

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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April 2023 (PBES Review Draft) Revised March 2025





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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.



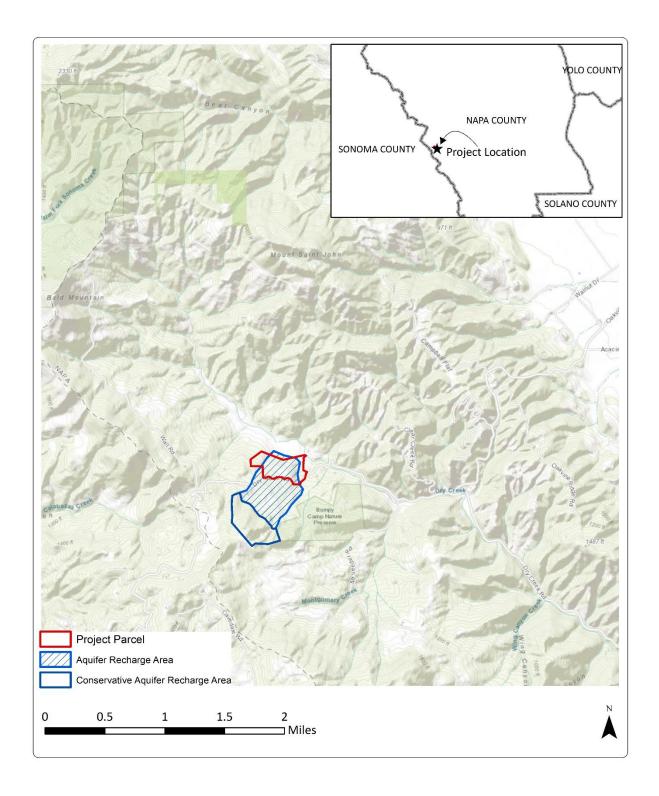


Figure 1: Project location map.



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).



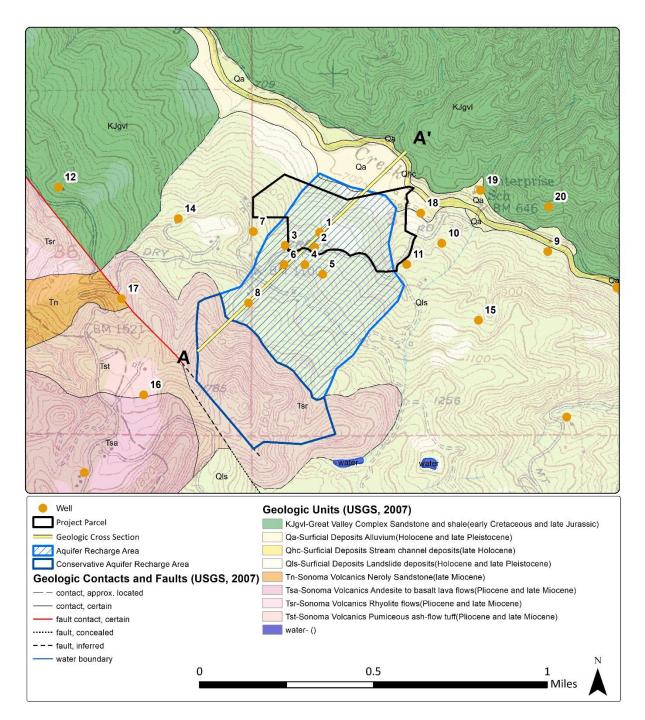


Figure 2: Surficial geology and locations of wells in the vicinity of the project parcel. Surficial geology based on data from the Geologic Map and Map Database of Eastern Sonoma and Western Sonoma Counties, California (Graymer et al., 2007).



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

Table 1: Well completion details for wells in the vicinity of the project	t parcel.
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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	2004
Static Water Level (ft)	85	56	20	200
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.

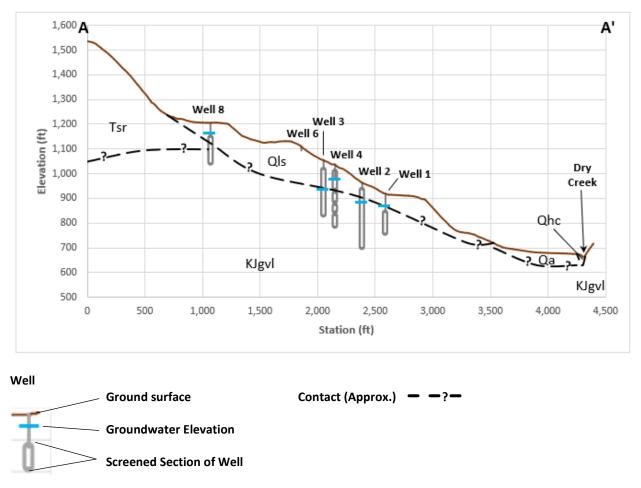


Figure 3: Hydrogeologic cross section A -A' through the project parcel (see Figure 2 for location and geologic map units).

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 mi² 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 QIs 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 acreft/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).



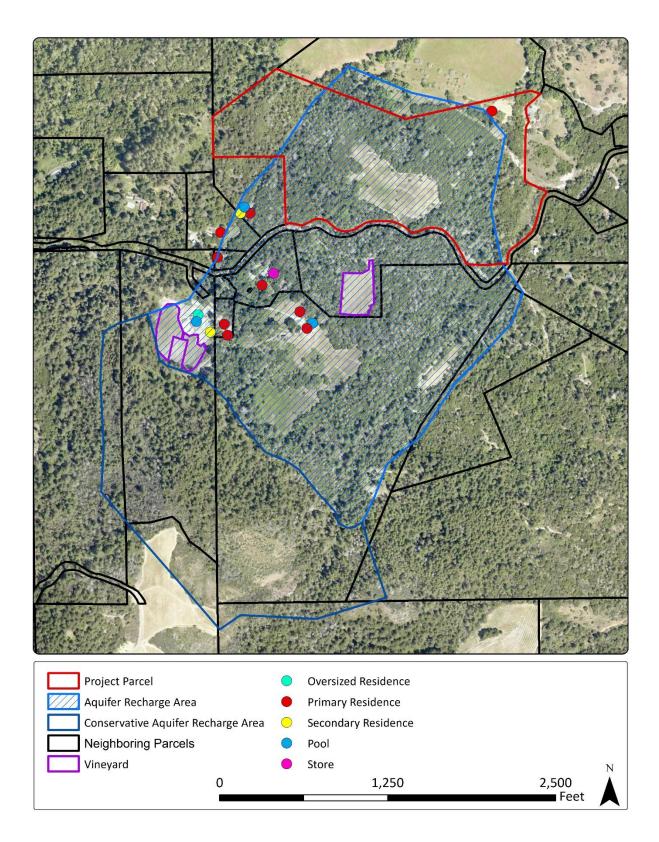


Figure 4: Existing water uses identified within the project recharge area.



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.

	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 2: Estimated groundwater use within the project recharge area in the proposed and existi	ng conditions.
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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



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

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.



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 and AET averaged 18.1 inches. Simulated groundwater recharge varied from near zero to 8.1 inches across the recharge area, with a spatial overage area, with a spatial average of 9.9 inches. Simulated groundwater 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 overage 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).



	2010 Normal Year		2014 D	ry 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%	-	-
∆ Soil Moisture	-0.4	-1%	-3.5	-14%	-	-
Recharge	9.9	23%	3.1	12%	6.3	18%

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

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. 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).

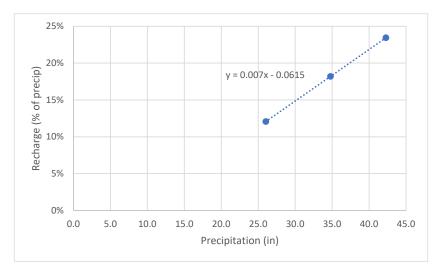


Figure 5: Relationship between precipitation and percent of precipitation as recharge for the larger project recharge area.

<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 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).

	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%	-	-
∆ Soil Moisture	-0.4	-1%	-3.8	-14%	-	-
Recharge	9.7	23%	3.1	12%	6.1	17%

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

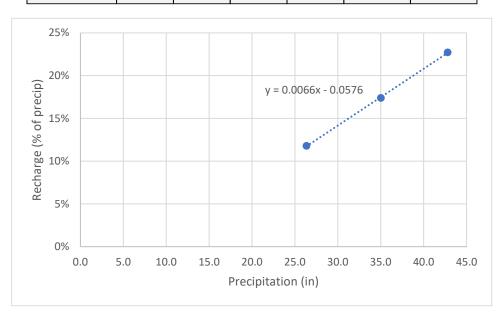


Figure 6: Relationship between precipitation and percent of precipitation as recharge for the conservation recharge area.

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. 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 recharge for the period 2012-2021 is estimated to be 13.0 acre-ft/yr (6.3 in/yr per Table 6 x 124)

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 mi²) 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.

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

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



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.

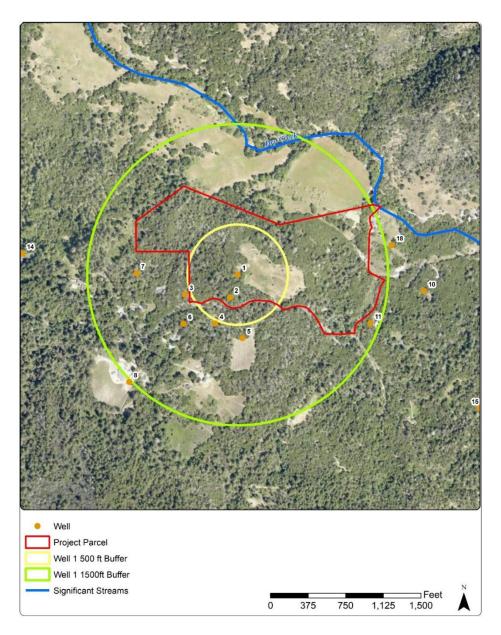


Figure 7: Well 1 surrounded by 500ft and 1500ft buffers with neighboring wells and significant streams.



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.

r		nan 10 gpm)), constructe	d in unconsoli		w capacity pumping ne upper part of the	
	Aquifer Hydraulic Conductivity	•	ble Distance e Water Cha		Minimum Surface Seal Depth (feet)	Depth of Uppermost Perforations	
	(ft/day)	500 feet	1000 feet	1500 feet	Depth (leet)	(feet)	
	80	1			50	100	
	50	1			50	100	
	30	1			50	100	
	0.5	1			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





-

E 26.00508 Well WL

State of California Well Completion Report Form DWR 188 Submitted 12/7/2020 WCR2020-016805

Owner's Well Nur	nber 1 Date V	Work Began 11/25/2020 Date Work Ended 12/04/2020
Local Permit Age	ncy Napa County Planning Building and Environme	ental Services
Secondary Permi	t Agency Per	ermit Number E20-00508 Permit Date 11/04/2020
Well Owner	r (must remain confidential pursuant	t to Water Code 13752) Planned Use and Activity
Name		Activity New Well
Mailing Address		Planned Use Water Supply Domestic
City March	State	e Ca Zip 94025
	V	Well Location
Address 620	t Dry Creek RD	APN 027-530-006
City Napa	Zip 94558 Co	ounty Napa Township 06 N
Latitude 38	 22 4 N Longitude -122	2 24 24 W Range 05 W
Deg.	Min, Sec. Deg.	Min. Sec. Departies Mariet Dishla
_	•	2.4066667 Baseline Meridian Mount Diablo
Vertical Datum	čili i i i i i i i i i i i i i i i i i	NGS84 Elevation Accuracy
Location Accura		
	Borehole Information	Water Level and Yield of Completed Well
Orientation Ve	entical Specify	Depth to first water 90 (Feet below surface)
Drilling Method	Direct Rotary Drilling Fluid Air	Depth to Static Water Level 48 (Feet) Date Measured 12/04/2020
		Estimated Yield* 25 (GPM) Test Type Air Lift
Total Depth of B	oring 400 Feet	Test Length 2 (Hours) Total Drawdown (feet)
Total Depth of C	ompleted Well 178 Feet	*May not be representative of a well's long term yield.
	Geolog	gic Log - Free Form
Depth from	1	
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	

<u> </u>	•	
249	310	95% shale / 5% sandstone
310	340	80% shale / 20% sandstone
340	400	shale & clay

					Casing	S				
Casing #		m Surface o Feet	Casing Ty	pe Material	Casings Specificatons	Wall Thickness (inches)	Outside Diameter (inches)	Screen Type	Slot Size if any (inches)	Description
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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	PVC OD: 5.563 in. SDR: 0.2 21 Thickness: 0.265 in.		0.265 5.563			
					Annular Ma	terial				
Śur	n from face to Feet	Fill		Fill	Type Details		Filter Pack	Size		Description
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3	52	Bento	nite Oth	er Bentonite					grout	
52	400	Other	Fill See	description.	-				pea gravel	

Other Observations:

	E	Borehole Specifications	Certification Statement						
Depth Surf	ace	Borehole Diameter (inches)	I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief Name HUCKFELDT WELL DRILLING INC						
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		400 9		Address		City	State	Zip	
						12/07/2020 Date Signed	439746 C-57 License Number		
				D	VR Use	Only			
			CSG #	State Well Number	S	te Code	Local W	eli Numbe	
				titude Deg/Min/Sec	N	Longitude	Deg/Mi	W n/Sec	
			TRS:						

APN:

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l I	1									iiiiiii		Y CHATEAU	POTELLE		VA5	INJECTION
										•	SO U	TL1 .				SPARGING
	· · · · · · · · · · · · · · · · · · ·	 								Illustrate or Describ Fences, Rivers, etc.	e Distance o	f Well from H	oads, Build	lings,	 ,	REMEDIATION OTHER (SPECIFY)
									<u> </u>	necessary. PLEASE	BE ACCUI	ATE & COL	WPLETE.	<i></i> 9	·	
· · · · · · · · · · · · · · · · · · ·	······									WATI	SR LEVE	L & YIEL	D OF C	OMPL	ETED	WELL
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						•				DEPTH OF STATIC WATER LEVEL	<u>, 60</u>	(Ft.) & D/	TE MEASL	JRED _	10/4/	/05
1	, ī			<u> </u>			i			ESTIMATED YIELD		[(GPM)	& TEST TY	/PE	air	
TOTAL DE		•		210 (F	eet)	210 -				TEST LENGTH		TOTAL DR)(Ft.)	
TOTAL DE	FIH OF	COMPLET	ED WI	<u> </u>		210 (Feet))			* May not be rep	resentative	of a well's	iong-term	yield.		
DEPT	пн	BORE-		••			CASING ((S)				DEPTH		ANN		MATERIAL
FROM SU	RFACE	BORE- HOLE DIA.		E(<u>≺)</u>	┨	IATERIAL /	INTERNA	u .	GAUGE	SLOT SIZE	FROM	SURFACE	E CE-	BEN-	TY	<u>'PE</u>
Ft. to	Ft.	(Inches)	BLANK	DUCTOR FILL PIPE	″	GRADE	DIAMETE (inches)	9R O	OR WALL	IF ANY	Ft	to Ft.	MENT	TONITE		FILTER PACK (TYPE/SIZE)
				리로		~~~		_		. (:::##(CD)	41		(<u>)</u>	<u>(ビ)</u>	(쓰)	••••••••••••••••••••••••••••••
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		HMÉNTS	(⊻)"			i, the un	idersigned,	certify	that this	 CERTIFIC s report is complete 	ation S ste and ac	LATEMEN curate to ti	ne best of	fmy k	nowled	ge and belief.
	_ Geologic	+								lians, Inc.				-		-
-		nstruction Di sical Log(s)	ngan			NAME (PE				TYPED OR PRINTED)						
		er Chemical	Analys	88			87	78 EL	Centr	to Ave., Napa	1, CA	94558				
	. Other				_[ADDRESS (<u></u>		0	0 *		CITY	1/25/	/06	STATE	^{z⊯} 396352
ATTACH AD	ditional i	INFORMATIC	on, if t	t existe	3.	Signed	57 LICENSED W	ATER WE		CTOR			DATE SIGNED		<u> </u>	-57 LICENSE NUMBER
				-										-		CSP 03 75

Well	#5			·
W CH		27-320-	.17	1
	ORIGINAL	STATE OF CA THE RESOURC		Do not fill in
	File with DWR	DEPARTMENT OF W	· · · · · · · · · · · · · · · · · · ·	N₀. 384937
		WATER WELL DR	ILLERS REPORT	
	Notice of Intent No.			State Well No. 074/05W 31
-	Local Permit No. or Date	· · · ·		lepth 260 ft. Completed depth 160 ft.
	1			(Describe by color, character, size or material)
	1	-	0 - 10 DK	wh class
	(2) LOCATION OF WELL (See instru	ructions):		ounclassing
	County Own	ner's Well Number	<u> </u>	ouncrayasina
	Well address if different from above	32_Section	14 - H2. DI	ownerg
	Distance from cities, mads, railroads, fences, etc.	3mi. Uest	112 112 1	Marian Sala Contrano
	of Unkuillegro	ide on	40-4-9	A A A A A A A A A A A A A A A A A A A
	Jig Crack 191.		45-60 Or	hon clay
		(3) TYPE OF WORK:		Ann Sand Stime
	Ny (JB	New Well Deepening . Reconstruction	N	
	3 780	Reconditioning	67 (1059	raspoil Shale
	3/ 15	Horizontal Well	105-108 04	a Sondstine
	TA A	Destruction Describe destruction materials and pro- cedures in Item 12)		V20 the comment
	(acso	(4) PROPOSED USE	TO/ JAN ON	JENE AL AVOIT
	XII	Domestic	ALLERO-	9.9 0.0
		Irrigation	74001950	ter sandstme
	6.7	Test Well	TARAY	plante et
	2 July	Municipal V 🛛		
	////	(Departibe)	\circ - \mathcal{A}	Cilary
	WELL LOCATION SKETCH	$\rightarrow \forall \rightarrow \cdots \leftarrow (\alpha)$		O
	(5) EQUIPMENT:	RAVEL BACK		
	Cable 🗌 Air 🖻 Viante	eter of bore		
	(7) CASING INSTALLED. (8) PE	ER SORATIONS: of performin or size of perform		
		Tellosta		
	ft ft if Wall	ft ft vsize	· · · ·	
	0 168 5 160 4	TO XES Fact	<i>bry</i> -	·
-			-	
	(9) WELL SEAL:	01		
		If yes, to depthft.		
	Method of sealing Conem		Work started 5-24-	19 7 Completed 5 - 2 1 19 22
	(10) WATER LEVELS:		WELL DRILLER'S STA	TEMENT:
	Depth of first water, if known Standing level after well completion	ft.	This well was drilled under m best of my knowledge and ball	y jurisdiction and this report is true to the
	(11) WELL TESTS:	Dilla	signed Jom P-	lhan
	Type of test Pump 🗋 Baile	ler 🗋 🛛 Air lift 🖪	NAME TUNION	Viel Drilling
	Depth to water at start of test ft Discharge gal/min after hours	At end of test ft.	Address 201 F	miles deriveration (Typed or minteel)
-	Chemical analysis made? Yes 🗌 No 🗗 If ye	es, by whom?	City Napa	
	Was electric log made Yes No a 17 yes	es, attach copy to this report DNAL SPACE IS NEEDED, USE !	License No CONSECUTIVELY NUMB	ERED FORM 86 96555

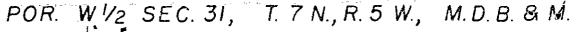
#6 • WATER WE orkiginal, Duplicate and Triplicate with the (Sections) REGIONAL WATER POLLUTION •	LL DRI 3 7076, 7077, 70			ORT	Do Not Fill In Nº 70918
CONTROL BOARD No STAT	E OF CA	LIFORN	IA	291	State Well No. Other Well No. 7N 5W-31
() OWNER:		(11) WEL	L LOO	 }:	·
		fotal depth	20		1 of completed well 20
	-				oj material, and structure.
	_	ft.	to	ft.	
	-	0	1		soil
(2) LOCATION OF WELL:	-	<u>, i</u>	5		wn clay
County NAPA Owner's number, if any	-	<u> </u>	<u>13</u> 15		ge gravel sand & clay own shale
R. F. D. or Street No. same as above on Dry Creek Roa. between Trnity Rd.& Town of Oakville.	<u>a </u>	15	20		e clay
150 ft. south of Dry creek road.		· · · · · · · · · · · · · · · · · · ·			
= mile east of Wahl Rd.			-		
	-	· · · · · ·		···	·
(3) TYPE OF WORK (cbeck):			-		
	undon 🗆 🕴 -				
If abandonment, describe material and procedure in Item 11.			•		
(4) PROPOSED USE (check): (5) EQUIPM	IENT:	· · · · · · · · · · · · · · · · · · ·			
Domestic // Industrial [] Municipal [] RotarBuck					
Interview D Test Well D Other D Cable	<u> </u>				
Inigation [] Test wen [] Other [] Dug Well	<u></u> -	·		···	
(6) CASING INSTALLED: If gravel pack	ked -				· · · · · · · · · · · · · · · · · · ·
	- -				
From ft. to ft. Diam. Wall of Bore it.	fr				
0 20 36" I.D. 49" 10	20				
CONCRETE PIPE					
					······································
	- -				
Type and size of shoe or well ring Size of gravel: 1	pea				
Describe joint			1	••	
		•	«		
(7) PERFORATIONS:					
Type of perforator used none Size of perforations in leasth, by	<u>-</u> -	τ.			
Eren	.ows per ft.				<u></u> .
		e. 			· •
ана аланана аланана аланана аланана аланана алана а					OFF:C'AL USE ONLY
					ULLOUTE OOL VIERS
(8) CONSTRUCTION: CONCRETE COVER INSTALL	LED				
(8) CONSTRUCTION: Was a surface sanitary seal provided? <i>D</i> . Yes	ft				
Were any strata scaled against pollution? 2 Yes D No If yes, note depth of strata				**	
From fc. to ft.				~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	
)0 10		••••			
Method of Sealing Redi Mix concrete		Work started	5/11	/64 19	. Completed 5/15/64 19
(9) WATER LEVELS:		WELL DRILL		ATEMENT:	-/
Depth at which water was first found 14	fr. 77	This well w ny knowledge			isdiction and this report is true to the best
Standing level before perforating	<u>fr.</u> P	NAME I	BAT.LAF	<u>ነው & ፑርርር</u>	P R
ading level after perforating	ft	40		oetz 19	
(10) WELL TESTS:		100165		CALIF.	Λ. <i>Α</i> . Λ
Was a pump test made? [] Yes Z No If yes, by whom?			Vol.s.	121	Yutih.
Yiekprox. 2 gal./min. with ft. craw down after	brs.	SIGNED]	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	1-17	Vell Diller
Temperature of water COOl Was a chemical analysis made? . Yes 1	<u>No</u> L	license No]	185456		Dated 6/8/64, 19
Was electric log made of well? 📋 Yes 💋 No					· •

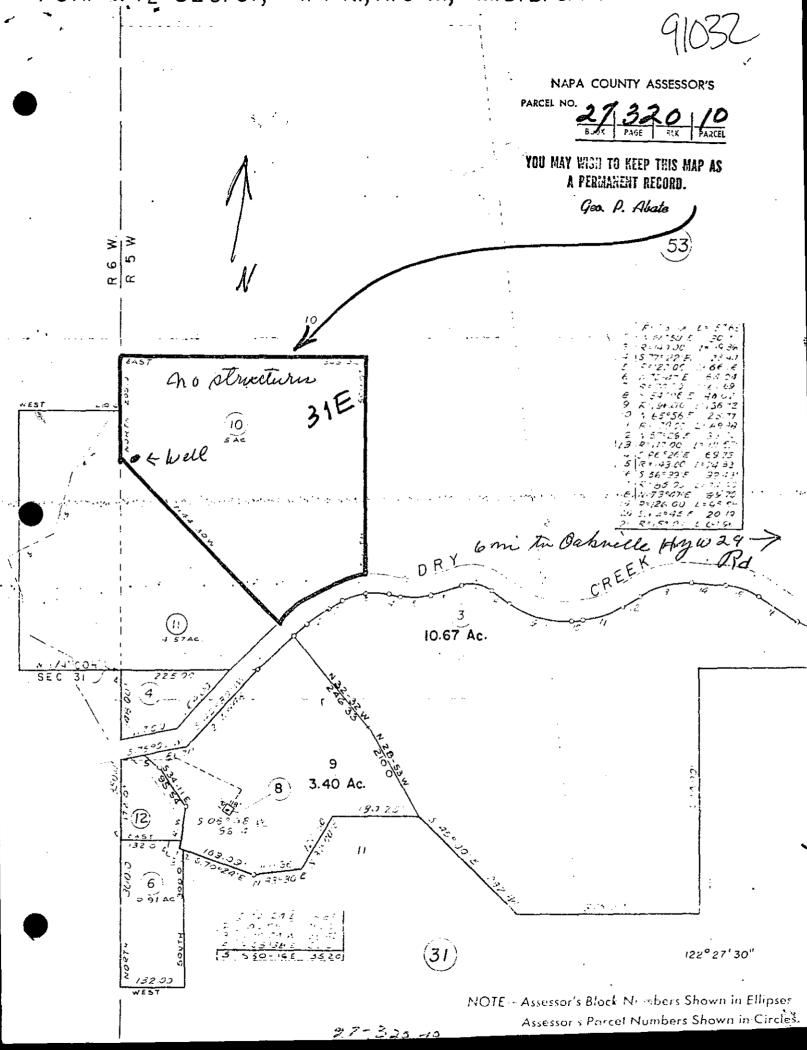
ORIGINAL			DEP	THE RESOUR	CALIFORNIA RCES AGENCY NATER RESO	URCES	Do I N ?	Not Fill In 91032
File with I	Water Co	ENTIAL L de Sec.	OG WA7	TER WELL D	RILLERS RI	EPORT	State Well No Other Well N	-TIMARU[24
	מ זו.				(11) WELL LO)G:		
					Total depth 70	ft. Dent	h of completed well	f
						color, character, size of a		
, .						A ft. to		
	ATION OF	-			p-24 A	and you	lawie	sys she
County <u></u> Cowaship, Range		Dr.M.C.R.	wher's number if	10y	24-53	Bliss	shale	·
	ities, roads, railro	ads foje.	27-3a	0-10			A	
					53-66	Black	andy	male the
New Well 🔀	Deepening	RK (<i>check</i>) ; [] Recon rial and procedu	ditioning 🔲	Destroying 🔲	66-70	Blue	hale	
		E (check):) EQUIPMENT:				
Domestic 🛛	🗙 Industria	l 🔲 Munici	pal 🔲 🛛 🛛 🛛			· · · ·		
rrigation [🗍 Test We	11 🔲 O		Rotary 🗌 Cable 🕅			· ·	
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O) CASH		THER:	If g	ravel packed				
_		- Gage	Diameter				•	
From ft.	fo ft. Dia	m. Wall	of Bore	From To ft. ft.				
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) — — —				·····				
ize of shoe or w	cell ring:	x6x8	a Size of gravel:	I			_	
Describe joint	Bu	to ful	d.			· · · · ·		
		IS OR SCH	EEN:	Jamed				
ype of periorati	tion or name of sc	Perf.	Rows			<u> </u>		
From	To	per	per	Size				
ft.	ft.	row 2	ft.	in. x in.				
	<u> </u>		10	843			. <u>.</u>	
53								
53							<u> </u>	
53								
53	STRUCTU							
53 (8) CONS	STRUCTIC nitary seal provid	<u> </u>	io [] To v	what depth JJ ft.		· · · · · · · · · · · · · · · · · · ·		
53 (8) CONS Was a surface sat		ed? Yes 🚺 N	0 [] To x	what depth 12 ft. If yes, note depth of strata				
(8) CONS Was a surface sac Were any strata s	nitary seal provid sealed against pol ft. to	ed? Yes X N lution? Yes [] ft.		• •				
53 (8) CONS Was a surface sat	nitary seal provid sealed against pol ft. to ft. to	ed? Yes 🏂 N lution? Yes 🗍		• •	Work start A RILLER	1476 , compl S STATEMENT:		•76
(8) CONS Was a surface sac Were any strata s From From Hetbod of sealing	nitary seal provid sealed against pol ft. to ft. to	ed? Yes A N lution? Yes [] ft. ft. ft.		• •	WEIA DRILLER	S STATEMENT: illed under my jursd	iction and this ref	976 Port is true to the bu
(8) CONS Was a surface sar Were any strata s From From Method of sealing (9) WAT Depth at which	nitary seal provid sealed against pol ft. to ft. to bg ER LEVE, water was first	ed? Yes X N lution? Yes ft. ft. ft. LS: found, if known		If yes, note depth of strata	WEIA DRILLER This well was d of my knowledge a	S STATEMENT: illed under my jursd	iction and this rep	976 ort is true to the bu
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WATER WELL DRILLERS REPORT No. 3710// State Well No Lead Permit No in Date 27998 Call Permit No in Date 2799 Call Permit No in Date 279 Call Permit No i				Do not fill in
	File with DWR			No 371077
Leal Permit No. or Date 2799.2		WAIER WELL D	RILLERS REFORI	NO. 511011
(12) WELL LOG. Teal depth [40]: Completed depth [40]:	Louis P	<u>as</u> ~		itate Well No.
Image: Provide Structures: Control Topology WELL (See instructions): New Well Depending New Well Depending Depending New Well Depending Depending Depending New Well Depending Depend	Local Permit No. or Date 22			
(2) LOCATION OF WELL (See instructions): 0 -30 Clauding instructions): Control Well address of different from allow of the MINIMER 30 -0 Clauding instructions): Demonskipser, wile control instructions in the Minimer 30 -0 Clauding instructions): Clauding instructions Dimenskipser, wile control instructions -0 -0 -0 -0 -0 -0 Dimenskipser, wile control instructions -0 -			(12) WELL LOG: Total depth	160ft. Completed depth 160 ft.
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Peccentruction Horizontal Well Dart materials and pro- colures in item 120 Generation () WELL LOCATION SECTCH (a) PROPOSED USE Industrial Test Well Munic (A) (b) Cuttorn SECTCH (c) PROPOSED (c) PROPOSED Industrial Test Well Numic (A) (c) PROPOSED Units (A) (c) PROPOSED Industrial Test Well Non- (c) PROPOSED (c) PROPOSED<	Chrief Ween	er no-on pry	90-160 Jul	spine +
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Gebruction materials and pro- cedures in them 120 (4) PROPOSED USF (3) PROPOSED USF (4) PROPOSED USF (5) Regular control of the second conthe second control of the second control of the		_ / /	$\wedge \rightarrow \rightarrow $	×~
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WELL LOCATION SKETCH Image: construction of size		م المشرية		<u>AN</u>
Inrigation Industrial Text Inrigation Industrial Text WELL LOCATION SKETCH Over Unit of the text (b) EQUIPMENT: Cable (c) CRAYER SECK (c) CASING INSTALLED (c) PERFORTINGS (c) CASING INSTALLED (c) PERFORTINGS (c) MELL SEAL: (c) PERFORTINGS (f) WELL SEAL: (c) For and the second secon	. <u>+</u> + .♡			
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Municisk Ober WELL LOCATION SKETCH Ober (8) EQUIPMENT: Reverso Cable Air (9) EQUIPMENT: Reverso (10) WELL ISEAL: (10) PERPORTITION Was states entrary call provided? Yes, b No Hyes, to depth (10) WELL ISEAL: (11) Wester Was states entrary call provided? Yes, b No Hyes, to depth (10) WATER LEVELS: West and of tes depth (11) WELL TESTS: No Hyes, by whom? Was wellest and of tes depth Artific Was wellest and of tes depth Artific Artific test and of test depth Artific Was wellest made ft Weth L STAL: No Hyes, to depth Was states entrary call provided? Yes, to depth (10) WATER LEVELS: West there is the order of the more is the or			i A D COS)``
WELL LOCATION SKETCH Werthe (b) EQUIPMENT: (c) CRANK KACK: (c) Other Bucket (c) Other (c) PERPOSENTIONS: (c) CRASH CANNON OF SIZE of State		Test Well		<u> </u>
WELL LOCATION SKETCH Werking (S) EQUIPMENT: (G) CRAVE MCK: Rotary Reverse Cable Atr Other Backet Other Backet Type of Effortune or Size of strue - (7) CASING INSTALLED (8) PERPONATIONS: Steel Plantic B Type of Effortune or Size of strue - (9) WELL SEAL: Wall Was surface sanitary seal provided? Yee, No (10) WATER LEVELS: No From To (10) WATER LEVELS: No It is started It is sto to depth (11) WELL TESTS: No War well test made? Yee, No War well test made? Yee, No It is backet? No War well test made? Yee, No Standing level after well completion Atr lift, No War well test made? Yee, No			All 2 Cros	
(s) EQUIPMENT: Rotary Reverse Cable Air Other Bucket Bucket No CK: Steel Cable Air Type of printing on visue of when From The Dig Gage or From The The			$\mathcal{O} = \mathcal{O}$	
Notary - Reverse - Wake No - Side Cable - Air - Wake No - Side Other - Bucket - Reverse of the complexity of the comp	WELL LOCATION SKETC		<u> </u>	
Notary - Reverse - Wake No - Side Cable - Air - Wake No - Side Other - Bucket - Reverse of the complexity of the comp		(A) GRAVIEL RACK:		
Ober Bocket Indeed from - (7) CASING INSTALLED. (8) PERFORATIONS - Steel Plastic Indeed from - From T Dia Gage or To Fit H Mail H Size - (9) WELL SEAL: - - - Was surface sanitary seal provided? Yes, No If yes, to depth ft - (10) WATER LEVELS No If yes, to depth ft - Weet stata seaked against pollution? Yes, No If yes, to depth ft - - (10) WATER LEVELS: Work started - - - - (11) WELL TESTS: No It yes, by whon? It with the set of my knowledge and bleif. - <td></td> <td>$\langle N \rangle = \sigma \langle N \rangle$</td> <td></td> <td></td>		$\langle N \rangle = \sigma \langle N \rangle$		
(7) CASING INSTALLED (8) PERPORTITION: Steel Plastic From TR Dia Gage or Wall Total Total Total (9) WELL SEAL:			(O) > -	
Steel Plastic B Inserter Type of refrontion or size of steel			<u> </u>	
From Th Dia Cage or Wall Dia Dia Cage or Wall Dia Dia <thdia< th=""> Dia Dia</thdia<>		(8) PERFORATIONS:	<u> </u>	······
ft ft ft size - 0 160 60 50 - (9) WELL SEAL: - - Was surface sanitary seal provided? Yes No If yes, to depth - Were strata sealed against pollution? Yes No If yes, to depth - Method of sealing				
(9) WELL SEAL: - Was surface sanitary seal provided? Yes, No If yes, to depth 2 ft Were strata scaled against pollution? Yes No If yes, to depth 2 ft Method of sealing	ft. ft. Wal	ll te field		
(9) WELL SEAL: Was surface sanitary seal provided? Yes No □ If yes, to depth 2 ft Were strata sealed against pollution? Yes □ No No □ If yes, to depth 2 ft Method of sealing	0 160 3 160	0 60 XXX EX3		· · · · · · · · · · · · · · · · · · ·
(9) WELL SEAL: Was surface sanitary seal provided? Yes, No □ If yes, to depth 2 ft Were strata sealed against pollution? Yes □ No ⊠ Intervalft Method of sealing		SHILL		
Was surface sanitary seal provided? Yes No I If yes, to depth			· · · · · · · · · · · · · · · · · · ·	
Were strata sealed against pollution? Yes No & Interval ft Method of sealing		× No □ If yes to depth 22 ft		
(10) WATER LEVELS: WELL DRILLER'S STATEMENT: Depth of first water, if known 40 ft ft Standing level after well completion 40 ft ft (11) WELL TESTS: Was well test made? Yes No was well test made? Yes No If yes, by whom? Bailer Air lift to NAME Well On the properties of the pro	Were strata sealed against pollution? Ye	es 🗌 No 🔀 Interval ft.		·
Depth of first water, if known GO ft Standing level after well completion GO ft Standing level after well completion GO ft (11) WELL TESTS: No If yes, by whom? Juliu was well test made? Yes No If yes, by whom? Juliu pth to water at start of test Go ft Air lift NAME Discharge gal/min after bours Water temperature it Chemical analysis made? Yes No If yes, by whom? City Was electric log made Yes No If yes, attach copy to this report License No. Signed DWID 400 Test yes attach copy to this report License No. Signed Signed	· · · · · · · · · · · · · · · · · · ·	ent		
Standing level after well completion 40 ft Mass well test made? Yes D No If yes, by whom? If the st of my knowledge and belief. Was well test made? Yes D No If yes, by whom? If the st of my knowledge and belief. Path to water at start of test 40 ft. Air lift 40 NAME NAME Poth to water at start of test 40 ft. At end of test 60 ft. Discharge 0 gal/min after bours Water temperature it. Address 387 City ZIP 2155 Was electric log made Yes No If yes, attach copy to this report License No. 200 210	(10) WATER LEVELS:	0	WELL DRILLER'S STATEM	ENT:
(11) WELL TESTS: Signed Was well test made? Yes by No be of test Pump bit to water at start of test ft. Air lift NAME Pith to water at start of test ft. Air lift NAME Person filer, to composition (Typed or printed) Chemical analysis made? Yes No If yes, by whom? Chemical analysis made? Yes No If yes, by whom? City City Was electric log made Yes No If yes, attach copy to this report License No. Description of this report Diven tage arm and the start of this report License No. Was electric log made Yes No If yes, attach copy to this report License No. Description of this report Diven tage arm and the start of this report License No. Was electric log made Yes No If ADDITIONAL SPACE IS NEEDED. USE NEXT CONSECUTIVELY NUMBERED FORM			This well was drilled under my juris	diction and this report is true to the
Was well test made? Yes No I ff yes, by whom? <u>JURCUM</u> Bailer Atrend of test At end of test At e	······································			there ?
Opth to water at start of test It At end of test It At end of test It Discharge gal/min after bours Water temperature Address Person first to comportion (Tr ped or printed) Chemical analysis made? Yes No. If yes, by whom? City	Was well test made? Yes 🖉 No		Signed Difference	WAII Driller
Discharge gal/min after bours Water temperature Address Address Period	pth to water at start of test 40 ft.		NAME	repration) (Typed or brinted)
Was electric log made Yes No If yes, by whom? City	Discharge/00 gal/min after 2			amont the of
IF ADDITIONAL SPACE IS NEEDED. USE NEXT CONSECUTIVELY NUMBERED FORM	•		allo na	
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Owner's Well No.	12-22-04		***11405	.031	.5020	╎└─┸	LATITUDE			LO	NGITUDE
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Well#10 Rig #4 J.Miller		FERRELL, TIMOTHY LEE
ORIGINAL	STATE OF C	ALIFORNIA Do not fill in
	THE RESOUR	CES AGENCY
File with DWR	DEPARTMENT OF V	VATER RESOURCES NO. 103155
e of Intent No	_ WATER WELL D	RILLERS REPORT
Local Permit No. or Date		State Well No. Other Well No.
I		(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)
(<u> </u>
(2) LOCATION OF WELL (S. County Napa	27 - 27 - 27 - 27 - 27 - 27 - 27 - 27 -	25 - 50 blue shale green clay soft
Co		50- 195 blue shale hard
	me	<u>195 - 210 gray rock fract.</u>
TownshipRange		210 - 295 blue shave hard
Distance from cities, roads, railroads, fences, e	tc	
	(3) TYPE OF WORK:	
	New Well X Deepening	
	Reconstruction	
	Reconditioning	
404350' 104 1 S	ů E	
H- JV W12 150-7 (Fi	Destruction _ (Describe destruction materials and	HD- Alle
DRIDE WAY) &	destruction materials and procedures in Item 122	
('d	(4) PROPOSED USE	
	Domestic	
DRIVE WAY	Irrigation	
	Industrial	
	Test Well	
	Stock	
WELL LOCATION SKETCH	Other	
	GRAVEL PACK:	
Rotary 🖾 Reverse 🗆 Xes Cable 🗆 Air 🕰	I No K Size	
	ked fromtototo	
	YERFORATIONS: Power saw	
	e of perforation or size of screen	<u> </u>
ft. ft. Wall	ft. ft. size	-
0 295 6 160 1	15' 295 % X8x3"	
		-
		-
(9) WELL SEAL:	Boot a	
Was surface sanitary seal provided? Yes 🖾	No [] If yes, to depth <u>~2</u> ft.	-
Were strata sealed against pollution? Yes Method of sealing <u>Grout</u>	: No 🖾 Intervalft.	-
(10) WATEB LEVELS:		Work started 12-30. 1977 Completed 1-7 19.78 WELL DRILLER'S STATEMENT:
Depth of first water, if known \perp	951 ft.	This well was drilled under my jurisdiction and this report is true to the best of mu
	<u>00 †ft.</u>	knowledge and belief.
(11) WELL TESTS: Was well test made? Yes XX No □	If yes, by whom? Drillers	SIGNED (Well Driller)
Type of test Pump _] ()	Bailer [] Air lift [X]	NAME Doshier-Gregson Drilling.Inc.
l.		(Person, firm, or corporation) (Typed or printed) Address 5365 Napa-Valle jo Hwy.
	hours Water tomperature	City_Vallejo,CaZip_94590
	(If yes, by whom?	License No. 294001 Date of this report $1/4/78$
	, or, weater copy to this tehout	Late of this report

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

ONGINAL ETATE OF CALFORMA 31 4/H Do not fill in File with DWR DEFARTMENT OF WATER RESOURCES N0.34198 Water Mean No. or Bas Defartment OF WATER RESOURCES No. 34198 Water Well DRILLERS REPORT No. 00.0000 No. 000000000000000000000000000000000000	Well #11 ORIGINAL	STATE OF C	ALIFORNIA 31	нH	Do not fill in
WATER WELL DRILLERS REPORT Sate Well Y Gate Well Y Const.	File with DWR				No 3/1198
Long Penel No. er Dat. Data Will A DUPUEL (See instractor and see instractor and					10.04100
(12) WELL LOG: Tool deput 280_k. Depth of completed set 280_k. (2) LOCATION OF WELL (See instracting Part): #27-330-09 (3) MARKEN DEPUTION OF WELL (See instracting Part): #27-330-09 (3) MARKEN DEPUTION OF WELL (See instracting Part): #27-330-09 (3) TYPE OF WORKS (4) Address of different from above Same (5) TOPE OF WORKS (6) TYPE OF WORKS (7) CARTION SETTER (9) WILL LOCATION SETTER (10) PUPUENT: (11) WELL SEAL (12) WELL SEAL (12) WELL SEAL (12) WELL LOG: Tool deput 280_k (12) WELL SEAL (12) WELL SEAL (12) WELL SEAL (12) WELL SEAL (13) TYPE OF WORKS Not seal Not seal (14) PROFORD Particle MILL LOCATION SETTER MILL LOCATION SETTER Particle State Not seal Particle State Paricle State		WAIER WELL DE	ULLERS REPOR	Jule Well	No.
Image: first transformed to the second s	Local Permit No. or Date			Other Well	NUMORUO 51
Image Image <thimage< th=""> Image <th< td=""><td></td><td></td><td>(12) WELL LOG:</td><td>Total depth 280 fr D</td><td>anth of completed will 280 ft</td></th<></thimage<>			(12) WELL LOG:	Total depth 280 fr D	anth of completed will 280 ft
(2) LOCATION OF WELL (See instract Pap): #27-330-09 3 40 Brown sandstone & small rock (2) LOCATION OF WELL (See instract Pap): #27-330-09 40 - 52 Grey andstone (2) Well dates of inflorent from show Same 52 - 58 Grey andstone (3) TOPE of Wolk 58 - 165 Shale vock (4) - 52 Grey andstone 58 - 165 Shale vock (5) LOCATION OF WELL (See instracting the see set instration of the set of t			from ft. to ft. Forma	tion (Describe by color,	character, size or material)
Communication Construction AD 52 Greey sandstone Well address if officers from down Same Section 52 58 Greey sandstone Well address if officers from down Same Section 168 175 Sinals Descree from cities, reads, raileads, fraces, etc. 168 175 Sinals 168 Well address if officers from down Same Section 168 175 Sinals 168 Descree from cities, reads, raileads, fraces, etc. 168 175 Sinals 168 168 Well & Counter from down Same Recommunication Recommunication Recommunication 175 Sinals 175 Sinal Descrete from down Same Recommunication Recommunication Recommunication 175 Sinals 175 Well & Docarton Fract 10 Promote from down Same 10 10 10 10 10 10 Well & Docarton Fract 10 Sinals 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10			03		
Weil address if different from shows <u>Same</u> 52 - 58 <u>Groy shale black rock</u> Townshop Barge 58 - 168 <u>Shale</u> Jimme from chier, made, minese, etc 168 - 175 <u>Shale</u> Shale 175 280 <u>Shale</u> 177 <u>Shale</u> 177 <u>Shale</u> 175 280 <u>Shale</u> 177 <u>Shale</u> 177 <u>Shale</u> 175 <u>Sha</u>	(2) LOCATION OF WELL (See ins	(tractions): #27 - 330 - 09	v		
Township Bange Section 58 168 Shale Distance from etite, noch, rainadi, fence, ec. 168 - 175 280 - 175 280 - 175 Distance from etite, noch, rainadi, fence, ec. 175 - 280 - 175 280 - 175 280 - 175 Image: Section 3) TYPE OF WORK: 175 - 280 - 175 168 - 175 280 - 175 Image: Section 3) Weith E Despation Respation 175 - 280 - 175 175 - 180 - 175 Image: Section 3) TYPE OF WORK: Image: Section 175 - 180 - 175 175 - 175 Image: Section 100 - 175 100 - 175 100 - 175 100 - 175 Image: Section Image: Section Image: Section 175 - 180 - 175 100 - 175 Image: Section Image: Section Image: Section 100 - 175 100 - 175 Image: Section Image: Section Image: Section - 175 - 180 - 175 100 - 175 100 - 175 Image: Section Image: Section - 175 - 175 Image: Section - 175 - 175 100 - 175 100 - 175 Image: Section - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 175 - 1	County Napa Own	er's Well Number		~~ `	
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New Well & Deepening Reconstruction Reconstruction <t< td=""><td></td><td></td><td>- //</td><td></td><td></td></t<>			- //		
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Beconditioning Horizontal Well Destruction Horizontal Well VELL LOCATION SECTOR Domestic VELL LOCATION SECTOR Domestic VELL LOCATION SECTOR Domestic Vell Dolar Other Are Well Standard Horizontal Well Object To Other Are Well Object To	a skuilt	New Well 🛃 Deepening 🗍		~	
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well Location Sketch ober well Location Sketch ober (5) EQUIPMENT: (6) GRAVEL PACK: Rotary 30 Reverse (a) Cashed At (b) Cashed No. 1 (c) Cashed Type of perform onlying of stereor (7) CASING INSTALLED (3) PERFORENCE: (9) WELL SEAL:	الم الم الم الم الم	Irrigation	<u> </u>	V 02 0	· · ·
WELL LOCATION SKETCH State WELL LOCATION SKETCH Other (5) EQUIPMENT: (6) CRAVEN PACK: Cable Air (7) CASING INSTALLED (6) PERFORMONS: Cable Air (7) CASING INSTALLED (6) PERFORMONS: Steel I Type of performan objec of screep From To To Dia Keel I The of performan objec of screep From To Vestatic Concrete Was usface snaftary seal provided? Yes & No I If yes, to depth 20 ft. - - (9) WELL SEAL: - Was sufface snaftary seal provided? Yes No I If yes, to depth 20 ft. - - Wee strata seled against pollution? Yes To X Interval Method of scaling Concrete Work started Kawa More started 9-19 10 77 (10) WATER LEVELS: - Perpt of first water, if Kawa At end of test 200 ft. Type of test Pump X Bale I At end of test 200 ft. Type of test Pump X Bale I	and the second		$ \bigcirc \lor \bigcirc $	<u> </u>	
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WELL LOCATION SKETCH Other (5) EQUIPMENT: (6) CRAVEL PACK: Rotary 25 Reverse (6) CRAVEL PACK: Cable	1 - A - K) <u> </u>	
(5) EQUIPMENT: (6) CRANT PACK: Rotary 23 Reverse Cable □ Air Other □ Bucket □ Bucket □ Air Other □ Bucket □ Bucket □ (6) FERFORSTINES: Steel 2 Plastic □ Concent Type of performan on the of screep From To ft ft ft ft ft ft ft ft gainst pollution? Yes 25 No 2 State (9) WELL SEAL: - Was surface sanitary seal provided? Yes 25 No 11 Hyes, to depth 20 ft - Method of scaling Concrete (10) WATER LEVELS: - Depth of fits water, if knownft. ftstanding level after well completion 42 ft At end of test_20ft. Yas will test made? Yes 5					
Rotary Severe Reveree Not Size Cable Air Cable Air Cable Cab	·				
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Steel X Plastic Convert Type of perfinition object of screegy - From To Dia. Case of ft To Step - ft ft m. Wall ft To Step - O 280 5 8 40 280 - - (9) WELL SEAL: - - - - - Was surface sanitary seal provided? Yes $\frac{3}{2}$ No \Box If yes, to depth 20 ft. - - Were strata sealed against pollution? Yes \Box No χ Interval ft. - - (10) WATER LEVELS: No \Box If yes, by whon? Driller Well DRILLER'S STATEMENT: This uell was drilled under my instidiction and this report is true to the best of my knowledge and belief Standing level after well completion 42 Meller \Box Mar McLean & Williams Well Drilling Type of test Pump χ No \Box If yes, by whon? Driller NAME McLean & Williams Well Drilling Optities No χ If yes, by whon? Driller NAME McLean & Williams Well Drilling Optities No χ If yes, by whon? Core Was used at		\ \			
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From Io Dia. C3g2 or Free fith Size - Io Io Wall ft ft Size - O 280 5/8 40 280 - (9) WELL SEAL: - - Was surface sanitary seal provided? Yes Ξ No \Box If yes, to depth 20 ft. - Were strata sealed against pollution? Yes \Box No Ξ Interval ft. - (10) WATER LEVELS: Output fit Were strate on the fit is known in the fit is fit is the fit is f	Steel Plastic Concrete Type of p	pertination of size of screen	P	. <u></u> ,	
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(9) WELL SEAL: - Was surface sanitary seal provided? Yes ≤ No ⊆ If yes, to depth 20_ft. - Were strata sealed against pollution? Yes ⊆ No X Intervalft. - Method of sealingCONCreteft. - (10) WATER LEVELS: - Depth of first water, if knownft. - (11) WELL TESTS: Well completionft. Was water at start of testft. At end of testft. Depth to water at start of testft. At end of testft. Discharge10_ gal/min afterft. At end of testft. Chemical analysis made? Yes No				· _ · ·	·
(9) WELL SEAL: Was surface sanitary seal provided? Yes 3 No \square If yes, to depth 20 ft. Were strata sealed against pollution? Yes \square No 3 Interval ft. Method of sealing <u>Concrete</u> (10) WATER LEVELS: Depth of first water, if known <u>ft</u> (11) WELL TESTS: Was well test made? Yes 3 No \square If yes, by whom? <u>Driller</u> Mar hift \square Depth to water at start of test <u>42</u> ft. At end of test <u>200</u> ft Discharge <u>10</u> gal/min after <u>21</u> hours Water temperature Chemical analysis made? Yes \square No Ξ If yes, by whom? <u>Concrete</u> City <u>Napa, CA</u> 272321 Dept to yater of the sealer o	-0 280 b 18 -4				
(3) WELL SERL: Was surface sanitary seal provided? Yes \$\frac{3}{2}\$ No [] If yes, to depth 20 ft. Were strata sealed against pollution? Yes [] No X Interval ft. Method of sealing <u>Concrete</u> Work started <u>9-19 19 77</u> Completed <u>10-3 19 77</u> (10) WATER LEVELS: Depth of first water, if known <u>42</u> ft. (11) WELL TESTS: Was well test made? Yes X No [] If yes, by whom? <u>Driller</u> Bailer [] Air bift [] Depth to water at start of test <u>42 ft</u> . Depth to water at start of test <u>21 hours</u> Water temperature Chemical analysis made? Yes [] No X			_		<u> </u>
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Depth of first water, if known	· · · · · · · · · · · · · · · · · · ·				bleted 10-3 19_//
Standing level after well completion42ft. ft. knowledge and belief (11) WELL TESTS: Was well test made? Yes X No If yes, by whom? Driller Type of test Pump X Bailer Air lift Depth to water at start of test ft. At end of test 200 ft Discharge 10gal/min_after 21 hours Water temperature Chemical analysis made? Yes No If yes, by whom?	Depth of first water, if known	ft.			report is true to the best of mu
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Type of test Pump X Bailer Air lift NAME McLean & Williams Well Drilling Depth to water at start of test 42 ft. At end of test 200 ft. Discharge 10 gal/min after 2½ hours Water temperature NAME McLean & Williams Well Drilling Chemical analysis made? Yes No X If yes, by whom? City Napa, CA Zip 94558	(11) WELL TESTS:	a hu mhama Driller	SIGNED	(Well Driller)	
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 Address 878 E1 Centro Avenue Chemical analysis made? Yes \Box No $\frac{2}{4}$ If yes, by whom? CA 272321 \Box $10-3-77$	Type of test Pump X Baile	er 🗍 🦳 Air lift 🗔	NAME McLean &	Williams We	<u>ell Drilling</u>
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DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED. USE NEXT CONSECUTIVELY NUMBERED FORM 43816-850 7-76 50M QUAD OT 05P

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Well #13 ORIGINAL DWR USE ONLY - DO NOT FILL STATE OF CALIFORNIA 071106101316 WELL COMPLETION REPORT File with DWR STATE WELL NO./STATION NO. Refer to Instruction Pamphlet Page ____ of 5943 **Owner's Well No.** LONGITUDE LATITUDE h Ended Date Work Began 🛰 0 Local Permit Agency APN/TRS/OTHER 659 Permit Date ≤ Permit No. GEOLOGIC LOG (SPECIFY) ORIENTATION (∠) HORIZONTAL . ANGLE VERTICAL DEPTH TO FIRST WATER 42 (Ft) BELOW SURFACE DEPTH FROM DESCRIPTION Describe material grain size, color, etc WELL FOCATION Ft to me A nroum Address 🕿 ∂ ∞ City 20 County. iya APN Book Page Parcel⊂ Township _ Range Section Longitude. Latitude WEST NORTH DEG. SEC. DEG, MIN. MIN. SEC. $l \cap$ ACTIVITY (∠) - LOCATION SKETCH NORTH NEW WELL MODIFICATION/REPAIR _ Deepen Other (Specify) ١٢ 15 DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG" PLANNED USE(S) EAST NEG. N it WATER SUPPLY Domestic Public iniastion Industrial "TEST WELL" CATHODIC PROTEC SOUTH TION Illustrate or Describe Distance of Well from Landmarks such as Roads, Bukkings, Fences, Rivers, etc. PLEASE BE ACCURATE & COMPLETE. OTHER (Specify) DRILLING 1-FLUID METHOD WATER LEVEL & YIELD OF COMPLETED WELL DEPTH OF STATIC (Ft.) & DATE MEASURED 5-22-97 ESTIMATED YIELD*__ Ð (GPM) & TEST TYPE <u>í r</u> 70 (Feet) TEST LENGTH _____ (Hrs.) TOTAL DRAWDOWN _____ _. (Ft.) TOTAL DEPTH OF BORING . <u>[](</u> * May not be representative of a well's long-term yield. TOTAL DEPTH OF COMPLETED WELL (Feet) ANNULAR MATERIAL CASING(S) DEPTH FROM SURFACE DEPTH BORE FROM SURFACE TYPE TYPE (ビ) HOLE SLOT SIZE GAUGE OR WALL INTERNAL CE- BEN-MENT TONITE DIA. SCREEN CON-DUCTOR FILL PIPE MATERIAL/ DIAMETER IF ANY FILTER PACK **BLANK** FILL GRADE (inches) THICKNESS (TYPE/SIZE) (inches) (Inches) Ft. to Ft. Ft. to Ft E (∠)| (上) .(∠) 200 D 22 activ 70 es Gravel actor 22 10 **CERTIFICATION STATEMENT** -ATTACHMENTS (∠) I, the undersigned certify that this report is complete and accurate to the best of my knowledge and belief. Geologic Log Weil Construction Diagram MANG (PERSON Geophysical Log(s) Soll/Water Chemical Analyses _ Other. ATTACH ADDITIONAL INFORMATION. IF IT EXISTS. DATE SIGNED URIZED REPRESENTATIVE IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM DWB 188 BEV, 7-90

#14 ORIGINAL File with DWR	STATE OF CALIFORNIA WELL COMPLETION REPOR Refer to Instruction Pampbles	T $0_7 N_0 S_{11}$
Page of Owner's Well No. Date Work Began 5-7-99 Local Permit Agency	Junt - 13-99 528424	
Permit No. 46 - 08 GEOLOGIC L ORIENTATION (\angle) VERTICAL HORIZO DEPTH TO FIRST WATEL	MTAL (SPECIFY) N	WELKOWNER
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Soll/Water Chemical Analyses Other	Signed WELL DIRLEGATION DEPRESENTATIVE	$\frac{1102 - 1100}{5-17-99} \frac{1102}{248677}$

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Other ATTACH ADDITIONAL INFORMATION, IF IT	EXISTS Signed .	Ric	Pul	lim			5-15-		248677
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IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

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#17	Fred			
ORIGINAL File with DWR	STATE OF CALIF WELL COMPLETI	ORNIA ON REPORT		NEY - DO NOT FILL IN -
Page of	Refer to Instruction		STATE	WELL NO./STATION NO.
Owner's Well No.	<u> </u>	2775		
Date Work Began 6 300	Anded B TOTOL	•		
Eocal Permit Agency Permit No 96-115-90	Permit Date 8800		L	APN/TRS/OTHER
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DRILLING VISTA	HORIZONTAL ANGLE (SPEC FY)			
DEPTH FROM SURFACE	DESCRIPTION			
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		Address City	<u> </u>	
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		Fences, Rivers, etc. and at	unce of Well from Roads, B tach a map. Use additional CCURATE & COMPLET	paper if OTHER (SPECIFY)
		WATER L	EVEL & YIELD OF	COMPLETED WELL
		DEPTH TO FIRST WATE	R <u>90 (Ft.) BELOW</u>	
		DEPTH TO FIRST WATE	R 90 (Ft.) BELOW	SURFACE
310		DEPTH TO FIRST WATE DEPTH OF STATIC WATER LEVEL	rr 90 (Ft.) BELOW 5 (Ft.) & DATE ME <i>l</i> 50 (GPM) & TEST	V SURFACE ASURED 6-27-01 TYPE Chin I # 15-T
TOTAL DEPTH OF BORING 310	Freet) 3/0 (Freet)	DEPTH TO FIRST WATE DEPTH OF STATIC WATER LEVEL ESTIMATED YIELD · TEST LENGTH	R 90 (Ft.) BELOW 5 (Ft.) & DATE ME/ 50 (GPM) & TEST . (Hrs.) TOTAL DRAWDOW	V SURFACE ASURED 6-27-01 TYPE Ani 111-T IN 200 (FL.)
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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-waterbalance 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).



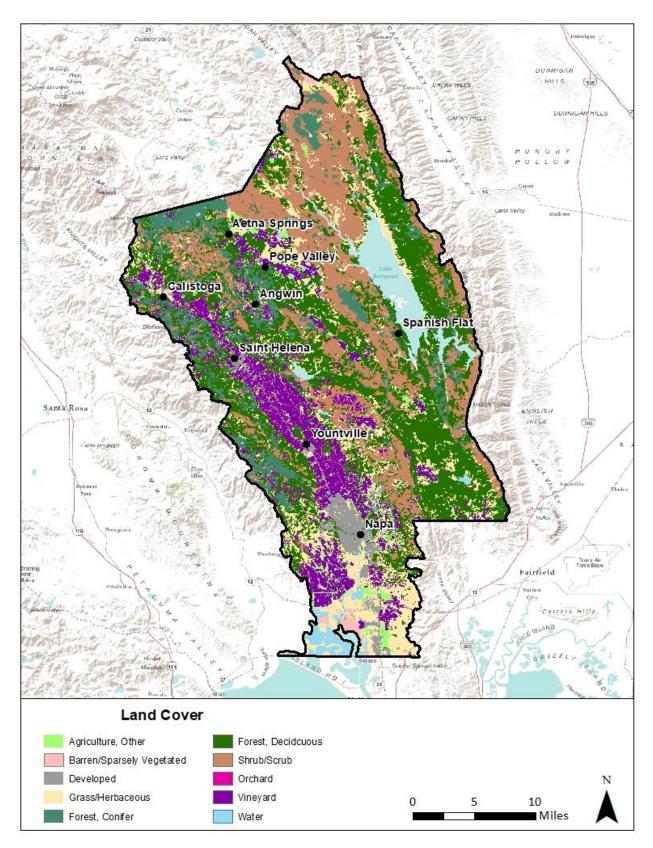


Figure 1: Land cover distribution used in the Napa County SWB model.



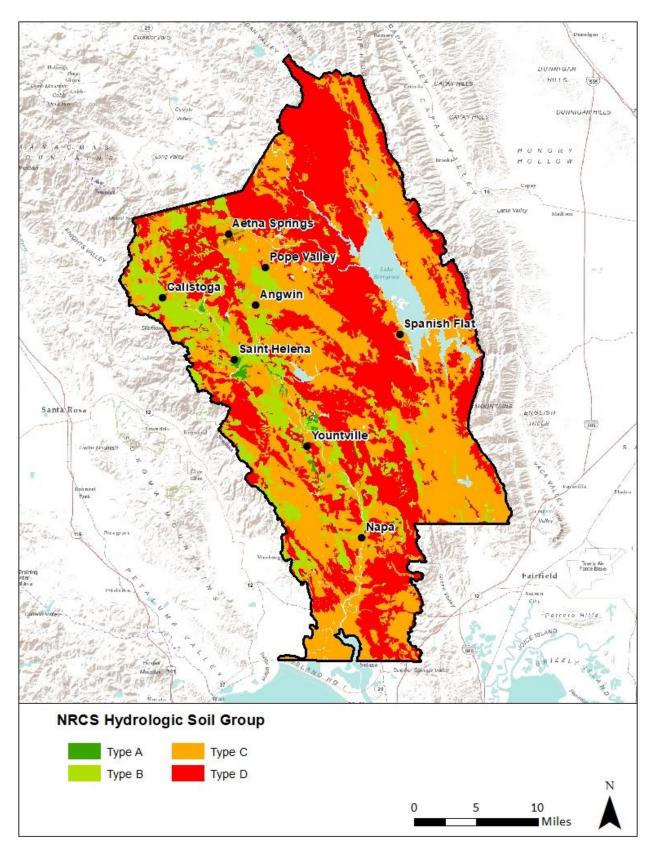


Figure 2: Hydrologic soil group distribution used in the Napa County SWB model.



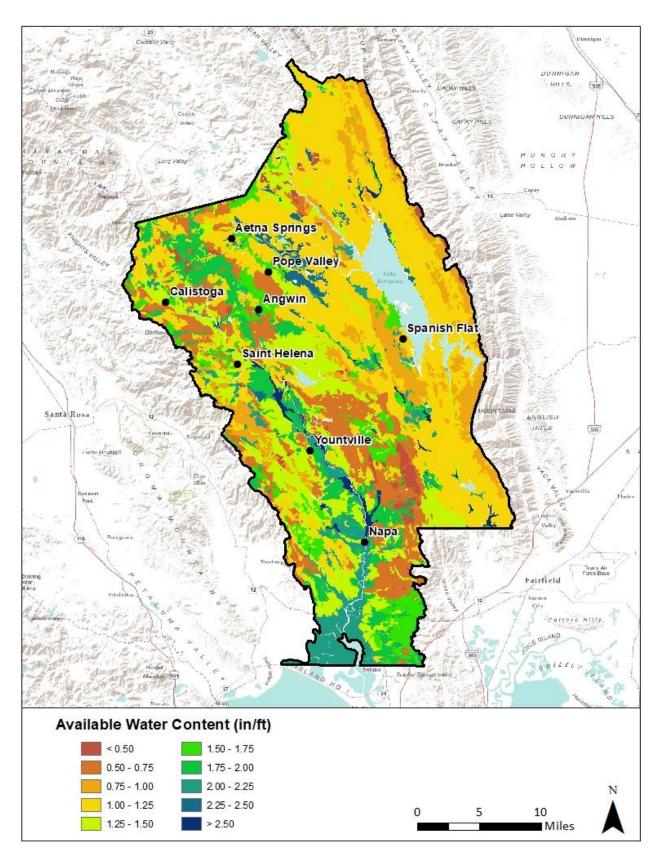


Figure 3: Available water capacity distribution used in the Napa County SWB model.



Land Cover		eption Values ()	Curve Number by NRCS Soil Type ()				Rooting Depth by NRCS Soil Type (ft)				
	Growing Season	Dormant Season	Туре А	Туре В	Туре С	Type D	Туре А	Туре В	Туре С	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 1: Soil and land cover properties used in the Napa County SWB model.

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

Soil Group	Infiltration Rate (in/hr)
А	> 0.3
В	0.15 - 0.3
С	0.05 - 0.15
D	<0.05

SOIL MOISTURE RETAINED, IN INCHES

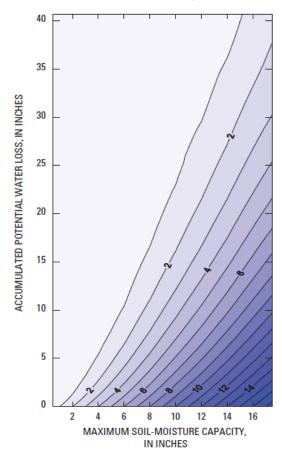


Figure 4: Soil-moisture-retention table (Thornthwaite and Mather 1957).



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).

Station	Data Used	1981 - 2010 Mean Annual Precip (in)	WY 20 Precip (in)	010 % Avg	WY 2014 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%	

Table 3: Weather stations used in the Napa Count	y SWB model. See Figures 7-9 for associated timeseries.
Tuble 5. Weather Stations asea in the Hapa count	y styp model see ngares / s for associated inteseries.

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



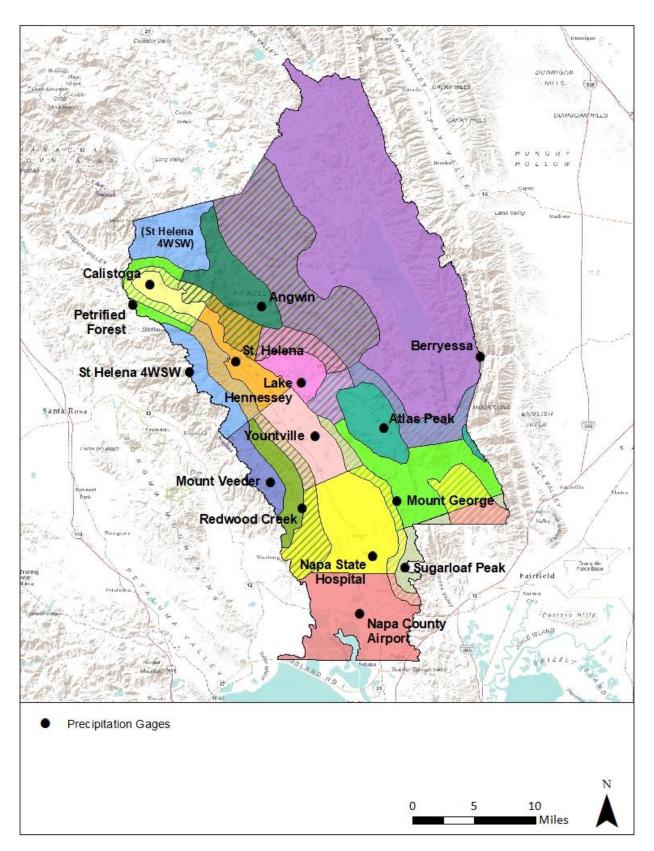


Figure 5: Precipitation zones used in the Napa County SWB model. Hatching indicates areas where two precipitation records were averaged across a zone.



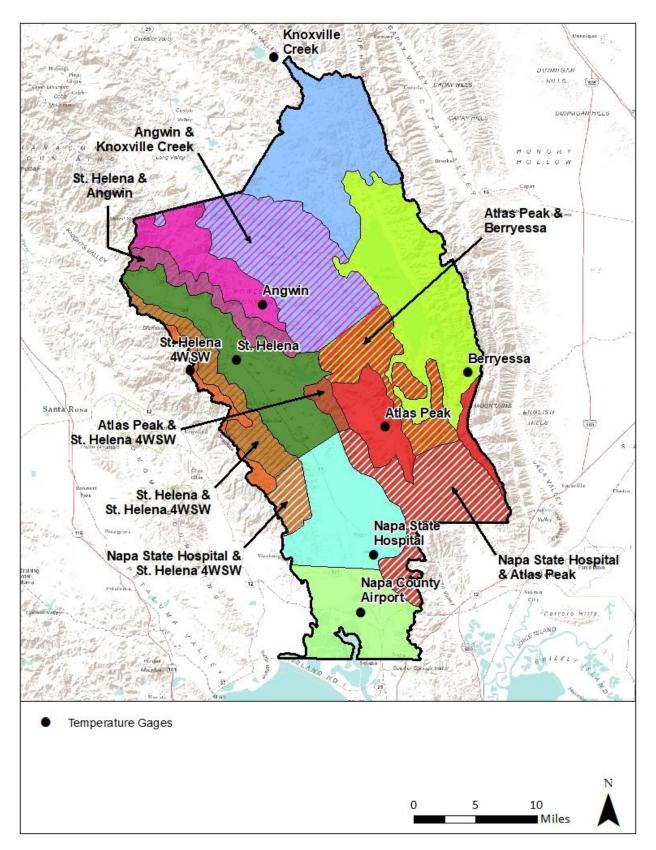


Figure 6: Temperature zones used in the Napa County SWB model. Hatching indicates areas where two temperature records were averaged across a zone.



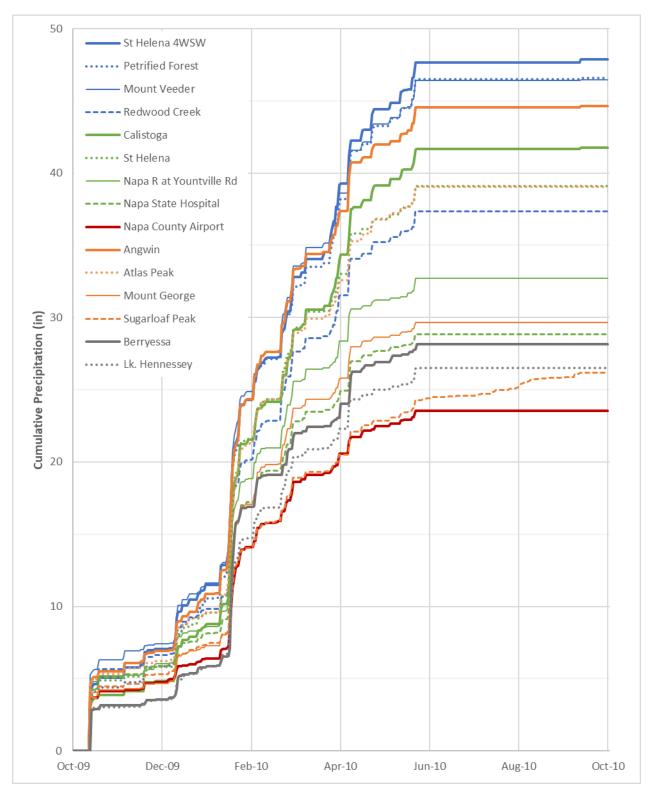


Figure 7a: Daily precipitation data used in the Napa County SWB model for WY 2010.

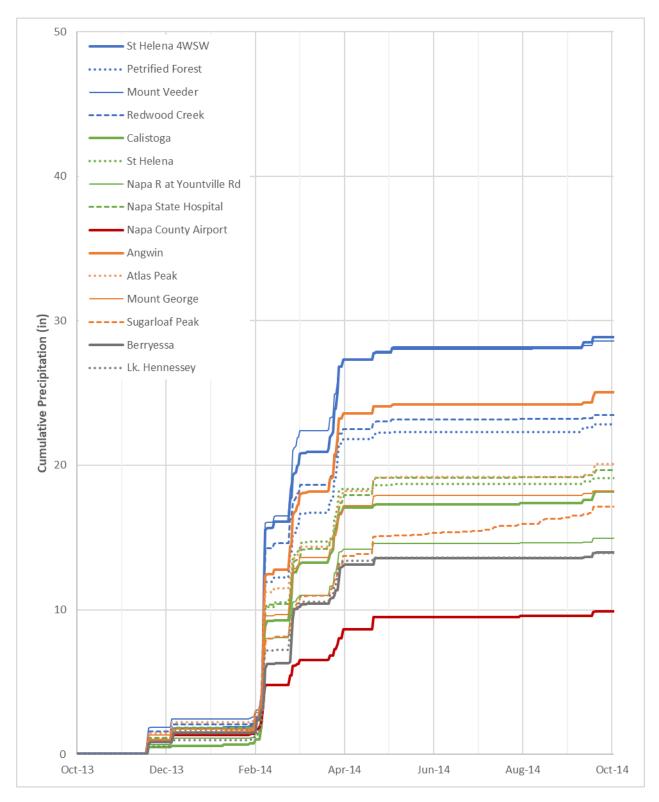


Figure 7b: Daily precipitation data used in the Napa County SWB model for WY 2014.

OEI

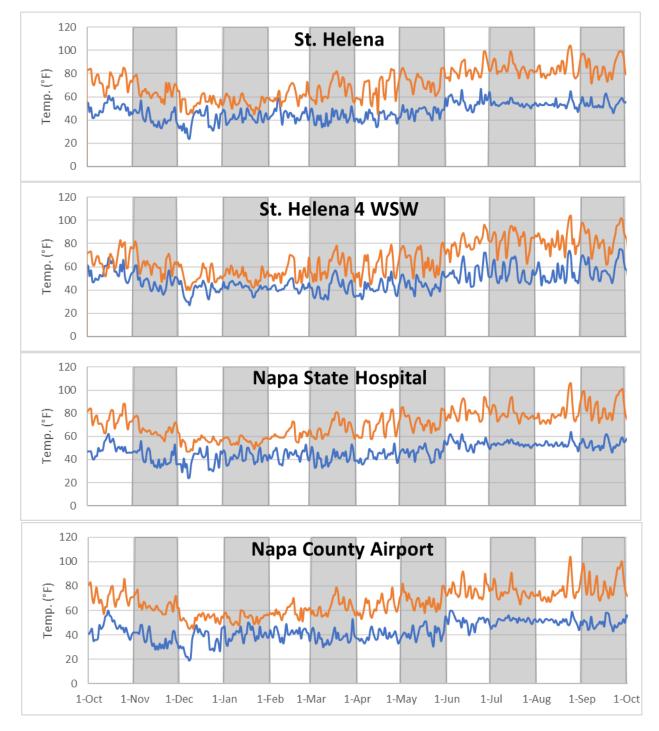


Figure 8: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.



DRAFT

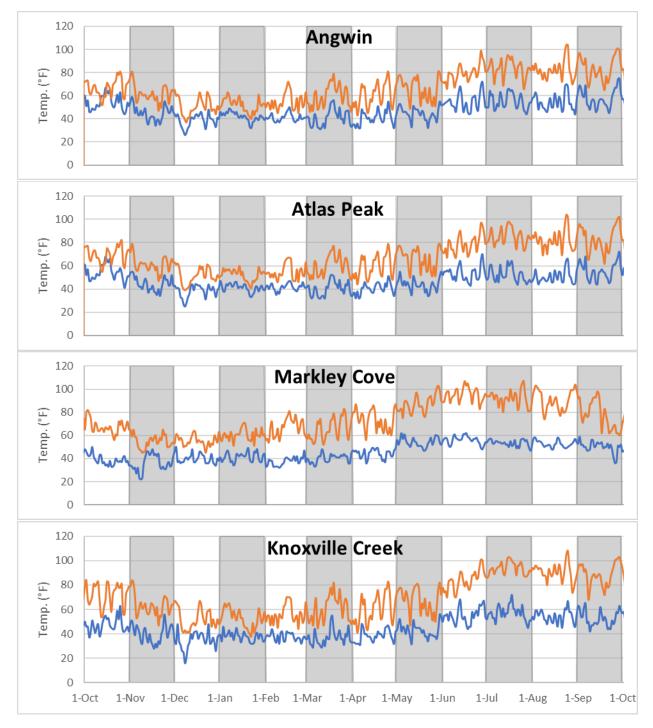


Figure 8 – cont.



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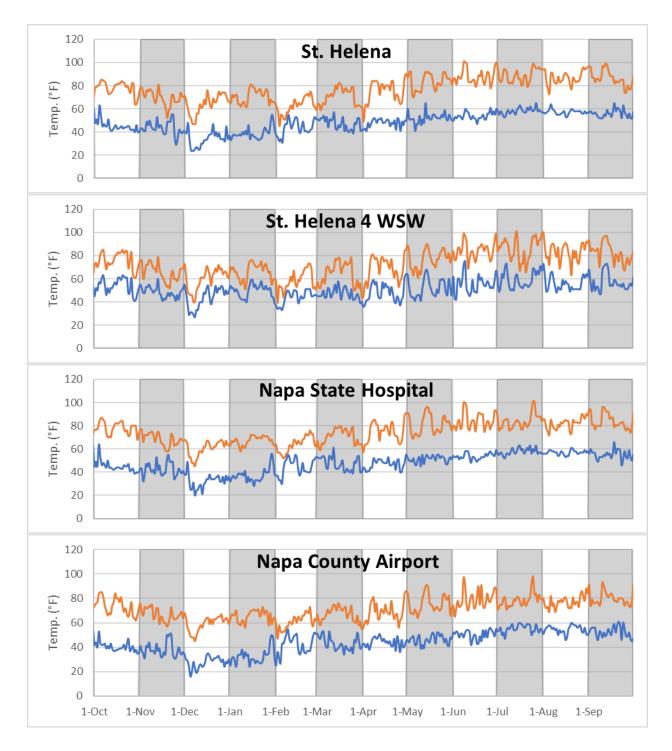


Figure 9: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.



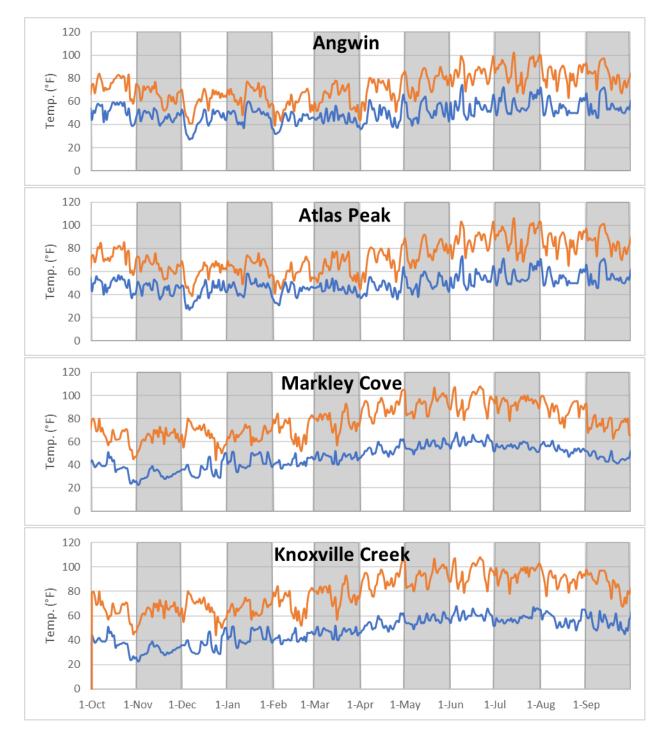


Figure 9 – cont.



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 ($1.2 - 14.3 \text{ mi}^2$) 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.

USGS Gage	HUC	Mean Precip, 2010 (in)		ET, 2010 ecip)		Runoff, 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%

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

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 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.



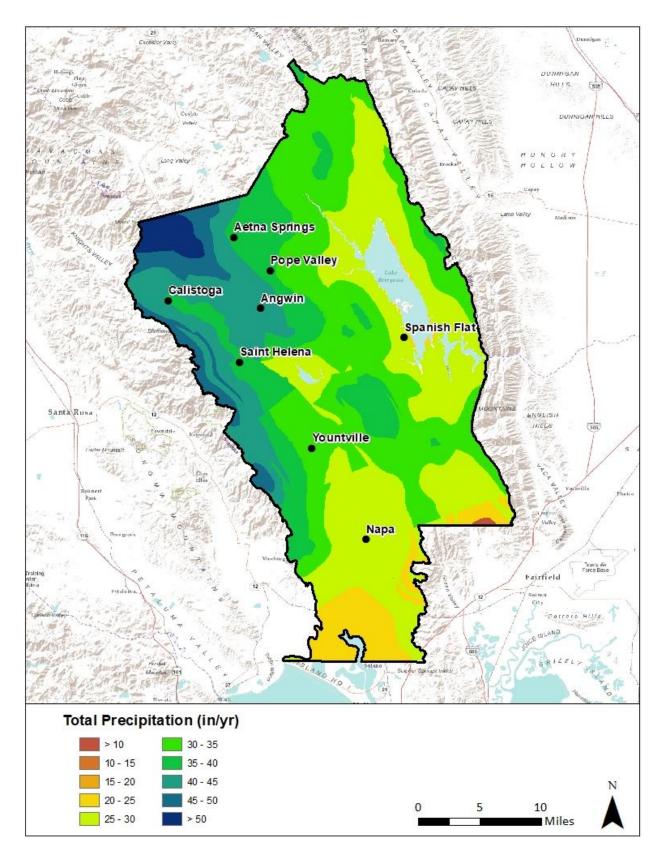


Figure 10: Water Year 2010 precipitation simulated with the Napa County SWB model.



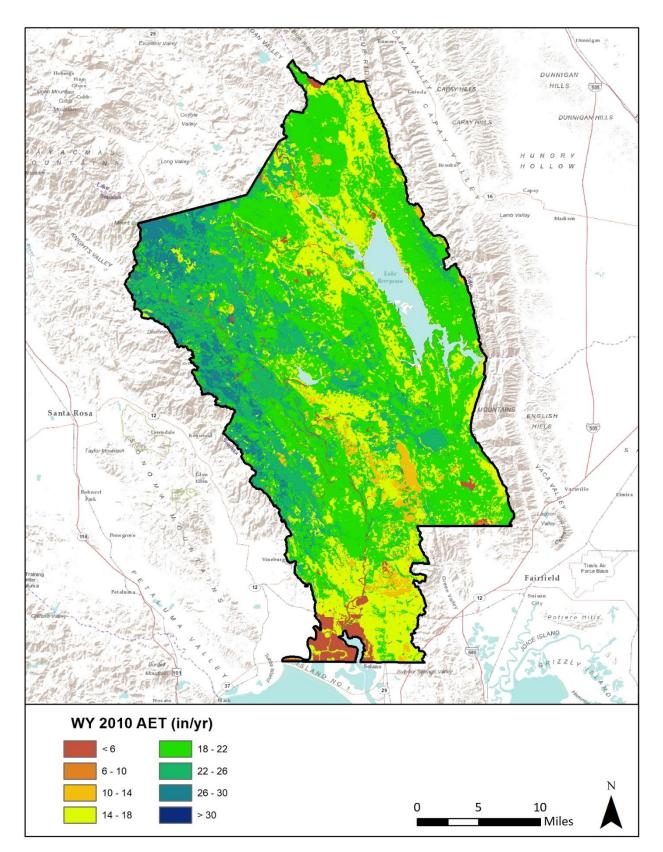


Figure 11: Water Year 2010 AET simulated with the Napa County SWB model.



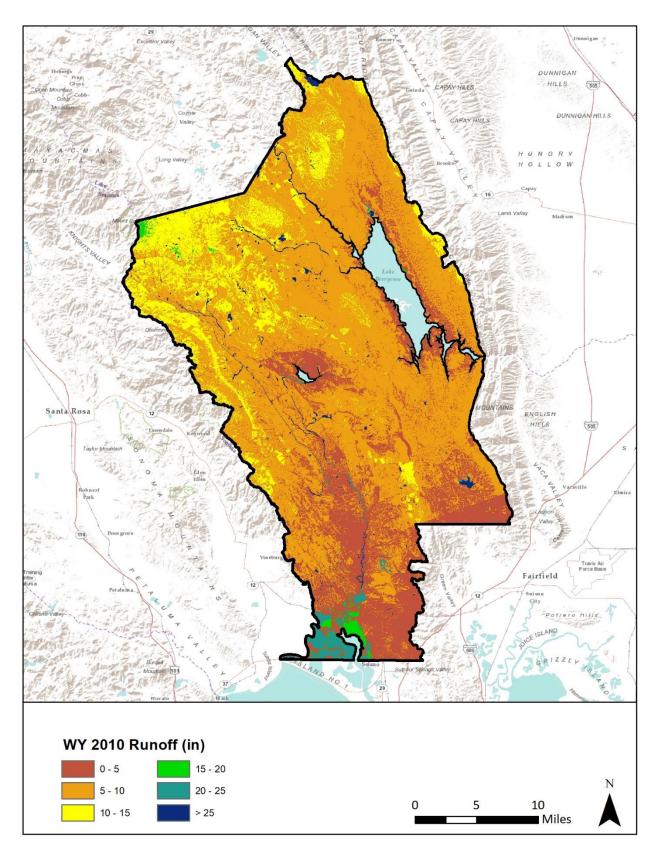


Figure 12: Water Year 2010 runoff simulated with the Napa County SWB model.



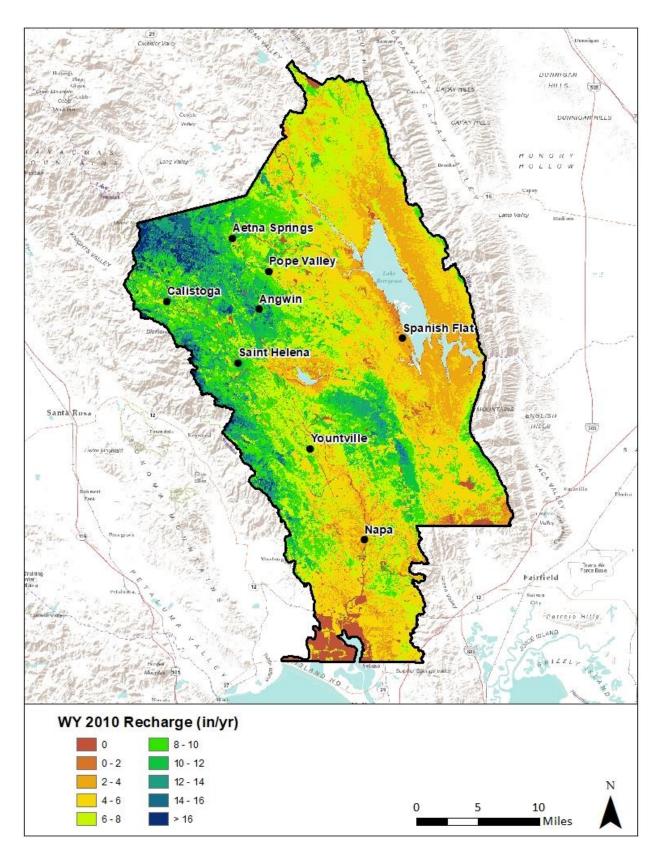


Figure 13: Water Year 2010 recharge simulated with the Napa County SWB model.



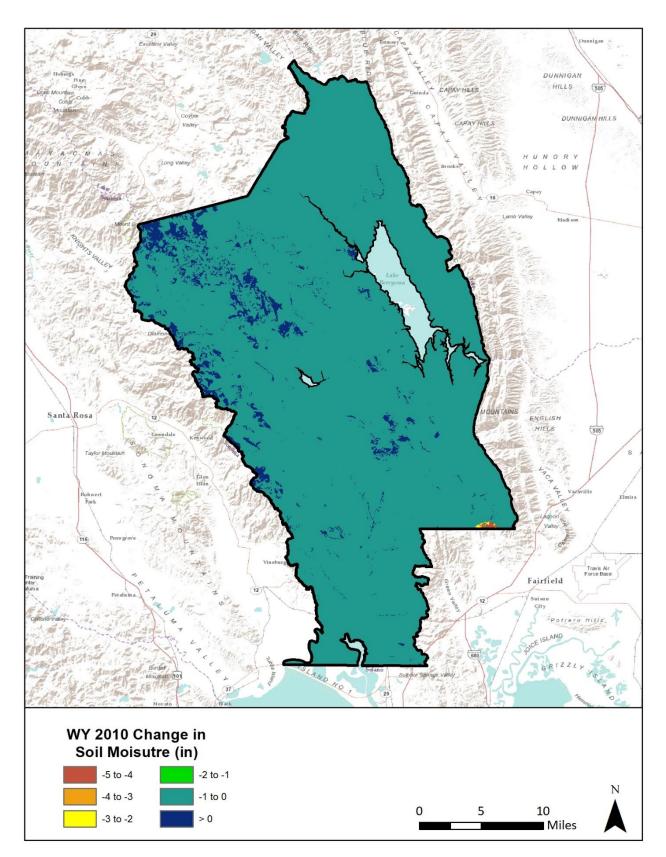


Figure 14: Water Year 2010 change in soil moisture content simulated with the Napa County SWB model.



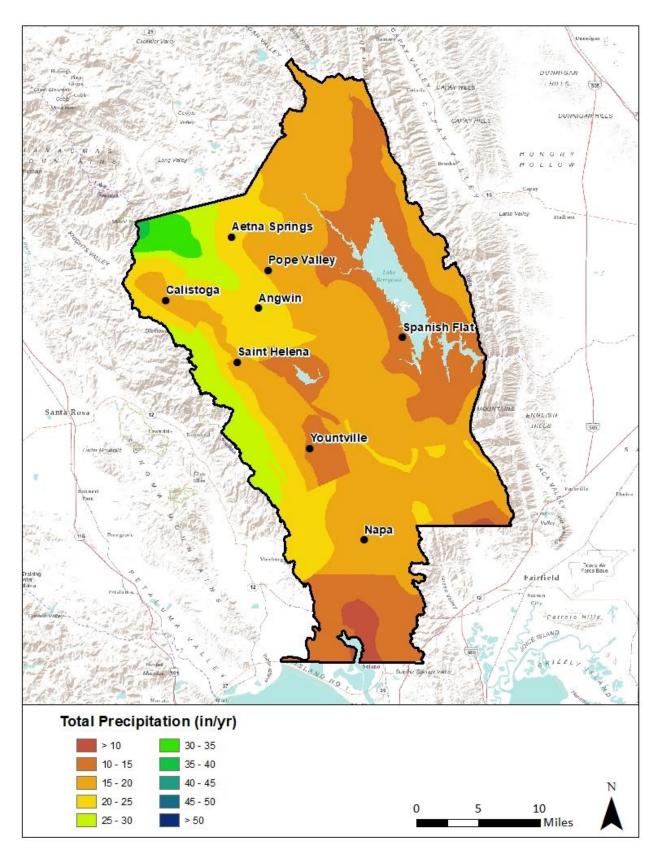


Figure 15: Water Year 2014 precipitation simulated with the Napa County SWB model.



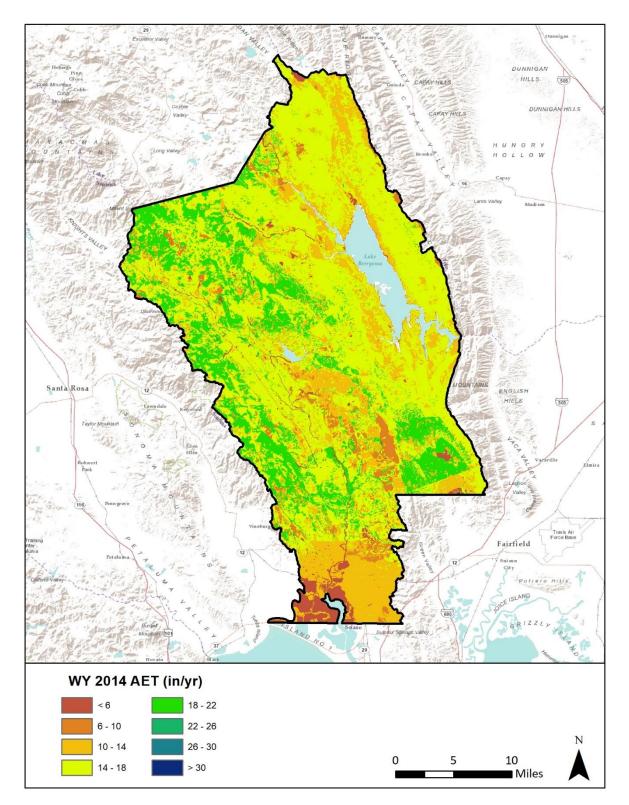


Figure 16: Water Year 2014 AET simulated with the Napa County SWB model.



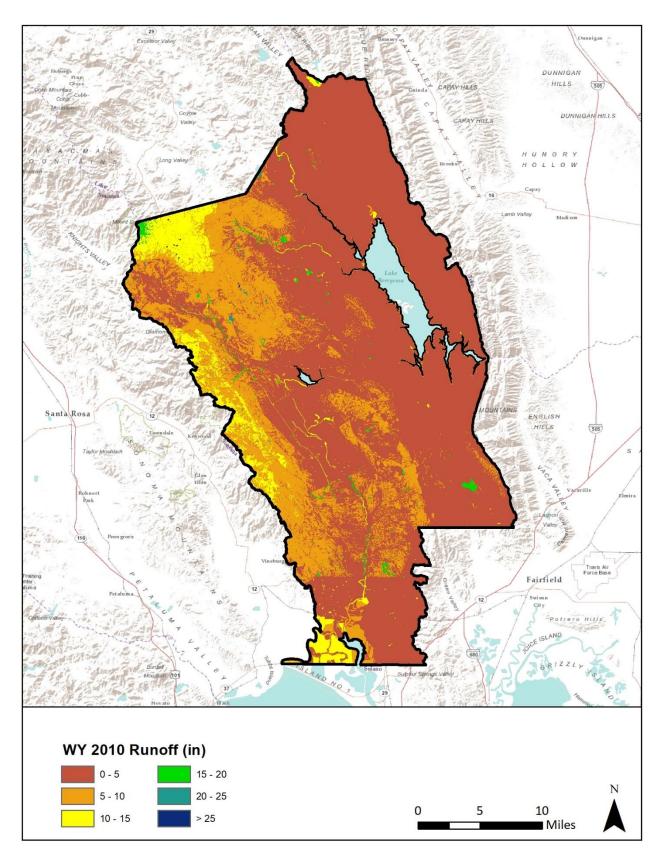


Figure 17: Water Year 2014 recharge simulated with the Napa County SWB model.



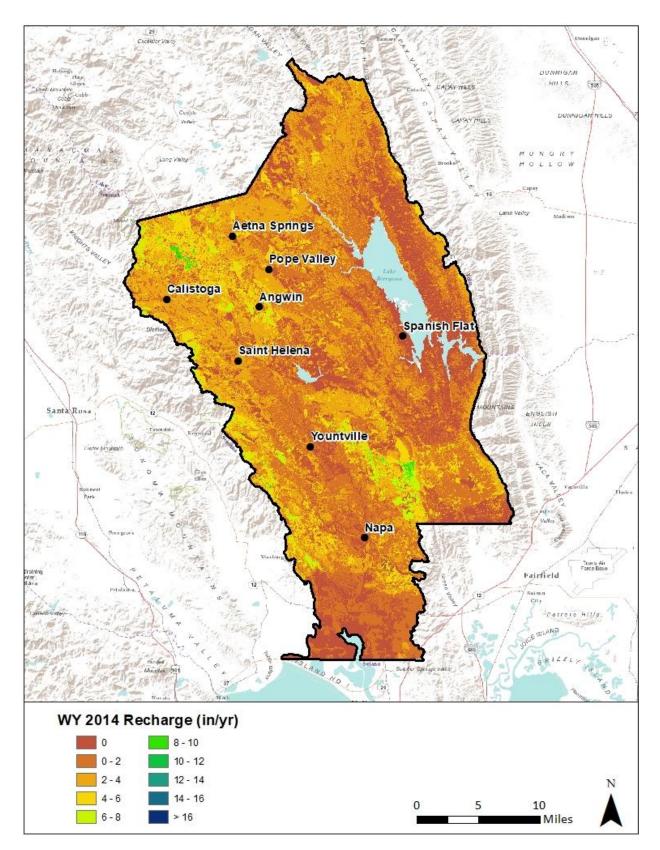


Figure 18: Water Year 2014 recharge simulated with the Napa County SWB model.



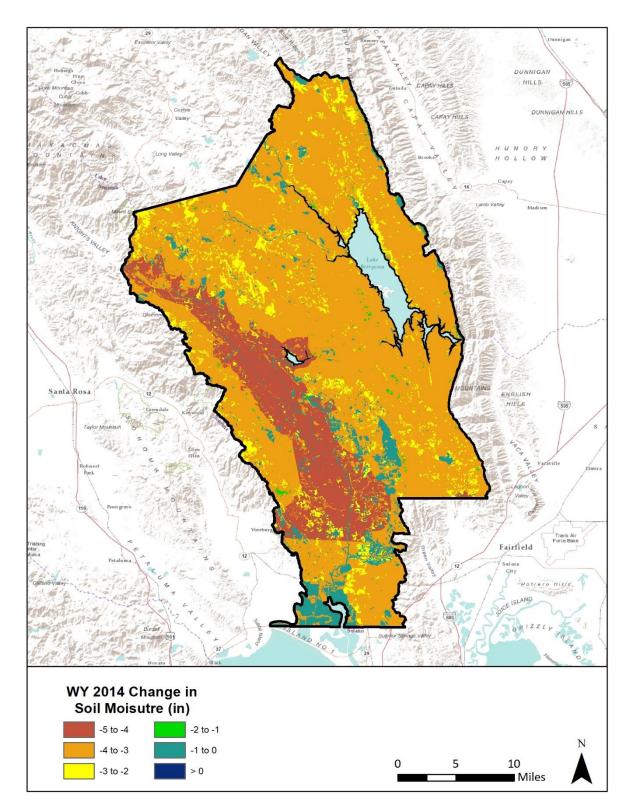


Figure 19: Water Year 2014 change in soil moisture content simulated with the Napa County SWB model.



 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%



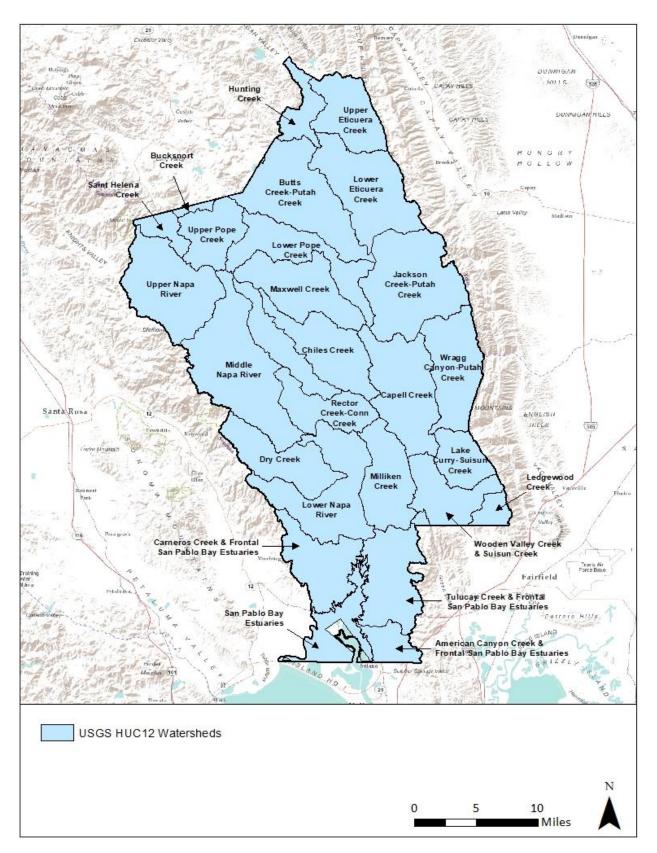


Figure 20: Major watersheds areas used to summarize water budget information in Tables 5 - 8.



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 Inclusion of baseflow with direct runoff in these calculations may from groundwater. inappropriately reduce the estimated volume of water infiltrated into the soil and available for recharge; the LSCE approach therefore tends to underestimate groundwater recharge. 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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