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Water Availability Analysis

Harcross Winery and Vineyard, Use Permit #P23-00105-UP, Viewshed Protection Program #P25-000314-VIEW, and Agricultural Erosion Control Plan #P23-00325-ECPA
Planning Commission Hearing Date May 7, 2025

Water Availability Analysis

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Napa, CA 94558
(AP 027-530-006)

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Contents

Introduction

The applicant is seeking a use permit for a small 5,000 gallon per year winery and 3.0 acres (+/-) of vineyard at 6402 Dry Creek Road (APN 027-530-006). The applicant previously received permits from the County of Napa to build one new primary residence at the project parcel. An existing residence may or may not be retained; both residential units are accounted for in estimates of groundwater requirements in this Water Availability Analysis (WAA) to provide an estimate of potential groundwater use on the parcel.

The parcel is approximately 5 miles northwest of the City of Yountville and less than a mile east of the Sonoma County line in Napa County in the Dry Creek watershed (Figure 1). For purposes of WAA preparation, the parcel lies in the “hillside” zone where groundwater availability is determined on a site-specific basis. There are two wells on the property, one completed in 2020 and the other completed in 1979 that has since been destroyed by wildfire and is no longer in use. Water for the proposed vineyard and residences will be supplied by the existing well completed in 2020.

This Water Availability Analysis (WAA) was developed based on the guidance provided in the Napa County Department of Planning, Building, & Environmental Services' Water Availability Analysis Guidance Document formally adopted by the Napa County Board of Supervisors in May 2015. The WAA includes the following elements: estimates of existing and proposed water uses within the project recharge area, compilation of drillers' logs from the area and characterization of local hydrogeologic conditions, analyses to estimate groundwater recharge relative to proposed uses (Tier 1), assessment of potential well interference (Tier 2), and an analysis of potential effects on surface water bodies within 1500 ft of the project parcel (Tier 3).

Limitations

Groundwater systems of Napa County and the Coast Range are typically complex, and available data rarely allows for more than general assessment of groundwater conditions and delineation of aquifers. Hydrogeologic interpretations are based on the drillers' reports made available to us through the California Department of Water Resources, available geologic maps and hydrogeologic studies, and professional judgment. This analysis is based on limited available data and relies significantly on interpretation of data from disparate sources of disparate quality. Existing and proposed future water use on and near the project site is estimated based on information received from the applicant and on regionally appropriate water duties for the observed and expected uses. The recharge estimates presented below are based on established soil water balance modeling techniques for calculating infiltration recharge and they do not explicitly simulate surface water/groundwater interaction in perennial streams or bedrock geology in controlling percolation of infiltrating water to aquifers.

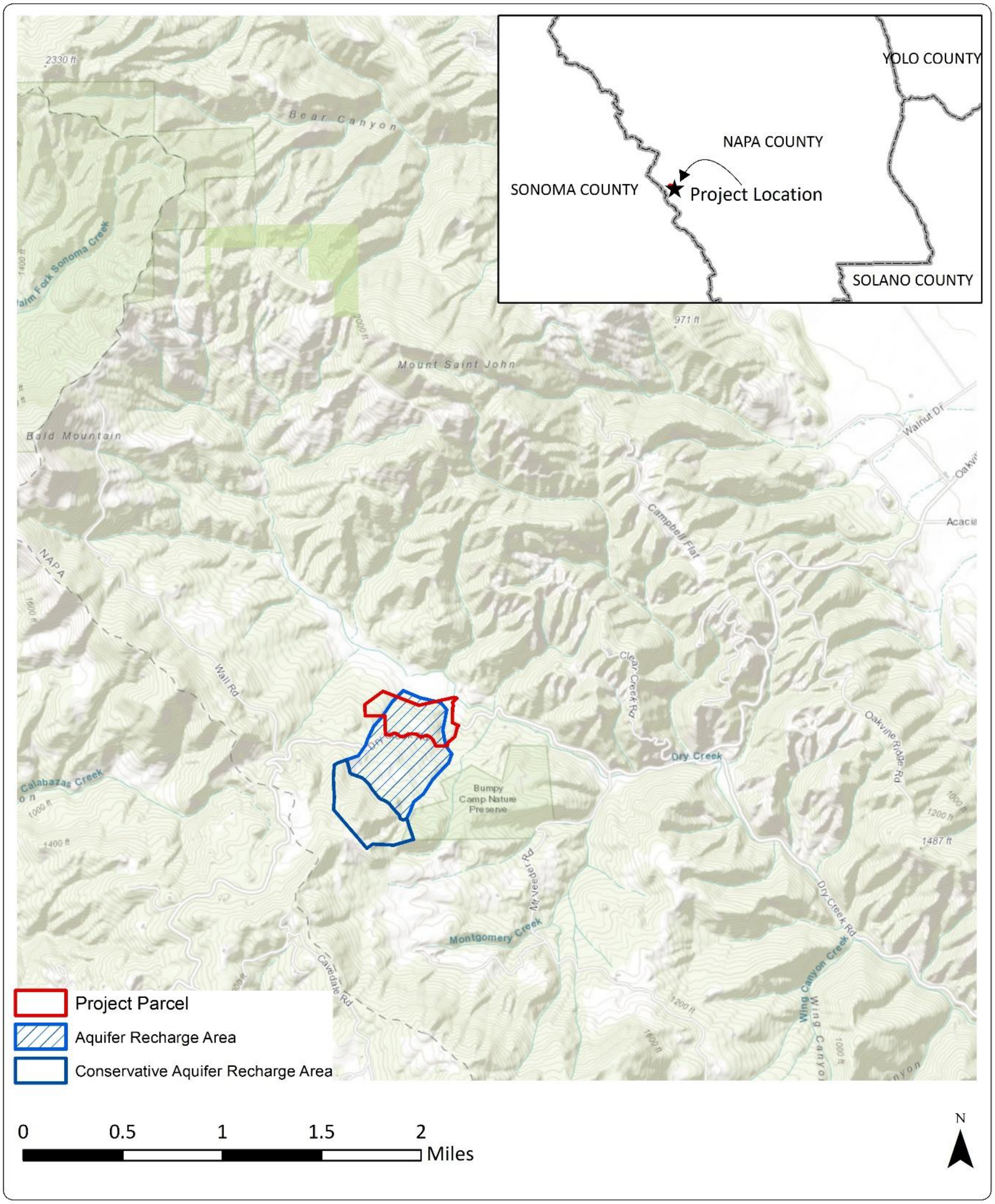

Figure 1: Project location map.

Hydrogeologic Conditions

This project parcel is located in mountainous terrain west of Napa Valley on relatively gentle slopes southwest of Dry Creek (Figure 1). The project parcel is underlain primarily by Holocene and late Pleistocene-aged surficial landslide deposits (map unit Qls; Figure 2); the northeast corner of the parcel extends onto surficial alluvium deposits (map unit Qa near Dry Creek) and provides a small amount of parcel frontage on Dry Creek that presumably provides the property with potential rights to surface flows. The surficial landslide deposits are characterized as “chaotic deposits of sand, silt clay, angular boulders, and blocks of bedrock up to hundreds of meters long deposited by gravity driven sliding and flow…locally composed primarily of volcanic rocks” (Graymer et al., 2007). The alluvial deposits (Map unit Qa) are characterized by “sand, silt, and gravel deposited in fan, valley fill, terrace, or basin environments” (Graymer et al., 2007).

These landslide deposits are to presumed to consist of rocks mapped adjacent to its mapped extent on the slopes southwest of the project parcel: lava flows and tuffs of the Sonoma Volcanics (Map unit Tsr and Tsa) which are mapped to the west and south of the Qls deposits. Well logs for wells drilled within the landslide deposits at and close to the project parcel consistently describe an initial layer of clay with rock ranging in thickness from 25 to 50 feet which are presumed to be landslide deposits underlain by alternating layers of siltstone, shale and sandstone rocks likely associated with the Great Valley Complex. Further upslope the log for Well 8 closer to mapped portions of the Sonoma Volcanics also reports a thicker layer of clays with rocks (60 ft) along with layers of broken red ash.

The Great Valley complex is a mixture of rocks of the Coast Range Ophiolite and the Great Valley Sequence. In Napa County the Coast Range Ophiolite consists of mostly large blocks of serpentinite with igneous oceanic crust (LSCE, 2013). While the Great Valley Sequence whose characterized by “mostly rhythmically thin-bedded fine-grained quart lithic wacke and greenish-gray to black mudstone and shale” (Graymer et. al, 2007). These rocks were originally deposited in a deep water marine environment. The units are well lithified and highly fractured resulting in limited groundwater found almost exclusively in fractures. Successful wells completed in the KJgvl unit produce at best only a few gallons per minute (LSCE, 2013).

The ridgeline to the southwest is underlain by Pliocene and late Miocene-aged Sonoma Volcanics rhyolite flows (map unit Tsr), pumiceous ash-flow tuff (map unit Tst), andesite to basalt lava flows (map unit Tsa), and late Miocene-aged Neroly sandstone (map unit Tn) (Figure 2). This unit is located adjacent to the landslide deposits in an area identified as the landslide scarp. The extent of these units is presumed to extend under the upper portions of the landslide at least down to an elevation equal to that of Well 8.

Well Data

Well Completion Reports for wells near the project parcel were obtained through the California Department of Water Resources’ Well Completion Report Map Application and through the County of Napa Planning, Building, and Environmental Services Department’s Electronic Document Retrieval system. The subset of these logs which could be accurately georeferenced based on parcel and location sketch information is discussed below. Logs for these wells are compiled in Appendix A.

The project well (Well 1) was completed to a depth of 178 feet in 2020. The driller's log for Well 1 indicates that in the upper 50 feet brown clay and shale were encountered; these materials are interpreted as landslide deposits. Below 50 feet, the bore encountered hard shale, shale, clay, hard siltstone, and sandstone, interpreted as the Great Valley Complex underlying the landslide deposits. At the time of completion, Well 1 had a static water level of 48 feet and an estimated yield of 25 gpm. Well 1 is screened from depths of 78 to 158 feet which corresponds to the shales and sandstones of the Great Valley Complex. The project well is sealed to a depth of 52 ft, and first water was reported at a depth of 90 ft, indicating that the landslide deposits are not a source of groundwater.

There is an older well (Well 2) that is no longer in use on the project parcel that was completed to a depth of 260 feet in 1979 that has recently been destroyed by wildfire. The driller's log for Well 2 indicates that the upper 27 feet clay and rock stingers were encountered likely indicative of surficial landslide deposits. Below 27 feet the borehole encounters a mix of blue shale, blue clay, limestone shale and black rock, likely indicative of the Great Valley Complex underlaying the surficial landslide deposits. It is unknown if this well has ever been productive since the WCR reports a yield of 0 gpm. At the time of completion, Well 2 had a static water level of 80 feet and an estimated yield of 0 gpm. Well 2 is screened from 30 to 260 feet.

Well Completion Reports provided information for eighteen other nearby wells that could be accurately georeferenced, eleven of which penetrate the surficial landslide deposits (Wells 3 – 11, Well 14 and Well 15, see Figure 2 and Table 1). These wells are typically completed to depths of less than 300 feet and generally have low estimated yields of less than 10 gpm. One well completed in the Sonoma Volcanics, Well 8, was reported to yield 100 gpm; this is likely an overestimate due to the short length of test and given that the test method (air-lift) which usually produces less reliable production estimates. Static water levels are typically 50 feet or less, with two wells reporting static water levels around 100 feet (Table 1). Driller's logs typically indicate initial shallow layers of clay ranging 20 feet to 50 feet deep. Typically, below the layer of clay the borehole encounters blue shale, sandstone, gray shale, stringers, soft shale, fractured rock, red ash, likely indicative of the Great Valley Complex and Sonoma volcanics underlaying the shallow landslide deposits.

Wells 12 and 20 were completed in Great Valley Complex sandstone and shale. Well 12 was completed to a depth of 315 feet and Well 20 was completed to a depth of 200 feet, both have low yields of under 10 gpm and static water levels of less than 50 feet. Driller's logs for Well 12 indicate the initial 90 feet was a mix of volcanic clay and rock, then deeper into the borehole shale and sandstone, likely indicative of the Great Valley Complex. The driller log for Well 20 indicates initial 40 feet of hard clay followed by shale, likely indicative of the Great Valley Complex. Wells 18 and 19 were completed in surficial alluvium deposits. Well 18 was completed to a depth of 202 feet and Well 19 was completed to a depth of 120 feet. Both wells have low yields of under 10 gpm and static water levels of under 60 feet. The driller log for Well 18 indicates an initial 40 feet of brown clay, 20 feet of gravel, then the borehole encounters sandstone and shale, likely indicative of the Great Valley Complex underlying the surficial alluvium deposits. The driller log for Well 19 indicates mostly shale with some sandstone, likely indicative of the Great Valley Complex.

Wells 13, 16, and 17 were completed in different Sonoma Volcanics. Well 13 located in the Sonoma Volcanics Rhyolite flows was completed to a depth of 170 feet, has a low yield of 1 gpm, and static water level of 40 feet. The Diller log for Well 13 indicates 25 feet of brown ash and below gray sandstone with gray shale. Well 16 located in the border of Sonoma Volcanics Pumiceous ash flow tuff and Sonoma Volcanics Andesite to basalt lava flows was completed to a depth of 198 feet, has a high yield of 120 gpm, and a static water level of 18 feet. The driller log for Well 16 indicates 40 feet of tan ash, and below encounters blue sandy volcanic rock, clay, and shale. Well 17, located near the contact between Sonoma Volcanics Neroly Sandstone and Sonoma Volcanics Rhyolite flows, was completed to a depth of 310 feet, has a yield of 50 gpm, and a static water level of 85 feet. The driller log for Well 17 indicates brown, white and gray ash to depths of 255 feet. Below these depths the borehole encountered gray shale likely indicative of the Great Valley Complex (Figure 2 and Table 1).

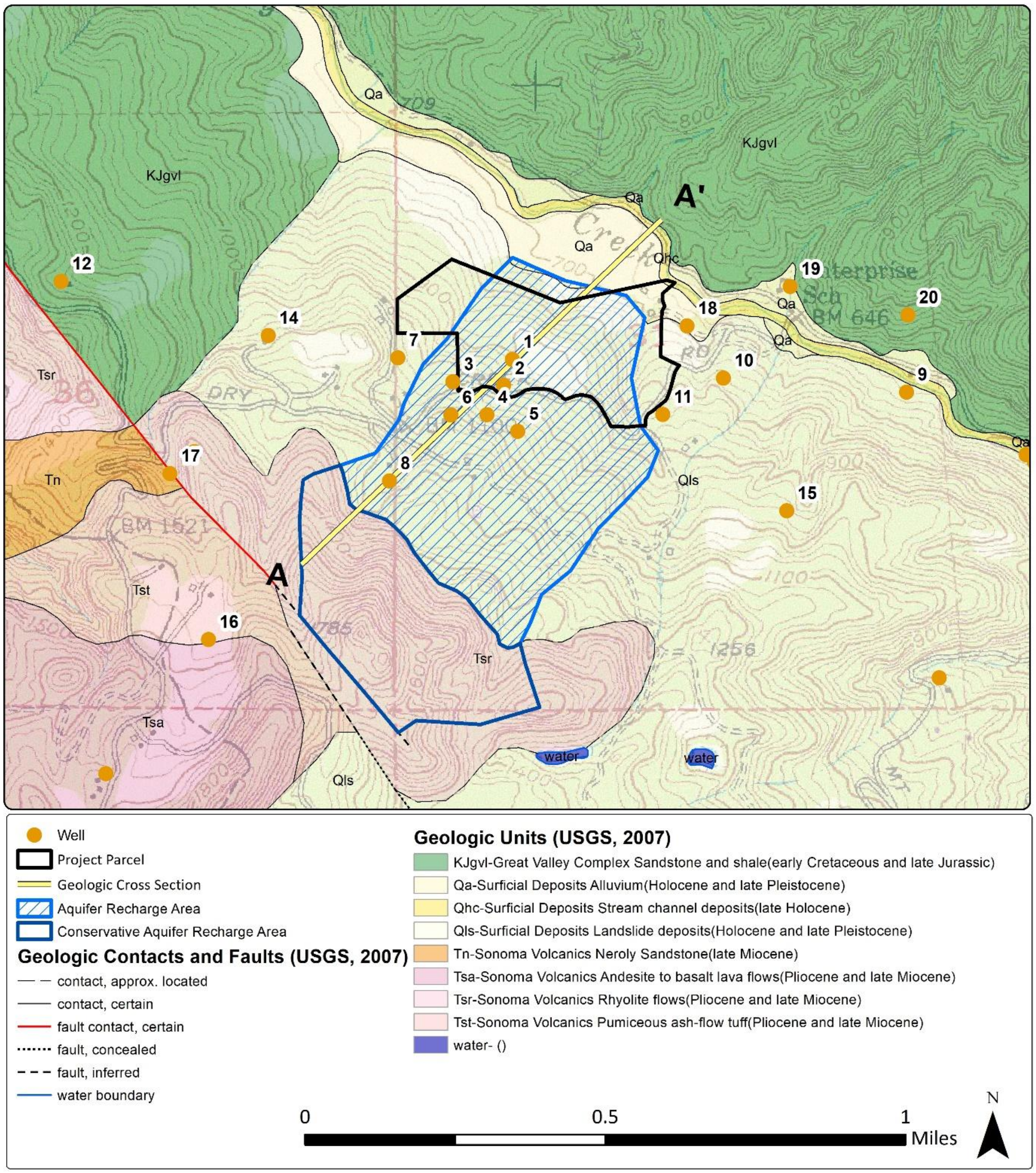

Figure 2: Surficial geology and locations of wells in the vicinity of the project parcel. Surficial geology based on data from the Geologic Map and Map Database of Eastern Sonoma and Western Sonoma Counties, California (Graymer et al., 2007).

Table 1: Well completion details for wells in the vicinity of the project parcel.

Well No.	1	2	3	4	5	6	7	8
DWR WCR No.	16805	121597	36275	913067	384937	70918	91032	371077
Year Completed	2020	1979	1986	2005	1992	1964	1976	1991
Well Depth (ft)	178	260	225	210	160	20	70	160
Static Water Level (ft)	48	80	120	60	Unk.	Unk.	45	40
Estimated Yield (gpm)	25	0	1.5	1	1	2	7	100
Top of Screen (ft)	78	30	40	30	40		53	60
Bottom of Screen (ft)	158	260	220	210	160		70	160
Geologic Map Unit	Qls	Qls	Qls	Qls	Qls	Qls	Qls	Qls

Well No.	9	10	11	12	13	14	15	16
DWR WCR No.	913028	103155	34198	391066	475943	528424	710226	710534
Year Completed	2005	1978	1977	1992	1997	1999	2000	2000
Well Depth (ft)	290	295	280	315	170	200	280	198
Static Water Level (ft)	10	100	42	50	40	50	40	18
Estimated Yield (gpm)	2	4	10	1	6	25	10	120
Top of Screen (ft)	30	115	40	40	45	80	60	58
Bottom of Screen (ft)	290	295	280	320	170	200	280	198
Geologic Map Unit	Qls	Qls	Qls	KJgvl	Tsr	Qls	Qls	Tst/Tsa

Well No.	17	18	19	20
DWR WCR No.	762775	777416	778362	804717
Year Completed	2001	1999	2001	2004
Well Depth (ft)	310	202	120	200
Static Water Level (ft)	85	56	20	21
Estimated Yield (gpm)	50	8	0.5	8
Top of Screen (ft)	90	82	28	30
Bottom of Screen (ft)	310	202	120	200
Geologic Map Unit	Tn/Tsr/Tst	Qa	Qa	KJgvl/Qa

Geologic Cross Section

A geologic cross section oriented southwest to northeast is shown in Figure 3 (see Figure 2 for location). Elevations along this cross section range from 1,500 feet on the ridgeline to the west of the project parcel to 700 feet near Dry Creek. Well logs along the cross section indicate the Holocene and late Pleistocene-aged surficial landslide deposits range in depth from 20 to 50 feet. The Tsr unit of the Sonoma Volcanics is shown to underlie the upper portion of the landslide while the Great Valley Complex (map unit KJgvl) is shown below the landslide deposits and the Tsr unit extending further east to the opposite side of the Dry creek valley. Water surface elevations along the cross section appear to mostly match the elevation of the base of the Qls deposits. The project aquifer is likely semiconfined or confined. Note that Well 2 was destroyed by wildfire and is not in use.

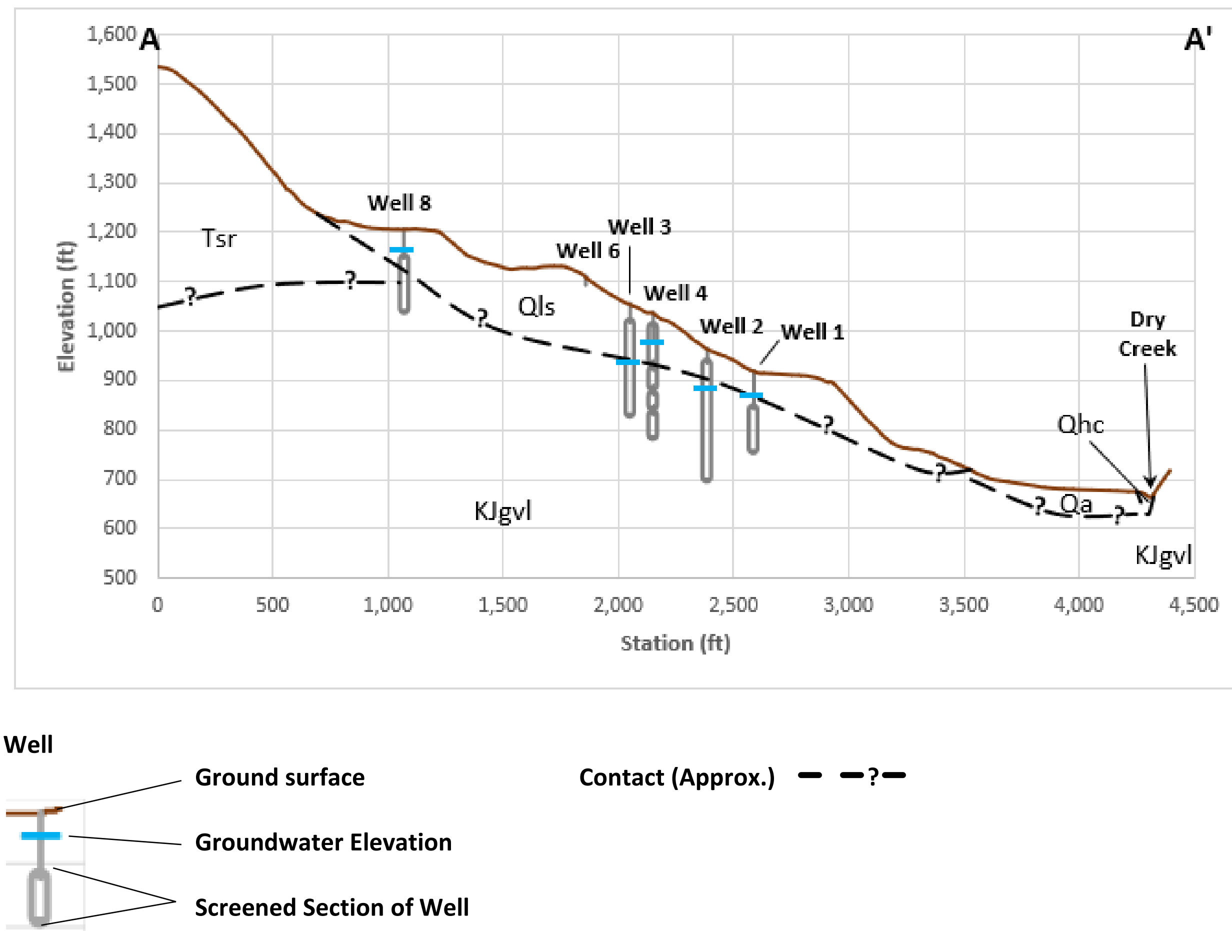

Figure 3: Hydrogeologic cross section A -A' through the project parcel (see Figure 2 for location and geologic map units).

Project Recharge Area

The Tier 1 WAA focuses on estimating groundwater recharge for comparison to groundwater use. Groundwater recharge in hillside areas of Napa County results primarily from infiltration of precipitation distributed across the land surface. To accomplish Tier 1 objectives in a manner consistent with hydrogeologic principles and water balance techniques used to estimate groundwater recharge, we define an area of the landscape encompassing the project parcel(s) that represents the likely source area for infiltration recharge of the aquifer utilized by the project well(s). The so-defined project recharge area is also used to estimate existing groundwater use on surrounding properties so that a more comprehensive assessment of groundwater availability can be performed that places proposed project use of groundwater in context with existing groundwater use from the project aquifer. The recharge area thus also represents the project groundwater impact area and is sometimes referred to as the project recharge/impact area.

The project well (Well 1) and the old well (Well 2) are screened within the sedimentary rocks of the Great Valley Complex. Therefore, the project aquifer has been conceptualized as a portion of the large block of the Great Valley Complex mapped near the project parcel. As described above, the rocks of the Great Valley Complex (KJgvl) are well lithified and highly fractured and the aquifer is therefore conceptualized as a fractured bedrock aquifer. Although it is possible that groundwater found in the fractures within the KJgvl unit may have some connection to the distant portions of the mapped unit (putting the potential aquifer area at 5 mi^2 or greater), and that an additional and potentially significant source of recharge is infiltration of surface flow from Dry Creek, a more conservative conceptualization of the aquifer is a local fracture network (on the order of 100's of acres) that provides most of the water accessed by the project wells. To evaluate the proposed project impacts at an appropriate scale, a project impact area conceptualized as the area most likely to contribute direct precipitation recharge to the project wells was defined. This area includes a portion of the landslide deposits and the uphill area of Sonoma Volcanics draining to them (Figure 2). The fault line along the ridge serves as the western boundary. The northern and southern edges of the project impact area are defined along the drainage axes of small unnamed tributaries to Dry Creek which cut into the landslide deposits. The downhill (eastern) boundary is defined by the 720 ft contour and downhill edge of the Qls unit. As defined, the project recharge area covers approximately 183 acres.

An alternative conservative conceptualization of recharge processes was also developed to take into account evidence that direct precipitation recharge may be inhibited by hydrogeologic factors. This conservative conceptualization of recharge is predicated on characterization of the landslide deposit (Qls, Figure 2) as "clay" in geologic logs contained in WCR's. Thick clay strata may act as an aquitard that could substantially restrict precipitation recharge over a large portion of the project recharge/impact area described above. Landslide deposits of this type are typically heterogenous with potentially complex stratigraphy, and it is unlikely that the landslide deposit fully restricts recharge infiltration. Hence, in this "conservative" scenario, recharge to the project aquifer utilized by the project well and nearby wells is assumed occur in two distinct recharge regimes: 1) direct precipitation infiltration in the 59 acres comprised of the Sonoma Volcanics (Tsr; as shown in Figure 2) at the same rate as the preceding scenario, and 2) direct precipitation infiltration in the 124 acres covered by landslide deposits at a reduced rate to estimate the effects of the proportion of clay in the landslide deposits on infiltration processes.

Water Demand

Within the project recharge area, water demand was estimated for both the existing and proposed conditions. Uses on the project parcel were determined using site details provided by the applicant and verified using satellite imagery and during a site visit. Uses on other neighboring parcels within the project recharge area were determined using satellite imagery. Water use rates were estimated using data from the County of Napa's Water Availability Analysis Guidance Document dated May 12, 2015.

Existing Use

In the existing condition the project parcel contains a single primary residence that may be retained as a secondary residence; a new primary residence is under construction. The parcel also contains an uncovered pool. Table 3 presents assumed use rates and total use on the project parcel. All existing uses are supplied by Well 1.

Neighboring parcels within the project recharge area contain one oversized residence, ten primary residences, two secondary residences, three pools, and approximately 3.6 acres of vineyard (Figure 4). Table 4 summarizes uses and use rates for water demand on neighboring parcels within the project recharge area.

Based on these uses, water demand within the project recharge area is approximately 12.16 acre-ft/yr (Table 2). Of this, 0.85 acre-ft/yr is from the project parcel (Table 3). The remaining 11.31 acre-ft/yr comes from neighboring parcels, primarily residential use, and vineyard irrigation (Table 4).

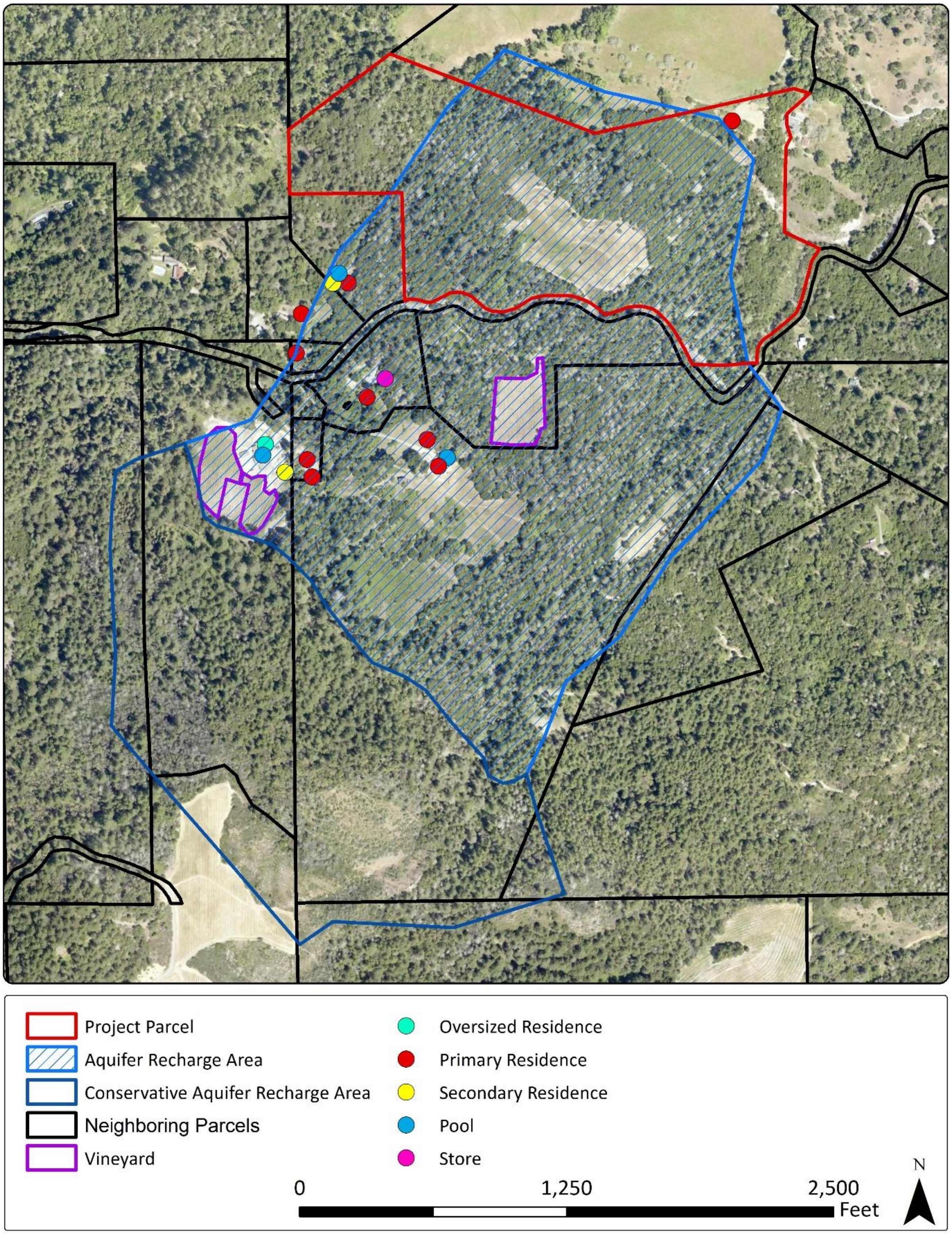

Figure 4: Existing water uses identified within the project recharge area.

Proposed Use

The proposed conditions include two residences on the project parcel; water use for these residences are conservatively estimated at the high end of the range of residential use (Table 5). As previously noted, a second residence on the parcel may or may not be retained. In addition, 3.0 acres (+/-) of vineyard will be planted on the project parcel. A 5,000 gallon per year winery with a tasting room is also proposed. The winery will have 4 full-time employees and 1 part-time employee with a tasting room that will be open 7 days a week with 14 visitors a day. There will be 10 events with 24 people and 1 event with 50 people a year where the tasting room will be closed to the public. Table 5 summarizes the proposed water demand on the project parcel. All water use will be supplied by existing Well 1.

The project is estimated to increase groundwater use on the parcel by 2.72 acre-ft/yr to 3.57 acre-ft/yr (Table 5). Total water use within the project recharge area is estimated to increase to 14.88 acre-ft/yr.

Table 2: Estimated groundwater use within the project recharge area in the proposed and existing conditions.

	Existing Condition (acre-ft/yr)	Proposed Condition (acre-ft/yr)
Project Parcel	**0.85**	**3.57**
Residential Use	0.85	1.85
Irrigation Use	0.00	1.50
Winery Use	0.00	0.11
Employee/Guest Use	0.00	0.11
Neighboring Parcels	**11.31**	**11.31**
Residential Use	9.50	9.50
Irrigation Use	1.81	1.81
Total	**12.16**	**14.88**

Table 3: Estimated groundwater use from the project parcel in the existing condition.

	# of Units	Use per Unit	Annual Water Use (AF/yr)
Residential Use			**0.85**
Residences, Primary	1 Residence	0.75 AF/Residence	0.75
Pools	1 Pool	0.10 AF/Pool	0.10
Total			**0.85**

Table 4: Estimated groundwater use on neighboring parcels in the existing and proposed condition.

	# of Units	Use per Unit	Annual Water Use (AF/yr)
Residential Use			**9.50**
Residences, Oversized	1 Residence	1.00 AF/Residence	1.00
Residences, Primary	10 Residences	0.75 AF/Residence	7.50
Residences, Secondary	2 Residences	0.35 AF/Residence	0.70
Pools	3 Pools	0.10 AF/Pool	0.30
Agricultural Use			**1.81**
Vineyard	3.62 Acres	0.50 AF/acre/yr	1.81
Total			**11.31**

Table 5: Estimated proposed water demand from the project parcel.

	# of Units	Use per Unit	Annual Water Use (AF/yr)
Residential Use			**1.85**
Residences, Oversized	1 Residence	1.00 AF/Residence	1.00
Residences, Primary	1 Residence	0.75 AF/Residence	0.75
Pools	1 Pool	0.10 AF/Pool	0.10
Agricultural Use			**1.50**
Vineyard	3 Acres	0.50 AF/acre/yr	1.50
Winery Use			**0.11**
Process Water	5000 Gallons	2.15 AF/100,000 gal.	0.11
Guest & Employee Use			**0.11**
Tasting Room Visitations	4956 Guests	3 gal./Guest	0.05
Events w/ On-Site Catering	290 Guests	15 gal./Guest	0.01
Full-Time Employees	4 Employees	15 gal./shift @ 250 shifts/yr	0.05
Part-Time Employees	1 Employee	15 gal./shift @ 125 shifts/yr	0.01
Total			**3.57**

Groundwater Recharge Analysis

Methods

Groundwater recharge within the project recharge area was estimated using a Soil Water Balance (SWB) of Napa County developed by OEI. This model implements the U.S. Geologic Survey's SWB modeling software and produces a spatially distributed estimate of annual recharge. This model operates on a daily timestep and calculates runoff based on the Natural Resources Conservation Service (NRCS) curve number approach and Actual Evapotranspiration (AET) and recharge based on a modified Thornthwaite-Mather soil-water-balance approach (Westenbroek et al., 2010). Details of this model are included in Appendix B.

Groundwater recharge for this project area was previously simulated for Water Year 2010 which was selected because annual precipitation in that year was nearest to the 30 year average for the period 1981-2010. OEI's SWB modeling also estimated recharge for Water Year 2014 to represent drought year conditions. In late November 2022, County of Napa instituted a new policy prescribing that for purposes of estimating groundwater recharge, the mean annual precipitation to be used is that mean for Water Years 2012-2021 derived from the newest PRISM data. County of Napa has provided gridded GIS data of the mean precipitation for this period for use by WAA practitioners.

OEI's use of the SWB model is believed to provide more accurate estimates of potential groundwater recharge because it is a physically based distributed model that incorporates information characterizing the water balance in the soil column. Calculation of evapotranspiration using local climate data along with soil moisture storage and precipitation is believed to provide a more accurate representation of local conditions; evapotranspiration is the largest component of the water balance. Unfortunately, the SWB model structure does not allow for a groundwater recharge calculation based on a mathematical average because the model is driven by daily climate data. Consequently, OEI has adapted the SWB model estimates for the prior "average year" (WY 2010) and the "drought year" (WY 2014) to provide an estimate for the average annual rainfall for the period 2012-2021 developed by County of Napa.

OEI has utilized SWB models for WY 2010 and WY 2014 for dozens of project sites in the County of Napa. We have observed that potential recharge for WY 2010 is consistently much greater than for WY 2014 across a wide variety of terrain, vegetation, soils and climate. This is most easily characterized by the percentage of annual precipitation available for recharge that we calculate for each project site. Our approach for adapting the SWB model outputs to estimate groundwater recharge for the specified annual average precipitation is to assume that the percentage of annual rainfall available for groundwater recharge is a linear function of annual rainfall and interpolating between the recharge percentage for WY 2010 and WY 2014. The linear interpolation procedure is unique for each project site; the application for this project site is graphically displayed in Figure 5. The water balance data from the SWB model years is tabulated in Table 6.

Estimated Groundwater Recharge

As previously noted, there is uncertainty regarding the uniformity of precipitation recharge for the project aquifer owing to evidence of substantial clay content in the landslide deposits overlying much of the recharge/impact area. Consequently, two groundwater recharge scenarios are evaluated to bound the uncertainty. The recharge estimate for the larger extent of the project aquifer recharge area is discussed first, followed by discussion of the more conservative project aquifer recharge estimate.

OEI's approach to site-specific WAA's identifies the likely direct precipitation recharge area for the project parcel considering local hydrogeologic conditions and surface drainage patterns. The recharge area also serves as a "project impact area" within which we estimate groundwater use for evaluation of the comparison between estimated recharge and estimated use. There are two sub-areas that comprise the total recharge area: the "Conservative Aquifer Recharge Area" (59 acres) underlain by the Sonoma Volcanics and the "Aquifer Recharge Area" (124 acres) underlain by Surficial Landslide Deposits (Figure 2). Together, these two sub-areas comprise the total recharge area (183 acres) used to estimate groundwater recharge for "Maximum" and "Conservative" recharge estimates. The impetus for discriminating between these two areas is the interpretation from Well Completion Report geologic logs that the Surficial Landslide Deposits corresponding to the larger sub-unit (124 acres) of the total recharge area have high occurrence of clay suggesting that percolation of direct precipitation to groundwater might be significantly inhibited. In contrast, the smaller "Conservative" area of 59 acres is considered to have recharge capacity uninhibited by the high clay content associated with the landslide deposits. We chose the term "Conservative" for the second recharge estimate to emphasize the disproportionate contribution to recharge in the smaller conservative area underlain by Sonoma Volcanics relative to large portion of the total recharge area underlain by clay-rich landslide deposits where a significantly reduced rate of percolation to groundwater is inferred.

<u>Total Recharge Area</u>. This recharge area corresponds to the combined "aquifer recharge area" and "conservative aquifer recharge area" shown in Figure 2, a total of 183 acres. Average annual precipitation for Water Years 2012 through 2021 was 34.8 inches across the recharge area. For the simulated Water Year 2010 (average water year) precipitation was 42.3 inches spatially averaged across the project recharge area. Spatially-averaged simulated evapotranspiration (AET) was 24.5 inches (Table 6). Simulated groundwater recharge varied from 6.5 to 17.1 inches across the recharge area, with a spatial average of 9.9 inches. Components of the water balance were also calculated for the project parcel and are very similar to those calculated for the project recharge area. In simulated Water Year 2014 (dry water year), precipitation averaged 26.0 inches across the project recharge area and AET averaged 18.1 inches. Simulated groundwater recharge varied from near zero to 8.1 inches across the recharge area, with a spatial average of 3.1 inches (Table 6). Assuming a linear relationship between precipitation and simulated recharge as a percent of precipitation (Figure 5), the average annual recharge rate corresponding to mean precipitation over the 10-year interval represented by Water Years 2012 to 2021 is 6.3 inches (Table 6).

Table 6: Summary of water balance results estimated by the SWB model for WY 2010 & 2014 and calculated recharge from the precipitation average of 2012-2021 WYs.

	2010 Normal Year		2014 Dry Year		2012-2021 WY Average	
	inches	% of precip	inches	% of precip	inches	% of precip
Precipitation	42.3	-	26.0	-	34.8	-
AET	24.5	58%	18.1	70%	-	-
Runoff	8.3	20%	8.3	32%	-	-
Δ Soil Moisture	-0.4	-1%	-3.5	-14%	-	-
Recharge	9.9	23%	3.1	12%	6.3	18%

Groundwater recharge estimated as a depth of water (6.3 inches, Table 6) can also be expressed as a total volume by multiplying the estimated recharge rate by a representative area. <u>For the 183-acre project recharge/impact area, average annual groundwater recharge for the period 2012-2021 is estimated to be 96.1 acre-ft/yr (0.525 ft/yr x 183 ac). For the 48.3-acre project parcel it is estimated to be 25.4 acre-ft/year (0.525 ft/yr x 48.3 ac).</u>

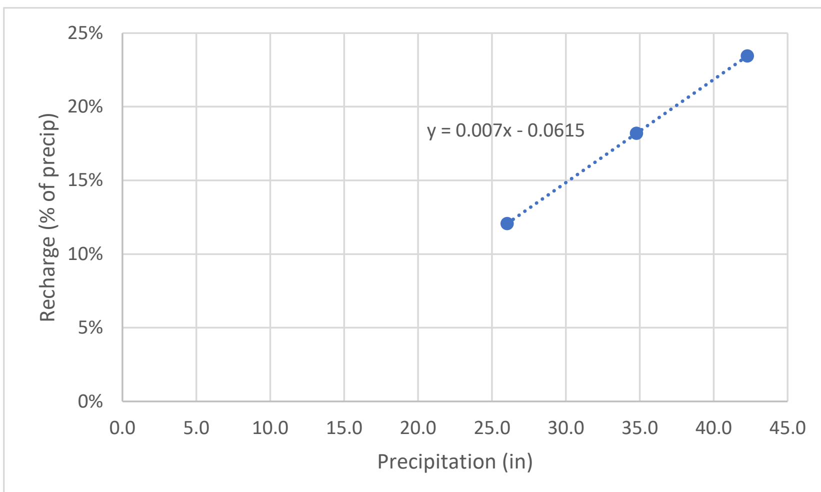

Figure 5: Relationship between precipitation and percent of precipitation as recharge for the larger project recharge area.

<u>Conservative Recharge Estimate</u>. This recharge estimate includes the SWB estimate of recharge to the "conservative aquifer recharge area" (59 acres) shown in Figure 2 plus recharge on the portion of the larger recharge area overlying the landslide deposits at an assumed rate equivalent to 20% of rate estimated for the "maximum" estimate recharge scenario. Water Years 2012-2021 average precipitation averaged 35 inches across the 59-acre conservative recharge area. For the simulated Water Year 2010 (average water year) precipitation averaged 42.8 inches across the project recharge area and simulated actual evapotranspiration (AET) averaged 24.9 inches. Simulated groundwater recharge varied from 8.4 to 15.4 inches across the recharge area, with a spatial average of 9.7 inches. Components of the water balance were also calculated for the project parcel and are very similar to those calculated for the project recharge area. In

simulated Water Year 2014 (dry water year), precipitation averaged 26.3 inches across the project recharge area and simulated AET averaged 18.5 inches. Simulated groundwater recharge varied from 1.9 inches to 6.8 inches across the recharge area, with a spatial average of 3.1 inches. Assuming a linear relationship between the precipitation of the selected average and dry year results of simulated recharge percent (Figure 6), Water Years 2012 to 2021 had an average of 6.1 inches of recharge (Table 7).

Table 7: Summary of water balance results estimated by the SWB model for WY 2010 & 2014 for the conservative project recharge area.

	2010 Normal Year		2014 Dry Year		2021-2021 WY Average	
	inches	% of precip	inches	% of precip	inches	% of precip
Precipitation	42.8	-	26.3	-	35.0	-
AET	24.9	58%	18.5	70%	-	-
Runoff	8.6	20%	8.6	32%	-	-
Δ Soil Moisture	-0.4	-1%	-3.8	-14%	-	-
Recharge	9.7	23%	3.1	12%	6.1	17%

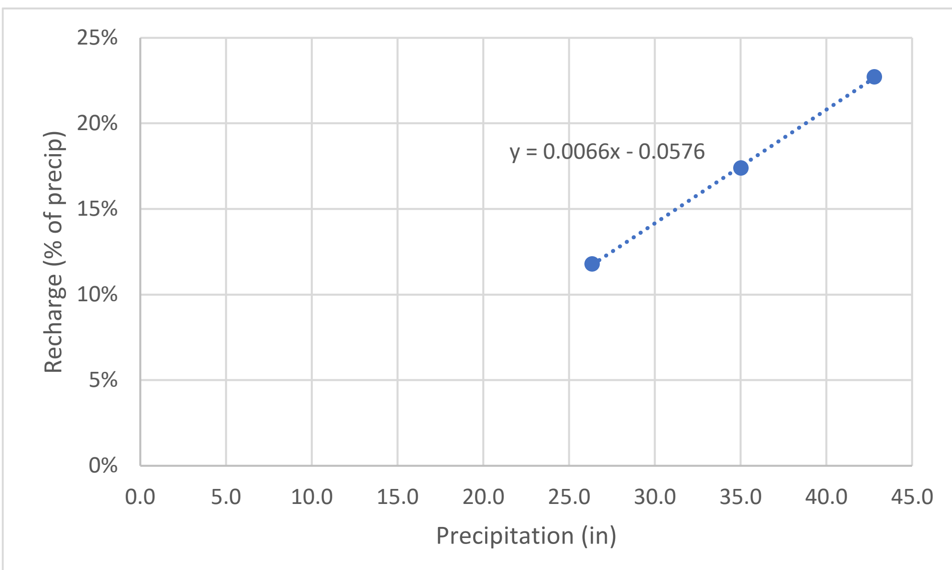

Figure 6: Relationship between precipitation and percent of precipitation as recharge for the conservation recharge area.

Groundwater recharge estimated as a depth of water (6.1 inches, Table 7) can also be expressed as a total volume by multiplying the estimated recharge rate by a representative area. <u>For the 59-acre "conservative recharge area" (Figure 2), average annual groundwater recharge for the period 2012-2021 is estimated to be 30.0 acre-ft/yr (0.508 ft/yr x 59 ac); for the 124-acre portion of the larger project recharge area mantled by landslide deposits average annual groundwater recharge for the period 2012-2021 is estimated to be 13.0 acre-ft/yr (6.3 in/yr per Table 6 x 124</u>

acres x 0.2), yielding the total conservative recharge estimate of 43.0 acre-ft/yr. For recharge at the parcel scale, we applied the mean annual recharge rate (43.0 ac-ft/year divided by the recharge area of 183 acres or 0.236 ac-ft per acre) to the parcel (48.3 acres) to derive the parcel recharge estimate which is 11.4 acre-feet.

Comparison with Other Regional Recharge Rate Estimates

Estimates of groundwater recharge have been produced for watersheds in the Napa River watershed ranging from 5% to 21% of annual precipitation (LSCE, 2013). This study estimated a mean annual recharge rate of 6% or annual precipitation averaged across the entire Dry Creek watershed upstream of the USGS stream gauge (17.2 mi^2) operated from 1952 to 1966. Recharge estimates from other regional studies for the Santa Rosa Plain, Sonoma Valley, and the Green Valley Creek watershed. These regional analyses estimated that mean annual recharge was equivalent to between 7% and 28% of mean annual precipitation (Farrar et. al., 2006; Flint and Flint 2014, Kobor and O'Connor, 2016; Wolfenden and Hevesi, 2014). The recharge rates estimated for this project are near the middle of the range of estimated recharge rates reported in regional studies. These comparisons are useful for determining the overall reasonableness of the results; precise agreement among these estimates is not expected owing to significant variations in climate, land cover, soil types, and underlying hydrogeologic conditions and owing to differences in spatial scale and methods.

Comparison of Water Demand and Groundwater Recharge-Tier 1

The total proposed groundwater use within the project recharge area is estimated to be 14.9 acre-ft/yr. This amount of groundwater use is equivalent to 15% to 35% of estimated recharge based on average precipitation for Water Years 2012-2021 for the maximum recharge estimate (Table 8). Although we do not believe that estimated recharge for the project parcel alone is hydrogeologically realistic, recharge rates in relation to water demand for the project parcel are also presented in Table 8 for perspective.

Table 8: Comparison of proposed water use to average annual groundwater recharge for the larger and conservative project recharge areas.

Recharge Scenario	Area (acres)	Total Proposed Groundwater Demand (ac-ft/yr)	Average Water Years 2012-2021	
			Groundwater Recharge (ac-ft/yr)	Demand as % of Recharge
Full Recharge/Impact Area Maximum Estimate Conservative Estimate	183	14.9	96.1 43.0	15% 35%
Project Parcel Maximum Estimate Conservative Estimate	48.3	3.57	25.4 11.4	14% 31%

Well Interference Analysis-Tier 2

The County of Napa's WAA Guidance Document indicates that a well interference analysis (Tier 2 Analysis) is required if neighboring wells are located within 500 feet of a project well or if a spring is located within 1,500 feet of a project well. There are two wells on the project parcel. Well 1 and Well 2 on the project parcel are located within 135 feet of each other. Well 2 is no longer in use and was destroyed in a fire. Neighboring wells are located greater than 500 feet away from the project well (Figure 7). No springs are known to exist within 1,500 ft of the project well (Well 1). As such impacts to neighboring wells and springs are not expected to be significant and a well interference analysis is not required for this project.

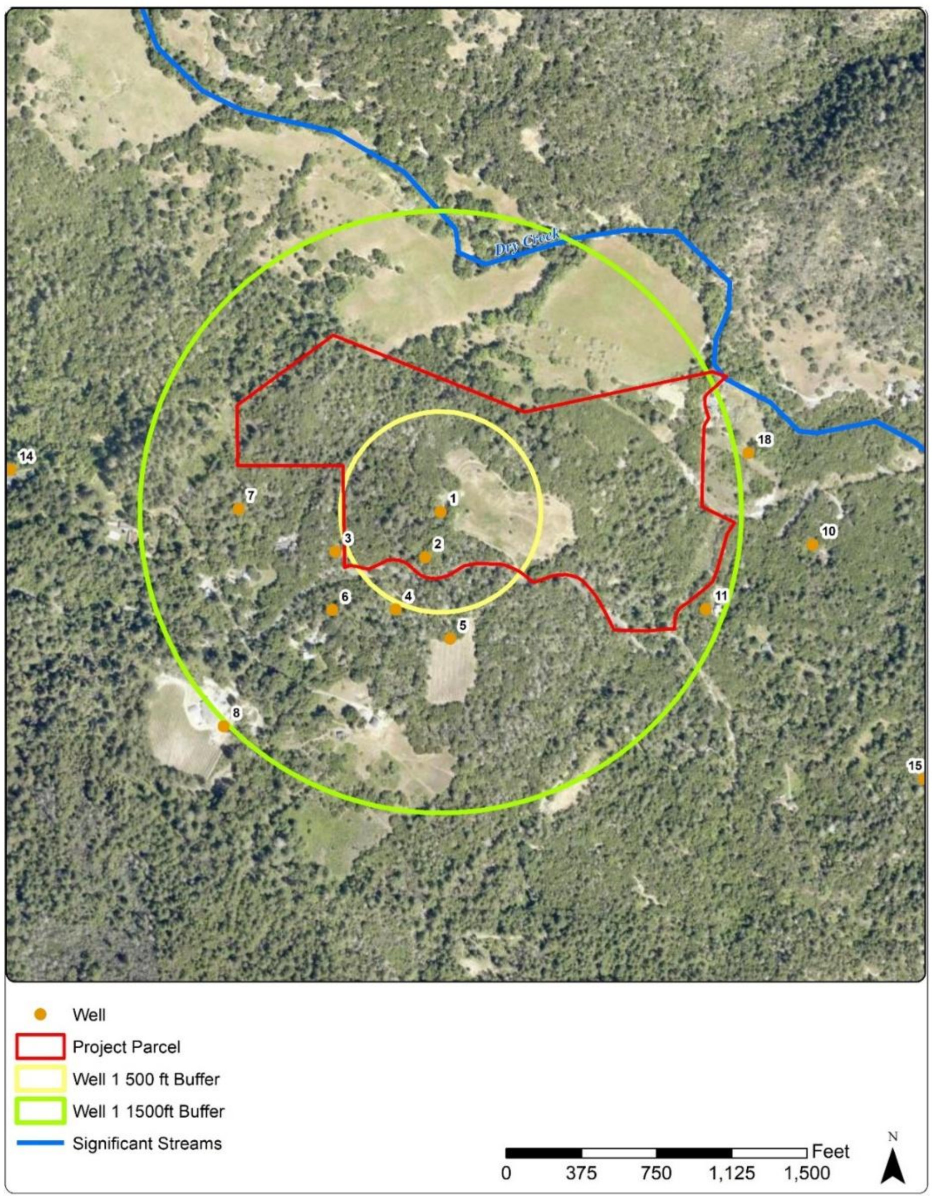

Figure 7: Well 1 surrounded by 500ft and 1500ft buffers with neighboring wells and significant streams.

Groundwater - Surface Water Interaction Risk Assessment-Tier 3

As shown in Figure 7, the project well (Well 1) is within 1,500 ft of the nearest stream of concern for potential streamflow depletion identified by County of Napa (Dry Creek). Well 1 is about 1,300 ft south of Dry Creek at its nearest point. The Tier 3 WAA guidance provides well set-back standards and construction assumptions that "if applicable would be expected to preclude any significant adverse effects on surface waters". Specifically, the "Tier 3 Groundwater Surface Water Interaction Criteria" section (pp. 10-13 of the Napa County guidance document dated May 12, 2015) states:

> *The groundwater/surface water criteria are presumptively met if the distance standards and project well construction assumptions are met (see Tables 3, 4, and 5).* (p. 10)

Table 3 is reproduced below.

Table 3. Well Distance Standards and Construction Assumptions; Very low capacity pumping rates (i.e., less than 10 gpm), constructed in unconsolidated deposits in the upper part of the aquifer system (unconfined aquifer conditions).

Aquifer Hydraulic Conductivity (ft/day)	Acceptable Distance from Surface Water Channel			Minimum Surface Seal Depth (feet)	Depth of Uppermost Perforations (feet)
	500 feet	1000 feet	1500 feet		
80	✓			50	100
50	✓			50	100
30	✓			50	100
0.5	✓			50	100

The effective pumping rate and actual pumping rate of the project wells (described below) are consistent with the "Very low capacity pumping rate" category of wells (defined by Napa County to be less than 10 gpm), and because the project well is more than 500 ft from the stream of concern, conformance with Tier 3 guidelines are evaluated using Table 3 (page 12 of the Napa WAA Guidance document).

The Tier 3 criteria also indicate that the minimum depth of the well surface seal should be 50 ft and the depth of uppermost well perforations should be 100 ft. The surface seal for this well is 52 ft deep and the uppermost perforations are at a depth of 78 ft. Though the depth of perforations is shallower than recommended, the entirety of the perforated interval of the well lies below a surficial landslide deposit that likely comprises an aquitard interfacing with Dry Creek. The geologic map (Figure 2) indicates that a strip of Quaternary alluvial deposits (map unit Qal) lies on the narrow valley floor of Dry Creek suggesting that Dry Creek would likely interact with alluvial deposits of Dry Creek. The landslide deposit appears to underlie the Qal based on the geologic log of Well 18, the only well record available within the Qal deposit (Figure 2 and Appendix A). The Well Completion Report documents that the upper 40 ft of the Qal is clay and that the well perforations begin at a depth of 82 ft. This information indicates that the project well aquifer underlying Dry Creek is vertically separated from the stream bed of Dry Creek by the clay-rich landslide deposits that are expected to behave as an aquitard that would have very limited potential to exchange groundwater with surface water in Dry Creek.

The deviation from the guidelines for depth of uppermost perforations (78 ft versus 100 ft) has no significance with respect to groundwater-surface water interaction and potential streamflow depletion because the well is situated on a hillside above Dry Creek and the entire length of the completed well lies about 100 ft above the channel bed of Dry Creek. Though a piezometric gradient may exist flowing towards Dry Creek from the hillside where the well is situated, because the entirety of the well is constructed above the streambed elevation of Dry Creek, there is little potential for streamflow depletion due to the clay-rich aquitard (the landslide deposits) forming vertical separation of the aquifer accessed by the project well and the streambed.

The effective pumping rate for the PW can be estimated based on estimated annual project groundwater use. Total annual project groundwater use is comprised of 1.50 ac-ft for irrigation and 2.07 ac-ft for residential, winery, and visitor use. Assuming a 150 day irrigation season, average daily irrigation demand is 0.01 ac-ft. Assuming non-irrigation use is spread evenly through the year, the average daily use excluding irrigation is 0.0057 ac-ft. The combined average daily demand during the irrigation season would be 0.0157 ac-ft, equivalent to about 5120 gallons per day. The pumping rate required to supply this quantity of water in a 24 hour period is about 3.6 gallons per minute (gpm). If 10 gpm were considered a threshold pumping rate that should not be exceeded, an operational pumping schedule totaling 9 hours per day of pumping at 9.3 gpm would satisfy estimated daily project groundwater demand. These calculations demonstrate that the project well would operate as a “very low capacity well”; consequently, the well complies with Tier 3 guidelines.

Summary

The proposed project includes a 5,000 gallon per year winery with a tasting room and 3.0 acres of vineyard. There is also an existing residence and a new primary residence under construction. The winery and related employee and visitor use, vineyard, and residences, including a pool, will be supplied with groundwater from Well 1 which is perforated in rocks of the Great Valley Complex that are vertically separated from Dry Creek by clay-rich landslide deposits about 50 ft thick that overlay the aquifer. Including the proposed winery and vineyard, total estimated groundwater use on the project parcel will be 3.57 acre-ft/yr.

Application of a Soil Water Balance (SWB) model provided the basis for quantifying estimated average annual recharge for two scenarios to account for uncertainty regarding the spatial extent of infiltration recharge to the project aquifer associated with the clay-rich landslide deposits that mantle the project site. Estimated groundwater recharge for the project aquifer ranges from 43.0 to 96.1 acre-ft/yr; groundwater use from the project aquifer (14.9 acre-ft/yr) represents between 15% and 35% of estimated annual groundwater recharge for the project recharge area (Table 8). Groundwater use for the proposed project (3.57 ac-ft/yr) represents between about 14% and 31% of estimated annual groundwater recharge to the project aquifer pro-rated for the area of the project parcel.

The closest neighboring well to the project well (Well 1) is located 535 feet south of the project well. Given the distance separating the project well from neighboring wells is greater than 500 feet, well interference associated with water use for the proposed project is unlikely and the project is in conformance with Tier 2 WAA guidelines.

Dry Creek, the closest surface water body is located about 1,300 feet to the north of Well 1. The project well will operate as a "very low capacity well" requiring pumping rates less than 10 gpm. As such, the project well conforms with Tier 3 WAA guidelines for acceptable levels of groundwater-surface water interaction. Furthermore, clay-rich deposits about 50 ft thick form an aquitard separating Dry Creek from the project aquifer that substantially limit potential exchange between Dry Creek and the project aquifer.

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APPENDIX A

WELL COMPLETION REPORTS

Well #1

E 20-00508 Well WL

State of California

Well Completion Report

Form DWR 188 Submitted 12/7/2020
WCR2020-016805

Owner's Well Number: 1 | Date Work Began: 11/25/2020 | Date Work Ended: 12/04/2020

Local Permit Agency: Napa County Planning Building and Environmental Services

Secondary Permit Agency: | Permit Number: E20-00508 | Permit Date: 11/04/2020

Well Owner (must remain confidential pursuant to Water Code 13752)

Name: [redacted]

Mailing Address: [redacted]

City: [redacted] | State: Ca | Zip: 94025

Planned Use and Activity

Activity: New Well

Planned Use: Water Supply Domestic

Well Location

Address: 6204 Dry Creek RD

City: Napa | Zip: 94558 | County: Napa

Latitude: 38 Deg. 22 Min. 4 Sec. N | Longitude: -122 Deg. 24 Min. 24 Sec. W

Dec. Lat.: 38.3677778 | Dec. Long.: -122.4066667

Vertical Datum: | Horizontal Datum: WGS84

Location Accuracy: | Location Determination Method:

APN: 027-530-006

Township: 06 N

Range: 05 W

Section: 15

Baseline Meridian: Mount Diablo

Ground Surface Elevation:

Elevation Accuracy:

Elevation Determination Method:

Borehole Information

Orientation: Vertical | Specify:

Drilling Method: Direct Rotary | Drilling Fluid: Air

Total Depth of Boring: 400 Feet

Total Depth of Completed Well: 178 Feet

Water Level and Yield of Completed Well

Depth to first water: 90 (Feet below surface)

Depth to Static Water Level: 48 (Feet) | Date Measured: 12/04/2020

Estimated Yield*: 25 (GPM) | Test Type: Air Lift

Test Length: 2 (Hours) | Total Drawdown: (feet)

*May not be representative of a well's long term yield.

Geologic Log - Free Form

Depth from Surface Feet to Feet		Description
0	49	brown clay & shale
49	50	siltstone
50	53	hard shale
53	80	shale & clay
80	81	hard siltstone
81	110	shale & clay
110	112	hard brown shale
112	130	shale & clay
130	132	sandstone
132	179	shale & clay
179	192	shale
192	193	siltstone
193	225	shale
225	237	hard shale
237	249	shale & clay

249	310	95% shale / 5% sandstone
310	340	80% shale / 20% sandstone
340	400	shale & clay

Casings

Casing #	Depth from Surface Feet to Feet		Casing Type	Material	Casings Specificatons	Wall Thickness (inches)	Outside Diameter (inches)	Screen Type	Slot Size if any (inches)	Description
1	0	78	Blank	PVC	OD: 5.563 in. | SDR: 21 | Thickness: 0.265 in.	0.265	5.563			
1	78	158	Screen	PVC	OD: 5.563 in. | SDR: 21 | Thickness: 0.265 in.	0.265	5.563	Milled Slots	0.032	
1	158	178	Blank	PVC	OD: 5.563 in. | SDR: 21 | Thickness: 0.265 in.	0.265	5.563			

Annular Material

Depth from Surface Feet to Feet		Fill	Fill Type Details	Filter Pack Size	Description
0	3	Cement	Other Cement		concrete
3	52	Bentonite	Other Bentonite		grout
52	400	Other Fill	See description.		pea gravel

Other Observations:

Borehole Specifications

Depth from Surface Feet to Feet		Borehole Diameter (inches)
0	55	12
55	400	9

Certification Statement

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief

Name HUCKFELDT WELL DRILLING INC
Person, Firm or Corporation

994 KAISER ROAD — NAPA — CA — 94558
Address — City — State — Zip

Signed *electronic signature received* — 12/07/2020 — 439746
C-57 Licensed Water Well Contractor — Date Signed — C-57 License Number

DWR Use Only

CSG #	State Well Number	Site Code	Local Well Number

N — Latitude Deg/Min/Sec

W — Longitude Deg/Min/Sec

TRS:

APN:

Well #2

ORIGINAL

File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

31 E/F

Do not fill in

No. 121597

State Well No.

Other Well No. 07N05W 31

of Intent No.

Local Permit No. or Date

(
A
C

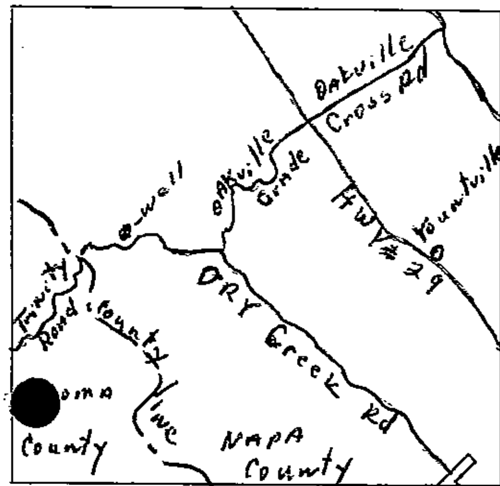
(2) LOCATION OF WELL (See instructions): A.P. #27-530-06

County Napa Owner's Well Number

Well address if different from above Same

Township T.6.N Range R.4.W. Section

Distance from cities, roads, railroads, fences, etc.



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐

Reconstruction ☐

Reconditioning ☐

Horizontal Well ☐

Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☒

Irrigation ☐

Industrial ☐

Test Well ☐

Stock ☐

Municipal ☐

Other ☐

(5) EQUIPMENT:

Rotary ☒ Reverse ☐

Cable ☐ Air ☐

Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☐ Size Pea

Diameter of bore 8 3/4

Packed from 20 to 260 ft.

(7) CASING INSTALLED:

Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	260	6	160	30	260	STD

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.

Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.

Method of sealing Concrete

(10) WATER LEVELS:

Depth of first water, if known ft.

Standing level after well completion 80 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Driller

Type of test Pump ☒ Bailer ☐ Air lift ☐

Depth to water at start of test 80 ft. At end of test 260 ft

arge 0 gal/min after $1\frac{1}{2}$ hours Water temperature

ical analysis made? Yes ☐ No ☒ If yes, by whom?

Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 260 ft. Depth of completed well 260 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	24	Clay.
24	27	Rock stringer.
27	85	Blue shale & blue clay.
85	94	Rock stringer.
94	123	Blue shale & clay.
123	194	Blue shale.
194	260	Gray lime stone shale & black rock, hard drilling.

Work started 7-30- 1979 Completed 8-22- 1979

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED (Well Driller)

NAME McLean & Williams Inc.
(Person, firm, or corporation) (Typed or printed)

Address 878 El Centro Ave.

City Napa, CA Zip 94558

License No. 365829 Date of this report 8-15-79

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #3

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

Do not fill in

No. 36275

State Well No. ______

Other Well No. 07N05W31E

...ntent No. 15024

Local Permit No. or Date 8/6/86

(1) ...

Ad...

Ci...

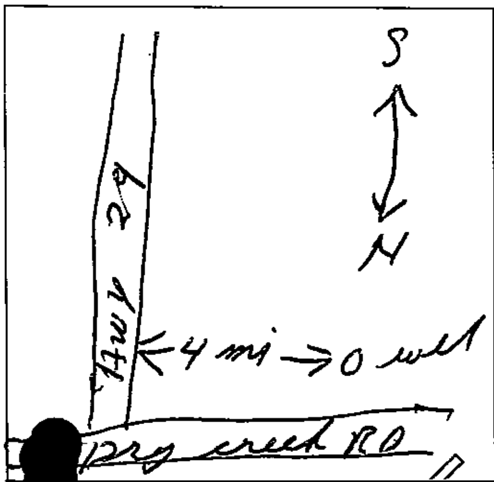
(2) LOCATION OF WELL (See instructions):

County 28 Owner's Well Number ______

Well address if different from above Same

Township 27 Range 320 Section 10

Distance from cities, roads, railroads, fences, etc. 4 mi west of Hwy 29 on Dry Creek RD



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☑ Deepening ☐

Reconstruction ☐

Reconditioning ☐

Horizontal Well ☐

Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☑

Irrigation ☐

Industrial ☐

Test Well ☐

Stock ☐

Municipal ☐

Other ☐

(5) EQUIPMENT:

Rotary ☑ Reverse ☐

Cable ☐ Air ☐

Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☐ No ☑ Size pea

Diameter of bore 9

Packed from 22 to 225 ft.

(7) CASING INSTALLED:

Steel ☐ Plastic ☑ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen ______

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	225	5	160	40	220	1x3

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☑ No ☐ If yes, to depth 22 ft.

Were strata sealed against pollution? Yes ☐ No ☒ Interval ______ ft.

Method of sealing cement

(10) WATER LEVELS:

Depth of first water, if known ______ ft.

Standing level after well completion 120 ft.

(11) WELL TESTS:

Was well test made? Yes ☑ No ☐ If yes, by whom? driller

Type of test Pump ☐ Bailer ☑ Air lift ☐

Depth to water at start of test 120 ft. At end of test 220 ft

Discharge 15 gal/min after 2 hours Water temperature ______

Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ______

Electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 225 ft. Depth of completed well 225 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	20'	brown clay
20	108'	blue shale
108	220'	blue shale, streaks of sandstone
220	225'	hard gray shale

Work started 8/6/1986 Completed 8-12-1986

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED Bill Pullem (Well Driller)

NAME Pullian Well Drilling (Person, firm, or corporation) (Typed or printed)

Address 2877 Piedmont

City Napa Zip 94558

License No. 248677 Date of this report 7/12/88

Well #4

ORIGINAL
File with DWR

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 0913067

DWR USE ONLY — DO NOT FILL IN
07N05W31
STATE WELL NO./STATION NO.
LATITUDE | LONGITUDE
APN/TRS/OTHER

Page ___ of ___
Owner's Well No. ___
Date Work Began 9/28/05, Ended 10/04/05
Local Permit Agency Napa
Permit No. E05-0504 Permit Date 7/28/05

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD air FLUID foam

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
0	20	topsoil, red clay, shale
20	30	red clay
30	90	shale
90	110	shale, stringers gray rock
110	130	hard soft shale
130	150	shale fractured
150	170	shale
170	190	hard soft shale
190	210	soft shale

TOTAL DEPTH OF BORING 210 (Feet)
TOTAL DEPTH OF COMPLETED WELL 210 (Feet)

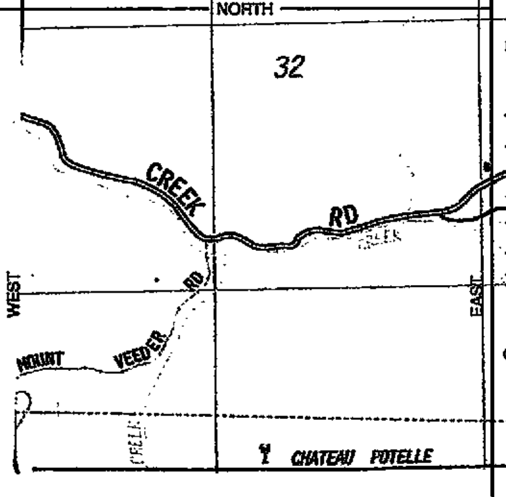
WELL OWNER

WELL LOCATION

Address 6479 Dry Creek Road
City Napa
County Napa
APN Book 27 Page 320 Parcel 014
Township ___ Range ___ Section ___
Lat ___ N DEG. MIN. SEC. Long ___ W DEG. MIN. SEC.

LOCATION SKETCH

NORTH



WEST | EAST
SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)
X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

USES (✓)
WATER SUPPLY
X Domestic ___ Public
___ Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 60 (Ft.) & DATE MEASURED 10/4/05
ESTIMATED YIELD * 1. (GPM) & TEST TYPE air
TEST LENGTH 5 (Hrs.) TOTAL DRAWDOWN 200 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	30	12 1/4	X				F480	6"	200	
30	70	9 7/8		X			F480	6"	200	factory
70	90	9 7/8	X				F480	6"	200	
90	110	9 7/8		X			F480	6"	200	factory
110	130	9 7/8	X				F480	6"	200	
130	150	9 7/8		X			F480	6"	200	factory
150	170	9 7/8	X				F480	6"	200	
170	210	9 7/8		X			F480	6"	200	factory

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	28	X			
28	210				#6 sand pack

ATTACHMENTS (✓)
___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___
ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT
I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME McLean & Williams, Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
878 El Centro Ave., Napa, CA 94558
ADDRESS CITY STATE ZIP
Signed ___ 1/25/06 396352
C-57 LICENSED WATER WELL CONTRACTOR | DATE SIGNED | C-57 LICENSE NUMBER

Well #5

27-320-14

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

ORIGINAL
File with DWR

Do not fill in

No. 384937

State Well No. 07N 05W 31

Other Well No.

Notice of Intent No.

Local Permit No. or Date 30991

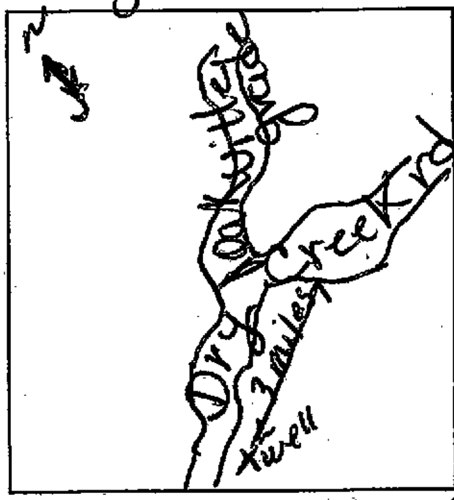
(2) LOCATION OF WELL (See instructions):

County 28 Owner's Well Number

Well address if different from above Dry Creek rd.

Township 27 Range 32 Section 14

Distance from cities, roads, railroads, fences, etc. 3 mi. West of Oakville grade on Dry Creek rd.



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☑ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☑
Irrigation ☑
Industrial ☐
Test Well ☐
Municipal ☐
Other ☐
(Describe)

(5) EQUIPMENT:

Rotary ☐ Reverse ☐
Cable ☐ Air ☑
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☑ No ☐ Size Pea
Diameter of bore 8 5/8
Packed from 21 to 160 ft.

(7) CASING INSTALLED:

Steel ☐ Plastic ☑ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	160	5	160	40	160	Factory

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☑ No ☐ If yes, to depth 21 ft.

Were strata sealed against pollution? Yes ☐ No ☑ Interval ft.

Method of sealing Cement

(10) WATER LEVELS:

Depth of first water, if known 45 ft.

Standing level after well completion 40 ft.

(11) WELL TESTS:

Was well test made? Yes ☑ No ☐ If yes, by whom? Driller

Type of test Pump ☐ Bailer ☐ Air lift ☑

Depth to water at start of test — ft. At end of test — ft.

Discharge 1 gal/min after 5 hours Water temperature —

Chemical analysis made? Yes ☐ No ☑ If yes, by whom?

Was electric log made Yes ☐ No ☑ If yes, attach copy to this report

(12) WELL LOG: Total depth 260 ft. Completed depth 160 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	10	brown clay
10	14'	brown clay & sand
14	42	brown clay
42	45	brown sandstone
45	60	green clay
60	67	brown sandstone
67	105	gray oil shale
105	107	gray sandstone
107	140	oil shale & gray
140	145	gray sandstone
145	160	oil shale & gray clay

Work started 5-24-1992 Completed 5-27-1992

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed Tom Pulliam (Well Driller)

NAME Pulliam Well Drilling (Person, firm or corporation) (Typed or printed)

Address 2874 Redmond

City Napa ZIP 94558

License No. 298677 Date of this report 6-8-92

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DWR 188 (REV. 12-86)

86 96355

CONFIDENTIAL
NOT FOR PUBLIC
WATER CODE SEC. 13752

Well #6

ORIGINAL
File Original, Duplicate and Triplicate with the
REGIONAL WATER POLLUTION
CONTROL BOARD No.________
(... appropriate number)

WATER WELL DRILLERS REPORT
(Sections 7076, 7077, 7078, Water Code)

STATE OF CALIFORNIA

297

Do Not Fill In
№ 70918
State Well No.
Other Well No. 7N/5W-31M

(1) OWNER:

(2) LOCATION OF WELL:
County NAPA Owner's number, if any—
R. F. D. or Street No. same as above on Dry Creek Road
between Trnity Rd.& Town of Oakville.
150 ft. south of Dry creek road.
½ mile east of Wahl Rd.

(3) TYPE OF WORK (check):
New well ☑ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☑ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary Bucket ☑
Cable ☐
Dug Well ☐

(6) CASING INSTALLED:
SINGLE ☑ DOUBLE ☐

From ft.	to ft.	Diam.	Gage or Wall
0	20	36" I.D.	
CONCRETE PIPE			

If gravel packed

Diameter of Bore	from ft.	to ft.
49"	10	20

Type and size of shoe or well ring
Size of gravel: ½" pea
Describe joint

(7) PERFORATIONS:
Type of perforator used none
Size of perforations in., length, by in.
From ft. to ft. Perf. per row Rows per ft.

(8) CONSTRUCTION: CONCRETE COVER INSTALLED
Was a surface sanitary seal provided? ☑ Yes ☐ No To what depth ft.
Were any strata sealed against pollution? ☑ Yes ☐ No If yes, note depth of strata
From ft. to ft.
10 10
Method of Sealing Redi Mix concrete

(9) WATER LEVELS:
Depth at which water was first found 14 ft.
Standing level before perforating ft.
Standing level after perforating ft.

(10) WELL TESTS:
Was a pump test made? ☐ Yes ☑ No If yes, by whom?
Yield: Aprox. 2 gal./min. with ft. draw down after hrs.
Temperature of water cool Was a chemical analysis made? ☐ Yes ☑ No
Was electric log made of well? ☐ Yes ☑ No

(11) WELL LOG:
Total depth 20 ft. Depth of completed well 20 ft.
Formation: *Describe by color, character, size of material, and structure.*

ft. to	ft.	
0	1	top soil
1	5	brown clay
5	13	large gravel sand & clay
13	15	brown shale
15	20	blue clay

FOR OFFICIAL USE ONLY

Work started 5/11/64 19 . Completed 5/15/64 19

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME BALLARD & FOOTE
(Person, firm, or corporation) (Typed or printed)
Address 4625 Stoetz Lane
SEBASTOPOL, CALIF.
[SIGNED] Robert H. Foote
Well Driller
License No. 185456 Dated 6/8/64, 19

Well #7

ORIGINAL
File with DWR

CONFIDENTIAL LOG
Water Code Sec. 13752

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

Do Not Fill In
№ 91032
State Well No.
Other Well No. 07N05W31E

(1) OWNER:

(2) LOCATION OF WELL:
County Napa Owner's number, if any
Township, Range, and Section Dry Crk Rd.
Distance from cities, roads, railroads, etc. 27-320-10

(3) TYPE OF WORK (check):
New Well ☒ Deepening ☐ Reconditioning ☐ Destroying ☐
If destruction, describe material and procedure in Item 11.

(4) PROPOSED USE (check):
Domestic ☒ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

(5) EQUIPMENT:
Rotary ☐
Cable ☒
Other ☐

(6) CASING INSTALLED:
STEEL: SINGLE ☒ DOUBLE ☐ OTHER:

If gravel packed

From ft.	To ft.	Diam.	~~Gage or~~ Wall	Diameter of Bore	From ft.	To ft.
0	70	8	188			

Size of shoe or well ring: 3/16 x 6 x 8 Size of gravel:
Describe joint Butt Weld.

(7) PERFORATIONS OR SCREEN:
Type of perforation or name of screen Machine Sawed

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
53	70	2	10	1/8 x 3

(8) CONSTRUCTION:
Was a surface sanitary seal provided? Yes ☒ No ☐ To what depth 12 ft.
Were any strata sealed against pollution? Yes ☐ No ☐ If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing Grout

(9) WATER LEVELS:
Depth at which water was first found, if known ft. 53
Standing level before perforating, if known ft.
Standing level after perforating and developing ft. 45

(10) WELL TESTS:
Was pump test made? Yes ☒ No ☐ If yes, by whom? Driller
Yield: 7 gal./min. with 8 ft. drawdown after 1 hrs.
Temperature of water Was a chemical analysis made? Yes ☐ No ☒
Was electric log made of well? Yes ☐ No ☒ If yes, attach copy

(11) WELL LOG:
Total depth 70 ft. Depth of completed well ft.
Formation: Describe by color, character, size of material, and structure

ft. to ft.	
0-24	Sticky yellow Clay & shale
24-53	Blue shale
53-66	Black Sandy shale & rock
66-70	Blue shale

Work started Jan. 14 76, Completed Jan 19 1976

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Rittle & Pulliam (Person, firm, or corporation) (Typed or printed)
Address 1541 Mark West Spgs Rd.
Santa Rosa, Calif.
[SIGNED] Walter L Rittle (Well Driller)
License No. 288649 Dated Jan. 20 76

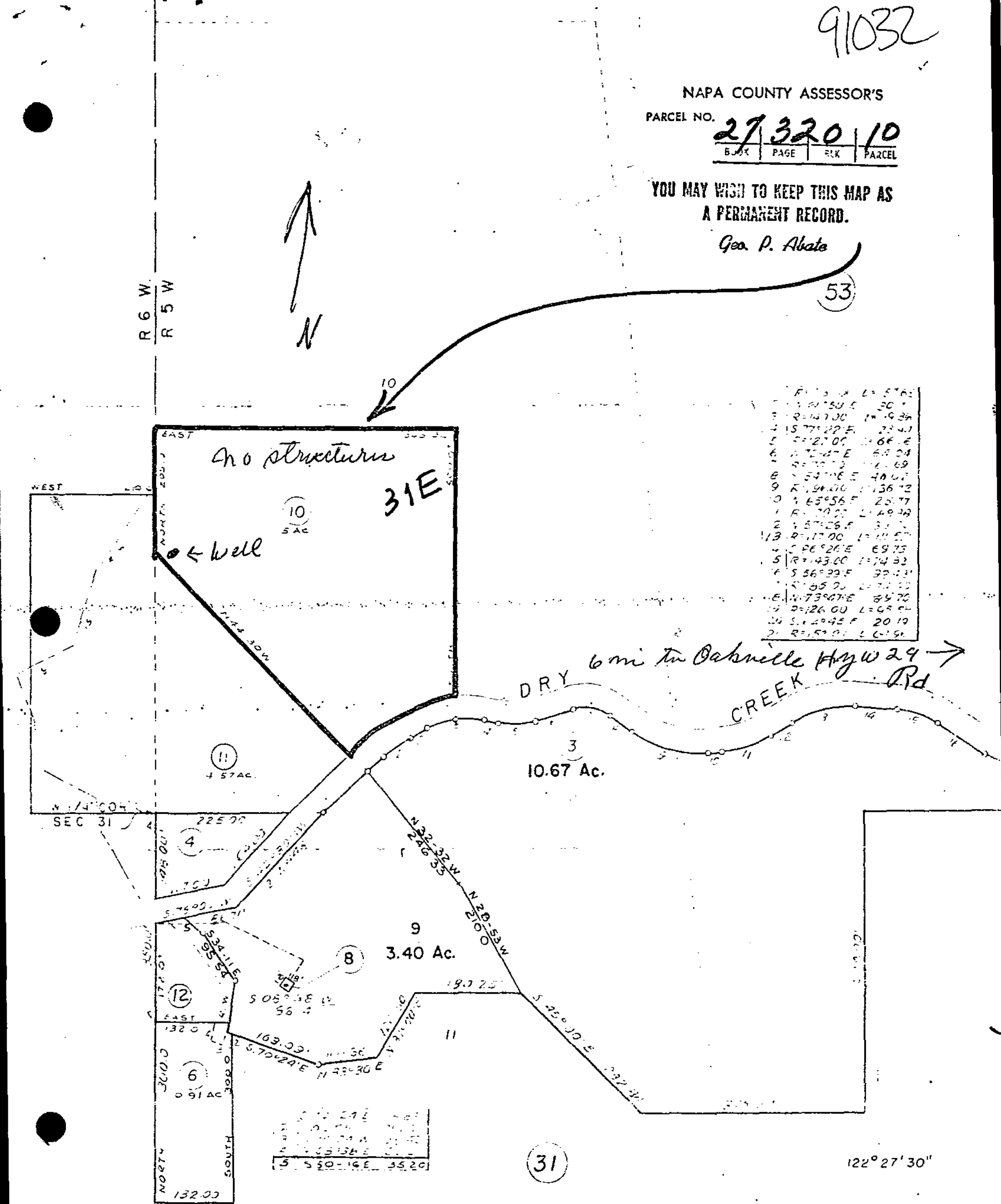
SKETCH LOCATION OF WELL ON REVERSE SIDE

CONFIDENTIAL LOG
Water Code Sec. 13752

DWR 188 (REV. 9-68)

25179-950 9-68 50M TRIP ΔD OSP

POR. W 1/2 SEC. 31, T. 7 N., R. 5 W., M.D.B. & M.



NOTE -- Assessor's Block Numbers Shown in Ellipses
Assessor's Parcel Numbers Shown in Circles.

27-320-10

Well #8

parcel 27-070-32

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

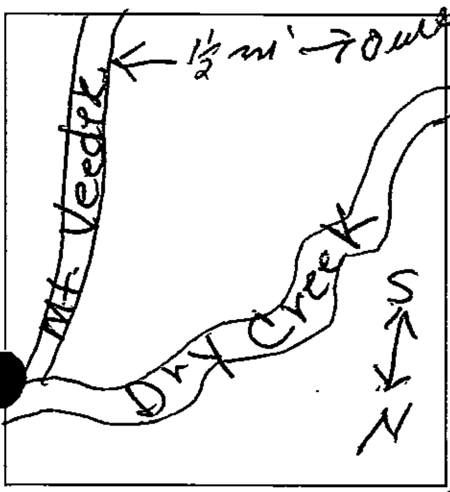
Do not fill in

No. 371077

Notice of Intent No. ______
Local Permit No. or Date 27998

State Well No. ______
Other Well No. 07N06W36

(2) LOCATION OF WELL (See instructions):
County 28 Owner's Well Number ______
Well address if different from above Same
Township 27 Range 070 Section 32
Distance from cities, roads, railroads, fences, etc. 1½ mi. West of Mt. Veeder rd. on Dry Creek rd.



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☒
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size Pea
Diameter of bore 9"
Packed from 22 to 160 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	160	5	160	60	160	5x3

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 22 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ______ ft.
Method of sealing cement

(10) WATER LEVELS:
Depth of first water, if known 60 ft.
Standing level after well completion 40 ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Driller
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 40 ft. At end of test 160 ft.
Discharge 100 gal/min after 2 hours Water temperature ______
Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ______
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 160 ft. Completed depth 160 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	30'	Clay
30	60'	Clay, rock
60	90'	broken up red ash
90	160'	blue shale & streaks of sandstone

Work started 1-28-1991 Completed 2-1-1991

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed Bill Pulliam
(Well Driller)

NAME Pulliam Well Drilling
(Person, firm, or corporation) (Typed or printed)
Address 2877 Piedmont Ave.
City Napa ZIP 94558
License No. 248677 Date of this report 2-11-91

DWR 188 (REV. 12-86) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 86 96355

Well #9

ORIGINAL
File with DWR

Page ___ of ___

Owner's Well No. ________

Date Work Began 12-22-04, Ended 1-14-05

Local Permit Agency Napa

Permit No. E04-0571 Permit Date 10/7/04

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 0913028

DWR USE ONLY — DO NOT FILL IN

07N05W31

STATE WELL NO./STATION NO.

LATITUDE | LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD mud FLUID betonite

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	10	brown clay
10	30	gray shale
30	50	gray shale & white rock stringers
50	70	hard gray shale stringers white rock
70	90	hard gray shale
90	110	hard gray shale stringers soft shale
110	130	hard&soft gray shale
130	170	soft gray shale stringers hard shale
170	210	hard gray shale white & gray rock stingers
210	290	hard & soft gray shale

TOTAL DEPTH OF BORING 290 (Feet)

TOTAL DEPTH OF COMPLETED WELL 290 (Feet)

WELL LOCATION

Address 6091 Dry Creek Road

City Napa

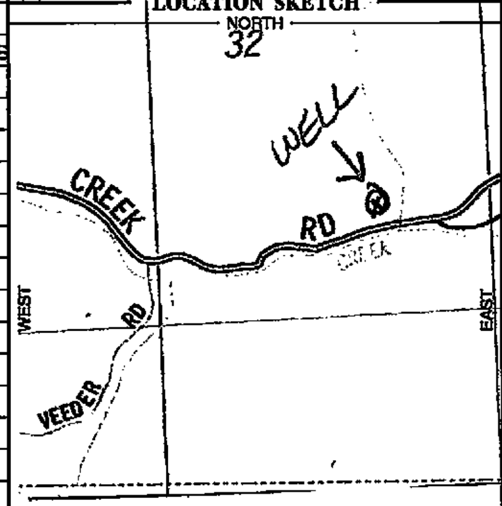
County Napa

APN Book 27 Page 330 Parcel 014

Township ___ Range ___ Section ___

Lat ___ N Long ___ W
DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

USES (✓)

WATER SUPPLY
X Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 10 (Ft.) & DATE MEASURED 1/14/05

ESTIMATED YIELD * 2. (GPM) & TEST TYPE air

TEST LENGTH 12 (Hrs.) TOTAL DRAWDOWN 270 (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	30	12 1/4	X				F480	6"	200	
30	50	9 7/8		X			F480	6"	200	factory
50	70	9 7/8	X				F480	6"	200	
70	130	9 7/8		X			F480	6"	200	factory
130	150	9 7/8	X				F480	6"	200	
150	170	9 7/8		X			F480	6"	200	factory
170	250	9 7/8	X				F480	6"	200	
250	290	9 7/8		X			F480	6"	200	factory

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	30	X			
30	290				#6 sand pack

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME McLean & Williams, Inc.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

878 El Centro Ave., Napa, CA 94558
ADDRESS CITY STATE ZIP

Signed Shawny Sal... 1/27/05 396352
C-57 LICENSED WATER WELL CONTRACTOR DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

OSP 03 78838

Well #10 Rig #4 J.Miller FERRELL, TIMOTHY LEE

ORIGINAL

File with DWR

e of Intent No.______

l Permit No. or Date______

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 103155

State Well No.______

Other Well No. 07N/05W-3#G

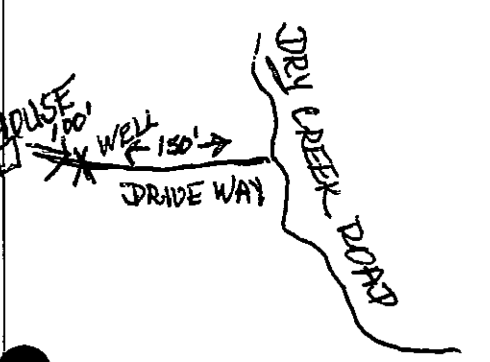
(2) LOCATION OF WELL (See instructions):

County Napa Owner's Well Number 27-330-08

Well address if different from above Same

Township______ Range______ Section______

Distance from cities, roads, railroads, fences, etc.______



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well [X] Deepening [ ]
Reconstruction [ ]
Reconditioning [ ]
Horizontal Well [ ]
Destruction [ ] (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic [X]
Irrigation [ ]
Industrial [ ]
Test Well [ ]
Stock [ ]
Municipal [ ]
Other [ ]

(5) EQUIPMENT:
Rotary [X] Reverse [ ]
Cable [ ] Air [X]
Other [ ] Bucket [ ]

(6) GRAVEL PACK:
Yes [ ] No [X] Size______
Diameter of bore______
Packed from______ to______ ft.

(7) CASING INSTALLED:
Steel [ ] Plastic [X] Concrete [ ]

(8) PERFORATIONS: Power saw
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	295	6"	160	115'	295'	1/8x3"

(9) WELL SEAL:
Was surface sanitary seal provided? Yes [X] No [ ] If yes, to depth Boot 23 ft.
Were strata sealed against pollution? Yes [ ] No [X] Interval______ ft.
Method of sealing Grout

(10) WATER LEVELS:
Depth of first water, if known 195' ft.
Standing level after well completion 100' ft.

(11) WELL TESTS:
Was well test made? Yes XX No [ ] If yes, by whom? Drillers
Type of test Pump [ ] Bailer [ ] Air lift [X]
Depth to water at start of test 100 ft. At end of test Blowen from 295' ft.
Discharge 4 gal/min after______ hours Water temperature______
ical analysis made? Yes [ ] No [X] If yes, by whom?______
Was electric log made? Yes [ ] No [X] If yes, attach copy to this report

(12) WELL LOG: Total depth 295 ft. Depth of completed well 295 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	25	topsoil clay
25	50	blue shale green clay soft
50	195	blue shale hard
195	210	gray rock fract.
210	295	blue shale hard

Work started 12-30 1977 Completed 1-7 1978

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED J D Doshier
(Well Driller)

NAME Doshier-Gregson Drilling Inc.
(Person, firm, or corporation) (Typed or printed)

Address 5365 Napa-Vallejo Hwy.

City Vallejo, Ca Zip 94590

License No. 294001 Date of this report 1/4/78

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #11

ORIGINAL

File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY 31 G/H
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 34198

State Well No.

Other Well No. 07N/05W 31

Notice of Intent No.

Local Permit No. or Date

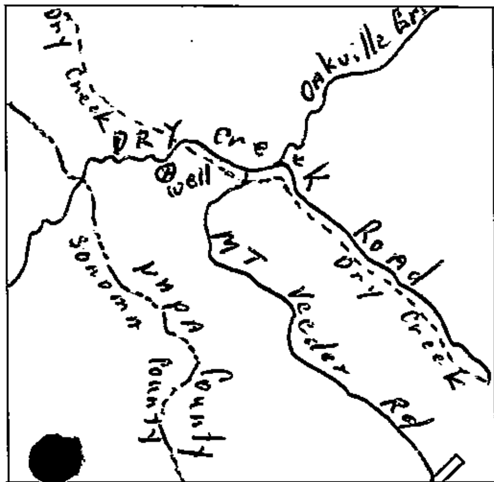
(2) LOCATION OF WELL (See instructions): A.P. #27-330-09

County Napa Owner's Well Number

Well address if different from above Same

Township Range Section

Distance from cities, roads, railroads, fences, etc.



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☒
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☐ No ☒ Size
Diameter of bore
Packed from to ft.

(7) CASING INSTALLED:
Steel ☒ Plastic ☐ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	280	6 5/8		40	280	

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 20 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing Concrete

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion 42 ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Driller
Type of test Pump ☒ Bailer ☐ Air lift ☐
Depth to water at start of test 42 ft. At end of test 200 ft
Discharge 10 gal/min after $2\frac{1}{2}$ hours Water temperature
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 280 ft. Depth of completed well 280 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	3	Top soil
3	40	Brown sandstone & small rock
40	52	Grey sandstone
52	58	Grey & black rock
58	168	Shale
168	175	Grey sandstone
175	280	Shale

Work started 9-19 1977 Completed 10-3 1977

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

SIGNED O. D. Williams
(Well Driller)

NAME McLean & Williams Well Drilling
(Person, firm, or corporation) (Typed or printed)

Address 878 El Centro Avenue

City Napa, CA Zip 94558

License No. 272321 Date of this report 10-3-77

Well #12

ORIGINAL
File with DWR

Page 1 of 1

Owner's Well No. 92-2710

Date Work Began ______, Ended April 92

Local Permit Agency Napa County

Permit No. 30654 Permit Date 3-27-92

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 391066

DWR USE ONLY — DO NOT FILL IN
07N06W36
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	1	Topsoil
1	40	Red Volcanic clay
40	60	Brown volcanic clay
60	90	volcanic rock
90	210	sandstone
210	230	shale
230	265	sandstone
265	280	shale
280	295	sandstone
295	315	shale

TOTAL DEPTH OF BORING 315 (Feet)

TOTAL DEPTH OF COMPLETED WELL 315 (Feet)

WELL OWNER

Address 118 Wall Rd
City Napa Ca
County Napa
APN Book 027 Page 090 Parcel 017
Township ___ Range ___ Section ___
Latitude ___ NORTH Longitude ___ WEST
DEG. MIN. SEC.

LOCATION SKETCH

NORTH
WEST EAST
SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY
X Domestic
___ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary Air FLUID ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 50 (Ft.) & DATE MEASURED 4-1-92

ESTIMATED YIELD* 1 (GPM) & TEST TYPE air lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN 260 (Ft.)

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE: BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	40	11.5	x				F480 PVC	5	c200	
40	320	"		X			"	"	"	micro

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	21	X			
21	320			X	3/8 pea

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME FISCH BROS DRILLING INC.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

5001 Gravenstein Hwy No. Sebastopol Ca. 95472
ADDRESS CITY STATE ZIP

Signed Brian Burnham by c.j.usher 4-15-92 399226
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #13

ORIGINAL
File with DWR

Page ___ of ___

Owner's Well No.

Date Work Began 5-20-97 Ended 5-22-97

Local Permit Agency Napa County

Permit No. 446591 Permit Date 5/21/97

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 475943

DWR USE ONLY — DO NOT FILL IN

07N/06W/36

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER 45 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION *Describe material, grain size, color, etc.*
0	25	brown ash
25	170	gray sandstone with gray shale

TOTAL DEPTH OF BORING 170 (Feet)

TOTAL DEPTH OF COMPLETED WELL 170 (Feet)

WELL LOCATION

Address Same

City Same

County Napa

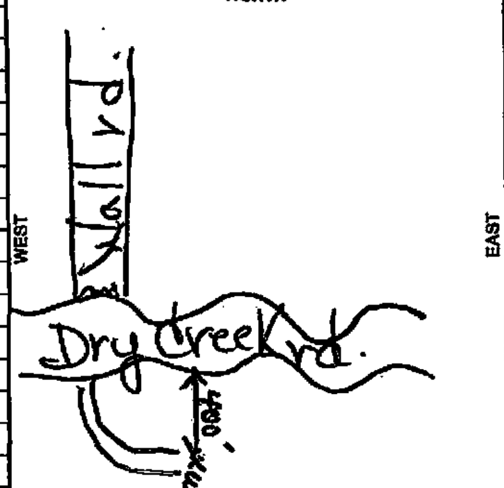
APN Book ___ Page ___ Parcel 27-070-38

Township ___ Range ___ Section ___

Latitude ___ NORTH Longitude ___ WEST (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH



WEST EAST SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR

___ Deepen

___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USE(S) (✓)

___ MONITORING

WATER SUPPLY

✓ Domestic

___ Public

___ Irrigation

___ Industrial

___ "TEST WELL"

___ CATHODIC PROTECTION

___ OTHER (Specify)

DRILLING METHOD Air FLUID Air

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 40 (Ft.) & DATE MEASURED 5-22-97

ESTIMATED YIELD* 6 (GPM) & TEST TYPE Air lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN 130 (Ft.)

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	45	8 3/4	✓				Plastic	5	200	
45	170	8 3/4		✓			"	5	"	Factory 1/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	22	✓			
22	170				Pea Gravel

ATTACHMENTS (✓)

___ Geologic Log

___ Well Construction Diagram

___ Geophysical Log(s)

___ Soil/Water Chemical Analyses

___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Pulliam Well Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

3877 Piedmont Ave. Napa Ca. 94558
ADDRESS CITY STATE ZIP

Signed [signature]
WELL DRILLER/AUTHORIZED REPRESENTATIVE

5-23-97 DATE SIGNED 248627 C-57 LICENSE NUMBER

DWR 188 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

369

Well #14

ORIGINAL
File with DWR

Page ____ of ____

Owner's Well No. ____

Date Work Began 5-7-99 Ended 5-13-99

Local Permit Agency Napa County

Permit No. 96-10871 Permit Date 1-25-99

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 528424

DWR USE ONLY — DO NOT FILL IN

07N05W31

STATE WELL NO./STATION NO.

LATITUDE | LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ____ HORIZONTAL ____ ANGLE ____ (SPECIFY)

DEPTH TO FIRST WATER 80 (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION Describe material, grain size, color, etc.
0	60	brown clay & shale
60	80	blue shale
80	160	black shale, streaks of broken up black rock
160	200	blue shale

TOTAL DEPTH OF BORING 200 (Feet)

TOTAL DEPTH OF COMPLETED WELL 200 (Feet)

WELL OWNER

WELL LOCATION

Address Same

City Napa

County Napa

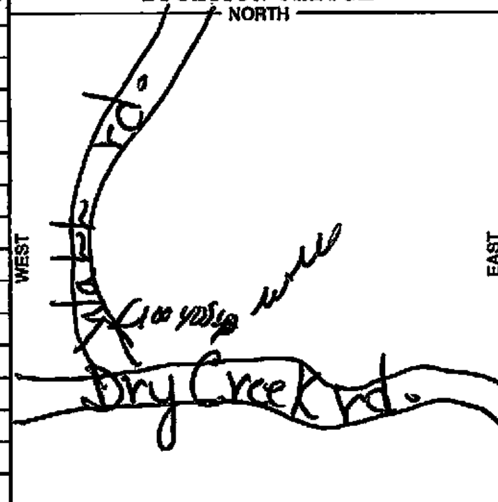
APN Book ____ Page ____ Parcel 27-090-22

Township ____ Range ____ Section ____

Latitude ____ NORTH DEG. MIN. SEC. Longitude ____ WEST DEG. MIN. SEC.

LOCATION SKETCH

NORTH



WEST | EAST

SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR

____ Deepen

____ Other (Specify)

____ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

____ MONITORING

WATER SUPPLY

____ Domestic

____ Public

X Irrigation

____ Industrial

____ "TEST WELL"

____ CATHODIC PROTECTION

____ OTHER (Specify)

DRILLING METHOD ROTARY FLUID MUDD

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL 50 (Ft.) & DATE MEASURED 5-12-99

ESTIMATED YIELD* 25 (GPM) & TEST TYPE AIR LEFT

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN 160 (Ft.)

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	22	10 5/8	X				PLASTIC	5	200	
22	80	8 5/8	X				"	"	"	
80	200	8"	FACTORY PERF				"	"	"	5/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	22	X			
22	200	PEA GRAVEL			

ATTACHMENTS (✓)

____ Geologic Log

____ Well Construction Diagram

____ Geophysical Log(s)

____ Soil/Water Chemical Analyses

____ Other ____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Pulliam Well Drilling 369
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

5877 Piedmont Ave. Napa Ca. 94558
ADDRESS CITY STATE ZIP

Signed [signature] 5-17-99 248677
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #15

ORIGINAL
File with DWR

Page ____ of ____
Owner's Well No. [redacted]
Date Work Began 10-5-00, Ended 10-16-00
Local Permit Agency Napa County
Permit No. 96-11644 Permit Date 9-25-00

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 710226

DWR USE ONLY — DO NOT FILL IN
07N05W31
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD rotary FLUID mud

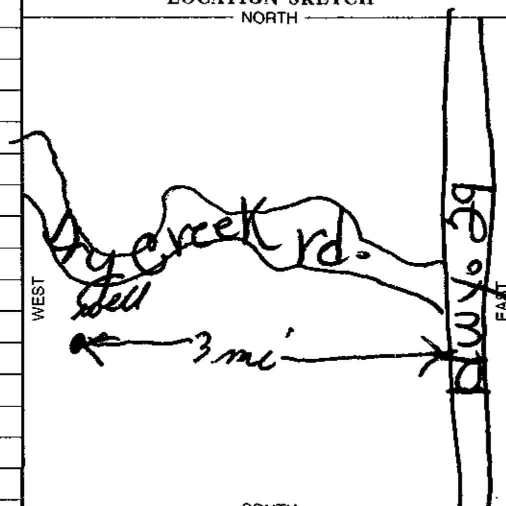
DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION Describe material, grain size, color, etc.
0	50	brown clay
50	120	broken up shale and sandstone
120	200	shale
200	225	sandstone
225	280	blue shale

TOTAL DEPTH OF BORING 300 (Feet)
TOTAL DEPTH OF COMPLETED WELL 280 (Feet)

WELL LOCATION

Address Same
City Napa
County Napa
APN Book ____ Page ____ Parcel 27-310-05
Township ____ Range ____ Section ____
Latitude ____ NORTH (DEG. MIN. SEC.) Longitude ____ WEST (DEG. MIN. SEC.)

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY *(Describe Procedures and Materials Under "GEOLOGIC LOG")*

PLANNED USES (✓)

WATER SUPPLY
___ Domestic ___ Public
X Irrigation ___ Industrial
MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 50 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 40 (Ft.) & DATE MEASURED 10-13-00
ESTIMATED YIELD * 10 (GPM) & TEST TYPE AIR LEFT
TEST LENGTH 3 (Hrs.) TOTAL DRAWDOWN 260 (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	24	10 5/8	X				PLASTIC	5"	200	
24	60	8"	X				"	"	"	
60	280	8"	FACT PERF				"	"	"	5/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	24	X			
24	280	PEA GRAVEL			

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Pulliam Well Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

2877 Piedmont Av Napa Ca. 94558
ADDRESS CITY STATE ZIP

Signed Bill Pulliam 10-15-00 248677
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 11-97 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #16

ORIGINAL
File with DWR

Page 1 of 1

Owner's Well No.

Date Work Began 10-17-00 , Ended 10-27-00

Local Permit Agency Napa County Environmental Mgmt.

Permit No 96-11642 Permit Date 9-19-00

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 710534

DWR USE ONLY -- DO NOT FILL IN

07N06W36

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD ___ FLUID ___

DEPTH FROM SURFACE Ft	to Ft	DESCRIPTION *Describe material, grain size, color, etc.*
0	40	tan ash
40	190	blue sandy volcanic rock
190	440	85% clay/ 15% shale

TOTAL DEPTH OF BORING 440 (Feet)

TOTAL DEPTH OF COMPLETED WELL 198 (Feet)

WELL OWNER

CITY STATE ZIP

WELL LOCATION

Address Dry Creek Rd

City Napa

County Napa

APN Book 27 Page 070 Parcel 36

Township ___ Range ___ Section ___

Latitude ___ NORTH Longitude ___ WEST
DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USES (✓)

WATER SUPPLY
___ Domestic ___ Public
X Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 55 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 18 (Ft.) & DATE MEASURED 10-27-00

ESTIMATED YIELD * 120 (GPM) & TEST TYPE air lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	60	13								
60	320	10								
320	440	9								
0	58		X				PVC F480	6	SDR-21	
58	198			X			PVC F480	6	SDR-21	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	28	X			concrete
28	40		X		chips
40	52	X			cement
52	250			X	#6 sand
250	440			X	pea gravel

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME HUCKFELDT WELL DRILLING
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

2110 Penny Lane Napa CA 94559
ADDRESS CITY STATE ZIP

Signed [signature] 10-28-00 439-746
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

Well #17

ORIGINAL
File with DWR

Page ____ of ____

Owner's Well No. ____

Date Work Began 6-22-01 Ended 6-27-01

Local Permit Agency Napa County

Permit No. 96-11590 Permit Date 8800

Fred

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 762775

DWR USE ONLY — DO NOT FILL IN

07N06W36

STATE WELL NO./STATION NO.

LATITUDE | LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD rotary FLUID mud

DEPTH FROM SURFACE Ft. to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0 170	brown & white ash
170 230	loss circulation
230 245	brown & white ash
245 255	gray ash some shale
255 300	loss circulation
300 310	gray shale

TOTAL DEPTH OF BORING 310 (Feet)

TOTAL DEPTH OF COMPLETED WELL 310 (Feet)

WELL OWNER

WELL LOCATION

Address Same

City Same

County Napa

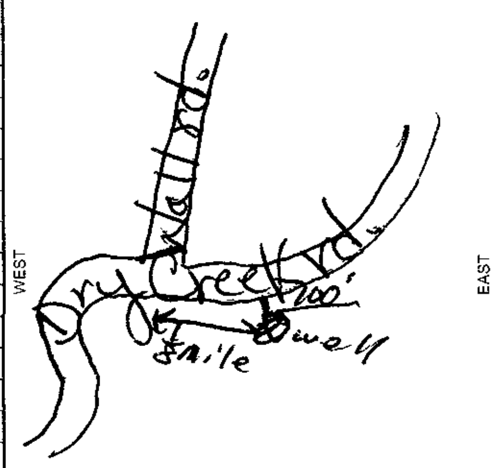
APN Book ____ Page ____ Parcel 27-070-3800

Township ____ Range ____ Section ____

Latitude ____ NORTH (DEG. MIN. SEC.) Longitude ____ WEST (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH



WEST | EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
✓ Domestic ___ Public
___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 90 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 85 (Ft.) & DATE MEASURED 6-27-01

ESTIMATED YIELD * 50 (GPM) & TEST TYPE Air lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN 200 (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft. to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0 23	11	✓				Plastic	5	200	
23 90	8 3/4	✓				"	"	"	
90 310	8 3/4		✓			"	"	"	Factory 1/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft. to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0 23	✓			
23 310				Pea Gravel

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Pulliam Well Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS 2877 Piedmont CITY Napa STATE Ca ZIP 94558

Signed Tom Pulliam
WELL DRILLER/AUTHORIZED REPRESENTATIVE

DATE SIGNED 7-31-01 C-57 LICENSE NUMBER 248677

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #18

ORIGINAL
File with DWR

Page 1 of 1

Owner's Well No. ____

Date Work Began 10-14-99, Ended 10-28-99

Local Permit Agency Napa County Environmental Mgmt.

Permit No. 96-11354 Permit Date 10-04-99

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 777416

DWR USE ONLY — DO NOT FILL IN

07N05W31

STATE WELL NO./STATION NO.

LATITUDE | LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD rotary FLUID ____

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	40	brown clay
40	60	gravel
60	100	50% sandstone/ 50% shale
100	200	60% sandstone/ 40% sahle
200	300	85% shale/ 15% sandstone

TOTAL DEPTH OF BORING 300 (Feet)

TOTAL DEPTH OF COMPLETED WELL 202 (Feet)

WELL LOCATION

Address same

City ____

County Napa

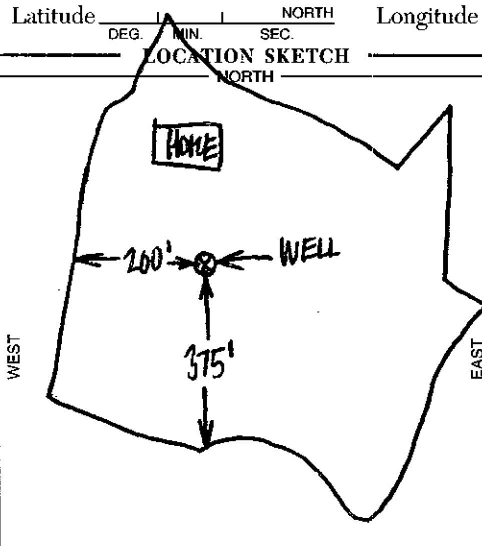
APN Book 27 Page 330 Parcel 10

Township ____ Range ____ Section ____

Latitude ____ NORTH (DEG. MIN. SEC.) Longitude ____ WEST (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH



WEST | EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
- ___ Deepen
- ___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
- X Domestic ___ Public
- ___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 80 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 56 (Ft.) & DATE MEASURED 10-28-99

ESTIMATED YIELD * 8 (GPM) & TEST TYPE air lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	25	10								
25	300	9								
0	82		X				PVC F480	5	SDR-21	
82	202			X			PVC F480	5	SDR-21	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	24	X			concrete
24	300			X	pea gravel

ATTACHMENTS (✓)

- ___ Geologic Log
- ___ Well Construction Diagram
- ___ Geophysical Log(s)
- ___ Soil/Water Chemical Analyses
- ___ Other ____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME HUCKFELDT WELL DRILLING
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS 2110 Penny Lane CITY Napa STATE CA ZIP 94559

Signed Dan Huckfeldt (WELL DRILLER/AUTHORIZED REPRESENTATIVE) DATE SIGNED 11-03-99 C-57 LICENSE NUMBER 439-746

DWR 188 REV. 11-97 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #19

ORIGINAL
File with DWR

Page 1 of 1

Owner's Well No.

Date Work Began 5-15-01, Ended 5-17-01

Local Permit Agency Napa County Environmental Mgmt.

Permit No. 96-11809 Permit Date 5-15-01

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 778362

DWR USE ONLY — DO NOT FILL IN

01N06W31

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD Rotary FLUID

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	3	top soil
3	200	95% shale/ 5% sandstone

TOTAL DEPTH OF BORING 200 (Feet)

TOTAL DEPTH OF COMPLETED WELL 120 (Feet)

WELL OWNER

WELL LOCATION

Address same

City

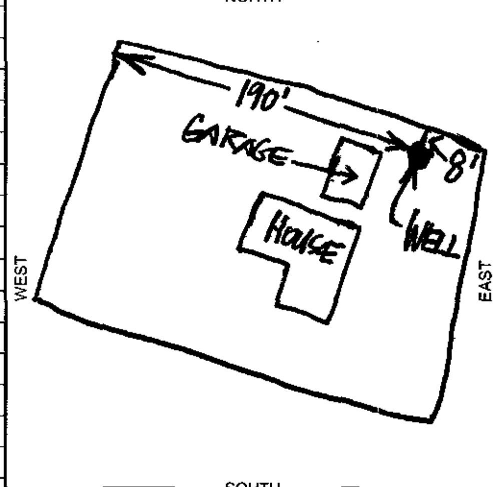
County Napa

APN Book 27 Page 530 Parcel 05

Township Range Section

Latitude NORTH DEG. MIN. SEC. Longitude WEST DEG. MIN. SEC.

LOCATION SKETCH



Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. **PLEASE BE ACCURATE & COMPLETE.**

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
X Domestic ___ Public
X Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 30 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 20 (Ft.) & DATE MEASURED 5-17-01

ESTIMATED YIELD * ½ (GPM) & TEST TYPE air lift

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)

* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	25	10								
25	200	9								
0	28		X				PVC F480	5	SDR-21	
28	120			X			PVC F480	5	SDR-21	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	21	X			concrete
21	200			X	pea gravel

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME HUCKFELDT WELL DRILLING
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

2110 Penny Lane Napa CA 94559
ADDRESS CITY STATE ZIP

Signed [signature] 8-20-01 439-746
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

Well #20

ORIGINAL
File with DWR

Page 1 of 1

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **804717**

DWR USE ONLY — DO NOT FILL IN

07N05W31

STATE WELL NO./STATION NO.

LATITUDE | LONGITUDE

APN/TRS/OTHER

Owner's Well No. MASSOLETTI

Date Work Began 7/14/04, Ended 7/20/04

Local Permit Agency NAPA COUNTY ENVIRONMENTAL DEPT

Permit No. E04-0184 Permit Date 7/14/04

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DRILLING METHOD ROTARY FLUID AIR

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain, size, color, etc.
0	10	TOP SOIL
10	38	HARD CLAY
38	140	FRACTURED SHALE
140	240	HARD SHALE

TOTAL DEPTH OF BORING 240 (Feet)

TOTAL DEPTH OF COMPLETED WELL 200 (Feet)

WELL OWNER

WELL LOCATION

Address DRY CREEK RD

City NAPA CA 94558

County NAPA

APN Book 027 Page 330 Parcel 005

Township ___ Range ___ Section ___

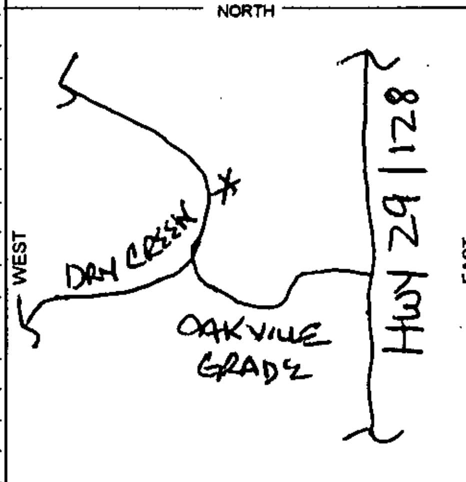
Latitude ___ DEG. MIN. SEC. Longitude ___ DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST

EAST



SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR
- ___ Deepen
- ___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
- ✓ Domestic ___ Public
- ___ Irrigation ___ Industrial

MONITORING ___
TEST WELL ___
CATHODIC PROTECTION ___
HEAT EXCHANGE ___
DIRECT PUSH ___
INJECTION ___
VAPOR EXTRACTION ___
SPARGING ___
REMEDIATION ___
OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

1

DEPTH TO FIRST WATER 140 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 21 (Ft.) & DATE MEASURED 7/20/04

ESTIMATED YIELD * 8 (GPM) & TEST TYPE AIR LIFT

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN N/A (Ft.)

May not be representative of a well's long-term yield.

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	30	11 1/2	✓				F480 PVC	5"	.265	
30	200	8 3/4"	✓	✓			F408 PVC	5"	.265	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	22	✓			
22	240			✓	3/8" PEA GRA

ATTACHMENTS (✓)

- ___ Geologic Log
- ___ Well Construction Diagram
- ___ Geophysical Log(s)
- ___ Soil/Water Chemical Analysis
- ___ Other ___

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME DAVE BESS PUMP & WELL
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

1115 MT GEORGE AVE NAPA CA 94558
ADDRESS CITY STATE ZIP

Signed ___ 08/03/04 C-10/C-57 487027
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

APPENDIX B

NAPA COUNTY GROUNDWATER RECHARGE ANALYSIS

Napa County Groundwater Recharge Analysis

Introduction

Developing accurate estimates of the spatial and temporal distribution of groundwater recharge is a key component of sustainable groundwater management. Efforts to quantify recharge are inherently difficult owing to the wide variability of factors controlling hydrologic processes, the wide range of available tools/methods for estimating recharge, and the difficulty in assessing the accuracy of estimates because direct measurement of recharge rates is, for the most part, infeasible (Healy 2010, Seiler and Gat 2007).

Numerical modeling is a common approach for developing recharge estimates. Soil-water-balance modeling is one category of numerical models particularly well-suited for estimating recharge across large areas with modest data requirements. This study describes an application of the U.S. Geological Survey's (USGS) Soil Water Balance Model (SWB) (Westenbroek et al. 2010) to develop spatial and temporal distributions of groundwater recharge across Napa County. This model operates on a daily timestep and calculates surface runoff based on the Natural Resources Conservation Service (NRCS) curve number method and potential evapotranspiration based on the Hargreaves-Samani methods (Hargreaves and Samani 1985). Actual evapotranspiration (AET) and recharge are calculated using a modified Thornthwaite-Mather soil-water-balance approach (Westenbroek et al. 2010).

It is important to note that the SWB model focuses on surface and soil-zone processes and does not simulate the groundwater system or track groundwater storage over time. The model also does not simulate surface water/groundwater interaction or baseflow; thus, the runoff estimates represent only the surface runoff component of streamflow resulting from rainstorms and the recharge estimates represent only the infiltration recharge component (also referred to as diffuse recharge) of total recharge (stream-channel recharge is not simulated).

This modeling work and summary report has been prepared by O'Connor Environmental, Inc., for it's private use in relation to Water Availability Analyses (WAA) prepared on behalf of private clients for projects using groundwater in "hillside" areas of Napa County as required by Napa Planning, Building & Environmental Services. The modeling to-date is complete in its current form but remains subject to revision; it is considered a working draft with information suitable for use to support WAA projects. Parties interested in obtaining more information regarding the modeling or who may wish to offer comments should contact O'Connor Environmental, Inc.

Model Development

The model was developed using a 30-meter (98.4 ft) resolution rectangular grid. Water budget calculations were made on a daily time step. Key spatial inputs included a flow direction map developed from the USGS 1 arc-second resolution Digital Elevation Model (DEM), a land cover map derived from the U.S. Forest Service (USFS) CALVEG dataset that was supplemented by a database of agricultural areas maintained by the County of Napa (Figure 1), a distribution of Hydrologic Soil Groups (A through D classification from lowest to highest runoff potential; Figure 2), and a distribution of Available Water Capacity (AWC) developed from the NRCS Soil Survey Geographic Database (SSURGO) (Figure 3).

A series of model parameters were assigned for each land cover type/soil group combination including an infiltration rate, a curve number, dormant and growing season interception storage values, and a rooting depth (Table 1).

Infiltration rates for hydrologic soil groups A through D were applied based on Cronshey et al. (1986) (Table 2) along with default soil-moisture-retention relationships based on Thornthwaite and Mather (1957) (Figure 4). Curve numbers were assigned based on standard NRCS methods. Interception storage values and rooting depths were assigned based on literature values and from previous modeling experience including a SWB model covering Sonoma County and calibrated using runoff volumes from several stream gages (OEI 2017).

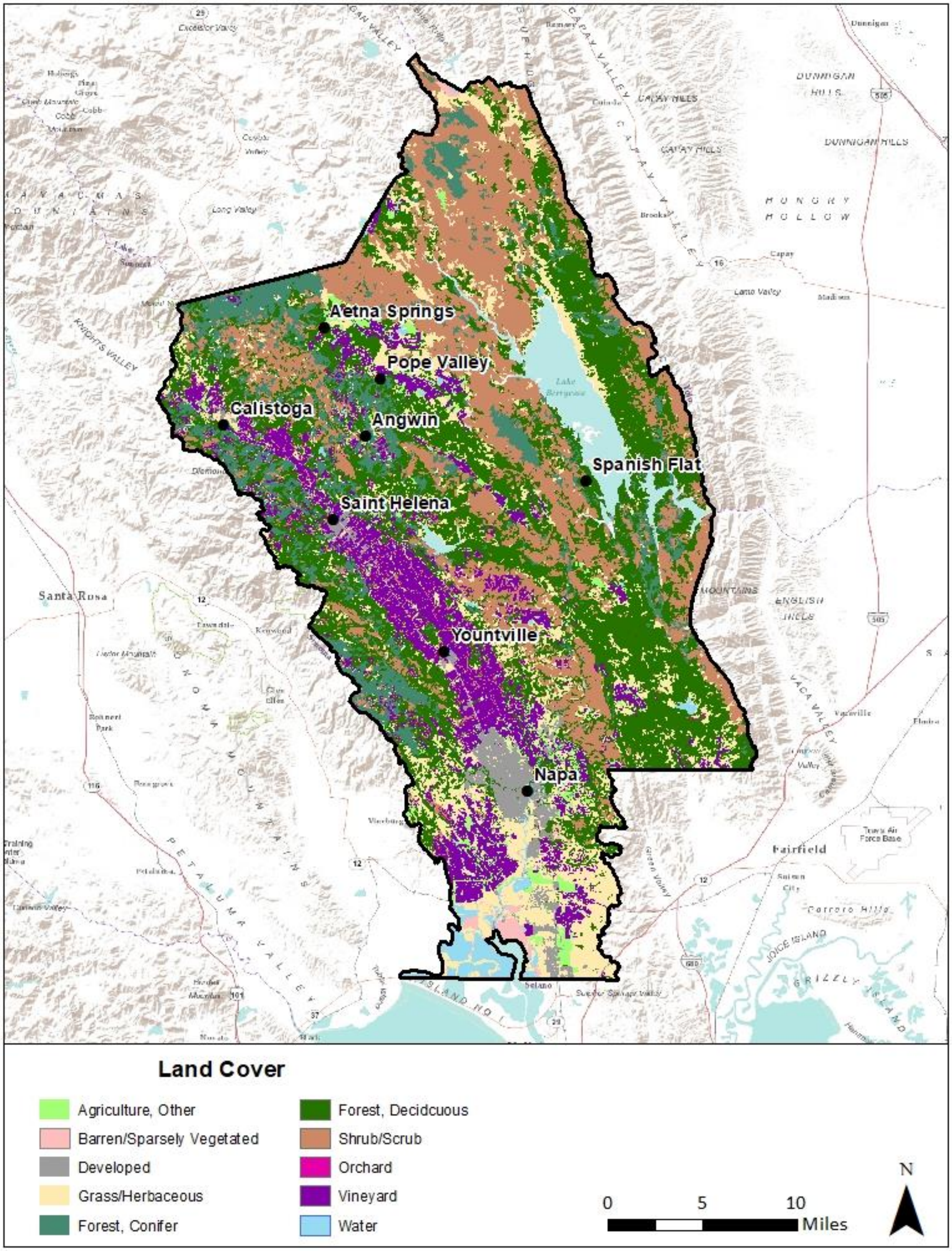


Figure 1: Land cover distribution used in the Napa County SWB model.

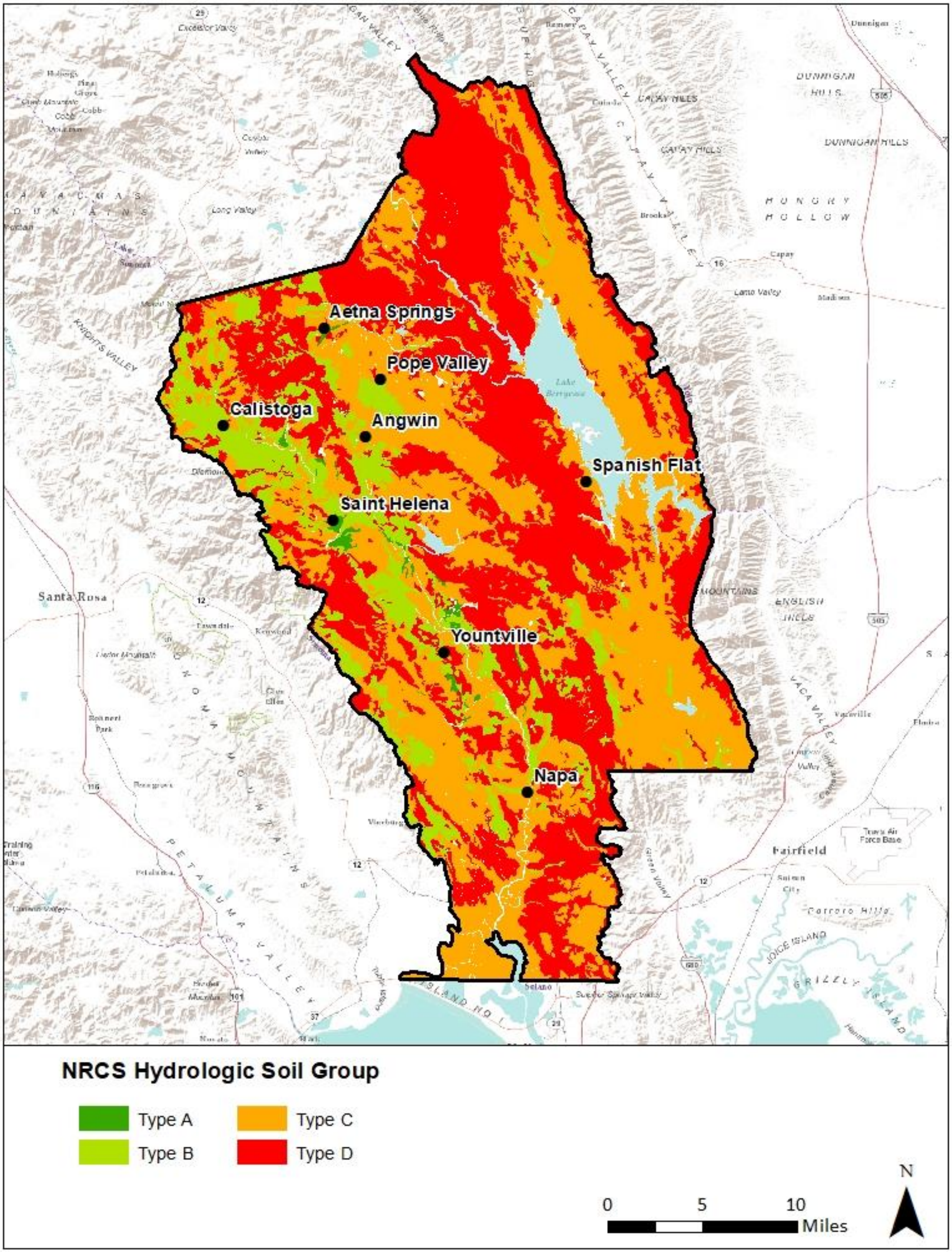


Figure 2: Hydrologic soil group distribution used in the Napa County SWB model.

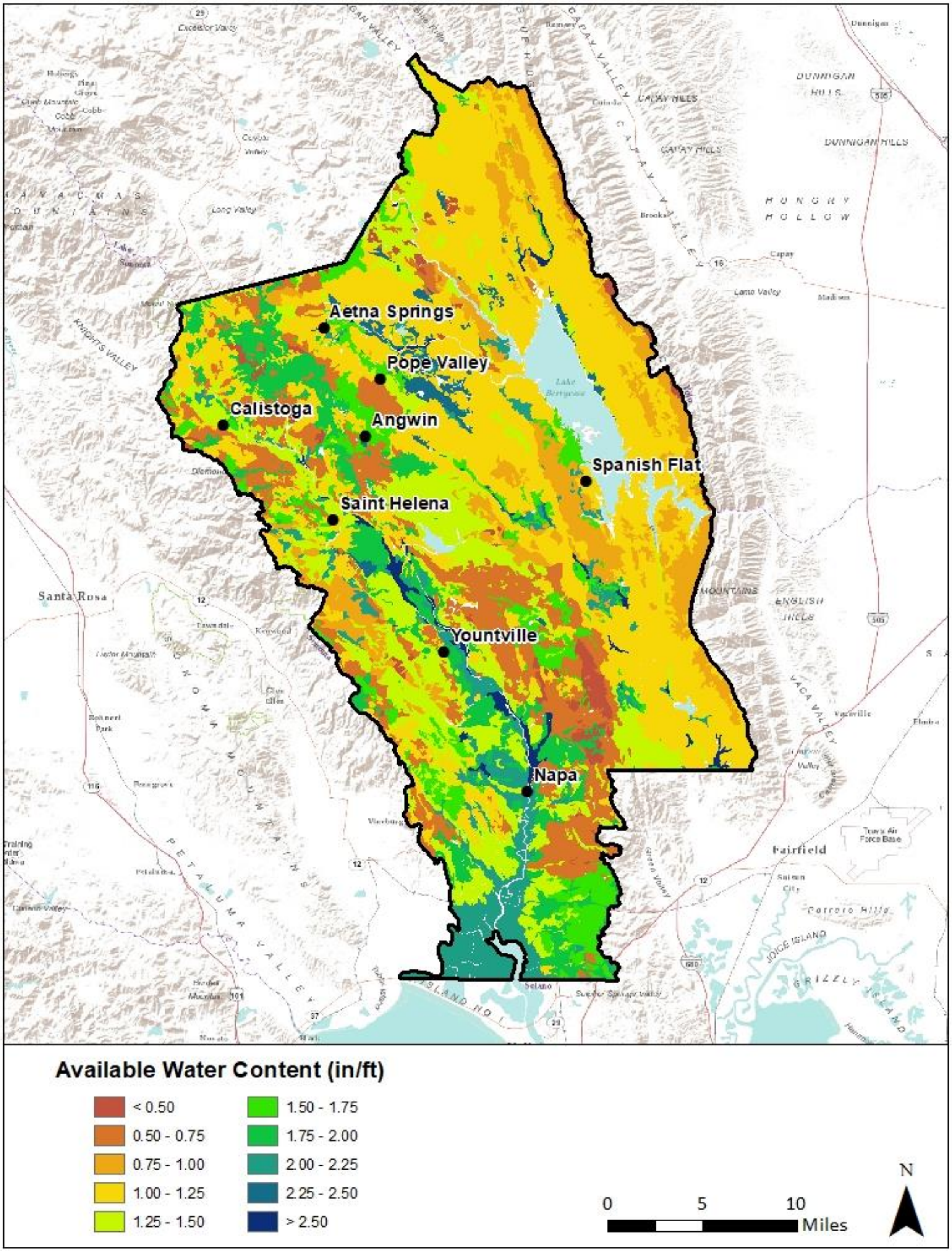


Figure 3: Available water capacity distribution used in the Napa County SWB model.

Table 1: Soil and land cover properties used in the Napa County SWB model.

Land Cover	Interception Storage Values ()		Curve Number by NRCS Soil Type ()				Rooting Depth by NRCS Soil Type (ft)			
	Growing Season	Dormant Season	Type A	Type B	Type C	Type D	Type A	Type B	Type C	Type D
Agriculture, Other	0.080	0.040	38	61	75	81	2.0	1.9	1.8	1.7
Barren	0.000	0.000	77	86	91	94	0.0	0.0	0.0	0.0
Developed	0.005	0.002	61	75	83	87	2.3	2.1	2.0	1.8
Grassland/Herbaceous	0.005	0.004	30	58	71	78	1.3	1.1	1.0	1.0
Forest, Coniferous	0.050	0.050	30	55	70	77	5.9	5.1	4.9	4.7
Forest, Deciduous	0.050	0.020	30	55	70	77	5.9	5.1	4.9	4.7
Shrub/Scrub	0.080	0.015	30	48	65	73	3.2	2.8	2.7	2.6
Orchard	0.050	0.015	38	61	75	81	3.2	2.8	2.7	2.6
Vineyard	0.080	0.015	38	61	75	81	2.2	2.1	2.0	1.9
Water	0.000	0.000	100	100	100	100	0.0	0.0	0.0	0.0

Table 2: Infiltration rates for NRCS hydrologic soil groups (Cronshey et al. 1986).

Soil Group	Infiltration Rate (in/hr)
A	> 0.3
B	0.15 - 0.3
C	0.05 - 0.15
D	<0.05

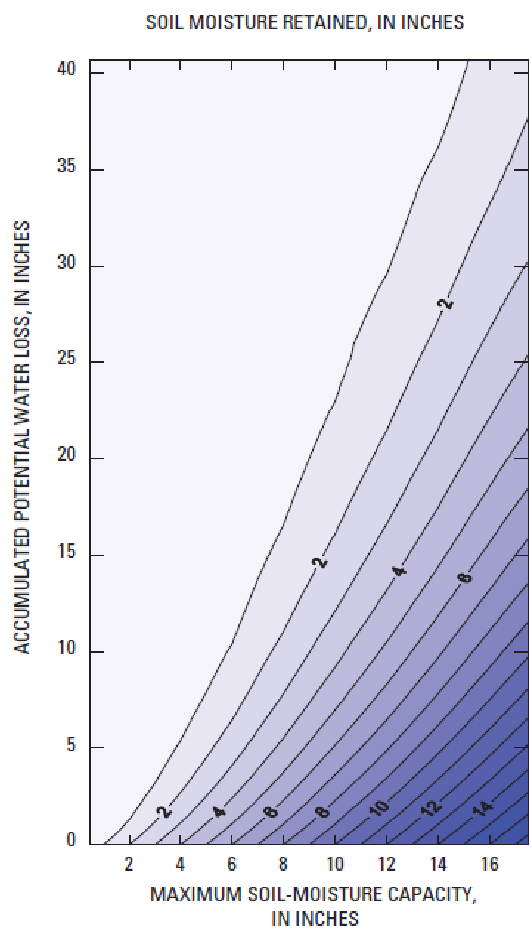


Figure 4: Soil-moisture-retention table (Thornthwaite and Mather 1957).

The SWB model utilizes daily precipitation and mean daily temperature data derived from climate stations. To account for the spatial variability of these parameters, daily precipitation and mean daily temperature were input as gridded (spatially-distributed) time-series. The gridded precipitation time-series was created using data from 15 weather stations in Napa County, and the gridded mean temperature time-series was created using data from 8 stations (Table 3). These stations were selected based on completeness of the records and to provide station data representative of the range of climates experienced in the county. Data was obtained from the California Data Exchange Center (CDEC), the National Climatic Data Center (NCDC), and from Napa One Rain.

To create the gridded time-series, the model domain was divided into discrete areas represented by individual weather stations (Figures 5 and 6). This delineation was based on climate variations described by existing gridded mean annual (1981-2010) precipitation and temperature data (PRISM 2010) and local knowledge of climatic variations across the county.

For the precipitation time-series, each area representing a weather station was subdivided into four to twenty-three zones based on 1-inch average annual precipitation contours. Within each zone the raw station data was multiplied by a unique scaling factor. This scaling factor was calculated as the ratio of average annual precipitation within a zone to average annual precipitation at the representative rain gage. In certain locations, typically near the boundary of areas represented by gages located on the valley bottom and at higher elevations, this scaling was unable to smoothly resolve differences in annual and event precipitation totals. To more accurately estimate precipitation near these boundaries, precipitation records from the two gages in question were averaged using weights calculated proportionally to the difference between PRISM mean annual precipitation at a rain gage and within a selected zone. The resulting gridded time-series is comprised of 220 individual time-series based on the scaled station data from 15 stations.

The assignment of temperature stations was based on the understanding that the spatial variability of temperatures across Napa County is relatively homogenous, with elevation being the primary variable. Temperature records were classified either as Mountain, Valley Bottom, or East County and applied within areas the PRISM datasets described as being similar. To smooth the transition from Mountain zones to Valley Bottom and East County zones, Hillside zones were created where the temperature records of the two nearest gages were averaged.

Missing and suspect data was encountered in the raw precipitation and temperature data from the weather stations used by the model. Values that were significantly outside the typical range, and where similar observations were not found at nearby stations, were removed from the datasets. These and missing values were filled using scaled data from other nearby stations. Precipitation data used for gap filling was scaled using the ratio of the 1981 to 2010 mean annual precipitation (PRISM 2010) between the two stations. Temperature data was scaled using the ratio of the 1981 to 2010 mean monthly minimum and maximum temperatures (PRISM 2010) between the two stations.

The current analysis focuses on Water Year 2010 (October 1, 2009 – September 30, 2010) and Water Year 2014 (October 1, 2013 – September 30, 2014). These years were selected because they represent periods with data available from most weather stations in the county and where most stations reported annual precipitation totals close to the long-term average (WY 2010) and significantly below the long term average (WY 2014). Based on a comparison between station data and PRISM average precipitation depths during Water Year 2010, rainfall averaged 101% of long-term average conditions and ranged from 78% at Lake Hennessey to 111% at the Napa County Airport. In Water Year 2014, rainfall averaged 55% of long-term average conditions and ranged from 41% at Lake Hennessey to 73% at the Napa State Hospital (Table 3).

Table 3: Weather stations used in the Napa County SWB model. See Figures 7- 9 for associated timeseries.

Station	Data Used	1981 - 2010 Mean Annual Precip (in)	WY 2010		WY 2014	
			Precip (in)	% Avg	Precip (in)	% Avg
Angwin[1]	Precip & Temp	42.54	44.64	105%	25.04	59%
Atlas Peak[1]	Precip & Temp	41.76	39.04	93%	20.08	48%
Berryessa[1]	Precip & Temp	28.97	28.16	97%	13.97	48%
Calistoga[2]	Precip	39.41	41.75	106%	18.18	46%
Knoxville Creek[1]	Temp Only	-	-	-	-	-
Lake Hennessey[3]	Precip Only	34.09	26.52	78%	13.92	41%
Mt. George[3]	Precip Only	31.15	29.64	95%	18.24	59%
Mt. Veeder[3]	Precip Only	44.81	46.44	104%	28.6	64%
Napa County Airport[2]	Precip & Temp	21.14	23.56	111%	9.87	47%
Napa River at Yountville Cross Rd[3]	Precip Only	31.86	32.72	103%	14.93	47%
Napa State Hospital[2]	Precip & Temp	26.81	28.85	108%	19.66	73%
Petrified Forest[3]	Precip Only	42.39	46.6	110%	22.84	54%
Redwood Creek At Mt. Veeder Road[3]	Precip Only	34.71	37.36	108%	23.48	68%
Saint Helena[2]	Precip & Temp	37.43	39.11	104%	19.11	51%
Saint Helena 4WSW[1]	Precip & Temp	45.44	47.88	105%	28.88	64%
Sugarloaf Peak[3]	Precip Only	32.20	26.16	81%	17.12	53%

1 – Data accessed from California Data Exchange Center (CDEC)
2 – Data accessed from National Climate Data Center (NCDC)
3 – Data access from Napa One Rain

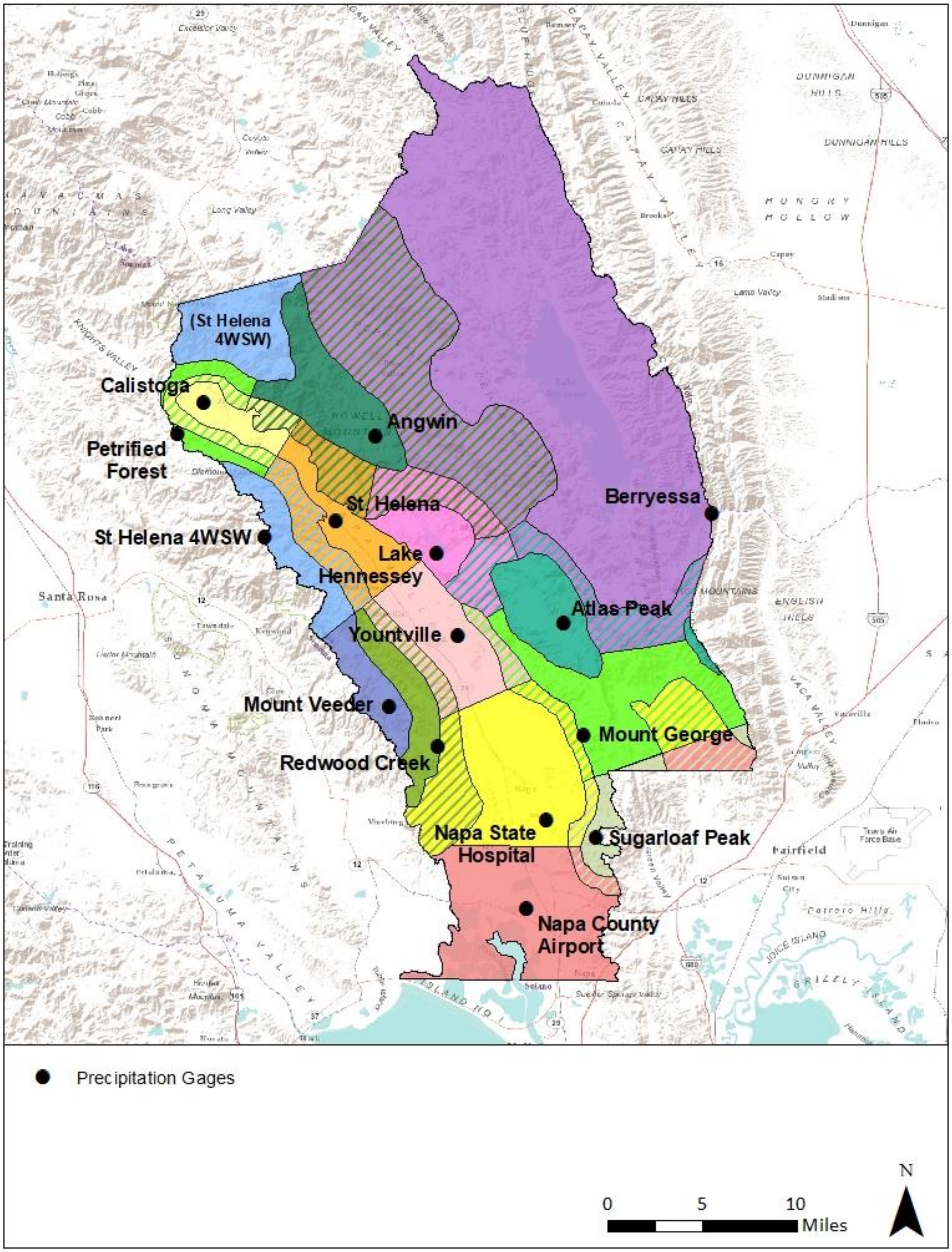


Figure 5: Precipitation zones used in the Napa County SWB model. Hatching indicates areas where two precipitation records were averaged across a zone.

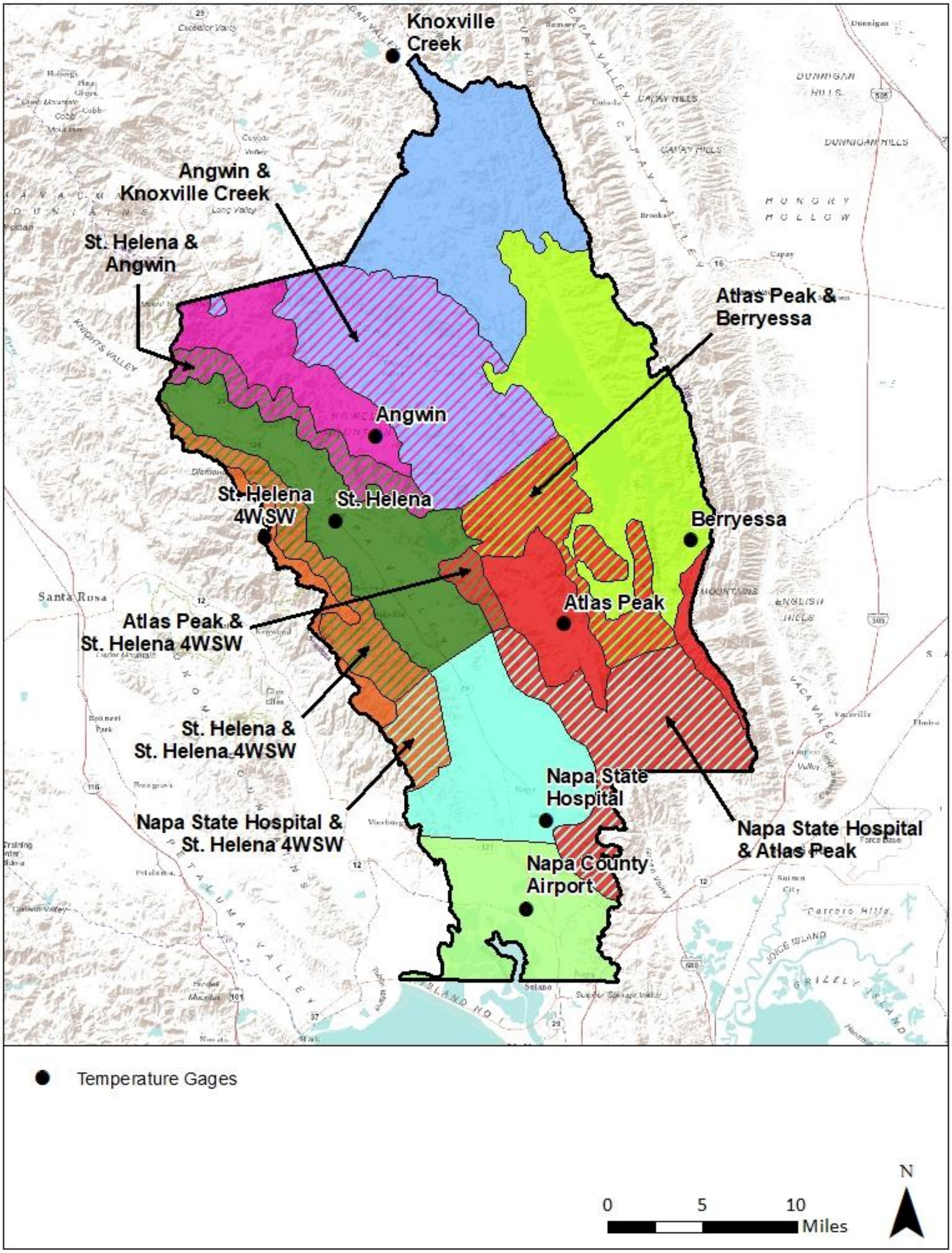


Figure 6: Temperature zones used in the Napa County SWB model. Hatching indicates areas where two temperature records were averaged across a zone.

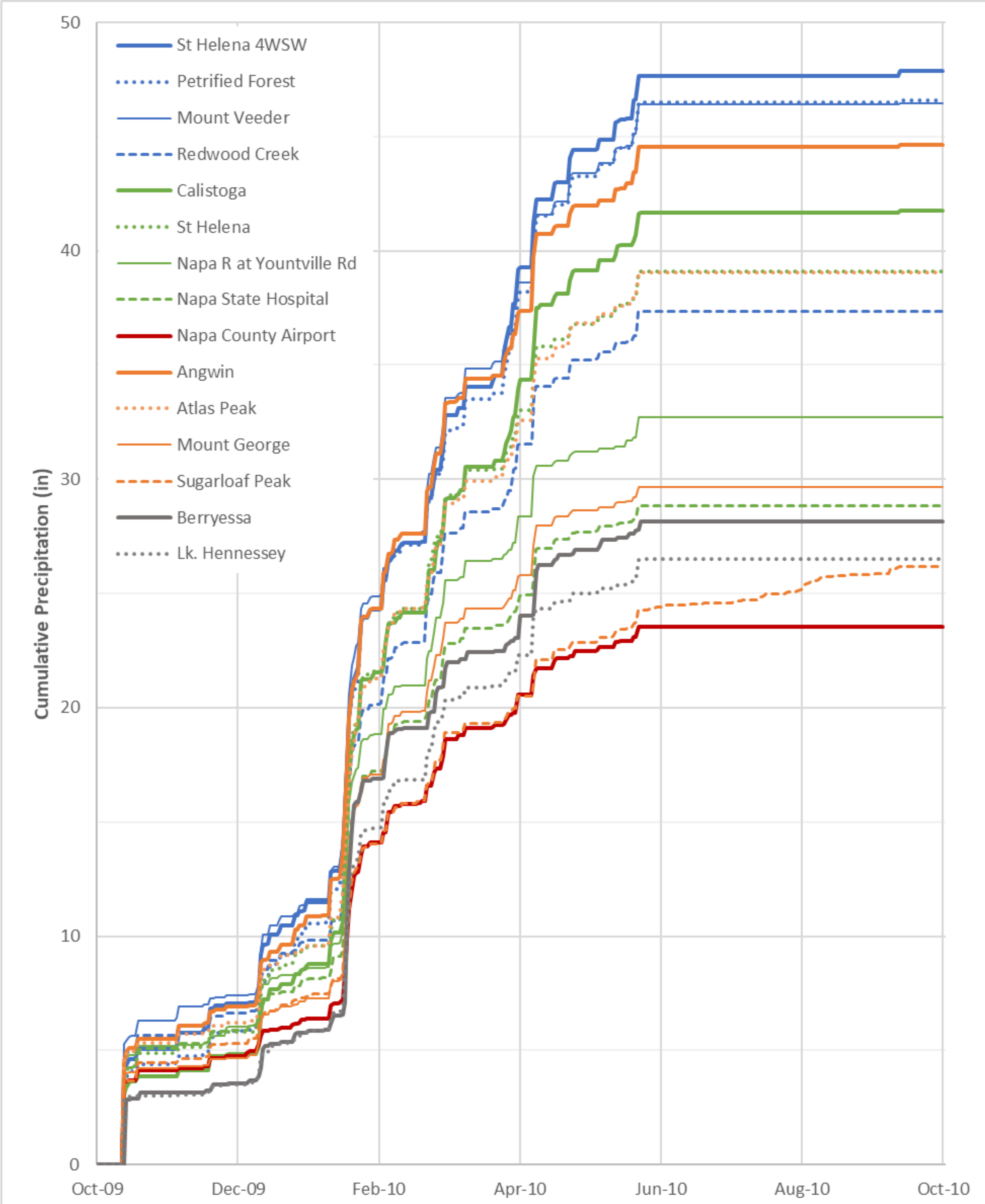


Figure 7a: Daily precipitation data used in the Napa County SWB model for WY 2010.

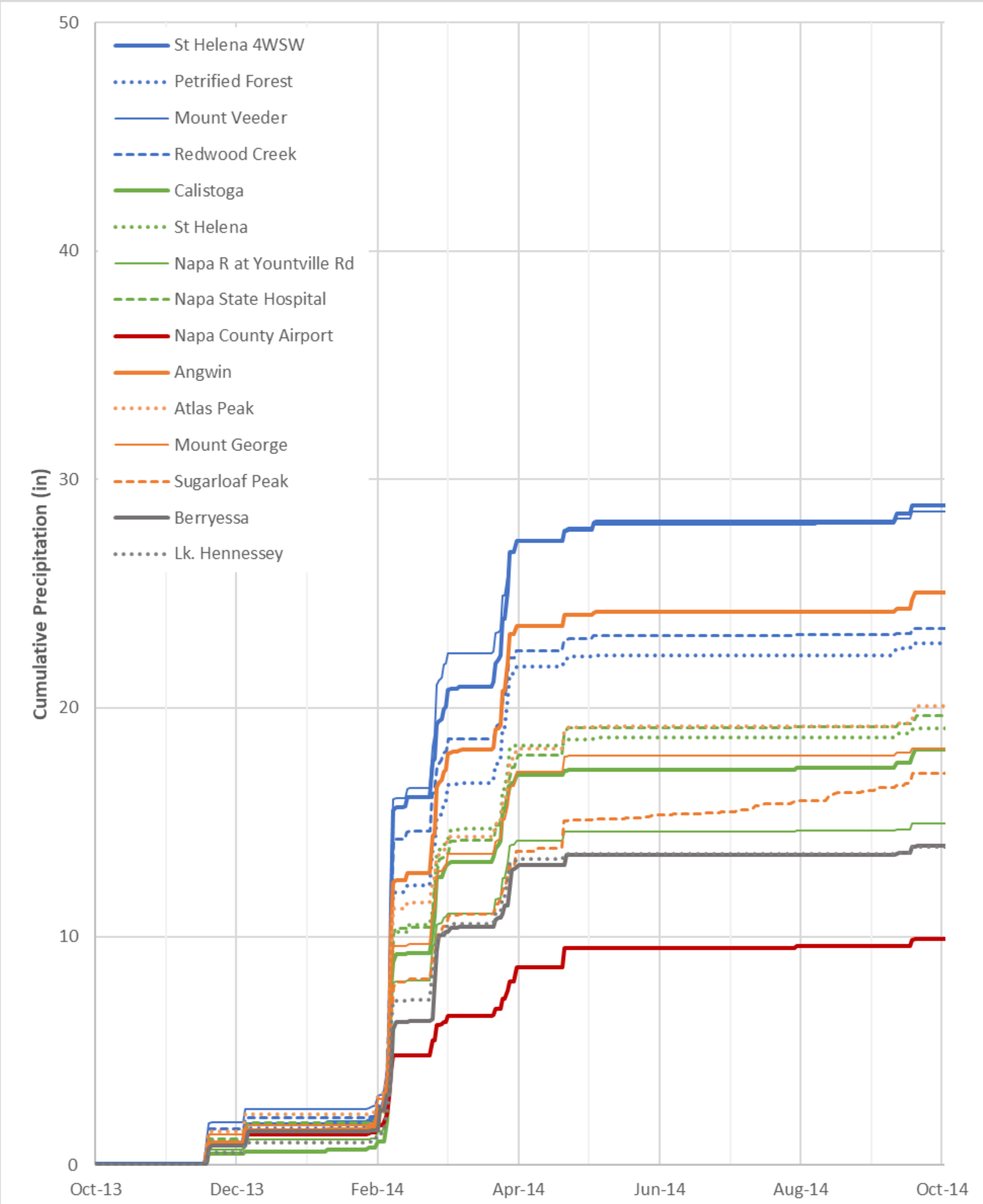


Figure 7b: Daily precipitation data used in the Napa County SWB model for WY 2014.

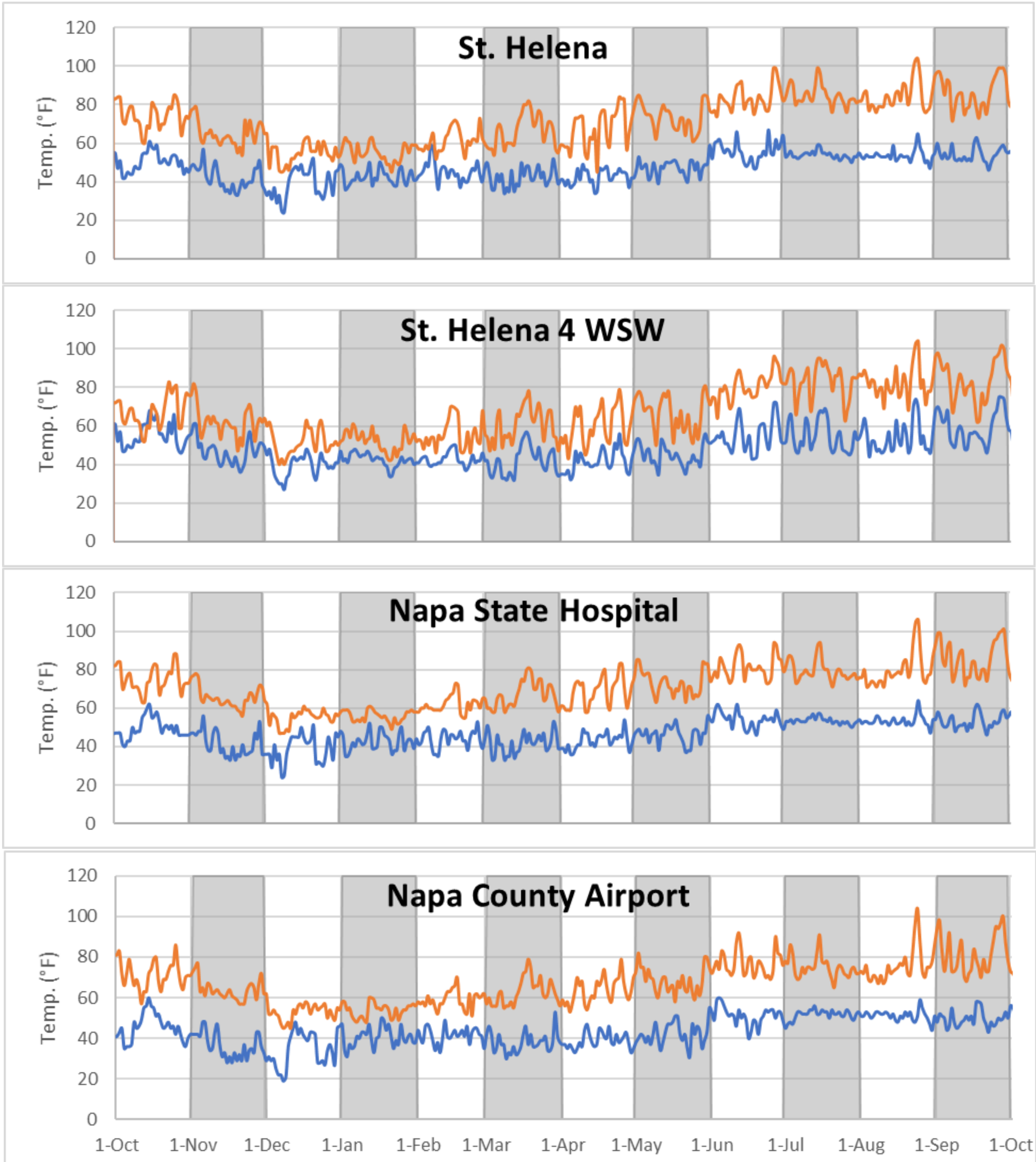


Figure 8: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.

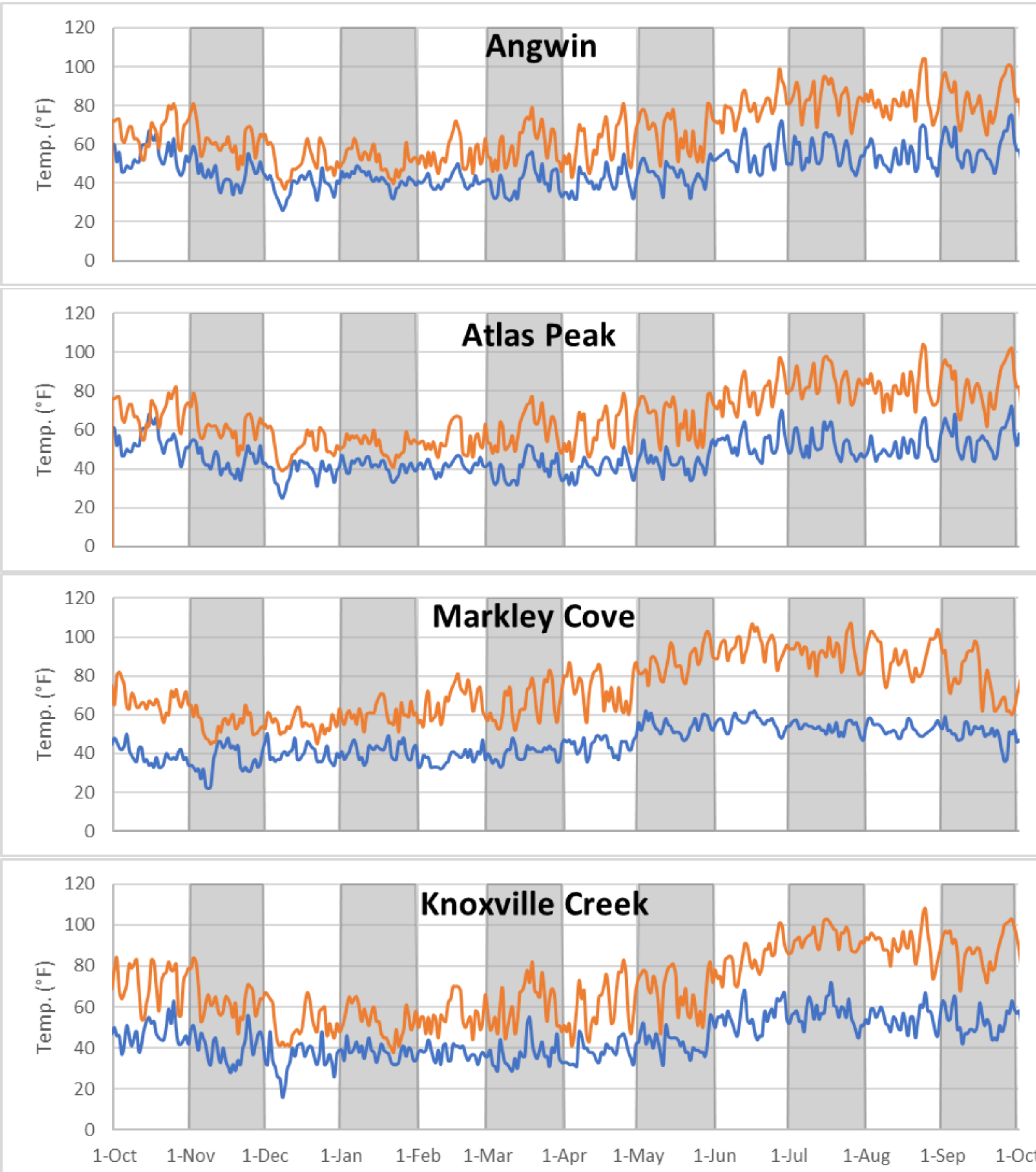


Figure 8 – cont.

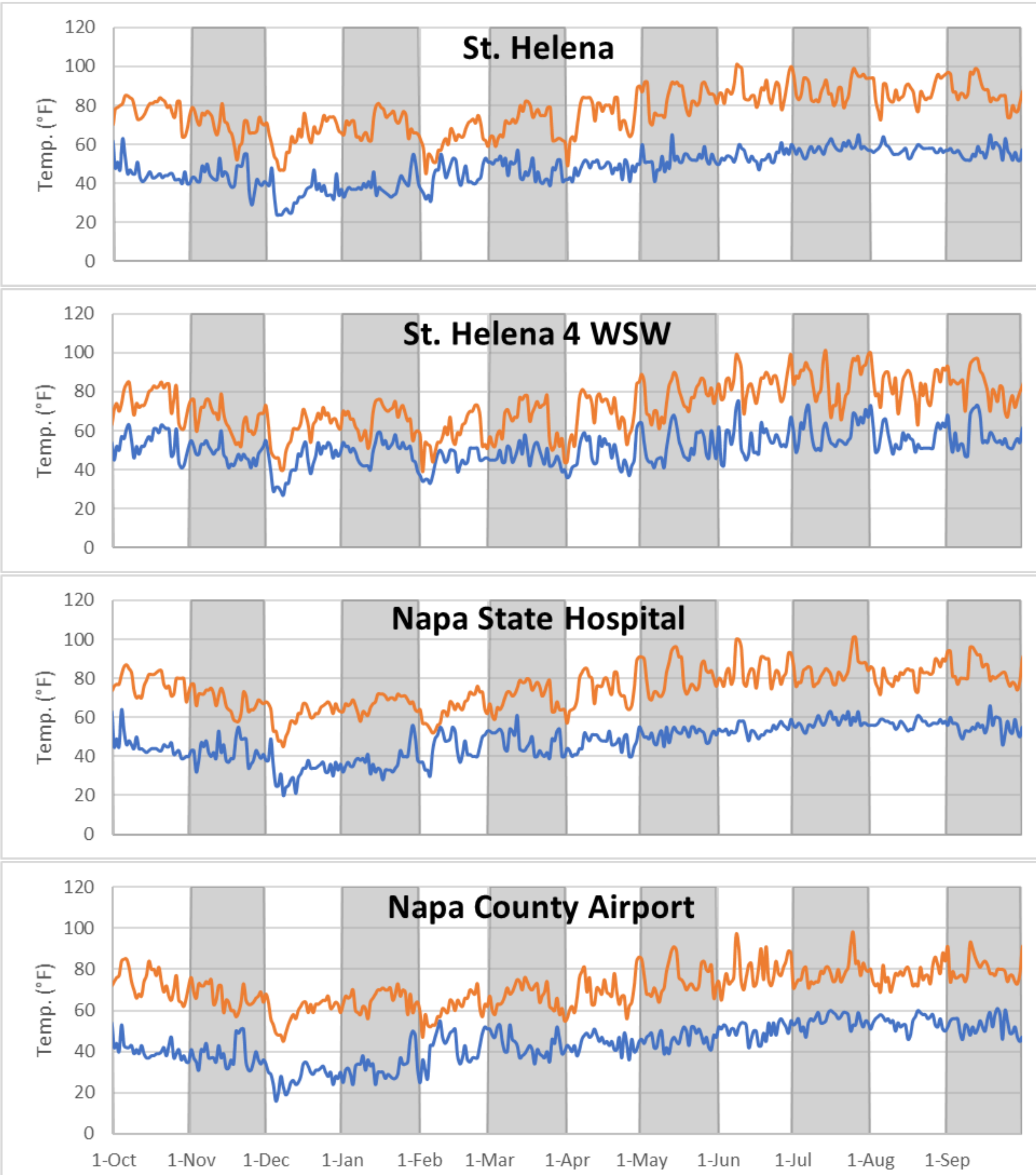


Figure 9: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.

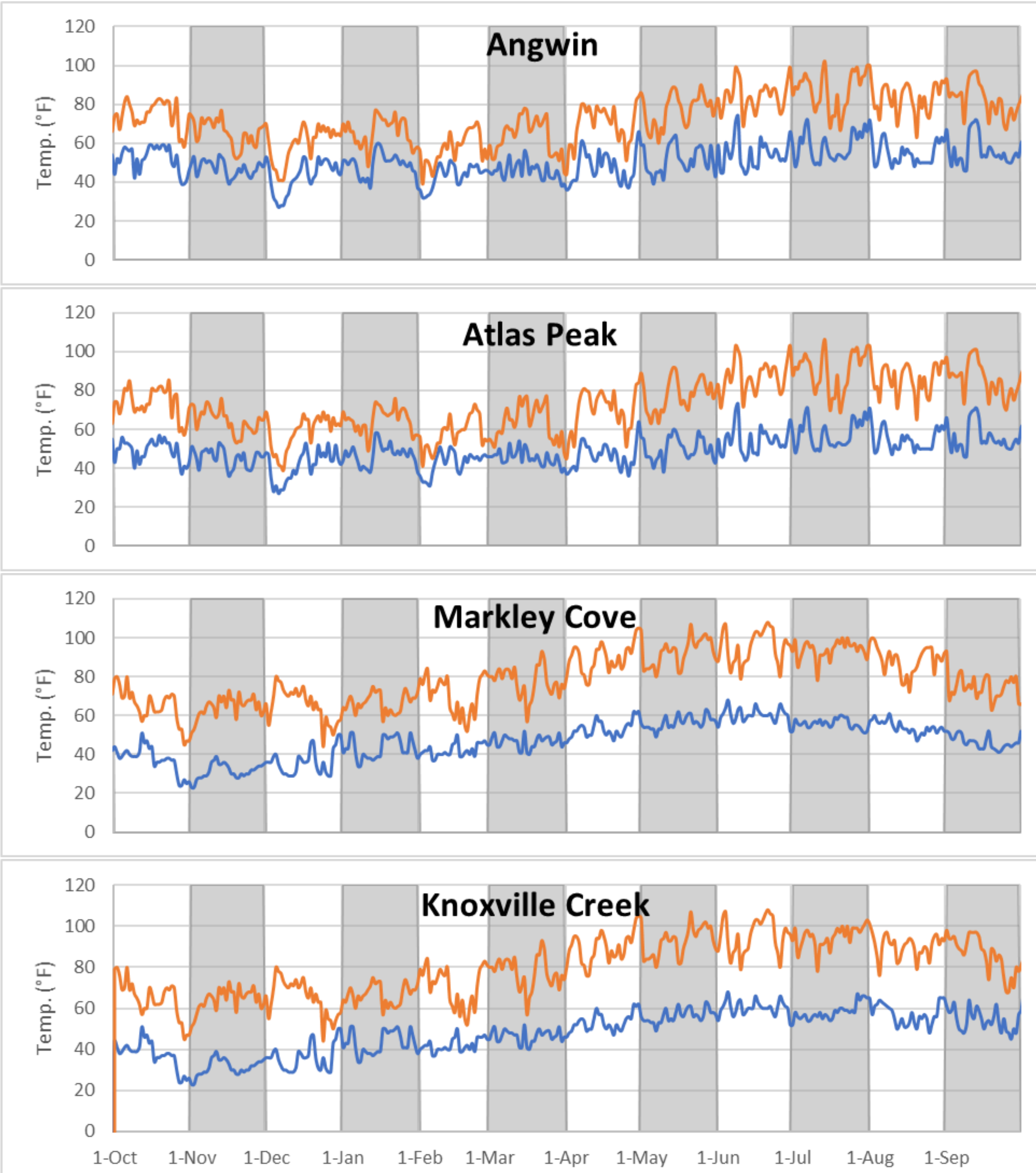


Figure 9 – cont.

Model Calibration

Available data are insufficient to calibrate the Water Year 2010 and 2014 SWB simulations; however, the land cover and soil properties used in the model were obtained from a previously prepared and calibrated SWB model of Sonoma County (OEI 2017). The Sonoma County model was calibrated against total monthly runoff volumes derived using baseflow separation of streamflow data for five watersheds within Sonoma County. Gages were selected because they represented relatively small watersheds (1.2 – 14.3 mi^2) without significant urbanization, diversions, groundwater abstraction, reservoir impoundments, or large alluvial bodies where significant exchanges between surface water and groundwater may be expected. These attributes are desirable because the hydrographs can more readily be separated into surface runoff and baseflow components and the surface runoff pattern is more directly comparable to the SWB simulated surface runoff which does not account for water use, reservoir operations, or surface water/groundwater exchange.

SWB utilizes a simplified routing scheme whereby surface runoff is routed to downslope cells or out of the model domain on the same day in which it originates as rainfall, thus it is not capable of accurately estimating streamflow over short time periods. The use of the total monthly surface runoff volumes provided a means of calibrating the Sonoma County SWB model to measured surface runoff data within the limitations of the model's approach to simulating surface runoff.

The SWB model of Sonoma County reproduced seasonal variations in surface runoff in all five calibration watersheds. Monthly Mean Errors (ME) ranged from -0.2 to 0.4 inches with a mean value of 0.1 inches. Annual surface runoff totals ranged from an under-prediction of approximately 10% at Franchini Creek to an over-prediction of approximately 19% at Buckeye Creek, with a mean over-prediction of approximately 6% across the five watersheds. These results indicate that the SWB model was able to reproduce monthly surface runoff volumes with a reasonable degree of accuracy and that the model tends to over-predict surface runoff somewhat, suggesting that the model may generate a low-range estimate of recharge.

Although the climate in Napa County is slightly drier than in Sonoma County, the vegetation, soils, and geology are similar and parameters calibrated using data from Sonoma County should be applicable to Napa County. Calibration of the Napa County SWB model was not performed due to a lack of publicly-available contemporary discharge records in suitable watersheds. Contemporary discharge records exist for USGS gaging stations located along the Napa River near St. Helena and Napa, but the watersheds above these gages are large and contain significant groundwater abstraction, reservoir impoundments, and alluvial bodies. USGS gages on smaller watersheds in Napa County have been inactive since 1983 or earlier. Discharge records exist through Napa One Rain for several streams gaged by the Napa County Resource Conservation District (RCD) but the RCD has cautioned against use of these discharge records for calibration purposes due to incomplete rating curve development.

Estimates of groundwater recharge are also available from an earlier model prepared by Luhdorff and Scalmanini Engineers and MBK Engineers (LSCE 2013). This report provided estimates of average annual recharge as a percentage of average annual precipitation for nine watersheds in Napa County. Averaged across the same nine watersheds, the SWB model predicts significantly higher rates of recharge than the model prepared by LSCE, which predicts slightly lower AET but significantly more runoff (Table 4). Differences in methodology between these two models complicate direct comparisons. The LSCE model calculated infiltration into the soil as the difference between monthly precipitation and discharge volumes within each watershed. Discharge volumes were calculated from USGS stream gages and included both direct runoff and baseflow from groundwater. Inclusion of baseflow with direct runoff in these calculations may inappropriately reduce the estimated volume of water infiltrated into the soil and available for recharge.

Table 4: Comparison of results from SWB model and Luhdorff and Scalmanini model.

USGS Gage	HUC	Mean Precip, 2010 (in)	Mean AET, 2010 (% Precip)		Mean Runoff, 2010 (% Precip)		Mean Recharge, 2010 (% Precip)	
			SWB	LSCE	SWB	LSCE	SWB	LSCE
Conn Ck nr Oakville	11456500	34.8	59%	53%	21%	25%	21%	21%
Dry Ck nr Napa	11457000	41.5	56%	50%	18%	43%	25%	6%
Milliken Ck nr Napa	11458100	32.3	52%	41%	20%	51%	28%	8%
Napa Ck at Napa	11458300	36.6	61%	43%	16%	46%	23%	11%
Napa R nr Napa	11458000	39.5	56%	48%	20%	35%	24%	17%
Napa R nr St Helena	11456000	47.9	46%	45%	23%	42%	30%	14%
Redwood Ck nr Napa	11458200	39.6	53%	49%	26%	40%	22%	10%
Tulucay Ck nr Napa	11458300	27.0	64%	49%	16%	47%	20%	5%

Model Results

The principal elements of the annual water budget simulated with the Napa County SWB model for Water Years 2010 and 2014 are presented in map form in Figures 10 - 19 and in tabular form for 27 major watershed areas in Napa County (Tables 5 - 8). The watersheds are based on USGS HUC-12 watersheds and are named for the stream which comprises the largest proportion of the area; in many cases the areas consist of multiple tributary streams (Figure 20).

In Water Year 2010 (representing "average" hydrologic conditions) precipitation varied from 21.8 inches in the Ledgewood Creek watershed to 53.3 inches in the Saint Helena Creek watershed (Figure 10, Table 5). Actual evapotranspiration (AET) ranged from 13.4 inches in the Jackson Creek watershed to 25.2 inches in the Saint Helena Creek watershed (Figure 11). Surface runoff ranged from 3.4 inches in the Ledgewood Creek watershed to 13.5 inches in the Saint Helena Creek watershed (Figure 12). Recharge ranged from 3.3 inches in the Ledgewood Creek watershed to 14.4 inches in the Saint Helena watershed. (Figure 13). Small decreases in soil moisture storage (up to 1.8 inches) occurred in most watersheds, with changes in most watersheds being less than an inch (Figure 14). Note that the San Pablo Bay estuaries have been excluded from these comparisons.

Expressed as a percentage of the annual precipitation, AET ranged from 77% in the Ledgewood Creek watershed to 45% in the Jackson Creek watershed (Table 6). Surface runoff ranged from 15% of precipitation in the Ledgewood Creek watershed to 42% in the Jackson Creek watershed. Recharge ranged from 10% of the precipitation in the Jackson Creek watershed to 27% in the Saint Helena watershed.

In Water Year 2014 (representing “dry” hydrologic conditions during the second year of an extreme three-year drought) precipitation varied from 10.1 inches in the American Canyon Creek watershed to 32.2 inches in the Saint Helena Creek watershed (Figure 15, Table 7). Actual evapotranspiration (AET) ranged from 10.3 inches in the Jackson Creek watershed to 17.8 inches in the Saint Helena Creek watershed (Figure 16). Surface runoff ranged from 0.7 inches in the American Canyon Creek watershed to 13.2 inches in the Saint Helena Creek watershed (Figure 17). Recharge ranged from 0.6 inches in the Wragg Canyon watershed to 4.1 inches in the Saint Helena watershed. (Figure 18). Large decreases in soil moisture storage of between 2.3 and 4.3 inches were also simulated (Figure 19).

Expressed as a percentage of the annual precipitation, AET ranged from 55% in the Saint Helena Creek watershed to 121% in the Jackson Creek watershed (Table 8). These very large AET rates caused significant decreases in soil moisture. Decreases in soil moisture ranged from 9% of precipitation in the Saint Helena watershed to 36% in the American Canyon Creek watershed. Surface runoff ranged from 7% of precipitation in the American Canyon Creek watershed to 41% in the Saint Helena Watershed. Recharge ranged from 18% in the Milliken Creek Watershed to 5% in the Jackson Creek and Wragg Canyon watersheds.

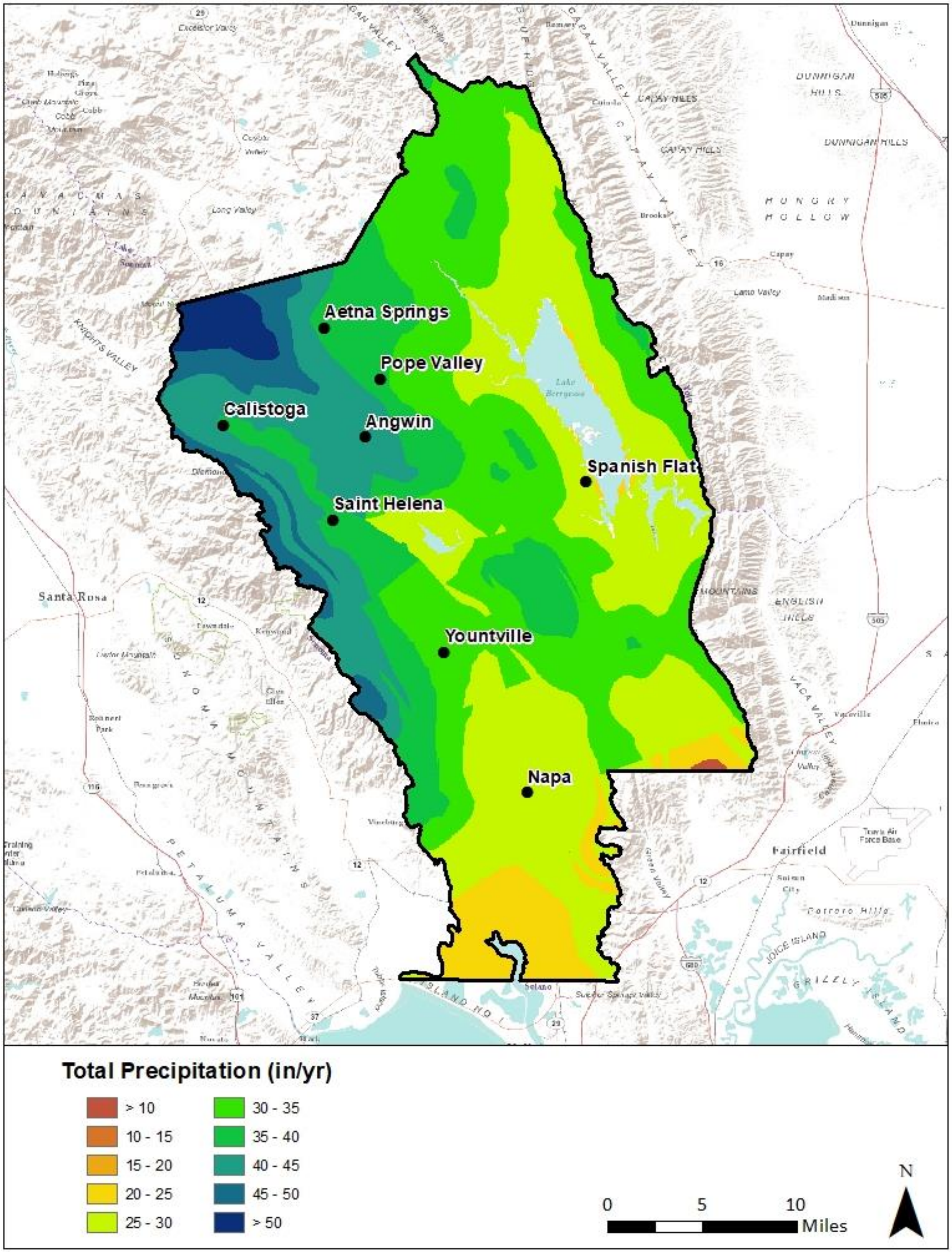


Figure 10: Water Year 2010 precipitation simulated with the Napa County SWB model.

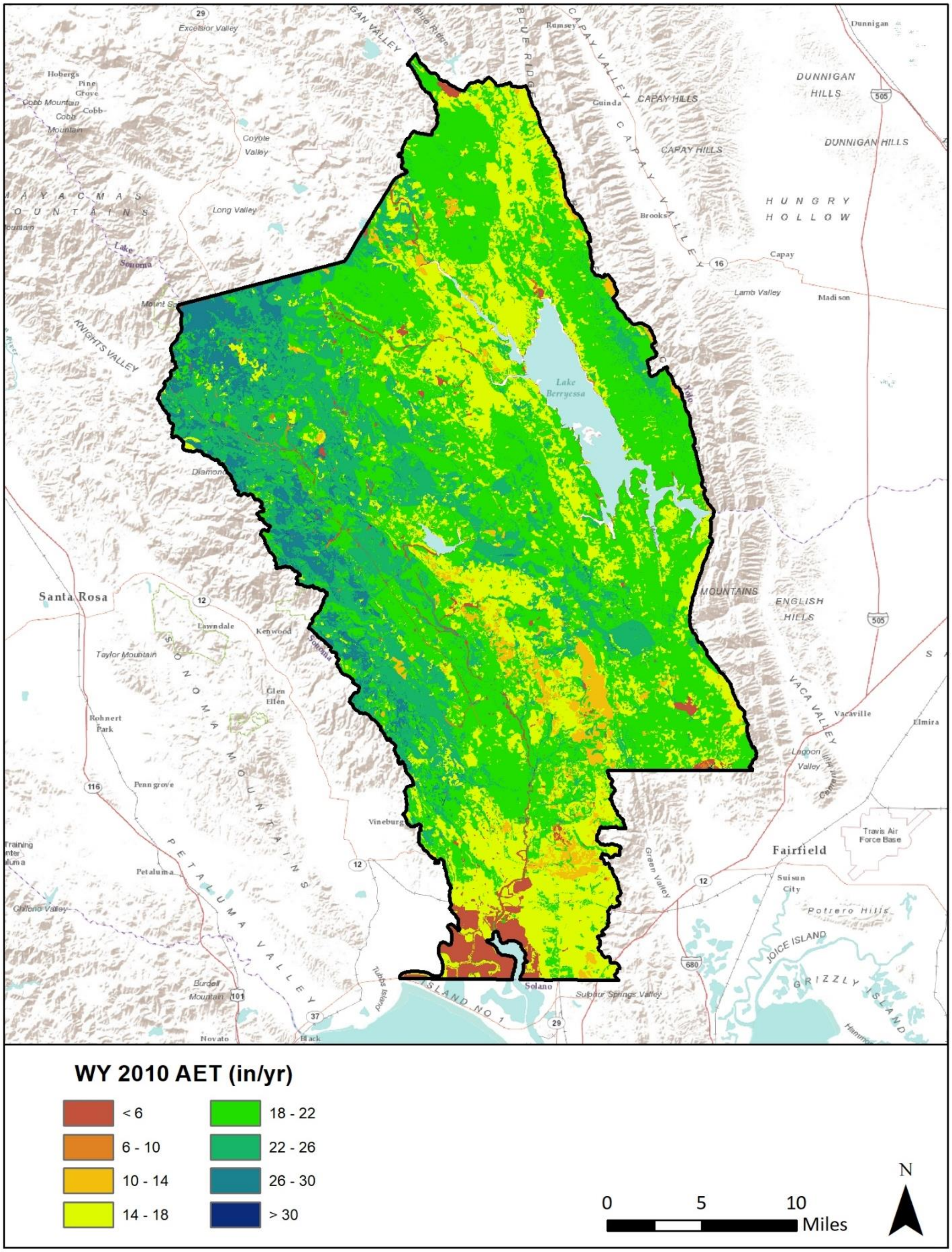


Figure 11: Water Year 2010 AET simulated with the Napa County SWB model.

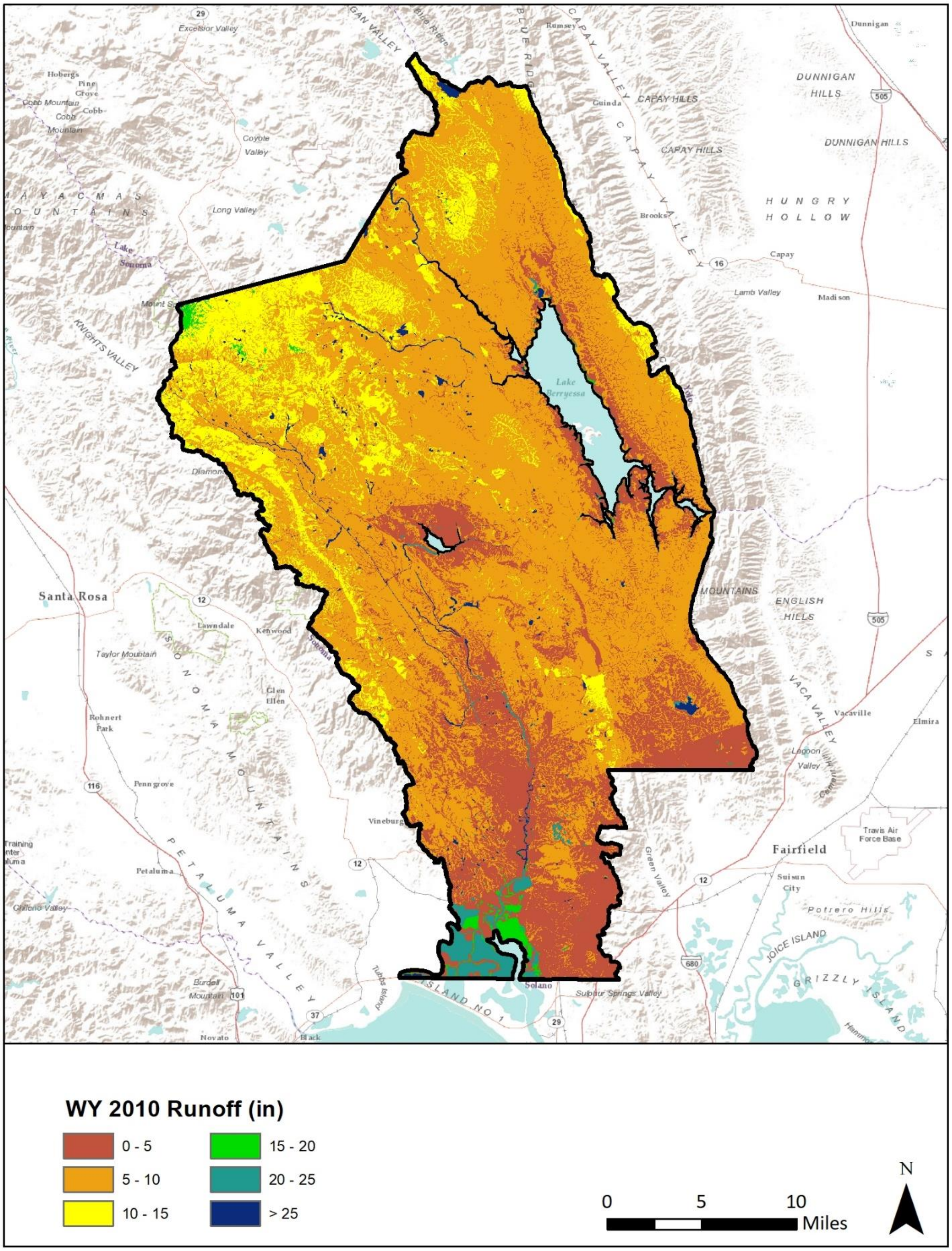


Figure 12: Water Year 2010 runoff simulated with the Napa County SWB model.

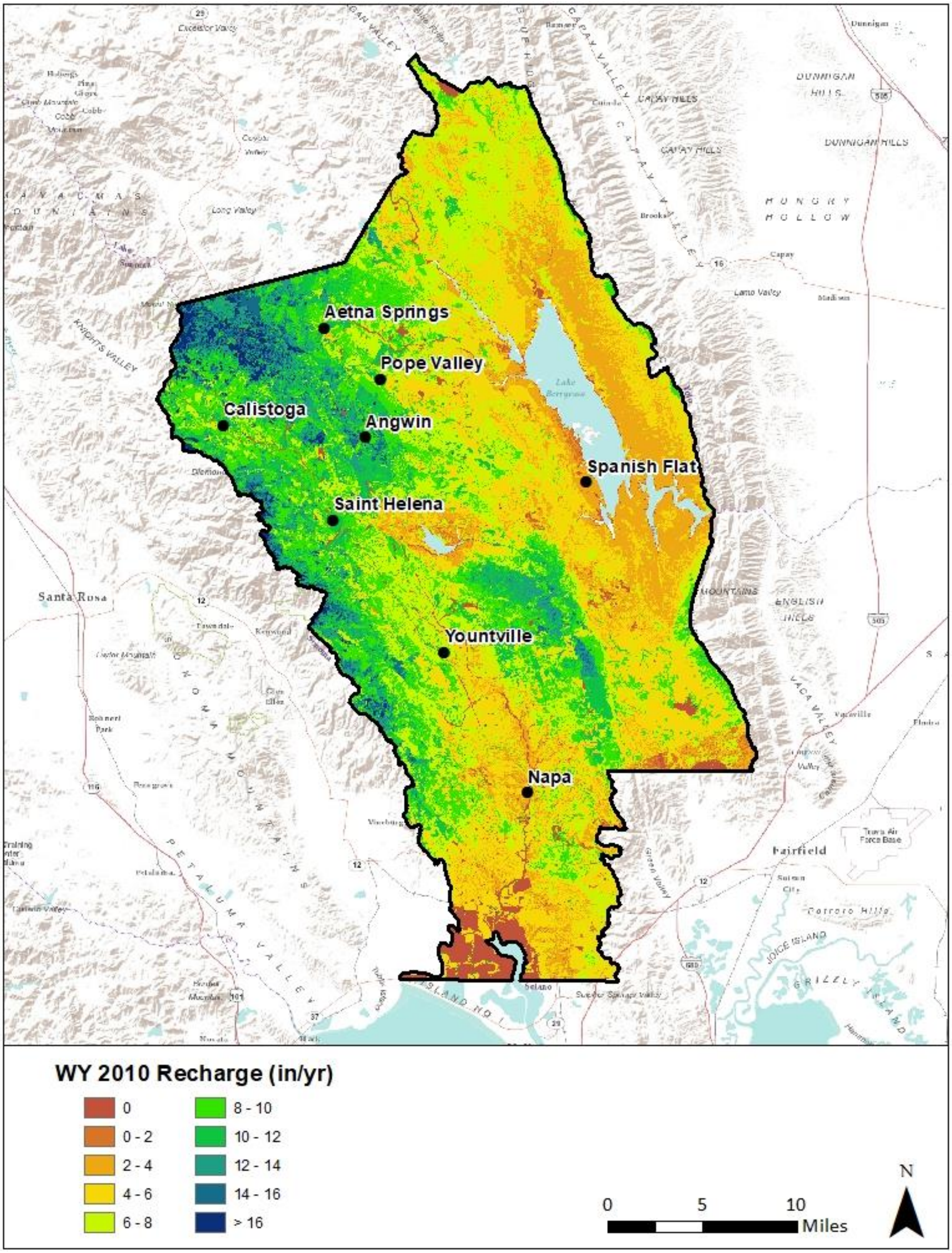


Figure 13: Water Year 2010 recharge simulated with the Napa County SWB model.

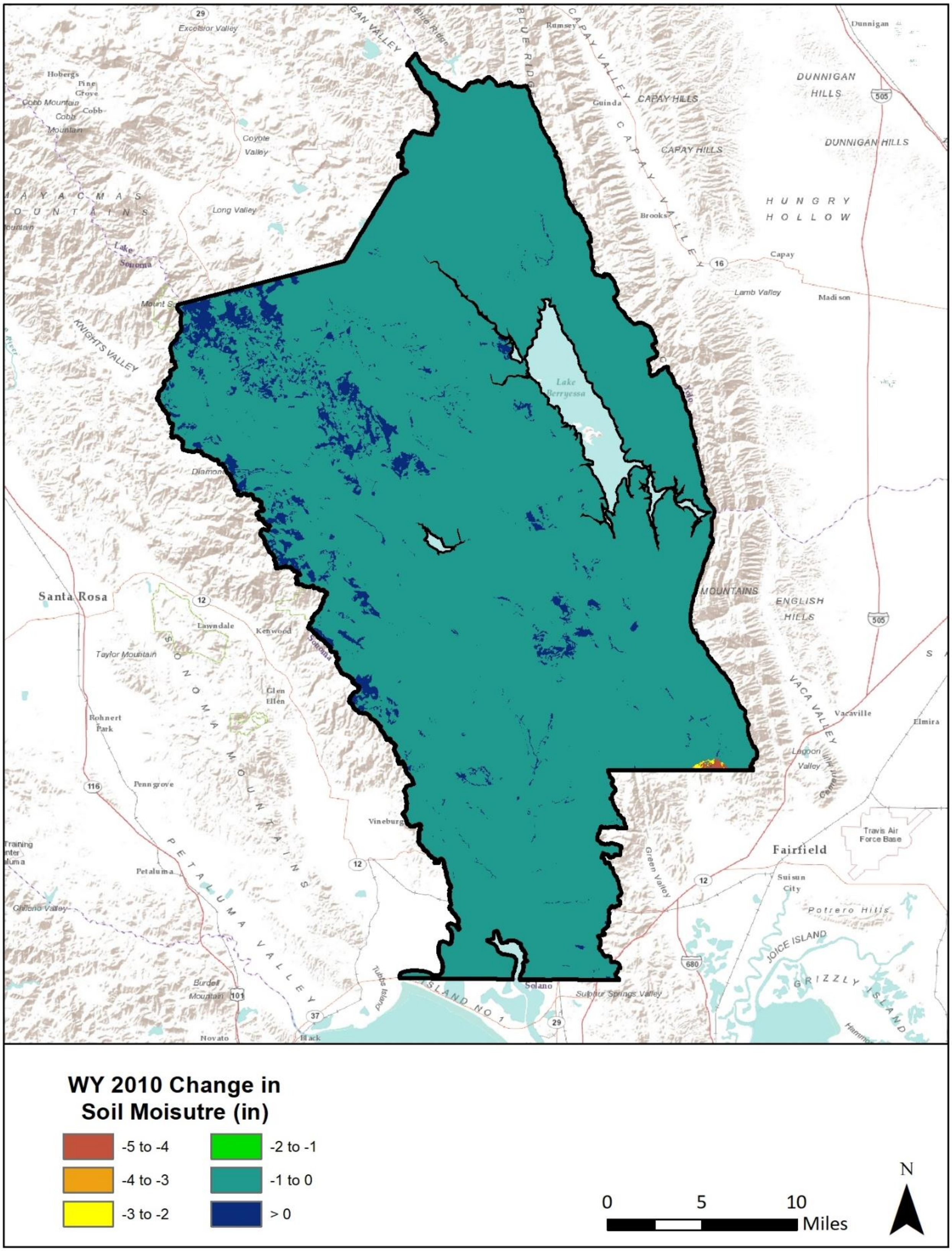


Figure 14: Water Year 2010 change in soil moisture content simulated with the Napa County SWB model.

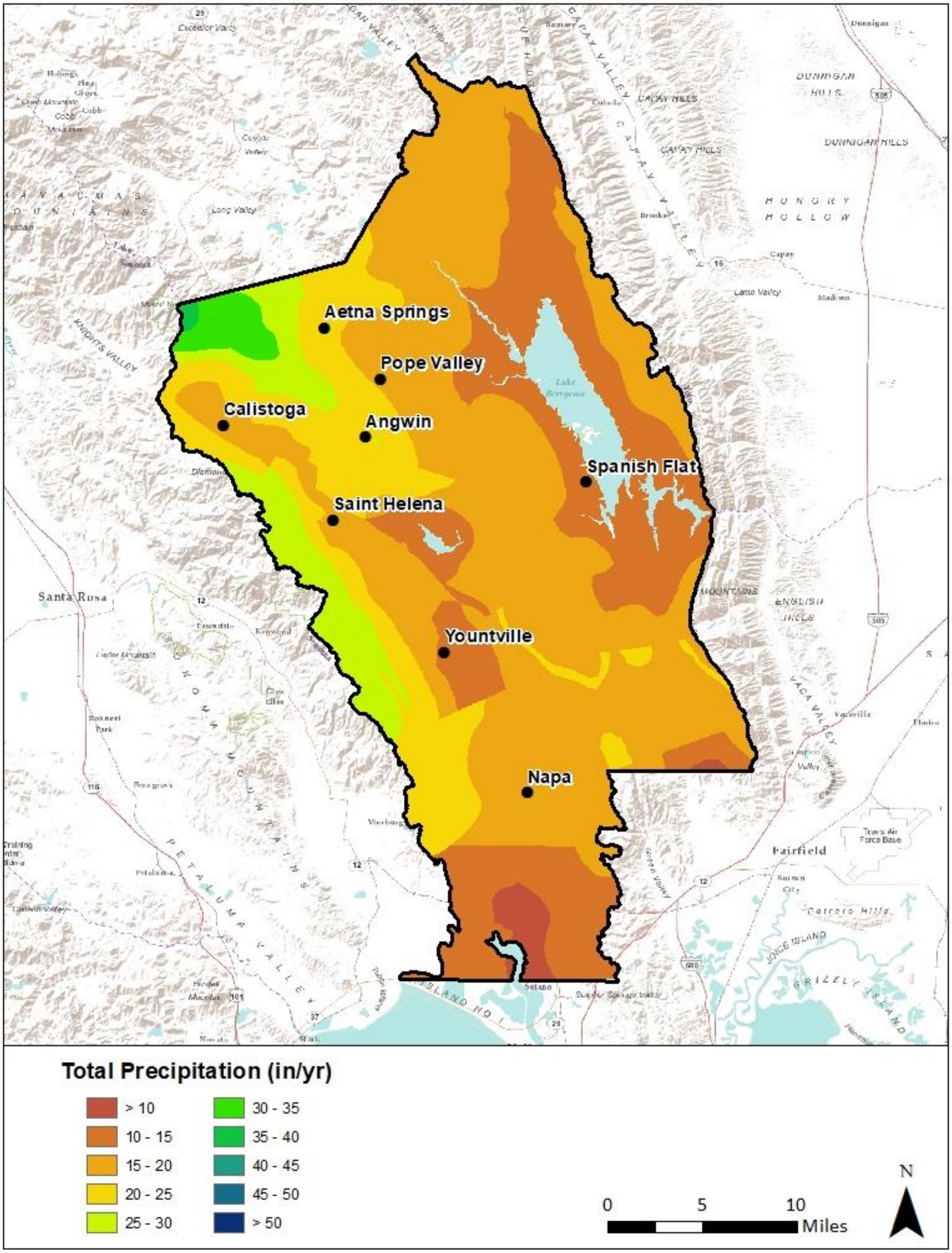


Figure 15: Water Year 2014 precipitation simulated with the Napa County SWB model.

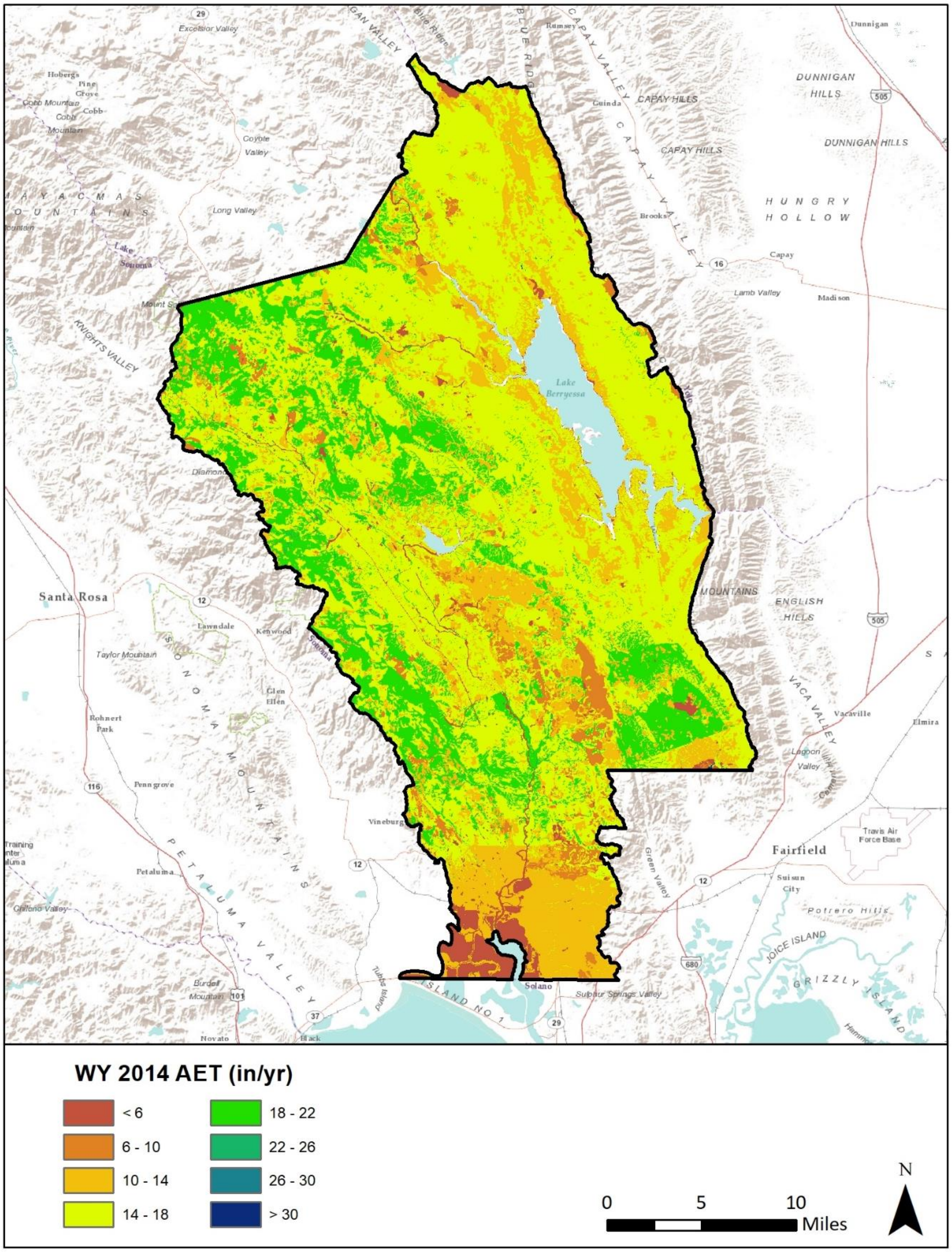


Figure 16: Water Year 2014 AET simulated with the Napa County SWB model.

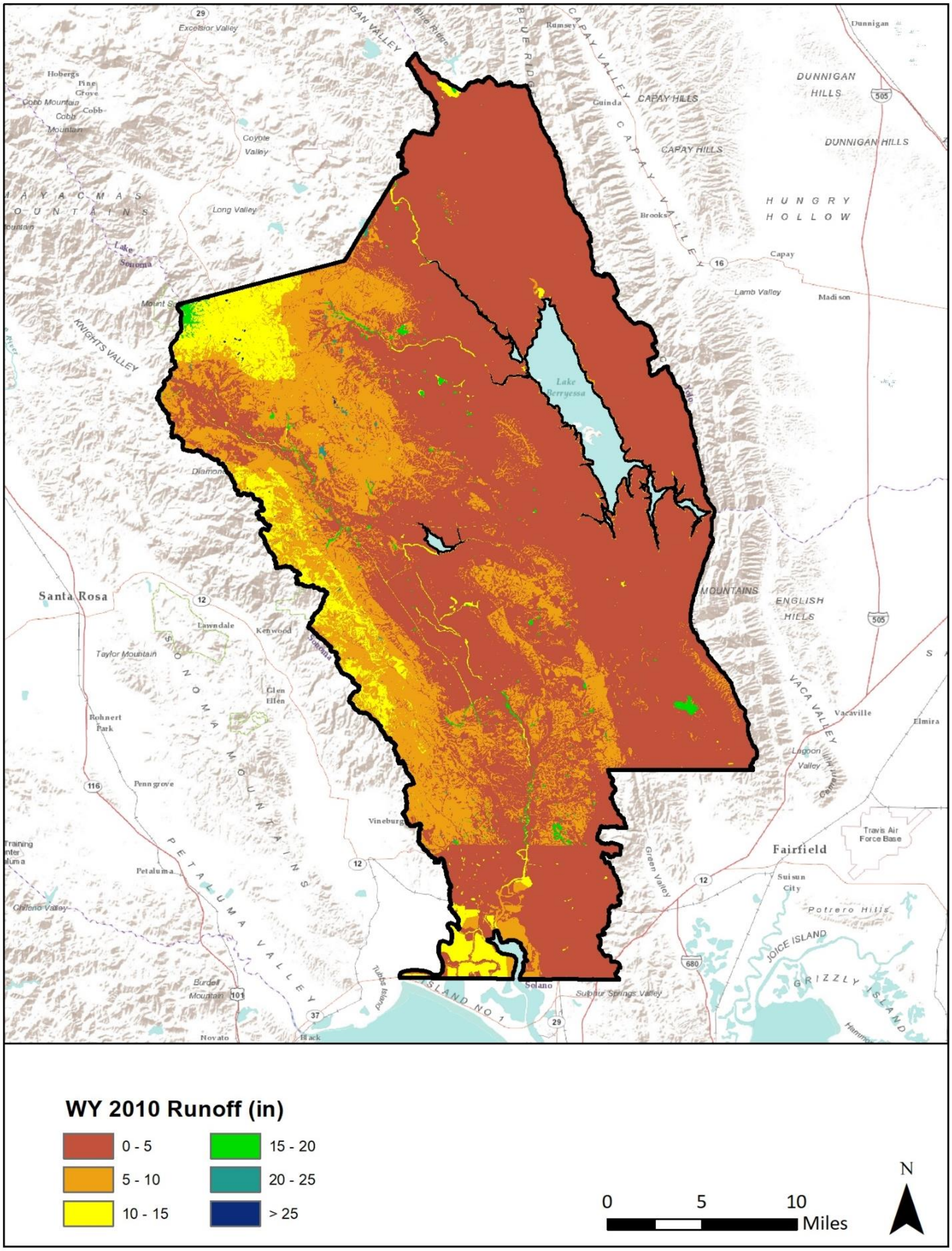


Figure 17: Water Year 2014 recharge simulated with the Napa County SWB model.

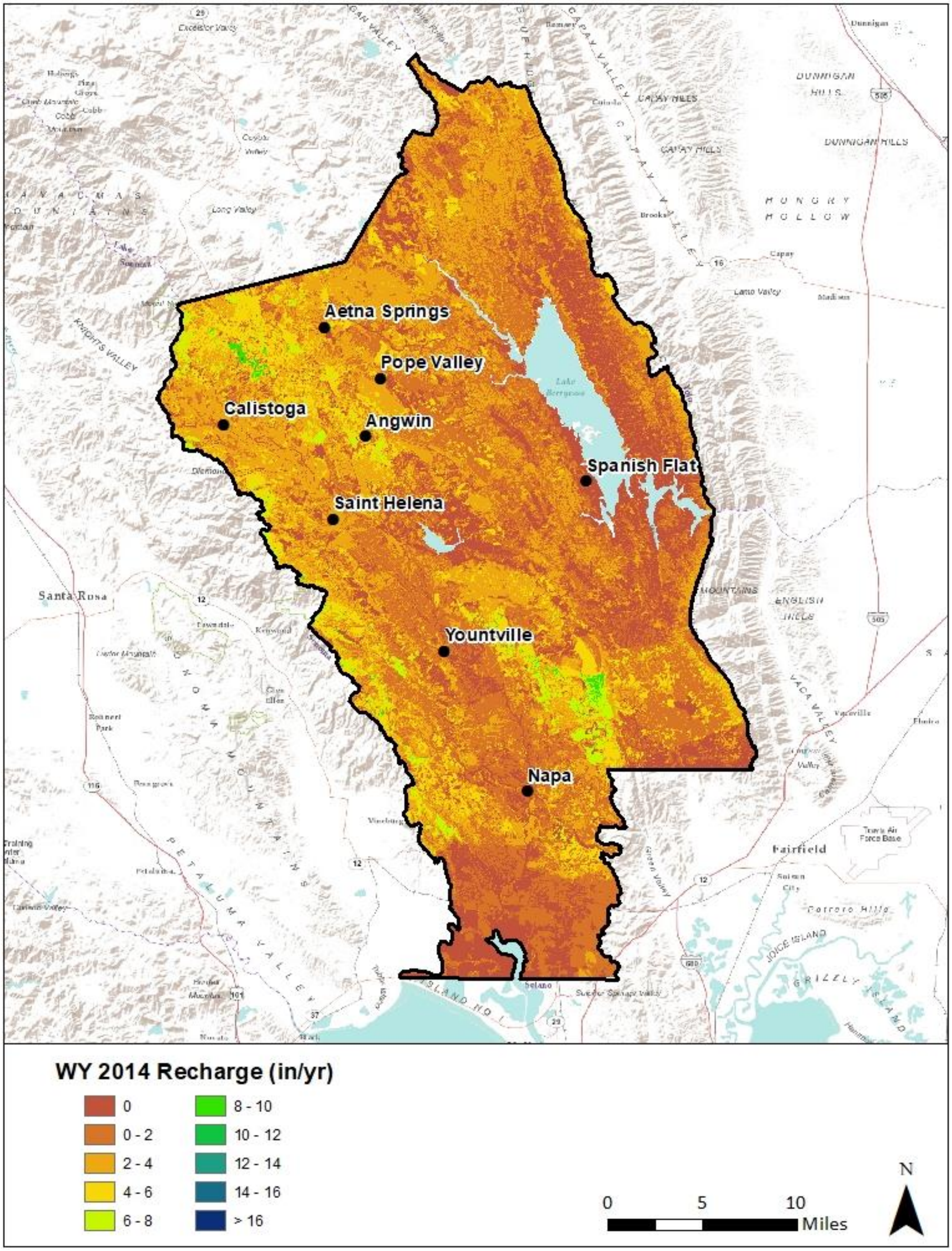


Figure 18: Water Year 2014 recharge simulated with the Napa County SWB model.

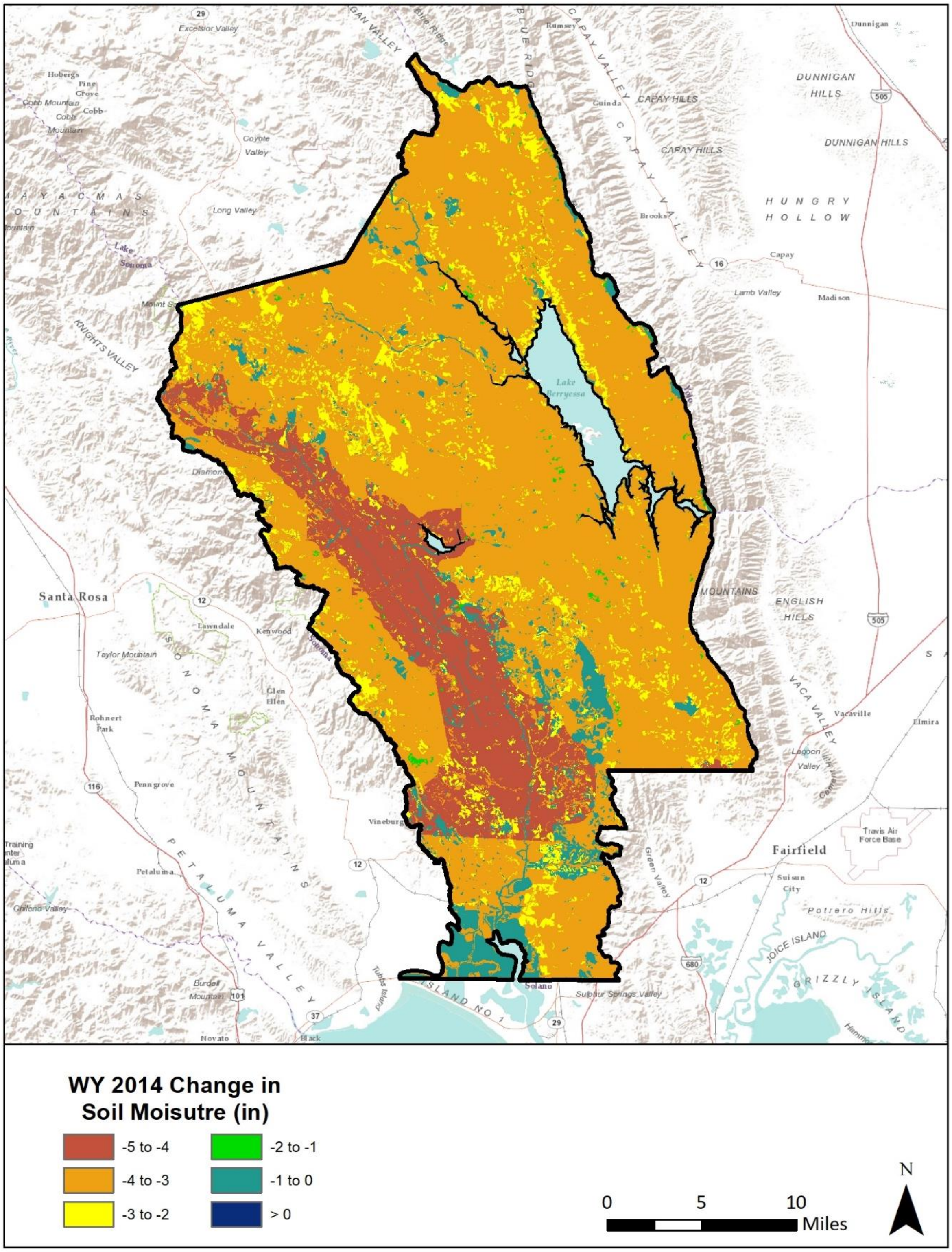


Figure 19: Water Year 2014 change in soil moisture content simulated with the Napa County SWB model.

Table 5: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for Water Year 2010 expressed as depths. See Figure 20 for watershed locations.

Name	Drainage Area (mi^2)	Precipitation (in)	AET (in)	Surface Runoff (in)	Recharge (in)	Soil Moisture Change (in)
American Canyon Creek	10.8	24.1	16.3	3.7	4.7	-0.6
Bucksnort Creek	1.9	47.9	24.5	12.1	11.1	0.1
Butts Creek-Putah Creek	49.9	33.0	17.4	9.7	6.2	-0.7
Capell Creek	43.0	31.1	19.1	7.4	5.0	-0.6
Carneros Creek	29.7	28.0	18.6	5.2	5.5	-0.6
Chiles Creek	32.0	34.6	21.1	7.1	6.8	-0.5
Dry Creek	28.8	37.0	22.2	7.2	8.4	-0.5
Hunting Creek	12.0	33.7	19.0	9.7	5.7	-0.8
Jackson Creek-Putah Creek	54.5	29.9	13.4	12.6	3.0	-0.5
Lake Curry-Suisun Creek	16.4	30.7	18.9	6.5	5.9	-0.6
Lake Hennessey-Conn Creek	20.0	35.1	19.6	8.5	7.3	-0.4
Ledgewood Creek	6.4	21.8	16.9	3.4	3.3	-1.8
Lower Eticuera Creek	44.0	30.0	17.7	8.1	4.7	-0.7
Lower Napa River	45.0	31.7	19.9	5.6	6.7	-0.6
Lower Pope Creek	31.8	33.9	18.0	9.7	6.5	-0.6
Maxwell Creek	35.1	34.7	19.6	8.7	6.9	-0.6
Middle Napa River	60.3	39.9	22.8	8.5	9.2	-0.5
Milliken Creek	29.7	30.9	16.9	6.6	7.9	-0.6
Rector Creek-Conn Creek	22.3	32.8	18.0	7.1	8.2	-0.7
Saint Helena Creek	7.7	53.3	25.2	13.5	14.4	0.1
San Pablo Bay Estuaries	19.5	23.9	8.1	13.8	2.3	-0.3
Tulucay Creek	34.2	26.1	16.7	4.6	5.4	-0.7
Upper Eticuera Creek	25.6	31.2	17.2	8.6	6.1	-0.8
Upper Napa River	44.6	44.7	23.6	10.6	10.8	-0.4
Upper Pope Creek	21.7	44.5	22.7	10.5	11.5	-0.3
Wooden Valley & Suisun Creeks	23.3	29.0	19.0	5.1	5.5	-0.6
Wragg Canyon-Putah Creek	34.2	28.3	16.3	8.6	3.3	-0.6

Table 6: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for Water Year 2010 expressed as a percentage of precipitation. See Figure 20 for watershed locations.

Name	Drainage Area (mi^2)	Precipitation (in)	AET (%)	Surface Runoff (%)	Recharge (%)	Soil Moisture Change (%)
American Canyon Creek	10.8	24.1	67%	15%	19%	-3%
Bucksnort Creek	1.9	47.9	51%	25%	23%	0%
Butts Creek-Putah Creek	49.9	33.0	53%	29%	19%	-2%
Capell Creek	43.0	31.2	61%	24%	16%	-2%
Carneros Creek	29.7	29.7	66%	19%	20%	-2%
Chiles Creek	32.0	34.6	61%	21%	20%	-1%
Dry Creek	28.8	37.8	60%	20%	23%	-1%
Hunting Creek	12.0	33.7	56%	29%	17%	-2%
Jackson Creek-Putah Creek	54.5	29.7	45%	42%	10%	-2%
Lake Curry-Suisun Creek	16.4	30.7	61%	21%	19%	-2%
Lake Hennessey-Conn Creek	20.0	36.0	56%	24%	21%	-1%
Ledgewood Creek	6.4	21.8	77%	15%	15%	-8%
Lower Eticuera Creek	44.0	30.0	59%	27%	16%	-2%
Lower Napa River	45.0	31.7	63%	18%	21%	-2%
Lower Pope Creek	31.8	33.9	53%	29%	19%	-2%
Maxwell Creek	35.1	34.7	56%	25%	20%	-2%
Middle Napa River	60.3	40.4	57%	21%	23%	-1%
Milliken Creek	29.7	30.9	55%	21%	26%	-2%
Rector Creek-Conn Creek	22.3	32.8	55%	22%	25%	-2%
Saint Helena Creek	7.7	53.3	47%	25%	27%	0%
San Pablo Bay Estuaries	19.5	23.9	34%	58%	10%	-1%
Tulucay Creek	34.2	26.1	64%	18%	21%	-3%
Upper Eticuera Creek	25.6	31.2	55%	28%	19%	-3%
Upper Napa River	44.6	44.7	53%	24%	24%	-1%
Upper Pope Creek	21.7	44.5	51%	23%	26%	-1%
Wooden Valley & Suisun Creeks	23.3	29.0	65%	18%	19%	-2%
Wragg Canyon-Putah Creek	34.2	28.3	58%	31%	12%	-2%

Table 7: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for Water Year 2014 expressed as depths. See Figure 20 for watershed locations.

Name	Drainage Area (mi^2)	Precipitation (in)	AET (in)	Surface Runoff (in)	Recharge (in)	Soil Moisture Change (in)
American Canyon Creek	10.8	10.1	12.3	0.7	0.7	-3.6
Bucksnort Creek	1.9	28.8	17.6	11.5	2.6	-3.0
Butts Creek-Putah Creek	49.9	16.9	14.2	3.9	1.9	-3.2
Capell Creek	43.0	15.8	14.8	3.1	1.1	-3.1
Carneros Creek	29.7	15.0	14.7	4.6	2.0	-3.7
Chiles Creek	32.0	18.3	16.5	3.7	1.5	-3.3
Dry Creek	28.8	21.5	16.5	6.8	2.5	-3.7
Hunting Creek	12.0	16.7	15.4	3.1	1.6	-3.4
Jackson Creek-Putah Creek	54.5	14.9	10.3	6.1	0.7	-2.3
Lake Curry-Suisun Creek	16.4	18.4	16.1	3.7	1.9	-3.4
Lake Hennessey-Conn Creek	20.0	19.1	14.8	5.7	2.2	-3.2
Ledgewood Creek	6.4	12.2	13.9	1.7	0.8	-4.3
Lower Eticuera Creek	44.0	14.9	14.0	2.6	1.3	-3.1
Lower Napa River	45.0	19.4	15.9	5.0	2.2	-3.6
Lower Pope Creek	31.8	17.8	14.5	4.5	2.0	-3.2
Maxwell Creek	35.1	18.3	15.9	3.8	2.0	-3.3
Middle Napa River	60.3	21.3	16.5	6.6	2.5	-3.7
Milliken Creek	29.7	18.7	13.7	4.5	3.4	-2.9
Rector Creek-Conn Creek	22.3	16.5	13.6	4.0	2.3	-3.4
Saint Helena Creek	7.7	32.2	17.8	13.2	4.1	-3.0
San Pablo Bay Estuaries	19.5	10.4	6.0	5.6	0.5	-1.6
Tulucay Creek	34.2	14.6	13.5	2.6	1.7	-3.3
Upper Eticuera Creek	25.6	15.5	14.1	2.5	2.1	-3.2
Upper Napa River	44.6	22.9	16.2	6.9	3.3	-3.5
Upper Pope Creek	21.7	25.6	16.8	8.5	3.5	-3.2
Wooden Valley & Suisun Creeks	23.3	17.9	16.4	3.1	2.0	-3.5
Wragg Canyon-Putah Creek	34.2	14.1	12.6	3.6	0.6	-2.8

Table 8: Simulated precipitation and recharge values averaged across HUC-12 watersheds in Napa County for Water Year 2014 expressed as a percentage of precipitation. See Figure 20 for watershed locations.

Name	Drainage Area (mi^2)	Precipitation (in)	AET (%)	Surface Runoff (%)	Recharge (%)	Soil Moisture Change (%)
American Canyon Creek	10.8	10.1	121%	7%	7%	-36%
Bucksnort Creek	1.9	28.8	61%	40%	9%	-10%
Butts Creek-Putah Creek	49.9	16.8	84%	23%	11%	-19%
Capell Creek	43.0	15.8	94%	20%	7%	-20%
Carneros Creek	29.7	17.6	98%	30%	13%	-25%
Chiles Creek	32.0	18.4	90%	20%	8%	-18%
Dry Creek	28.8	22.1	77%	32%	12%	-17%
Hunting Creek	12.0	16.7	92%	18%	10%	-20%
Jackson Creek-Putah Creek	54.5	14.7	69%	41%	5%	-16%
Lake Curry-Suisun Creek	16.4	18.4	88%	20%	10%	-19%
Lake Hennessey-Conn Creek	20.0	19.6	78%	30%	12%	-17%
Ledgewood Creek	6.4	12.2	114%	14%	7%	-35%
Lower Eticuera Creek	44.0	14.9	94%	18%	9%	-21%
Lower Napa River	45.0	19.4	82%	26%	11%	-19%
Lower Pope Creek	31.8	17.8	81%	25%	11%	-18%
Maxwell Creek	35.1	18.3	87%	21%	11%	-18%
Middle Napa River	60.3	21.8	77%	31%	12%	-18%
Milliken Creek	29.7	18.7	74%	24%	18%	-16%
Rector Creek-Conn Creek	22.3	16.5	83%	24%	14%	-21%
Saint Helena Creek	7.7	32.2	55%	41%	13%	-9%
San Pablo Bay Estuaries	19.5	10.4	58%	53%	4%	-16%
Tulucay Creek	34.2	14.6	93%	18%	12%	-23%
Upper Eticuera Creek	25.6	15.5	91%	16%	14%	-21%
Upper Napa River	44.6	22.9	71%	30%	14%	-15%
Upper Pope Creek	21.7	25.6	66%	33%	14%	-12%
Wooden Valley & Suisun Creeks	23.3	17.9	91%	17%	11%	-20%
Wragg Canyon-Putah Creek	34.2	14.1	90%	26%	5%	-20%

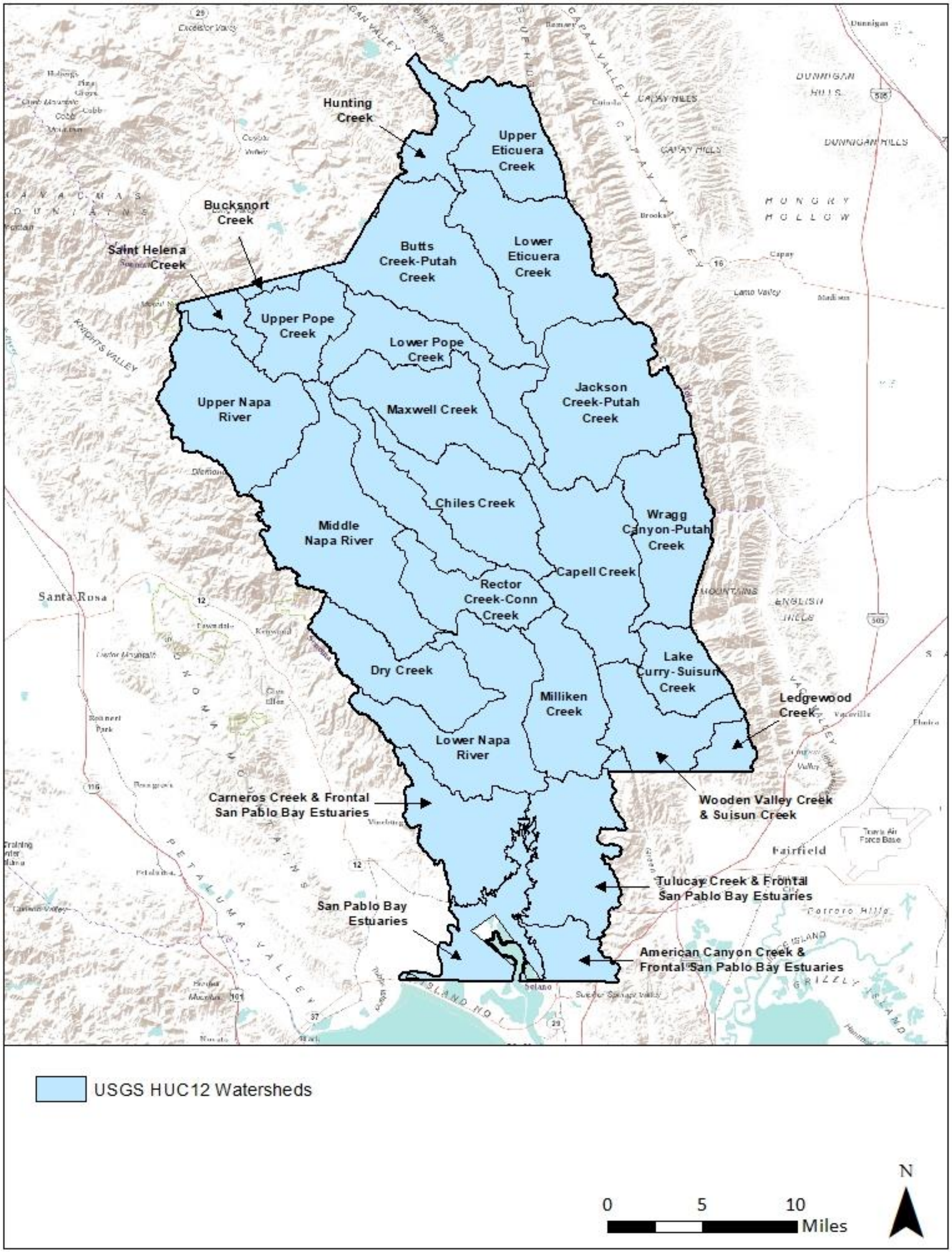


Figure 20: Major watersheds areas used to summarize water budget information in Tables 5 - 8.

Discussion and Conclusion

Numerous previous modeling studies have estimated water budget components in several larger watershed areas in Sonoma and Napa Counties including the Santa Rosa Plain, the Green Valley and Dutch Bill Creek watersheds, and the Sonoma Valley (Farrar et. al., 2006; Kobor and O'Connor, 2016; Woolfenden and Hevesi, 2014). Comparisons to these water budgets are useful for evaluating the SWB results, but one would not expect precise agreement owing to significant variations in climate, land cover, soil types, underlying hydrogeologic conditions, and different spatial scales of modeling studies. These regional analyses estimate that average annual recharge varies from 7% to 19% of the annual precipitation. The equivalent county-wide value from this study is slightly higher at 20%.

Water budgets for the Napa River and selected sub-basins were also estimated in a previous study by Luhdorff and Scalmanini Engineers and MBK Engineers (LSCE 2013). The LSCE study estimated that, as a percentage of annual precipitation, AET comprised slightly less, runoff significantly more, and recharge substantially less of the typical annual water budget. LSCE (2013) calculated infiltration of precipitation based on the difference between total monthly streamflow at selected gaging stations and total monthly precipitation for the gages' drainage area. Streamflow volumes include both direct runoff (overland flow and interflow) and baseflow from groundwater. <u>Inclusion of baseflow with direct runoff in these calculations may inappropriately reduce the estimated volume of water infiltrated into the soil and available for recharge; the LSCE approach therefore tends to underestimate groundwater recharge</u>. Additionally, many of the gauging stations used for the analysis are located in reaches that may be significantly influenced by upstream reservoir releases, surface water diversions, groundwater abstraction, and/or surface water groundwater exchanges, further complicating the interpretation of the LSCE (2013) runoff rates and the interrelated calculations of AET and recharge rates. In contrast, the SWB model presented here is based on calibrated parameter values developed for a similar model in Sonoma County which was calibrated to gauges specifically selected to minimize the effects of reservoir releases, water use, or significant surface water/groundwater interaction, and after separating and removing the baseflow component of streamflow.

The recharge estimates presented here arguably represent the best available county-wide estimates produced at a fine spatial resolution using a consistent and objective data-driven approach. This analysis focused on two Water Years, 2010 and 2014, which represent average and drought conditions respectively. Input parameters were determined based on literature values and values calibrated through prior modeling experience in Sonoma County.

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