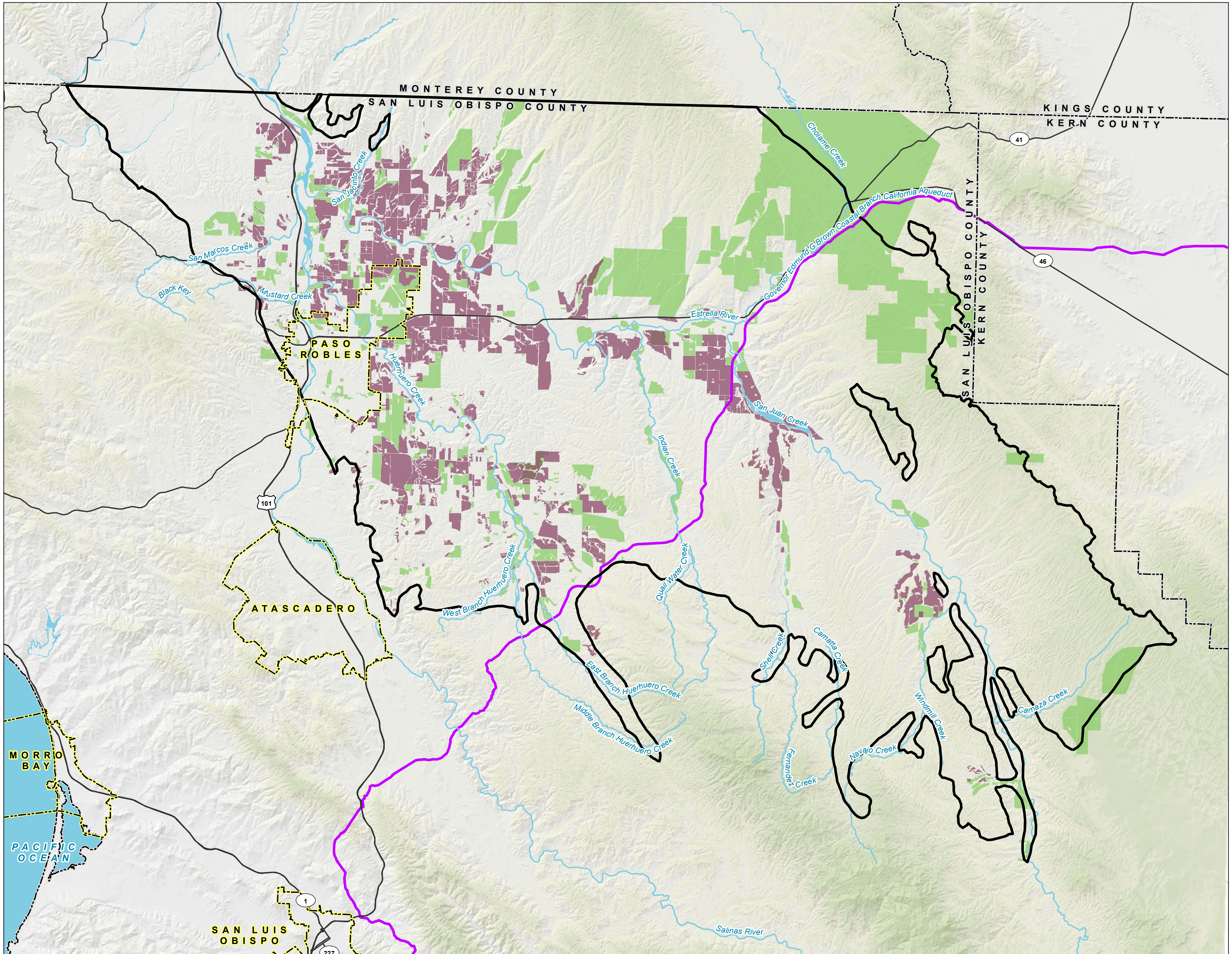
FIGURE 7

Agricultural Distribution of Vineyards Compared with Other Crop Types

Paso Robles Subbasin



LEGEND

Crop Type

- Vineyard
- Non-Vineyard

All Other Features

- Major Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary
- County Boundary

N

0 2 4 6
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

GSI Water Solutions, Inc.

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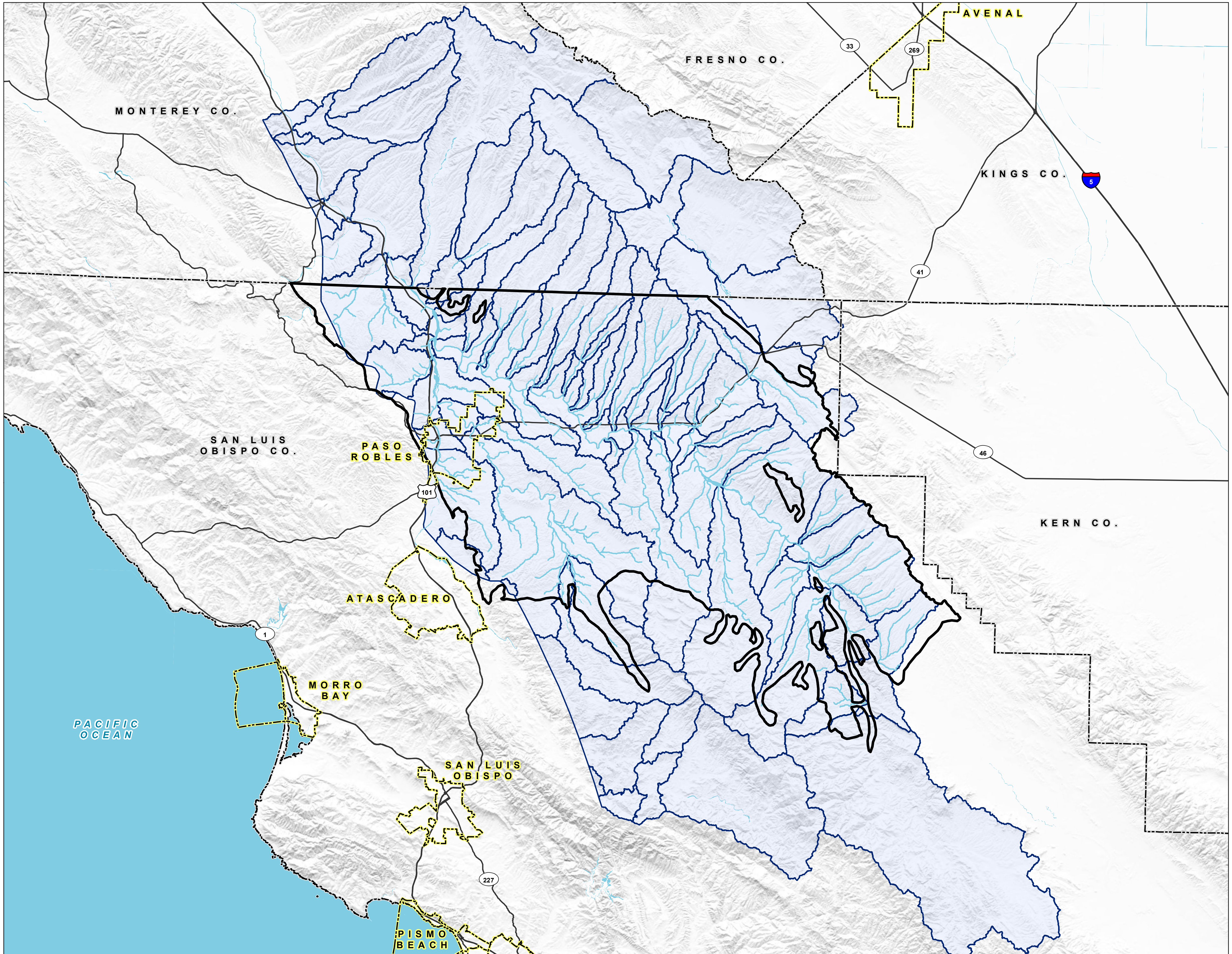

FIGURE 8

HSPF Watershed Model Sub-Watersheds

Paso Robles Subbasin

LEGEND

HSPF Model Reach

HSPF Model Sub-Watershed Boundary

All Other Features

Major Road

Salinas Valley Groundwater Basin - Paso Robles Area

City Boundary

County Boundary

NOTE

HSPF: Hydrologic Simulation Program - Fortran

N

0 3 6 9

Miles

Date: May 8, 2020

Data Sources: USGS, ESRI, CA DWR

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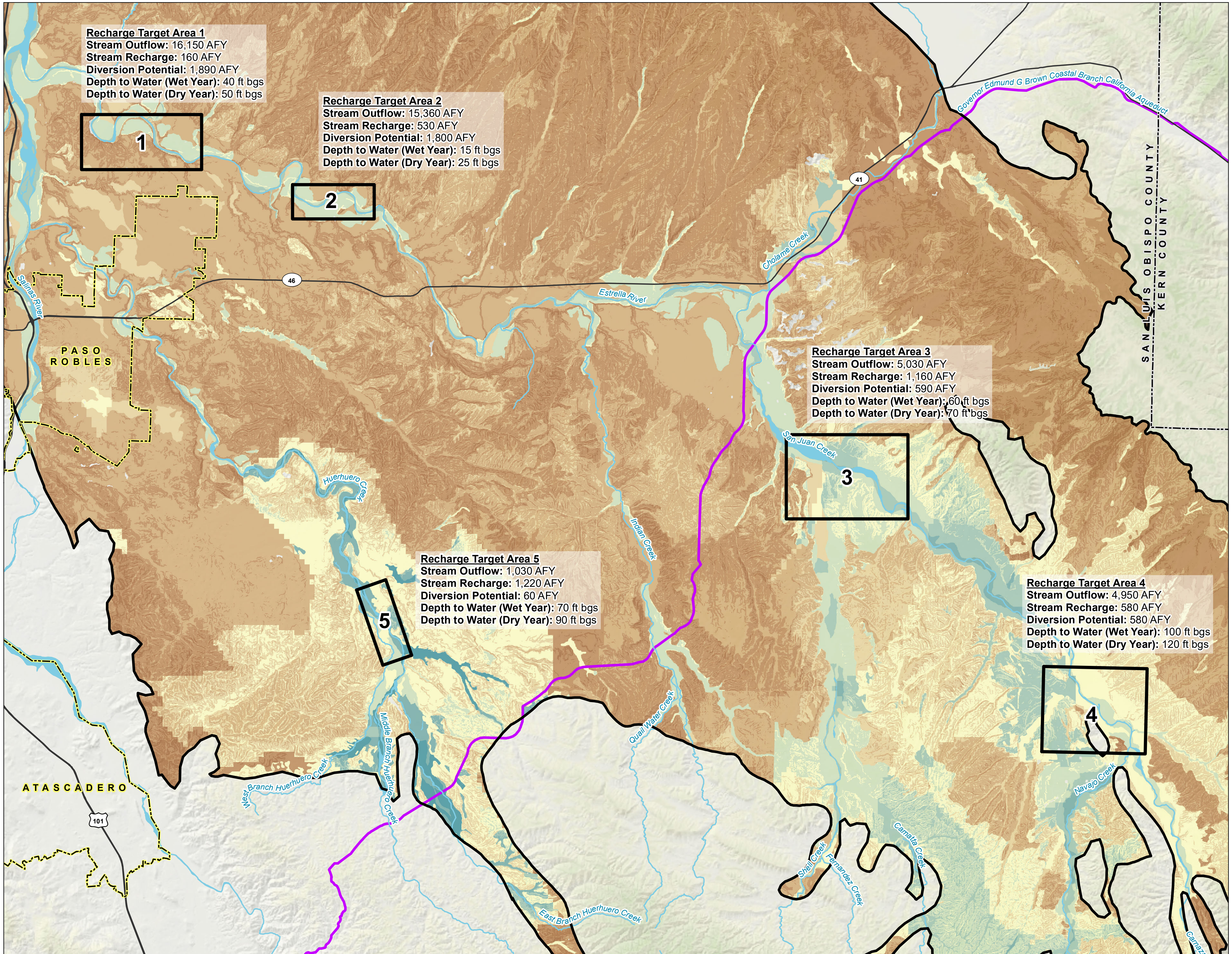

FIGURE 9

Selected Recharge Target Areas

Paso Robles Subbasin

LEGEND

Target Area

Recharge Potential Index

- 0 - 2 (Low)
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10 (High)

All Other Features

- Major Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- City Boundary
- County Boundary

NOTES

AFY: Acre Feet per Year
bgs: below ground surface

N

0 1 2 3
Miles

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

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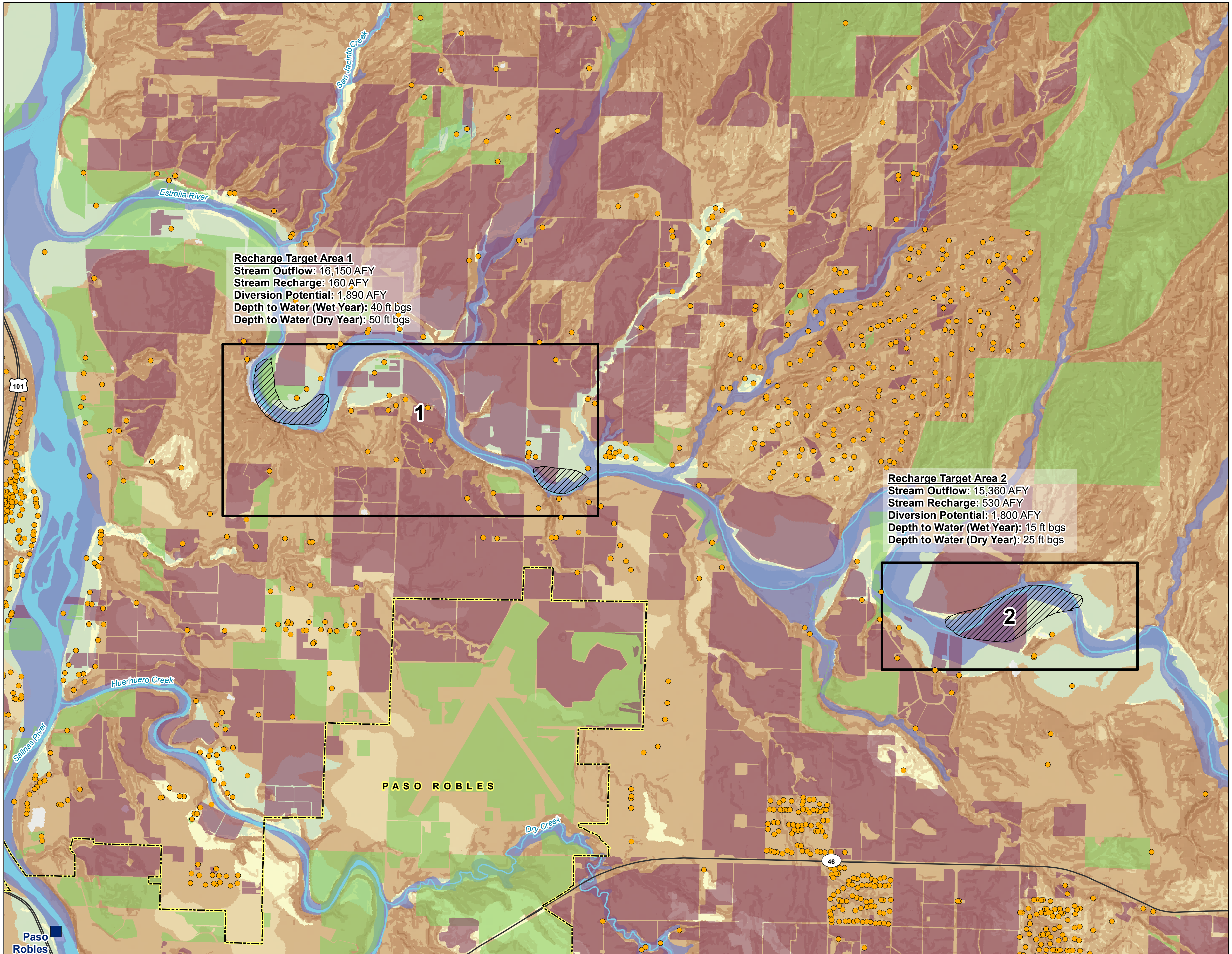
FIGURE 10

Selected Target Areas 1 and 2 Along the Estrella River

Paso Robles Subbasin



LEGEND

- Assumed Septic Tank Location (any address location outside of San Miguel or Paso Robles Service Area)
- Wastewater Treatment Facility
- Potential Recharge
- Target Area

Crop Type

- Vineyard
- Non-Vineyard

Recharge Potential Index

- 0 - 2 (Low)
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10 (High)

All Other Features

- Watercourse
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- 100-year Flood Zone
- City Boundary
- County Boundary

NOTE

bgs: below ground surface

N

0 2,000 4,000 6,000
Feet

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

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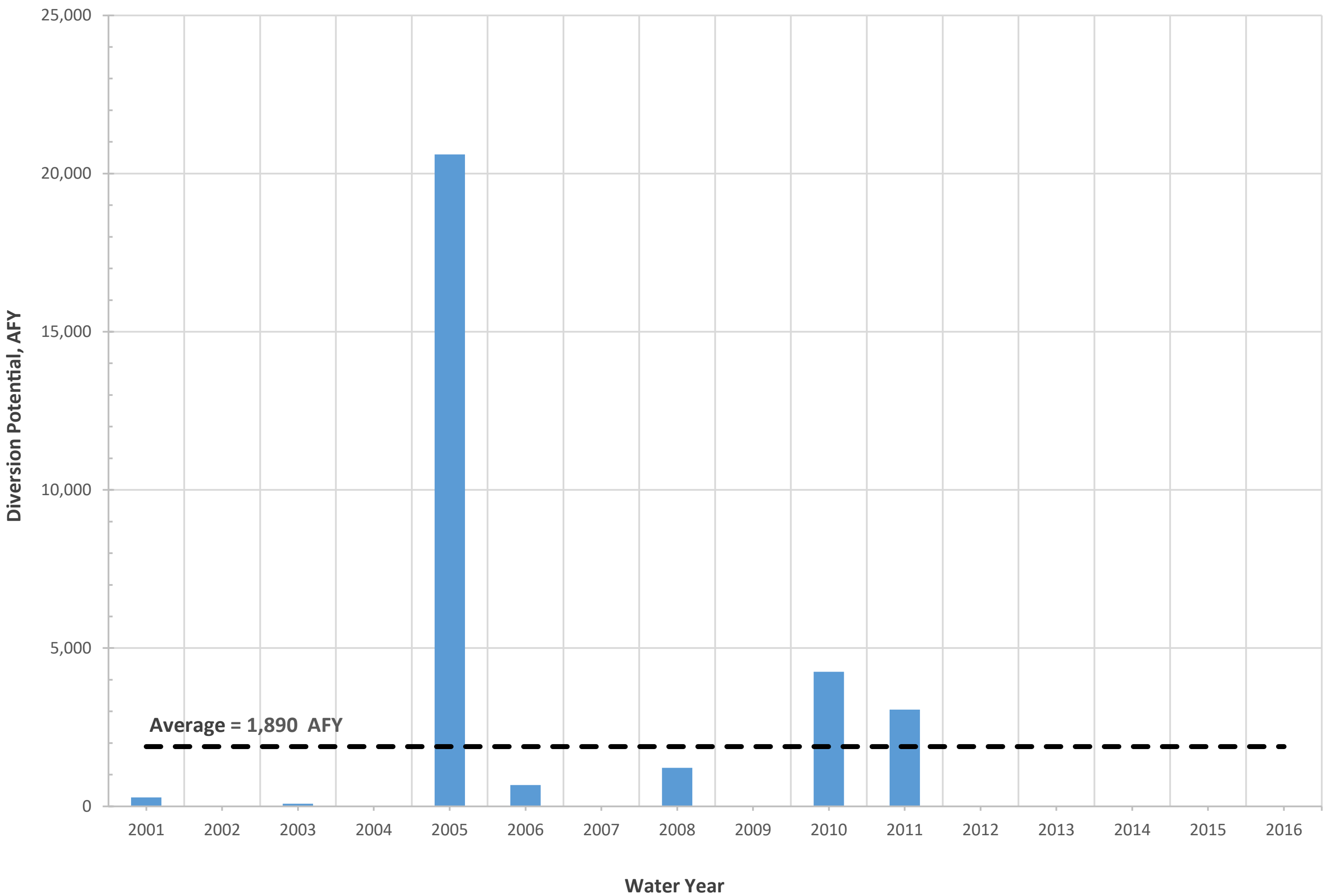
FIGURE 11

Annual Diversion Potential for Recharge Target Area 1 - Estrella River

Paso Robles Subbasin



LEGEND

Diversion Potential

Average Diversion Potential

NOTES

AFY: Acre Feet per Year

GSI Water Solutions, Inc.

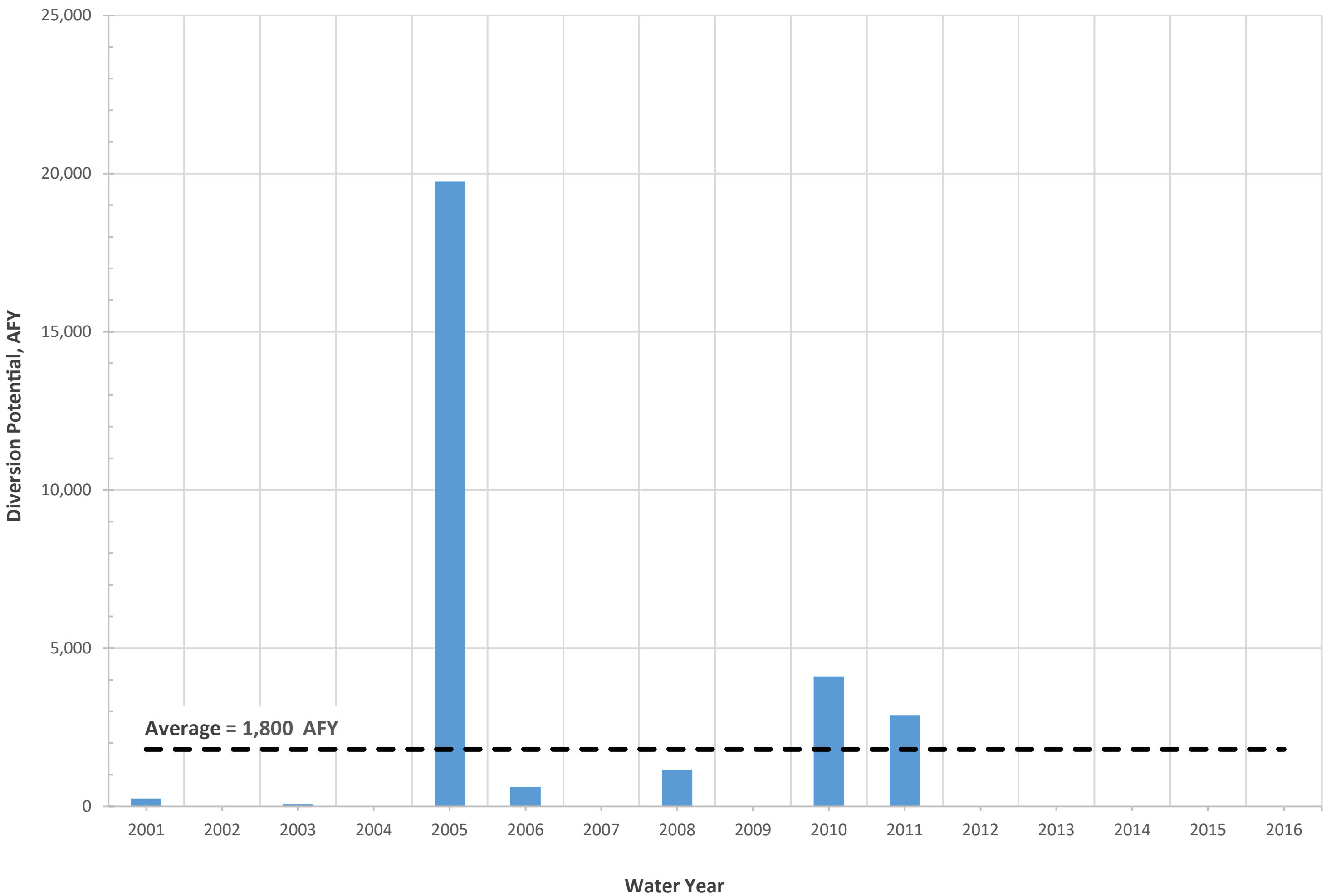


FIGURE 12

Annual Diversion Potential for Recharge Target Area 2 - Estrella River

Paso Robles Subbasin

LEGEND

- Diversion Potential
- Average Diversion Potential

NOTES

AFY: Acre Feet per Year

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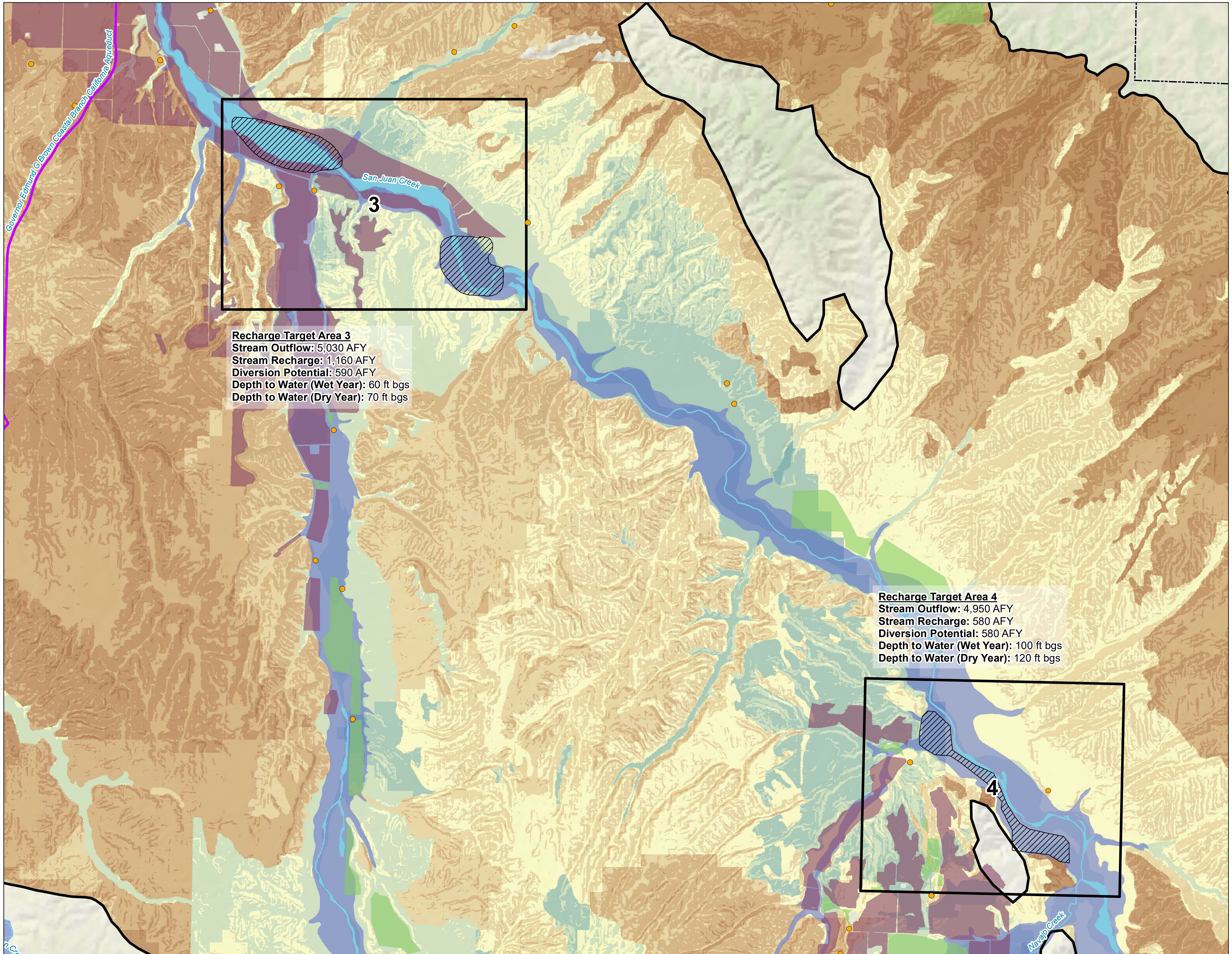
FIGURE 13

Selected Target Areas 3 and 4 Along San Juan Creek

Paso Robles Subbasin



LEGEND

- Assumed Septic Tank Location (any address location outside of San Miguel or Paso Robles Service Area)
- Wastewater Treatment Facility
- Potential Recharge Area
- Target Area

Crop Type

- Vineyard
- Non-Vineyard

Recharge Potential Index

- 0 - 2 (Low)
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10 (High)

All Other Features

- Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- 100-year Flood Zone
- City Boundary
- County Boundary

N

0 2,500 5,000 7,500
Feet

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

GSI Water Solutions, Inc.

Document Path: Y:\0757_Shandon San Juan\Source Figures\004 - Flood Water Capture Recharge Study\Figure13_Target_Areas_3_4.mxd

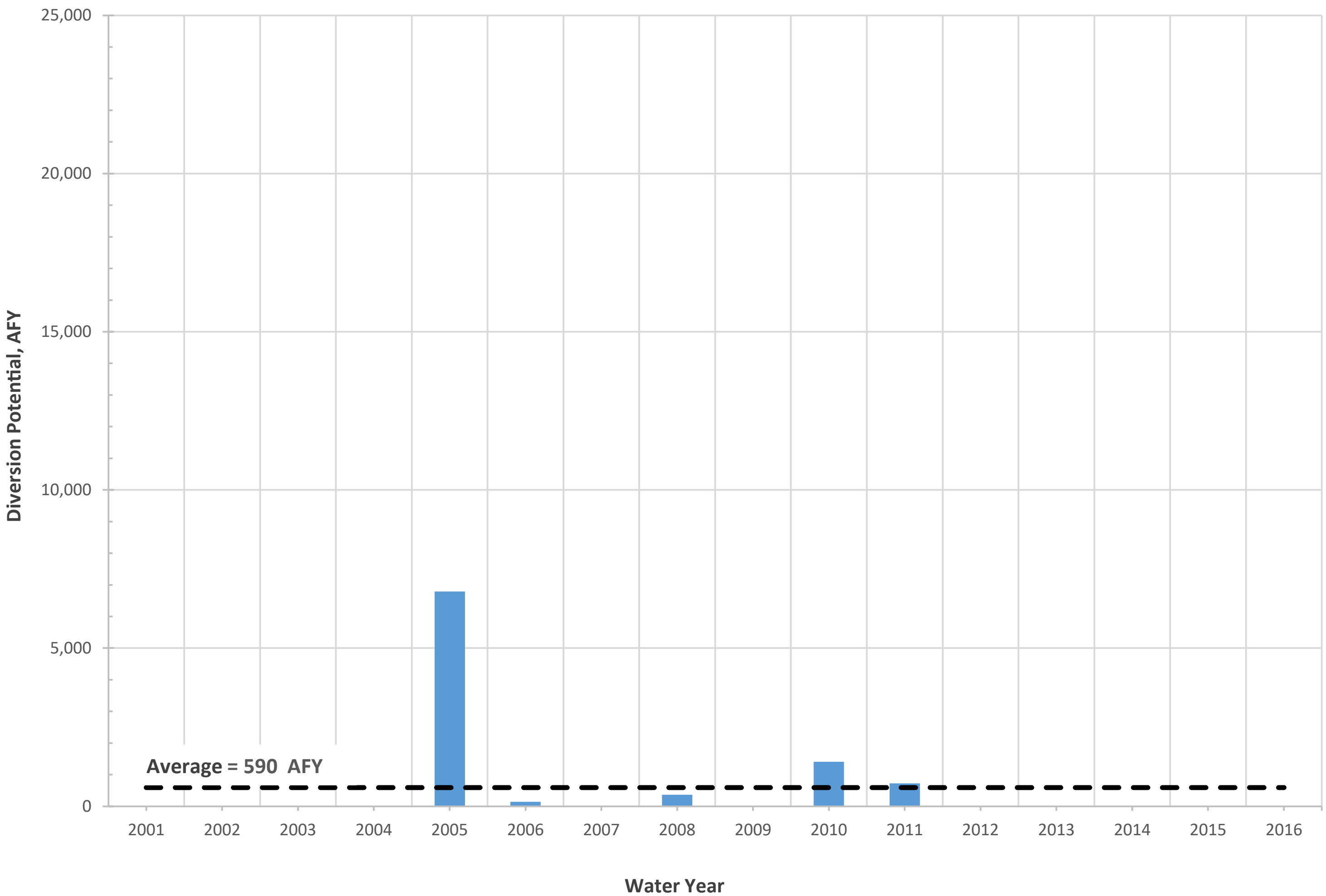


FIGURE 14

Annual Diversion Potential for Recharge Target Area 3 - San Juan Creek

Paso Robles Subbasin

LEGEND

Diversion Potential

Average Diversion Potential

NOTES

AFY: Acre Feet per Year

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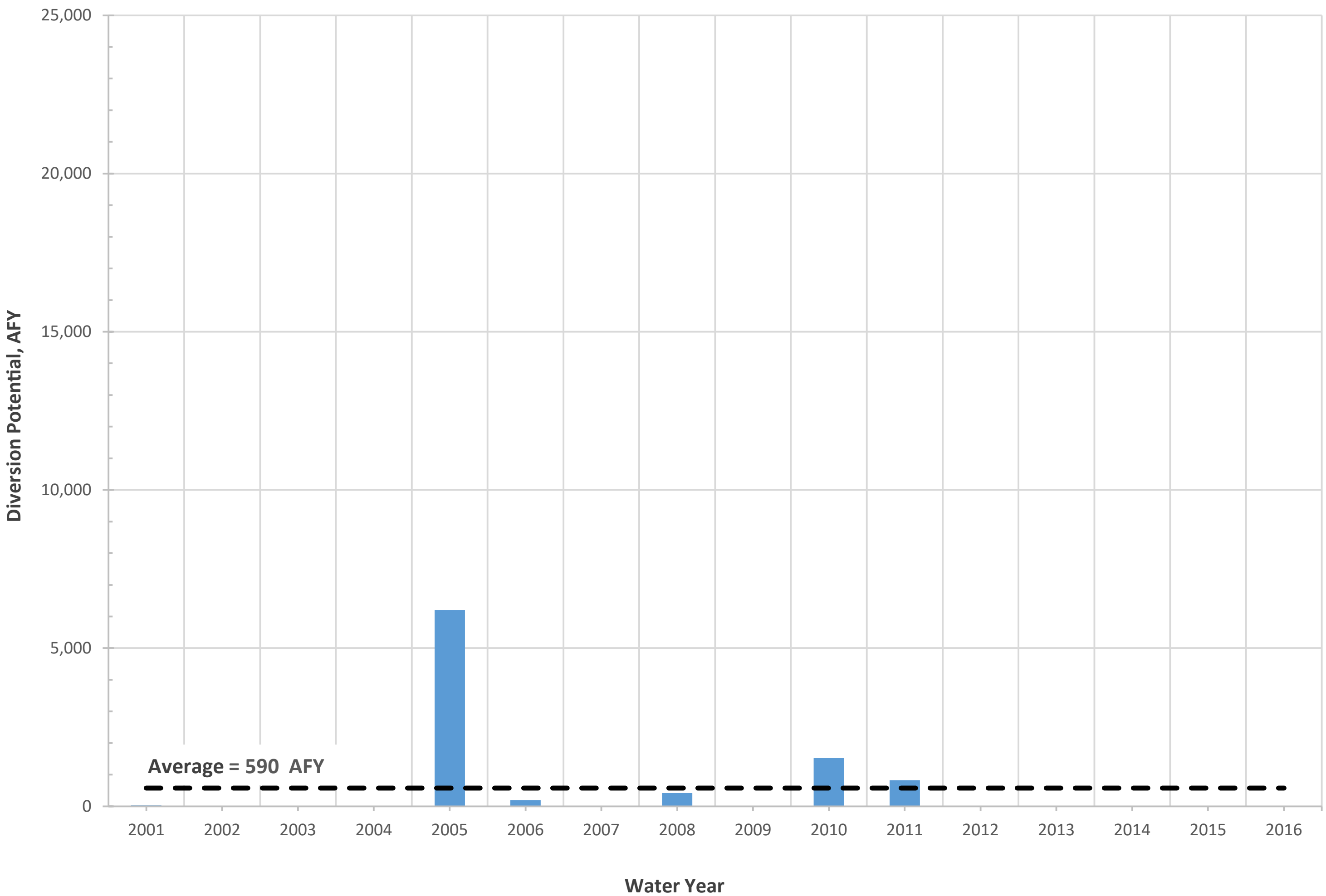

FIGURE 15

Annual Diversion Potential for Recharge Target Area 4 - San Juan Creek

Paso Robles Subbasin

LEGEND

Diversion Potential

Average Diversion Potential

NOTES

AFY: Acre Feet per Year

GSI Water Solutions, Inc.

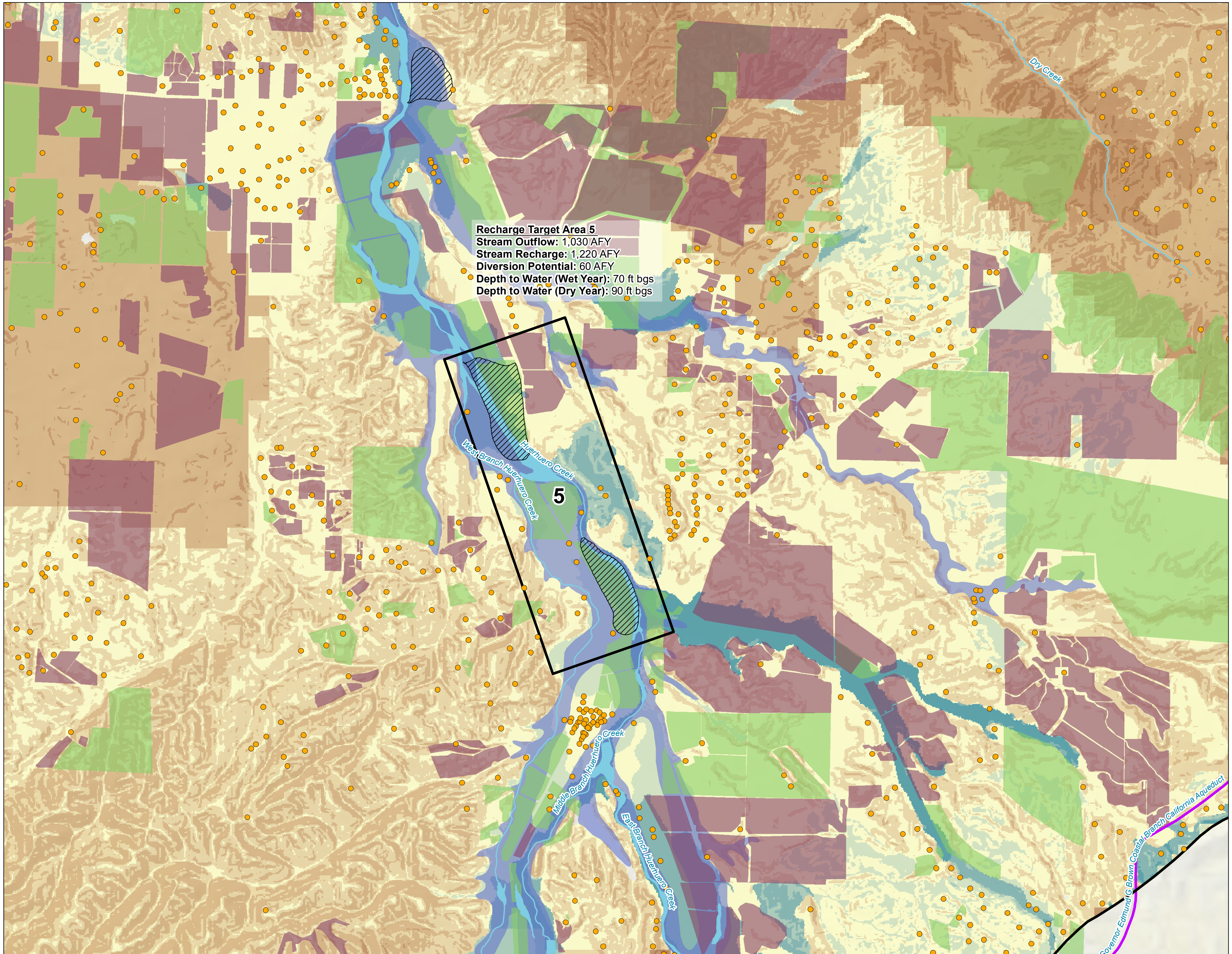

FIGURE 16

Selected Target Area 5 Along Huer Huero Creek

Paso Robles Subbasin

LEGEND

- Assumed Septic Tank Location (any address location outside of San Miguel or Paso Robles Service Area)
- Wastewater Treatment Facility
- Potential Recharge Area
- Target Area

Crop Type

- Vineyard
- Non-Vineyard

Recharge Potential Index

- 0 - 2 (Low)
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10 (High)

All Other Features

- Watercourse
- Coastal Branch California Aqueduct
- Major Road
- Salinas Valley Groundwater Basin - Paso Robles Area
- 100-year Flood Zone
- City Boundary
- County Boundary

N

0 1,500 3,000 4,500
Feet

Date: May 8, 2020
Data Sources: USGS, ESRI, SLO Co., CA DWR

GSI Water Solutions, Inc.

Document Path: Y:\0757_Shandon San Juan\Source Figures\004 - Flood Water Capture Recharge Study\Figure16_Target_Area_5.mxd

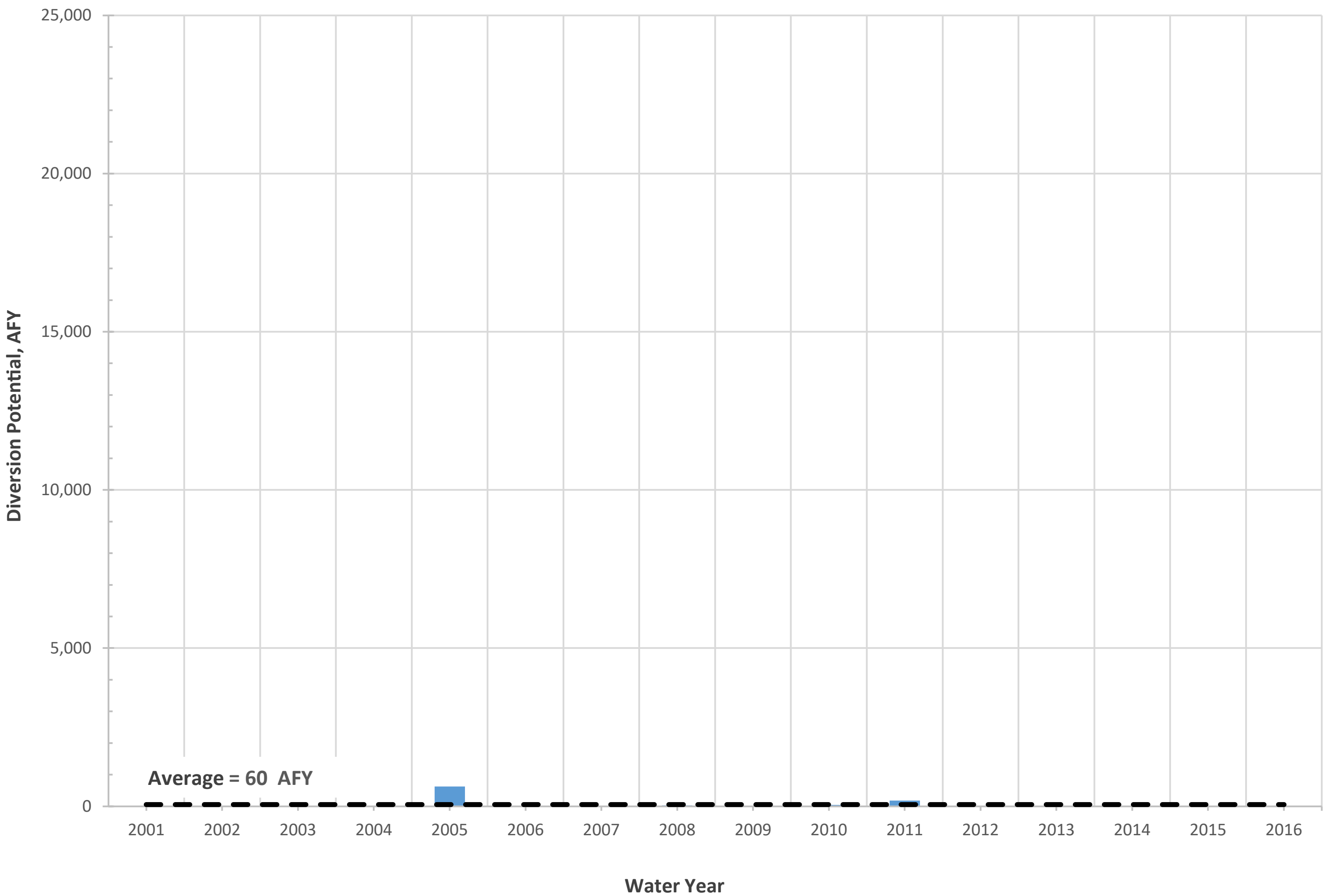

FIGURE 17

Annual Diversion Potential for Recharge Target Area 5 -Huer Huero Creek

Paso Robles Subbasin

LEGEND

- Diversion Potential
- Average Diversion Potential

NOTES

AFY: Acre Feet per Year

GSI Water Solutions, Inc.