Water Availability Analysis
Schramsberg Vineyards

APN's 020-390-007, 020-390-008, 020-390-011, 020-390-014, 020-390-015, and 020-390-017

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Introduction

Schramsberg Vineyards is planning to convert forest and grassland to develop 11 gross acres of vineyard on the subject property. The subject property is located at 1400 Schramsberg Road and consists of six contiguous parcels (Napa County APN's 020-390-007, 020-390-008, 020-390-011 020-390-014, 020-390-015, and 020-390-017) approximately 2.5 miles southeast of Calistoga (Figure 1). The subject property comprising a total of 225 acres contains approximately 44.9 acres of existing vineyards, three residences and the Schramsberg Vineyards Winery. Several wells provide water for the various existing water uses; the location of the water supply wells (Wells 1 through 4) are shown in Figure 2. Water for the proposed vineyard areas will be supplied by all four wells.

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), an analysis of the potential for well interference at neighboring wells located within 500-ft of project Well 1 (Tier 2), and an analysis of the potential for well interference at surface water bodies within 1500 feet of the project wells (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 and Napa County, 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.

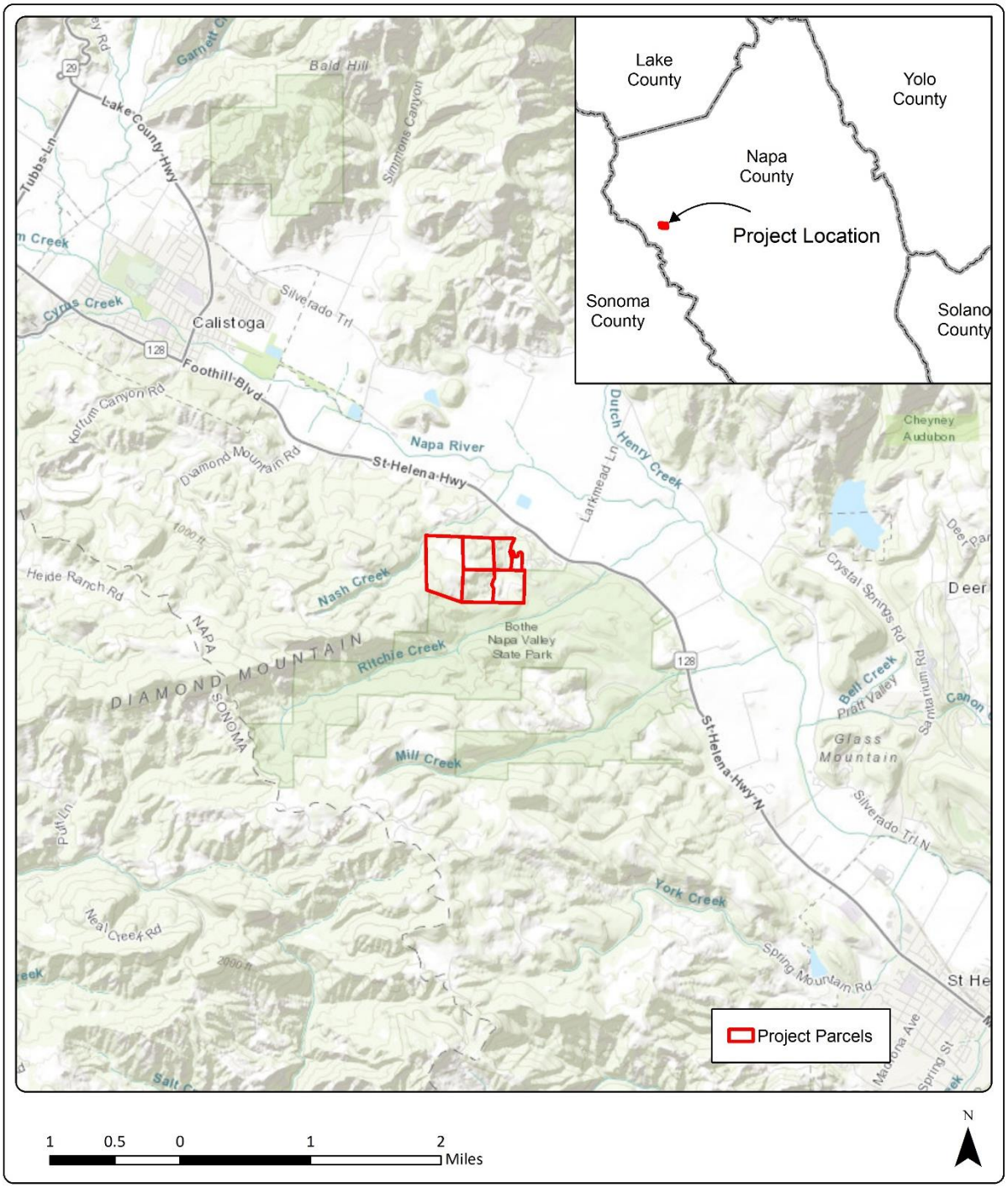


Figure 1: Project location map

Hydrogeologic Conditions

The contiguous block of project parcels are located approximately 2.5 miles southeast of Calistoga at the foot of Diamond Mountain in the northwestern portion of the Napa Valley sharing a portion of its southern and eastern boundaries with the Bothe-Napa Valley State Park (Figure 1). Bedrock geology mapped in the area of the project parcels is typical of the mountains and hills located near Calistoga in the northern Napa Valley. The main geologic unit mapped at the project site and primarily intersected by the wells on the project parcels (Wells 1-5) is the Rhyolite of Calistoga of the Tertiary-aged Sonoma Volcanics (Map unit Tsrc, see Figure 2). This portion of the Tsrc unit is part of an approximately 2 square-mile block bound to the south, west and east by a fault contact with the Tuff of the Petrified Forest (map unit Tstp), a similarly aged unit of the Sonoma Volcanics and to the north by younger Quaternary-aged stream terrace (unit Qt), alluvial fan (unit Qhf) and fluvial and lacustrine deposits (QTg). The Tsrc unit forms dome-shaped hills that dot the landscape in and around Calistoga and is described as highly variable assemblages of massive or flow banded rhyolite; intercalated crystal and lithic tuff, and lithoidal welded tuff grading to vitrophyre, locally perlitic; and agglomerate with glassy bombs (Delattre and Gutierrez, 2013).

The Tuff of the Petrified Forest (unit Tstp) is mapped in fault contact with the Tsrc to the south of the project parcels. This unit is coeval with the Tsrc unit and is described as a thick section of silicic tuff, tuff breccia, and agglomerate with several intercalated andesitic to dacitic lava flows (Delattre and Gutierrez, 2013).

Several thin outcrops of younger Unnamed fluvial and lacustrine deposits (unit QTg) unconformably overlie the Tsrc unit in and around the project parcels (Figure 2). This unit consists of weakly consolidated gravel, tuffaceous sand, silt and clay. This unit is not considered to be part of the project aquifer.

A landslide (Qls) is mapped on the northeastern project parcel. The location of this landslide was not investigated as a part of this study. Field observations and an evaluation of the potential impacts to the proposed project will be summarized if necessary, in a separate Landslide Hazard Evaluation by O'Connor Environmental Inc.

In general, wells drilled in the Sonoma Volcanics tend to have low to moderate yield. Typical yields range from 16 to 50 gallons per minute (gpm) with reported yields as high as several hundred gpm (LSCE 2013). Unwelded sections of tuff are considered good water producers (DWR 1982). Denser bedrock units such as the Rhyolite of Calistoga typically have low primary porosity and are only water-yielding where fractured (DWR 1982).

Several west-to-east trending faults are mapped traversing the project parcels (Figure 2). Mapping by CGS indicates the northern two of these are approximately located normal faults with the downthrown blocks located on the north (downhill) side of the faults. The southern two are inferred with the northern fault mapped as a normal fault with the downthrown block to the

north. Faults can act as conduits or barriers to the flow of groundwater. These faults are not mapped as active in any State database. Although we have recognized their mapped locations, we do not have any additional information that would help us interpret their potential impacts upon the local hydrogeology. As such, for the purposes of this hydrogeologic analysis we will be ignoring any potential effects the mapped faults may have.

Well Data

Our search of the Department of Water Resources and County of Napa records found a total of 22 Well Completion Reports for wells completed in similar geology and located within approximately one mile of the project parcels. Well locations on the project parcels (Wells 1-5) were identified by Schramsberg Vineyards personnel; the remaining wells on surrounding parcels were located using the locations marked on the well logs as guidance and then confirmed using aerial photos of the area. Well locations are shown in Figure 2. Relevant well information was compiled and summarized (see Table 1 and Appendix A).

Table 1: Well completion details for the wells on the project parcels (Wells 1 - 5) and nearby wells.

Well Number	1	2	3	4	5	6	7	8	9	10	11
Year Completed	2008	1974	1987	2005	1978	1988	2004	2012	2013	2003	2000
Depth (ft)	490	202	245	620	420	405	560	455	500	470	495
Estimated Yield (gpm)	40	30	40	180	10	75	70	30	12	75	30
Static Water Level (ft)	200	10	45	120	200	210	147	160	60	230	200
Top of Screen (ft)	246	100	145	210	260	200	120	135	115	80	235
Bottom of Screen (ft)	486	202	245	610	420	405	560?	455	475	450	435
Geologic Unit	Qls/Trsc	Tsrc	Tsrc	Tsrc	Qls/Tsrc	Tsrc/QTg	Tsrc/adf	Tsrc	Tsrc	Tsrc	Tsrc

Well Number	12	13	14	15	16	17	18	19	20	21	22
Year Completed	2013	2001	1981	2017	2012	2014	2014	1991	1999	1991	2014
Depth (ft)	690	484	440	400	320	500	490	335	595	430	500
Estimated Yield (gpm)	40	60	12	30	20	150	80	50	45	30	97
Static Water Level (ft)	420	60	150	103	130	20	0	50	90	120	0
Top of Screen (ft)	180	310	220	290	120	100	77	215	160	110	100
Bottom of Screen (ft)	660	465	440	390	320	500	490	335	588	430	500
Geologic Unit	Tsrc	Tsrc	Tstp	QTg?	QTg?/Qhf	Tsrc/QTg?	QTg?	QTg?	Tsrc/QTg?	Tsrc	Tsrc

All wells identified were productive. Well bores range from 202 to 690 feet deep, with an average depth of about 476 feet. Geologic materials encountered in all wells are described by drillers as various volcanic rock of varying colors interbedded with ash and some clays of varying color. These descriptions are consistent with what we would expect in an area mapped as rhyolitic lavas within a larger geologic formation made up of various volcanic rocks. All logs indicate that drillers did not encounter the bottom of the Sonoma Volcanics. Reported static water level for most wells and levels ranged between 0 and 420 feet below ground surface with an average depth of 128 feet. Well yields reported on Well Completion Reports ranged from 10 to 180 gallons per minute, with an average of 55 gallons per minute. Typically, operational well yields are about half or less compared to yields reported on Well Completion Reports. There are four operational project wells (Wells 1-4) that serve various needs on the project parcels.

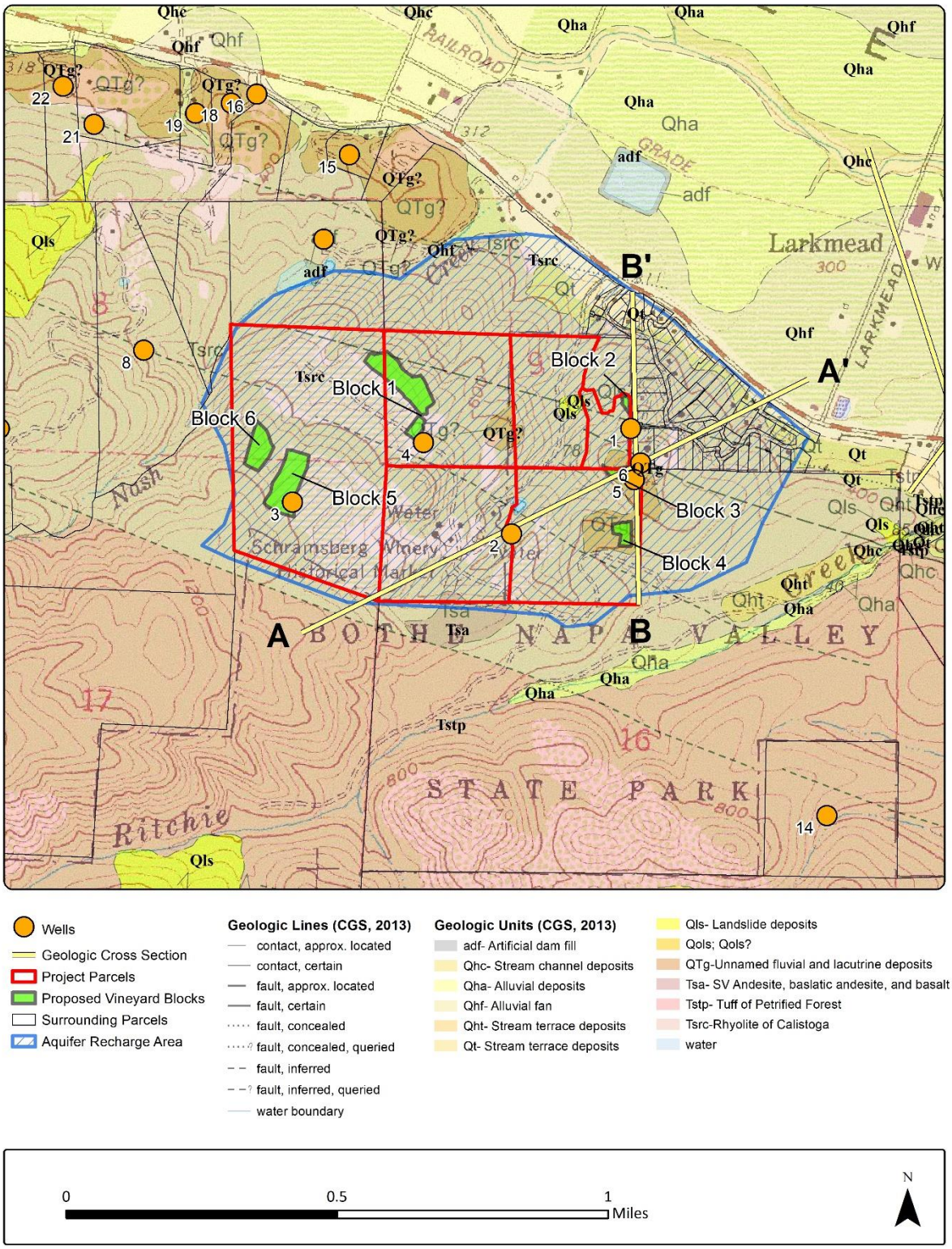


Figure 2: Surficial geology and locations of wells on and near the project parcel. Surficial geology based on data from the Preliminary Geologic Map of the Calistoga 7.5" Quadrangle, Napa and Sonoma Counties, California (Delattre and Gutierrez, 2013).

Well 1, is also known as the Claes Well and is located on parcel number 020-390-017. This parcel has a residence and the 4.4-acre Claes Vineyard. Water for this residence and vineyard is supplied by Well 1 which was drilled in 2008 to a depth of 490 ft and completed to a depth of 486 ft. The geologic log describes a sequence of brown ash, clay and gray rock for the first 75 ft, brown clay and red ash and gray rock were encountered between 75 ft and 140 ft, and a sequence of ash strata of various colors and thicknesses makes up the remaining 350 ft down to a depth of 490 ft. The sequence of rocks described in this log is consistent with more tuffaceous portions of the Rhyolite of Calistoga and similar tuffaceous units within the Sonoma Volcanics in general. Well 1 is screened between 286 ft and 486 ft. The Well 1 well log reports depth to first water as 230 ft and a static water level of 200 ft after development in May 2008. At the time of development, the well was pumped using airlift methods at an estimated rate of 40 gpm for 4 hours; drawdown was not reported.

Well 2 is also located on the project parcel southwest of Well 1 (APN 020-030-015) and is known as the McEachran Well. This well serves the Schramsberg Winery, the McEachran Vineyards and all residences on the project parcels outside of the Claes Vineyard residence. The McEachran Well was completed in 1974 to a depth of 202 feet. The well is completed in materials consistent with what would be expected in the Sonoma Volcanics and includes “soft rock” (presumed to be ash strata) of varying colors interlayered with harder “stringers” and rock strata. The screened interval begins at a depth of 100 ft and extends to the bottom of the well at 202 ft. Water was first encountered at 24 feet within a 94-foot-thick layer of “Soft brown Rock w/Hard Stringers”. After development of the well the reported static water level was 10 feet below ground surface. After six hours of pumping the well driller reported an estimated yield of 30 gallons per minute with a drawdown of 40 ft.

Well 3 is known as the Mt. Diamond Well and is located on the westernmost project parcel (APN 020-390-007). The well log reports that the well was drilled in 1987 to a depth of 245 feet. Materials encountered during drilling include interlayered strata of clay-rich ash and hard volcanic rock, consistent with the mapped geology. At the time of development, the static water level was 45 feet and after 3 hours of pumping at an estimated discharge of 40 gpm a drawdown of 55 feet was reported. In August 2019 a static water level was measured at 88.4 ft below ground surface; it is unknown how recently the well had been pumped prior to this measurement, but we believe that the well was generally in service at that time. Well 3 serves as one of the primary water sources for the vineyards and as a secondary well for the Schramsberg Winery, the McEachran Vineyards and all residences on the project parcels.

Well 4 is known as the Tractor Shed Well and is located on the north-central parcel (APN 020-390-008). Well 4 was drilled in September 2005 to a depth of 620 ft and completed to a depth of 610 ft. The depth to first water is reported to be 150 ft with static water at 120 ft after development. An airlift pump test was performed at the time of development pumping at an estimated rate of 180 gpm for 5 hours. Drawdown was not reported. The well log reports materials consistent with the mapped geology of the Sonoma Volcanics including brown ash, gray volcanic rock followed by gray clays and ash and then various colors of ash and fractured rock.

Well 4 supplies water to various vineyard areas, the winery, and residences across the project parcels.

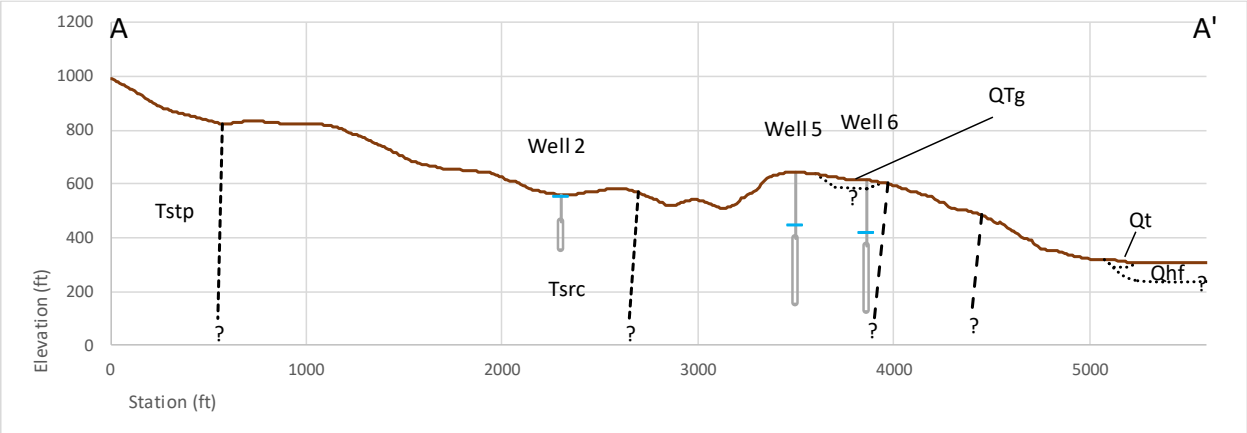
Well 5 is located at the top of the hill directly south of Well 1 on project parcel APN 020-030-015. This well was drilled in 1978 to a depth of 420 feet. Materials reported in the well log are consistent with rocks of the Sonoma Volcanics. Although this well was productive at the time of drilling with an estimated yield of 10 gpm it has since become less productive and is not presently used for irrigation, nor are there plans to use Well 5 for irrigation in the future.

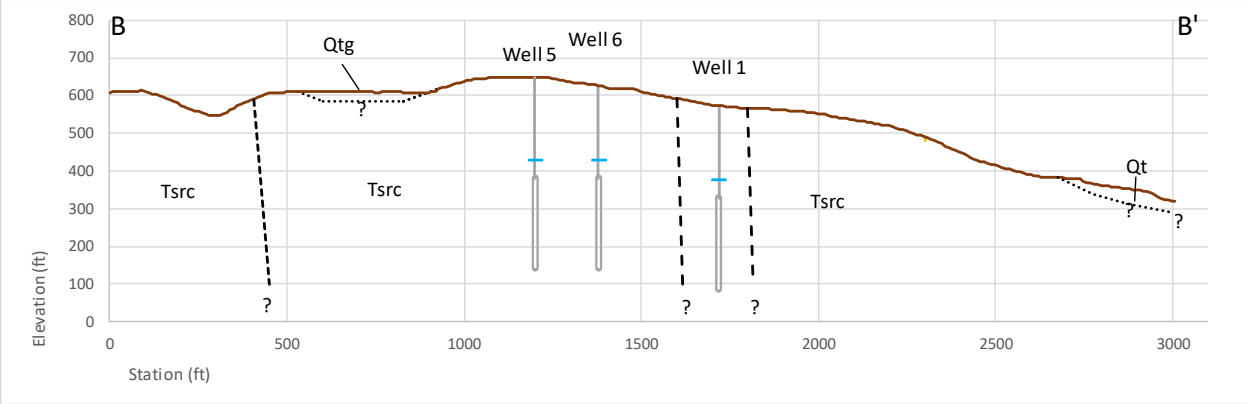
Well 6 is located on the neighboring parcel APN 020-271-007 just east of the Claes Vineyard parcel (Figure 2) and is the water source for the Tucker Acres Mutual Water Company. According to California Department of Water Resources (Appendix B) the Tucker Acres Mutual Water Company serves 200 people through 23 service connections. It is assumed that these connections are to the residential parcels east of the project property. Well 6 was drilled in 1986 to a depth of 405 feet and penetrates strata of brown and black ash and rock in the upper 220 feet of the boring. Gray rock with brown ash is reported from 220 feet to 320 feet where gray rock and green ash begin and extend to the bottom of the well. Depth to first water was reported as 245 feet while the static water level was at 210 feet after well completion. At the time of development, a 4-hour pumping test was performed. After pumping at a rate of 75 gpm, drawdown of 190 feet was recorded yielding specific capacity of 0.39 gpm/ft.

Geologic Cross Sections

Two geologic cross sections are shown in Figure 3 (see Figure 2 for locations). Cross Section A-A' is oriented west to east and shows the locations of Well 2 (the McEachran Well) and Well 5 along with the neighboring Well 6 (Tucker Acres Mutual Water Company Well). Water surface elevations shown are those reported at the time of well development. The upper limit of the conceptualized recharge area for the project aquifer extends to the western-most fault contact at approximately Station 500 ft (Figure 3).

Cross section B-B' is oriented south to north and shows the locations of Well 5, Well 1 (Claes Well) along with the neighboring Well 6 (Tucker Acres Mutual Water Company Well). All three wells reported similar depths to water and are screened at similar depths with Well 1 penetrating approximately 130 feet deeper than Well 6. Faults shown are inferred (southern-most fault) and approximately located. Impacts of these faults upon groundwater flow are unknown. Faults can act both as groundwater flow conduits and barriers however no conclusions regarding their influence have been made for this analysis. Potential impacts from proposed increases in pumping of Well 1 upon Well 6 are discussed in a separate section of this report; faults are presumed to have no effect on groundwater.



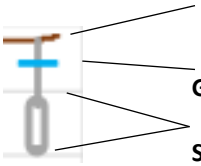


Contacts: ?---------- **Contact, Approximately Located, Queried where uncertain**

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Well



Ground surface

Groundwater Elevation

Screened Section of Well

Figure 3: Hydrogeologic cross section A -A' and B–B' through the vicinity of the project parcel (see Figure 2 for locations). Note different scales for each cross section.

Project Aquifer

The extent of the project recharge/project impact area is defined in part by surface water drainage patterns and in part the extent of local geologic units along with potential impact areas associated with the five wells on the project parcels. The southern boundary of the project recharge area is defined by the fault contact between the Tsrc and the Tstp units while the northern boundary is defined topographically at the base of the hills along State Highway 128. The northwestern and eastern boundaries of the project aquifer are defined by surface drainages. To the northwest the flow line of Nash Creek is used as a boundary while to the east the boundary is drawn along the flow line of convergent topography draining to the north which is considered a the reasonable extent of potential impact of Wells 1 and 5.

The total area of the project aquifer is 348 acres. The recharge area is underlain by the Tsrc unit of the Sonoma Volcanics. The wells on the project parcels (Wells 1-5) are all screened within the Sonoma Volcanics. Given that the majority of depths to groundwater are relatively great and that impermeable layers of material including clays are reported in local drillers logs and are known to be present within the Sonoma Volcanics, the project aquifer is likely confined or semi-confined.

Water Demand

Within the project recharge area, water demand was estimated for both the existing and proposed conditions. Water use by the vineyards, wineries and residences located on the project parcels owned by Schramsberg Vineyards was determined using site details provided by Schramsberg Vineyards. The project recharge area also includes portions of 62 neighboring parcels. Use on these parcels was estimated based on Napa County assessor's parcel, agricultural and winery GIS database information along with satellite imagery. Uses within the recharge area include winery use, residential use and irrigation for vineyards and gardens.

Existing Use

In the existing condition, the project parcels (APN's 020-390-007, 020-390-008, 020-390-011 020-390-014, 020-390-015, and 020-390-017) contain three residences, 44.9 acres of vineyard, a small garden and a winery. The demand of the moderately sized single-family residences was reported by the applicant as 0.5 acre-ft annually each; this rate is in the low range provided from the County of Napa's Water Availability Analysis Guidance Document dated May 12, 2015 for single family dwellings.

The existing 44.9 acres of vineyard are located on portions of five of the six project parcels. Schramsberg Vineyards reports annual water demand for vineyards to be 0.20 acre-ft/acre resulting in a demand of 9.0 acre-ft/yr.

Currently the Schramsberg Vineyards winery is permitted to for annual production of 180,000 gallons with a total of 39 full time employees. Based on Napa County water use guidelines, demand for winery processing water is 2.15 acre-ft per 100,000 gallons of wine while winery domestic and landscaping demand is an additional 0.5 acre-ft per. Annual production of 180,000

gallons corresponds to winery demand of approximately 4.8 acre-ft. Employee daily use is estimated to be 15 gallons per employee per Napa County. Assuming the 39 employees work five days a week all year (260 days) the total demand equals 0.47 acre-ft annually in addition to the 4.8 acre-ft required by the winery (Table 2).

Daily tours and tastings at the Schramsberg Vineyards winery are approved to host a maximum of 34,944 tasting visitors annually. We have assumed that business office visitors are included in this total. For marketing events that include on-site catering Schramsberg is approved for several events with varying numbers of guests with an annual maximum of 1,730 guests. Napa County guidance assumes daily water use of 3 gallons per tasting/office visitor and 15 gallons per visitor for marketing events. Based on these rates the existing maximum annual demand for all 36,674 visitors to the winery is 0.4 acre-ft (aggregated average of 3.55 gallons per visitor).

Schramsberg Vineyards also maintains 4 acres of garden and orchard areas irrigated with groundwater. The applicant reports water demand of 4 acre-ft per acre (from Napa County Guidance (2015)) which results in a total demand of 16 acre-ft annually (Table 5) for the garden and orchard areas.

Considering the uses above, the existing water use on the Schramsberg Vineyards parcels totals 32.1 acre-ft/yr (Table 2).

Table 2: Existing and proposed groundwater uses associated with the Schramsberg Vineyards Parcels.

Schramsberg Vineyards Parcels	Residential Use (acre-ft/yr)	Irrigation Use (acre-ft/yr)	Winery Use (acre-ft/yr)	Employee Use (acre-ft/yr)	Event Use (acre-ft/yr)	Total Use (acre-ft/yr)
Existing Use	1.5	25.0	4.8	0.47	0.40	**32.1**
Proposed Use	1.5	27.2	4.8	0.47	0.40	**34.3**

In addition to uses on the Schramsberg Vineyards parcels, use on the surrounding parcels within and intersecting the project recharge area includes 39 residences and associated landscaping, vineyard, and the Castello De Amorosa winery. The Castello De Amorosa winery is located on a parcel along the northern edge of the project recharge area and only the southern portion of the parcel is intersected by the project recharge area. Figure 2 shows the Castello De Amorosa well (Well 7) outside of the recharge area however, the exact location of Well 7 is unknown so to be conservative the estimated water use associated with the winery is included in the total use calculations for the project recharge area. Four residences are large and are assumed to have a demand of 0.75 acre-ft per year, the upper limit suggested by Napa County guidance for residential use (Table 4). The other 35 residences are located on parcels east of the project area and appear to be of modest size; consequently, a demand of 0.5 acre-ft per year (similar to that of the Project parcel residences) is applied. Lawn and landscaping areas above the first 1,000 ft^2 on these parcels total to 1,400 ft^2 (Table 4).

A total of 33.4 acres of vineyard is located on or connected to non-project parcels with wells within the project recharge area. Assuming annual vineyard irrigation demand of 0.5 acre-ft per

acre per year per Napa County Guidance, the 33.4 acres of vines would require 16.7 acre-ft annually.

Water use for the Castello Di Amorosa winery was estimated using information reported in the Napa County Winery GIS shapefile. The current information associated with the permit for Castello Di Amorosa shows an annual production of 250,000 gallons with 6 employees which amounts to a total winery demand of 6.7 acre-ft. Tastings are public and a maximum of 31,200 visitors are allowed annually. No marketing event visitors are listed. Assuming usage of 3 gallons per visitor for tastings the maximum visitor use for Castello Di Amorosa is 93,600 gallons (0.29 acre-ft) annually.

Based on these uses, the existing water demand within the project recharge area is estimated to be 76.5 acre-ft/yr (Table 3). Residential water demand is estimated to be 22.7 acre-ft/yr (Table 4), irrigation demand is estimated to be 41.7acre-ft/yr (Table 5), winery use is estimated to be 11.4 acre-ft/yr (Table 6) winery guest use is estimated to be 0.69 acre-ft/yr (Table 7), and winery employee use is estimated to be 0.54 acre-ft/yr (Table 8).

Table 3: Existing and proposed groundwater uses within the project recharge area.

	Residential use (acre-ft/yr)	Irrigation Use (acre-ft/yr)	Winery Use (acre-ft/yr)	Event Use (acre-ft/yr)	Employee Use (acre-ft/yr)	Total Use (acre-ft/yr)
Existing Use	22.7	41.7	11.4	0.69	0.54	**76.5**
Proposed Use	22.7	43.9	11.4	0.69	0.54	**78.7**

Table 4: Estimated existing and proposed residential groundwater use within the project recharge area.

Use Category	# of Units	Use per Unit (ac-ft/yr)	Use per 1,000 square feet above first 1,000 (ac-ft/yr)	Annual Water Use (ac-ft/yr)
Oversized Main Residence	4	0.75		3.00
Main Residence	38	0.50		19.0
Pools	6	0.10		0.60
Lawn	1.4		0.10	0.14
TOTAL				**22.7**

Table 5: Estimated existing and proposed vineyard and garden irrigation use within the project recharge area.

Use Category	Number of Acres	Use per Acre (ac-ft/yr)	Annual Water Use (ac-ft/yr)
Existing Project Vineyard Irrigation	44.9	0.2	9.0
Existing Non-Project Vineyard Irrigation	33.4	0.5	16.7
Existing Garden/Orchard Irrigation	4.00	4	16.0
TOTAL			**41.7**
Proposed Project Parcel Vineyard Irrigation	55.9	0.2	11.2
Proposed Non-Project Vineyard Irrigation	33.4	0.5	16.7
Proposed Garden/Orchard Irrigation	4.00	4.0	16.0
TOTAL			**43.9**

Table 6: Estimated existing and proposed winery use within the project recharge area.

Use Category	Annual Production	Use per 100,000 gal of	Annual Water Use (ac-ft/yr)
Winery Process Use	430,000	2.15	9.25
Winery Domestic Use	430,000	0.50	2.15
TOTAL			**11.4**

Table 7: Estimated existing and proposed winery guest use within the project recharge area.

Visitor Category	# of Vistors	Use per Visitor (gal/day)	Annual Water Use (ac-ft/yr)
Tours, Tastings and Office	66,144	**3**	0.61
Marketing w/ Onsite Catering	1,730	15	0.08
TOTAL			**0.69**

Table 8: Estimated existing and proposed employee use within the project recharge area.

Work Category	# of Employees	# Work Days per Year	Use per Employee (gal/day)	Annual Water Use (ac-ft/yr)
Full-time	45	260	15	0.54
TOTAL				**0.54**

Proposed Use

In the proposed condition, six new vineyard blocks (Figure 2) will be planted increasing vineyard acreage on the Project parcels by 11 acres to a total area of 55.9 acres. In this condition the estimated water use will increase by 2.2 acre-ft/yr to 34.3 acre-ft /yr for the project parcel (Table 2) and to 78.7 acre-ft/yr within the project recharge area (Table 3). All increases in groundwater use are from increased vineyard irrigation (Table 5). Tentatively, vineyard Block 1 will be irrigated using Well 4, Blocks 2 and 3 will be irrigated using Well 1, Block 4 will be irrigated from Well 2 and water for Block 5 will come from Well 3 (Figure 2).

Groundwater Recharge Analysis

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 C.

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 9.

Results

Water Years 2012 to 2021 average precipitation averaged 33.4 inches across the project recharge area. For the simulated Water Year 2010 (average water year) precipitation averaged 43.2 inches across the project recharge area and simulated actual evapotranspiration (AET) averaged 22.4 inches. Simulated groundwater recharge across the recharge area has a spatial average of 10.2 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 (Table 6). In simulated Water Year 2014 (dry water year), precipitation averaged 20.3 inches across the project recharge area and simulated AET averaged 12.1 inches. Simulated groundwater recharge across the recharge area has a spatial average of 3.1 inches (Table 9). Assuming a linear relationship between the precipitation of the selected average and dry year result of simulated recharge percent (Figure 4), Water Years 2012 to 2021 had an average of 6.8 inches recharge (Table 9).

Groundwater recharge estimates can also be expressed as a total volume by multiplying the estimated recharge rate by a representative area. For the 348-acre project recharge area, these calculations yield an estimated total recharge of 91.1 acre-ft/yr during the drought conditions of water year 2014 and of 294.6 acre-ft/yr for the average water year of 2010 (Table 10). For the combined 225.05 acres of project parcels, these calculations yield an estimated total recharge of 190.4 acre-ft/yr of recharge for Water Year 2010 and 58.9 acre-ft/yr in Water Year 2014. For the impact area the averaged 2012-2021 WYs the recharge is estimated to be 196.4 acre-ft/yr. For the project parcel the estimated recharge is 126.9 acre-ft/yr (Table 10).

LSCE (2013) estimated recharge based on water balance modeling in several watersheds in the county underlain primarily by Sonoma Volcanics (Milliken Creek, Tulucay Creek, Conn Creek and Napa River above Calistoga). The recharge estimates in these watersheds ranged from 5 to 21% of annual precipitation. The recharge estimates produced from this study (24% of average water year precipitation) using SWB are just above the range of the LSCE estimates for larger watershed areas underlain by Sonoma Volcanics and appear to be reasonable.

Table 9: Summary of recharge results from the SWB model within the Project Impact area and calculated recharge from the average of 2012-2021 WYs.

	2010 Normal Year		2014 Dry Year		2012-2021 WY Average	
	inches	% of precip	inches	% of precip	inches	% of precip
Precipitation	43.2	-	20.3	-	33.4	-
AET	22.4	52%	12.1	59%	-	-
Runoff	11.4	26%	8.9	44%	-	-
Change in Soil Moisture	-0.8	-2%	-3.8	-19%	-	-
Recharge	10.2	24%	3.1	15%	6.8	20%

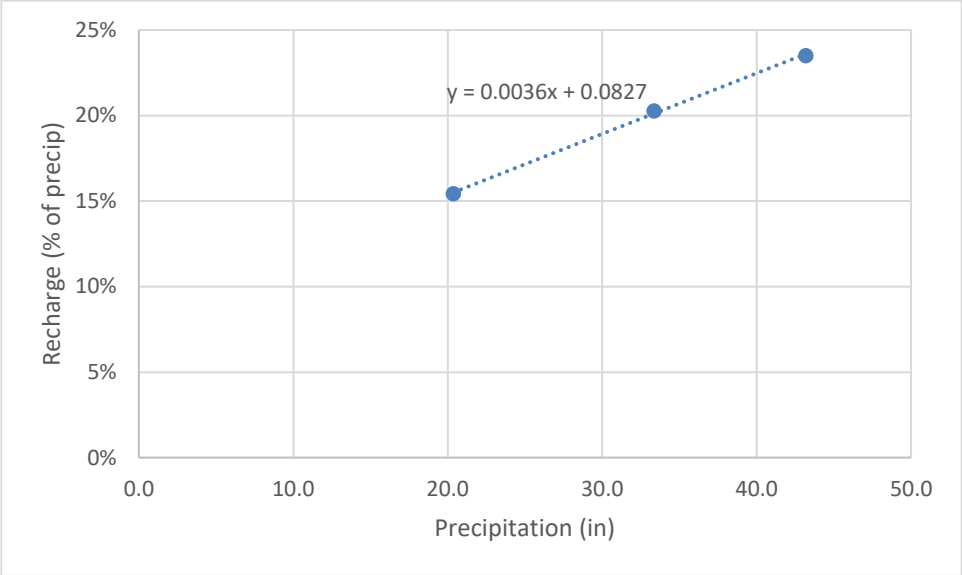


Figure 4: Relationship between precipitation and percent of precipitation as recharge

Comparison of Water Demand and Groundwater Recharge

The total proposed groundwater use combined for all parcels intersecting the recharge area is estimated to be 78.7 acre-ft/yr (Table 10). Using the calculated recharge from the 2012-2021 WY average the use is equivalent to 40% of the 196.4 acre-ft/yr recharge during a 10-year averaged period A similar comparison can be drawn for the Schramsberg Vineyards parcels where the estimated use of 34.3 acre-ft/yr is equivalent to 27% of the calculated recharge from the 2012-2021 WY average(Table 10).

These comparisons indicate that there is a surplus of groundwater resources in terms of estimated average annual groundwater recharge to the project recharge area. Given the surplus, the 2.2 acre-ft/yr increase in water use associated with the proposed increase in vineyard acreage is highly unlikely to result in reductions in groundwater levels or depletion of groundwater resources over time.

Table 10: Comparison of proposed water use to average annual groundwater recharge for the project recharge area and for the contiguous project parcels.

		Average of 2012-2021 Water Years		
	Total Proposed Demand (ac-ft/yr)	Recharge (ac-ft/yr)	Recharge Surplus (ac-ft/yr)	Demand as % of Recharge
Project Recharge Area	78.7	196.4	117.7	40%
Project Parcel Area	34.3	126.9	92.6	27%

Well Interference Analysis

The Napa County WAA guidance document indicates that a well interference analysis (Tier 2 WAA) is required if neighboring wells lie within 500-feet of a project well. Well 1, which serves existing vines associated with the Claes Vineyard and a residence on parcel APN 020-390-010, is the only project well that is near enough to the parcel boundary to potentially meet this definition. The project proposes to add 0.18 acres of vineyard to the Claes Vineyard (Block 2 in Figure 5) along with 0.65 acres in Block 3, which would increase demand on Well 1 by 0.17 acre-ft annually. When added to the current demand from the residence and 4.4 acres of existing vineyard, the total proposed use at Well 1 is 1.6 acre-ft/yr. The only neighboring well identified within 500 feet of Well 1 is Well 6, which is located approximately 350 feet to the southeast on the adjacent parcel APN 021-271-007 (Figure 5). It should be noted Well 5 in not currently in use for irrigation and will not be used for irrigation in the future and is therefore not considered in this interference analysis.

Driller's reports were obtained from the DWR for both the project well and the neighboring well (Appendix A) and are summarized in the Hydrogeologic conditions section. Both wells are completed in similar materials reported as interbedded ash and gray rock and are assumed to penetrate the same aquifer. The screened intervals of Well 1 and Well 6 overlap vertically for approximately 100 ft as shown in cross-section B-B' (Figure 2 and Figure 3). Coupled with the fact that the two wells are completed within similar geology, this overlap strongly suggests that pumping in either well will likely have some impact upon water level in the other. An approximately located fault is mapped between Well 1 and Well 6 (Figure 2 and Figure 3); the character of this fault and its impacts upon groundwater flow are unknown and we therefore assume it does not affect local hydrogeology for purposes of this analysis.

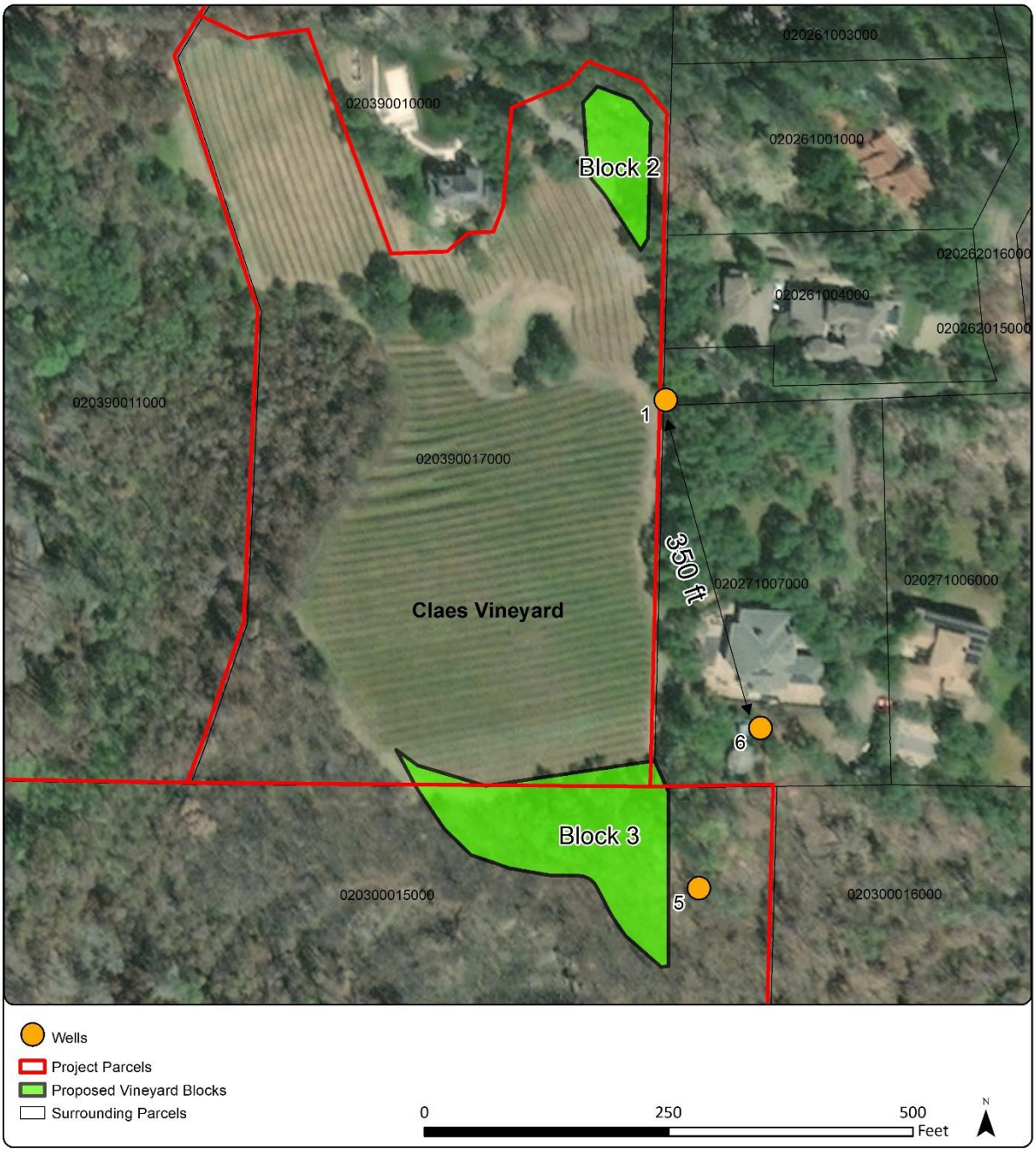


Figure 5. Locations of Well 1 and Well 6 with existing and proposed vineyard areas irrigated using water from Well 1. Note: Well 5 is not in use for irrigation currently and will not be used for irrigation in the future.

Approach

The Napa WAA guidance recommends applying the Theis equation to wells located within 500 ft of the project well to estimate drawdown. The Theis equation (from Driscoll, 1986) is as follows:

$$s' = (Q/4\pi T)\, W(u)$$

with W(u) being the well function where

$$u = (r^2 S/4Tt)$$

and the well function integral expanded as a series as:

$$W(u)= -0.5772 - \ln(u) + u - (u^2/2\cdot 2!) + (u^3/3\cdot 3!) - (u^4/4\cdot 4!)\ldots$$

where:

s' = drawdown (units in ft)

r = radial distance (units in ft)

S = storativity (dimensionless)

T = transmissivity (units in ft^2/day)

Q = discharge at the well (in gpm)

t = time (days)

Several assumptions are made when using the Theis equation:

1. The aquifer is homogeneous, isotropic, uniformly thick and of infinite areal extent.
2. Prior to pumping, the piezometric surface is horizontal
3. The fully penetrating well is pumped at a constant rate.
4. Flow is horizontal within the aquifer.
5. Storage within the well can be neglected.
6. Water removed from storage responds instantaneously with a declining head.

The 2015 Napa County guidance document pertaining to WAA's allows for 10 to 15 feet of water level drawdown attributable to well interference. For wells with casing diameter of six inches or less, drawdown of 10 feet is recommended as a threshold of concern; for wells with casing diameter greater than six inches, drawdown of 15 feet is recommended as a threshold of concern. To estimate the potential drawdown (s) at Well 6 350 feet from Well 1, estimates of the parameters T, t and S defined above are required.

Estimated Aquifer Parameters

Typically, a time-drawdown pumping test would be performed on the project well to determine aquifer parameters to be used in a well interference analysis; however, no detailed pumping test data is available for the project well or nearest neighboring well. The Well Completion Report for Well 1 describes an airlift test at the time of well development in 2008 when the well was pumped at an estimated rate of 40 gpm for 4 hours but the drawdown associated with this pumping is unknown.

The Well Completion Report for Well 6 describes a four-hour pump test that was performed at the time of well development in 1986. At that time the well was pumped at an estimated rate of 75 gpm which resulted in 190 feet of drawdown. Given the relatively close proximity (350 ft) of Well 6 to the project well (Well 1) and the fact that the two are located in the same geologic unit, this data has been used to estimate aquifer properties used in the well interference analysis. Potential drawdown of groundwater caused by the operation of the project well under proposed demand and irrigation conditions is evaluated based on data from the pump test performed on Well 6 along with a range of hydraulic aquifer properties from the literature and the Napa WAA document.

Transmissivity

Transmissivity (T) of the aquifer at the well can be estimated by two methods. First, T can be roughly approximated using single well pump test data and well theory, limited by a set of assumptions (Driscoll 1986, p. 1021). In this method, an empirical equation for confined and unconfined aquifers relates specific capacity (S_c, gallons per minute per foot of drawdown determined from a pump test) to transmissivity as:

$$2{,}000\ S_c = T \text{ (confined aquifers)};\ 1{,}500\ S_c = T \text{ (unconfined aquifers)}$$

where S_c is in units of gallons per minute per foot (gpm/ft) and T is in units of gallons per day per foot (gpd/ft). This approximation of T should not be relied upon if time-drawdown pumping data are available. Such data are not available for either the project well (Well 1) or the neighboring well (Well 6); hence, we use this approximation as described below.

Confined aquifer conditions are suggested by the extent and depth of clay-rich/bedrock strata overlying the water-bearing strata observed in Well Completion Reports. Consequently, one estimate of T is given by 2,000 S_c. The four-hour pump test of Well 6 in 1986 (Appendix A) gave S_c = 0.39 gpm/ft; estimated T from this method is 790 gpd/ft, equivalent to about 106 ft^2/day. This value is in reasonable agreement with, but below, a value for T calculated by Faye (1973) from an average S_c value representative of the Sonoma Volcanics of 0.6 gpm/ft, equivalent to T of 1,200 gpd/ft (160 ft^2 /day).

T can also be estimated using reference hydraulic conductivity (K) values for aquifer materials and multiplying by the saturated aquifer thickness (b) based on the definition T = K b. Napa

County Guidance suggests a range of K values between 10^{-2} to 10^{2} for Fractured Basalt (e.g. Sonoma Volcanics; Appendix G Table F3 in Napa 2015). A saturated aquifer thickness can be estimated by assuming conservatively that it only includes the static water level in the well down to the bottom of the screened interval of the well (saturated thickness is likely greater). Well 1 is screened to a depth of 486 ft and the well completion report for Well 1 reports the static water level to be at 200 ft therefore the estimated saturated aquifer thickness at the project site would be 286 ft. Applying this to the range of K values gives a broad range of T values from 2.86 gpd/ft to 28,600 gpd/ft (0.38 to 3,820 ft^2/day). The broad range of this estimate has limited utility for purposes of this analysis; however, the estimated T above of about 790 gpd/ft does fall in the center of this broad range.

For additional perspective on the validity of the foregoing estimate of T, we also consider estimated T from aquifer test data developed for another WAA on the Napa Valley floor southeast of Calistoga (APN 020-150-017) two miles northeast of the project site (OEI 2015). That analysis used aquifer test data and AQTESOLV software to estimate T of 548 gpd/ft (73.2 ft^2/day). Since these estimates were derived from a pumping test of wells penetrating the tuff of the Sonoma Volcanics (unit Tst) generally similar to tuffs identified in well logs across the Schramsberg project site, these estimates of T may be considered a reasonable reference estimate for the Schramsberg project aquifer. The off-site estimate of 548 gpd/ft is lower than but comparable to T of 790 gpd/ft determined from the reported Specific Capacity of Well 6. The T derived from aquifer test data in Calistoga along with the larger magnitude T of 1,200 gpd/ft derived from Faye (1973) provide estimated upper and lower bounds for the estimate of T derived from Specific Capacity data for Well 6.

Storativity

Storativity (S) can be determined by an analytical pump test utilizing a pumping well and at least one observation well. Such pump test data are not available for this site. Consequently, S must be estimated for purposes of evaluating likely values of r_o (the radius of influence of the well of interest) and estimating potential drawdown at Well 6. In an unconfined aquifer, S ranges from 0.01 to 0.3; in confined aquifers S ranges from about 0.001 to 0.00001 (Lohman 1972). A range of values of S for the confined aquifer are considered in the following analysis to estimate the radius of influence of the well and the drawdown of water elevation that might be experienced in neighboring wells.

S can also be calculated using known Specific Storage (S_s) values for certain aquifer materials and multiplying by the saturated aquifer thickness. Napa County Guidance suggests a range of specific storage values between 10^{-6} to 2.1^{-5} for Rock, fissured (Appendix G Table F3 in Napa 2015). For confined aquifers Storativity (S) is equal to specific storage (S_s) times saturated thickness of the aquifer. Applying the estimated saturated thickness of 286 ft to the range of S_s values gives a range of S from 0.0029 to 0.0060. This estimate of S is at the high end of the range of storativity (0.001 to 0.00001) from Lohman (1972).

Pumping Regime

Time since pumping began (t) was determined based on annual irrigation demand for the Claes Well (Well 1) applied over a typical irrigation season to estimate daily demand. Assuming a 6-month (180 day) irrigation season, the proposed irrigation demand of 1.23 acre-ft for the 4.8 acres of the Claes Vineyard (existing 4.4 acres plus proposed 0.4 acres) and the additional 1.3 acres of Block 3 is equivalent to weekly daily demand of 15,560 gallons. Irrigation practices are typically limited by well pumping capacity and storage tank capacity. The project well pumps to a 10,500-gallon storage tank and the vines are typically irrigated once a week.

Assuming that the project well pumps at a rate of 20 gpm (about half of the stated rate of 40 gpm reported in the air lift test performed at the time of development in 2008), approximately 13 hours of pumping would meet the average weekly irrigation demand of 15,560 gallons. In addition to the vineyard, Well 1 serves the residence on the parcel. Assuming an annual water use of 0.5 acre-ft for all water use including landscaping generates daily demand of 446 gallons for residential use.

Since irrigation occurs once a week during the growing season, we use the weekly irrigation demand plus one day of residential demand to simulate a single day maximum pumping episode. Based on the proposed acreage, weekly irrigation demand totals to 15,560 gallons. Adding the estimated daily residential demand of 446 gallons gives a potential maximum pumping demand of 16,006 gallons. If we ignore the 10,500 gallons of storage available (which will reduce pumping time required) and assume weekly irrigation is met by direct pumping, it would take 13.3 hours pumping at 20 gpm to pump 16,006 gallons. Based on the time calculated, the value of t used for this analysis is 0.56 days (13.3 hours/24 hours per day).

Estimated Drawdown

The Theis equation (Theis, 1935) (Eq. 1) is commonly solved using the Cooper-Jacob approximation to simplify the well function (Eq. 2, Cooper and Jacob, 1946). However, this approximation is only valid when u is below a defined value. Driscoll (1986) places this value at 0.05; Kruseman and de Ridder (1994) place it at 0.01. For the combinations of parameters evaluated in this study, u exceeds these values. Instead of using the Cooper-Jacob approximation, the well function was solved more generally as an upper incomplete gamma function (Eq. 3). The well function is a special case of the upper incomplete gamma function where a is equal to zero which may be solved using Wolfram Alpha[1], an advanced online mathematics engine (Eq. 4). Resulting values of the well function were substituted into the Theis equation:

[1] https://www.wolframalpha.com/input/?i=Gamma%5B0%2C+0%5D

$$s = \frac{Q}{4\pi T} w(u), \text{ where } u = \frac{r^2 S}{4Tt}, and\ w(u) = \int_u^\infty \frac{e^{-x}}{x} dx \quad (1)$$

Where s = drawdown (m), Q = pumping rate (m^3/day), T = transmissivity (m^2/day), r = distance from pumped well (m), S = storativity (dimensionless), and t = time since pumping began (days).

$$w(u) \cong -0.572 - \ln(u) \quad (2)$$

$$\Gamma(a, x) \equiv \int_x^\infty t^{a-1} e^{-t} dt \quad (3)$$

$$\Gamma(0, u) = \int_u^\infty t^{-1} e^{-t} dt = w(u) \quad (4)$$

Because specific pump test data were not available for the project well (Well 1), aquifer properties were estimated from well production data reported for Well 6 (located 350 ft to the north) at the time of well development. The estimated T value used is 790 gpd/ft from the specific capacity derived from the well development production data as described above. This value falls within the range of transmissivities used in previous OEI analyses and reported in the literature (Faye, 1973) within the Sonoma Volcanics. Storativity values ranging from 0.00001 to 0.001 were evaluated based on the previously stated range for confined aquifers with pumping for 13.3 hours at 20 gpm. Applying these parameters, estimated drawdown at Well 6 ranges from 1.6 ft to 13.6 ft (Table 11).

Table 11. Estimated drawdown at Well 6 after pumping 13.3 hours at 20 gpm for T value of 790 gpd/ft across varied S values.

After 13.3 hrs Pumping at 20gpm	
S	Drawdowns (ft)
0.001	1.6
0.0001	7.1
0.00001	13.6

The WAA Tier 2 guidelines suggest a threshold of concern for drawdown of 15 ft for wells with a casing diameter greater than six inches. Well 6 is constructed with a casing diameter of eight inches. Consequently, even with the lowest reported value of storativity (S) operation of the project well (Well 1) to meet projected peak weekly demand does not cause significant drawdown in the nearest neighboring well. If we consider the range of storativity values 0.0029 to 0.0060 calculated from the specific storages for Rock, fissured given by Napa County Guidance, it suggests that storativity is likely closer to the upper end of the range which is associated with the lower end of the drawdown estimates.

Well Interference Analysis Conclusion

This analysis indicates that pumping at the Claes parcel well (Well 1) is unlikely to result in significant drawdown at neighboring wells including Well 6. The maximum drawdown estimate of 13.6 feet is less than the 15 ft threshold of concern suggested by Napa County. In order to perform a more robust analysis of well interference potential, a pump test would need to be performed on the project irrigation well with one or more nearby wells serving as monitoring wells. Such a pump test would be expected to provide more directly applicable estimates of the aquifer parameters T and S used to estimate the lateral extent of drawdown caused by operation of the project irrigation well and the depth of drawdown of the water surface in any neighboring wells. That being said, the amount of estimated increase in pumping required is 38% of the existing peak weekly demand which, to date, has not caused any issues with the water supply of Well 6.

Groundwater-Surface Water Interactions

Napa County Tier 3 WAA guidance for assessment of groundwater-surface water interactions was modified by the emergency policy adopted in June 2022. PBES guidance now identifies streams of concern for groundwater-surface water interaction; Nash Creek lies to the north of the project site and Ritchey Creek lies to the south. Figures 6 displays the location of project irrigation wells to document whether they lie within the 1,500 ft well setback used for Tier 3 analyses. As shown in Figure 6, Well 3 lies 1,299 ft from Nash Creek and consequently requires analysis per Tier 3 criteria. Well 2 lies 1,566 ft from Ritchey Creek, Well 4 lies 1,593 ft from Nash Creek and Well 1 lies 2,215 ft from Ritchey Creek. Well 2 lies at a distance very near the 1,500 ft buffer and, in an abundance of caution, is also evaluated per Tier 3 criteria.

Tier 3 WAA Guidance

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)

These standards consider the planned pumping rate of the project well along with the well depth, screened interval, and seal depth along with aquifer hydraulic conductivity values and present acceptable distances based on specific combinations of all parameters. Tables 3, 4 and 5 in the Napa WAA guidance document present these distance standards and assumptions for wells constructed in unconsolidated (e.g. alluvium) aquifer materials and unconfined aquifers; these assumptions are intended primarily for wells in the Napa Valley Groundwater Basin. The project wells are not in alluvium and lie outside the boundary of the NVGB.

The Tier 3 WAA guidance for wells drilled in bedrock in the "hillside zone" (All Other Areas excluding the MST aquifer in southeast Napa) is as follows:

> *All Other Areas, will be subject to other distance standards based on site-specific aquifer conditions. Distance standards for project wells completed in consolidated formations will generally be no more restrictive than those shown in* ***Tables 3, 4, and 5*** *for hydraulic conductivity values of 0.5 ft/day*. (p. 11)

In other words, standards described in Tables 3, 4 and 5 for wells in bedrock aquifers are to be considered as wells with hydraulic conductivity values of 0.5 ft/day. Schramsberg Vineyards (per Samantha Rubanowitz email Nov. 9, 2022) reports that Well 3 pumps at an average rate of 30 gpm and Well 2 pumps at 30 to 35 gpm. To conform with the "acceptable distance" criteria of Table 4, Well 3 will be operated at a maximum rate of 29.9 gpm.

Table 4. Well Distance Standards and Construction Assumptions; Low capacity pumping rates (i.e., between 10 gpm and 30 gpm), constructed in unconsolidated deposits in the upper part of the aquifer system (unconfined aquifer conditions).

Aquifer Hydraulic Conductivity (ft/day)	Acceptable Distance from Surface Water Channel			Minimum Surface Seal Depth (feet)	Depth of Uppermost Perforations (feet)
	500 feet	1000 feet	1500 feet		
80			✓	50	150
50			✓	50	150
30			✓	50	100
0.5		✓		50	100

As indicated in the table above, wells pumping at rates < 30 gpm are not considered to have adverse effects on streamflow if located > 1,000 ft from stream channels of concern. Well 3 is more than 1,000 ft from Nash Creek, has a well seal extending 51 ft below ground surface (bgs), and the uppermost well perforations begin 145 ft bgs. Well 3 is screened entirely within Sonoma Volcanics. As noted above Well 3 has the capacity to pump between 30 and 35 gpm; provided that Well 3 is pumped at a maximum rate of 29.9 gpm, it conforms with Table 4 criteria and is stipulated to have insignificant potential effect on streamflow in Nash Creek.

Well 2 is about 1,566 feet from Ritchey Creek (Figure 6). The uppermost perforations are 100 feet bgs, and the well is screened entirely within Sonoma Volcanics, a bedrock aquifer with low transmissivity. As such, based on Napa Tier 3 WAA guidance the aquifer hydraulic conductivity may be assumed to be is 0.5 ft/day per Napa Guidance Table 4 above. Well 2 operates at pumping rates of 30 to 35 gpm and has a surface seal extending to 24 ft bgs. Although Well 2 is not subject to Tier 3 WAA criteria, it is evident that it is compliant or very nearly compliant with the Tier 3 WAA criteria. This discussion of Well 2 in the context of Tier 3 criteria has been provided to demonstrate that Well 2 does not represent a significant concern with respect to potential streamflow depletion given that is lies just 66 ft beyond the 1,500 ft setback distance.

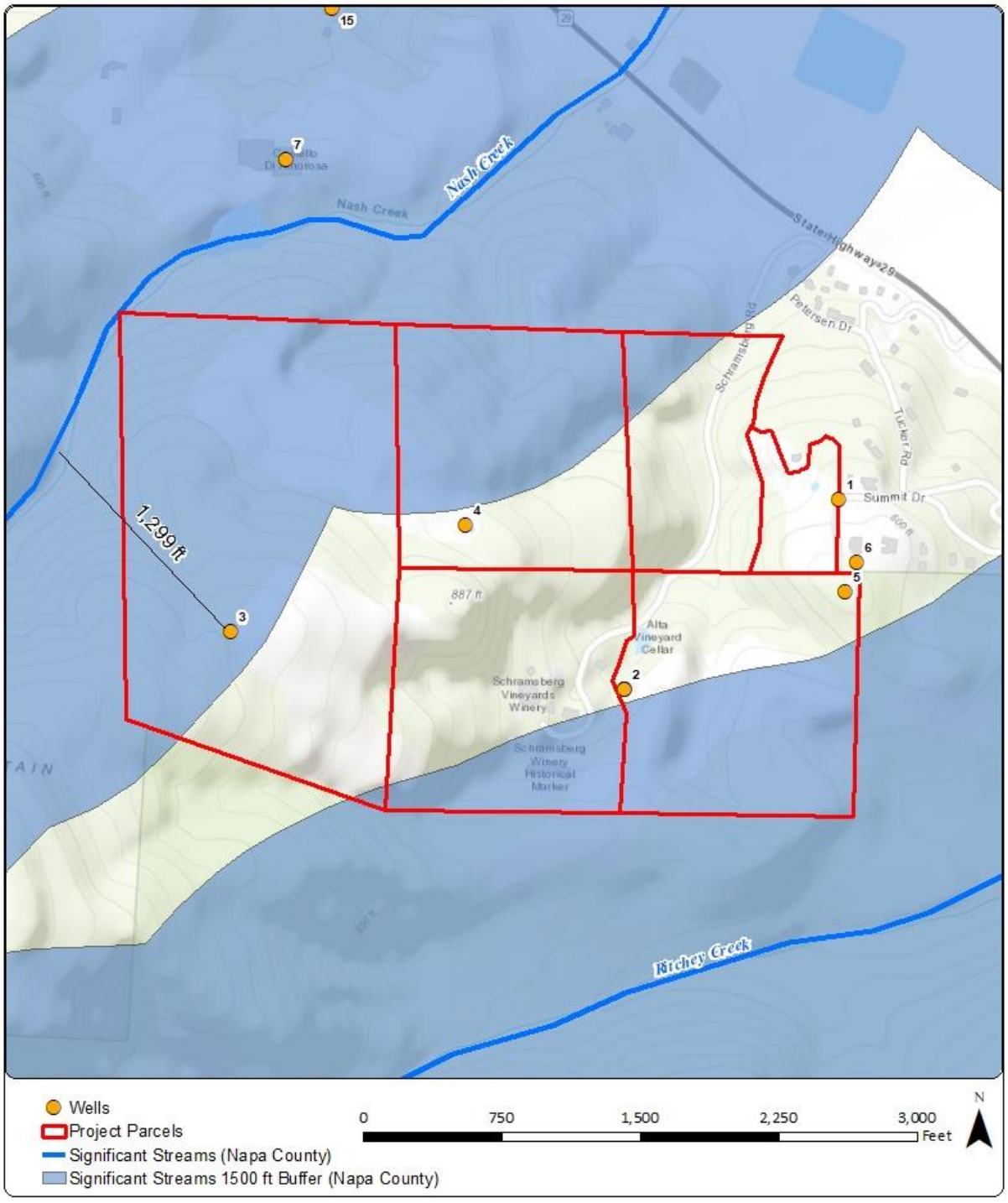


Figure 6. Project Well locations with respect to Napa County Significant Streams Nash and Ritchey Creeks with 1,500 ft buffer. Well 3 is within 1,500 ft of Nash Creek.

Summary and Conclusions

The applicant proposes to convert forest and grassland to develop 11 gross acres of vineyard on the project parcels. As a result of this project, water demand on the project parcel is estimated to increase from 32.1 to 34.3 acre-ft/yr. The total proposed water use for the project aquifer recharge area is estimated to be 78.7 acre-ft/yr. Analysis of the averaged 10-year period of precipitation for Water Years 2012 to 2021 resulted in recharge of 6.8 inches/yr or 196.4 acre-ft/yr across the impact area. The proposed use represents about 40% of the WY2012-2021 average annual recharge indicating that the project is unlikely to result in declines in groundwater elevations or depletion of groundwater resources over time and conforms with Tier 1 WAA criteria.

The nearest neighboring well to project Well 1 is Well 6 which is located 350 feet to the east. An evaluation of potential well interference (Tier 2 WAA) revealed that the proposed increase in pumping required at Well 1 is unlikely to result in significant drawdown at Well 6.

Project irrigation well (Well 3) lies is 1,299 feet from the nearest stream of concern (Nash Creek) identified by County of Napa. An evaluation of potential stream depletion (Tier 3 WAA) associated with operation of project wells indicated that project irrigation wells, including Well 3 (when pumped at a rate of 29.9 gpm or less), conform with Napa County criteria indicating that the wells will not have significant impact on streamflow in streams of concern.

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APPENDIX A

WELL COMPLETION REPORTS

Well #1 Claes Well

ORIGINAL
File with DWR

Page ___ of ___
Owner's Well No. ___

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 1073631

DWR USE ONLY — DO NOT FILL IN
08N06W09
STATE WELL NO./STATION NO.
LATITUDE ___ LONGITUDE ___
APN/TRS/OTHER

Date Work Began 05/26/2008, Ended 05/30/2008
Local Permit Agency Napa County
Permit No. E08-00132 Permit Date 03/31/2008

GEOLOGIC LOG

ORIENTATION (✓) XX VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIF
DRILLING METHOD Rotary FLUID Air

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	15	Brown Ash & Gray Rock
15	22	Brown Clay
22	75	Brown Ash & Gray Rock
75	140	Brown Clay & Ash Red & Gray Rock
140	210	Light Gray Ash
210	270	Light Purple Ash
270	340	Black, Red & Gray Ash
340	470	Gray, Black & red Ash
470	490	Brown Clay & Ash

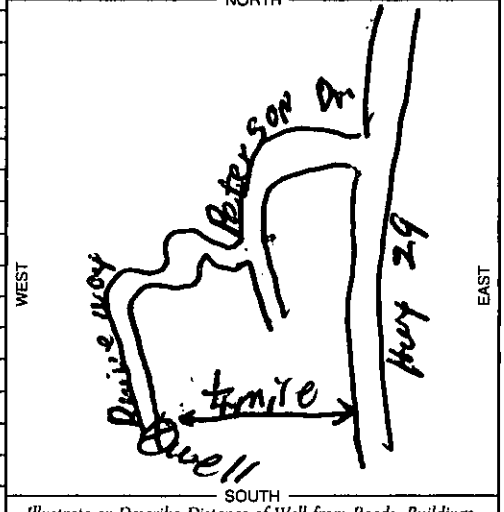
TOTAL DEPTH OF BORING 490 (Feet)
TOTAL DEPTH OF COMPLETED WELL 486 (Feet)

WELL OWNER

WELL LOCATION

Address 3927 Peterson Drive
City Calistoga
County Napa
APN Book 020 Page 390 Parcel 010-000
Township ___ Range ___ Section ___
Lat ___ DEG. ___ MIN. ___ SEC. N
Long ___ DEG. ___ MIN. ___ SEC. W

LOCATION SKETCH



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

ACTIVITY (✓)

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

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 230 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 200 (Ft.) & DATE MEASURED 5-30-08
ESTIMATED YIELD * 40 (GPM) & TEST TYPE Air lift
TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN UK (Ft.) GPM at day of test
* *May not be representative of a well's long-term yield*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (inches)	TYPE (✓) BLANK	SCREEN	CONDUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	53	11	✓				Plastic	5	F480	
53	246	8 3/4	✓				"	"	"	
246	486	8 3/4		✓			"	"	"	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	53	✓			
53	486				Pea Gravel

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

NAME Pulliam Well Exploration (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 5110 Highway 128 CITY Napa STATE CA ZIP 94558
Signed Jon Pulliam C-57 LICENSED WATER WELL CONTRACTOR
DATE SIGNED 6-14-08 808-508 C-57 LICENSE NUMBER

DWR 188 REV. 05-03 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM OSP 03 78836

Well #2 McEachran Well

CONFIDENTIAL LOG
Water Code Sec. 13752

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

020 300 015

Do Not Fill In

No 94406

State Well No. _____

Other Well No. 08N06W16C

ORIGINAL
File with DWR

(1) OWNER:

(2) LOCATION OF WELL:
County Napa Owner's number, if any 1311
Township, Range, and Section Schramsburg Rd., Calistoga
Distance from cities, roads, railroads, etc. P #20-300-15

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

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

(5) EQUIPMENT:
Rotary [X]
Cable [ ]
Other [ ]

(6) CASING INSTALLED:
STEEL: OTHER:
SINGLE [X] DOUBLE [ ]

From ft.	To ft.	Diam.	Gage or Wall
0	202'	6"	12

If gravel packed

Diameter of Bore	From ft.	To ft.

Size of shoe or well ring: None
Size of gravel:
Describe joint Butt Weld

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

From ft.	To ft.	Perf. per row	Rows per ft.	Size in. x in.
100'	202'	20	3	1/8 X 3"

(8) CONSTRUCTION:
Was a surface sanitary seal provided? Yes [X] No [ ] To what depth 24' ft.
Were any strata sealed against pollution? Yes [ ] No [X] If yes, note depth of strata
From ft. to ft.
From ft. to ft.
Method of sealing Neat Cement

(9) WATER LEVELS:
Depth at which water was first found, if known 45' ft.
Standing level before perforating, if known 10' ft.
Standing level after perforating and developing 10' ft.

(10) WELL TESTS: Tested by Bailing.
Was pump test made? Yes [ ] No [ ] If yes, by whom? Drillers
30 gal./min. with 40' ft. drawdown after 6 hrs.
Temperature of water Was a chemical analysis made? Yes [ ] No [X]
Was electric log made of well? Yes [ ] No [ ] If yes, attach copy

(11) WELL LOG:
Total depth 202' ft. Depth of completed well 202' ft.
Formation: *Describe by color, character, size of material, and structure*

ft. to	ft.	
0	1	Soil
1	18	Boulders & Clay
18	112	Soft Brown Rock w/Hard Stringers
112	114	Soft Black Volcanic Rock
114	118	Granular Pink & White
118	124	Dry Soft Pink & Gray
124	151	Dry Soft Brown Granular w/Gray Stringers
151	169	Hard Brown, Gray & White Fractured Rock
169	173	Hard Lavender, White & Gray Fractured Rock
173	177	Soft Brown w/Dry Hard Stringers
177	192	Hard Blue & Fractured Lavender Rock
192	202	Dry Soft Blue w/Hard Blue Stringers

Work started Apr. 8 19 74, Completed Apr. 12 19 74

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
NAME Doshier And Gregson Drilling, Inc.
(Person, firm, or corporation) (Typed or printed)
Address 5365 Napa-Vallejo Highway
[SIGNED] J. D. Doshier
(Well Driller)
License No. 258826 Dated April 12, 19 74

SKETCH LOCATION OF WELL ON REVERSE SIDE

25179-950 9-69 50M TRIP △D OSP

Well #3

08Q
17B/c ?

ORIGINAL

File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in
No. 210175

Notice of Intent No. [redacted]
Permit No. or Date 18894

State Well No.
Other Well No 08N06W17B

(2) LOCATION OF WELL (See instructions):
County Napa Owner's Well Number 20-390-06
Well address if different from above same
Township Range Section
Distance from cities, roads, railroads, fences, etc.

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

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

WELL LOCATION SKETCH

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

(6) GRAVEL PACK:
Yes ☒ No ☐ Size Fine Pea
Diameter of bore 12¼
Packed from 51 to 245 ft.

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

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

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	245	8"	CL200	145	245	.032

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 51 ft.
Were strata sealed against pollution? Yes ☐ No ☐ Interval ft.
Method of sealing Grout on pack

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion 45' ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Weeks
Type of test Pump ☐ Bailer ☒ Air lift ☐
Depth to water at start of test 45 ft. At end of test 100 ft
Discharge 40 gal/min after 3 hours Water temperature cool
[redacted]cal analysis made? Yes ☐ No ☒ If yes, by whom?
[redacted] electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 245 ft. Depth of completed well 245 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	5	Volcanic rock
5	10	Clayee brown ash
10	14	Volcanic rock
14	22	Boulders with streaks of brown clay
22	30	Gray ash with boulders
30	81	Brown clayee ash with embedded volcanic ash
81	83	Hard volcanic rock
83	115	Brown clayee ash with embedded ash
115	133	Hard volcanic rock
133	135	Hard volcanic rock (fluid loss)
135	155	Hard volcanic rock with brown clay streaks
155	195	Brown clayee ash with embedded ash
195	220	Brown ash
220	235	Brown clay with streaks of gray ash
235	237	Multi colored clay with ash
237	245	Hard volcanic rock

Work started 4/1/87 19 Completed 4/9/87 19

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

SIGNED Gerald G. Thompson, By Ward Thompson (Well Driller)
NAME WEEKS DRILLING AND PUMP COMPANY (Person, firm, or corporation) (Typed or printed)
Address P. O. Box 176
City Sebastopol, CA Zip 95472
License No. C57-177681 Date of this report 4/15/87

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

NOT FOR PUBLIC VIEW
DO NOT PUBLISH ON WATER CODE SECTION 13752

Well #4 Tractor Shed Well

ORIGINAL
File with DWR

Page ___ of ___
Owner's Well No. ___

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet
No. 1079524

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO./STATION NO. 08N06W09
LATITUDE ___ LONGITUDE ___
APN/TRS/OTHER ___

Date Work Began 7/10/2005, Ended 7/25/2005
Local Permit Agency Napa County
Permit No. 06/14/2005 Permit Date E05-0427 Permit No.

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD Rotary FLUID Mud

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	8	Gray Rock & Brown Ash
8	105	Brown Ash
105	190	Gray Volcanic Rock
190	205	Gray Clay & Gray Ash
205	420	Pink, Brown, & Black Ash
420	450	Fractored Red, Black, & Gray Ash
450	520	White & Brown Ash
520	620	Lost Circulation

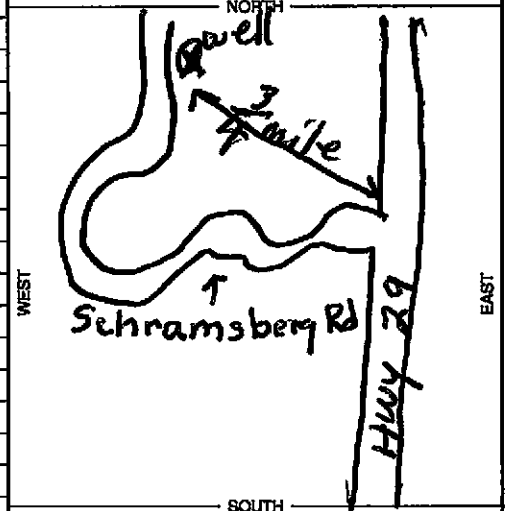
TOTAL DEPTH OF BORING 620 (Feet)
TOTAL DEPTH OF COMPLETED WELL 610 (Feet)

NOT FOR PUBLIC RELEASE CONFIDENTIAL WATER CODE SECTION 13752

WELL LOCATION

CITY ___ STATE ___ ZIP ___
Address 1400 Schramsberg Road
City Calistoga
County Napa
APN Book 020 Page 390 Parcel 008
Township ___ Range ___ Section ___
Lat ___ DEG. ___ MIN. ___ SEC. N
Long ___ DEG. ___ MIN. ___ SEC. W

LOCATION SKETCH



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

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

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 150 (FT.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 120 (Ft.) & DATE MEASURED 7-26-05
ESTIMATED YIELD * 180 (GPM) & TEST TYPE Air Lift
TEST LENGTH 5 (Hrs.) TOTAL DRAWDOWN 44 (Ft.)
* *May not be representative of a well's long-term yield* GPM ✓ Day of test

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CONDUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	54	14	✓				Plastic	8	200	
54	210	12½	✓				"	"	"	
210	610	12¼		✓			"	"	"	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	54	✓			
54	610			Well Pack Gravel	

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

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

NAME Pulliam Well Exploration (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 5110 Highway 128 CITY Napa STATE CA ZIP 94558
Signed [signature] C-57 LICENSED WATER WELL CONTRACTOR
DATE SIGNED 7-31-05
C-57 LICENSE NUMBER 808-508

DWR 188 REV. 05-03 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM OSP 03 78836

Well #5

020 390 10

ORIGINAL

File with DWR

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

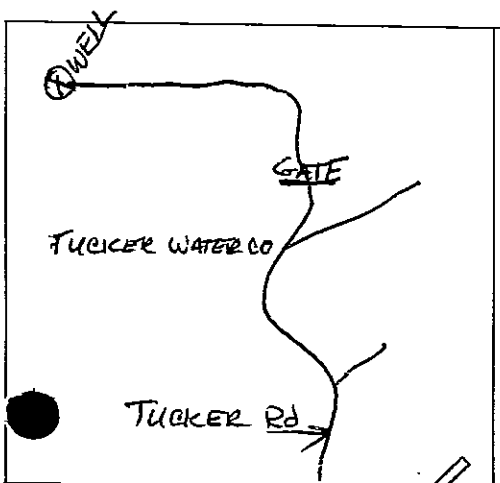
Do not fill in
No. 103191

[redacted] of Intent No.
[redacted] Permit No. or Date

State Well No.
Other Well No. 08N06W09P

(2) LOCATION OF WELL (See instructions):

County Napa Owner's Well Number 20-390-10
Well address if different from above Peterson Dr.
Township Calistoga Range Section
Distance from cities, roads, railroads, fences, etc.



WELL LOCATION SKETCH

(3) TYPE OF WORK:

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

(4) PROPOSED USE:

Domestic ☒
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:

Rotary ☐ Reverse ☐
Cable ☐ Air ☒
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☐ No ☒ Size
Diameter of bore 8 3/4
Packed from to ft.

(7) CASING INSTALLED:

Steel ☐ Plastic ☒ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	260	6	160

(8) PERFORATIONS:

Type of perforation or size of screen machine

From ft.	To ft.	Slot size
260	420	1/8 x 3

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 23 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing

(10) WATER LEVELS:

Depth of first water, if known 300 ft.
Standing level after well completion 200 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Driller
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 200 ft. At end of test complete
Discharge 10 gal/min after hours Water temperature
[redacted]cal analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:

Total depth 420 ft. Depth of completed well 420 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	25	Topsoil clay & gray rock
25	75	Clay gravel
75	200	Sand clay & rock
200	225	Gray rock hard stringers brwn rock fract
225	250	Brown rock fract
250	275	Brown & gray rock fract
275	300	Brown & green rock fract
300	350	Green rock fract
350	420	Green brown & white rock

Work started 6/9/ 1978 Completed 6/10, 78

WELL DRILLER'S STATEMENT:

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

SIGNED (Well Driller)
NAME Doshier-Gregson Drilling, Inc. (Person, firm, or corporation) (Typed or printed)
Address 5365 Napa-Vallejo Hwy
City Vallejo Zip 94590
License No. 294001 Date of this report 6/13/78

DO NOT FILL IN
WATER CODE SEC. 13752
FOR PUBLIC USE

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

Well #6

ORIGINAL

File with DWR

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

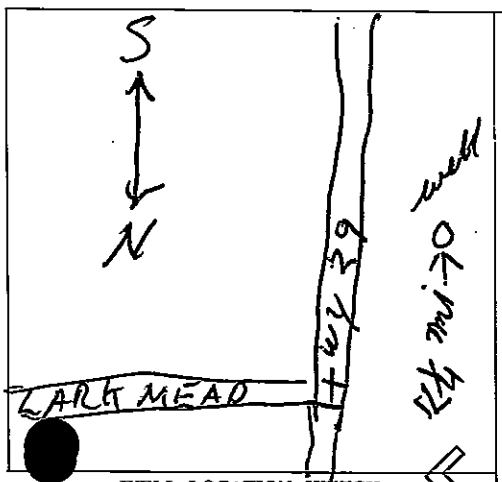
Do not fill in
No. 36282

Notice of Intent No. 18311
Local Permit No. or Date 10/22/86

State Well No.
Other Well No. 08N06W09Q

(2) LOCATION OF WELL (See instructions):

County 28 Owner's Well Number
Well address if different from above Same
Township 30 Range 3W Section 01
Distance from cities, roads, railroads, fences, etc. ¼ mi south of Larkmead Rd on ¼ Hwy 29



WELL LOCATION SKETCH

(3) TYPE OF WORK:

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

(4) PROPOSED USE:

Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☑
Other ☐

(5) EQUIPMENT:

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

(6) GRAVEL PACK:

Yes ☑ No ☐ Size #2
Diameter of bore 10
Packed from 51 to 405 ft.

(7) CASING INSTALLED:

Steel ☐ Plastic ☑ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	405	6	200

(8) PERFORATIONS:

Type of perforation or size of screen

From ft.	To ft.	Slot size
200	405	.023

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☑ No ☐ If yes, to depth 51 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing cement

(10) WATER LEVELS:

Depth of first water, if known 225 ft.
Standing level after well completion 210 ft.

(11) WELL TESTS:

Was well test made? Yes ☑ No ☐ If yes, by whom? driller
Type of test Pump ☐ Bailer ☐ Air lift ☑
Depth to water at start of test 210 ft. At end of test 200 ft.
Discharge 75 gal/min after 4 hours Water temperature
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Electric log made? Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:

Total depth 405 ft. Depth of completed well 405 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	143	brown ash, rock
143	169	soft black ash
169	220	brown ash, rock
220	340	gray rock, brown ash, dry
340	405	gray rock, green ash

Work started 10/27/19 86 Completed 11-7 19 86

WELL DRILLER'S STATEMENT:

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

SIGNED (Well Driller)
NAME Fullion Drilling (Person, firm, or corporation) (Typed or printed)
Address 2877 Piedmont Ave.
City Napa Zip 94558
License No. 248677 Date of this report 7/13/88

DWR 188 (REV. 7-76) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 45816-950 7-76 50M QUAD ①T OSP

SCANNED FOR PUBLIC USE
NOT FOR PUBLIC WATER
SEC. 13752

Well #7

ORIGINAL
File with DWR

Page ___ of ___
Owner's Well No. ___
Date Work Began 5/10/04, Ended 5-24-04
Local Permit Agency Napa
Permit No. 96-12662 Permit Date 5/10/04

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet
No. 0900847

DWR USE ONLY — DO NOT FILL IN
07N06W08
STATE WELL NO./STATION NO.
LATITUDE ___ LONGITUDE ___
APN/TRS/OTHER ___

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPE
DRILLING METHOD mud FLUID betonite

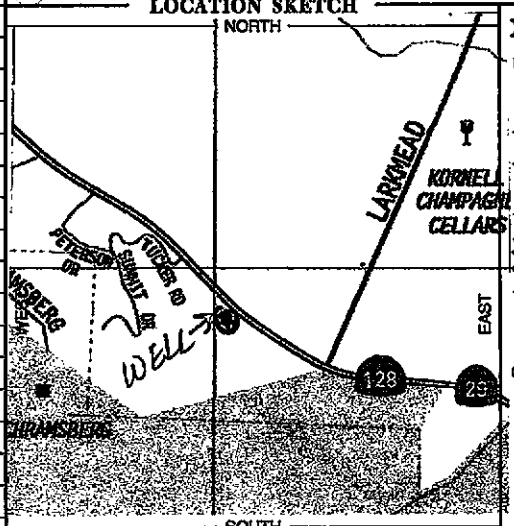
DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	2	topsoil
2	20	brown clay white rock
20	30	brown rock
30	50	brown red tan red clay
50	70	red brown tank fract rock
70	90	gray ash stringers red rock
90	110	brown gray red rock
110	130	brown soft rock
130	150	red brown gray rock
150	170	red brown tan soft rock
170	190	red brown tan soft rock
190	210	brown reddish gray rock
210	230	gray red brown rock
230	250	white red brown gray rock
250	270	black white rock
270	290	red brown gray rock
290	310	brown red gray rock
310	330	lt red gray brown white
330	350	tan brown gray fract
350	370	brown red gray rock
370	390	brown tan red gray rock
390	410	red brown tan gray rock
410	430	red brown tan rock
430	450	red brown black fract
450	470	black red brown rock
470	490	black brown soft rock
490	510	black white red brown
510	530	red black green shale
530	560	red green white black

TOTAL DEPTH OF BORING 560 (Feet)
TOTAL DEPTH OF COMPLETED WELL 560 (Feet)

WELL LOCATION

Address 4045 N. St. Helena Hwy
City Calistoga
County Napa
APN Book 020 Page 390 Parcel 12
Township ___ Range ___ Section ___
Lat ___ DEG. ___ MIN. ___ SEC. N Long ___ DEG. ___ MIN. ___ SEC. W

LOCATION SKETCH



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

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

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 147 (Ft.) & DATE MEASURED 5/24/04
ESTIMATED YIELD * 70. (GPM) & TEST TYPE air
TEST LENGTH 1.5days (Hrs.) TOTAL DRAWDOWN 520 (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	60	14	X				F480	8"	200	
60	120	12 3/4	X				F480	8"	200	
120	180	12 3/4		X			F480	8"	200	factory
180	220	12 3/4	X				F480	8"	200	
220	280	12 3/4		X			F480	8"	200	factory
280	320	12 3/4	X				F480	8"	200	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	60	X			
60	560				#6 sand pack

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

DE 12:10 6W S.P.B
DAD - CLINICAL DIVISION

CERTIFICATION STATEMENT

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

NAME McLean & Williams, Inc. (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 878 El Centro Ave., Napa, CA 94558 CITY STATE ZIP
Signed ___ (C-57 LICENSED WATER WELL CONTRACTOR) DATE SIGNED 11/23/04 C-57 LICENSE NUMBER 396352

DWR 188 REV. 05-03 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM OSP 03 78836

Well #8

ORIGINAL
File with DWR

Page ___ of ___

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 0947971

DWR USE ONLY — DO NOT FILL IN
08N/06W/08
STATE WELL NO./STATION NO.
LATITUDE 38 33 19 LONGITUDE 122 32 56
APN/TRS/OTHER

Owner's Well No. ___
Date Work Began 9-24-12 Ended 10-5-12
Local Permit Agency Napa County
Permit No. E12-00473 Permit Date 8-13-12

GEOLOGIC LOG

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

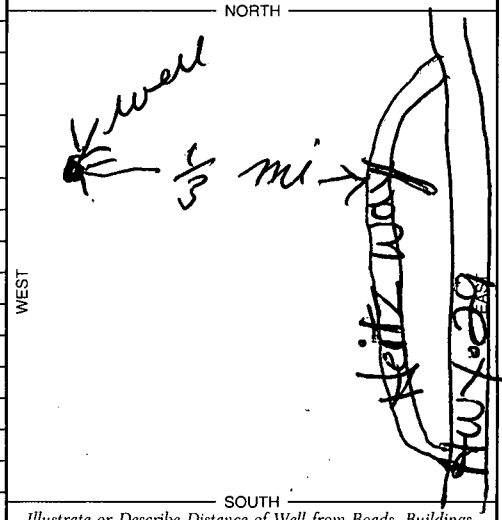
DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	120	brown ash & boulders
120	440	ash, streaks of broken up ash
440	455	sticky clay

TOTAL DEPTH OF BORING 455 Feet)
TOTAL DEPTH OF COMPLETED WELL 455 Feet)

WELL LOCATION

Address 4199 Nevis Way
City Calistoga
County Napa
APN Book ___ Page ___ Parcel 020-390-003
Township ___ Range ___ Section ___
Lat ___ DEG. ___ MIN. ___ SEC. N
Long ___ DEG. ___ MIN. ___ SEC. W

LOCATION SKETCH



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

ACTIVITY (✓)

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

USES (✓)

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 160 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 160 (Ft.) & DATE MEASURED 10-5-12
ESTIMATED YIELD 30 (GPM) & TEST TYPE AIR LIFT
TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN 440 (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	57	12"	X				PLASTIC	6"	200	
57	135	10"	X				"	"	"	
135	455	10"	FACT				PREF "	"	"	3/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	57	X			
57	455	WELL	PACK	#6	

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

NAME Pulliam Well Drilling
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 2877 Piedmont Av. CITY Napa STATE Ca. ZIP 94558
Signed Bill Pulliam
C-57 LICENSED WATER WELL CONTRACTOR
DATE SIGNED 10-16-12
C-57 LICENSE NUMBER 748677

DWR 188 REV. 05-03 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM OSP 03 78836

Well #9

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

Page _____ of _____

Owner's Well Number 2

Date Work Began 05/[illegible]/2013 5-20-13 Date Work Ended 5/25/2013

Local Permit Agency Napa County

Permit Number E13-00054 Permit Date 2/14/13

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0178229

DWR Use Only – Do Not Fill In

08N06W08

State Well Number/Site Number

3833 22 N Latitude 122 33 08 W Longitude

APN/TRS/Other

Geologic Log

Orientation ◉ Vertical ○ Horizontal ○ Angle Specify _____

Drilling Method Direct Rotary Drilling Fluid air / mud

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	20	White & Gray Ash & Gray Rock
20	60	Yellow Clay Yellow Rock
60	100	White Rock Rusty colored
100	140	Gray Green Rock
140	300	Gray Clay & Gray Green Rock
300	400	Gray green Rock with Gray Clay
400	430	Gray, Green, Red & White Rock
430	460	White, Green & Black Rock Rust
460	480	Yellow Clay
480	500	Yellow Clay, Gray Roick
		Perforation Layout
		P = Perforation
		B = Blank
		0 to 115 ft Blank
		P B
		B P
		P 175 ft P
		B B
		P P 475 ft
		B
		P
		B 275 ft
		P
		B
		P
		B
		P 375 ft

Total Depth of Boring 500 Feet

Total Depth of Completed Well 475 Feet

Well Owner

N

M

C

Well Location

Address 4331 Azalea Springs Way

City Calistoga County Napa

Latitude ___ Deg. ___ Min. ___ Sec. N Longitude ___ Deg. ___ Min. ___ Sec. W

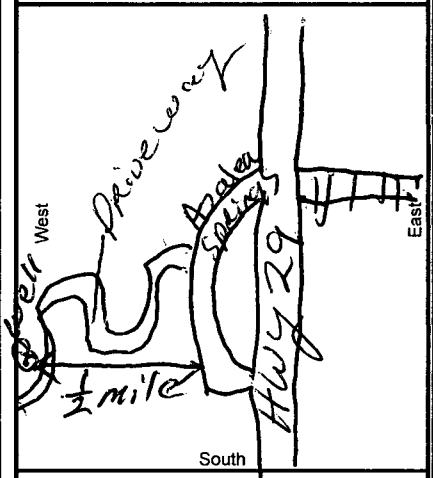
Datum _____ Decimal Lat. _____ Decimal Long. _____

APN Book 020 Page 390 Parcel 015-000

Township _____ Range _____ Section _____

Location Sketch

(Sketch must be drawn by hand after form is printed.)



Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. **Please be accurate and complete.**

Activity

◉ New Well

○ Modification/Repair

○ Deepen

○ Other _____

○ Destroy

Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

◉ Water Supply

☐ Domestic ☐ Public

☑ Irrigation ☐ Industrial

○ Cathodic Protection

○ Dewatering

○ Heat Exchange

○ Injection

○ Monitoring

○ Remediation

○ Sparging

○ Test Well

○ Vapor Extraction

○ Other _____

Water Level and Yield of Completed Well

Depth to first water 120 (Feet below surface)

Depth to Static Water Level 60 (Feet) Date Measured 05/25/2013

Estimated Yield * 12 (GPM) Test Type Air Lift

Test Length 8.0 (Hours) Total Drawdown 400 (Feet)

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

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	55	12	Blank	PVC Sch. 40	R21	6		
55	115	9.5	Blank	PVC Sch. 40	R21	6		
115	475	9.5	Screen	PVC Sch. 40	R21	6	Milled Slots	0.032

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	55	Cement	Cement / Val Clay
55	475	Filter Pack	#6 well pack

Attachments

☐ Geologic Log

☐ Well Construction Diagram

☐ Geophysical Log(s)

☐ Soil/Water Chemical Analyses

☐ Other _____

Attach additional information, if it exists.

Certification Statement

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

Name Pulliam Well Exploration Inc
Person, Firm or Corporation

4371 Cantelow Road Vacaville CA 95688
Address City State Zip

Signed [signature] 06/04/2013 808-505
C-57 Licensed Water Well Contractor Date Signed C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #10

ORIGINAL
File with DWR

Page ___ of ___

Owner's Well No. ___

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 0900871

DWR USE ONLY — DO NOT FILL IN
08N06W08
STATE WELL NO./STATION NO.
LATITUDE ___ LONGITUDE ___
APN/TRS/OTHER

Date Work Began 10/9/03, Ended 10/23/03

Local Permit Agency Napa

Permit No. 9612579 Permit Date 10/7/03

GEOLOGIC LOG

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

DRILLING METHOD mud FLUID betonite

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	40	brown clay
40	80	brown & gray clay
80	110	gray clay
110	130	gray black clay
130	170	gray clay
170	190	gray black clay
190	230	gray clay
230	250	white gray fract
250	270	white gray rock
270	290	white gray green yellow rock
290	330	white black brown rock
330	350	gray brown white green
350	370	brown gray black
370	410	brown green white
410	430	white green yellow black
430	470	white green soft

TOTAL DEPTH OF BORING 470 (Feet)

TOTAL DEPTH OF COMPLETED WELL 450 (Feet)

WELL OWNER

WELL LOCATION

Address 4325 Azalea Springs Way

City Calistoga

County Napa

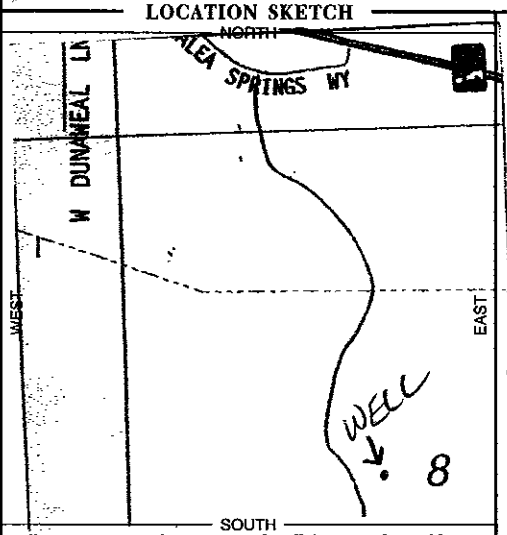
APN Book 020 Page 390 Parcel 002

Township ___ Range ___ Section ___

Lat ___ DEG. ___ MIN. ___ SEC. N

Long ___ DEG. ___ MIN. ___ SEC. W

LOCATION SKETCH



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

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

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

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 230 (Ft.) & DATE MEASURED 10/23/03

ESTIMATED YIELD * 75. (GPM) & TEST TYPE air

TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN 440 (Ft.)

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

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	67	14"	X				F480	8"	200	
67	80	12 3/4	X				F480	8"	200	
80	110	12 3/4		X			F480	8"	200	factory
110	190	12 3/4	X				F480	8"	200	
190	350	12 3/4		X			F480	8"	200	factory
350	370	12 3/4	X				F480	8"	200	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	67	X			
67	80				pea gravel
80	450				#6 sand

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

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

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

Signed [signature] C-57 LICENSED WATER WELL CONTRACTOR

1/23/04 DATE SIGNED

396352 C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

OSP 03 78836

WELL COMPLETION REPORT No. 0900871

A.P.#020-390-002

4325 Azalea Springs Way

Casing list continued:

370 - 410	12 3/4	Perf	F480	8"	200	factory
410 - 430	12 3/4	Blank	F480	8"	200	
430 - 450	12 3/4	Perf	F480	8"	200	factory

Well #11

ORIGINAL
File with DWR

Page ___ of ___

Owner's Well No. ___

Date Work Began 12-1-00, Ended 12-7-00

Local Permit Agency NAPA COUNTY

Permit No. 96-11286 Permit Date 8-27-99

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 819555

DWR USE ONLY — DO NOT FILL IN
08N06W08
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

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

DRILLING METHOD ___ FLUID ___

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	1	DECOMPOSED VEGITATION
1	280	WHITE CONSOLIDATED VOLCANIC
280	360	STAINED WHITE CONSOLIDATED VOLCANIC
360	495	WHITE CONSOLIDATED VOLCANIC

TOTAL DEPTH OF BORING 495 (Feet)

TOTAL DEPTH OF COMPLETED WELL 435 (Feet)

WELL LOCATION

Address 4451 ST. HELENA HWY.,

City CALISTOGA

County NAPA

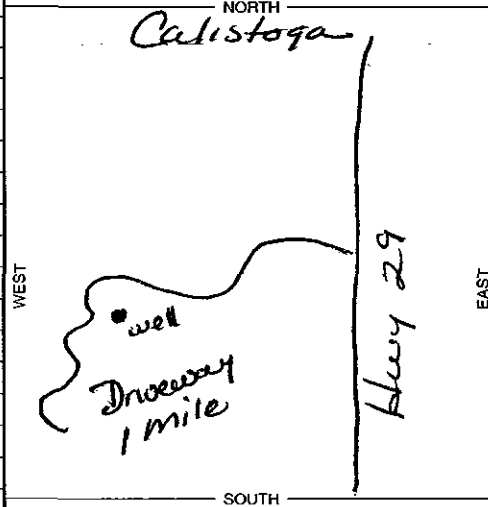
APN Book 20 Page 400 Parcel 18

Township ___ Range ___ Section ___

Latitude ___ DEG. ___ MIN. ___ SEC. NORTH

Longitude ___ DEG. ___ MIN. ___ SEC. WEST

LOCATION SKETCH



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

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

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

PLANNED USES (✓)

WATER SUPPLY
X Domestic ___ Public
X Irrigation ___ Industrial

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 240 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 200 (Ft.) & DATE MEASURED ___

ESTIMATED YIELD * 30 (GPM) & TEST TYPE AIR LIFT

TEST LENGTH 6 (Hrs.) TOTAL DRAWDOWN ___ (Ft.)

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

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	235	8	X				PVC	5	200	
235	435	8		X			PVC	5	200	.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	20	X			
20	435				GRAVEL

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

NAME A & K DRILLING, INC. (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS P.O. BOX 750143 CITY PETALUMA STATE CA ZIP 94975

Signed D. O'Keefe WELL DRILLER/AUTHORIZED REPRESENTATIVE

DATE SIGNED 1-24-01 C-57 LICENSE NUMBER 720534

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #12

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form.

File Original with DWR

Page _____ of _____

Owner's Well Number _____

Date Work Began 11/04/2013 Date Work Ended 11/18/2013

Permit Agency Napa County

Permit Number E13-00555 Permit Date 9/3/13

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0195080

DWR Use Only – Do Not Fill In

State Well Number/Site Number: 08N06W17

Latitude: 38 33 09 N Longitude: 122 33 20 W

APN/TRS/Other: 020-390-014

Geologic Log

Orientation: ◉ Vertical ○ Horizontal ○ Angle Specify _____

Drilling Method Direct Rotary Drilling Fluid Air / mud

Depth from Surface Feet	to Feet	Description Describe material, grain size, color, etc
0	120	Yellow Clay & White Ash
120	180	Black Ash
180	300	Yellow & White Ash
300	410	Black Ash
410	440	Yellow Ash
440	560	Black & White Ash
560	605	Black Ash with Purple Rock
605	650	Purple Rock
650	690	Brown Clay
		Perforation Layout
		P = Perforation
		B = Blank
		0 to 180 Blank P
		P 200 ft B
		B P
		B B
		B P 500 ft
		B B
		B 300 ft P
		B B
		B P
		B P 600 ft
		P B
		B 400 ft P
		P 660 ft

Total Depth of Boring 690 Feet

Total Depth of Completed Well 660 Feet

Well Owner

Name _____

Mailing _____

City _____

Well Location

Address 4331 Azalea Springs Way

City Calistoga County Napa

Latitude _____ Deg. _____ Min. _____ Sec. N Longitude _____ Deg. _____ Min. _____ Sec. W

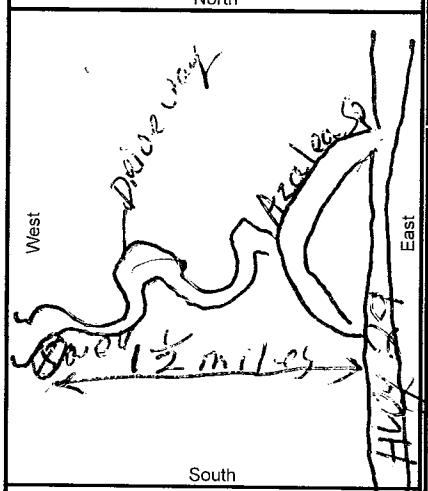
Datum _____ Dec. Lat. _____ Dec. Long. _____

APN Book 020 Page 390 Parcel 014-000

Township _____ Range _____ Section _____

Location Sketch

(Sketch must be drawn by hand after form is printed.)



Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. **Please be accurate and complete.**

Activity

◉ New Well
○ Modification/Repair
○ Deepen
○ Other _____
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

◉ Water Supply
☐ Domestic ☐ Public
☑ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other _____

Water Level and Yield of Completed Well

Depth to first water 450 (Feet below surface)

Depth to Static Water Level 420 (Feet) Date Measured 11/18/2013

Estimated Yield * 40 (GPM) Test Type Air Lift

Test Length 20.0 (Hours) Total Drawdown 200 (Feet)

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

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	60	12	Blank	PVC Sch. 40	R21	6		
60	180	9	Blank	PVC Sch. 40	R21	6		
180	200	9	Screen	PVC Sch. 40	R21	6	Milled Slots	0.032
200	360	9	Blank	PVC Sch. 40	R21	6		
360	660	9	Screen	PVC Sch. 40	R21	6	Milled Slots	0.032

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	56	Cement	Cement / Val Clay
56	660	Filter Pack	# 6 Well Pack

Attachments

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

Attach additional information, if it exists.

Certification Statement

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

Name Pulliam Well Exploration Inc
Person, Firm or Corporation

4371 Cantelow Road Vacaville CA 95688
Address City State Zip

Signed _____
C-57 Licensed Water Well Contractor

12/17/2013 Date Signed

808-508 C-57 License Number

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #13

ORIGINAL
File with DWR

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 737012

DWR USE ONLY — DO NOT FILL IN
08 N 06 W 08
STATE WELL NO./STATION NO.
LATITUDE | LONGITUDE
APN/TRS/OTHER

Page 1 of 1
Owner's Well No. # 1
Date Work Began 8-30-01, Ended 9-10-01
Local Permit Agency Co of Napa Environmental Mangt.
Permit No. 96-11903 Permit Date 8-31-01

GEOLOGIC LOG

ORIENTATION (✓) ✓ VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD Rotary FLUID Bentonite

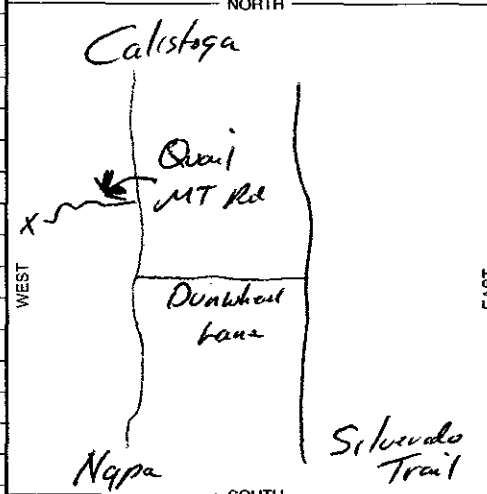
DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	36	Clay Volcanic Ash
36	366	Hard Volcanic Ash Light brown in color Sand & Ash Mix
366	395	Soft Ash Slight Saturation Water Approx 5 GPM Per 30'
395	465	Water bearing Ash & Rock Mix

TOTAL DEPTH OF BORING 484 (Feet)
TOTAL DEPTH OF COMPLETED WELL 470' (Feet)

WELL LOCATION

Address 4473 St Helena Hy
City Calistoga
County Napa
APN Book 20 Page 400 Parcel 19
Township ___ Range ___ Section ___
Latitude ___ DEG. ___ MIN. ___ SEC. NORTH
Longitude ___ DEG. ___ MIN. ___ SEC. WEST

LOCATION SKETCH



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

ACTIVITY (✓)

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

PLANNED USES (✓)

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 370 (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 60' (Ft.) & DATE MEASURED 9-01
ESTIMATED YIELD * 60 (GPM) & TEST TYPE Air Lift
TEST LENGTH 2 1/2 (Hrs.) TOTAL DRAWDOWN NA (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	25	11 1/2	X				PVCF480	5	200	
25	310	8 3/4	X				PVCF480	5	200	
310	465			X			PVCF480	5	200	032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	23	✓			
23	465			✓	3/8 Pea gravel

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

NAME D. Bess Pump & Well (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 1115 Mt. George Ave. CITY Napa STATE CA ZIP 94558
Signed [signature] WELL DRILLER/AUTHORIZED REPRESENTATIVE
9-12-01 DATE SIGNED
487027 C-57 LICENSE NUMBER

DWR 188 REV 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #14

ORIGINAL

File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

020 300 019

Do not fill in

No. 080077

State Well No.

Other Well No. 08N06W16R

e of Intent No.

eat Permit No. or Date

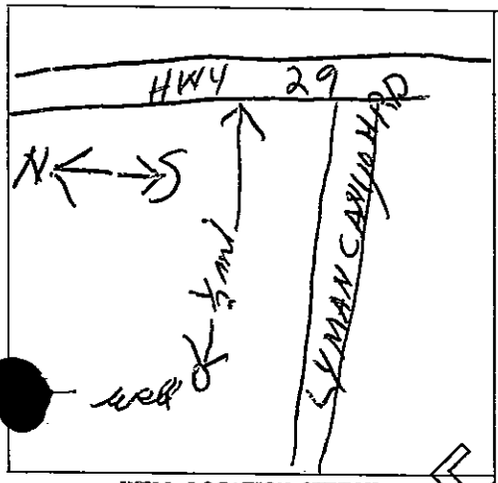
(2) LOCATION OF WELL (See instructions):

County Napa Owner's Well Number

Well address if different from above Same

Township 20 Range 300 Section 19

Distance from cities, roads, railroads, fences, etc. ½ mi. West of Hwy. 29 on Lyman Canyon rd.



WELL LOCATION SKETCH

(3) TYPE OF WORK:

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

(4) PROPOSED USE:

Domestic
Irrigation ☐
Industrial ☐
Test Well ☐
Stock ☐
Municipal ☐
Other ☐

(5) EQUIPMENT:

Rotary X Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☐ No X Size

Diameter of bore

Packed from ft. to ft.

(7) CASING INSTALLED:

Steel ☐ Plastic X Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	440	5	160

(8) PERFORATIONS:

Type of perforation or size of screen

From ft.	To ft.	Slot size
220	440	3

(9) WELL SEAL:

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

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

Method of sealing cement

(10) WATER LEVELS:

Depth of first water, if known ft.

Standing level after well completion 150 ft.

(11) WELL TESTS:

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

Type of test Pump ☐ Bailer X Air lift ☐

Depth to water at start of test 150 ft. At end of test 350 ft

Charge 12 gal/min after 3 hours Water temperature

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

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

(12) WELL LOG:

Total depth 440 ft. Depth of completed well 440 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	250	brown ash, boulders
250	400	green & brown ash
400	430	green ash, broken up rock
430	440	grey ash

Work started 4-30- 19 81 Completed 4-27- 19 81

WELL DRILLER'S STATEMENT:

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

SIGNED Bill Pullian (Well Driller)

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

Address 2877 Piedmont Ave.

City Napa Zip 94558

License No. 348677 Date of this report 6-15-81

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

NOT FOR PUBLIC USE
WATER CODE SEC. 13752

Well #15

E: 4/12/17

File Original with DWR

State of California

Well Completion Report

No. e0337568

Page 1 of 1

Owner's Well Number Well #2

Date Work Began 02/24/2017 Date Work Ended 3/6/2017

Local Permit Agency Napa County Environmental Health

Permit Number OE17-00014 Permit Date 2/3/17

DWR Use Only – Do Not Fill In

State Well Number/Site Number: 08N06W08

Latitude: 38 33 40 N Longitude: 122 32 33 W

APN/TRS/Other

Geologic Log

Orientation: ◉ Vertical ○ Horizontal ○ Angle Specify

Drilling Method Direct Rotary Drilling Fluid Polymer mud

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	2	Loam / roots
2	10	Orange sandy silt, tufa
10	16	Tan ash tufa
16	20	Fractured tufa, tan orange
20	40	Tan yellow sandy ash
40	50	Fractured tan orange gray tufa
50	65	Orange clayey sand
65	90	Reddish brown volcanic sand, soft
90	190	Multi-colored volcanic sand conglomerate, soft
190	200	Fractured volcanic tufa, ash
200	300	Volcanic conglomerate, soft, multi-colored sand
		gravels in greenish sandy, silty, ash matrix
300	400	Same, very soft becomes sandier

Total Depth of Boring 400 Feet

Total Depth of Completed Well 400 Feet

Well Location

Address 4109 Heitz Way

City Calistoga County Napa

Latitude 38 (Deg) 33 (Min) 40 (Sec) N Longitude 122 (Deg) 32 (Min) 33 (Sec) W

Datum Decimal Lat. Decimal Long.

APN Book 020 Page 220 Parcel 007

Township 8N Range 6W Section 8

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North / West / East / South

Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. **Please be accurate and complete.**

Activity

◉ New Well
○ Modification/Repair
○ Deepen
○ Other
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

◉ Water Supply
☑ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other

Water Level and Yield of Completed Well

Depth to first water (Feet below surface)

Depth to Static Water Level 103 (Feet) Date Measured 03/03/2017

Estimated Yield * 30 (GPM) Test Type Air Lift

Test Length 4.0 (Hours) Total Drawdown 280 (Feet)

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

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	50	11						
50	400	9 7/8						
0	290		Blank	PVC Sch. 40	SDR21	5		
290	390		Screen	PVC Sch. 40	SDR21	5	Milled Slots	0.032
390	400		Blank	PVC Sch. 40	SDR21	5		

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	55	Cement	
55	220	Filter Pack	#6 Sand
220	400	Filter Pack	8x16 Sand

Attachments

☐ Geologic Log
☐ Well Construction Diagram
☐ Geophysical Log(s)
☐ Soil/Water Chemical Analyses
☑ Other Site Map

Attach additional information, if it exists

Certification Statement

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

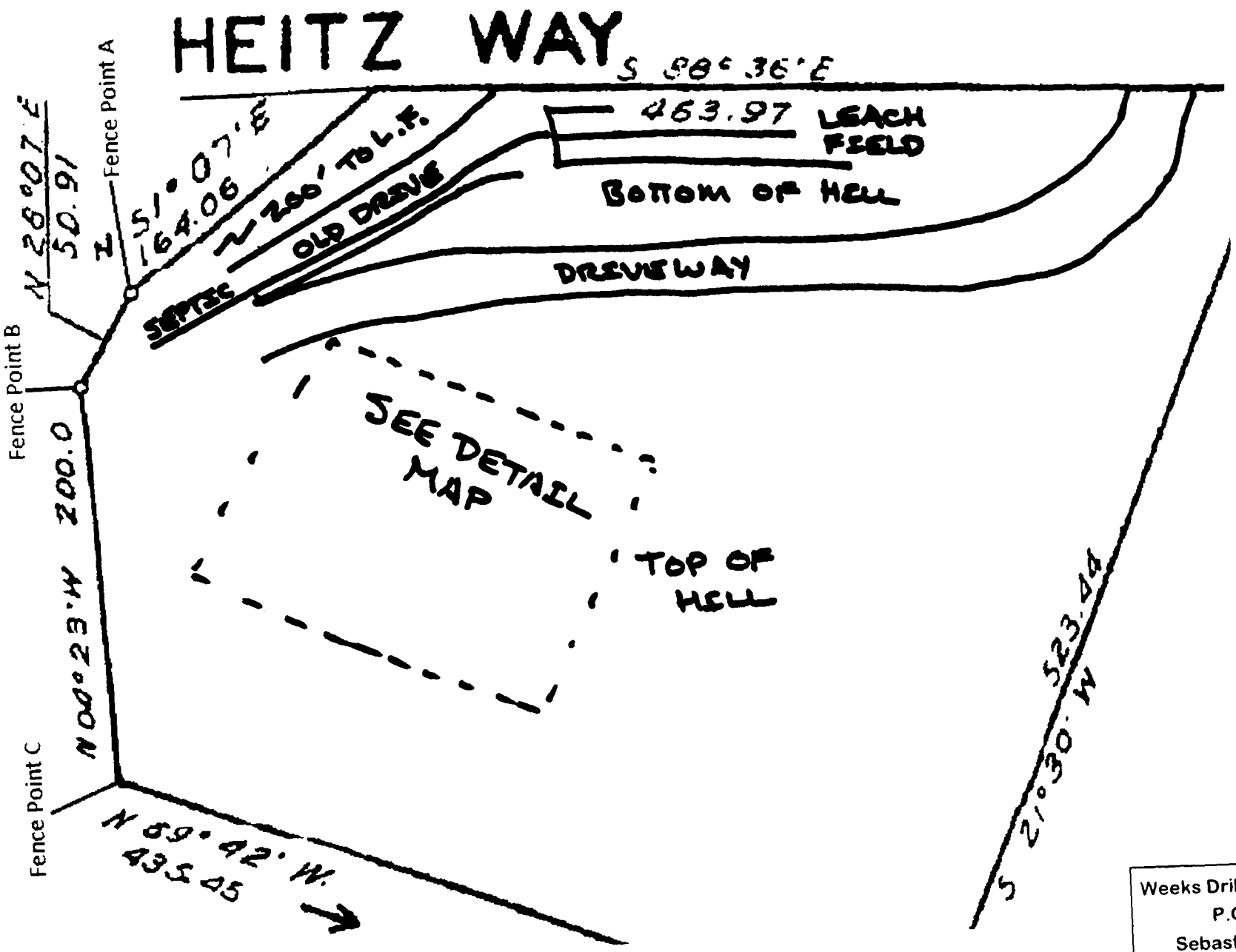
Name Weeks Drilling & Pump Company (Person, Firm or Corporation)

P.O. Box 176 (Address) Sebastopol (City) CA (State) 95473 (Zip)

Signed (C-57 Licensed Water Well Contractor) 3/10/17 (Date Signed) 177681 (C-57 License Number)

DWR 188 REV 1/2006

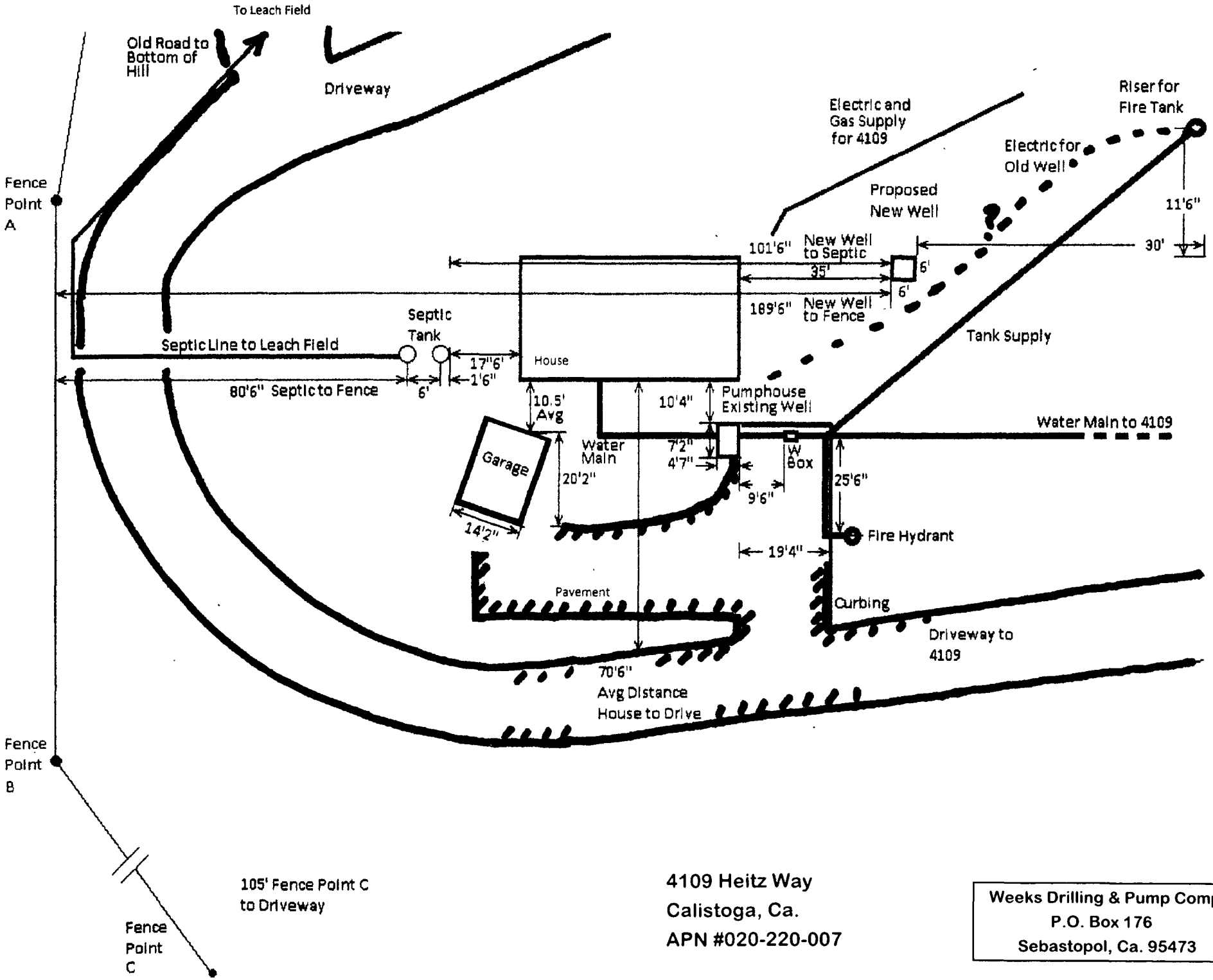
4109 Heitz Way
Calistoga, Ca.
APN #020-220-007



C 033788

2/19/17

Weeks Drilling & Pump Company
P.O. Box 176
Sebastopol, Ca. 95473



4109 Heitz Way
Calistoga, Ca.
APN #020-220-007

Weeks Drilling & Pump Company
P.O. Box 176
Sebastopol, Ca. 95473

e 0337568

E: 4/19/17

Well #16

ORIGINAL
File with DWR

Page ___ of ___

Owner's Well No. ___

Date Work Began 10-25-12 Ended 10-30-12

Local Permit Agency Napa County

Permit No. E12-00474 Permit Date 8-13-12

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 0947972

DWR USE ONLY — DO NOT FILL IN

08N06W08

STATE WELL NO./STATION NO.

LATITUDE 383344 LONGITUDE 1223245

APN/TRS/OTHER

GEOLOGIC LOG

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

DRILLING METHOD rotary FLUID Mud

DEPTH FROM SURFACE Ft. to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0 120	brown ash & boulders
120 320	hard black ash, streaks of fractured broken up black ash

TOTAL DEPTH OF BORING 320 (Feet)

TOTAL DEPTH OF COMPLETED WELL 320 (Feet)

WELL LOCATION

Address 4471 Redwood Way

City Calistoga

County Napa

APN Book ___ Page ___ Parcel 020-210-011

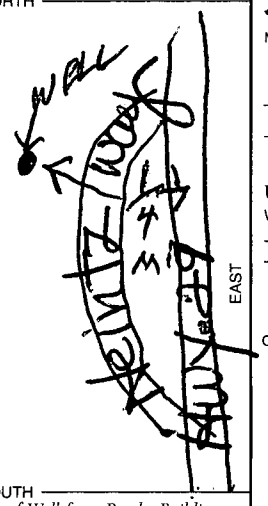
Township ___ Range ___ Section ___

Lat ___ DEG. ___ MIN. ___ SEC. N

Long ___ DEG. ___ MIN. ___ SEC. W

LOCATION SKETCH

NORTH



WEST EAST

SOUTH

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

ACTIVITY (✓)

✓ NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

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

USES (✓)

WATER SUPPLY
___ Domestic ___ Public
✓ Irrigation ___ Industrial

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 140 (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 130 (Ft.) & DATE MEASURED 10-30-12

ESTIMATED YIELD * 20 (GPM) & TEST TYPE AIR LIFT

TEST LENGTH 3 (Hrs.) TOTAL DRAWDOWN 300 (Ft.)

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

CASING (S)

DEPTH FROM SURFACE Ft. to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0 51'	12"	X				PLASTIC	6"	200	
51 120	10"	X				"	"	"	
120 320	10"	FACT				PERF	"	"	3/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft. to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0 51	X			
51 320	WELL	Pack	#6	

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

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

2877 Piedmont Napa Ca. 94558
ADDRESS CITY STATE ZIP

Signed Bill Fulliam
C-57 LICENSED WATER WELL CONTRACTOR

11-1-12 DATE SIGNED

248677
C-57 LICENSE NUMBER

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

OSP 03 78836

Well #17

R 9/17/14

ORIGINAL
File with DWR

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 0955824

DWR USE ONLY — DO NOT FILL IN
STATE WELL NO / STATION NO: 08N06W08
LATITUDE: 38 33 46 N
LONGITUDE: 122 32 41 W
APN/TRS/OTHER:

Page ___ of ___
Owner's Well No. 8-4-14
Date Work Began 8-4-14 Ended 8-13-14
Local Permit Agency Napa County
Permit No. E14-0863 Permit Date 7-30-14

GEOLOGIC LOG

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

DEPTH FROM SURFACE Ft. to Ft.	DESCRIPTION (Describe material, grain size, color, etc.)
0 110	brown ash & rock
110 330	brown ash streaks of broken up brown & black ash
330 460	green clay streaks of broken up black & green ash
460 500	gray clay

TOTAL DEPTH OF BORING 500 Feet
TOTAL DEPTH OF COMPLETED WELL 500 Feet

WELL LOCATION

Address #199 Heintz Way
City Calistoga
County Napa
APN Book ___ Page ___ Parcel 020-390-003
Township ___ Range ___ Section ___
Lat ___ DEG. ___ MIN ___ SEC N
Long ___ DEG. ___ MIN. ___ SEC. W

LOCATION SKETCH

NORTH
well
¼ mi
Heintz Way
WEST
EAST
SOUTH

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

ACTIVITY (✓)

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

USES (✓)

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 10' (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 20' (Ft.) & DATE MEASURED 8-13-14
ESTIMATED YIELD * 150 (GPM) & TEST TYPE AIR LIFT
TEST LENGTH 3 (Hrs.) TOTAL DRAWDOWN 250 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft. to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0 60	12"	X				PLASTIC	6"	200	
60 100	9⅞	X				"	"	"	
100 500	9⅞		FACT			PERF	"	"	3/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft. to Ft.	TYPE: CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0 60	X			
60 500				WELL PACK #8

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

NAME Pullum Well Drilling (PERSON, FIRM, OR ORGANIZATION) (TYPED OR PRINTED)
ADDRESS 2877 Piedmont Av. CITY Napa STATE CA ZIP 94558
Signed Bill Pullum C-57 LICENSED WATER WELL CONTRACTOR
DATE SIGNED 8-14-14
C-57 LICENSE NUMBER 248677

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

OSP 03 78836

Well #18

2-9/17/14

ORIGINAL
File with DWR

Page ___ of ___

STATE OF CALIFORNIA
WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 0955810

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO. STATION NO.: 08N06W08

LATITUDE: 38 33 46 N — LONGITUDE: 122 32 41 W

APN/TRS/OTHER:

Owner's Well No. ___

Date Work Began 1-29-14 Ended 2-4-14

Local Permit Agency Napa County

Permit No. E13-00810 Permit Date 12-10-13

GEOLOGIC LOG

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

DRILLING METHOD rotary FLUID mud

DEPTH FROM SURFACE Ft. to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0 20	brown Clay
20 50	sandy clay, boulders, streaks of gravel
50 130	brown clay, boulders
130 350	brown ash, boulders, streaks of black broken up ash
350 355	black broken up ash
355 470	gray ash, streaks of broken black & green ash
470 490	hard clay

TOTAL DEPTH OF BORING 490 Feet

TOTAL DEPTH OF COMPLETED WELL 487 Feet

Address 1775 Redwood Way

City Clayton

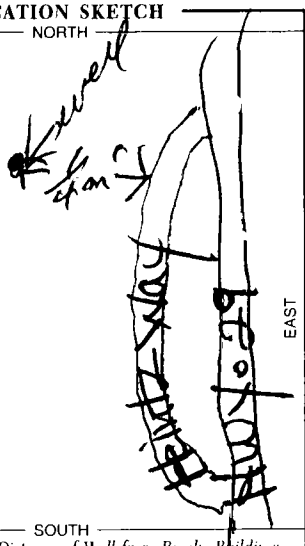
County Napa

APN Book ___ Page ___ Parcel 020-210-011

Township ___ Range ___ Section ___

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

LOCATION SKETCH



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

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

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

USES (✓)

WATER SUPPLY
X Domestic ___ Public
X Irrigation ___ Industrial

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 25' (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL 0 (Ft.) & DATE MEASURED 2-4-14

ESTIMATED YIELD * 80 (GPM) & TEST TYPE AIR LIFT

TEST LENGTH 2 (Hrs.) TOTAL DRAWDOWN 300 (Ft.)

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

CASING (S)

DEPTH FROM SURFACE Ft. to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓): BLANK	SCREEN	CONDUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0 57	11"	X				PLASTIC	5"	200	
57 77	9"	X				"	"	"	
77 490	9"	FACT			PREF	"	"	"	3/32

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft. to Ft.	TYPE: CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0 57	X			
57 487				WELL PACK #6

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

NAME William Wells Drilling
(PERSON, FIRM OR CORPORATION) (TYPED OR PRINTED)

ADDRESS 2567 Pledmont Av. CITY Napa STATE CA ZIP 94558

Signed Bill Wells C-57 LICENSED WATER WELL CONTRACTOR

DATE SIGNED 2-10-14 C-57 LICENSE NUMBER 456277

DWR 188 REV. 05-03

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

OSP 03 78836

Well #19

10-210-12

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

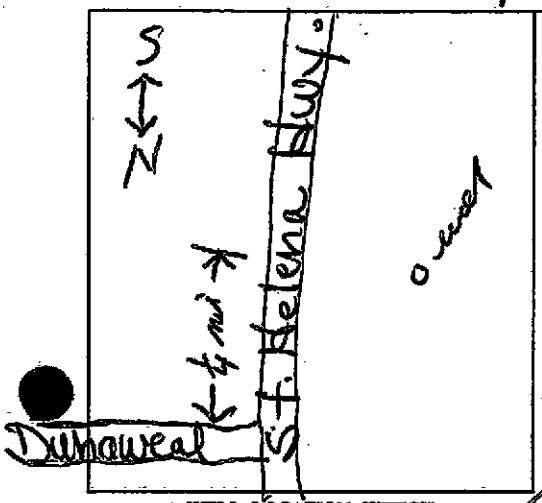
Do not fill in
No. 384918

Notice of Intent No.
Local Permit No. or Date 29019

State Well No. 08N06W08
Other Well No.

(1
Ac
Ci

(2) LOCATION OF WELL (See instructions):
County 28 Owner's Well Number
Well address if different from above 4501 St. Helena Hwy.
Township 20 Range 210 Section 12
Distance from cities, roads, railroads, fences, etc. 1/4 mi. So. of Dunaweal Lane on St. Helena Hwy.



WELL LOCATION SKETCH

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

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

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

(6) GRAVEL PACK:
Yes ☒ No ☐ Size Rice
Diameter of bore 9"
Packed from 23 ft. to 335 ft.

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

From ft.	To ft.	Dia. in.	Gage or Wall
0	335	5	160

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

From ft.	To ft.	Slot size
215	335	FACTORY PREF

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 23 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing cement

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion 50 ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? Drilling
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 50 ft. At end of test 200 ft.
Discharge 50 gal/min after 2 hours Water temperature
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 335 ft. Completed depth 335 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	25	brown ash, rock
25	32	clay
32	57	brown ash & broken up rock
57	235	brown ash & clay
235	335	green ash & black broken up rock

Work started 7-19-1991 Completed 7-29-1991

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Signed (Well Driller)
NAME Pullam Well Drilling (Person, firm, or corporation) (Typed or printed)
Address 287 Piedmont Ave.
City Napa ZIP 94558
License No. 248677 Date of this report 8-4-91

ONE IN USE
NOT FOR PUBLIC USE
WATER CODE SEC. 13752

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

Well #20

ORIGINAL
File with DWR

Page 1 of 1
Owner's Well No. # 3
Date Work Began 10-23-99, Ended 11-6-99
Local Permit Agency Co of Napa Environmental Mangt.
Permit No. 96-11184 Permit Date 7-27-99

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet
No. 822300

DWR USE ONLY — DO NOT FILL IN
08N/06W08
STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

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

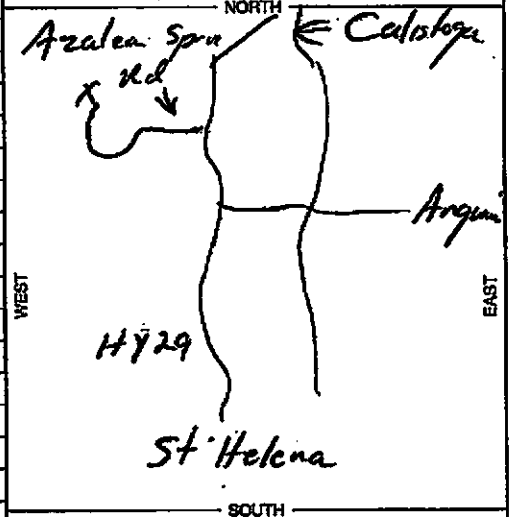
DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	3	Top Soil
3	26	Red Clay Boulders
26	37	White Ash
37	112	Brown Ash 1/2 GPM
112	127	Yellow Ash
127	295	White Ash
295	482	White Ash / Mult Color Rock Mx
482	506	Mult Color Vol Rock
506	518	White Ash / Vol Rock
518	530	Reddish Vol Cinder
530	595	Hard Black Basalt

TOTAL DEPTH OF BORING 595 (Feet)
TOTAL DEPTH OF COMPLETED WELL 588 (Feet)

WELL LOCATION

Address 4301 Azalea Springs Rd
City Calistoga
County Napa
APN Book 20 Page 210 Parcel 10
Township ___ Range ___ Section ___
Latitude ___ DEG. ___ MIN. ___ SEC. NORTH
Longitude ___ DEG. ___ MIN. ___ SEC. WEST

LOCATION SKETCH



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

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

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER 90' (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 90' (Ft.) & DATE MEASURED 11-1-99
ESTIMATED YIELD * 45+ (GPM) & TEST TYPE Air lift
TEST LENGTH 4 (Hrs.) TOTAL DRAWDOWN NA (Ft.)
** May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CONDUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	23	12 1/4	X				PVCF480	6	200	—
23	160	9	X				PVCF480	6	200	
160	588		X	X			PVCF480	6	200	032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	TYPE CEMENT (✓)	BENTONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	25	✓			
25	482			✓	3/8 Pea Gravel

ATTACHMENTS (✓)

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

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

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

NAME D. Bess Pump & Well (PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)
ADDRESS 1115 MT George Ave CITY Napa STATE Ca ZIP 94558
Signed Paul B (WELL DRILLER/AUTHORIZED REPRESENTATIVE) DATE SIGNED 11-9-99 C-57 LICENSE NUMBER 487027

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Well #21

STONE, NORMAN

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

ORIGINAL
File with DWR

Do not fill in

No. 384870

State Well No. 08N06W08

Other Well No.

Notice of Intent No.

Local Permit No. or Date

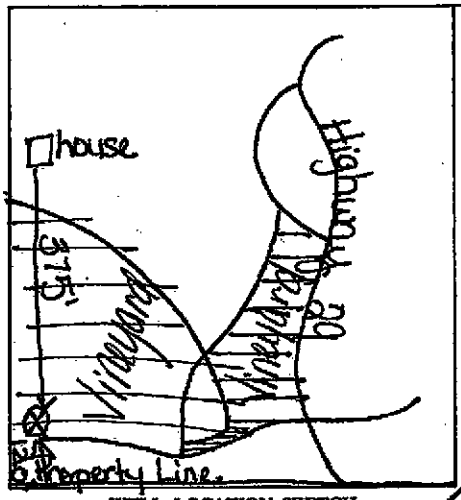
(2) LOCATION OF WELL (See instructions):

County Napa Owner's Well Number AP#20-210-10

Well address if different from above 4301 Azalea Springs Road

Township Range Section

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



WELL LOCATION SKETCH

(3) TYPE OF WORK:

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

(4) PROPOSED USE:

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

(5) EQUIPMENT:

Rotary ☒ Reverse ☐
Cable ☐ Air ☒
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☐ Size Pea
Diameter of bore 14"
Packed from 430 ft. to 21 ft.

(7) CASING INSTALLED:

Steel ☒ Plastic ☐ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	110	8	200
150	170	8	200
190	210	8	200

(8) PERFORATIONS:

Type of perforation or size of screen .032

From ft.	To ft.	Slot size
110	150	.032
170	190	.032
210	430	.032

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 21 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing Bentonite Pellets & Concrete

(10) WATER LEVELS:

Depth of first water, if known 130 ft.
Standing level after well completion 120 ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? Driller
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 120 ft. At end of test Complete ft.
Discharge 30 gal/min after 8 hours Water temperature
Chemical analysis made? Yes ☒ No ☐ If yes, by whom? Cal- Test
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG:

Total depth 430 ft. Completed depth 430 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	2	Topsoil
2	24	Brown Clay-Tuffa
24	40	Lt. & Dark Brown Rock Soft
40	100	Red, Brown, Grey, White, & BlackRock Soft
100	145	Red, Brown, Green, & Black Rock Fract Med
145	160	White, Tan, Black, & Grey Rock Soft
160	175	Gray, White, Black Stringers Brown Clay
175	190	Gray, Black, & Dark Green Rock Fract Med
190	205	Brown & Gray Clay
205	295	Black, Green, Brown & Gray Rock Soft
295	330	Gray, White, Brown, & Black Rock stringers Gray & Brown Clay
330	390	Black, White, Brown, & Gray Rock Stringer Green
390	430	Gray & Black Rock Stringer Brown-Gray Clay

Work started 10-17 19 91 Completed 10-31 19 91

WELL DRILLER'S STATEMENT:

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

Signed Raymond Webster (Well Driller)

NAME DOSHIER-GREGSON, INC. (Person, firm, or corporation) (Typed or printed)

Address 5365 Napa-Vallejo Highway

City Vallejo ZIP 94589

License No. 258826 Date of this report 11-01-91

COPIED IN NOT FOR PUBLIC USE WATER CODE SEC. 13752

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

Well #22

*The free Adobe Reader may be used to view and complete this form. However, software must be purchased to complete, save, and reuse a saved form. 12/17/14

File Original with DWR

Page _____ of _____

Owner's Well Number _____

Date Work Began 06/13/2014 Date Work Ended 7/1/2014

Local Permit Agency Napa County Planning, Building & Environmental Services

Permit Number E14-00337 Permit Date 5/2/14

State of California

Well Completion Report

Refer to Instruction Pamphlet

No. e0241006

DWR Use Only – Do Not Fill In

State Well Number/Site Number: 08N06W08

Latitude: 38 33 49 N Longitude: 122 33 10 W

APN/TRS/Other

Geologic Log

Orientation: ◉ Vertical ○ Horizontal ○ Angle Specify _____

Drilling Method Direct Rotary Drilling Fluid Bentonite mud

Depth from Surface Feet	to Feet	Description (Describe material, grain size, color, etc)
0	20	Sandstone, brown clay
20	100	Multicolor rock, brown clay.
100	140	Multicolor rock brown clay.
140	180	Multicolor rock brown clay.
180	220	Multicolor hard rock.
220	280	Multicolor rock brown clay.
280	480	Multicolor rock brown clay.
480	500	Multicolor rock.
		**********CASING**********
240	260	10. Blank F480 PVC .316 6.625
260	300	10. Screen F480 PVC .316 6.625 0.032
300	320	10. Blank F480 PVC .316 6.625
320	360	10. Screen F480 PVC .316 6.625 0.032
360	380	10. Blank F480 PVC .316 6.625
380	420	10. Screen F480 PVC .316 6.625 0.032
420	440	10. Blank F480 PVC .316 6.625
440	460	10. Screen F480 PVC .316 6.625 0.032
460	480	10. Blank F480 PVC .316 6.625
480	500	10. Screen F480 PVC .316 6.625 0.032

Total Depth of Boring 500 Feet

Total Depth of Completed Well 500 Feet

Well Location

Address Aurora Vineyards

City 4325 Azalea Springs Road County Napa

Latitude ___ ___ ___ N Longitude ___ ___ ___ W (Deg. Min. Sec.)

Datum _____ Dec. Lat. _____ Dec. Long. _____

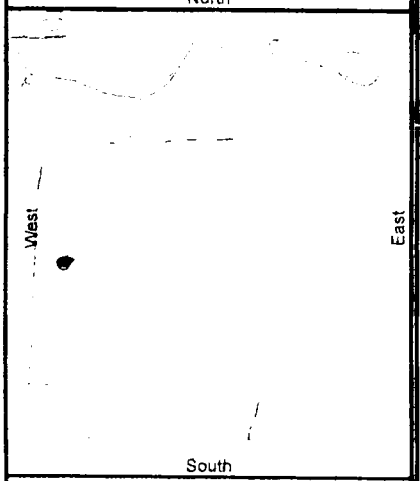
APN Book 020- Page 210- Parcel 023-000

Township _____ Range _____ Section _____

Location Sketch

(Sketch must be drawn by hand after form is printed.)

North



Illustrate or describe distance of well from roads, buildings, fences, rivers, etc. and attach a map. Use additional paper if necessary. Please be accurate and complete

Activity

◉ New Well
○ Modification/Repair
○ Deepen
○ Other _____
○ Destroy
Describe procedures and materials under "GEOLOGIC LOG"

Planned Uses

◉ Water Supply
☑ Domestic ☐ Public
☐ Irrigation ☐ Industrial
○ Cathodic Protection
○ Dewatering
○ Heat Exchange
○ Injection
○ Monitoring
○ Remediation
○ Sparging
○ Test Well
○ Vapor Extraction
○ Other _____

Water Level and Yield of Completed Well

Depth to first water _____ (Feet below surface)

Depth to Static Water Level 0 (Feet) Date Measured 07/01/2014

Estimated Yield * 97 (GPM) Test Type Air Lift

Test Length 12.0 (Hours) Total Drawdown 280 (Feet)

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

Casings

Depth from Surface Feet	to Feet	Borehole Diameter (Inches)	Type	Material	Wall Thickness (Inches)	Outside Diameter (Inches)	Screen Type	Slot Size if Any (Inches)
0	100	12.75	Blank	F480 PVC	.316	6.625		
100	120	10.	Screen	F480 PVC	.316	6.625	Milled Slots	0.032
120	140	10.	Blank	F480 PVC	.316	6.625		
140	180	10.	Screen	F480 PVC	.316	6.625	Milled Slots	0.032
180	200	10.	Blank	F480 PVC	.316	6.625		
200	240	10.	Screen	F480 PVC	.316	6.625	Milled Slots	0.032

Annular Material

Depth from Surface Feet	to Feet	Fill	Description
0	61	Cement	
61	500	Filter Pack	#6 sand pack

Attachments

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

Attach additional information, if it exists

Certification Statement

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

Name McLean & Williams, Inc. (Person, Firm or Corporation)

878 El Centro Ave. (Address) Napa (City) CA (State) 94558 (Zip)

Signed _____ (C-57 Licensed Water Well Contractor) 11/11/2014 (Date Signed) 396352 (C-57 License Number)

DWR 188 REV. 1/2006

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

APPENDIX B

Water System Details of Tucker Acres Mutual Water Co.

CA Drinking Water Watch

CA Drinking Water Watch

Links

Water System Details

Water System Facilities

Monitoring Schedules

Monitoring Results

Monitoring Results By Analyte

Lead And Copper Sampling

- Summaries
- Next Sampling Due Dates
- All Lead Sampling Results
- All Copper Sampling Results

Violations/Enforcement Actions

Site Visits

Consumer Confidence Reports

Return Links

Water System Search

County Map

Glossary

Contact Info

Water System Details

Water System No. :	CA2800516	**Federal Type :**	C
Water System Name :	TUCKER ACRES MUTUAL WATER CO.	**State Type :**	C
Principal County Served :	NAPA	**Primary Source :**	GW
Status :	A	**Activity Date :**	09-04-2015
Distribution System Classification :	D1	**Max Treatment Plant Classification :**	

Water System Contacts

Type	Address	Phone	Email - Web Address
Administrative Contact	PO BOX 645 CALISTOGA,CA 94515	Business 707-942-1210	
Physical Location Contact	CA2800516-TUCKER ACRES MUTUAL WATER CO.		

Division of Drinking Water District / County Health Dept. Info

Name	Phone	Email	Address
LPA58 - NAPA COUNTY	707-253-4471	stacey.harrington@countyofnapa.org	1195 Third Street, Ste. 210 NAPA CA 94559

Annual Operating Periods & Population Served

Start Month	Start Day	End Month	End Day	Population Type	Population Served
1	1	12	31	R	200

Service Connections

Type	Count	Meter Type	Meter Size Measure
CB	23	UN	0

Sources of Water

Name	Type Code	Status
BACK UP WELL	WL	A
WELL #2	WL	A

Service Areas

Code	Name
NT	INDUSTRIAL/AGRICULTURAL

Water Purchases

Seller Water System No.	Water System Name	Seller Facility Type	Seller State Asgn ID No.	Buyer Facility Type	Buyer State Asgn ID No.

APPENDIX C

Napa County SWB Groundwater Recharge Analysis

O'Connor Environmental

Napa County Groundwater Recharge Analysis

Introduction

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

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

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

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

Model Development

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

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

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

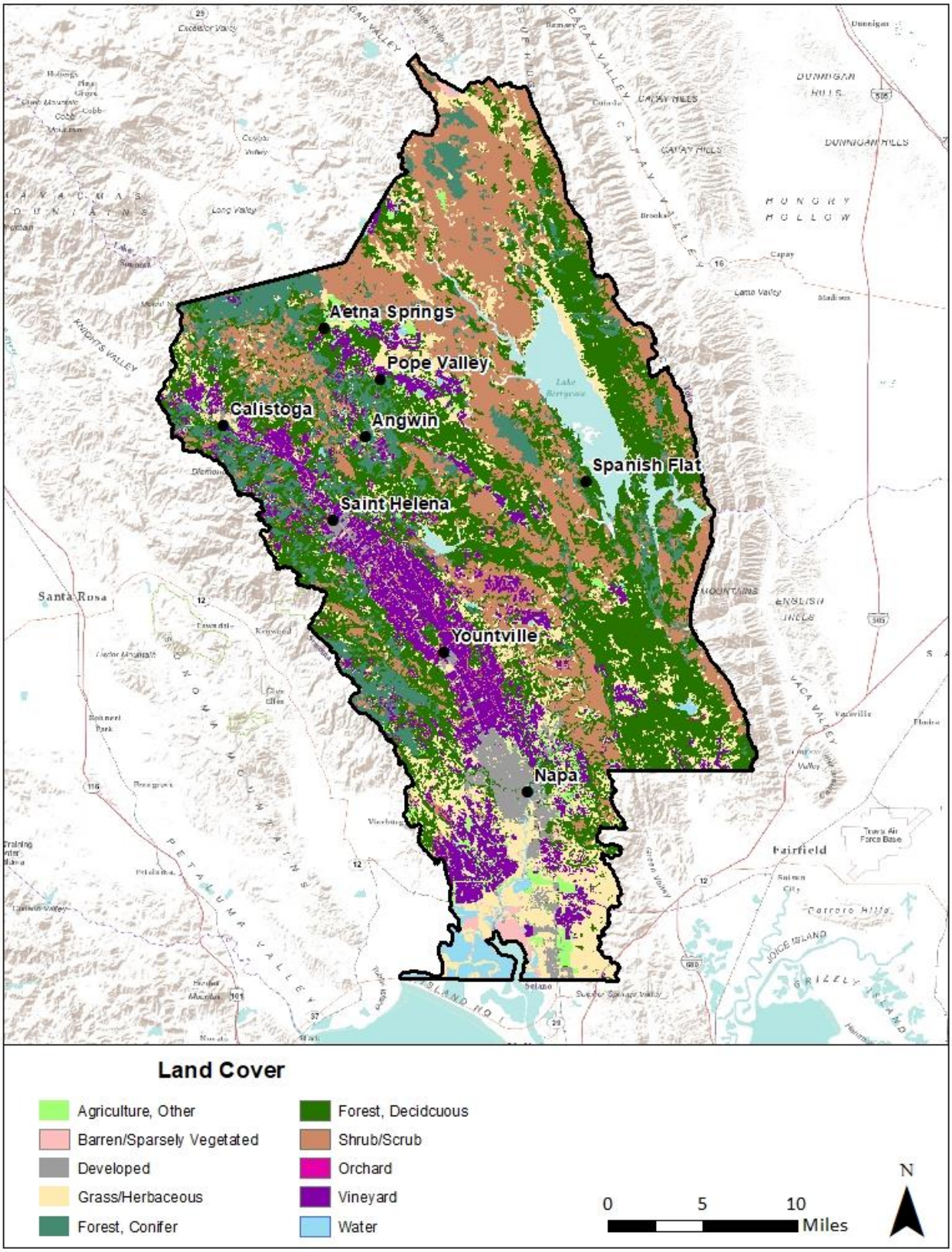


Figure 1: Land cover distribution used in the Napa County SWB model.

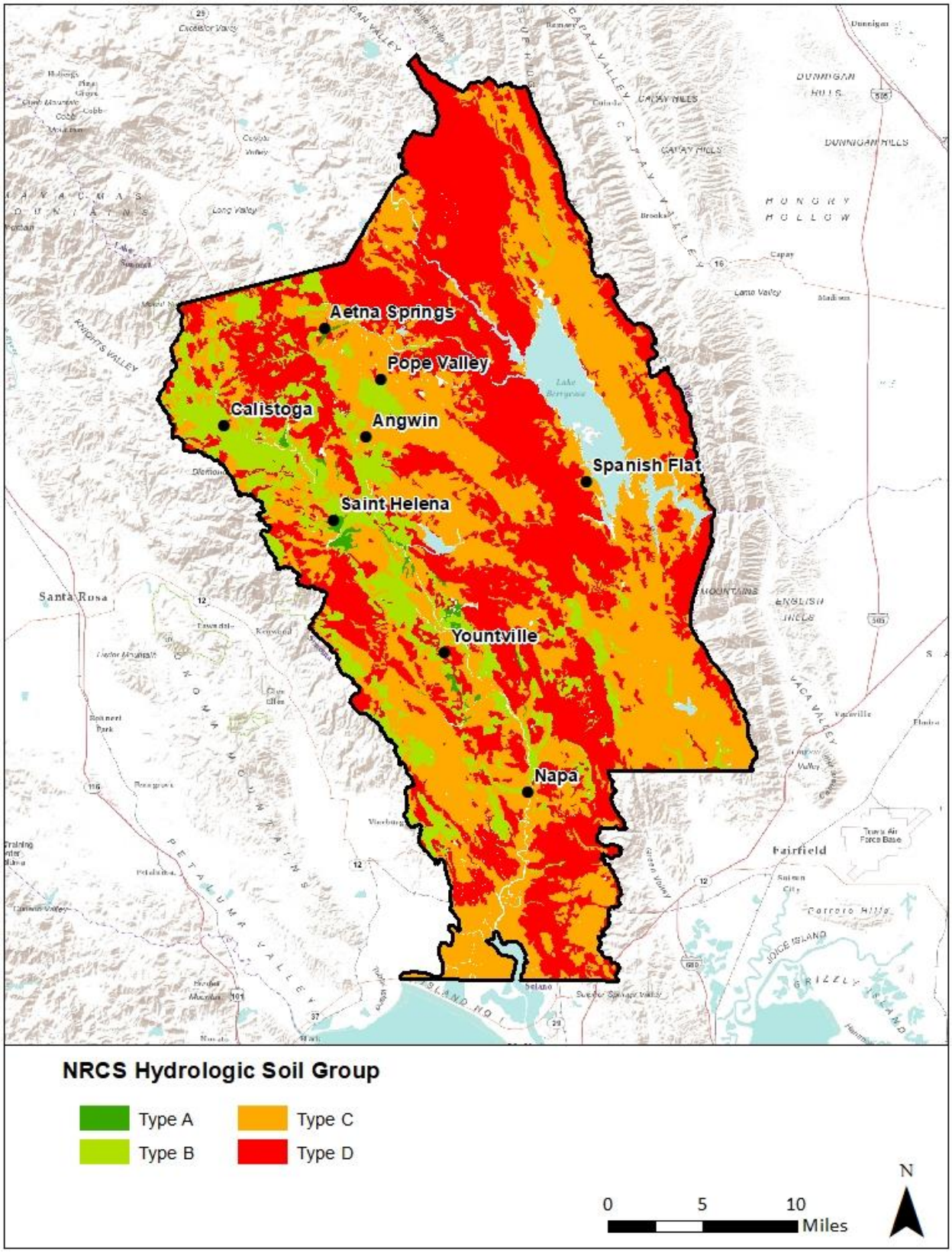


Figure 2: Hydrologic soil group distribution used in the Napa County SWB model.

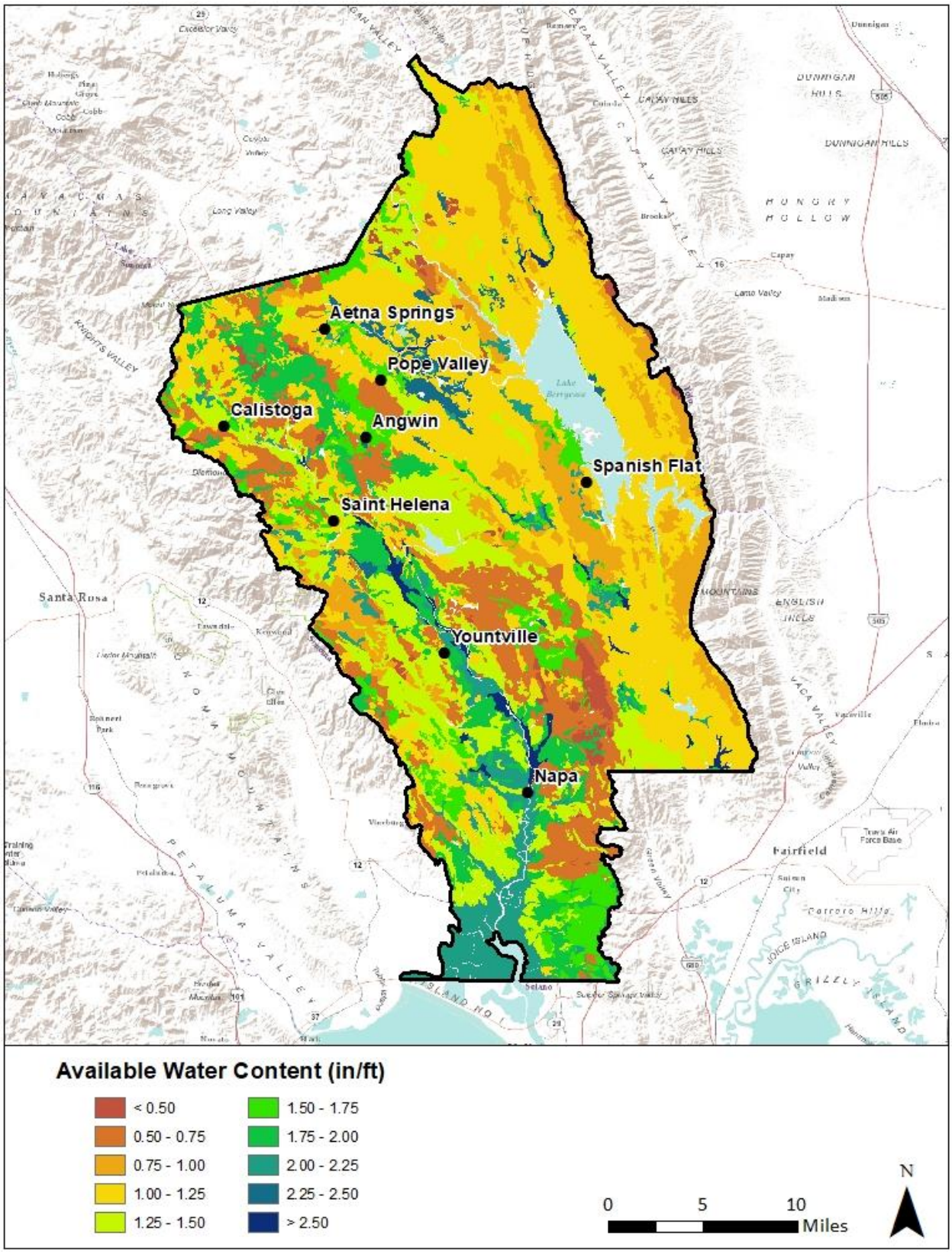


Figure 3: Available water capacity distribution used in the Napa County SWB model.

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

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

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

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

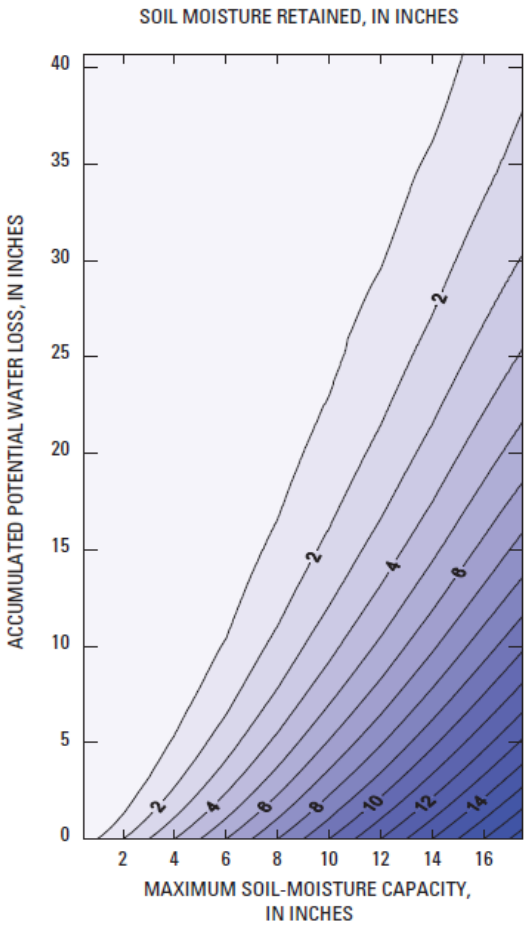


Figure 4: Soil-moisture-retention table (Thornthwaite and Mather 1957).

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

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

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

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

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

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

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

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

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

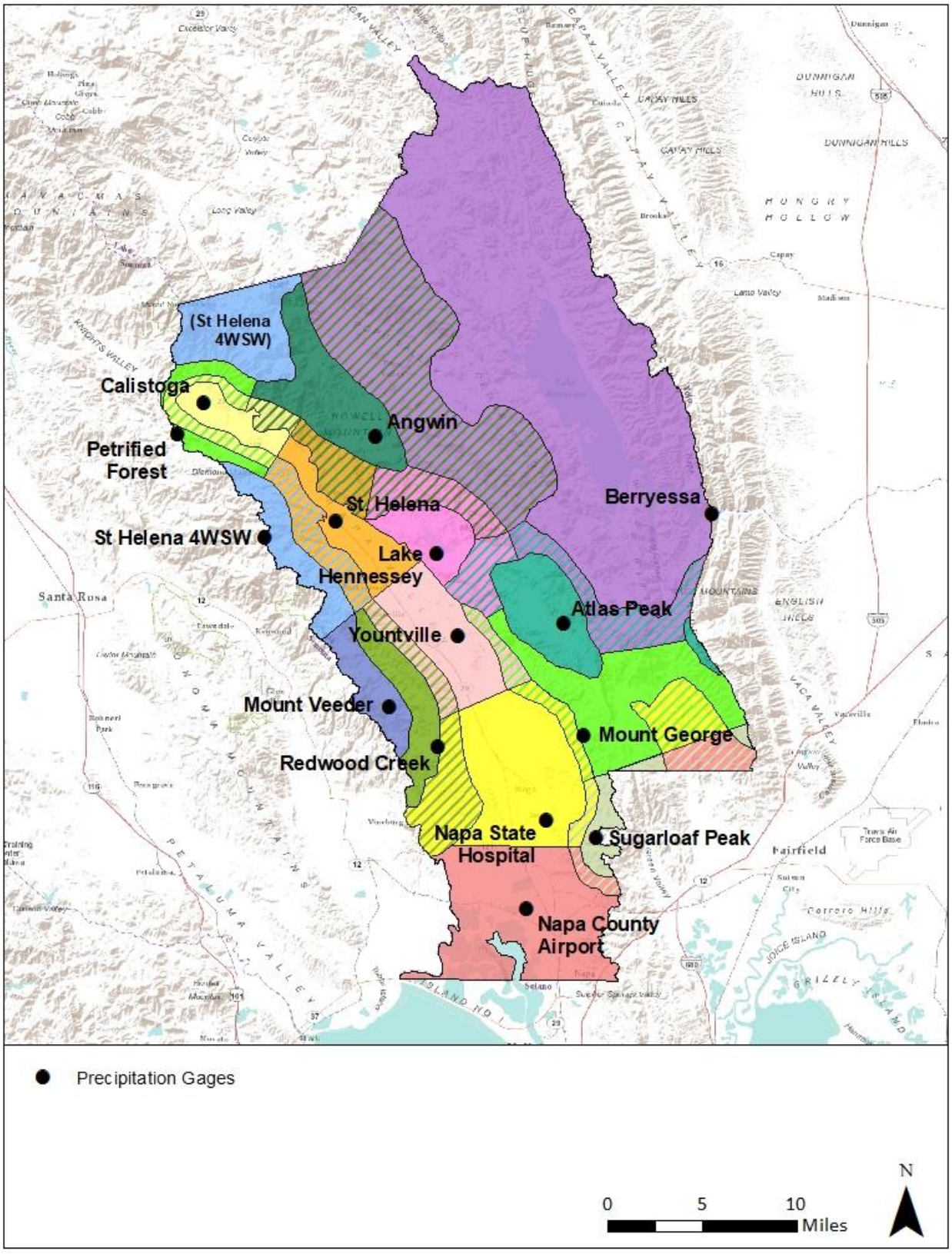


Figure 5: Precipitation zones used in the Napa County SWB model. Hatching indicates areas where two precipitation records were averaged across a zone.

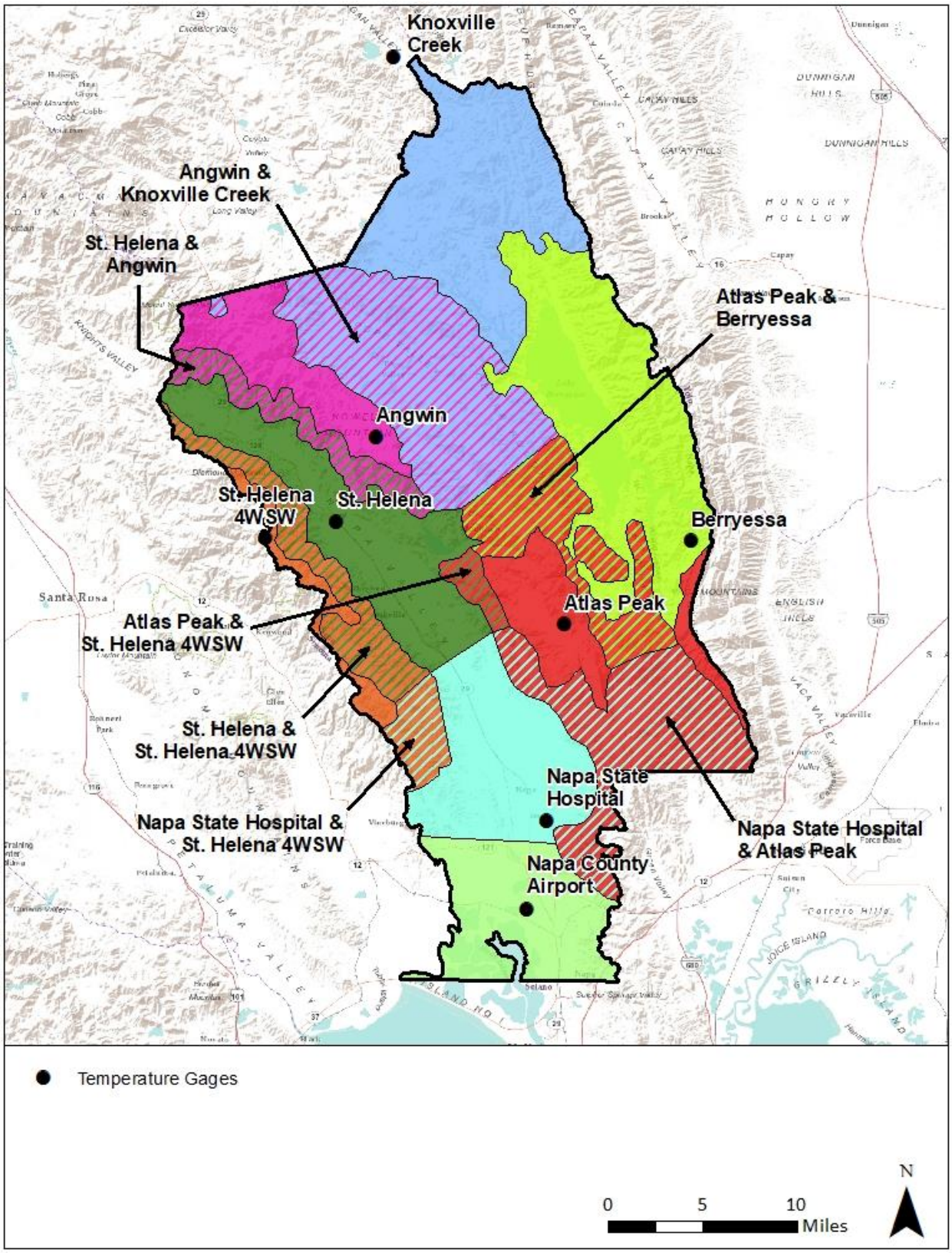


Figure 6: Temperature zones used in the Napa County SWB model. Hatching indicates areas where two temperature records were averaged across a zone.

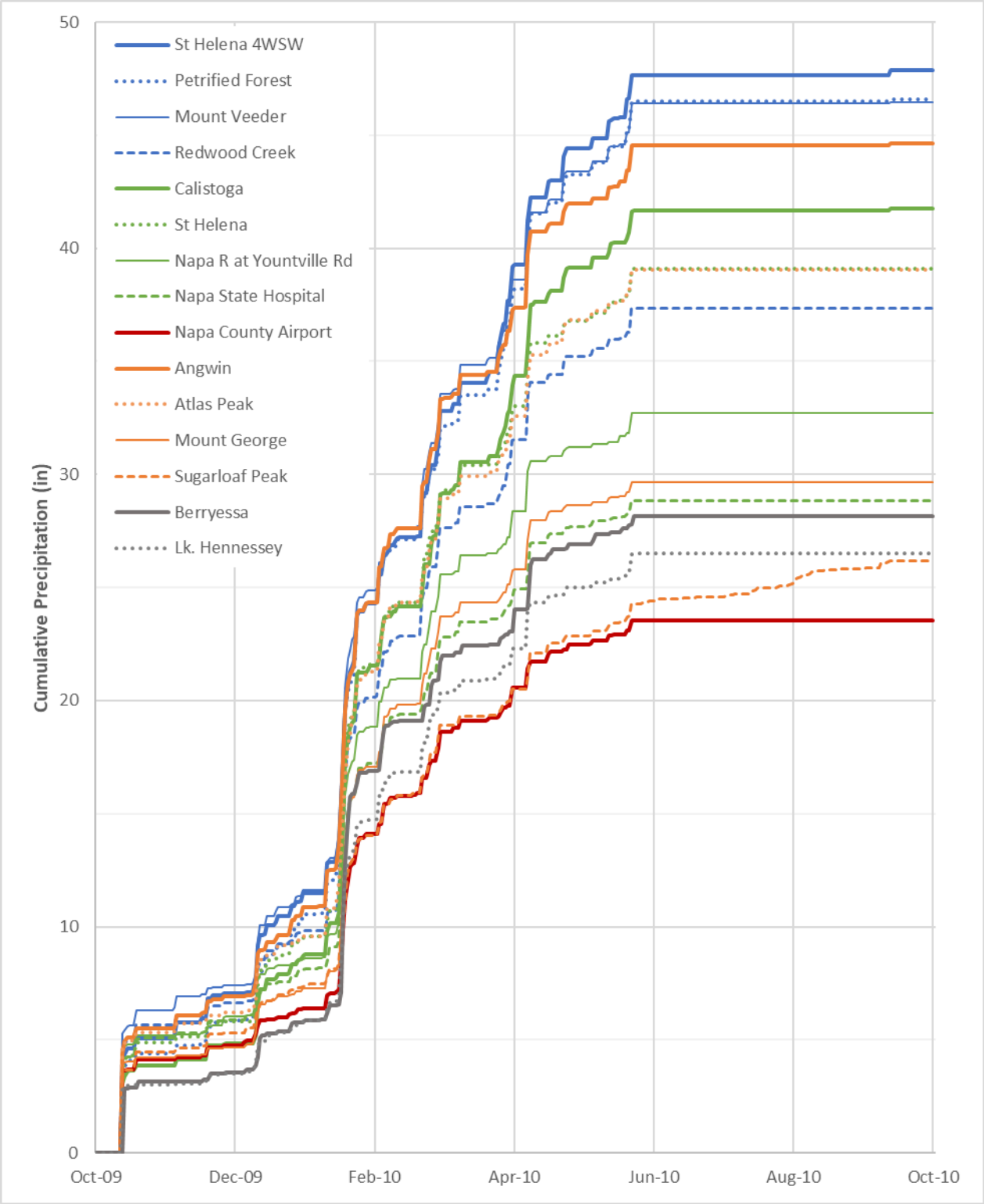


Figure 7a: Daily precipitation data used in the Napa County SWB model for WY 2010.

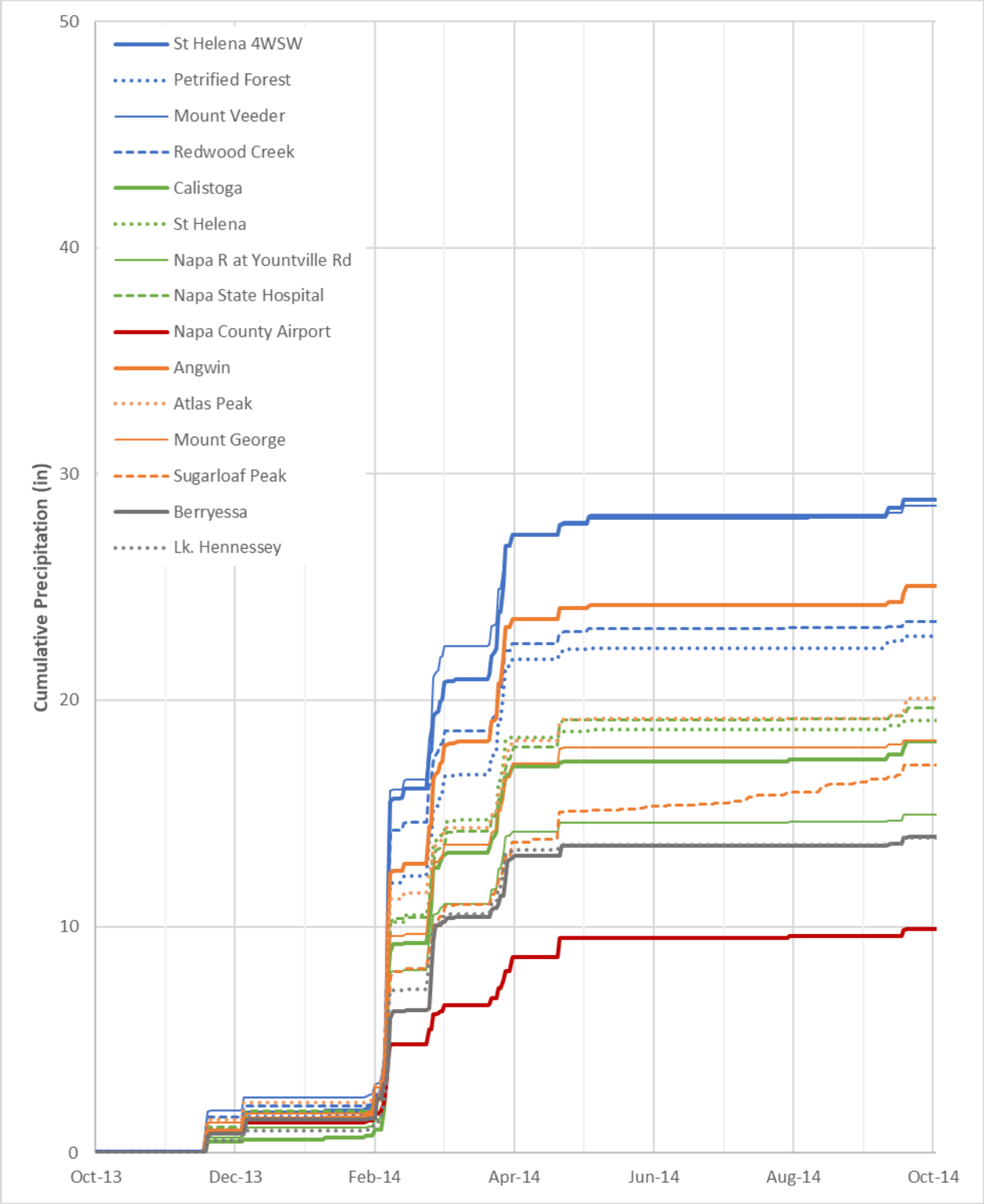


Figure 7b: Daily precipitation data used in the Napa County SWB model for WY 2014.

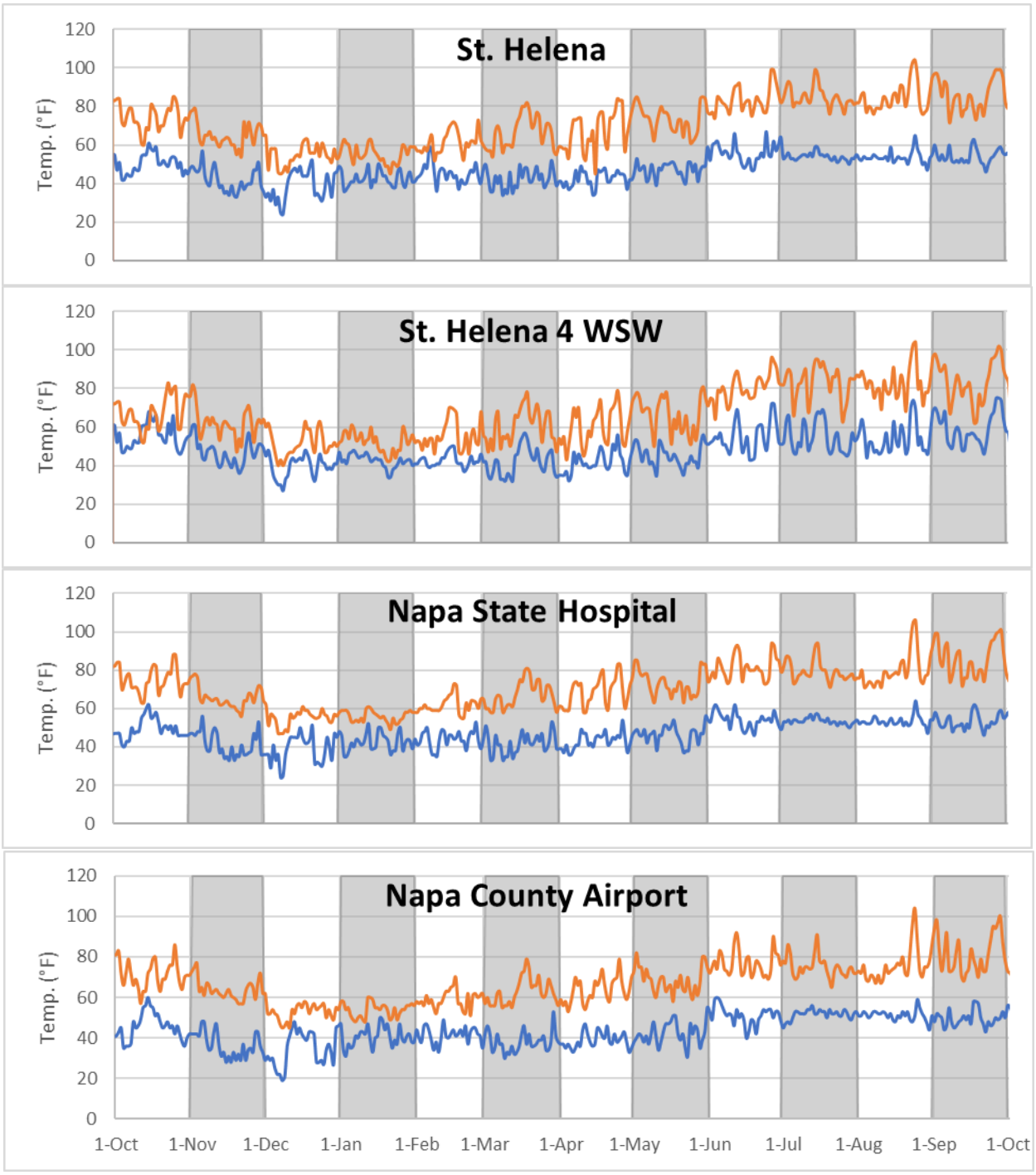


Figure 8: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.

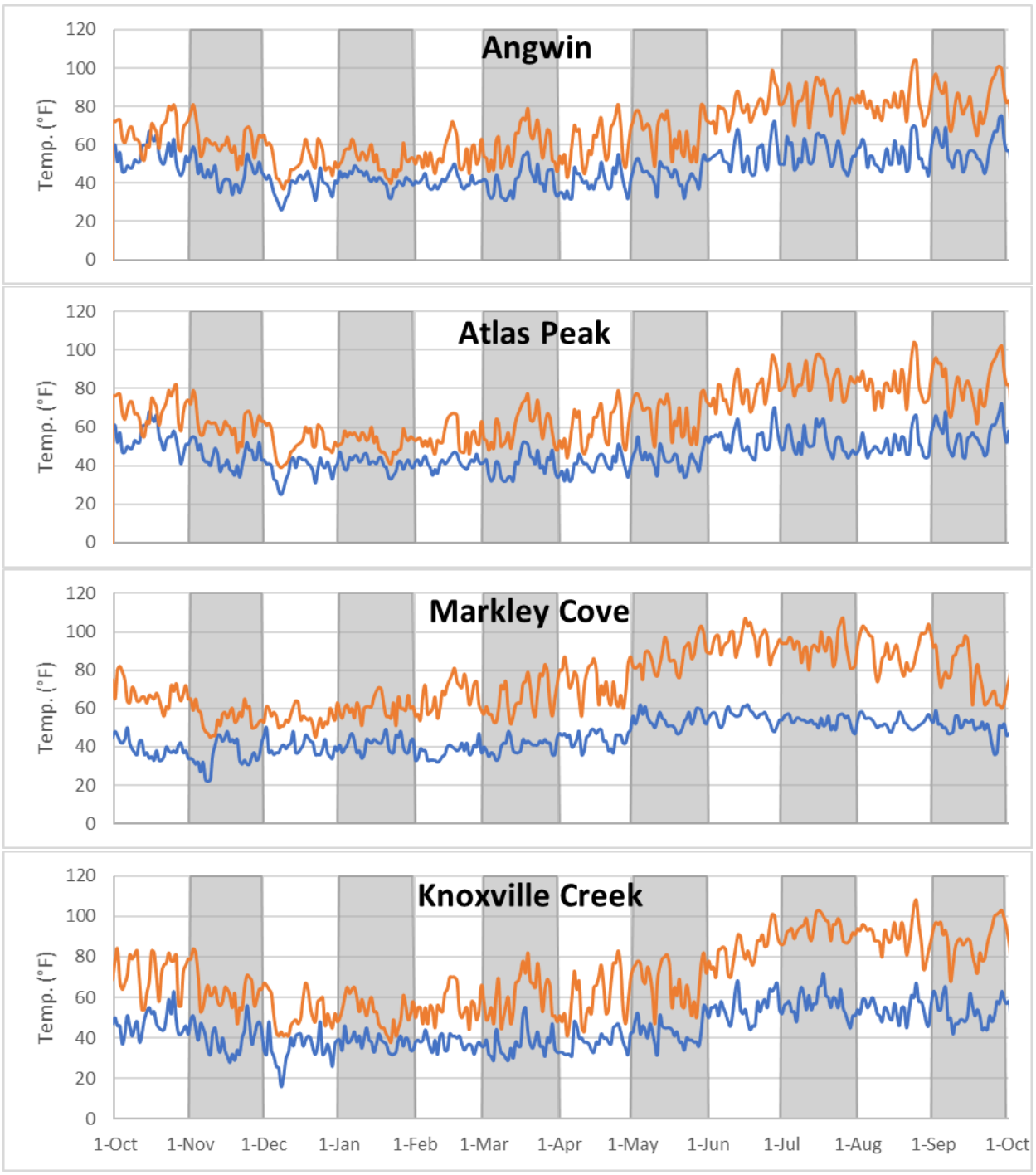


Figure 8 – cont.

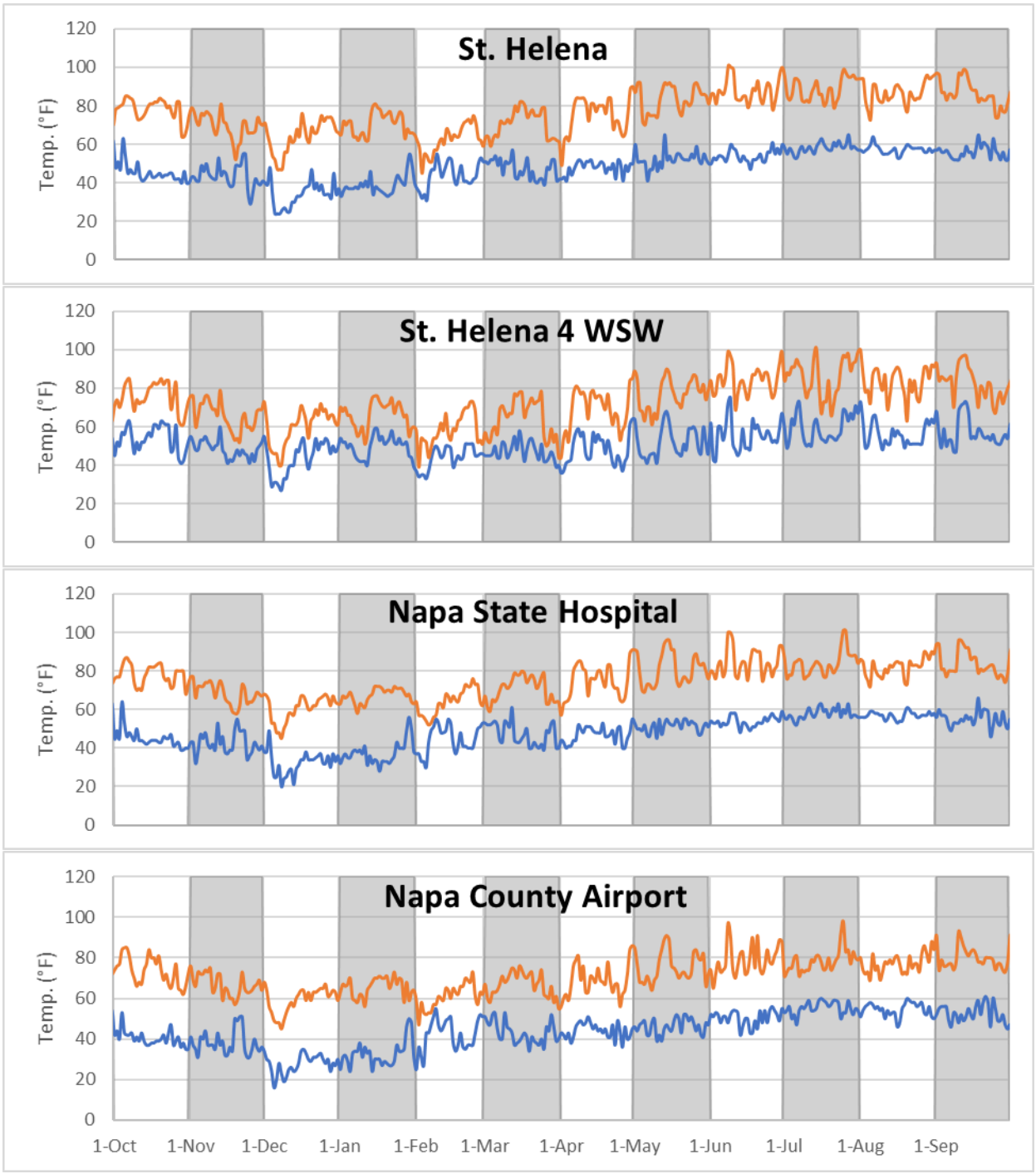


Figure 9: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.

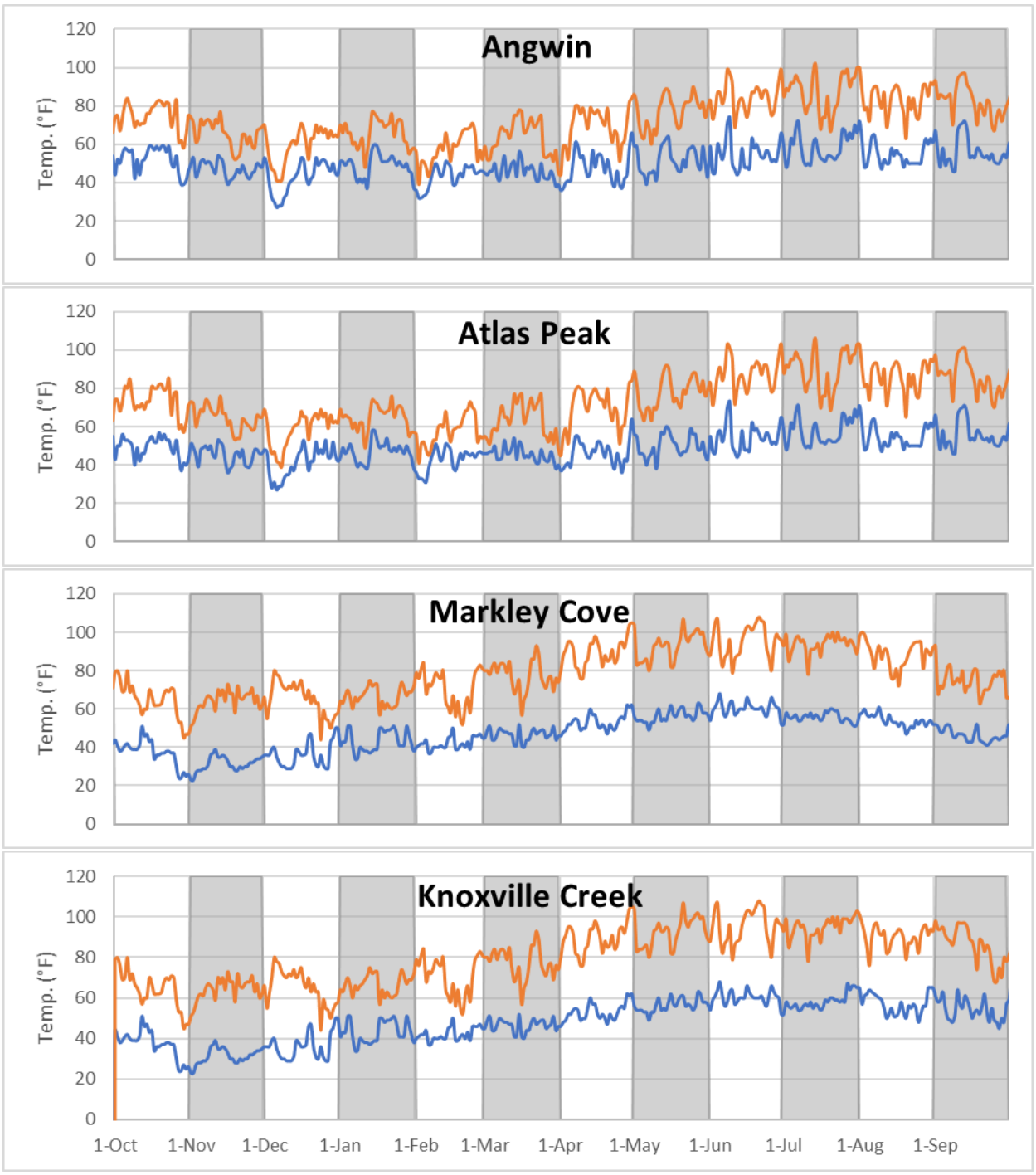


Figure 9 – cont.

Model Calibration

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

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

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

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

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

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

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

Model Results

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

In Water Year 2010 (representing "average" hydrologic conditions) precipitation varied from 21.8 inches in the Ledgewood Creek watershed to 53.3 inches in the Saint Helena Creek watershed (Figure 10, Table 5). Actual evapotranspiration (AET) ranged from 13.4 inches in the Jackson Creek watershed to 25.2 inches in the Saint Helena Creek watershed (Figure 11). Surface runoff ranged from 3.4 inches in the Ledgewood Creek watershed to 13.5 inches in the Saint Helena Creek watershed (Figure 12). Recharge ranged from 3.3 inches in the Ledgewood Creek watershed to 14.4 inches in the Saint Helena watershed. (Figure 13). Small decreases in soil moisture storage (up to 1.8 inches) occurred in most watersheds, with changes in most

watersheds being less than an inch (Figure 14). Note that the San Pablo Bay estuaries have been excluded from these comparisons.

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

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

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

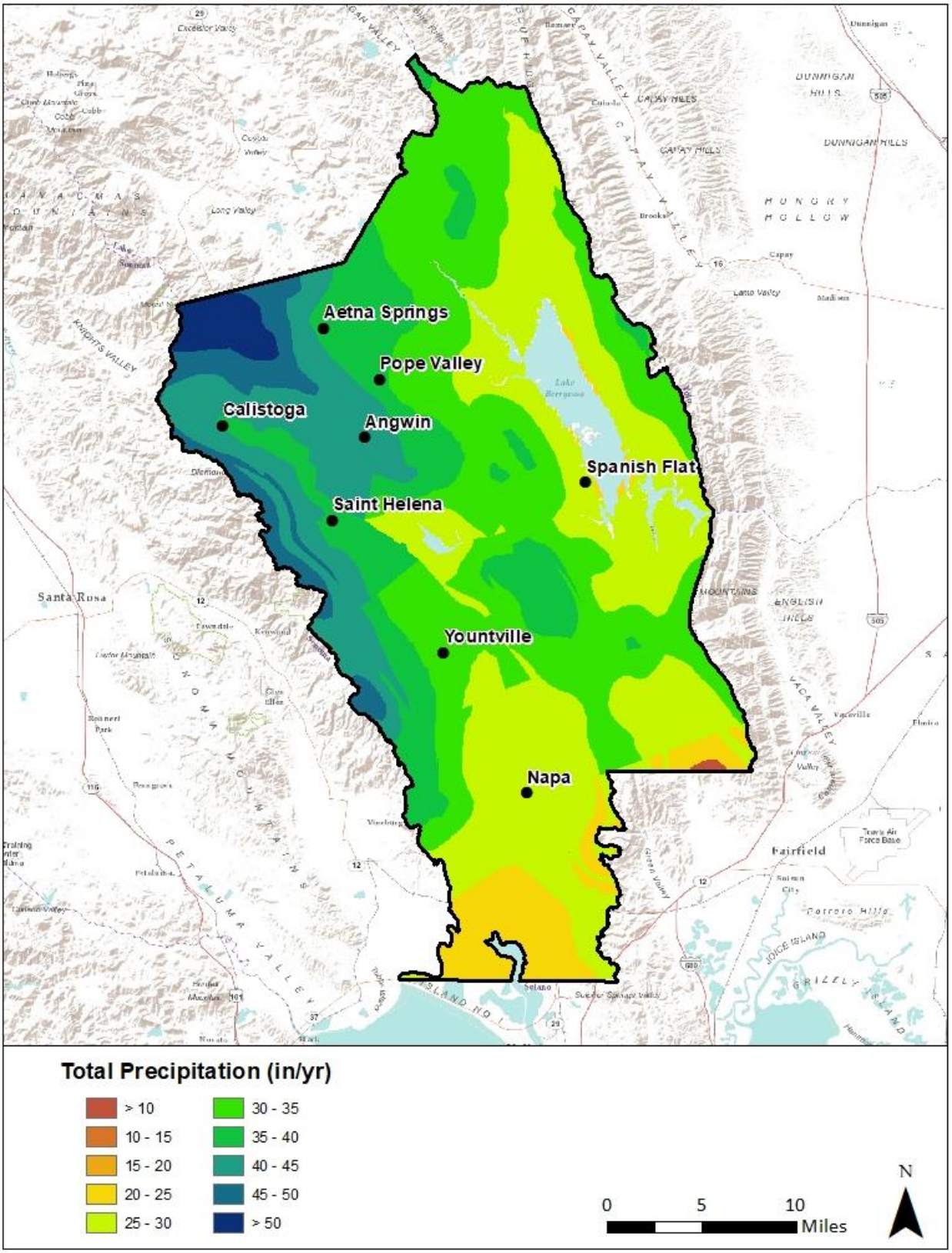


Figure 10: Water Year 2010 precipitation simulated with the Napa County SWB model.

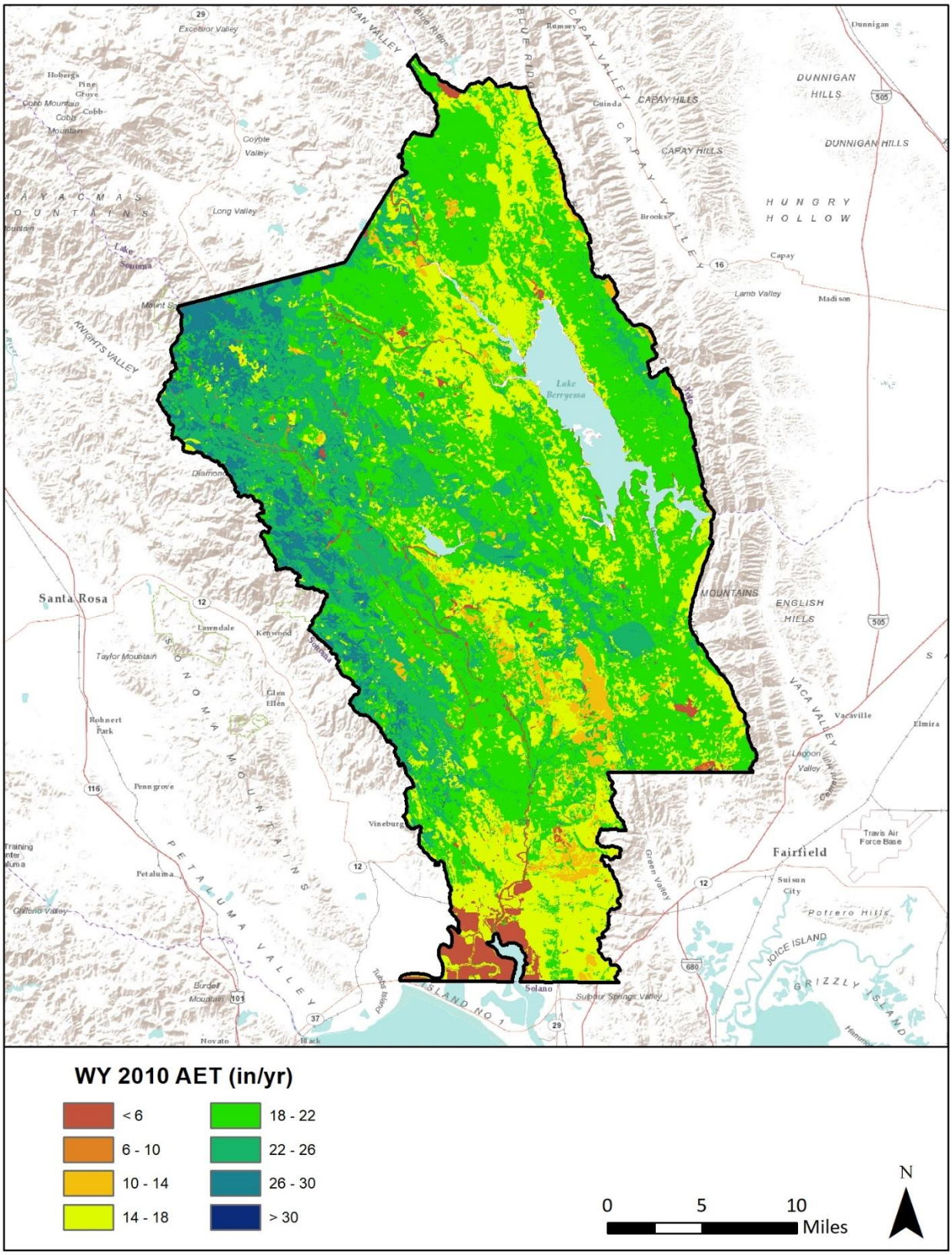


Figure 11: Water Year 2010 AET simulated with the Napa County SWB model.

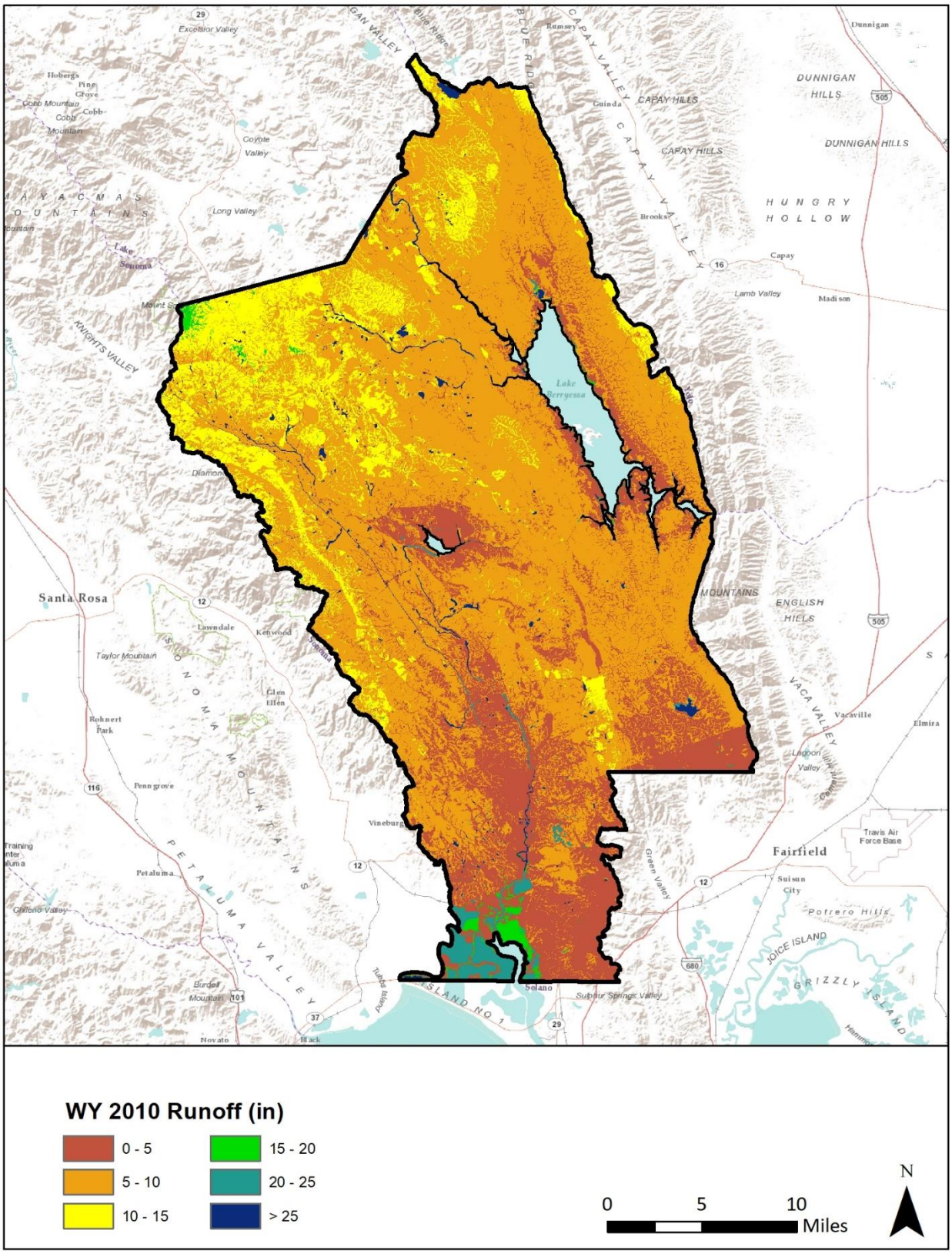


Figure 12: Water Year 2010 runoff simulated with the Napa County SWB model.

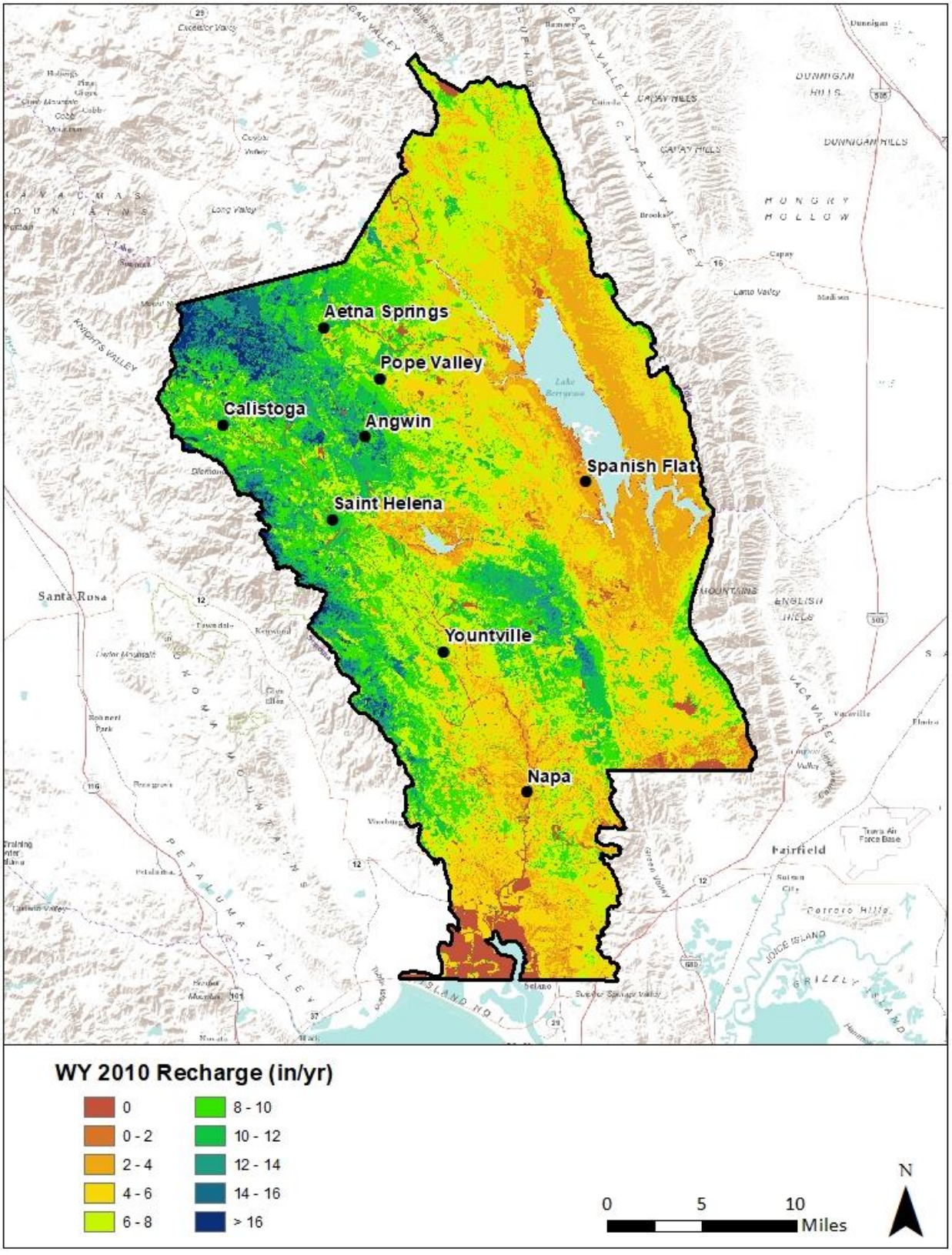


Figure 13: Water Year 2010 recharge simulated with the Napa County SWB model.

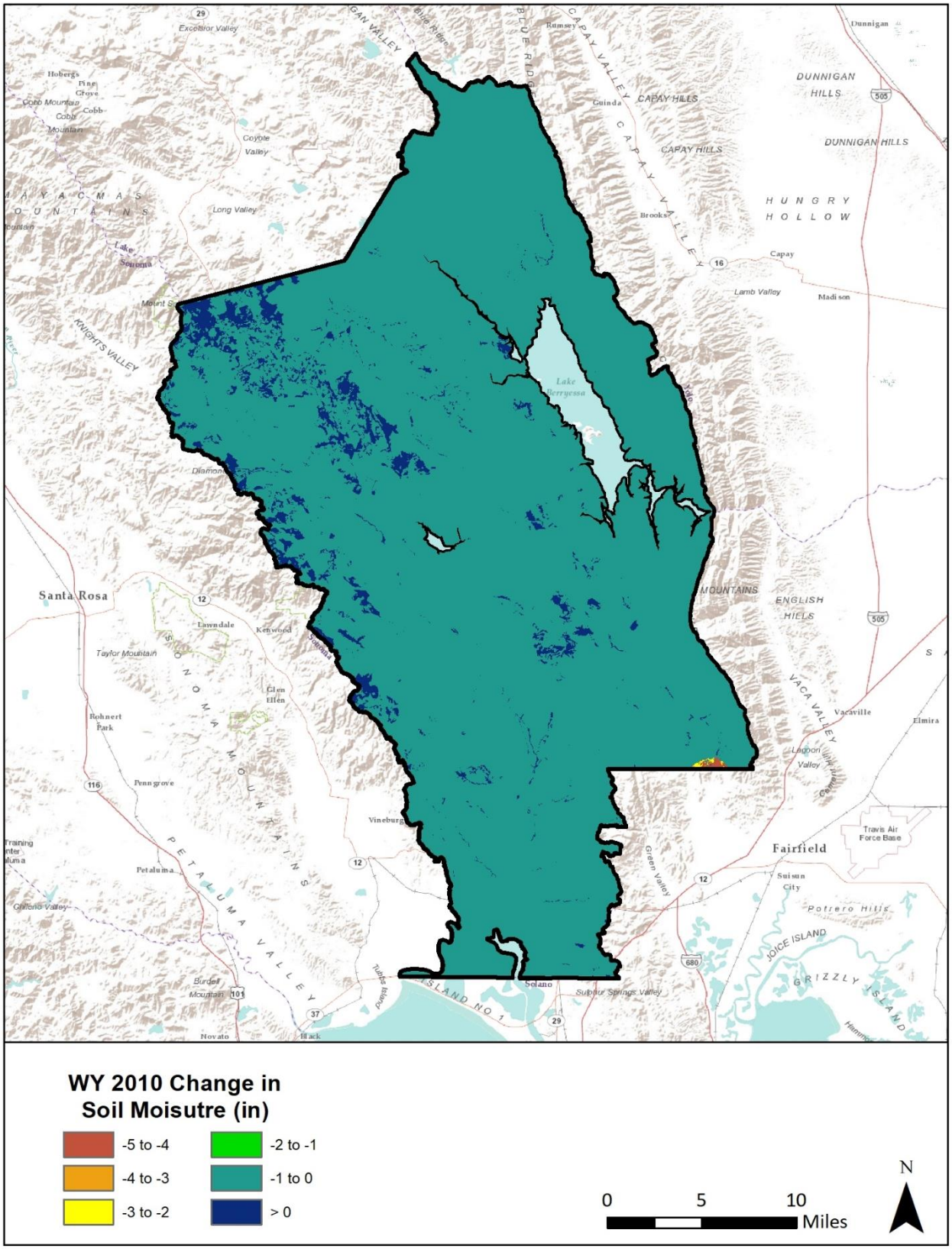


Figure 14: Water Year 2010 change in soil moisture content simulated with the Napa County SWB model.

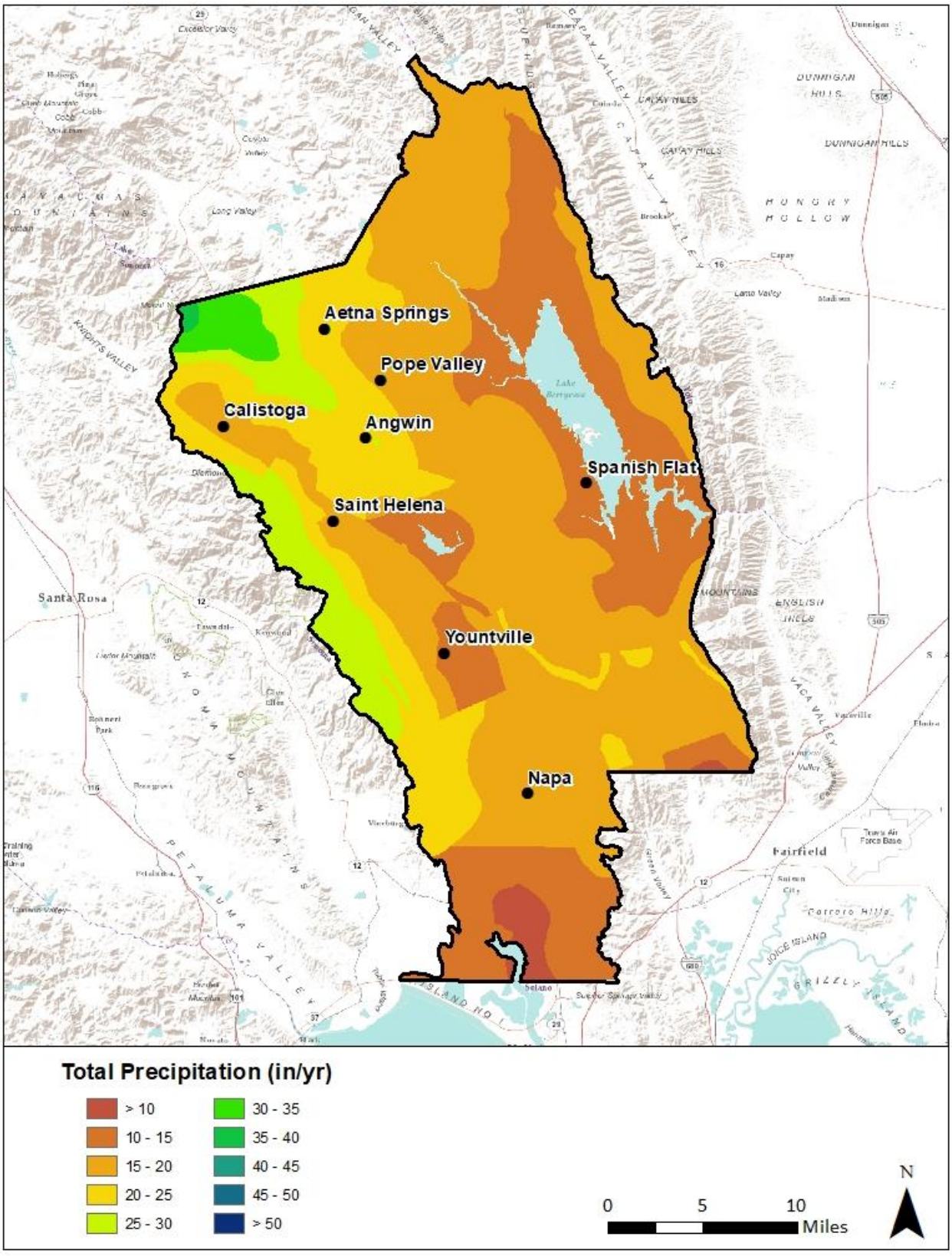


Figure 15: Water Year 2014 precipitation simulated with the Napa County SWB model.

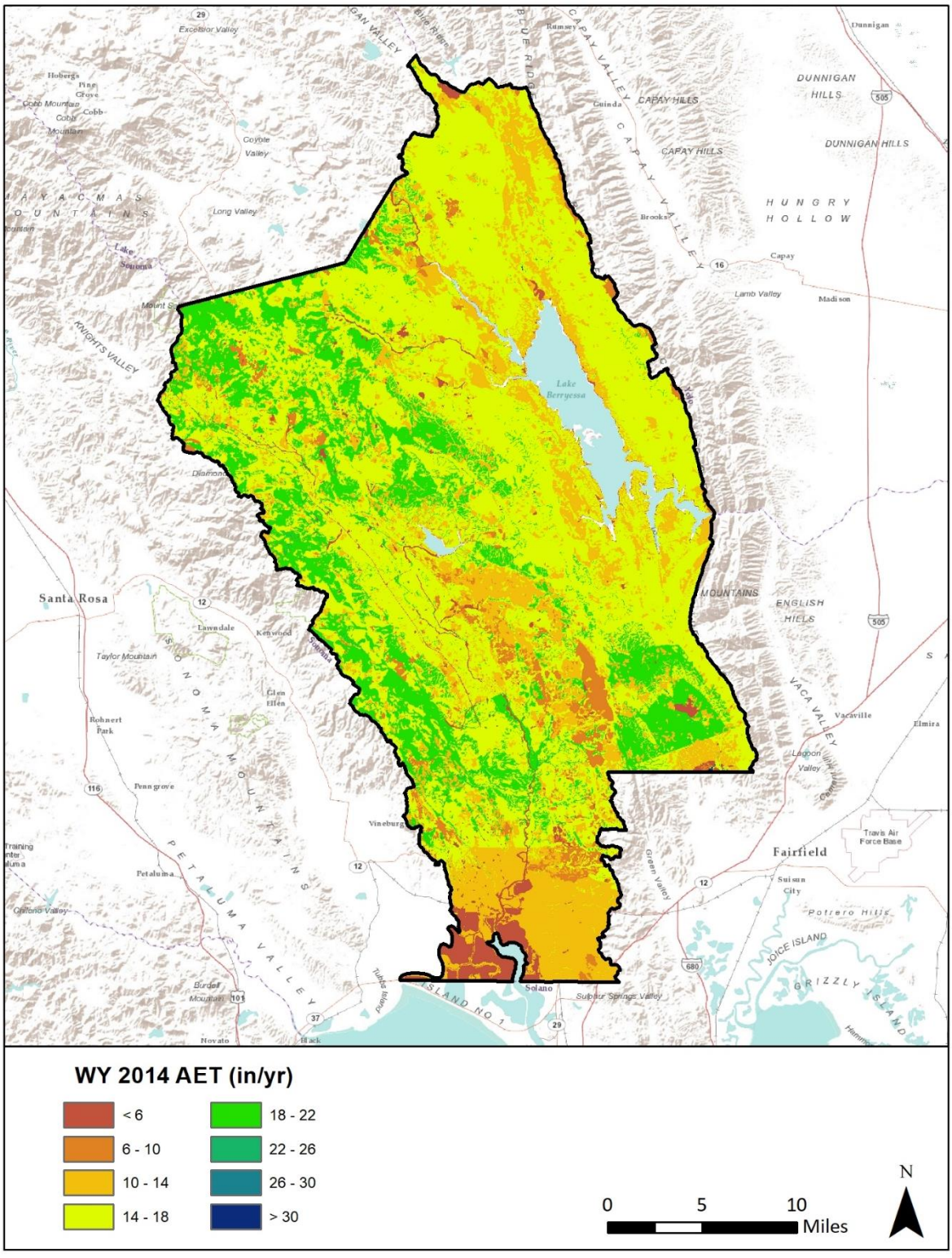


Figure 16: Water Year 2014 AET simulated with the Napa County SWB model.

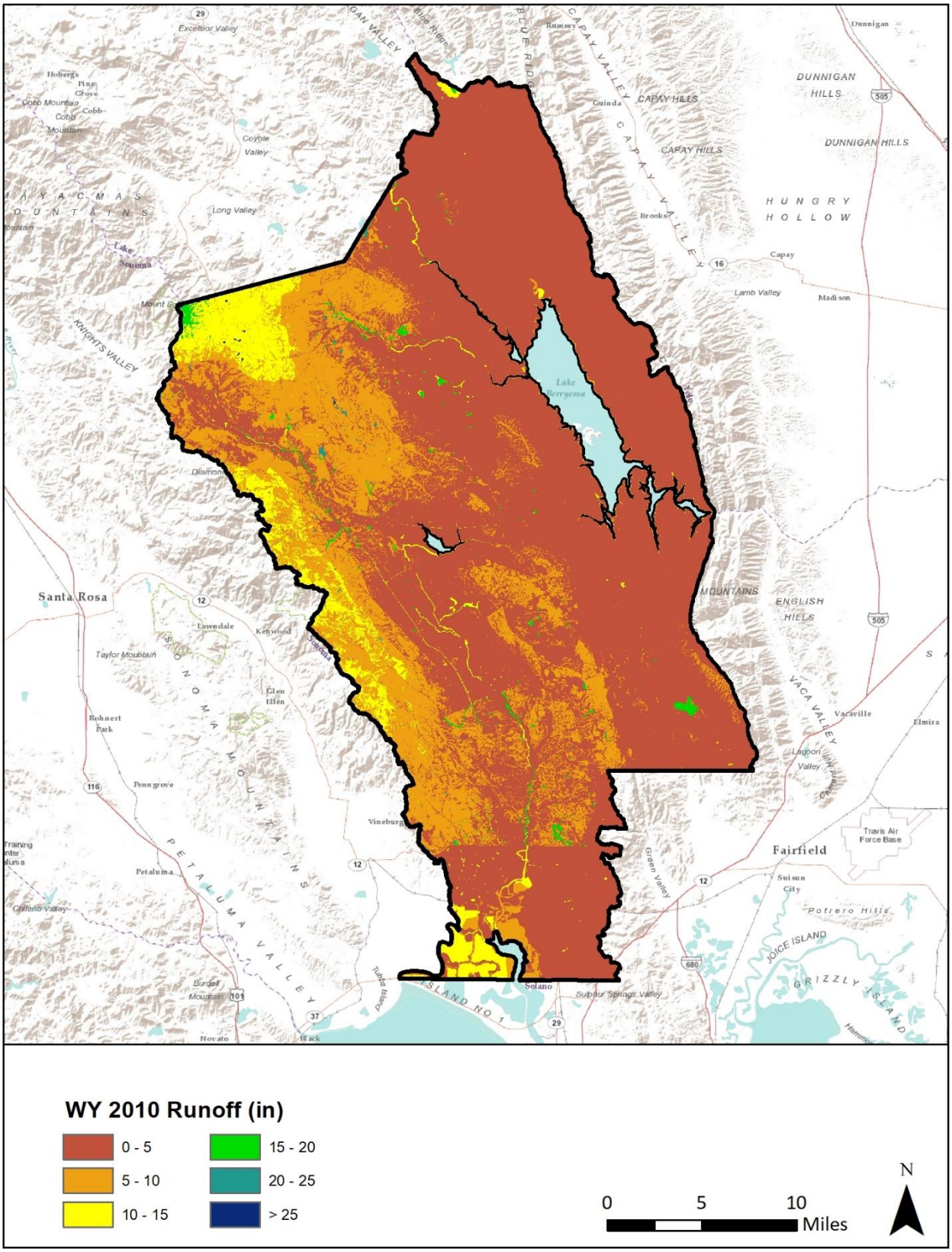


Figure 17: Water Year 2014 recharge simulated with the Napa County SWB model.

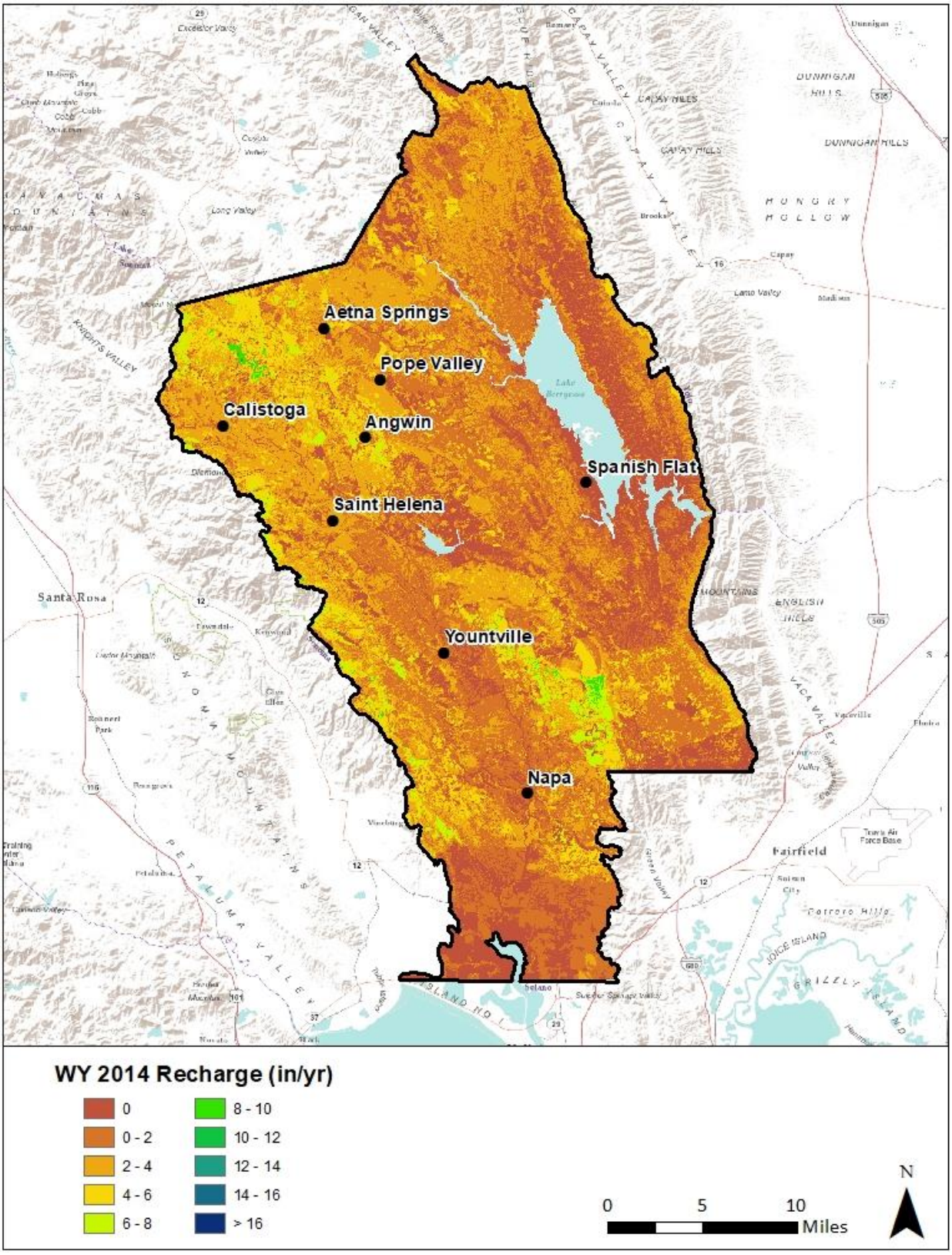


Figure 18: Water Year 2014 recharge simulated with the Napa County SWB model.

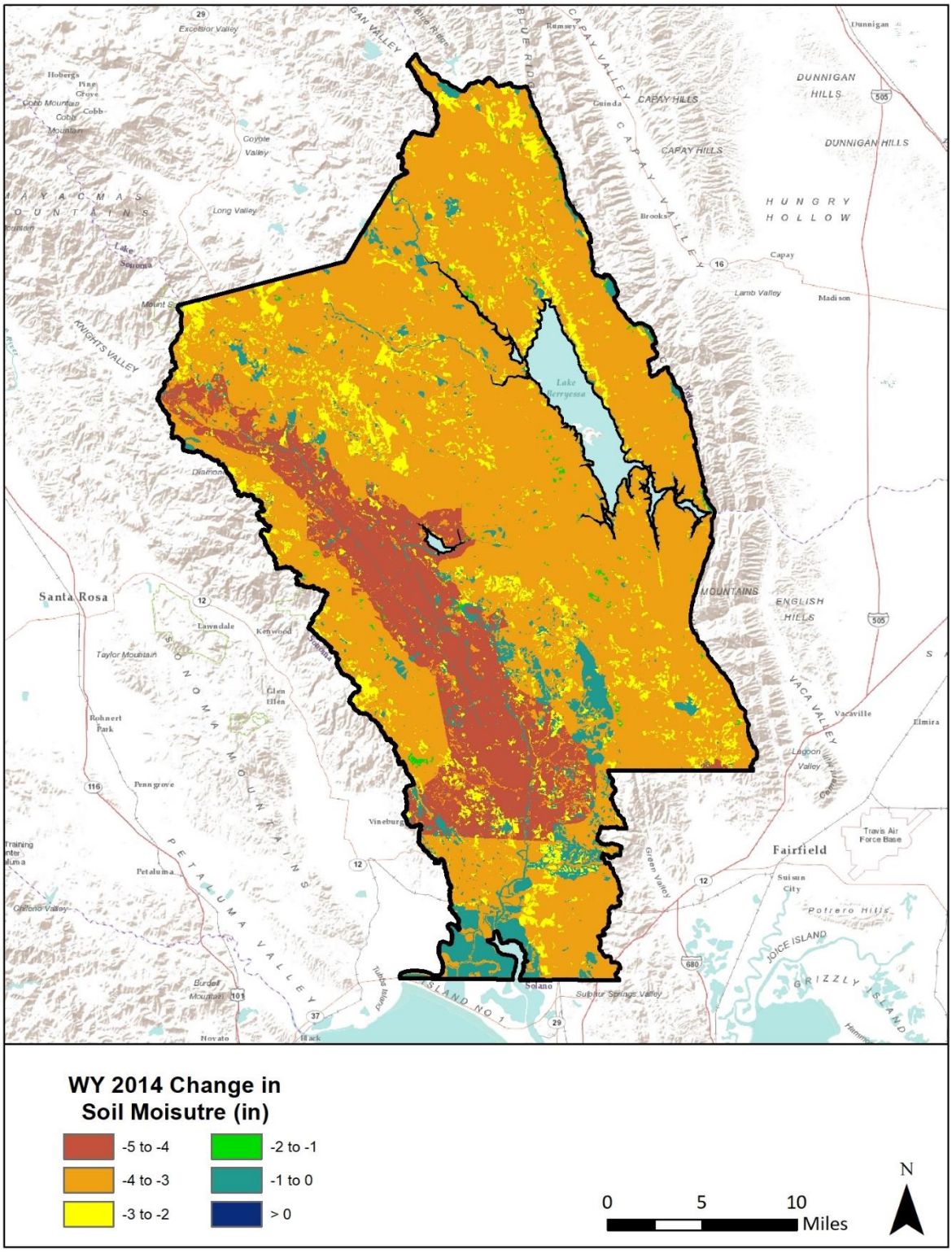


Figure 19: Water Year 2014 change in soil moisture content simulated with the Napa County SWB model.

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

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

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

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

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

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

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

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

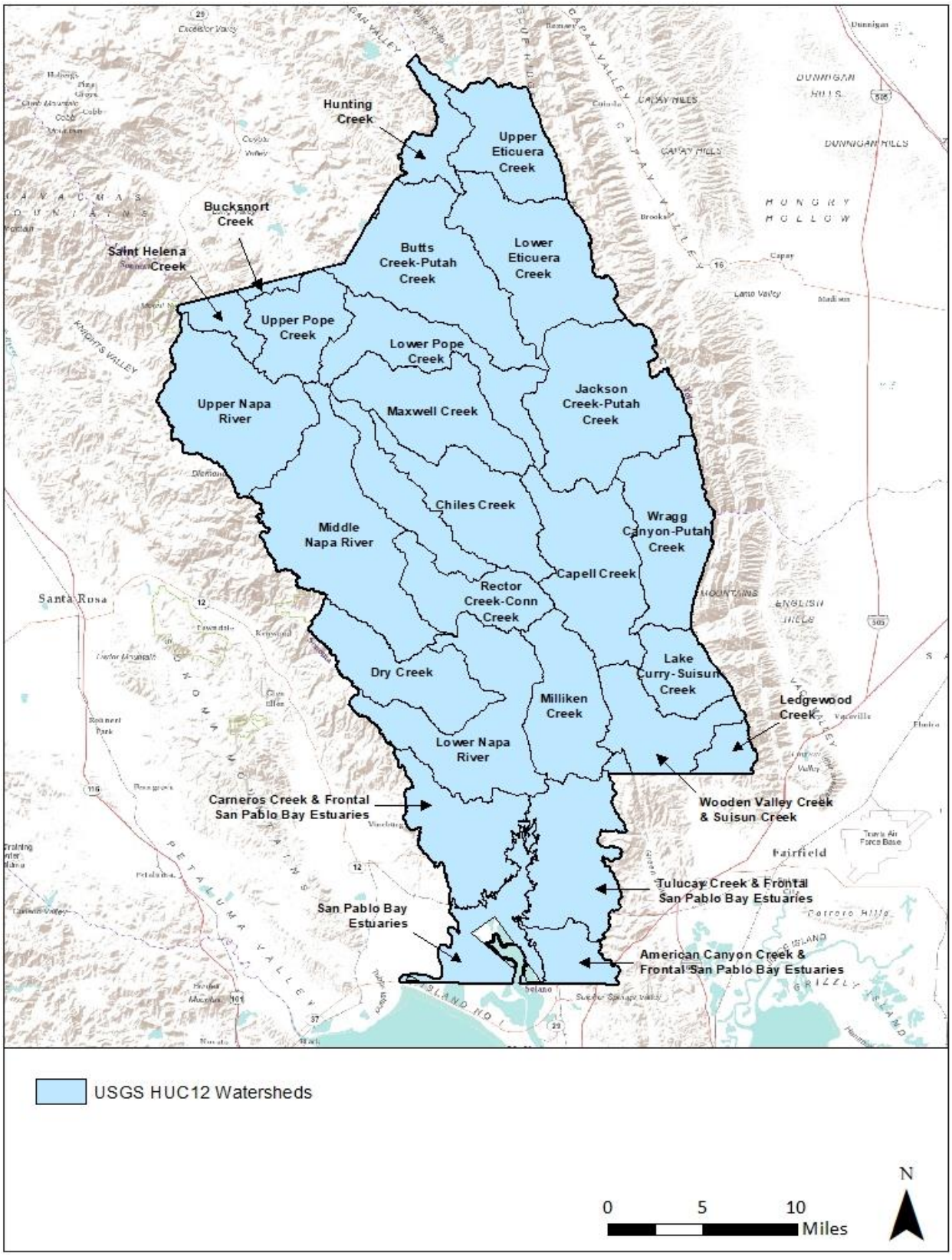


Figure 20: Major watersheds areas used to summarize water budget information in Tables 5 - 8.

Discussion and Conclusion

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

Water budgets for the Napa River and selected sub-basins were also estimated in a previous study by Luhdorff and Scalmanini Engineers and MBK Engineers (LSCE 2013). The LSCE study estimated that, as a percentage of annual precipitation, AET comprised slightly less, runoff significantly more, and recharge substantially less of the typical annual water budget. LSCE (2013) calculated infiltration of precipitation based on the difference between total monthly streamflow at selected gaging stations and total monthly precipitation for the gages' drainage area. Streamflow volumes include both direct runoff (overland flow and interflow) and baseflow from groundwater. Inclusion of baseflow with direct runoff in these calculations may inappropriately reduce the estimated volume of water infiltrated into the soil and available for recharge; the LSCE approach therefore tends to underestimate groundwater recharge. 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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