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Water Availability Analysis

A. S. Vineyards Use Permit Modification – P19-00273
Zoning Administrator Hearing Date (January 27, 2021)

WATER AVAILABILITY ANALYSIS
3283 St. Helena Highway, St. Helena
County of Napa, APN 022-080-004

Prepared for

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Introduction

The Sodhani Winery is seeking to modify an existing Napa County use permit (P14-00402UP) to expand winery production and add daily winery tours along with several private tastings and events. Presently, water demand for approved land use on the subject parcel includes a single-family residence, 6.3 acres of vineyard, a winery with a production of 12,000 gallons, 4 employees and landscaping. These uses were evaluated in a previous Water Availability Assessment (WAA) completed by O'Connor Environmental, Inc. (OEI) in 2015. This WAA builds on the previous assessment utilizing its hydrogeologic characterization while adding an improved and updated groundwater recharge estimate based on site-specific water balance modeling to evaluate water availability for proposed increases in winery production and addition of tours, tastings and events.

The project site is located about three miles north of central St. Helena and just to the south of Bale Grist Mill State Park at the west edge of the Napa Valley. The 12.1-acre parcel lies at the foot of the mountain slope adjacent to State Highway 29 (St. Helena Highway), and at the highest location on its western boundary is about 140 ft above the valley floor. The parcel is in the "Hillside" zone of the County with respect to the source of groundwater. Such Hillside parcels require a site-specific WAA to evaluate proposed project groundwater use in the context of local hydrogeologic conditions and in relation to estimated annual groundwater recharge.

This Water Availability Analysis (WAA) was developed based on 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, characterization of local hydrogeologic conditions, analyses to estimate groundwater recharge relative to proposed uses (Tier 1 WAA), and analysis of potential for well interference at neighboring wells located within 500-ft of project Well 1 (Tier 2 WAA).

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 by the property owner 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. Groundwater recharge estimates presented below are based on established soil water balance modeling techniques for calculating infiltration recharge and they do not account for the role of surface water/groundwater interaction or bedrock geology in controlling recharge and groundwater availability.

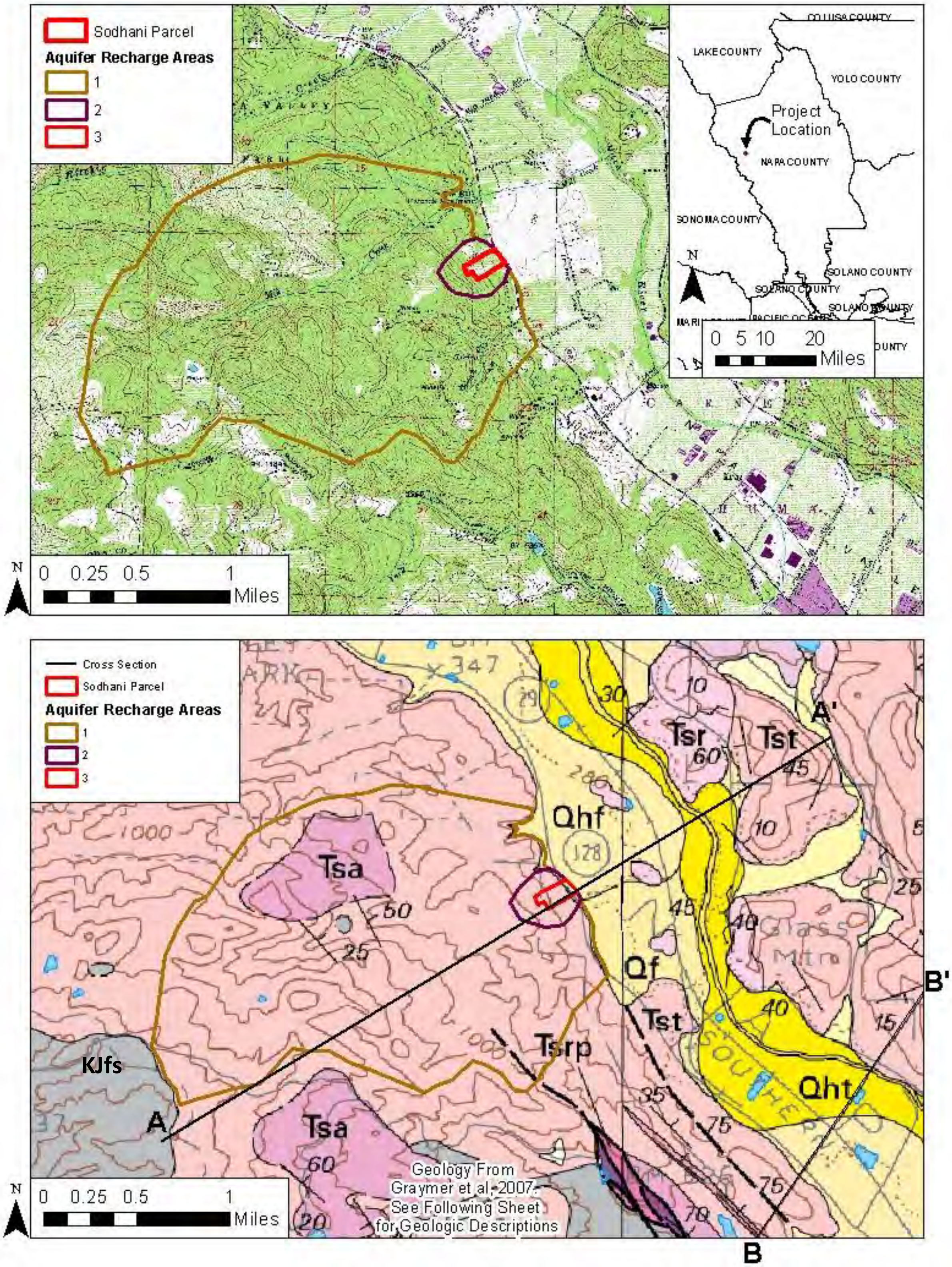
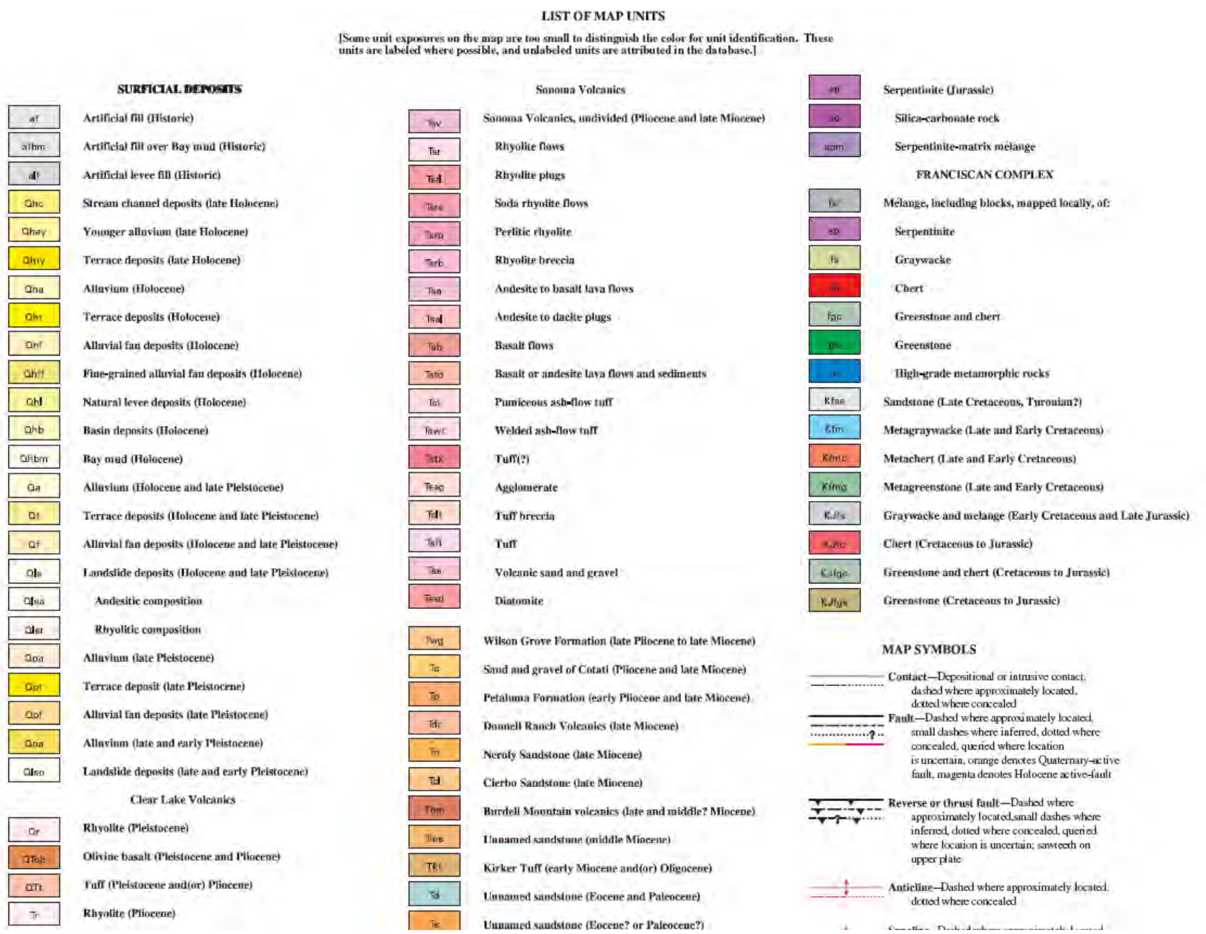


Figure 1. Topographic and geologic maps of project site and vicinity. Hypothesized aquifer recharge Area 1 represents maximum potential extent of drainage area affecting recharge; Area 2 represents likely minimum effective recharge area; Area 3 corresponds to the project parcel. Section B-B' is shown in Fig. 3; A-A' in Fig. 4.



<u>Geology Map Units shown in Figure 1 (after Graymer et al. 2007)</u>

Surficial Deposits

Qht-Terrace deposits (Holocene)
Qhf-Alluvial fan deposits (Holocene)
Qf-Alluvial fan deposits (Holocene and late Pleistocene)

Sonoma Volcanics

Tsr-Rhyolite flows
Tsrp-Perlitic rhyolite
Tsa-Anedesite to basalt lava flows
Tst-Pumiceous ash-flow tuff

Franciscan Complex

KJfs-Graywacke and mélange (Early Cretaceous and Late Jurassic)

Bedrock Geology

The recent U.S. Geological Survey map “Geologic Map and Map Database of Eastern Sonoma and Western Napa Counties, California” (Graymer et al. 2007) was used for interpretation of the project area geology, supplemented by the recent Napa County report “Update Hydrogeologic Conceptualization and Characterization of Conditions” (Luhdorff & Scalmanini, 2013).

Figure 1 shows the project parcel, topography, and surface geology for the vicinity north of St. Helena. The project parcel is located just to the west of the Napa Valley floor north of St. Helena (Figure 1) about 0.8 mile west of the Napa River and about 0.4 mile south of Mill Creek. The surficial geology at the project parcel is the tuffaceous member of the Sonoma Volcanics (map unit Tst), which mantles most of the mountain slopes on the west side of Napa Valley from St. Helena north to Calistoga and beyond. The Sonoma Volcanics consist of a thick and highly variable series of volcanic rocks including basalt, andesite, and rhyolite lava flows, tuff, tuff breccia, agglomerate, scoria, and their sedimentary derivatives (Kunkel and Upson, 1960). The tuffaceous, scoriaceous, and sedimentary units are the principle water-bearing units whereas the lava flows generally yield little to no water (Kunkel and Upson, 1960; Faye, 1973). The tuff underlying the project site and the likely aquifer and recharge area (map unit Tst) is described by Graymer et al. as:

> Pumiceous ash-flow tuff—Pumiceous tuff, locally welded, and aglomeratic tuff, andesite and basalt flow rocks, tuff breccia, and bedded tuff.

Normal (vertical) faults trending parallel to the orientation of Napa Valley are mapped in the vicinity of the boundary between the valley floor and the hillsides between the project site and St. Helena (Figure 1). Where mapped, the faults dip 75 degrees to the east. These faults have not been mapped as far north as the project site, but it should be assumed that these or similar faults are present at or near the project site. The hydrogeologic investigation for Napa Valley (Luhdorff & Scalmanini, 2013, Figure 5-3, Cross Section A-A’) also found evidence suggesting the presence of normal faults in the bedrock underlying the valley floor.

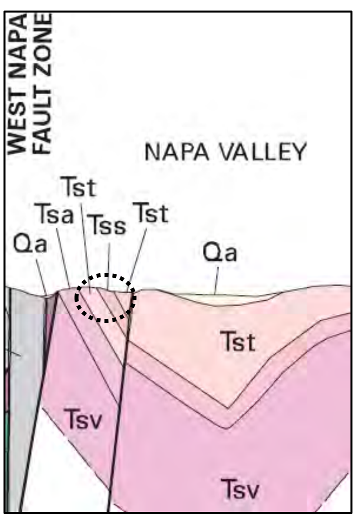
Bedding planes mapped within the tuff in the vicinity of the project site on the west side of the valley north of St. Helena (Figure 1) strike parallel to the fault and valley orientation and dip 25 to 50 degrees to the northeast.

Hydrogeologic Conditions

The hydrogeology of the project site is influenced by the foregoing geologic characteristics. The tuff is generally a water-bearing unit of the Sonoma Volcanics, but it includes a variety of layered rocks, some of which are not considered water bearing (e.g. andesite flows). This creates the potential for confined aquifer units where aquitards formed by andesite (or other relatively impermeable volcanic materials) separate strata of more permeable rocks. The orientation of rock layers is variable, but dips in the range 25 to 50 degree to the northeast. Consequently, it is possible that confined aquifer rock units underlying the project site extend to the surface on the hillslopes above and west of the project site. In addition, normal faults (vertical or near-vertical orientation) could be present that affect groundwater flow in the aquifer rocks within the tuff. Faults may or may not affect groundwater flow but can act as barriers to groundwater flow as well as conduits of groundwater flow.

Regardless of the rock types and structures that may affect the hydrogeologic conditions in the local aquifer, it is expected that the elevation of the potentiometric water surface underlying the mountain slopes west of the valley floor will lie approximately parallel to the ground surface. Consequently, it is expected that there would be a relatively steep hydraulic gradient extending from the project site (located at the base of the mountain front) to a point near the ridge crest about two miles to the west. It is possible that the groundwater flow to the project site originates high on the ridge to the west, infiltrated as rainfall on the ground surface and from stream channels into aquifer rocks, and flowing down-gradient across and through various aquifer rocks in complex flow paths before reaching the well at the project site. This conceptualization of a relatively large confined or semi-confined aquifer gives rise to the drainage area boundary referenced as Area 1 in Figure 1. Although this conceptualization is not unrealistic, it is based on relatively broad assumptions that would be difficult to confirm or constrain.

A more conservative conceptualization of the site aquifer hydrogeology can be inferred from hydrogeologic cross-sections based on the limited structural information on geologic strata and information on aquifer materials from on-site wells. Data describing the geologic materials logged during well construction and well construction details were obtained from Well Completion Reports or County well permits (Appendix D).



The regional geologic cross-section prepared by Graymer et al. (2007) is oriented southwest to northeast perpendicular to Napa Valley and crosses the west edge of the Napa Valley Floor about two miles south of the project site. Figure 2 shows the portion of that geologic sections shown as B-B' in Figure 1. The circled portion of Figure 2 indicates the portion of the section that corresponds most closely to the position of the project site and portrays steeply dipping geologic contacts presumed approximately parallel to bedding planes. About one mile west of the project site bedding planes in the tuff (map unit Tst) were mapped with dips of 25 and 50 degrees to the northeast, and about one mile southeast a bedding plane in Tst dips 35 degrees to the northeast.

Figure 2. Geologic cross-section from regional geology map shown as B-B' on Figure 1.

Based on the foregoing indications regarding the orientation of geologic strata within the tuff unit of the Sonoma Volcanics underlying the project site, it is possible to hypothesize the geometry of the aquifer rocks at the project site using the depths of water bearing strata identified in the well logs (Appendix D). As shown in Figure 3, we determined the depth of the top of geologic strata corresponding to the perforated sections of Well #1 (the project and "House" well) and projected them with a 25 degree northeast dip on the cross-section line A-A' (Figure 1) constructed approximately perpendicular to strike. The lower-most of the water-bearing strata in the project well (#1) reaches the ground surface to the west of a hill crest about 1,000 ft west of the project well (Figure 3). We also considered a 50-degree northeast dip and found the lower-most water bearing strata reaching the ground surface about 300 ft west of the project well. The projection of the 25 degree dip coincides approximately with a subsidiary ridge crest above the project site that forms a topographic divide and a local drainage area that encompasses the project site parcels as well as adjacent parcels to the north, west and south and shown as Area 2 in Figure 1.

Area 2 represents a conservative conceptualization of the rainfall-recharge area for the project aquifer and is considered the primary zone of recharge for the project aquifer for purposes of this WAA. As noted above, however, the complex character of groundwater in volcanic rocks, the position of the project well at the base of the mountain front west of Napa Valley, and the likely hydraulic gradient of groundwater underlying the mountain hillslopes to the west suggest that groundwater recharge for the project aquifer is likely to include a portion of Area 1.

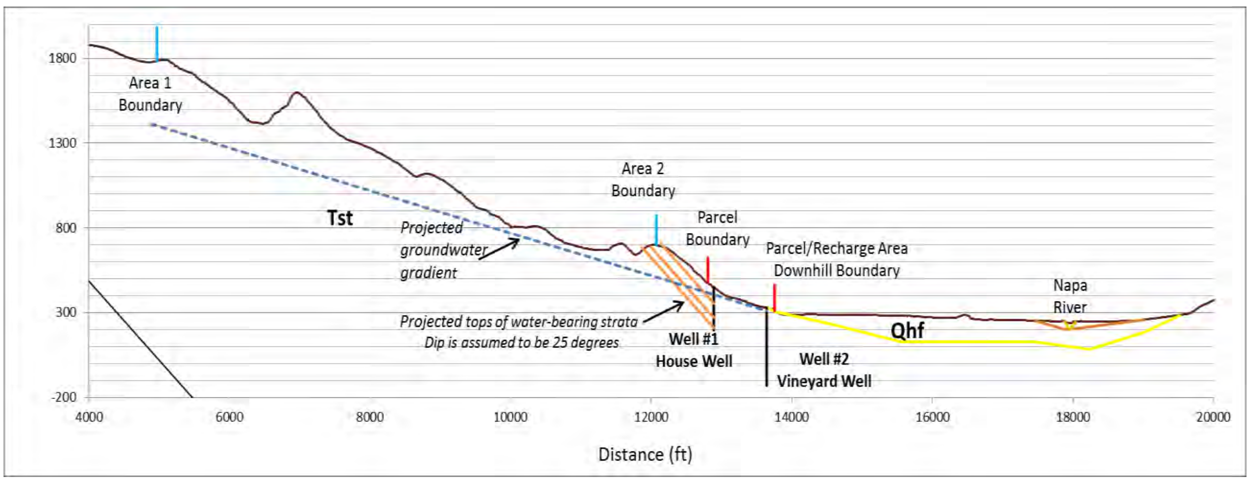


Figure 3. Local area geologic cross-section.

The conceptualization of the aquifer recharge zone for the project well congruent with the project parcel boundary is that represented as Area 3 (Figure 1). Given the likely groundwater hydraulic gradient extending up slope to the west (Figure 3), substantial groundwater flow originating from uphill beyond the parcel boundary likely reaches the project well. Furthermore, the upper 40 to 50 feet of the earth materials overlying the project site is comprised of gravel and boulder deposits likely to represent alluvial fan deposits (Qhf, Qf) mapped in adjacent areas to the east (Figure 1). There are several strata containing significant quantities of clay described in the well logs (project well-Appendix D; Sodhani irrigation well-Appendix E) interspersed with fractured volcanic rock, ash and sands, including a clay-rich stratum at the base of the alluvial fan deposits. Although these clay-rich strata do not necessarily prevent downward movement of groundwater, they are likely to inhibit it, suggesting that vertical flow paths from the surface of the project parcel may not be the primary means of recharging water-bearing strata found at depths of 85 to 250 ft below ground surface in Well #1. Preferential flow paths parallel to the dip of rock strata in more permeable rocks separated by clay-rich strata would convey infiltrating groundwater from upslope. Such circumstances suggest that the primary recharge zone for the project well extends uphill to the west of the project parcel, and that conceptualizing the recharge area for the project well as the project parcel alone would substantially misrepresent local hydrogeologic conditions.

Project Parcel Wells

There are two wells located on the project parcel (Figure 2). One well lies near the southeast corner of the parcel at the downhill edge of the vineyard and is referred to as “Vineyard Well” and Well #2 in Figure 2. This well has high concentrations of arsenic (130 ug/L) and is not potable but is suitable for vineyard irrigation (see water quality data, Appendix B). The second well is located near the southwest corner of the parcel and near the high spot on the parcel is referred to as the “House Well” and Well #1 in Figure 2. It provides potable water for domestic use in the residence on the property and is the source of potable water for the winery (see water quality analysis data, Appendix C). Because of the unsuitability of water from the Vineyard Well for use in the winery, this analysis focuses primarily on the House Well (Well 1) which is the project well.

Chemical analyses of water samples from Wells #1 and #2 (Appendices B and C, respectively) indicate some significant differences between the water from these wells. In particular, Well #2 has very high levels of arsenic that render it unfit for human consumption and domestic use, and elevated levels of copper and lead relative to Well #1. Other differences of note are that Well #2 also has high turbidity, low nitrate, and low pH relative to Well #1. These differences, along with the greater depth (200+ feet) and potential effects of faults near or between Wells #1 and #2, suggest that these wells are utilizing distinct local aquifers. Furthermore, it suggests that Well #2 to the south would not be utilizing the same aquifer as neighboring domestic wells owing to the high arsenic concentration

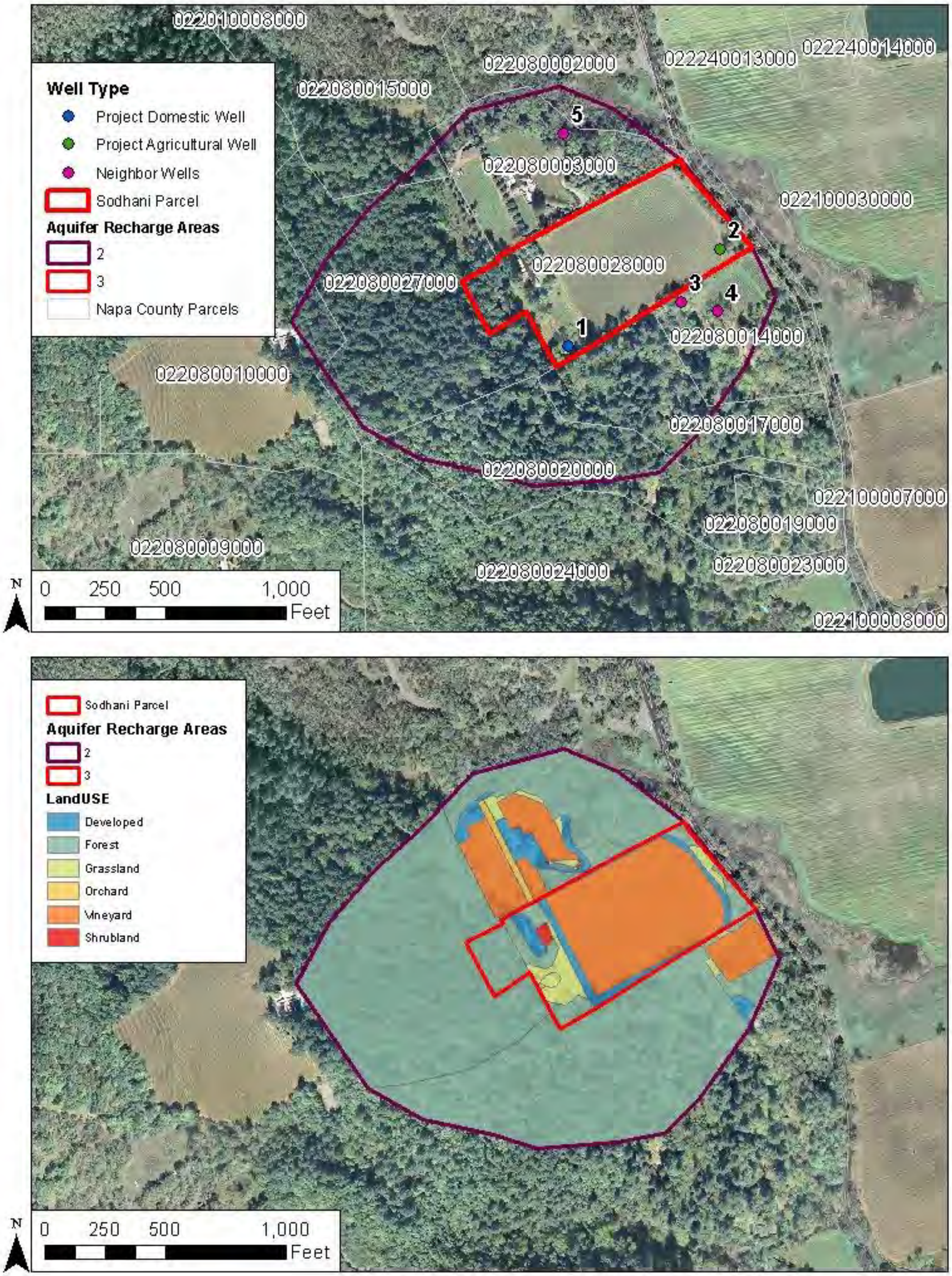


Figure 4. Local area parcel map and well locations (top) and recharge area land use map used in water use estimate (bottom). Well 1 is the project well. Well 3 is the nearest well on a neighboring parcel.

Water Demand

Within the project recharge area, water demand was estimated for both the existing and proposed conditions. Water use for the vineyard, winery and residence located on the project parcel for existing permitted land uses was determined using site details documented in a Water Availability Analysis Phase One Study prepared by Michael Muelrath, PE No. 67435, dated December 5, 2014 (Appendix A) previously submitted to the Department of Public Works (DPW). The project recharge area also includes portions of nine neighboring parcels. Water use on these parcels was estimated based on Napa County assessor's parcel, agricultural and winery GIS database information along with satellite imagery in 2015 again in November 2019. Uses within the recharge area include winery use, residential use and irrigation for vineyards and orchards.

In the following section of the WAA we first describe the existing water use for permitted land uses. Subsequently, we describe new proposed water use that is the subject of this WAA.

Existing Use

The existing water use condition on the project parcel will be the use associated with the use permit P14-00402UP approved in 2016. The permit includes winery production of 12,000 gallons, four winery employees (two full time and two part time) and winery landscaping. A single-family residence and 6.3-acre vineyard comprise the remaining existing uses on the parcel (Figure 2). Demand for the single-family residence is reported in the 2015 Water availability analysis as 0.75 ac-ft/yr. This corresponds to the upper end of the range of residential water use reported in the Napa County Guidance. Water demand for the 6.3 acres of vineyards is estimated to be 0.5 ac-ft/acre which equates to an annual demand of 3.2 ac-ft/year.

Based on Napa County water use guidelines, demand for winery processing water is 2.15 ac-ft per 100,000 gallons of wine; an additional water use duty of 0.5 ac-ft per 100,000 gallons is allocated for other domestic (indoor) and landscaping demand at the winery. Annual production of 12,000 gallons corresponds to winery demand of approximately 0.32 ac-ft. Employee daily use is estimated to be 15 gallons per employee per Napa County. Assuming the two full time employees work five days a week all year (260 days) and the two part time employees work half of that time (130 days), the total demand equals 0.04 ac-ft annually. Total existing use of groundwater on the project parcel is 4.25 ac-ft/ yr (Table 1).

Table 1. Existing and proposed groundwater uses associated with the Sodhani Winery parcel.

Project Parcel	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	0.75	3.2	0.32	0.036	0.00	**4.25**
Proposed Use	0.75	3.2	0.53	0.038	0.054	**4.52**

In addition to uses on the Sodhani parcel, use on the surrounding parcels within and intersecting the project recharge area includes four residences and associated landscaping, vineyard, orchard, and the adjacent Sabina Vineyards winery. Of the four residences, one is considered "large" and assumed to have a demand of 0.75 ac-ft per year, the upper limit suggested by Napa County guidance for residential use (Table 2). The other three residences are of modest size; consequently, a demand of 0.5 ac-ft per year is applied. Lawn and landscaping areas exceeding the first 1,000 ft^2 on these parcels totals 2,000 ft^2 (Table 2).

A total of 3.4 acres of vineyard is located on or connected to non-project parcels with wells within the project recharge area (Area 2). Assuming annual vineyard irrigation demand of 0.5 ac-ft per acre per year per Napa County Guidance, the 3.4 acres of vines would require 1.7 ac-ft annually. A small 0.3-acre orchard was also identified on a neighboring parcel. Napa County Guidance suggests a use rate of 4 ac-ft/acre for orchards which would amount to 1.2 ac-ft of annual demand (Table 3).

Water use for the Sabina Vineyards winery was estimated using information reported in the Napa County Winery GIS shapefile (last update reported on 4/20/2019). The current information associated with the permit for Sabina Vineyards shows an annual production of 8,000 gallons with 2 employees which amounts to a total winery demand of 0.23 ac-ft. No public tastings or other marketing events are listed are listed.

Based on these uses, the existing water demand within the project recharge area is estimated to be 10.4 ac-ft/yr (Table 5). Residential water demand is estimated to be 3.7 ac-ft/yr (Table 2), irrigation demand is estimated to be 6.1 ac-ft/yr (Table 3), winery use is estimated to be 0.53 ac-ft/yr (Table 4), and winery employee use is estimated to be 0.06 ac-ft/yr (Table 5).

Table 2. Existing and proposed residential water use within the project recharge area (Area 2).

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 Residenc	2	0.75		1.50
Main Residence	3	0.50		1.5
Pools	5	0.10		0.50
Lawn	2.0		0.10	0.20
TOTAL				**3.70**

Table 3. Existing and proposed irrigation in the project recharge area (Area 2).

Use Category	Number of Acres	Use per Acre (ac-ft/yr)	Annual Water Use (ac-ft/yr)
Project Vineyard Irrigation	6.3	0.5	3.2
Non-Project Vineyard Irrigation	3.4	0.5	1.7
Garden/Orchard Irrigation	0.30	4	1.2
TOTAL			**6.1**

Table 4. Existing winery use within the project recharge area (Area 2).

Use Category	Annual Production (gal/yr)	Use per 100,000 gal of production	Annual Water Use (ac-ft/yr)
Winery Process Use	20,000	2.15	0.43
Winery Domestic Use	20,000	0.50	0.10
TOTAL			**0.53**

Table 5. Existing winery employee use within the project recharge area (Area 2).

Work Category	# of Employees	# Work Days per Year	Use per Employee (gal/day)	Annual Water Use (ac-ft/yr)
Full-time	4	260	15	0.05
Part-time	2	130	15	0.012
TOTAL				**0.06**

Table 6: Existing and proposed water use within the project recharge area (Area 2).

	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	3.7	6.1	0.53	0.00	0.060	**10.4**
Proposed Use	3.7	6.1	0.74	0.05	0.062	**10.6**

Proposed Use

The proposed changes that will increase groundwater demand include an additional 8,000 gallons of wine production, tours, tastings and events as described in the Use Permit Modification summary document prepared by Applied Civil Engineering and summarized below.

Tours and tastings will occur seven days a week all year except on days with private events. A total of11 private events are proposed with one proposed to be held on a weekend. Of the remaining 354 days would be open for the daily tours and tastings with a maximum daily visitor count of 11. All 11 private food and wine pairing events will include catered food prepared offsite; in the Napa County guidance water use for these types of events is listed as 15 gallons per visitor per day (Table 9). These events will also include 37 catering staff days on top of the existing employee demand (Table 8). For the remaining tours and tastings water use is assumed to be three gallons per visitor per day (Table 9). The new proposed production at the Sodhani Winery is 20,000 gallons per year.

Water demand for the proposed uses will increase by 0.27 ac-ft/year to 4.52 ac-ft /yr for the project parcel (Table 1) and to 10.6 ac-ft/yr within the project recharge area (Table 6). All increases in groundwater use are from proposed increase in winery production (Table 7), a very small increase in employee use (Table 8) and proposed event use (Table 9).

Table 7: Proposed winery use within the project recharge area (Area 2).

Use Category	Annual Production (gal/yr)	Use per 100,000 gal of production	Annual Water Use (ac-ft/yr)
Winery Process Use	28000	2.15	0.60
Winery Domestic Use	28000	0.5	0.14
			0.74

Table 8: Proposed Employee water use within the project recharge area (Area 2).

Work Category	# of Employees	# Work Days per Year	Use per Employee (gal/day)	Annual Water Use (ac-ft/yr)
Full-time	4	260	15	0.05
Part-time	2	130	15	0.01
Catering Staff	-	37	15	0.002
TOTAL				**0.062**

Table 9: Proposed winery event water use within the project recharge area (Area 2).

Visitor Category	# of Vistors	Use per Visitor (gal/day)	Annual Water Use (ac-ft/yr)
Tours, Tastings and Office	3,894	**3**	0.04
Marketing Events w/ Offsite Catering	400	15	0.02
TOTAL			**0.05**

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 G.

Groundwater recharge was simulated for, Water Year 2010, which is selected to represent "normal" or average year conditions because annual precipitation totals across most of Napa County were close to their long-term 30-year averages (Figure 5). During the simulation of Water Year 2010, precipitation averaged 43 inches across the project recharge area (Area 2 in Figure 1), actual evapotranspiration (AET) averaged 25.8 inches and the change in soil moisture averaged -0.5 inches. Simulated groundwater recharge varied from 6 to 14.2 inches across the recharge area, with a spatial average of 8.5 inches. Across the project parcel the spatial average of recharge was 10.3 inches, higher by 1.8 inches for water year 2010 (Table 10).

Groundwater recharge estimates can also be expressed as a total volume by multiplying the estimated recharge rate by a representative area. For the 52.2-acre project recharge area (Area 2), these calculations yield an estimated total recharge of 37.1 ac-ft/yr for the average water year of 2010 (Table 11). <u>For the 12.1-acre project parcel, these calculations yield an estimated total recharge of 10.4 ac-ft/yr of recharge for Water Year 2010</u>.

LSCE (2013) estimated recharge based on water balance modeling in several watersheds in the county underlain primarily by Sonoma Volcanics (Milliken Creek, Tulocay 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 (20% of average water year precipitation) per SWB model predictions lies at the upper end of the range of the LSCE estimates for larger watershed areas underlain by Sonoma Volcanics.

In the previous OEI analysis, a water balance calculation for the project recharge area (referred to as Area 2 in that report) was performed using an adaptation of a water balance analysis for the Napa River watershed completed by Luhdorff and Scalmanini (2013). The OEI analysis applied the estimated mean annual recharge rate for the St. Helena sub-watershed of 0.436 ac-ft/acre to the project recharge area to estimate a minimum potential recharge value of 22.8 ac-ft. As we stated in the 2015 WAA, this recharge estimate is likely an underestimate (see discussion in our previous study, (OEI 2015 p.18)). OEI's SWB model prediction, based on site-specific water balance calculations, gives annual recharge in the project recharge area of 37.1 ac-ft.

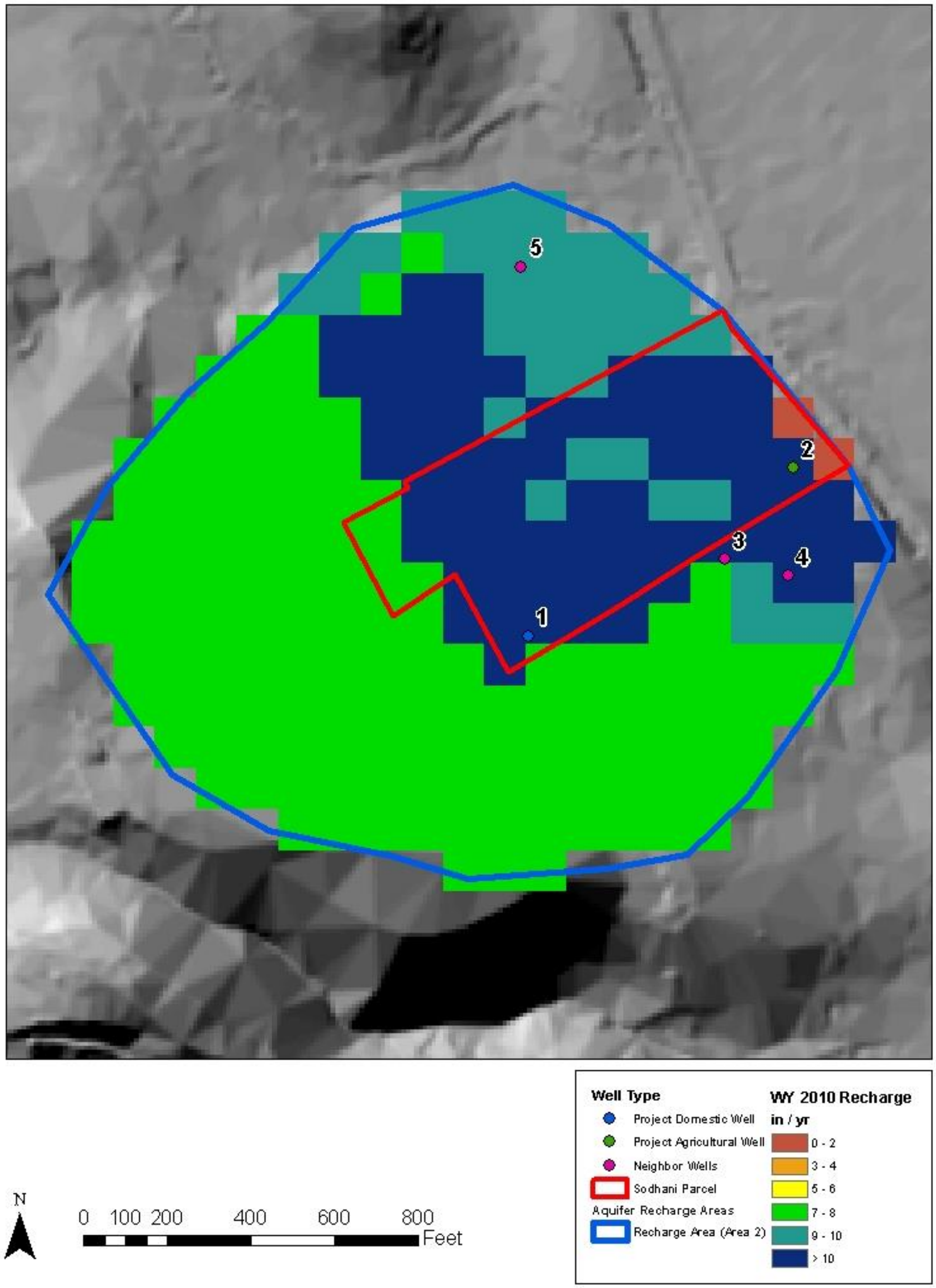


Figure 5. Recharge estimate for average year water year 2010.

Table 10: Summary of recharge results from the SWB model within the Project Recharge Area (Area 2) and on the Project parcel .

Project Recharge Area	**2010 Normal Year**	
	inches	**% of precip**
Precipitation	43.0	
AET	25.8	60%
Runoff	9.2	21%
Change in Soil Moisture	-0.5	-1%
Recharge	8.5	20%
Project Parcel Area	**2010 Normal Year**	
	inches	**% of precip**
Precipitation	42.9	
AET	23.6	55%
Runoff	9.7	23%
Change in Soil Moisture	-0.7	-2%
Recharge	10.3	24%

Comparison of Water Demand and Groundwater Recharge

The total proposed groundwater use for the project recharge area is estimated to be 10.6 ac-ft/yr. combined for all parcels intersecting the recharge area. Estimated groundwater use in the project recharge area is equivalent to 29% of the estimated average water year groundwater recharge of 37.1 ac-ft/yr. At the project scale, the proposed groundwater use for the Sodhani Winery parcel is estimated to be 4.5 ac-ft/yr (Table 11) which is equivalent to 43% of the estimated average water year recharge within the project parcel area.

These comparisons indicate that there is a substantial surplus of groundwater resources in terms of estimated average annual groundwater recharge to the project recharge area. Given the magnitude of this surplus, the 0.27 ac-ft/yr increase in water use associated with the proposed increase in wine production, employee use and added events is highly unlikely to result in reductions in groundwater levels or depletion of groundwater resources over time. Average (normal) year conditions are considered the appropriate reference value for water supply considerations and provide the best estimate for long-term groundwater availability represented by estimated groundwater recharge.

Table 11: Comparison of proposed water use to average groundwater recharge for the project recharge area (Area 2) and for the project parcel.

	Total Proposed Demand (ac-ft/yr)	Average Water Year (2010)		
		Recharge (ac-ft/yr)	Recharge Surplus (ac-ft/yr)	Demand as % of Recharge
Project Recharge Area	10.6	37.1	26.4	29%
Project Parcel Area	4.5	10.4	5.9	43%

Well Interference Potential

Per the prior WAA for the Sodhani Winery property (OEI 2015), the project well, also referred to as Well #1 and the "House Well", is located 504 feet (horizontal distance) from the nearest off-site neighboring well (Figure 5). The distance was determined by measuring the ground distance from Well #1 with a fiberglass tape the southwest corner of the vineyard, and along the southernmost vine row to a point due north of the neighboring well. This distance to the fence line on the property boundary was measured, and the remaining distance from the fence to the neighboring well was visually estimated to be 25 ft. These measurements were used to plot the well location in our project GIS map, and the distance from the project well to the nearest neighbor's well was measured using the GIS measuring tool. Mr. Arvind Sodhani used an iPhone 6 with the application GPS Tour to geo-locate Wells 1, 2 and 3 (Figure 2) as described in Appendix F. That method indicated that Wells 1 and 3 were separated by a distance of about 509 feet.

The WAA guidance document regarding well interference states that "…the Tier 2 well interference criterion is presumptively met if there are no non-project wells located within 500 feet of the existing or proposed project well(s) …" Given the location of the project well 504 to 508 feet from the nearest neighboring well, no further evaluation of potential well interference is required.

For reference with respect to Tier 3 WAA considerations, Figure 6 shows the absence of stream channels within a 1,500 foot radius of the project well.

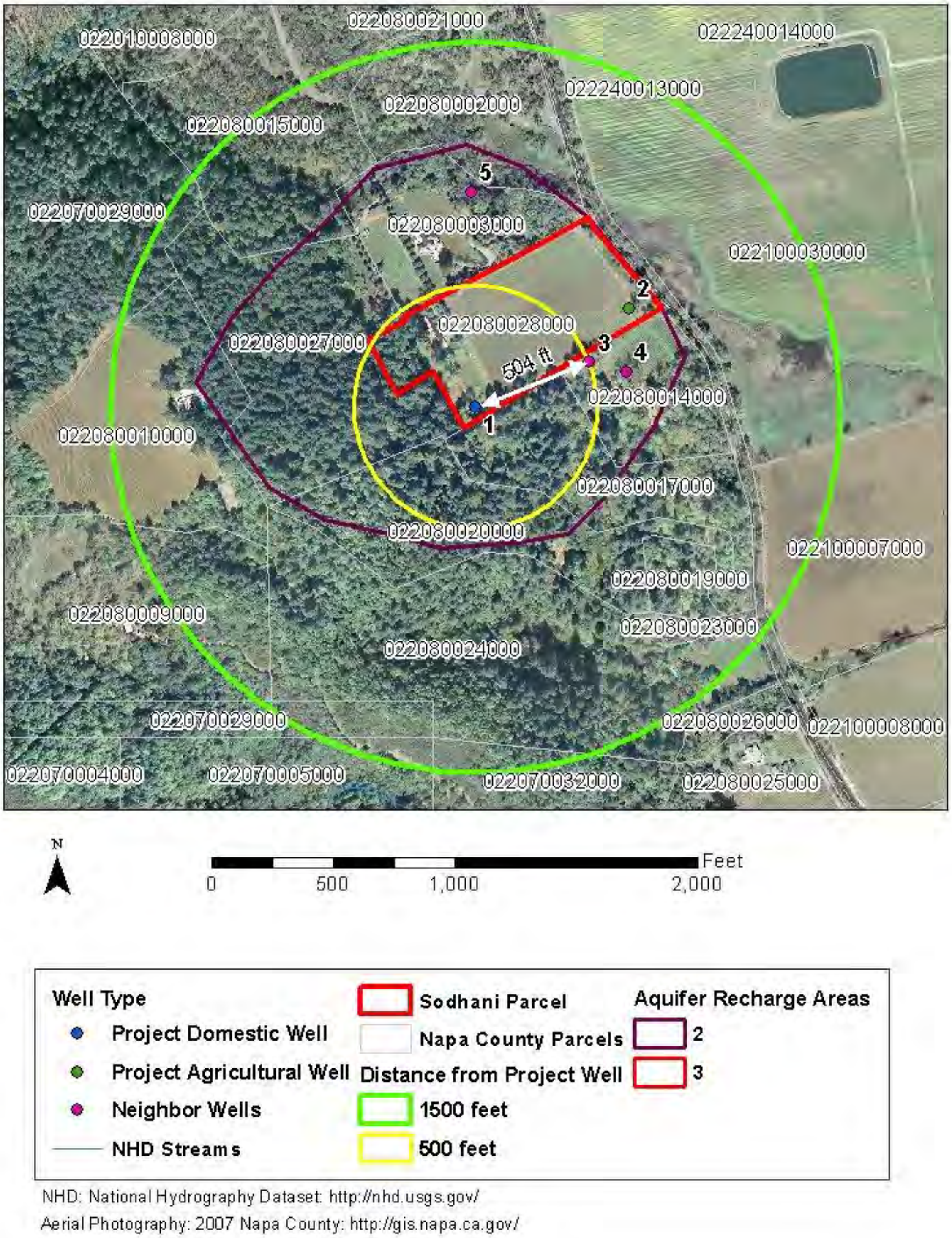


Figure 6. Location of wells and streams in relation to project well.

Conclusion

Mean annual groundwater recharge in the project recharge area (Area 2) is estimated using the Soil Water Balance model to be 37.1 acre-feet. The estimated annual demand for all water use within the project recharge area is 10.6 ac-ft/yr which represents 29% of the estimated average annual recharge. At the project parcel scale, estimated average recharge across the 12.1 acres is 10.4 acre-feet. Annual demand for the 12.1 acre proposed project parcel is 4.5 ac-ft which represents 43% of the estimated recharge during an average water year. The estimated surpluses under proposed conditions indicate that increase in water use associated with the proposed increase in wine production and added events is highly unlikely to result in reductions in groundwater levels or depletion of groundwater resources over time.

The nearest neighbor's well is located 504 feet from the proposed project well, indicating that potential well interference is negligible and requiring no further evaluation per the WAA procedures.

References

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Westenbroek, S.M., Kelson, V.A., Dripps, W.R., Hunt R.J., and Bradbury, K.R., 2010. SWB - A Modified Thornthwaite-Mather Soil-Water-Balance Code for Estimating Groundwater Recharge, U.S. Geological Survey Techniques and Methods 6-A31, 60 pgs.

Appendix A

Phase 1 Water Availability Assessment, December 2014

A Tradition of Stewardship
A Commitment to Service

Department of Public Works

1195 Third Street, Suite 201
Napa, CA 94559-3092
www.co.napa.ca.us/publicworks

Main: (707) 253-4351
Fax: (707) 253-4627

Donald G. Ridenhour, P.E.
Director

WATER AVAILABILITY ANALYSIS - PHASE ONE STUDY

Introduction: As an applicant for a permit with Napa County, It has been determined that Chapter 13.15 of the Napa County Code is applicable to approval of your permit. One step of the permit process is to adequately evaluate the amount of water your project will use and the potential impact your application might have on the static groundwater levels within your neighborhood. The public works department requires that a Phase 1 Water Availability Analysis (WAA) be included with your application. The purpose of this form is to assist you in the preparation of this analysis. You may present the analysis in an alternative form so long as it substantially includes the information required below. Please include any calculations you may have to support your estimates.

The reason for the WAA is for you, the applicant, to inform us, to the best of your ability, what changes in water use will occur on your property as a result of an approval of your permit application. By examining the attached guidelines and filling in the blanks, you will provide the information we require to evaluate potential impacts to static water levels of neighboring wells.

Step #1:

Provide a map and site plan of your parcel(s). The map should be an 8-1/2"x11" reproduction of a USGS quad sheet (1:24,000 scale) with your parcel outlined on the map. Include on the map the nearest neighboring well. The site plan should be an 8-1/2"x11" site plan of your parcel(s) with the locations of all structures, gardens, vineyards, etc in which well water will be used. If more than one water source is available, indicate the interconnecting piping from the subject well to the areas of use. Attach these two sheets to your application. If multiple parcels are involved, clearly show the parcels from which the fair share calculation will be based and properly identify the assessor's parcel numbers for these parcels. Identify all existing or proposed wells

Step #2: Determine total parcel acreage and water allotment factor. If your project spans multiple parcels, please fill a separate form for each parcel.

Determine the allowable water allotment for your parcels:

Parcel Location Factors

The allowable allotment of water is based on the location of your parcel. There are 3 different location classifications. Valley floor areas include all locations that are within the Napa Valley, Pope Valley and Carneros Region, except for areas specified as groundwater deficient areas. Groundwater deficient areas are areas that have been determined by the public works department as having a history of problems with groundwater. All other areas are classified as Mountain Areas.

Please underline your location classification below (Public Works can assist you in determining your classification if necessary):

Valley Floor	**1.0 acre feet per acre per year**
Mountain Areas	**0.5 acre feet per acre per year**
MST Groundwater Deficient Area	**0.3 acre feet per acre per year**

Assessor's Parcel Number(s)	Parcel Size (A)	Parcel Location Factor (B)	Allowable Water Allotment (A) X (B)
022-080-004	11.1	.5	5.5

Step #3:

Using the guidelines in Attachment A, tabulate the existing and projected future water usage on the parcel(s) in acre-feet per year (af/yr). Transfer the information from the guidelines to the table below.

EXISTING USE:			**PROPOSED USE:**		
Residential	.75	af/yr	Residential	.75	af/yr
Farm Labor Dwelling		af/yr	Farm Labor Dwelling		af/yr
Winery		af/yr	Winery	.26	af/yr
Commercial		af/yr	Commercial		f/yr
Vineyard*	2.3	af/yr	Vineyard*	2.3	af/yr
Other Agriculture		af/yr	Other Agriculture		af/yr
Landscaping		af/yr	Landscaping	.25	af/yr
Other Usage (List Separately):			Other Usage (List Separately):		
		af/yr	Winery Emp	.04	af/yr
		af/yr			af/yr
		af/yr			af/yr

TOTAL:	3.05	af/yr	**TOTAL:**	3.60	af/yr **TOTAL:**
	0.99 M	gallons**	**TOTAL:**	1.17 M	gallons**

Is the proposed use less than the existing usage? ☐ **Yes** ☑ **No** ☐ **Equal**

Step #4:

Provide any other information that may be significant to this analysis. For example, any calculations supporting your estimates, well test information including draw down over time, historical water data, visual observations of water levels, well drilling information, changes in neighboring land uses, the usage if other water sources such as city water or reservoirs, the timing of the development, etc. Use additional sheets if necessary.

Residential = 0.75 af/yr per County Guidelines and includes landscaping
Winery = 12,000 gallons x 2.15 af/yr per 100,000 gallons of wine per County Guidelines (production only)
Vineyard = 6.3 acres x 0.365 ac-ft/ac/r per County Guidelines and Vineyard Manager
Landscaping = 0.3 acres low water use landscaping around winery per landscape design and water estimates
Employees = 4 employees x 0.01 ac-ft/yr per employee per County Guidelines

Conclusion: Congratulations! Just sign the form and you are done! Public works staff will now compare your projected future water usage with a threshold of use as determined for your parcel(s) size, location, topography, rainfall, soil types, historical water data for your area, and other hydrogeologic information. They will use the above information to evaluate if your proposed project will have a detrimental effect on groundwater levels and/or neighboring well levels. Should that evaluation result in a determination that your project may adversely impact neighboring water levels, a phase two water analysis may be required. You will be advised of such a decision.

Signature: ______________________ **Date:** 12/5/2014 **Phone:** (707) 320-4968

REGISTERED PROFESSIONAL ENGINEER
MICHAEL R. MUELRATH
NO. 67435
Exp. 12/31/2014
CIVIL
STATE OF CALIFORNIA

Attachment A: Estimated Water Use Guidelines

Typical Water Use Guidelines:

Primary Residence	0.5 to 0.75 acre-feet per year (includes some landscaping)
Secondary Residence	0.20 to 0.30 acre-feet per year
Farm Labor Dwelling	0.06 to 0.10 acre-feet per person per year

Non-Residential Guidelines:

Agricultural:	
Vineyards	
Irrigation only	0.2 to 0.5 acre-feet per acre per year
Heat Protection	0.25 acre feet per acre per year
Frost Protection	0.25 acre feet per acre per year
Farm Labor Dwelling	0.06 to 0.10 acre-feet per person per year
Irrigated Pasture	4.0 acre-feet per acre per year
Orchards	4.0 acre-feet per acre per year
Livestock (sheep or cows)	0.01 acre-feet per acre per year
Winery:	
Process Water	2.15 acre-feet per 100,000 gal. of wine
Domestic and Landscaping	0.50 acre-feet per 100,000 gal. of wine
Industrial:	
Food Processing	31.0 acre-feet per employee per year
Printing/Publishing	0.60 acre-feet per employee per year
Commercial:	
Office Space	0.01 acre-feet per employee per year
Warehouse	0.05 acre-feet per employee per year

Appendix B
Water Quality Analysis, Project Well

David W Bess
David W Bess
1115 Mt George Ave
Napa, California 94558
Tel: 707-226-2539
Email: dave@dbesspumpandwell.com

RE: WaterQ Basic (Well Water for Dave Bess)

Work Order No.: DWQ1306008-A

Dear David W Bess:

Torrent Laboratory, Inc. received 1 sample(s) on June 13, 2013 for the analyses presented in the following Report.

All data for associated QC met EPA or laboratory specification(s) except where noted in the case narrative.

Torrent Laboratory, Inc. is certified by the State of California, ELAP #1991. If you have any questions regarding these test results, please feel free to contact the Project Management Team at (408)263-5258; ext 204.

Patti Sandrock
QA Officer

June 18, 2013
Date

Date: 6/18/2013

Client: David W Bess

Project: WaterQ Basic (Well Water for Dave Bess)

Work Order: DWQ1306008-A

CASE NARRATIVE

No issues encountered with the receiving, preparation, analysis or reporting of the results associated with this work order.

Observations:

Primary Contaminants- (Health)

No primary contaminants in the scope of analysis presented in this report were found to be outside of the EPA Federally established Maximum Contaminant Level (MCL) guidelines.

Secondary Contaminant - (Water Aesthetics)

No secondary contaminants in the scope of analysis presented in this report were found to be outside of the EPA Federally established Maximum Contaminant Level (MCL) guidelines (or recommended level where no MCLs exist).

This report is for House Well Sample only and is labeled and stored as DWQ-1306008-A.

The Irrigation Well sample will be reported separately as DWQ-1306008-B.

Sample Result Summary

Report prepared for: David W Bess
David W Bess

Date Received: 06/13/13
Date Reported: 06/18/13

House well DWQ1306008-001

Parameters:	Analysis Method	DF	MDL	PQL	Results	Unit
Boron	E200.7	1	0.001	0.020	0.048	mg/L
Copper	E200.8	1	0.077	0.50	0.52	ug/L
Lead	E200.8	1	0.018	0.10	0.11	ug/L
Arsenic	E200.8	1	0.11	0.30	1.9	ug/L
Total Hardness (As CaCO3)	SM2340B	1	0.0830	1.0	95	mg/L
Calcium Hardness (as CaCO3)	SM2340B	1	0.0830	0.50	54	mg/L
Nitrate as NO3	E300.0	1	0.077	0.50	4.8	mg/L
pH	SM4500HB	1	0.10	2.00	7.90	S.U.
Total Dissolved Solids	SM2540C	1	1	10	180	mg/L
Turbidity	E180.1	1	0.10	0.20	0.81	NTU

SAMPLE RESULTS

Report prepared for: David W Bess
David W Bess

Date Received: 06/13/13
Date Reported: 06/18/13

Client Sample ID:	House well	**Lab Sample ID:**	DWQ1306008-A-001A
Project Name/Location:	WaterQ Basic (Well Water for Dave Bess)	**Sample Matrix:**	Drinking Water
Project Number:			
Date/Time Sampled:	06/12/13 / 11:00		
Tag Number:	Drinking Water Sample for Dave Bess		

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Iron	E200.7	6/13/13	06/13/13	1	0.002	0.10	ND		mg/L	416020	8945
Manganese	E200.7	6/13/13	06/13/13	1	0.003	0.050	ND		mg/L	416020	8945
Boron	E200.7	6/13/13	06/13/13	1	0.001	0.020	0.048		mg/L	416020	8945

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Copper	E200.8	6/13/13	06/17/13	1	0.077	0.50	0.52		ug/L	416049	8962
Lead	E200.8	6/13/13	06/17/13	1	0.018	0.10	0.11		ug/L	416049	8962
Arsenic	E200.8	6/13/13	06/17/13	1	0.11	0.30	1.9		ug/L	416049	8962

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Total Hardness (As CaCO3)	SM2340B	6/13/13	06/13/13	1	0.0830	1.0	95		mg/L	416019	8943
Calcium Hardness (as CaCO3)	SM2340B	6/13/13	06/13/13	1	0.0830	0.50	54		mg/L	416019	8943

SAMPLE RESULTS

Report prepared for: David W Bess
David W Bess

Date Received: 06/13/13
Date Reported: 06/18/13

Client Sample ID:	House well	**Lab Sample ID:**	DWQ1306008-A-001B
Project Name/Location:	WaterQ Basic (Well Water for Dave Bess)	**Sample Matrix:**	Drinking Water
Project Number:			
Date/Time Sampled:	06/12/13 / 11:00		
Tag Number:	Drinking Water Sample for Dave Bess		

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Nitrite as N	E300.0	NA	06/13/13	1	0.095	0.50	ND		mg/L	416072	NA
Nitrate as NO3	E300.0	NA	06/13/13	1	0.077	0.50	4.8		mg/L	416072	NA

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
pH	SM4500HB	NA	06/13/13	1	0.10	2.00	7.90		S.U.	416060	NA

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Total Dissolved Solids	SM2540C	NA	06/14/13	1	1	10	180		mg/L	416058	NA

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Turbidity	E180.1	NA	06/13/13	1	0.10	0.20	0.81		NTU	416059	NA

SAMPLE RESULTS

Report prepared for:	David W Bess David W Bess	**Date Received:**	06/13/13
		Date Reported:	06/18/13

Client Sample ID:	House well	**Lab Sample ID:**	DWQ1306008-A-001C
Project Name/Location:	WaterQ Basic (Well Water for Dave Bess)	**Sample Matrix:**	Drinking Water
Project Number:			
Date/Time Sampled:	06/12/13 / 11:00		
Tag Number:	Drinking Water Sample for Dave Bess		

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Sulfide, Total	E376.1	NA	06/17/13	1	2	2.0	ND		mg/L	416062	NA

Laboratory Qualifiers and Definitions

DEFINITIONS:

Accuracy/Bias (% Recovery) - The closeness of agreement between an observed value and an accepted reference value.
Blank (Method/Preparation Blank) -MB/PB - An analyte-free matrix to which all reagents are added in the same volumes/proportions as used in sample processing. The method blank is used to document contamination resulting from the analytical process.
Duplicate - a field sample and/or laboratory QC sample prepared in duplicate following all of the same processes and procedures used on the original sample (sample duplicate, LCSD, MSD)
Laboratory Control Sample (LCS ad LCSD) - A known matrix spiked with compounds representative of the target analyte(s). This is used to document laboratory performance.
Matrix - the component or substrate that contains the analyte of interest (e.g., - groundwater, sediment, soil, waste water, etc)
Matrix Spike (MS/MSD) - Client sample spiked with identical concentrations of target analyte (s). The spiking occurs prior to the sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.
Method Detection Limit (MDL) - the minimum concentration of a substance that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero
Practical Quantitation Limit (PQL) - a laboratory determined value at 2 to 5 times above the MDL that can be reproduced in a manner that results in a 99% confidence level that the result is both accurate and precise. PQLs reflect all preparation factors and/or dilution factors that have been applied to the sample during the preparation and/or analytical processes.
Precision (%RPD) - The agreement among a set of replicate/duplicate measurements without regard to known value of the replicates
Surrogate (S) or (Surr) - An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. Surrogates are used in most organic analysis to demonstrate matrix compatibility with the chosen method of analysis
Tentatively Identified Compound (TIC) - A compound not contained within the analytical calibration standards but present in the GCMS library of defined compounds. When the library is searched for an unknown compound, it can frequently give a tentative identification to the compound based on retention time and primary and secondary ion match. TICs are reported as estimates and are candidates for further investigation.
Units: the unit of measure used to express the reported result - **mg/L** and ***mg/Kg*** (equivalent to PPM - parts per million in **liquid** and ***solid***), **ug/L** and ***ug/Kg*** (equivalent to PPB - parts per billion in **liquid** and ***solid***), **ug/m3**, ***mg.m3***, **ppbv** and ***ppmv*** (all units of measure for reporting concentrations in air), **%** (equivalent to 10000 ppm or 1,000,000 ppb), **ug/Wipe** (concentration found on the surface of a single Wipe usually taken over a 100cm2 surface)

LABORATORY QUALIFIERS:

B - Indicates when the anlayte is found in the associated method or preparation blank
D - Surrogate is not recoverable due to the necessary dilution of the sample
E - Indicates the reportable value is outside of the calibration range of the instrument but within the linear range of the instrument (unless otherwise noted) Values reported with an E qualifier should be considered as estimated.
H- Indicates that the recommended holding time for the analyte or compound has been exceeded
J- Indicates a value between the method MDL and PQL and that the reported concentration should be considered as estimated rather the quantitative
NA - Not Analyzed
N/A - Not Applicable
NR - Not recoverable - a matrix spike concentration is not recoverable due to a concentration within the original sample that is greater than four times the spike concentration added
R- The % RPD between a duplicate set of samples is outside of the absolute values established by laboratory control charts
S- Spike recovery is outside of established method and/or laboratory control limits. Further explanation of the use of this qualifier should be included within a case narrative
X -Used to indicate that a value based on pattern identification is within the pattern range but not typical of the pattern found in standards. Further explanation may or may not be provided within the sample footnote and/or the case narrative.

483 Sinclair Frontage Rd., Milpitas, CA 95035 | *tel:* 408.263.5258 | *fax:* 408.263.8293 | www.torrentlab.com

Sample Receipt Checklist

Client Name: David W Bess

Project Name: WaterQ Basic (Well Water for Dave Bess)

Work Order No.: DWQ1306008

Date and Time Received: 6/13/2013 10:30

Received By: ng

Physically Logged By: ng

Checklist Completed By: ng

Carrier Name: FedEx

Chain of Custody (COC) Information

Chain of custody present?	No
Chain of custody signed when relinquished and received?	No
Chain of custody agrees with sample labels?	No
Custody seals intact on sample bottles?	Not Present

Sample Receipt Information

Custody seals intact on shipping container/cooler?	Not Present
Shipping Container/Cooler In Good Condition?	Yes
Samples in proper container/bottle?	Yes
Samples containers intact?	Yes
Sufficient sample volume for indicated test?	Yes

Sample Preservation and Hold Time (HT) Information

All samples received within holding time?	Yes			
Container/Temp Blank temperature in compliance?	No	Temperature:	15	°C
Water-VOA vials have zero headspace?	No VOA vials submitted			
Water-pH acceptable upon receipt?	N/A			

pH Checked by: n/a

pH Adjusted by: n/a

Samples received in a cooler at 15 deg C.

Login Summary Report

Client ID: TL5834 David W Bess

QC Level:

Project Name: WaterQ Basic (Well Water for Dave Bess)

TAT Requested: 3 day:25

Project # :

Date Received: 6/13/2013

Report Due Date: 6/18/2013

Time Received: 10:30

Comments: 3day TAT! Metals (Cu,Pb, B, Mn, As and Fe), Anions (NO2, NO3), pH, Turb, TDS, Hardness.

Client did not fill out the CoC, and has been contacted by email for sampling date/time, and for a CoC with a signature on it. --KB 6/13/13.

Work Order # : ***DWQ1306008***

WO Sample ID	Client Sample ID	Collection Date/Time	Matrix	Scheduled Disposal	Sample On Hold	Test On Hold	Requested Tests	Subbed
DWQ1306008-001A	House well	06/12/13 11:00	Drinking Water				DWQ_200.8 DWQ_200.7 DWQ_Hardness	
Sample Note:	3day TAT! Metals (Cu, Pb, B, Mn, As and Fe)							
DWQ1306008-001B	House well	06/12/13 11:00	Drinking Water				DWQ_Anions DWQ_TDS DWQ_Turb DWQ_pH	
Sample Note:	Anions (NO2, NO3), pH, Turb, TDS.							
DWQ1306008-001C	House well	06/12/13 11:00	Drinking Water				DWQ_Sulfide	
Sample Note:	Sulfide.							
DWQ1306008-002A	Irrigation well	06/12/13 11:50	Drinking Water				DWQ_200.8 DWQ_200.7 DWQ_Hardness	
DWQ1306008-002B	Irrigation well	06/12/13 11:50	Drinking Water				DWQ_Anions DWQ_pH DWQ_Turb DWQ_TDS	
DWQ1306008-002C	Irrigation well	06/12/13 11:50	Drinking Water				DWQ_Sulfide	

Torrent LABORATORY, INC.

Torrent REQUEST FORM

Rush Turnaround Services

Same Day • 24 Hrs • 48 Hrs • 72 Hrs

Torrent Express™

Confirmation Number | TR13

Date | 6/13/13

Company | Dave Bess

Ordered By |

Email | XXXXXXXXXXXXXXXXXXXXX
(for Rush report)

For Torrent Lab Use Only

Project Name | XXXXXXXXXXXXXXX

Project Number | XXXXXXXXXXXXXX

Order ID | DWQ1306008

Order Taken By | XXXXXXXXXXXXXXX

Accounting |

Project Details

TAT Requested
(please check one)

☐ Same Day (2-8 Hours) ☐ One Day ☐ Noon ☐ 2 Day ☐ Noon ☑ 3 Day ☐ Noon ☐ 4 Day ☐ Noon

Number of Samples | 2

Matrix | Water
(i.e., sample type: Is your sample soil, water, etc?)

Analysis | Basic Well - no bacT, plus Fe

☐ Weekend work required (refer to chart below for respective surcharge)

This request form may be a courtesy notice which reflects the rush services requested on the chain-of-custody. Please contact *Torrent Express*™ project management immediately at pm@torrentlab.com with the subject line "Rush TAT Cancellation" if you do not want the analysis(es) to proceed. **Cancellation of a *Torrent Express*™ service may be subject to a cancellation fee.**

In order to facilitate processing and scheduling, please notify Torrent Laboratory at least 24 hours in advance for any *Torrent Express*™ service.

Sample(s) must be received or scheduled for pick-up before 5:00 pm in order to be processed that day; all samples received after 5:00 pm will be processed the following day.

All *Torrent Express*™ Same Day and Next Day rush services will be charged a $250.00 minimum (excluding certain fees) plus the respective surcharge(s); all other *Torrent Express*™ rush services will be charged a $150.00 minimum (excluding certain fees) plus the respective surcharge(s).

The following table briefly describes Torrent Laboratory's *Torrent Express*™ surcharge pricing structure, please refer to your company specific price list for the precise surcharges.

	Same Day	Next Day*	2 Day*	3 Day*	4 Day*
Regular Rush	300%	150%	75%	50%	37.5%
Noon	—	200%	100%	62.5%	50%
Weekend	300%	300%	—	—	—

*business day(s)

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Torrent LABORATORY, INC.

Torrent LABORATORY, INC.

483 Sinclair Frontage Road
Milpitas, CA 95035
Phone: 408.263.5258 RESET
FAX: 408.263.8293
www.torrentlab.com

CHAIN OF CUSTODY

• NOTE: SHADED AREAS ARE FOR TORRENT LAB USE ONLY •

LAB WORK ORDER NO: DWQ1306008

Company Name: Dave W. Bess	Location of Sampling:
Address: 1115 Mt George Ave	Purpose: Drinking Water - WaterQ-Basic (Well Water)
City: Napa State: CA Zip Code: 94558	Special Instructions / Comments: INCLUDE IRON IN THE METALS LIST. 3 DAY TAT!
Telephone: 707.226.2539 FAX:	
REPORT TO: Dave Bess SAMPLER:	P.O. #: EMAIL: dave@dbesspumpandwell.com

TURNAROUND TIME: ☐ 10 Work Days ☑ 3 Work Days ☐ Noon - Nxt Day ☐ 7 Work Days ☐ 2 Work Days ☐ 2 - 8 Hours ☐ 5 Work Days ☐ 1 Work Day ☐ Other

SAMPLE TYPE: ☐ Storm Water ☐ Air ☐ Waste Water ☑ Other ☐ Ground Water ☐ Soil

REPORT FORMAT: ☐ QC Level IV ☐ EDF ☐ Excel / EDD

ANALYSIS REQUESTED

LAB ID	CLIENT'S SAMPLE I.D.	DATE / TIME SAMPLED	MATRIX	# OF CONT	CONT TYPE	Cu, Pb, B, Mn, As,e	Hardness		TDS,pH,Turb,	Anions (NO2, NO3)	Sulfide				REMARKS
001A/B/C			DW			✓	✓		✓	✓	✓				
002A/B/C						✓	✓		✓	✓	✓				

RUSH 3 DAYS

	Relinquished By:	Print:	Date:	Time:	Received By:	Print:	Date:	Time:
1								10:30 AM
2								

Were Samples Received in Good Condition? ☑ Yes ☐ NO Samples on Ice? ☑ Yes ☐ NO Method of Shipment FedEx Sample seals intact? ☐ Yes ☐ NO ☑ N/A

NOTE: Samples are discarded by the laboratory 30 days from date of receipt unless other arrangements are made. Page 1 of 1

Log In By: KB Date: 6/13/13 Log In Reviewed By: Date:

Appendix C
Water Quality Analysis, Sodhani Irrigation Well

David W Bess
David W Bess
1115 Mt George Ave
Napa, California 94558
Tel: 707-226-2539
Email: dave@dbesspumpandwell.com

RE: WaterQ Basic (Well Water for Dave Bess)

Work Order No.: DWQ1306008-B

Dear David W Bess:

Torrent Laboratory, Inc. received 1 sample(s) on June 13, 2013 for the analyses presented in the following Report.

All data for associated QC met EPA or laboratory specification(s) except where noted in the case narrative.

Torrent Laboratory, Inc. is certified by the State of California, ELAP #1991. If you have any questions regarding these test results, please feel free to contact the Project Management Team at (408)263-5258; ext 204.

Patti Sandrock
QA Officer

June 18, 2013
Date

Date: 6/18/2013

Client: David W Bess

Project: WaterQ Basic (Well Water for Dave Bess)

Work Order: DWQ1306008-B

CASE NARRATIVE

No issues encountered with the receiving, preparation, analysis or reporting of the results associated with this work order.

Observations:

Primary Contaminants- (Health)

The following constituents in the scope of analysis presented in this report were found to be outside of the EPA Federally established Maximum Contaminant Level (MCL) guidelines.
Corrective action must be taken to control the failed constituents in order to ensure corrected levels will be below the MCLs.

Turbidity 57 NTU (MCL is 5.0)
Arsenic 130 ug/L (MCL is 10)

THIS WATER SHOULD NOT BE USED FOR DRINKING, BATHING or COOKING!

Secondary Contaminant - (Water Aesthetics)

No secondary contaminants in the scope of analysis presented in this report were found to be outside of the EPA Federally established Maximum Contaminant Level (MCL) guidelines (or recommended level where no MCLs exist).

This report is for Irrigation Well sample only and is labeled and stored as DWQ-1306008-B.

The House Well sample will be reported separately as DWQ-1306008-A.

Sample Result Summary

Report prepared for: David W Bess
David W Bess

Date Received: 06/13/13
Date Reported: 06/18/13

Irrigation well DWQ1306008-002

Parameters:	Analysis Method	DF	MDL	PQL	Results	Unit
Iron	E200.7	1	0.002	0.10	1.6	mg/L
Manganese	E200.7	1	0.003	0.050	0.10	mg/L
Boron	E200.7	1	0.001	0.020	0.057	mg/L
Copper	E200.8	1	0.077	0.50	5.9	ug/L
Lead	E200.8	1	0.018	0.10	3.0	ug/L
Arsenic	E200.8	1	0.11	0.30	130	ug/L
Total Hardness (As CaCO3)	SM2340B	1	0.0830	1.0	80	mg/L
Calcium Hardness (as CaCO3)	SM2340B	1	0.0830	0.50	41	mg/L
pH	SM4500HB	1	0.10	2.00	7.57	S.U.
Total Dissolved Solids	SM2540C	1	1	10	180	mg/L
Turbidity	E180.1	10	1.0	2.0	57	NTU

Torrent LABORATORY, INC.

SAMPLE RESULTS

Report prepared for: David W Bess
David W Bess

Date Received: 06/13/13
Date Reported: 06/18/13

Client Sample ID:	Irrigation well	**Lab Sample ID:**	DWQ1306008-B-002A
Project Name/Location:	WaterQ Basic (Well Water for Dave Bess)	**Sample Matrix:**	Drinking Water
Project Number:			
Date/Time Sampled:	06/12/13 / 11:50		
Tag Number:	Drinking Water Sample for Dave Bess		

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Iron	E200.7	6/13/13	06/13/13	1	0.002	0.10	1.6		mg/L	416020	8945
Manganese	E200.7	6/13/13	06/13/13	1	0.003	0.050	0.10		mg/L	416020	8945
Boron	E200.7	6/13/13	06/13/13	1	0.001	0.020	0.057		mg/L	416020	8945

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Copper	E200.8	6/13/13	06/17/13	1	0.077	0.50	5.9		ug/L	416049	8962
Lead	E200.8	6/13/13	06/17/13	1	0.018	0.10	3.0		ug/L	416049	8962
Arsenic	E200.8	6/13/13	06/17/13	1	0.11	0.30	130		ug/L	416049	8962

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Total Hardness (As CaCO3)	SM2340B	6/13/13	06/13/13	1	0.0830	1.0	80		mg/L	416019	8943
Calcium Hardness (as CaCO3)	SM2340B	6/13/13	06/13/13	1	0.0830	0.50	41		mg/L	416019	8943

SAMPLE RESULTS

Report prepared for: David W Bess
David W Bess

Date Received: 06/13/13
Date Reported: 06/18/13

Client Sample ID:	Irrigation well	**Lab Sample ID:**	DWQ1306008-B-002B
Project Name/Location:	WaterQ Basic (Well Water for Dave Bess)	**Sample Matrix:**	Drinking Water
Project Number:			
Date/Time Sampled:	06/12/13 / 11:50		
Tag Number:	Drinking Water Sample for Dave Bess		

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Nitrite as N	E300.0	NA	06/13/13	1	0.095	0.50	ND		mg/L	416072	NA
Nitrate as NO3	E300.0	NA	06/13/13	1	0.077	0.50	ND		mg/L	416072	NA

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
pH	SM4500HB	NA	06/13/13	1	0.10	2.00	7.57		S.U.	416060	NA

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Total Dissolved Solids	SM2540C	NA	06/14/13	1	1	10	180		mg/L	416058	NA

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Turbidity	E180.1	NA	06/13/13	10	1.0	2.0	57		NTU	416059	NA

SAMPLE RESULTS

Report prepared for:	David W Bess David W Bess	**Date Received:**	06/13/13
		Date Reported:	06/18/13

Client Sample ID:	Irrigation well	**Lab Sample ID:**	DWQ1306008-B-002C
Project Name/Location:	WaterQ Basic (Well Water for Dave Bess)	**Sample Matrix:**	Drinking Water
Project Number:			
Date/Time Sampled:	06/12/13 / 11:50		
Tag Number:	Drinking Water Sample for Dave Bess		

Parameters:	Analysis Method	Prep Date	Date Analyzed	DF	MDL	PQL	Results	Lab Qualifier	Unit	Analytical Batch	Prep Batch
Sulfide, Total	E376.1	NA	06/17/13	1	2	2.0	ND		mg/L	416062	NA

Torrent LABORATORY, INC.

Laboratory Qualifiers and Definitions

DEFINITIONS:

Accuracy/Bias (% Recovery) - The closeness of agreement between an observed value and an accepted reference value.
Blank (Method/Preparation Blank) -MB/PB - An analyte-free matrix to which all reagents are added in the same volumes/proportions as used in sample processing. The method blank is used to document contamination resulting from the analytical process.
Duplicate - a field sample and/or laboratory QC sample prepared in duplicate following all of the same processes and procedures used on the original sample (sample duplicate, LCSD, MSD)
Laboratory Control Sample (LCS ad LCSD) - A known matrix spiked with compounds representative of the target analyte(s). This is used to document laboratory performance.
Matrix - the component or substrate that contains the analyte of interest (e.g., - groundwater, sediment, soil, waste water, etc)
Matrix Spike (MS/MSD) - Client sample spiked with identical concentrations of target analyte (s). The spiking occurs prior to the sample preparation and analysis. They are used to document the precision and bias of a method in a given sample matrix.
Method Detection Limit (MDL) - the minimum concentration of a substance that can be measured and reported with a 99% confidence that the analyte concentration is greater than zero
Practical Quantitation Limit (PQL) - a laboratory determined value at 2 to 5 times above the MDL that can be reproduced in a manner that results in a 99% confidence level that the result is both accurate and precise. PQLs reflect all preparation factors and/or dilution factors that have been applied to the sample during the preparation and/or analytical processes.
Precision (%RPD) - The agreement among a set of replicate/duplicate measurements without regard to known value of the replicates
Surrogate (S) or (Surr) - An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. Surrogates are used in most organic analysis to demonstrate matrix compatibility with the chosen method of analysis
Tentatively Identified Compound (TIC) - A compound not contained within the analytical calibration standards but present in the GCMS library of defined compounds. When the library is searched for an unknown compound, it can frequently give a tentative identification to the compound based on retention time and primary and secondary ion match. TICs are reported as estimates and are candidates for further investigation.
Units: the unit of measure used to express the reported result - **mg/L** and ***mg/Kg*** (equivalent to PPM - parts per million in **liquid** and ***solid***), **ug/L** and ***ug/Kg*** (equivalent to PPB - parts per billion in **liquid** and ***solid***), **ug/m3**, ***mg.m3***, **ppbv** and ***ppmv*** (all units of measure for reporting concentrations in air), **%** (equivalent to 10000 ppm or 1,000,000 ppb), **ug/Wipe** (concentration found on the surface of a single Wipe usually taken over a 100cm2 surface)

LABORATORY QUALIFIERS:

B - Indicates when the anlayte is found in the associated method or preparation blank
D - Surrogate is not recoverable due to the necessary dilution of the sample
E - Indicates the reportable value is outside of the calibration range of the instrument but within the linear range of the instrument (unless otherwise noted) Values reported with an E qualifier should be considered as estimated.
H- Indicates that the recommended holding time for the analyte or compound has been exceeded
J- Indicates a value between the method MDL and PQL and that the reported concentration should be considered as estimated rather the quantitative
NA - Not Analyzed
N/A - Not Applicable
NR - Not recoverable - a matrix spike concentration is not recoverable due to a concentration within the original sample that is greater than four times the spike concentration added
R- The % RPD between a duplicate set of samples is outside of the absolute values established by laboratory control charts
S- Spike recovery is outside of established method and/or laboratory control limits. Further explanation of the use of this qualifier should be included within a case narrative
X -Used to indicate that a value based on pattern identification is within the pattern range but not typical of the pattern found in standards. Further explanation may or may not be provided within the sample footnote and/or the case narrative.

Sample Receipt Checklist

Client Name: David W Bess

Project Name: WaterQ Basic (Well Water for Dave Bess)

Work Order No.: DWQ1306008

Date and Time Received: 6/13/2013 10:30

Received By: ng

Physically Logged By: ng

Checklist Completed By: ng

Carrier Name: FedEx

Chain of Custody (COC) Information

Chain of custody present?	No
Chain of custody signed when relinquished and received?	No
Chain of custody agrees with sample labels?	No
Custody seals intact on sample bottles?	Not Present

Sample Receipt Information

Custody seals intact on shipping container/cooler?	Not Present
Shipping Container/Cooler In Good Condition?	Yes
Samples in proper container/bottle?	Yes
Samples containers intact?	Yes
Sufficient sample volume for indicated test?	Yes

Sample Preservation and Hold Time (HT) Information

All samples received within holding time?	Yes			
Container/Temp Blank temperature in compliance?	No	Temperature:	15	°C
Water-VOA vials have zero headspace?	No VOA vials submitted			
Water-pH acceptable upon receipt?	N/A			

pH Checked by: n/a

pH Adjusted by: n/a

Samples received in a cooler at 15 deg C.

Login Summary Report

Client ID: TL5834 David W Bess

QC Level:

Project Name: WaterQ Basic (Well Water for Dave Bess)

TAT Requested: 3 day:25

Project # :

Date Received: 6/13/2013

Report Due Date: 6/18/2013

Time Received: 10:30

Comments: 3day TAT! Metals (Cu,Pb, B, Mn, As and Fe), Anions (NO2, NO3), pH, Turb, TDS, Hardness.

Client did not fill out the CoC, and has been contacted by email for sampling date/time, and for a CoC with a signature on it. --KB 6/13/13.

Work Order # : ***DWQ1306008***

WO Sample ID	Client Sample ID	Collection Date/Time	Matrix	Scheduled Disposal	Sample On Hold	Test On Hold	Requested Tests	Subbed
DWQ1306008-001A	House well	06/12/13 11:00	Drinking Water				DWQ_200.8 DWQ_200.7 DWQ_Hardness	
Sample Note:	3day TAT! Metals (Cu, Pb, B, Mn, As and Fe)							
DWQ1306008-001B	House well	06/12/13 11:00	Drinking Water				DWQ_Anions DWQ_pH DWQ_TDS DWQ_Turb	
Sample Note:	Anions (NO2, NO3), pH, Turb, TDS.							
DWQ1306008-001C	House well	06/12/13 11:00	Drinking Water				DWQ_Sulfide	
Sample Note:	Sulfide.							
DWQ1306008-002A	Irrigation well	06/12/13 11:50	Drinking Water				DWQ_200.8 DWQ_200.7 DWQ_Hardness	
DWQ1306008-002B	Irrigation well	06/12/13 11:50	Drinking Water				DWQ_Anions DWQ_pH DWQ_Turb DWQ_TDS	
DWQ1306008-002C	Irrigation well	06/12/13 11:50	Drinking Water				DWQ_Sulfide	

483 Sinclair Frontage Rd., Milpitas, CA 95035 | tel: 408.263.5258 | fax: 408.263.8293 | www.torrentlab.com

Torrent LABORATORY, INC.

Torrent REQUEST FORM

Rush Turnaround Services

Torrent Express™

Confirmation Number | TR13

Date | 6/13/13

Company | Dave Bess

Ordered By |

Email | XXXXXXXXXXXXXXXXXXXXX
(for Rush report)

For Torrent Lab Use Only

Project Name | XXXXXXXXXXXXXXX

Project Number | XXXXXXXXXXXXXX

Order ID | DWQ1306008

Order Taken By | XXXXXXXXXXXXXXX

Accounting |

Project Details

TAT Requested
(please check one)

☐ Same Day (2-8 Hours) ☐ One Day ☐ Noon ☐ 2 Day ☐ Noon ☑ 3 Day ☐ Noon ☐ 4 Day ☐ Noon

Number of Samples | 2

Matrix | Water
(i.e., sample type: Is your sample soil, water, etc?)

Analysis | Basic Well - no bacT, plus Fe

☐ Weekend work required (refer to chart below for respective surcharge)

This request form may be a courtesy notice which reflects the rush services requested on the chain-of-custody. Please contact *Torrent Express*™ project management immediately at pm@torrentlab.com with the subject line "Rush TAT Cancellation" if you do not want the analysis(es) to proceed. **Cancellation of a *Torrent Express*™ service may be subject to a cancellation fee.**

In order to facilitate processing and scheduling, please notify Torrent Laboratory at least 24 hours in advance for any *Torrent Express*™ service.

Sample(s) must be received or scheduled for pick-up before 5:00 pm in order to be processed that day; all samples received after 5:00 pm will be processed the following day.

All *Torrent Express*™ Same Day and Next Day rush services will be charged a $250.00 minimum (excluding certain fees) plus the respective surcharge(s); all other *Torrent Express*™ rush services will be charged a $150.00 minimum (excluding certain fees) plus the respective surcharge(s).

The following table briefly describes Torrent Laboratory's *Torrent Express*™ surcharge pricing structure, please refer to your company specific price list for the precise surcharges.

	Same Day	Next Day*	2 Day*	3 Day*	4 Day*
Regular Rush	300%	150%	75%	50%	37.5%
Noon	—	200%	100%	62.5%	50%
Weekend	300%	300%	—	—	—

*business day(s)

Torrent LABORATORY, INC.

Torrent LABORATORY, INC.

483 Sinclair Frontage Road
Milpitas, CA 95035
Phone: 408.263.5258 RESET
FAX: 408.263.8293
www.torrentlab.com

CHAIN OF CUSTODY

• NOTE: SHADED AREAS ARE FOR TORRENT LAB USE ONLY •

LAB WORK ORDER NO: DWQ1306008

Company Name: **Dave W. Bess**	Location of Sampling:
Address: **1115 Mt George Ave**	Purpose: **Drinking Water - WaterQ-Basic (Well Water)**
City: **Napa** State: **CA** Zip Code: **94558**	Special Instructions / Comments: **INCLUDE IRON IN THE METALS LIST. 3 DAY TAT!**
Telephone: **707.226.2539** FAX:	
REPORT TO: **Dave Bess** SAMPLER:	P.O. #: EMAIL: **dave@dbesspumpandwell.com**

TURNAROUND TIME: ☐ 10 Work Days ☑ 3 Work Days ☐ Noon - Nxt Day ☐ 7 Work Days ☐ 2 Work Days ☐ 2 - 8 Hours ☐ 5 Work Days ☐ 1 Work Day ☐ Other

SAMPLE TYPE: ☐ Storm Water ☐ Air ☐ Waste Water ☑ Other ☐ Ground Water ☐ Soil

REPORT FORMAT: ☐ QC Level IV ☐ EDF ☐ Excel / EDD

ANALYSIS REQUESTED

LAB ID	CLIENT'S SAMPLE I.D.	DATE / TIME SAMPLED	MATRIX	# OF CONT	CONT TYPE	Cu, Pb, B, Mn, As,e	Hardness		TDS,pH,Turb,	Anions (NO2, NO3)	Sulfide				REMARKS
001A/B/C			DW			✓	✓		✓	✓	✓				
002A/B/C						✓	✓		✓	✓	✓				

RUSH 3 DAYS

	Relinquished By:	Print:	Date:	Time:	Received By:	Print:	Date:	Time:
1								10:30 AM
2								

Were Samples Received in Good Condition? ☑ Yes ☐ NO Samples on Ice? ☑ Yes ☐ NO Method of Shipment FedEx Sample seals intact? ☐ Yes ☐ NO ☑ N/A

NOTE: Samples are discarded by the laboratory 30 days from date of receipt unless other arrangements are made. Page 1 of 1

Log In By: KB Date: 6/13/13 Log In Reviewed By: Date:

Appendix D

Napa County Well Permit, Project Well

HEALTH DEPT. USE ONLY
FEE: 12.00
DATE: 2-20-74
RECEIPT NO: 0900
BY: N. Ettel

NAPA COUNTY HEALTH DEPARTMENT
DIVISION OF ENVIRONMENTAL HEALTH

RECEIVED
MAY 7 1974
DIVISION OF ENVIRONMENTAL HEALTH

A.P. # 22-080-04

APPLICATION & PERMIT TO CONSTRUCT A WATER WELL
(ORDINANCE #)

NAME Calley (Owner) ADDRESS St. Helena Hwy N (Job Location) DATE 2-20-74

NAME Walter Rettela (Well Driller) ADDRESS 1541 Mark West Springs Rd. Santa Rosa,

TYPE OF WORK: NEW WELL ✓ TEST HOLES ___ TYPE I PERMIT ✓ RECONDITIONING ___ DESTROYING ___ TYPE II PERMIT ___ DEEPENING ___ OTHER ___ FEE ___

PROPOSED USE: DOMESTIC ✓ TEST WELL ___ IRRIGATION ✓ OTHER ___ INDUSTRIAL ___ MUNICIPAL ___

Sewage Disposal On Site (Existing or Proposed) Public ___ Individual ✓ Private ___
Distance from well to any part of nearest sewage disposal system 100+ feet.
(Sketch of site to accompany application.

TYPE OF EQUIPMENT TO BE USED: Rotary ___ Cable ✓ Hand Dug ___ Other ___

CONSTRUCTION PROPOSED: Diameter of casing 8" Material steel Annular Space: Size 2"
Sealed with: Concrete ___ Grout ✓ Neat Cement ___ Puddled Clay ___ Other ___
Conductor Casing: Yes ___ No ✓ Material ___
Chlorination By: Owner ✓ Pump Co ___ Driller ___

Walter Rettela (SIGNATURE OF APPLICANT) 2-20-74 (DATE)

NOTICE TO DRILLER: COMPLETE THIS PORTION AND PROVIDE OWNER WITH THIS COPY.

CASING
250 – 8"

CONSTRUCTION
Total Depth 250 Ft.
Surface Seal to 25 Ft.
Any Stratas sealed: Yes ___ No X
If yes, depth of Stratas
From ___ Ft. to ___ Feet
From ___ Ft. to ___ Feet
Perforations
From 87 Ft. to 130 Feet
From 160 Ft. to 190 Feet
From 210 Ft. to 250 Feet

WATER LEVELS
First water at 70 Feet
Static level at 45 Feet

WELL TESTS
How performed Bailer
Yield 30 GPM with 80 Feet
Drawdown ___ Ft. after 1 Hrs.

WELL LOG
(Formation; describe by color, size of material, structure)

Ft. to Ft.		Ft. to Ft/	
0–20	Red clay	210–240	Brown ash
20–30	Clay & small boulders	240–245	Brown rock
30–40	Loose boulders	245–250	Brown ash
40–47	Clay		
47–60	broken basalt		
60–85	clay		
85–95	broken basalt		
95–110	brown ash		
110–125	broken basalt		
125–145	Brown ash		
145–160	Hard clay & gravel		
160–180	ash & gravel		
180–188	clay		
188–200	Brown rock		
200–210	clay & boulders		

Signed: Walter L Rettela
License # 228649

Appendix E
Well Completion Report, Sodhani Irrigation Well

TRIPLICATE
Owner's Copy
Page 1 of 2
Owner's Well No.
Date Work Began 7/2/99 Ended 7/14/99
Local Permit Agency NAPA CO. ENVIRONMENTAL MANAGEMENT
Permit No. 96-10399 Permit Date 10/8/99

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 719746

STATE WELL NO./STATION NO.
LATITUDE LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)
DRILLING METHOD MUD ROTARY FLUID Bentonite

DEPTH FROM SURFACE Ft. to Ft.		DESCRIPTION *Describe material, grain size, color, etc.*
0	3	Clay
3	10	Boulders
10	26	Gravels
26	48	HARD Cobbles
48	59	Coarse sand
59	76	Clayee sand
76	85	Hard multi-colored volcanic rock
85	94	Loose volcanic rock & some clay
94	96	Clay
96	105	Coarse snad & volcanic rock with small amount of clay
105	111	Hard & fractured volcanic rock
111	117	Sandy clayee ash
117	121	Hard fractured volcanic rock
121	124	Clay and ash
124	128	Hard fractured volcanic rock
128	130	Clay & ash
130	142	Hard fractured volcanic rock
142	148	Dry ash
148	162	Hard fractured volcanic rock
162	164	Clay and ash
164	167	Hard fractured volcanic rock
167	196	Clay and ash
196	198	Hard fractured volcanic rock
198	214	Clay and ash
214	218	Hard fractured volcanic rock
218	251	Volcanic conglomerate

TOTAL DEPTH OF BORING 458 (Feet)
TOTAL DEPTH OF COMPLETED WELL 458 (Feet)

WELL OWNER

Name HAROLD & CAROL GREEN
Mailing Address 3283 St. Helena Hwy
St. Helena, CA
CITY STATE ZIP

WELL LOCATION

Address 3283 St. Helena Hwy
City St. Helena, CA
County NAPA
APN Book 22 Page 080 Parcel 04
Township ___ Range ___ Section ___
Latitude ___ DEG. MIN. SEC. NORTH Longitude ___ DEG. MIN. SEC. WEST

LOCATION SKETCH

NORTH
WEST EAST
SOUTH

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

ACTIVITY (✓)

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

PLANNED USES (✓)

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

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE
DEPTH OF STATIC WATER LEVEL 21 (Ft.) & DATE MEASURED 7/14/99
ESTIMATED YIELD * 18 (GPM) & TEST TYPE BAIL
TEST LENGTH 1½ (Hrs.) TOTAL DRAWDOWN 97 (Ft.)
* *May not be representative of a well's long-term yield.*

CASING (S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	316	12¼								
316	458	10 5/8								
+ 2	458		X				PVC/F480	6"	CL200	
78	98			X						.032
138	158			X						.032

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	26	X			
26	458			X	3/8 PEA GR

SEE NEXT PAGE TO CONTINUE MICR-PERFORATIONS

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 WEEKS DRILLING AND PUMP COMPANY by Ward Thompson
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

P.O. Box 176 SEBASTOPOL, CA 95473
ADDRESS CITY STATE ZIP

Signed [signature] 7/15/99 177681
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 11-97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Owner's Copy

Page 2 of 2

Owner's Well No.

Date Work Began 7/2/99, Ended 7/14/99

Local Permit Agency NAPA CO. ENVIRONMENTAL MANAGEMENT

Permit No. 96-10399 Permit Date 10/8/99

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 719747

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

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

DRILLING METHOD MUD ROTARY FLUID Bent.

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION Describe material, grain size, color, etc.
251	262	Hard fractured volcanic rock
262	271	Volcanic conglomerate
271	274	HARD volcanic rock
274	283	Clay and ash
283	288	Hard fractured volcanic rock
288	293	Coarse sand
293	369	Hard multi-colored volcanic rock with seams of clay
369	382	Clayee ash
382	388	Hard and very fractured black and red volcanic rock
388	392	Clay and ash
392	412	Coarse sands & rock ledges
412	420	Clay and ash
420	449	Coarse sand and rock ledges
449	458	Stiff clay

TOTAL DEPTH OF BORING 458 (Feet)

TOTAL DEPTH OF COMPLETED WELL 458 (Feet)

WELL OWNER

Name HAROLD & CAROL GREEN

Mailing Address 3283 St. Helena Hwy

St. Helena, CA

CITY STATE ZIP

WELL LOCATION

Address 3283 St. Helena Hwy

City St. Helena, CA

County NAPA

APN Book 22 Page 080 Parcel 04

Township ___ Range ___ Section ___

Latitude ___ NORTH Longitude ___ WEST

DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST

EAST

SOUTH

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

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR

___ Deepen

___ Other (Specify)

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

PLANNED USES (✓)

WATER SUPPLY

___ Domestic ___ Public

X Irrigation ___ Industrial

MONITORING ___

TEST WELL ___

CATHODIC PROTECTION ___

HEAT EXCHANGE ___

DIRECT PUSH ___

INJECTION ___

VAPOR EXTRACTION ___

SPARGING ___

REMEDIATION ___

OTHER (SPECIFY) ___

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ___ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL SEE PAGE 1 (Ft.) & DATE MEASURED ___

ESTIMATED YIELD * ___ (GPM) & TEST TYPE ___

TEST LENGTH ___ (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)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
218	238			X						.032
278	298			X						.032
338	358			X						.032
398	418			X						.032
438	458			X						.032

(See Page 1 for other information)

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
SEE PREVIOUS PAGE 1					

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 WEEKS DRILLING AND PUMP COMPANY by Ward Thompson

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

P.O. Box 176 Sebastopol, CA 95473

ADDRESS CITY STATE ZIP

Signed Ward Thompson 7/15/99 177681

WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

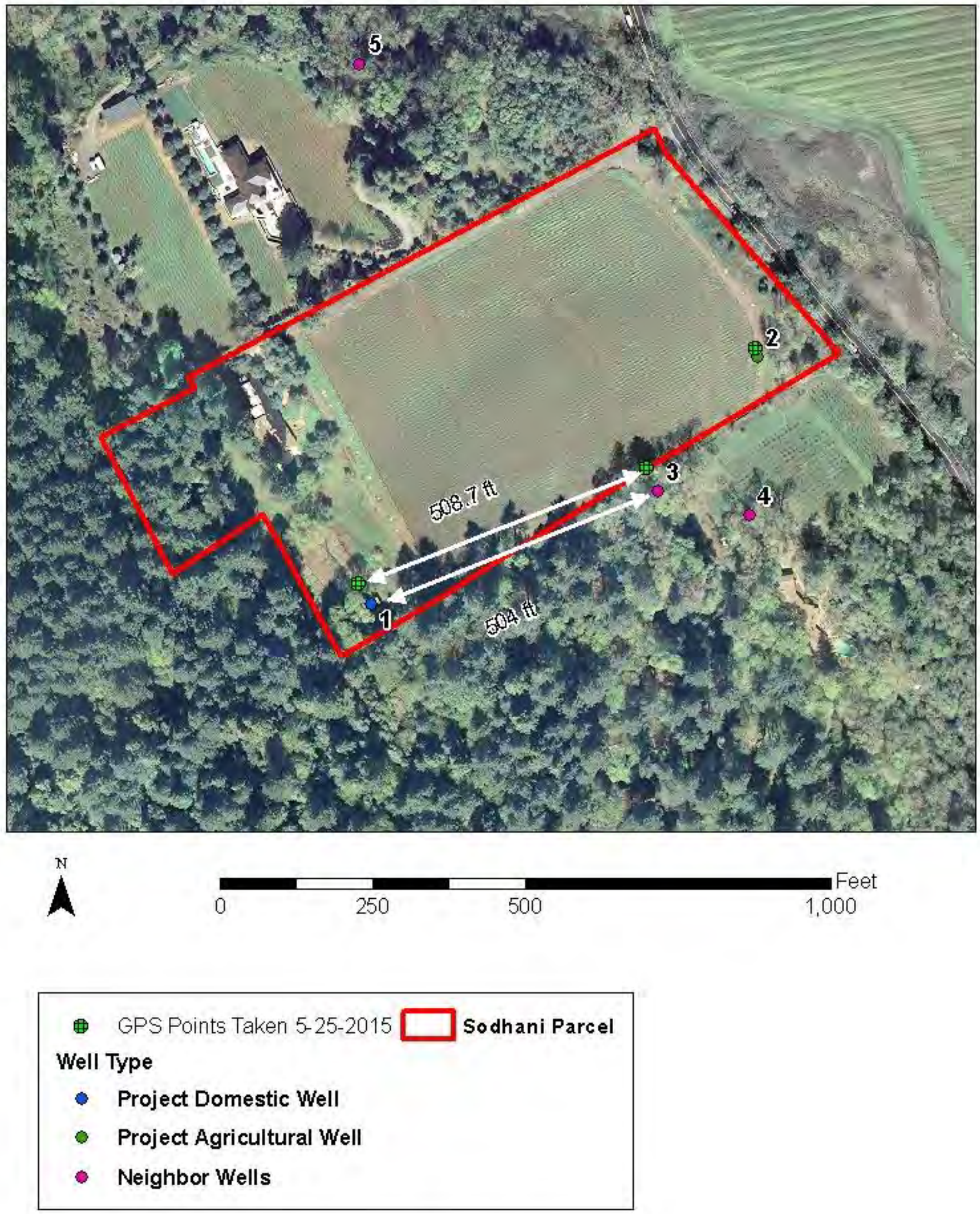
DWR 188 REV. 11/97

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

Appendix F
Supplemental Estimate of Distance Between Wells

To assist in documenting the project domestic well location relative to the neighboring well to the south GPS data points were taken by the Project property owner on May 25th 2015 using the "GPS Tour" application on his iPhone 6 Plus. The average RMSE in horizontal accuracy for the GPS system installed in a 3G iPhone is stated to be 9 m (Zandbergen, 2009). The latitude and longitude in decimal degrees for each well was recorded and then plotted in the GCS_WGS_1984 coordinate system using simple methods in ArcGIS (see Figure below). The points were then projected into NAD_1983_StatePlane_California_II_FIPS_0402_Feet coordinate system to match the exact coordinate system of the ArcMap document being used to ensure the most accurate georeferencing of the points. Well locations do not match exactly to the locations shown on the 2007 aerial photo and to those mapped in the field; nevertheless, the relative distances between the points are similar to those mapped using field techniques mentioned earlier in this analysis. This discrepancy can be attributed to the relatively large horizontal accuracy of the iPhone GPS. The measured distance between the two well points taken with the iPhone was 508.7 feet, quite close to the 504 ft determined by previous methods.

Zandbergen, P. A., 2009. Accuracy of iPhone Locations: A Comparison of Assisted GPS, WiFi and Cellular Positioning. *Transactions in GIS*, 2009, 13(s1): 5–26. Blackwell Publishing Ltd.



Aerial Photography: 2007 Napa County: http://gis.napa.ca.gov/

Additional Well Location Points Taken on May 25th, 2015.

Appendix G-

Napa County SWB Groundwater Recharge Analysis

Napa County Groundwater Recharge Analysis

Introduction

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

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

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

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

Model Development

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

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

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

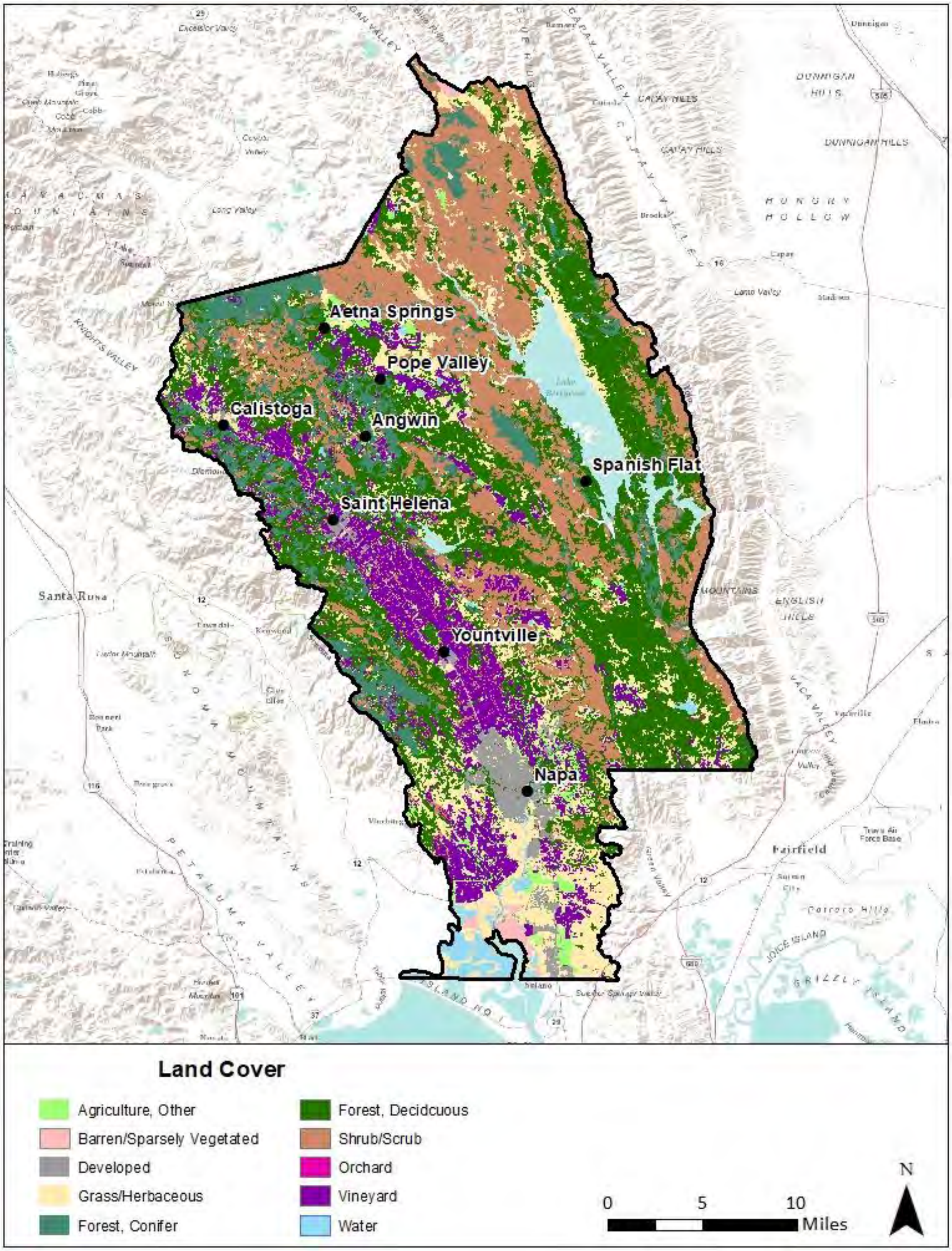


Figure 1: Land cover distribution used in the Napa County SWB model.

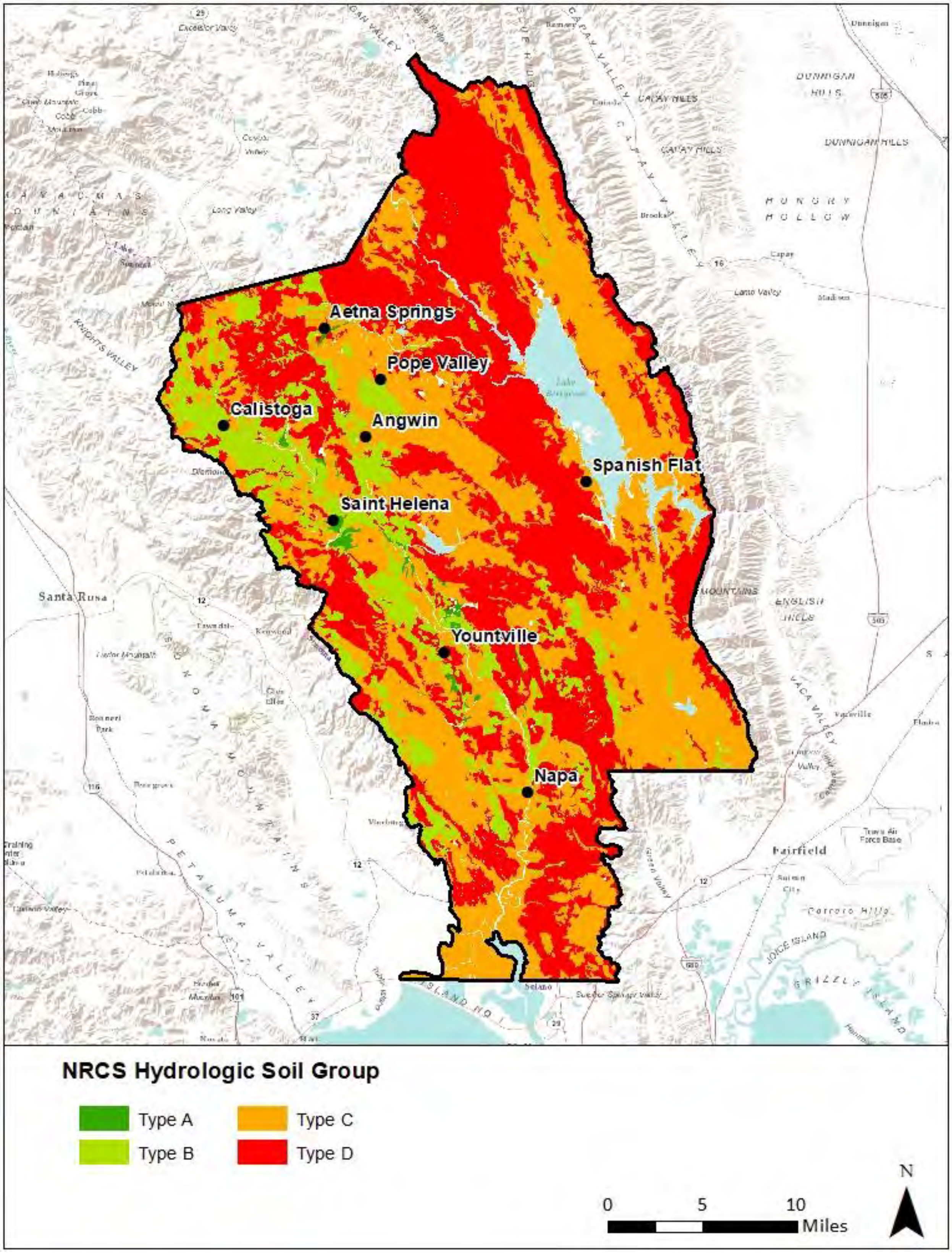


Figure 2: Hydrologic soil group distribution used in the Napa County SWB model.

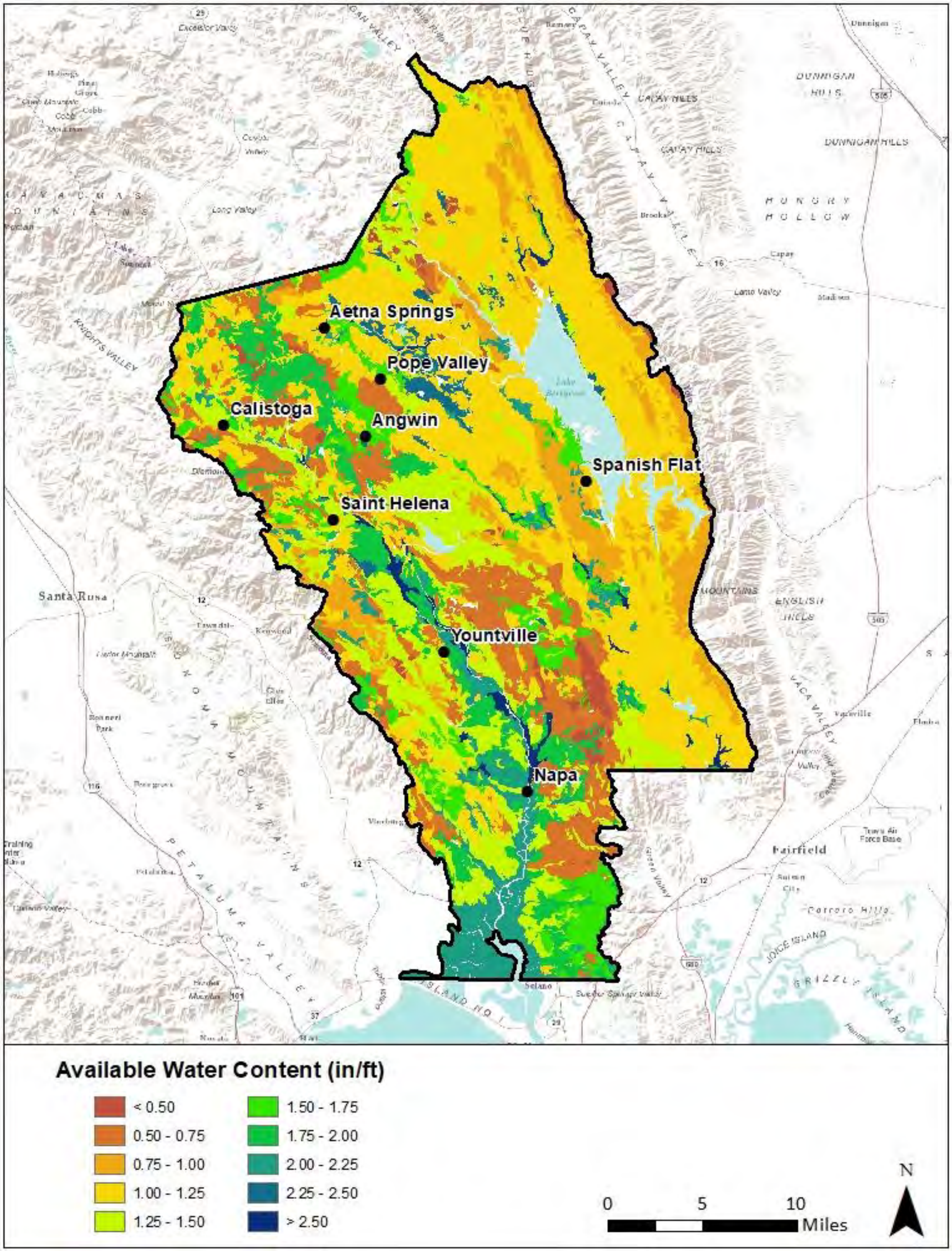


Figure 3: Available water capacity distribution used in the Napa County SWB model.

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

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

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

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

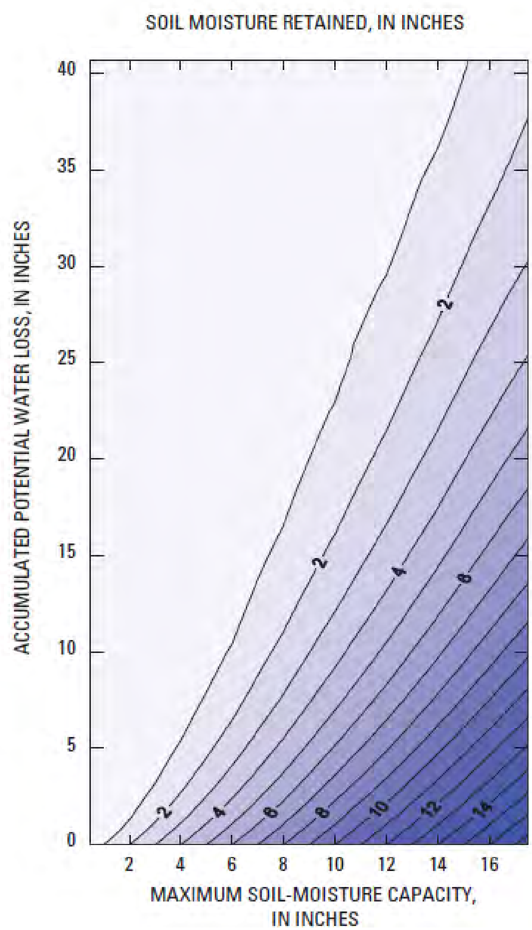


Figure 4: Soil-moisture-retention table (Thornthwaite and Mather 1957).

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

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

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

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

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

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

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

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

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

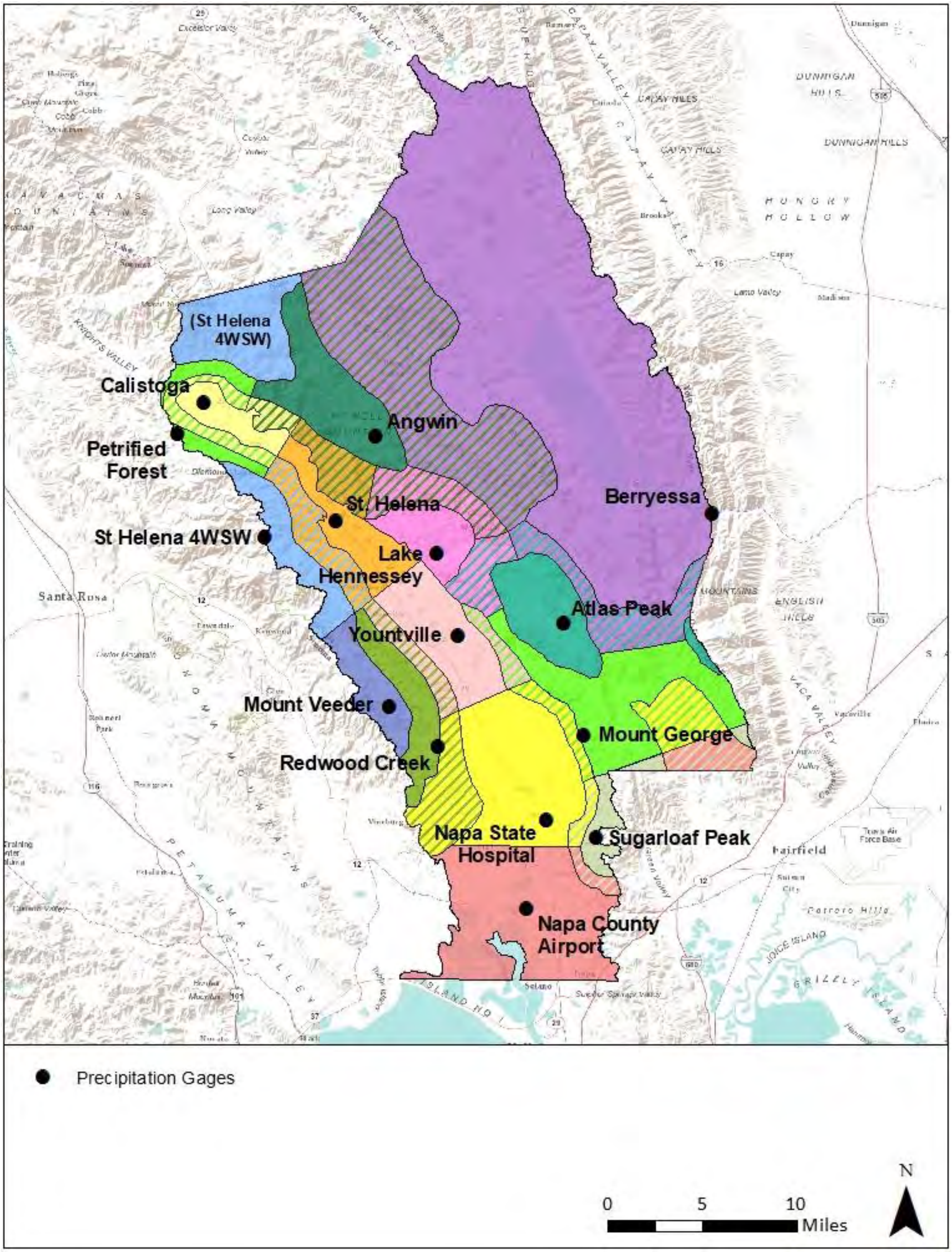


Figure 5: Precipitation zones used in the Napa County SWB model. Hatching indicates areas where two precipitation records were averaged across a zone.

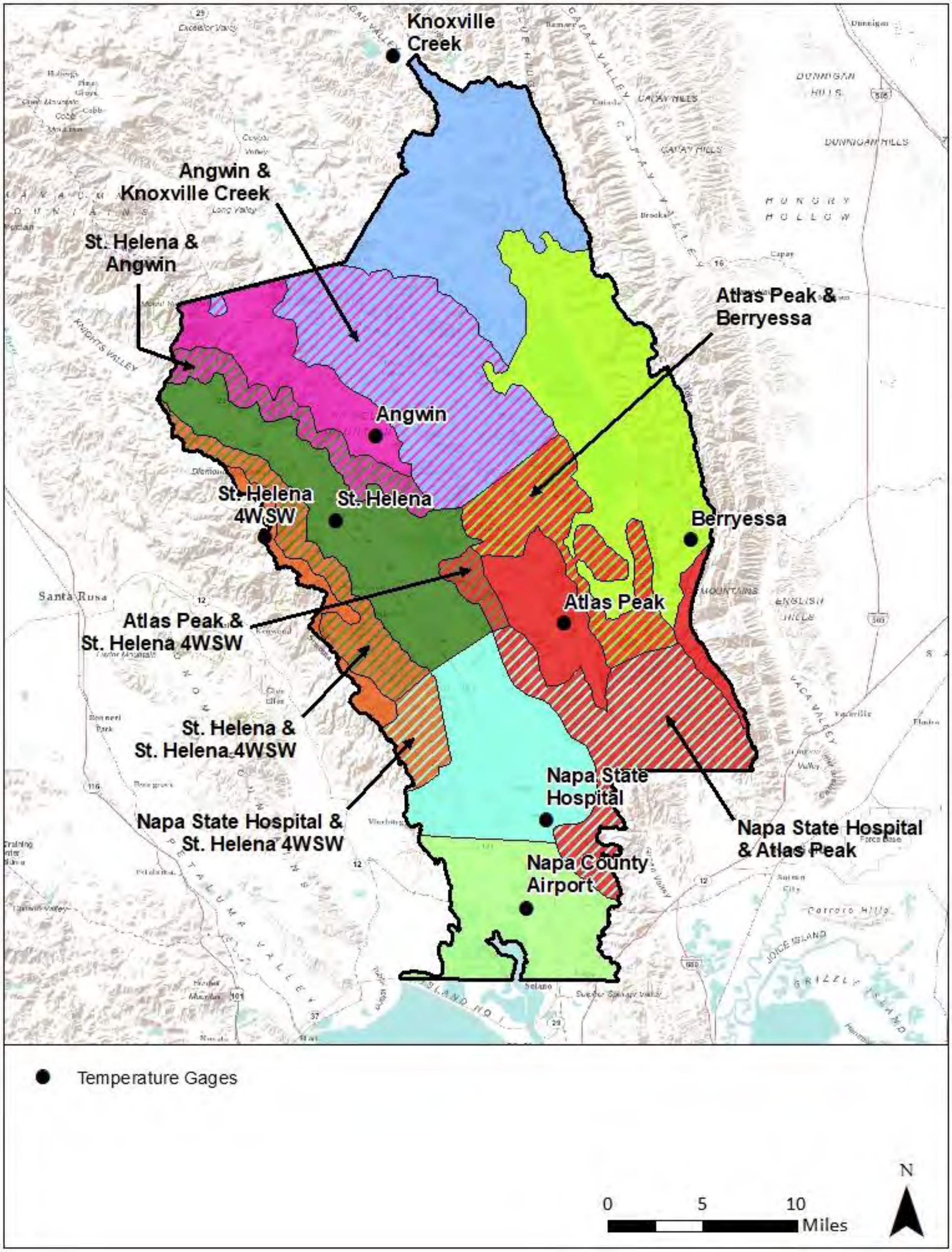


Figure 6: Temperature zones used in the Napa County SWB model. Hatching indicates areas where two temperature records were averaged across a zone.

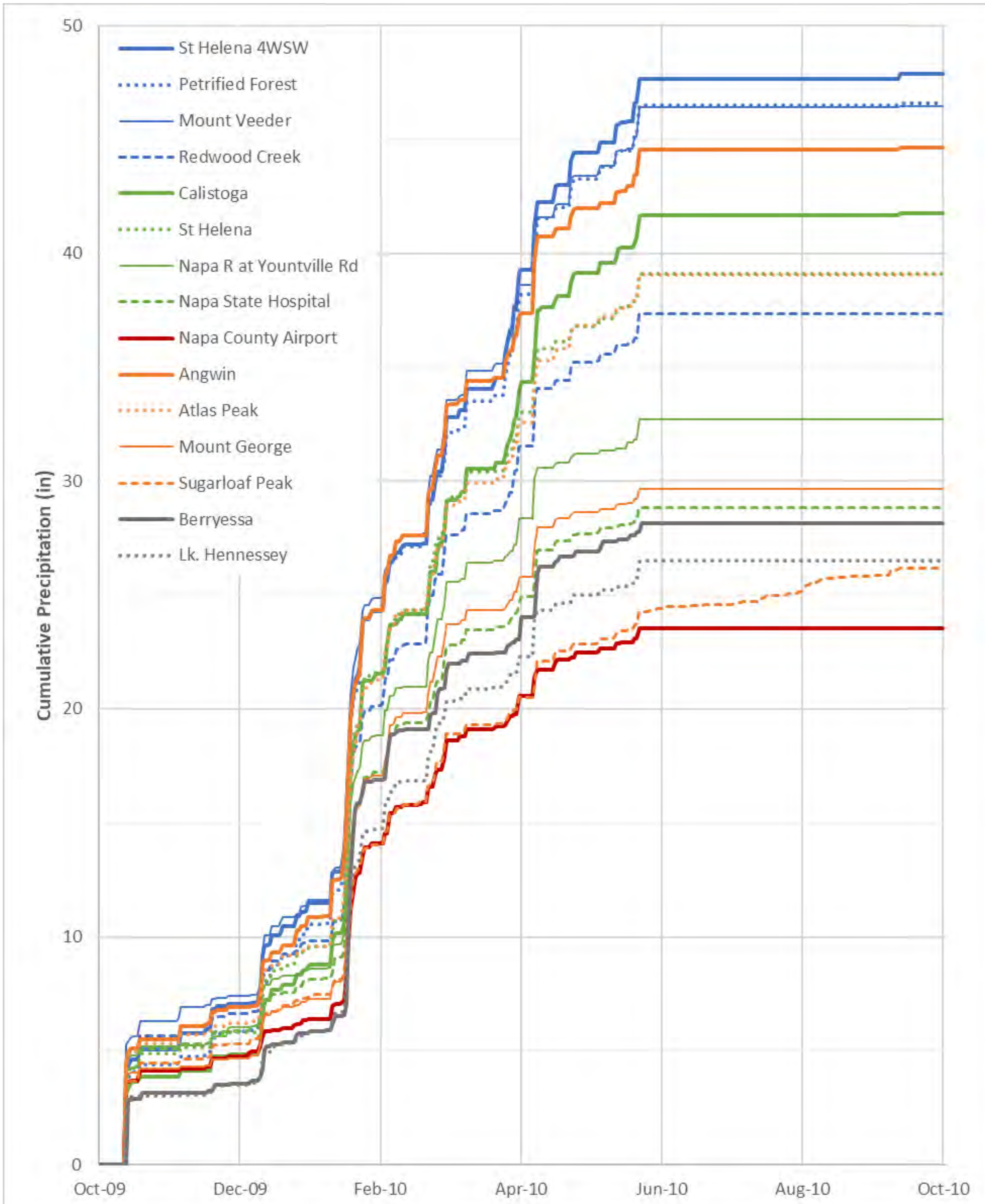


Figure 7a: Daily precipitation data used in the Napa County SWB model for WY 2010.

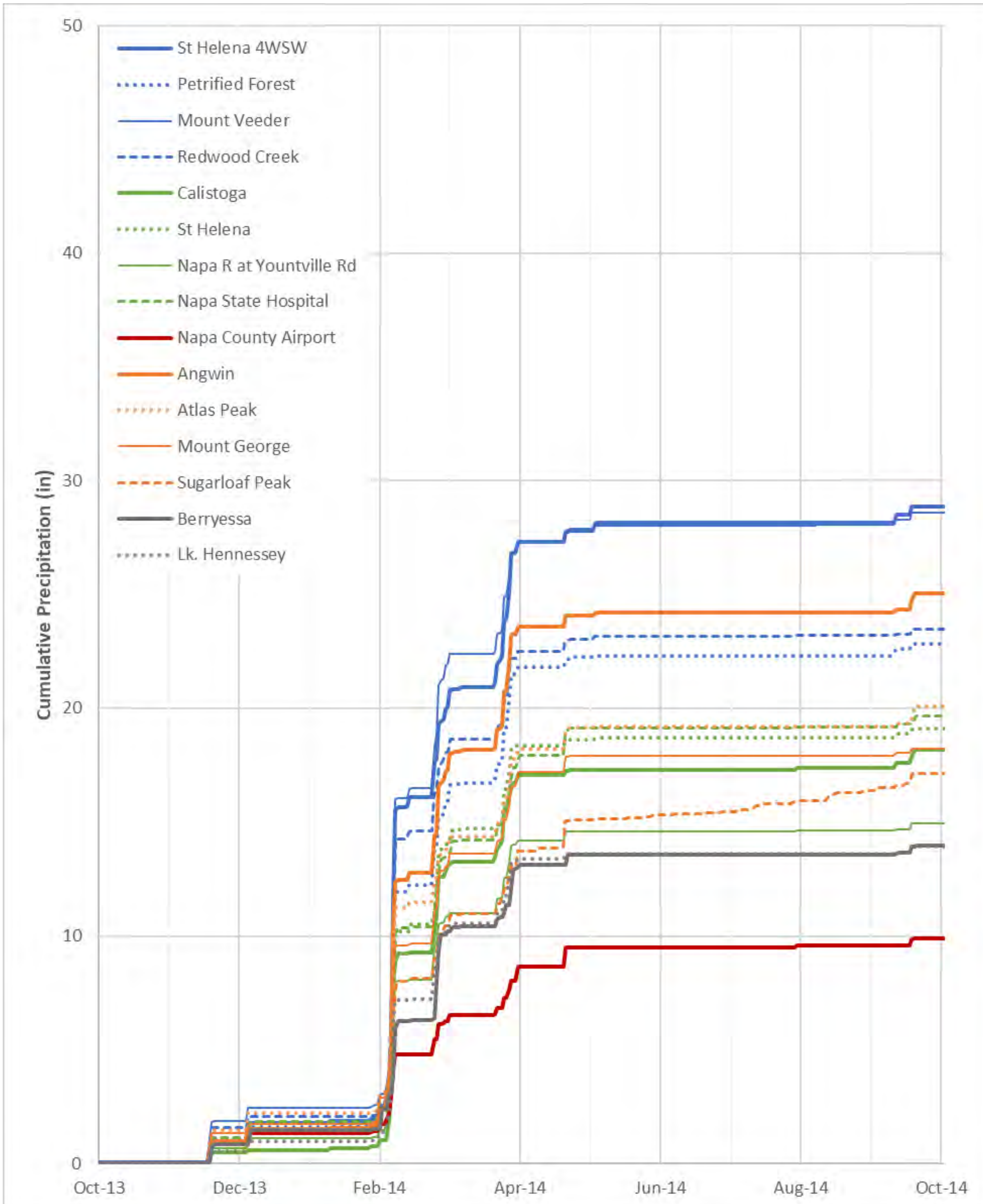


Figure 7b: Daily precipitation data used in the Napa County SWB model for WY 2014.

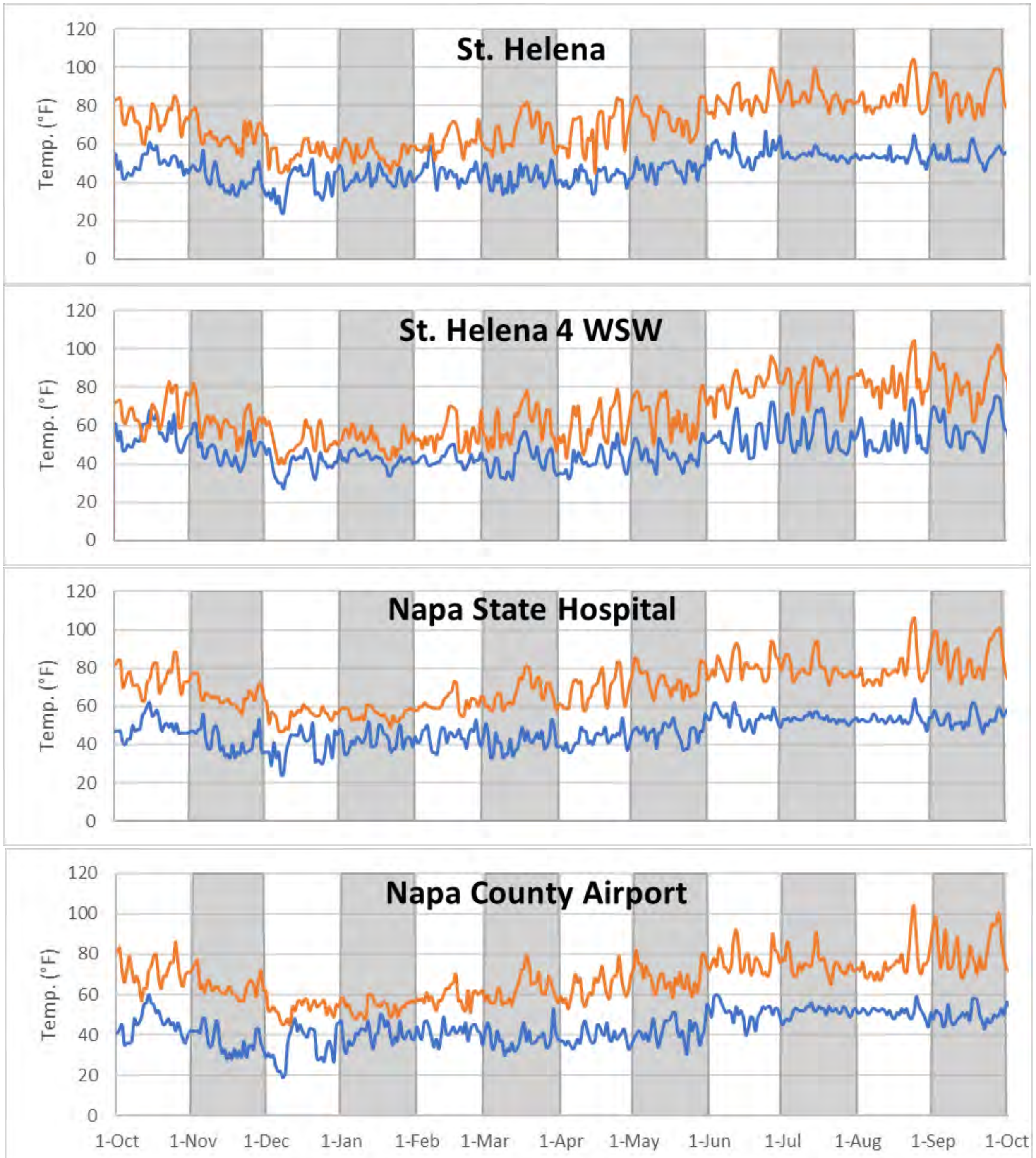


Figure 8: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.

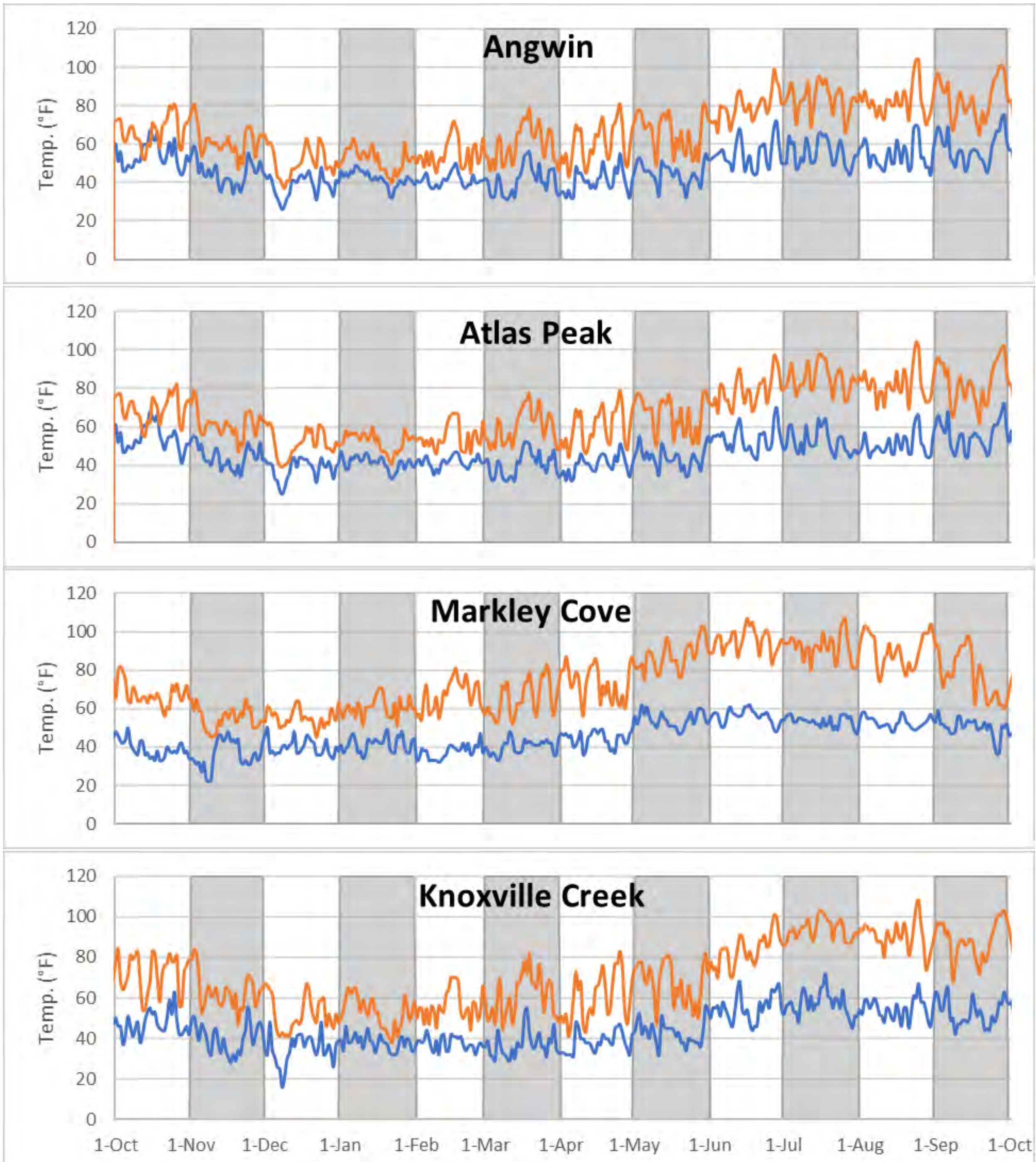


Figure 8 – cont.

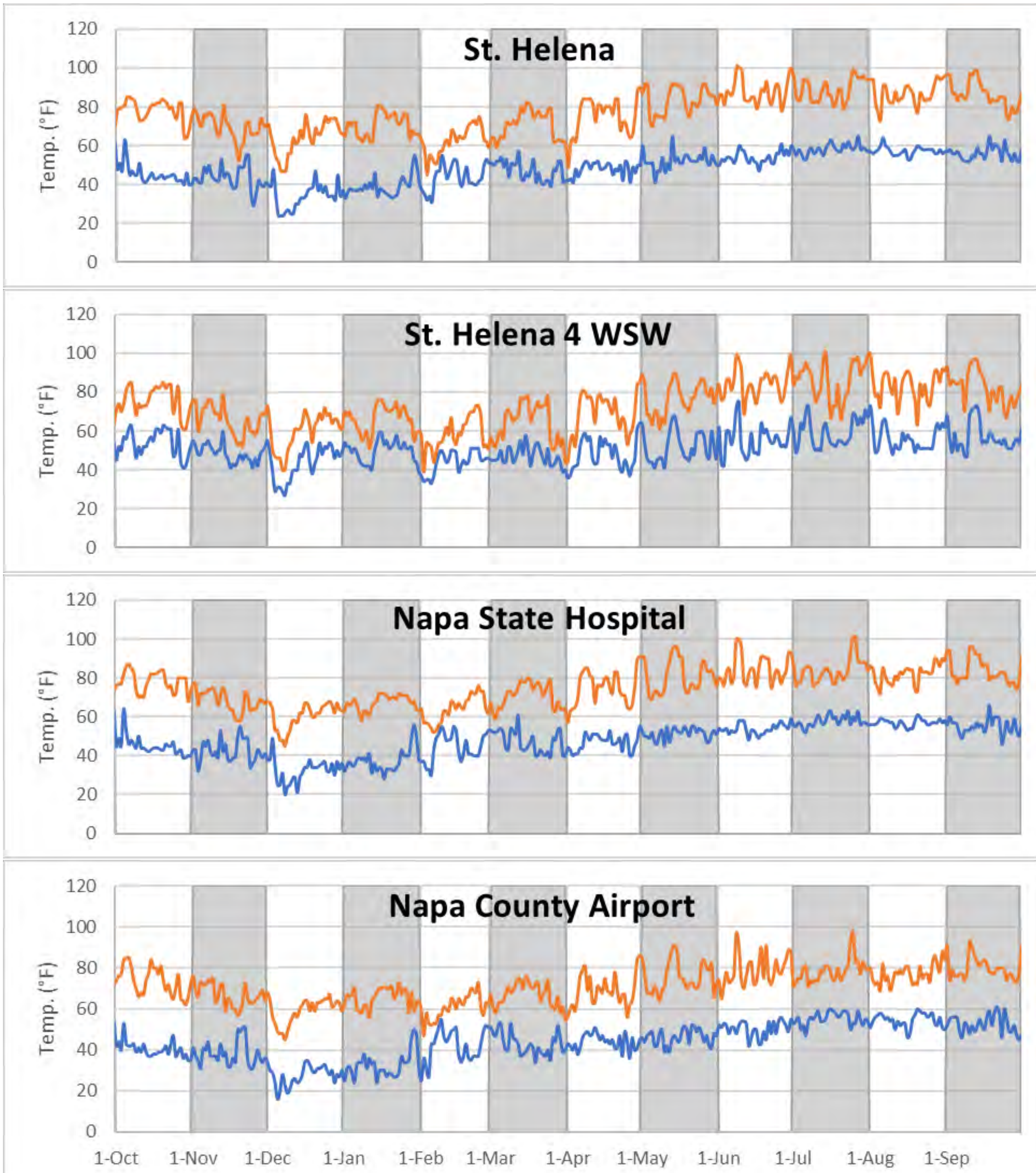


Figure 9: Daily minimum and maximum temperature data used in the Sonoma County SWB model for WY 2010.

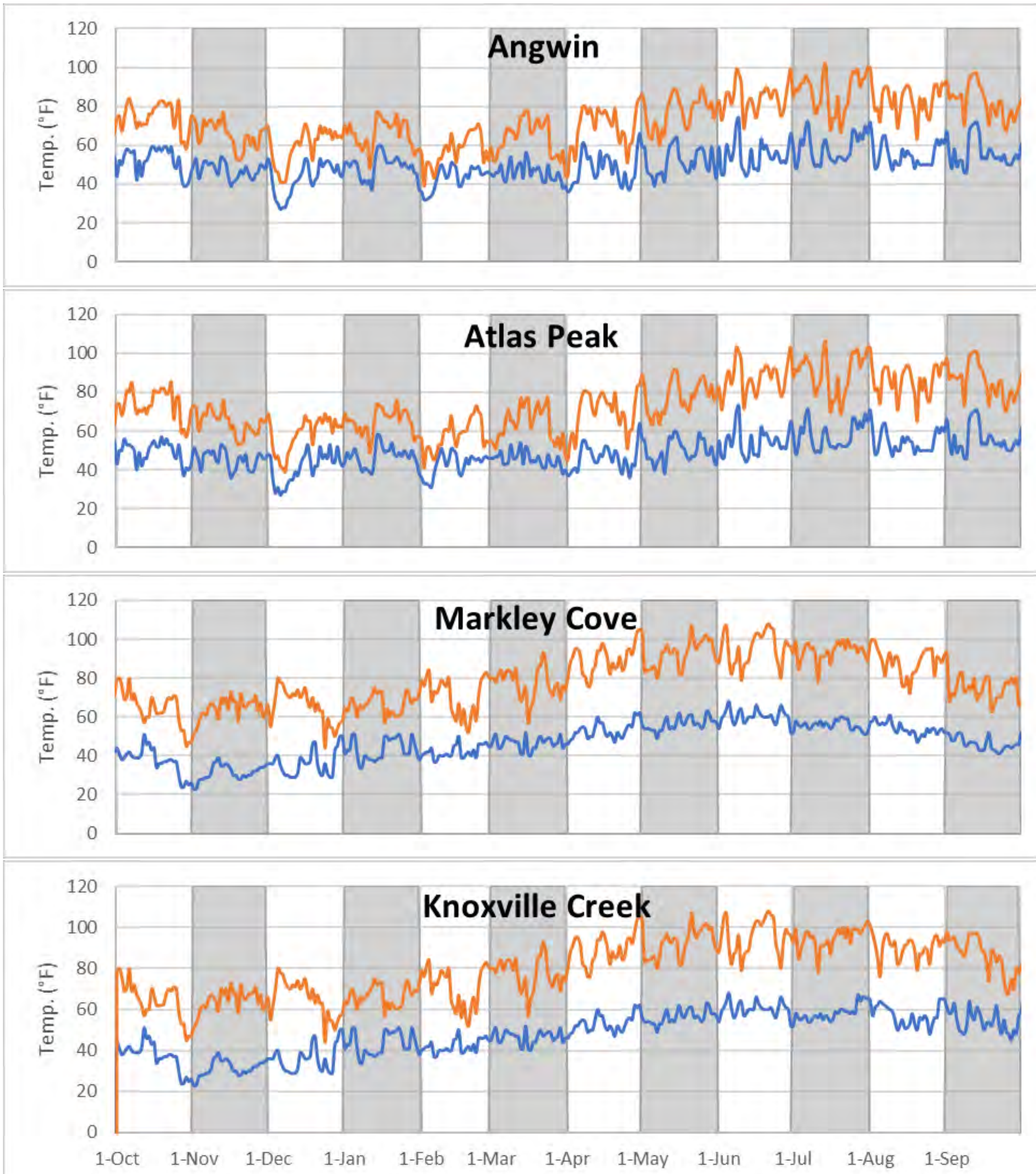


Figure 9 – cont.

Model Calibration

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

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

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

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

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

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

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

Model Results

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

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

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

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

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

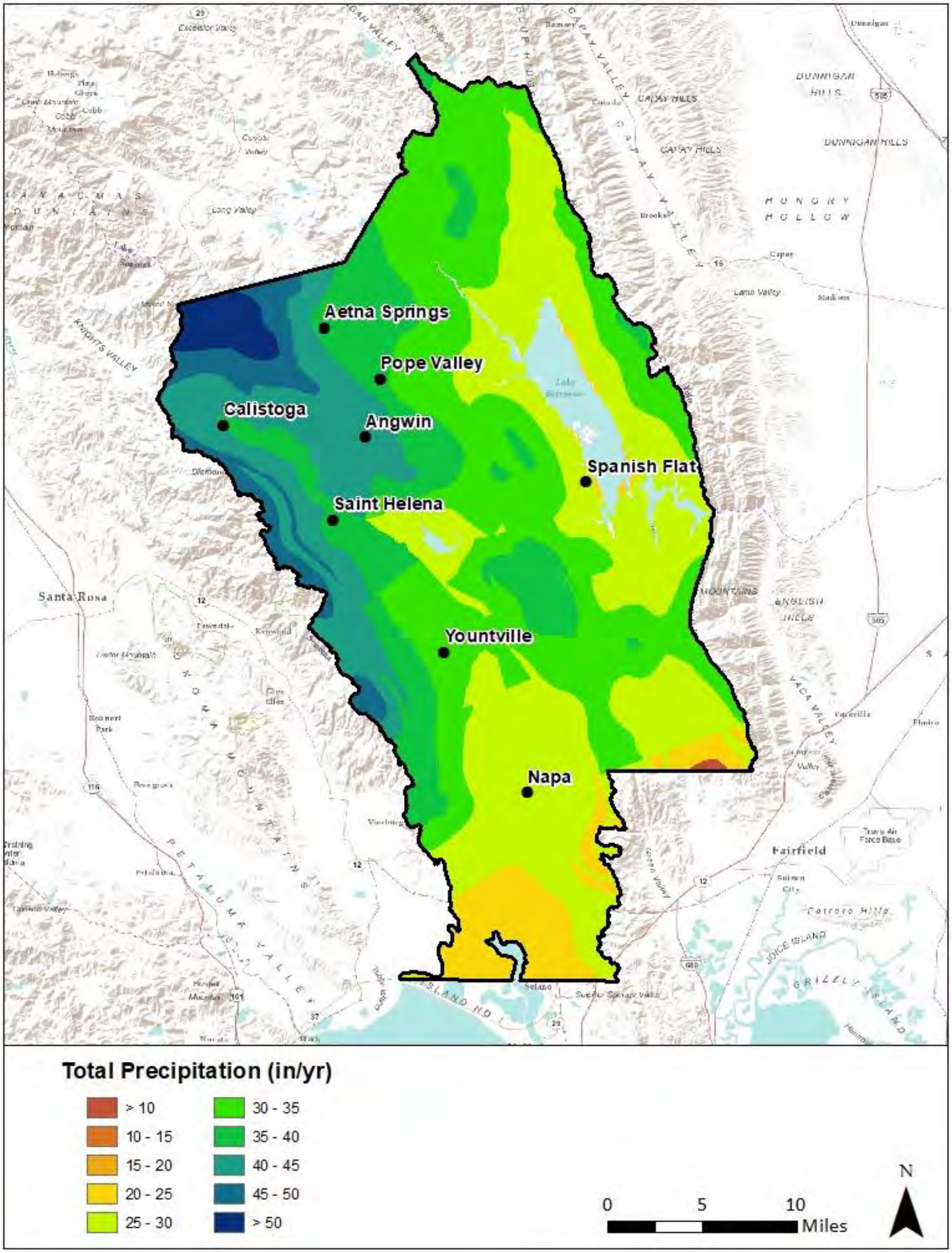


Figure 10: Water Year 2010 precipitation simulated with the Napa County SWB model.

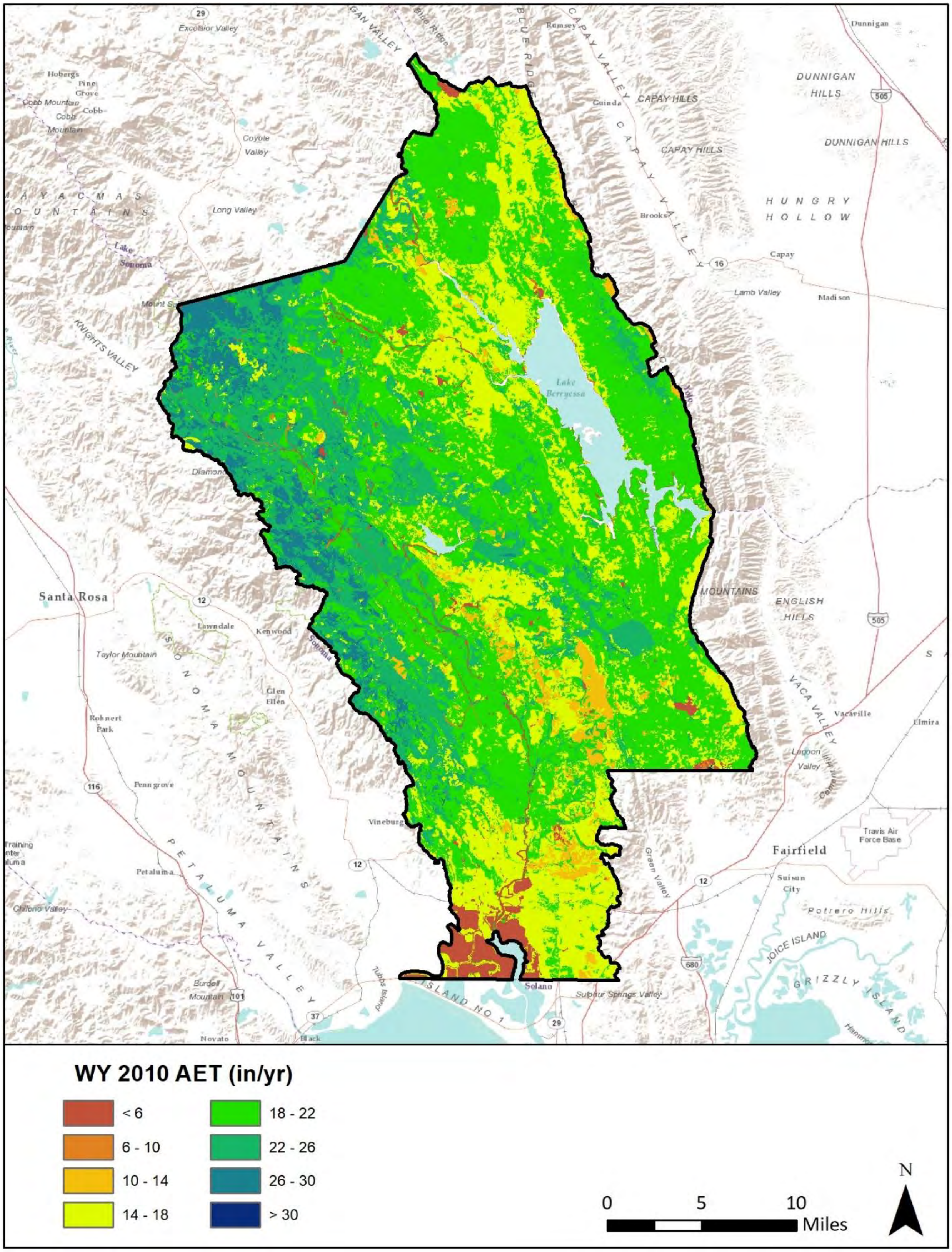


Figure 11: Water Year 2010 AET simulated with the Napa County SWB model.

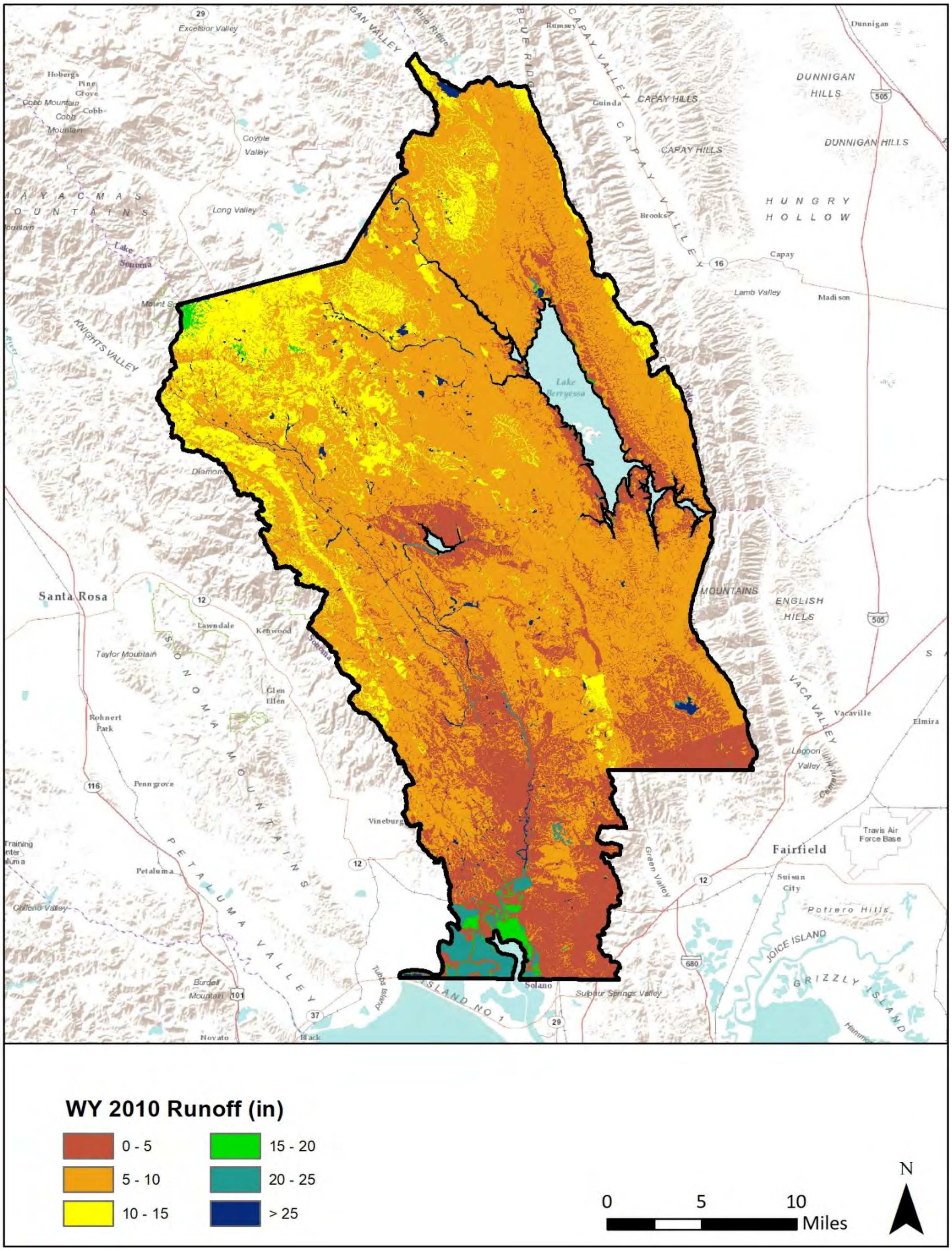


Figure 12: Water Year 2010 runoff simulated with the Napa County SWB model.

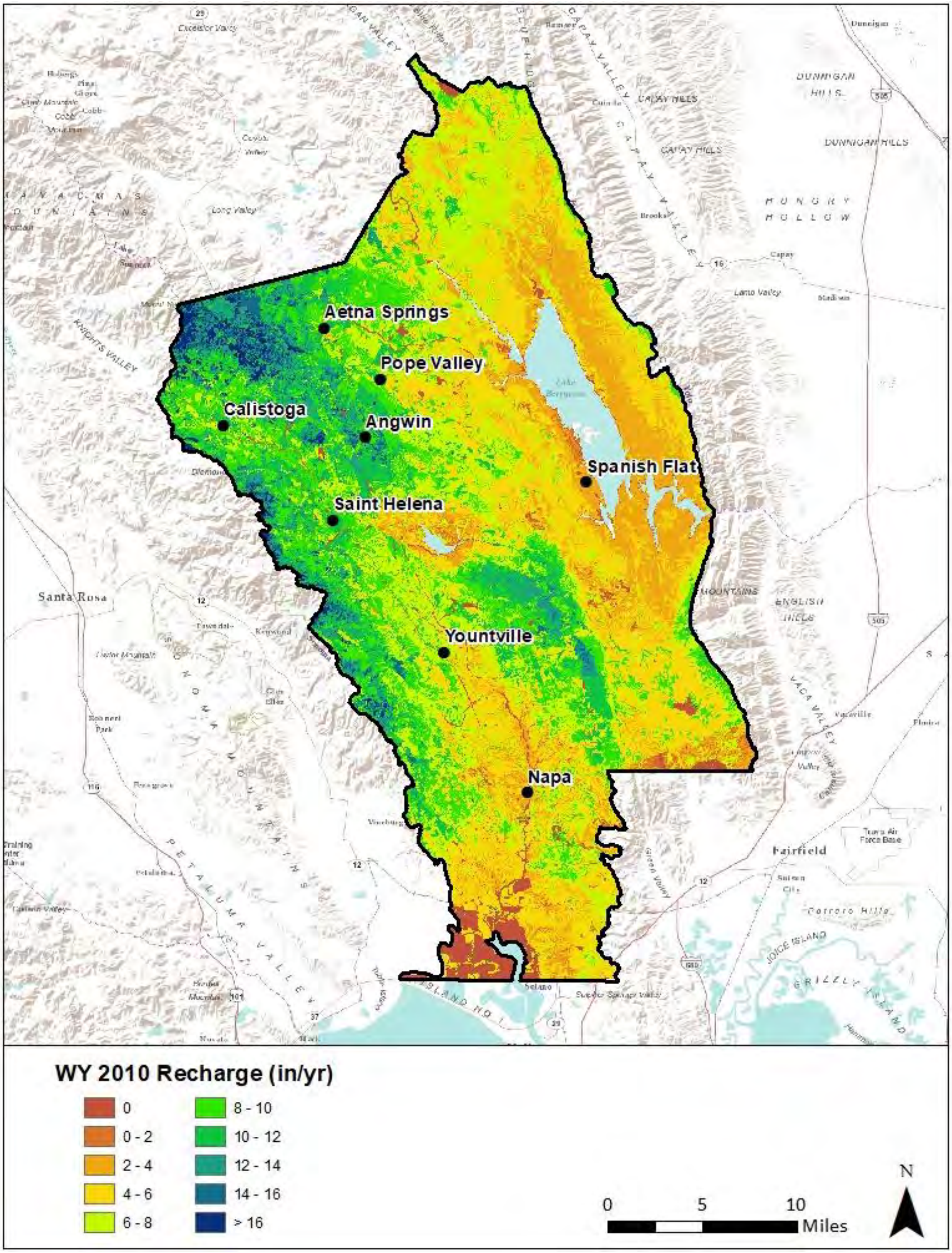


Figure 13: Water Year 2010 recharge simulated with the Napa County SWB model.

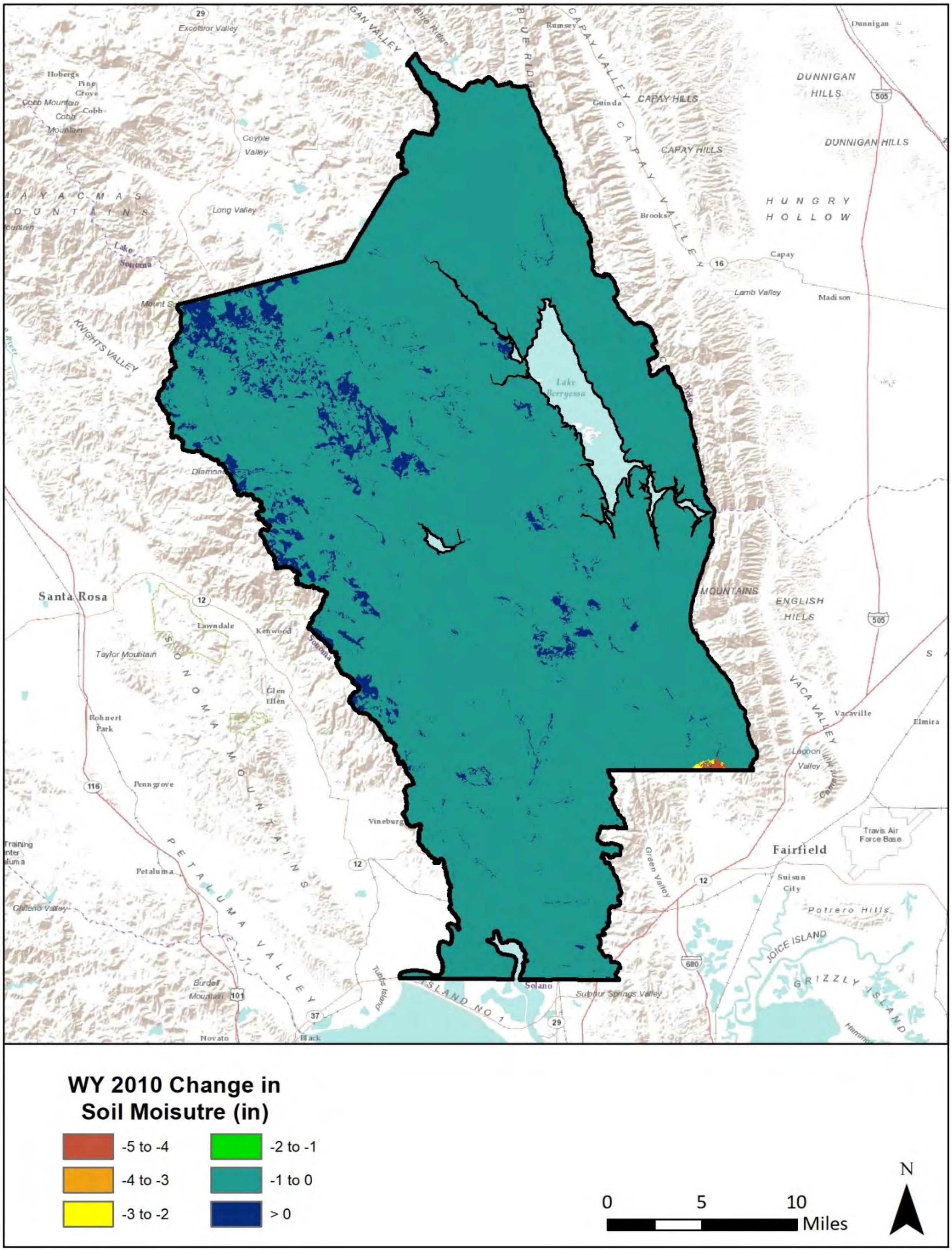


Figure 14: Water Year 2010 change in soil moisture content simulated with the Napa County SWB model.

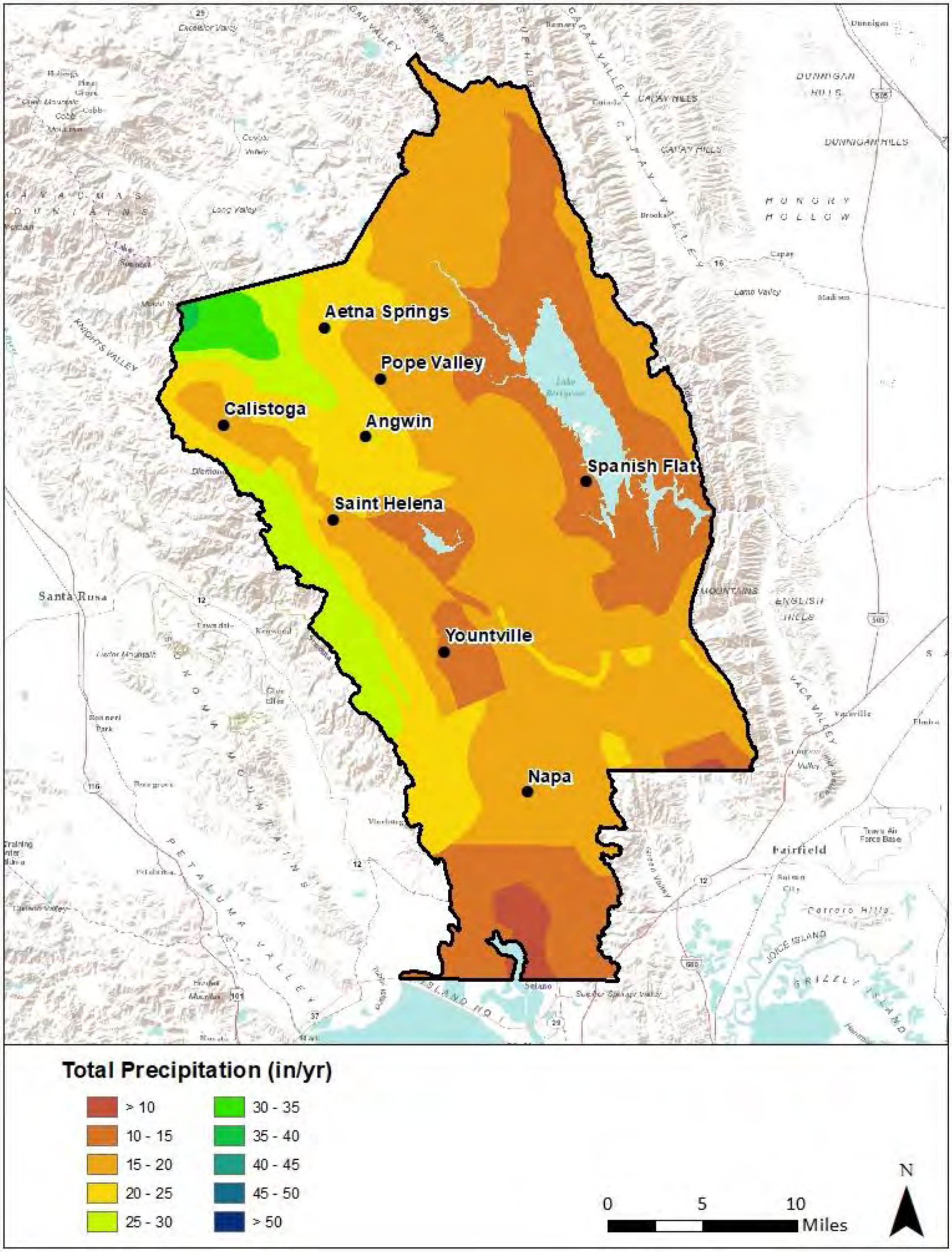


Figure 15: Water Year 2014 precipitation simulated with the Napa County SWB model.

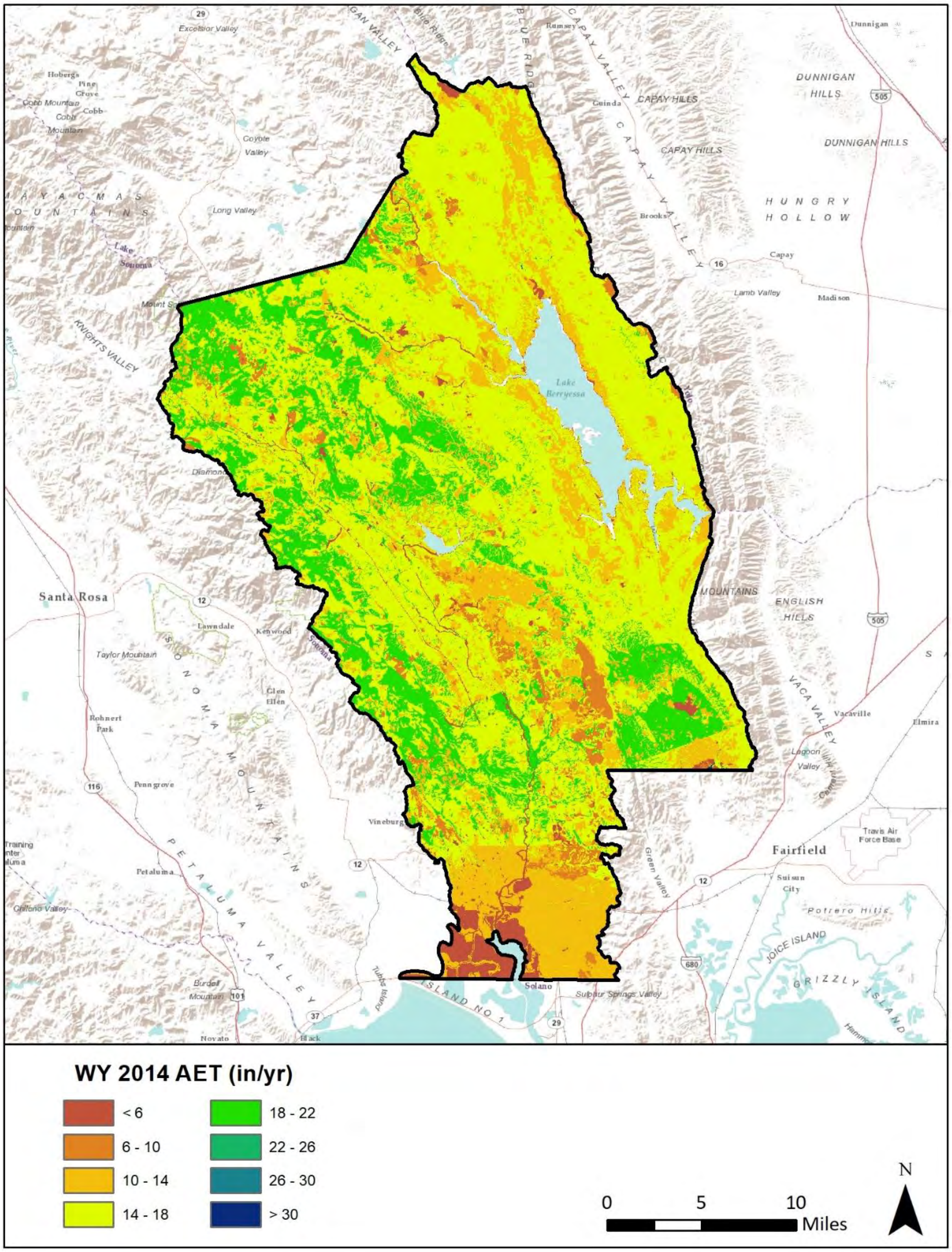


Figure 16: Water Year 2014 AET simulated with the Napa County SWB model.

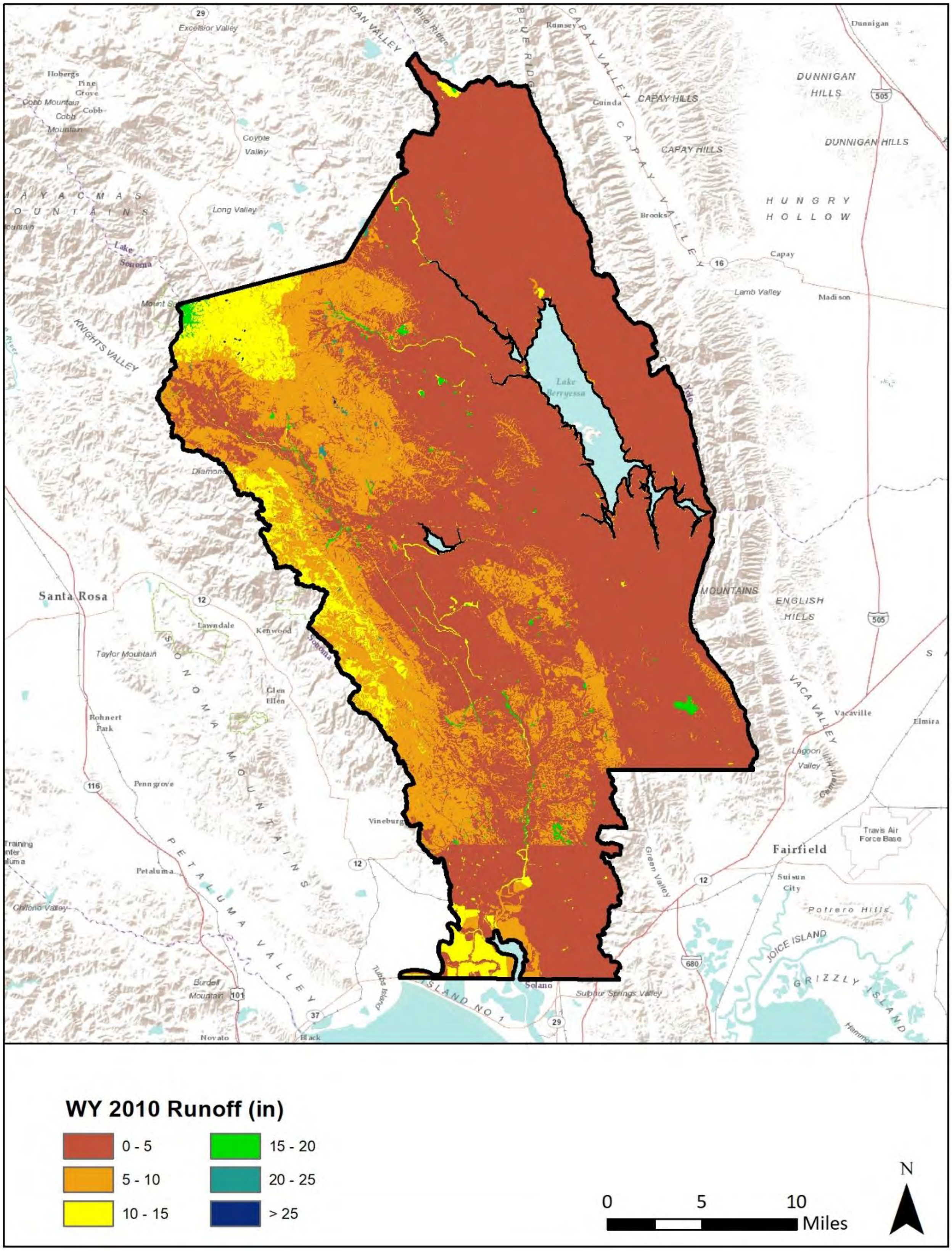


Figure 17: Water Year 2014 recharge simulated with the Napa County SWB model.

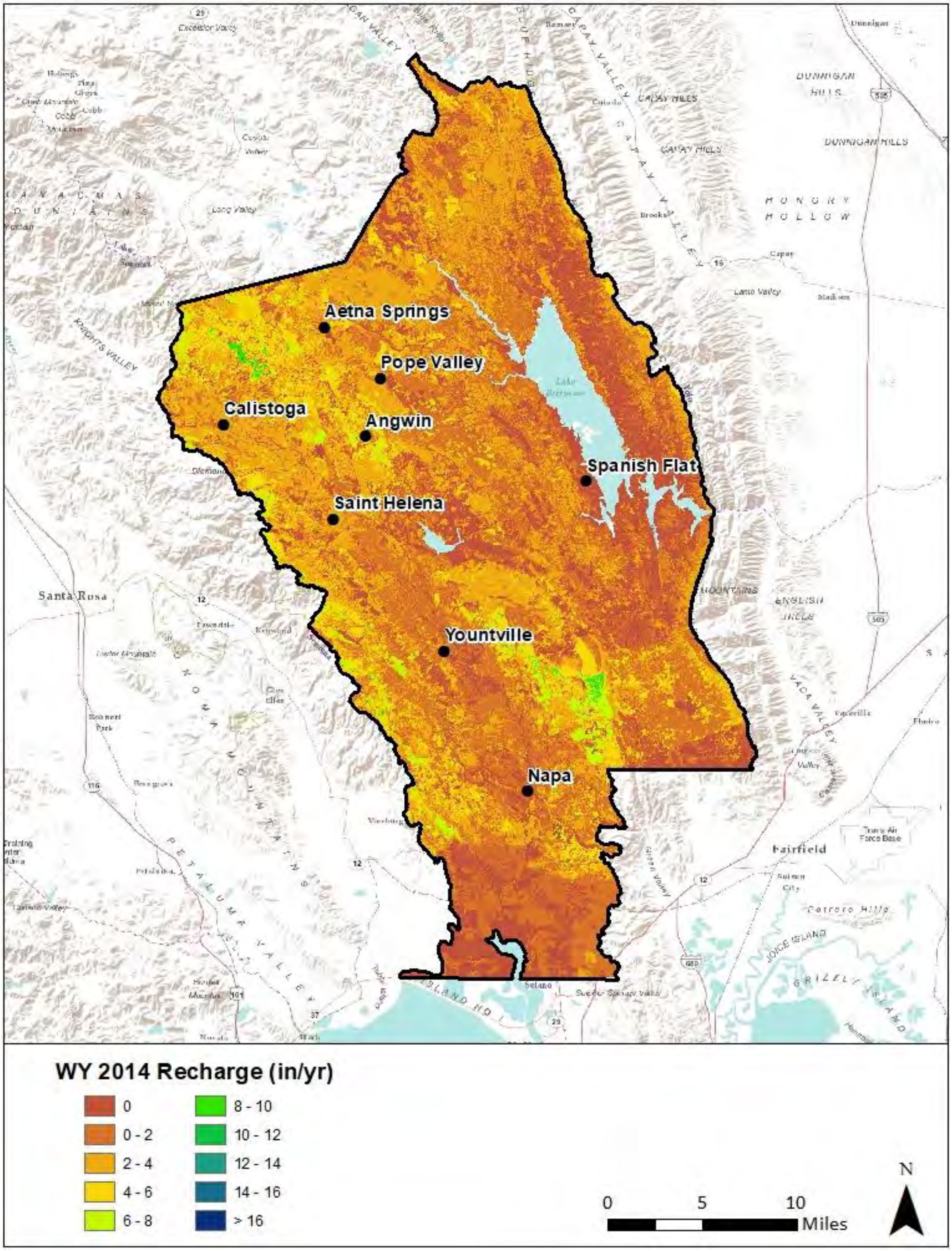


Figure 18: Water Year 2014 recharge simulated with the Napa County SWB model.

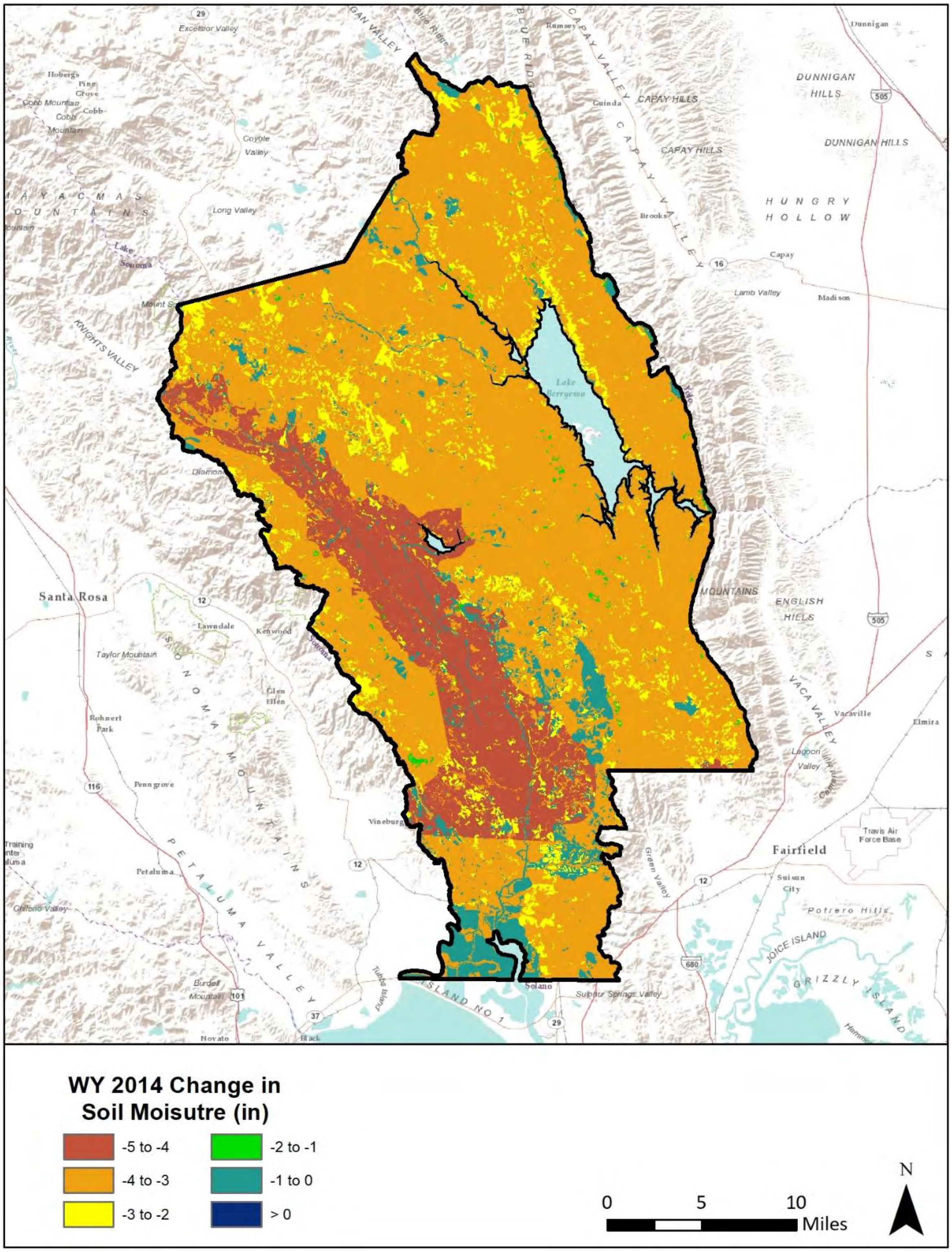


Figure 19: Water Year 2014 change in soil moisture content simulated with the Napa County SWB model.

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

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

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

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

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

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

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

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

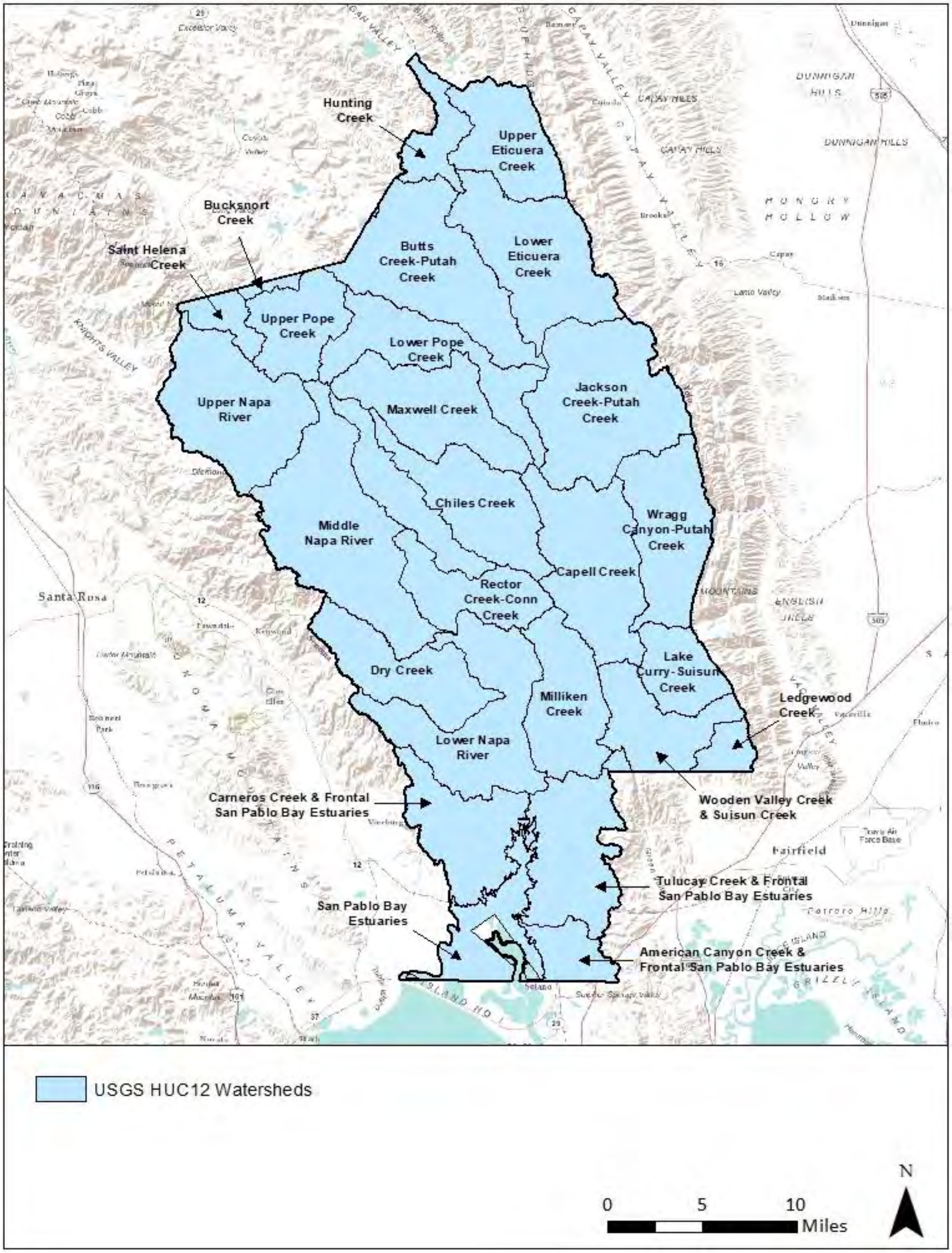


Figure 20: Major watersheds areas used to summarize water budget information in Tables 5 - 8.

Discussion and Conclusion

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

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

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

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