Background and Discussion

Introduction

This Section at a Glance

- Groundwater concerns in an area northeast of Napa, along Silverado Trail, caused the County to study the area in more depth (see Figure 1-1 for the boundaries of the study)
- Monitored wells in the area showed declines in level up to 2009, but have been stable since
- The goal of the study was to understand the current condition of groundwater in the area, how current and future pumping could affect the groundwater basin and nearby streams, and to propose actions going forward to ensure that any impacts are reduced or removed

In order to better understand recent changes in water level trends in a small portion of the Napa Valley Subbasin, Napa County directed an investigation into the northeastern corner of the Napa Subarea (Figure 1-1) (Note: figures referenced in this staff report can be found in the Groundwater Study report attached). This area, referred to as the northeast Napa Area, or Study Area, shows historical groundwater level trends east of the Napa River that are different from and not representative of those that are typical of groundwater level trends for the overall Napa Valley Subbasin. The Study Area contains two wells where water levels declined by 18.1 feet and 28.8 feet, respectively, between spring 2001 and spring 2009, but levels have stabilized since about 2009. (note: both wells are constructed in aquifer units with semi-confined characteristics, so groundwater level declines in these wells do not imply equivalent declines in the unconfined water table). Due to potential concerns relating to continued development requiring groundwater in the area, and due to the complex hydrogeologic setting which includes mapped faults and the Napa River in relatively close proximity to the area of interest, the County authorized this study to better understand groundwater conditions and potential factors relating to historical groundwater levels in the northeast Napa Area.

The study includes evaluation of the potential effects from pumping in the overall Study Area, potential mutual well interference in the Petra Drive area, and potential streamflow effects.

The objectives of this study were designed to:

1. Examine existing and future water use in the northeast Napa Area,
2. Identify sources of groundwater recharge, and
3. Evaluate the geologic setting to address questions regarding the potential for long-term effects on groundwater resources and streamflow.

Significant data collection and compilation were undertaken in order to inform the analysis. Existing information was reviewed, including well locations, well construction, and water use. Well performance data including yield, specific capacity, and pump test data (if available) were tabulated. The geologic and hydrogeologic setting was evaluated within the context of historical groundwater conditions and trends for the Study Area, and in consideration of previously mapped faults, the thickness of the alluvium, and the channel geometry of the Napa River and tributaries within the Study Area. The potential recharge to the Study Area was estimated spatially using a previously completed Root Zone Model (LSCE, 2016c). Datasets for water demands were developed for the study; these account for land uses, sources of supply, locations of wells and surface water diversions, and variations in rainfall over time. Streamflow, surface water level data (stage data), and diversion amounts were collected and estimated for the Napa River and 9 tributaries within the Study Area.

A transient numerical groundwater flow model has been developed that incorporates the data collected for a base period of water years from 1988 to 2015 to analyze groundwater conditions in the study area and the area of interest near Petra Drive. The purpose of the groundwater flow model included the assessment of the following:

- Potential mutual well interference of wells located in the Petra Drive area;
- Potential streamflow effects from current land use;
- Potential influence of previously documented groundwater cones of depression in the MST Subarea to the east of the Study Area;
- Groundwater supply sufficiency to meet current and potential future groundwater demands for the overall Study Area; and
- Potential groundwater management measures or controls (like those successfully implemented in the MST) that may be warranted in the Study Area.

Study Area Description

This Section at a Glance

- The area of concern centers around the intersections between Silverado Trail and both Petra Drive and Soda Canyon Road. The study area covers a much larger area than the two intersections (totaling approximately 10,880 acres) in order to understand the interaction between this area and its surroundings.
- A computer model, using data from 1988 to 2015, was used to understand the area in all types of conditions over a long period of time, to be able to model different future situations.

The northeast Napa Study Area (Study Area) covers approximately 10,880 acres within and adjacent to the Napa Valley Groundwater Subbasin and includes about 16% of the Subbasin (Figure 2-3). Approximately 1,960 acres of the Study Area (about 4% of the Napa Valley Subbasin) is east of the Napa River and includes the area of interest near Petra Drive. As its name suggests, the Study Area coincides with the northeastern portion of the Napa Valley Floor – Napa Subarea. The Study Area extends south from Dry Creek to Tulucay Creek along the Napa River, for about 6.5 miles. Laterally, the Study Area extends from the eastern boundary of the Napa Valley Subbasin westward to about the midline of the Subbasin. The Study Area purposely spans the Napa River to allow for a more complete analysis of interactions between surface water and groundwater, and to facilitate comparisons of groundwater conditions east of the Napa River with conditions in the larger portion of the Napa Valley Subbasin on the west side of the River.

The numerical groundwater flow model (Model) covers the Study Area, with its Active Model Area boundaries delineated based on the Napa Valley Subbasin hydrogeologic conceptual model (LSCE, 2016c). The Active Model Area covers 6,090 acres (which is somewhat smaller than the total Study Area), with over 2,000 acres located within the City of Napa, and the remainder overlying unincorporated areas of the Napa Valley Subbasin (Figure 1-1). The model simulates groundwater and surface water conditions over the selected base period of water year (WY) 1988 to 2015. This base period represents: long-term annual water supply; inclusion of both wet and dry stress periods; antecedent dry conditions; adequate data availability; inclusion of current land use conditions; and current water management conditions.

Land use in the Active Model Area is marked by agriculture (39%), as well as urban and semi-agricultural land uses (40%). Land use surveys from 1987, 1999, and 2011 conducted by the California Department of Water Resources (DWR) were incorporated into this analysis, including some identification of irrigation water source and irrigation methods. Land use classifications used are consistent with those applied in DWR land use surveys. Agricultural uses, municipal land use, rural residential and farmsteads, and wineries were incorporated into the land use assessment in this report. Water sources for all land use classes in the Study Area include groundwater, surface water, and recycled water.

Geology, Aquifers, and Groundwater Occurrence

This Section at a Glance:

- What is under the ground is complicated and differs from place to place, but is critical to understanding what is going on with water flows and storage
- The Model develops a flow balance, considering the various ways water comes into, and leaves the area (both groundwater and surface water);
- There are many ways for water to enter and leave the system, groundwater pumping is but one of them
- Underground faults and the Napa River can have a large impact on water flows in the northeast Napa study area

The geologic setting of the Napa Valley Subbasin determines the physical properties of the aquifer system as well as the structural properties that influence groundwater storage, availability, recharge and flow within the subsurface. These physical and structural properties are described as part of the conceptual model for the Napa Valley Subbasin, which includes the current Study Area (LSCE, 2016c). The components of the hydrogeologic conceptual model also describe the primary processes that lead to inflows, outflows and groundwater storage.

Subbasin inflows are characterized by:

1) Soil Root Zone Groundwater Recharge;
2) Napa Valley Subbasin Uplands Runoff;
3) Napa Valley Subbasin Uplands Subsurface Inflow; and
4) Surface Water Deliveries from sources outside the Subbasin.

Subbasin outflows consist of:

1) Surface Water Outflow by the Napa River;
2) Subsurface Groundwater Outflow;
3) Consumptive Use of Surface Water and Groundwater, due to evaporation and transpiration; and
4) Urban Wastewater Outflow.

Subbasin groundwater storage consists of groundwater storage, primarily from Quaternary alluvial deposits.

The Napa Valley Subbasin of the Napa-Sonoma Valley Groundwater Basin underlies much of the Napa Valley and lies entirely within Napa County. Three major geologic units in the Napa Valley area have been consistently recognized, except in the names applied to them and interpretations of how they were originally formed. These three major units are Mesozoic rocks, Tertiary volcanic and sedimentary rocks, and Quaternary sedimentary deposits. These same major geologic units exist within the northeast Napa Study Area and are represented in the numerical groundwater flow model.

Contemporary geologic cross sections developed in the vicinity of the Active Model Area have informed the model development and have been used to incorporate the current day hydrogeologic conceptualization into the model design (LSCE and MBK, 2013). These cross sections show the general subsurface geologic patterns of the lower valley associated with the northeast Napa Study Area..

The Quaternary alluvial deposits comprise the primary aquifer units of the Subbasin. The alluvium was divided into three facies according to patterns detected in the lithologic record and used to delineate the depositional environment which formed them: fluvial, alluvial fan, and sedimentary basin (LSCE and MBK, 2013 and LSCE, 2013). The alluvial deposits have different well yields and variable hydraulic properties. In the Study Area, alluvial deposits are a significant source of groundwater west of the Napa River; however, east of the River the alluvium is thinner and also indicated to be unsaturated in some locations. All of the Tertiary units beneath the Napa Valley Floor and beneath the Study Area appear to be low to moderately water yielding with poor aquifer characteristics (LSCE and MBK, 2013). Although wells completed in these Tertiary units may be locally capable of producing sufficient volumes of water to meet various water demands, their contribution to the overall production of groundwater within the Study Area is limited.

There are two main faults in the Study Area: the East Napa Fault Zone and the Soda Creek Fault (Figure-1-1). The East Napa Fault is a concealed fault extending northward just west of or below the river from near Trancas Street to Oak Knoll Avenue (LSCE and MBK, 2013). Other concealed faults, whether mapped or not, exist in this area as part of the East Valley Fault Zone. One such fault is located on the east side of the Napa River between Petra Drive and Oak Knoll Avenue, but its northward and southward extent is still unknown. Soda Creek Fault slices through the Sonoma Volcanics along the western edge of the MST and appears to limit flow from the MST into the Napa Valley, acting as a hydrologic barrier at depth.

Northeast Napa Area Model Development

This Section at a Glance:

- MODFLOW is the name of the model program used
- The modeled area is about 9.5 sq. miles, includes 10 rivers, creeks, and streams, 594 wells, and simulates conditions from 1988-2015
- It studies various scenarios, including if there were no pumping at all, or if pumping was doubled, and situations in between

The U.S. Geological Survey public domain software, MODFLOW (and accompanying model packages), was selected as the modeling platform to develop a numerical groundwater flow model to conduct analyses in the Study Area. The total active modeled area is approximately 9.5 square miles and contains 6 model layers (Figure 3-2). The model grid cell size is 100 feet by 100 feet. The first three model layers (layers 1-3) compose the alluvial aquifer; the next two model layers (layers 4-5) represent the underlying Tertiary sediments and rocks; and the base layer (layer 6) represents the Sonoma Volcanics. The transient model simulates groundwater and surface water conditions over a 28-year period from 1988 to 2015. The model includes a total of 10 rivers, creeks, and tributaries. Eleven surface water diversions are also represented. The model contains 594 wells (actual and “inferred”, with the latter based on estimated water demands and water sources). Irrigation pumping demands include demands for agricultural crop irrigation as well as irrigation demands for landscaping associated with residences and commercial land uses. Where groundwater is identified as the water source, water demands for indoor residential uses and winery uses were distributed to wells in the model domain.

The model was calibrated to improve its ability to simulate groundwater level measurements from throughout the Active Model Area by adjusting the following components: aquifer parameters (horizontal and vertical hydraulic conductivity and storage), streambed conductivity, model layering, and general head boundary conditions. 182 wells with water level data were used for model calibration, including 12 County monitored wells and 4 County surface water/groundwater interaction monitored locations.

Model Scenarios

The calibrated baseline model provides insight into the workings of the groundwater system in the northeast Napa Area. Three sensitivity scenarios were created to evaluate groundwater and surface water responses to a range of groundwater pumping conditions within the Active Model Area, relative to the results of the baseline calibrated model. The sensitivity scenarios include:

- Reduced pumping to zero (no pumping);
- Reduced pumping to rates in each well for each month in water year 1988;
- Doubled pumping in each well for each stress period for the duration of the simulation period.

FINDINGS AND RECOMMENDATIONS

THIS SECTION AT A GLANCE

- We have good news, and we have bad news…
- Over the 28-year period, the localized area is in balance
- Groundwater levels in two wells did show declines up until about 2009, but since have been stable
- One cause of the decline appears to be subsurface flow into the groundwater deficient area known as the MST (just to the east)
- Some groundwater from this area helps feed the Napa River, the amount of which is largely driven by climate (how much it rains); groundwater pumping has only a minor role in determining how much water goes to the river

The results for the northeast Napa Area study indicate that groundwater in this localized area is in balance, with inflows and outflows nearly equal, over the 28-year period studied. During drier years, groundwater levels have declined and in normal to wetter years groundwater levels have recovered. East of the Napa River, two wells in Napa County's monitoring network, completed in deeper formations, showed historical groundwater level declines; however, groundwater levels in these wells have stabilized since about 2009. The study indicates that the main factor contributing to prior declines in these wells is the effect of the cones of depression that developed in the MST in response to pumping in poorly permeable aquifer materials. The dense spacing of private water supply wells, particularly in the Petra Drive area, may also have contributed to the localized groundwater decline.

Groundwater discharge contributes significantly to the baseflow component of streamflow during most months of the year in this reach of the Napa River, which is categorized as perennial. However, most tributaries to the Napa River in the model domain such as Soda Creek, are categorized as seasonally intermittent. A losing condition is typical for Soda Creek, during most times of the year (especially in the summer and fall), and its flows are affected more by drier water years rather than by pumping.

Typical of streams in the area, less groundwater is discharged to the Napa River during drier water years when recharge and lateral subsurface flows into the Study Area are reduced. The influence of groundwater pumping and climatic effects, represented by recharge and lateral subsurface flow, on groundwater discharge to the Napa River were analyzed using the results from the baseline calibrated model and two sensitivity scenarios: pumping restricted to 1988 pumping levels and doubled pumping relative to the pumping estimated for the 1988 to 2015 study period.

Climatic effects were found to have a much greater effect on groundwater discharge to the River for all three groundwater pumping options. Additional pumping can occur in the northeast Napa Study Area; however, targeted management measures are recommended to ensure groundwater conditions remain sustainable and streamflow depletion caused by pumping does not become significant and unreasonable.

Because the northeast Napa Area, especially east of the River, includes a relatively thin veneer of alluvial deposits overlying semi-consolidated rock, and because the average annual water budget is about in balance, it is recommended that the area east of the Napa River become a management area within the

Napa Valley Subbasin to ensure groundwater sustainability. The management area would include 1,950 acres (4% of the Napa Valley Subbasin) (Figure 5-1).

Study findings and recommended actions to maintain groundwater sustainability in the northeast Napa Area (and also the Napa Valley Subbasin) are summarized below. The recommended actions are consistent with the potential groundwater management measures referenced in the Napa Valley Subbasin Basin Analysis Report (LSCE, 2016c).

Findings

This section at a Glance:

- Of all the ways water comes and goes from this area, groundwater pumping is the second smallest component
- While depletions of groundwater storage are not shown to have occurred in this area, over time, it appears the amount of groundwater flowing into this area through lateral subsurface flow has, while still positive, decreased somewhat. This may relate to climate changes, but in any event it is a situation worth monitoring to determine if it is going to decline further.
- Across the 28-year study period, on average, streams gained more flow from groundwater entering the channel than was lost due to infiltration along the channel. While a trend toward less groundwater discharge to streams is evident since the late 1990s, varying the model to show double the pumping or zero pumping shows that the trend is attributable to climatic conditions rather than pumping effects.
- Overall, Petra Drive wells are influenced more by groundwater conditions in the MST, although the wells on Petra Drive do influence each other due to their proximity to each other and similarities in their construction.

A summary of the findings from the analysis of groundwater and surface water in the northeast Napa Area are listed below:

1) Groundwater storage played the smallest role in the water b*udget, hovering around net-zero annually (inflow equals outflow and little water depleting or replenishing* storage).
2) Groundwater pumping makes up the next smallest component of flow in the model domain's water budget.
3) Lateral subsurface flow through all of the model's boundaries is generally a net positive number; more groundwater is flowing into the model domain than is flowing out through the subsurface. When groundwater does flow out of the model area through the subsurface, it typically leaves the model via the east side near the Soda Creek Fault. This is likely influenced by the lower groundwater levels in the MST driving the easterly horizontal flow gradient.
4) Recharge plays a key role; it is the second largest water budget component.
5) Within the model area, flows to the Napa River dominate the groundwater budget; a large component of groundwater in the model discharges into the Napa River as baseflow. On the other hand, tributaries in the area most often discharge to groundwater, recharging the groundwater system on a seasonal basis.
6) Tributaries on the east side of the Napa River consistently show net losing stream conditions over time, despite seasonal fluctuations where gaining stream conditions occur briefly. As an example, Soda Creek consistently exhibits net losing stream conditions on an annual basis (even during wet winter conditions and also during the scenario when no pumping was simulated); the Creek is more affected by precipitation, and therefore climate, than groundwater pumping in determining the rate of stream flow and leakage to groundwater.

7) The model results indicate a decreasing trend in the amount of groundwater contributing to stream flows starting in the late 1990s. As illustrated during the sensitivity scenario in which no groundwater pumping occurred, this recent trend can be attributed to less precipitation (climatic effects), and not due to groundwater pumping. Statistical analyses indicate that this trend is more related to climatic effects, including reduced recharge and subsurface lateral flows, rather than to groundwater pumping.

8) Lateral flow, the third largest component of the model domain water budget, was typically a net inflow into the area, but a trend is seen starting in 1992 that shows less regional groundwater flowing into the model area. In some years, the net annual lateral flow is out of the model domain, which may indicate a future trend, or may be the result of climatic effects during increasingly drier water years.

9) Geologic faulting in the model area is important to the overall behavior of water levels east of the Napa River. Additional concealed faults may be present, which may affect water levels in deeper wells in the Petra Drive area.

10) Statistical analyses of water budget components (including recharge, lateral flows and pumping) relative to stream leakage (groundwater contributions to Napa River baseflow) show that, over the 28-year base period, climate effects have a much greater influence on stream leakage than pumping. Climate-driven variables account for 87 to 92% of the effect on groundwater discharge to Napa River, while pumping contributes to 8 to 13% of the effect on groundwater discharge to the River.

11) Modeling scenarios showed:

    a) Annual stream leakage fluxes (in and out of the surface water) were very similar even with no pumping occurring showing minimal stream impacts due to pumping;

    b) When pumping was reduced, a slight increase in the amount of groundwater contribution to the Napa River occurred (this had about a third of the effect subsurface lateral flow had on this type of change). For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping reduced to 1988 conditions, the relative contribution to baseflow effects was 2%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.

    c) When pumping was doubled, a slight decrease in the amount of groundwater contributed to the Napa River occurred. For the period from 1995 to 2015, a subset of more recent years analyzed to evaluate whether the relative influence of pumping has changed with time, with pumping doubled, the relative contribution to baseflow effects was 10%. For the baseline scenario, over the same period, pumping is estimated to contribute to about 6% of the effect on baseflow.

12) Some drawdown effects on groundwater levels in the Petra Drive area are associated with mutual well interference; these are compounded by the high density of wells. However, these lowered levels are not as significant as the regional influence of the eastern boundary and movement of groundwater towards the MST.

- *See Summary Table next page* -

Summary of Recommendations

	RECOMMENDATIONS	Management Area (NE Napa/ East of River	All Napa Valley Subbasin
A	Add SW/GW Monitoring Wells	X	X
B	Management Area Designation	X	
C	Discretionary Projects – Additional WAA Review (Tier 2)	X	
D	New Well Tracking in Management Area	X	
E	New Well Pump Testing	X (All)	X (Deeper formations)
F	GW Flow Model Development		X
G	Increase Conservation & Recharge	X	X