Napa County Groundwater Conditions and Groundwater Monitoring Recommendations

Prepared for:
Napa County
Department of Public Works

FINAL REPORT
February, 2011

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

Table of Contents

List of Tables

List of Figures

(Figures included after end of report except where page number is indicated)

Appendices

EXECUTIVE SUMMARY

Groundwater and surface water are highly important natural resources in Napa County. Collectively, County entities along with numerous others, including municipalities, water districts, commercial and industrial operations, the agricultural community, and the public, are stewards for the water resources available to Napa County. The Napa County community actively supports and invests in its water resources to sustain agricultural productivity. Concurrently, municipal and private stakeholders are actively engaged in assessing the potential for the development of additional water supplies, both groundwater and surface water of good quality, to meet future urban and rural water demands. Similar to other areas in California, the County faces many future water-related challenges including:

- Increased competition for available supplies,
- Preserving the quality and availability of imported water supplies,
- Sustaining groundwater supplies,
- Additional challenges arising during drought conditions, and
- Changes due to global warming and/or climate change.

To address these challenges, long-term, systematic monitoring programs are essential to provide data that allow for improved evaluation of water resources conditions and availability to facilitate effective water resources management. Previously established groundwater and surface water monitoring networks in Napa County have resulted in the collection of data necessary to distinguish trends from short-term fluctuations, anticipate unintended consequences due to historical land uses, identify emerging issues, and design water resources management strategies. Understanding that there was a need to compile and evaluate monitoring data collected to date and identify shortcomings in existing monitoring programs, Napa County embarked on updating the countywide monitoring program with an initial emphasis on understanding groundwater conditions based on available data, and implementing an expanded groundwater monitoring and data management program as a framework for coordinated, integrated water resources management and dissemination of water resources information.

ES.1 Project Goals

This project, the countywide Comprehensive Groundwater Monitoring Program, addresses the initial goal of the County to understand current and historical groundwater conditions based on available data, developing an expanded data management system to store monitoring data from different County, state, and federal sources, and develop recommendations for expanded groundwater monitoring and water resources management. Broad project goals included gathering available groundwater-related data, cross-correlating ancillary data, evaluating historical groundwater level and quality data, and developing a centralized data management system that contains the data necessary to manage regional water resources and enable long-term protection of the County's surface and groundwater resources. This project led to a broader awareness of available groundwater data and how those data can be better used to assess current groundwater conditions and trends and also identify factors related to future assessment of groundwater availability. The project also led to an awareness of data security issues, data gaps, and actions needed to continue efforts to "qualify," organize, store, and disseminate water-related data to enhance the long-term value of the data. The County has been divided into 17 subareas based on geographic, geologic, and political boundaries. Spatial data coverage was good for some County subareas; however, for other subareas, monitoring network enhancements are needed. The project includes recommendations to enhance and expand countywide monitoring in order to facilitate understanding of groundwater availability and integrated regional water management and planning efforts.

ES.2 Geology and Groundwater Resources

The geology of Napa County can be divided into three broad geologic units based on their ages and geologic nature. These units are: 1) Mesozoic Basement Rocks (pre-65 million years (my)), which underlie all of Napa County, but they are primarily exposed in the Eastern County area and the Western Mountains Subarea, 2) Older Cenozoic Volcanic and Sedimentary Deposits (65 my to 2.5 my), including Tertiary Sonoma Volcanics (Miocene and Pliocene; 10 my to 2.5 my) which are found throughout the County, especially in the mountains surrounding Napa Valley, and 3) Younger Cenozoic Volcanic and Sedimentary Deposits (post 2.6 my to present), including the Quaternary alluvium of the Valley Floor. The two primary water-bearing units for Napa County are the tuffaceous member of the Sonoma Volcanics and the Quaternary alluvium.

Outside of the Napa Valley Floor, percolation of surface water appears to be the primary source of recharge. The rate of recharge within areas such as the Milliken, Sarco and Tulucay (MST) Subarea has been shown to be significantly higher where streams and tributaries cross highly permeable outcrops (e.g., the tuffaceous member of the Sonoma Volcanics or shallow alluvium). Direct infiltration of precipitation is a major component of recharge in the main Napa Valley. Recharge throughout much of the county is generally limited by underlying shallow bedrock of low permeability. An additional component of groundwater recharge is deep percolation through fractured rock and fault zones. This type of recharge can be very difficult to quantify due to the highly variable size and distribution of faults, fractures, and joints in a given area.

Areas of potential saltwater intrusion were preliminarily assessed through examination of available chloride, total dissolved solids (TDS), and sodium concentrations. The highest concentrations of each constituent are observed in the Napa River Marshes, Jameson/American Canyon, and Carneros Subareas. A lack of groundwater quality and well construction data for these areas is a limiting factor in determining the source and distribution of salinity.

ES.3 Data Management System

As part of the project to establish a countywide data management system (DMS), historical groundwater level data from the California Department of Water Resources (DWR), the U.S. Geological Survey (USGS), the State Water Resources Control Board (SWRCB), and the County were gathered and organized. Groundwater quality data as available from these entities as well as from the SWRCB GeoTracker program and the California Department of Public Health (DPH) were also incorporated. The countywide DMS was developed to establish a centralized repository for historical groundwater level and quality measurements, providing a foundation for programs that enhance integrated water resources management and planning. The countywide data can be further expanded upon to better understand available water resources (e.g., surface water resources and precipitation). Future applications of the DMS will lead to identification and improved understanding of the issues that may affect the quantity and/or quality of the County's water resources (e.g., climate change, human stresses due to withdrawal, or land use).

ES.4 Groundwater Conditions

ES.4.1 Groundwater Levels

Based on the available groundwater level data, groundwater levels in the county are generally stable, with the exception of the MST Subarea. Groundwater in the Napa Valley Floor generally flows toward the axis of the valley and south when not influenced by local pumping depressions. The MST Subarea, however, has shown significant declines in groundwater levels, especially in the central portion of the subarea. Contemporaneous changes in water level trends are possible to discern throughout the MST. The variation and timing of groundwater level declines and trends in the north, central, and southern areas of the MST that have historically occurred may be attributable to increased pumping and/or variations in geologic conditions. Wells in the immediate vicinity of the MST Subarea may be vulnerable to these variations as well, as seen from limited data in the eastern portion of the Napa Valley Floor-Napa (NVF-Napa) Subarea and the southwestern part of the Eastern Mountains Subarea. Most wells elsewhere in the valley with a sufficient record indicate that groundwater levels are more affected by climatic conditions, are within historic levels, and seem to recover from dry periods during subsequent wet or normal periods.

Groundwater level conditions outside of the Napa Valley Floor are much less known. Subareas south of the Valley have very limited water level data, making it difficult to impossible to assess any potential for historic or current saltwater intrusion from San Pablo Bay. Subareas east and west of the valley floor all have limited data or are lacking groundwater level data entirely (as seen in Livermore Ranch, Southern Interior Valleys, and Western Mountains Subareas). Where data are available, most records are short, spanning a few years at most, and it appears that groundwater level conditions are stable.

ES.4.2 Groundwater Quality

Historical groundwater quality records are typically lacking in Napa County. From records that do exist, groundwater is generally of good quality throughout most subareas. Poor groundwater quality exists in the south and the north central parts of the county. The poor groundwater quality includes concentrations of metals such as arsenic, iron, and manganese that exceed drinking water standards throughout the county. Elevated levels of boron are also prevalent in most subareas. Subareas south of the Napa Valley Floor, such as Carneros, Napa River Marshes, and the Jameson/American Canyons, have poor quality water due to high levels of electrical conductivity (EC), total dissolved solids (TDS), and chloride. The Calistoga Subarea of the Napa Valley Floor also has poor quality water in many wells due to hydrothermal conditions resulting in higher concentrations of metals. Nitrate concentrations are not generally a concern throughout the county, but nitrate levels tend to be higher in agricultural areas in the Napa Valley Floor.

Available groundwater quality data in the county are incomplete in regards to spatial distribution, number, and record. Many subareas do not have sufficient spatial coverage to gain a full understanding of groundwater quality. Six subareas have ten or less wells with available groundwater quality data, which limits the ability to determine representative quality and some subareas have no historical data. As a result, without sufficient groundwater quality records, it is impossible to determine trends in many subareas.

ES.5 Historical and Future Groundwater Monitoring

Historical to current (data extending through at least 2005) groundwater level and quality data were examined and groundwater data gaps identified in county subareas. Groundwater level measurements have been recorded at a total of 676 wells (173 wells/sites) through at least 2005. Of these sites where levels are measured, some type of well construction information (depth and/or perforated interval(s)) is readily available for 118 locations. Groundwater quality monitoring has been conducted at a total of 283 wells (or 153 wells/sites) through at least 2005. Of these sites where groundwater quality samples are collected, some type of well construction information (depth and/or perforated interval(s)) is readily available for 15 locations.

There are many areas in the county where further efforts to establish groundwater monitoring, using existing or new monitoring facilities, will improve the understanding of groundwater conditions and availability. The objectives and priorities for addressing groundwater level and quality monitoring needs are summarized below.

ES.5.1 Future Groundwater Level Monitoring

The primary objectives of the countywide groundwater level monitoring program include:

- Evaluate groundwater levels in the various county subareas to describe the occurrence and movement of groundwater and identify vertical hydraulic head differences in the aquifer system;
- Detect the occurrence of, and factors attributable to, natural (e.g., direct infiltration of precipitation, surface water seepage to groundwater, groundwater discharge to streams) or induced (e.g., pumping, purposeful recharge operations) factors that affect groundwater conditions and trends;
- Identify where data gaps occur and provide infill, replacement, and/or project-specific monitoring (e.g., such as may occur for planned projects or expansion of existing projects) as needed;
- Develop and/or refine water budgets for key subareas, including recharge, extraction, and change in storage in the aquifer(s); and

- Employ methods to better estimate groundwater basin conditions, assess local current and future water supply availability and reliability, and update analyses as additional data become available.

A preliminary ranking and priorities for improving or expanding groundwater level monitoring was prepared for each county subarea. Seven subareas (including the NVF-Calistoga, NVF-MST, NVF-Napa, NVF-St. Helena, NVF-Yountville, Carneros, and Pope Valley Subareas) are given a higher priority for improving the groundwater level monitoring network based on factors of current and/or projected land and water use. Groundwater level monitoring needs include improved spatial distribution of groundwater level monitoring, additional characterization of subsurface geologic conditions in each subarea to identify aquifer characteristics, further examination of well construction information to define which portion of the aquifer system is represented by water levels measured in the currently monitored wells (and in many cases to link construction information to the monitored wells), and improve the understanding of surface water - groundwater interactions and relationships.

ES.5.2 Groundwater Quality Monitoring

The primary objectives of the countywide groundwater quality monitoring program include:

- Evaluate groundwater quality conditions in the various county subareas and identify differences in water quality spatially between areas and vertically in the aquifer system within a subarea;
- Identify where data gaps occur and provide infill, replacement, and/or project-specific monitoring (e.g., such as may occur for planned projects or expansion of existing projects) as needed;
- Detect the occurrence of, and factors attributable to, natural or other constituents that are a concern;
- Assess the changes and trends in groundwater quality; and
- Identify the natural and human factors that affect changes in water quality.

A preliminary ranking and priorities for improving or expanding groundwater quality monitoring was prepared for each of the county subareas. Four subareas (including NVF-MST, Carneros, Jameson/American Canyon, and Pope Valley Subareas) are given a higher priority for improving the groundwater quality monitoring network based on factors of current and /or projected land uses and also the lack of spatially distributed groundwater quality monitoring. Three subareas, including Livermore Ranch, Southern Interior Valleys, and Western Mountains, are preliminarily assigned lower priorities for groundwater quality monitoring due to the likely lower levels of projected land and groundwater use. The ten remaining subareas are designated as medium priorities for groundwater quality monitoring. Many of these areas have current monitoring programs, so the emphasis in these areas is to further examine land use with respect to monitoring locations and the units(s) of the aquifer system represented by this monitoring.

Many subareas outside the Napa Valley Floor have limited spatial distribution of the current groundwater quality monitoring wells/sites. Basic data are described as a key monitoring need to accomplish groundwater quality objectives. Importantly, expansion and/or refinement of groundwater quality monitoring conducted in all subareas should be coordinated with efforts to expand or refine groundwater level monitoring.

ES.6 Findings and Recommendations

This project led to a broader awareness of available groundwater data and an assessment of current groundwater conditions and trends, and also identified factors related to future assessment of groundwater availability. Spatial data coverage was good for some County subareas; however, for other subareas, monitoring network enhancements are needed. Recommendations are presented to enhance and expand countywide monitoring to facilitate understanding of groundwater availability and integrated regional water management and planning efforts. Section 6 of this report includes a table that summarizes the recommended implementation steps, including the implementation time frame, a relative estimated budget, and the relative priority for implementation.

ES.6.1 Data Management System

At the outset of the development of the DMS, it was recognized that, in the future, the County would assist with the entry of other historical groundwater level and groundwater quality data. It was anticipated that future County staff time would be needed for this effort and also to incorporate well construction information for wells historically monitored in the County, recent surface water delivery information (as desired), and municipal pumping data. Other recommendations are provided in Section 6.

ES.6.2 CASGEM Groundwater Elevation Monitoring Program

Development of the countywide DMS, groundwater data quality evaluation, and the recommended groundwater level monitoring program presented herein provide a means for further coordination with statewide monitoring program interests, particularly groundwater elevation monitoring being implemented in response to the adoption of California Senate Bill SBX7- 6 in 2009. The California Department of Water Resources (DWR) is facilitating the statewide program, the California Statewide Groundwater Elevation Monitoring Program (CASGEM), where local entities can apply to DWR to assume the function of regularly and systematically collecting and reporting groundwater level data to determine seasonal and long-term trends in California's groundwater basins and subbasins. Napa County's overall project covers the continuation and expansion of countywide groundwater level monitoring efforts (including many basins, subbasins and/or subareas throughout the county) for the purpose of understanding groundwater conditions (i.e., seasonal and long-term groundwater level trends and also quality trends) and availability to enable integrated water resources management and planning to meet future water supply demands.

Another aspect of CASGEM is to make the groundwater level information available to the public. Napa County's combined efforts through this Comprehensive Groundwater Monitoring Program along with the related AB 303 Public Outreach Project (Center for Collaborative Policy and California State University Sacramento, 2010) create a framework for applying the findings and recommendations from these programs to the County's continued efforts to increase public outreach. An informed public enables support of planned water resources projects and programs proposed by the County and others. Recommendations for furthering County participation in the CASGEM program are summarized in this report. The County Board of Supervisors recently approved the County's plan to notify DWR that it intends to become the monitoring entity for Napa County (Napa County Board of Supervisors, meeting December 14, 2010).

ES.6.3 Groundwater Monitoring Program

The County's Comprehensive Groundwater Monitoring Program has resulted in recommendations for continuation of current monitoring programs and expansion and/or refinement of the programs conducted by the County and others. For the overall groundwater level and quality monitoring program to be successful, coordination with other cooperating entities, such as representatives from cities and towns in the County and numerous other entities, is required. A successful program will also require interest by and the cooperation of landowner participants who have already authorized use of their wells for current monitoring programs and also those that express an interest in being an active participant in the County's efforts to expand the countywide groundwater level and quality monitoring programs.

ES.6.3.1 Groundwater Level Monitoring Network

Groundwater level measurements have been recorded at a total of 676 wells (173 wells/sites) through at least 2005. Recommendations to implement the expansion and improvement of countywide groundwater level monitoring activities by the County and others include:

1. Replace water level monitoring wells that are completed in more than one aquifer with wells completed in (or representative of) a single aquifer (a phased approach is recommended for this effort that considers the historical record for existing wells in the network).
2. Continue groundwater level monitoring on at least a semi-annual basis; increase the spatial and vertical distribution of wells for monthly water level measurements as described in this report to allow more comprehensive evaluation of groundwater conditions and stream-aquifer relationships.
3. Perform GPS surveys with higher accuracy instrumentation, as may be needed, to establish reference point elevation data.
4. Communicate County groundwater level monitoring objectives to private and commercial landowners and invite participation in the ongoing program (i.e., access to suitable wells with construction information located in areas of interest to meet subarea-specific monitoring objectives).

ES.6.3.2 Groundwater Quality Monitoring Network

Groundwater quality monitoring has been conducted at a total of 283 wells (or 153 wells/sites) through at least 2005. Recommendations to implement the expansion and improvement of countywide groundwater quality monitoring activities include:

1. Implement efforts to expand and/or refine groundwater quality monitoring program such that more wells can be "qualified" with well construction information.
2. Review the historically monitored wells to determine whether some of these may be suited to the objectives of gathering basic data and/or expanding groundwater quality monitoring in the various County subareas.
3. Coordinate expansion of the groundwater quality monitoring program with the expansion/refinement of subarea groundwater level monitoring.
4. Communicate County groundwater quality monitoring objectives to private and commercial landowners and invite participation in the ongoing program (i.e., access to suitable wells with construction information located in areas of interest to meet subarea-specific monitoring objectives).
5. As feasible, replace monitoring wells that are completed in more than one zone or aquifer with wells completed in a single unit that meets regional and subarea-specific groundwater quality monitoring objectives.

ES.6.3.3 Groundwater Monitoring Program – Next Steps

Recommendations going forward to expand and improve the groundwater monitoring program include:

1. Establish the County's role as lead agency for ongoing groundwater monitoring program coordination and database oversight and management.
2. Establish plan for pertinent County departments (e.g., Groundwater Advisory Group representatives and others as appropriate, including County GIS persons(s)) to coordinate data collection, storage, and analysis efforts.
3. Identify potential collaborators (including local, federal, and state agency representatives) and interested stakeholders for the ongoing program.
4. Annually update the DMS (e.g., groundwater levels and quality and other water-related data), assess network and findings, and make changes to the program where necessary.
5. Discuss monitoring parameters of special interest with collaborators.
6. Review groundwater data annually and revise or make recommendations to revise data collection accordingly, pending changes to network wells and/or specific program objectives.
7. Identify locations for construction of dedicated monitoring wells for groundwater level and quality monitoring (e.g., County subareas where more subsurface information is required to better quantify groundwater availability and quality, recharge areas where aquifer-specific monitoring is lacking, surface water-groundwater interaction, etc.).
8. Replace (over time) wells in the monitoring network that have no well construction information (or are perforated in more than one zone) to improve the understanding of aquifer-specific conditions.
9. Coordinate efforts being conducted for water supply investigation work (e.g., testhole construction) with opportunities for constructing zone-specific dedicated monitoring facilities for countywide groundwater level and/or water quality monitoring.
10. Communicate program results to the cooperating entities in the form of periodic reports of groundwater conditions.

11. Provide an overview of program objectives, benefits, and results to general public via web information and other communication vehicles.
12. Seek funding to support program continuation, including DMS maintenance, data evaluation, and implementation of priority recommendations.
13. Explore the need to develop guidelines for testing private wells to evaluate potential groundwater quality issues.

ES.6.4 Regional and Local Physical Conceptualization

Understanding the hydrogeology of Napa County is essential to determine how much water is available and to what extent it can be sustainably produced. Previous hydrogeologic studies have focused on the MST Subarea and northern portion of the Napa Valley without much attention to the other areas within the county. With the exception of the Farrar and Metzger (2003) study, which looked at the MST, all of these studies are more than 30 years old. In the last 30+ years, hundreds of new wells have been drilled to greater depths than previously reached, supplying a potential abundance of new data. Due in part to the scarcity of hydrogeologic data available for the majority of Napa County, data collection and analysis need to be prioritized; the highest priority needs are presented below.

ES.6.4.1 Napa Valley Geology and Groundwater Conditions

Currently, analysis of the Napa Valley has been largely limited to two studies, one by Kunkel and Upson (1960) and one by Faye (1973). Since the Kunkel and Upson study, plate tectonics theory has been introduced, which significantly expanded the understanding of the relationship between individual geologic units within the County and the structures (faults, folds, and fractures) that accompany these relationships. Also, a large number of new wells (and therefore new well logs) have been added to the Valley, which expanded the breadth and depth of the aquifer materials explored and developed for groundwater production.

Delineation and description of the primary aquifer units are essential to determine how much available groundwater is present within the Napa Valley and to evaluate the response of the aquifer system to natural and induced stresses. The geologic cross sections prepared by Kunkel and Upson should be updated and expanded to include the last 50 years of new log data and plate tectonics theory. New cross sections should also be created throughout the Valley and into the surrounding foothills to better delineate the vertical/horizontal extent of the alluvium and underlying Sonoma Volcanics. Faye's isopach map of the alluvium and hydraulic conductivity distribution map should be updated to include the new well log data and be extended to the southern end of the Valley. As data become available, similar maps could be produced for the Sonoma Volcanics within the Napa Valley.

Faye's investigation identified direct infiltration of precipitation and percolation of surface water as the primary mechanisms for groundwater recharge in the Napa Valley. He also concluded that the contribution of percolating surface water was significantly limited by high groundwater levels. Farrar and Metzger (2003) subsequently noted that subsurface inflow to the southern Napa Valley has been significantly decreased by increased pumping within the MST. It is similarly likely that increased pumping in the areas surrounding the Napa Valley has reduced recharge to the Valley, thereby lowering groundwater levels and increasing the potential for recharge from streamflow. Surface water seepage plays a key role in recharge to the aquifer system, and groundwater plays a key role in discharge to streams. The interrelationships between surface water and groundwater due to changing stresses (including increased pumping) should be further examined. Both mass balance and streamflow infiltration methods could be used to improve estimates of regional and local recharge.

Summarized below are recommended goals for three other areas of the County.

ES.6.4.2 Pope Valley Subarea Hydrogeology

The Pope Valley Subarea is forecast to have an increase in development and a corresponding increase in groundwater pumping. Currently, subsurface geology has not been investigated and only limited hydrogeologic data are available. To determine the impact of current groundwater usage and enable informed decision making concerning future development within the Pope Valley Subarea, further analysis is recommended that includes:

- Monitoring groundwater levels;
- Monitoring groundwater quality;
- Collection and interpretation of geologic data (primarily well logs);
- Analysis of streamflow and precipitation;
- Estimation of pumping and irrigation demand; and
- Estimation of groundwater recharge and discharge.

ES.6.4.3 Carneros Subarea Hydrogeology

Limited data are available that describe the hydrogeologic setting of the Carneros Subarea. The available data suggest that groundwater resources are limited and may be susceptible to over development. Future planning decisions require knowledge of current groundwater conditions and the possible impacts that may result from additional pumping. A complete analysis of the Carneros Subarea is recommended, including:

- Monitoring groundwater levels;
- Monitoring groundwater quality;
- Estimation of recharge and discharge using both mass balance and streamflow infiltration methods;
- Determination of the extent and properties of aquifer materials; and
- Investigation of the influence of natural and induced hydrologic stresses occurring in neighboring subareas.

ES.6.4.4 Hydrogeology and Saltwater Intrusion Potential for the Jameson/American Canyon and Napa River Marshes Subareas

Similar to the Pope Valley and Carneros Subareas, limited data are available for the Jameson/American Canyons and Napa River Marshes Subareas which make up the southern County area. The two main issues facing this area are potential saltwater intrusion and the possibility that current water resources will not be sufficient to meet future demand. To establish current conditions and obtain information necessary for future development planning, further analysis is recommended that includes:

- Monitoring groundwater levels;
- Monitoring groundwater quality;
- Collection and interpretation of geologic data (primarily from well drillers' reports);
- Analysis of streamflow and precipitation;
- Estimation of recharge and discharge using both mass balance and streamflow infiltration methods; and
- Determination of the extent and properties of aquifer materials.

The current lack of groundwater data makes it difficult to determine the source and distribution of salinity in the southern County area with any certainty. A series of multi-level monitoring well clusters installed stepping south from the City of Napa toward San Pablo Bay would help in determining the geology of the Napa River Marsh Subarea and distribution of high salinity groundwater. This further subsurface exploration and characterization of the aquifer system, in conjunction with efforts to estimate subsurface outflow from the Napa Valley, would also help determine if freshwater within the Napa River Marshes Subarea could possibly be used to sustain increasing demand in the Jameson/American Canyon Subarea.

1.0 INTRODUCTION

Groundwater and surface water are highly important natural resources in Napa County. Collectively, County entities along with numerous others, including municipalities, water districts, commercial and industrial operations, the agricultural community and the public, are stewards for the water resources available to Napa County. The Napa County community actively supports and invests in its water resources to sustain agricultural productivity. Concurrently, municipal and private stakeholders are actively engaged in assessing the potential for the development of additional water supplies, both groundwater and surface water of good quality, to meet future urban and rural water demands. Similar to other areas in California, the County faces many future water-related challenges including:

- Increased competition for available supplies,
- Preserving the quality and availability of imported water supplies,
- Sustaining groundwater supplies,
- Additional challenges arising during drought conditions, and
- Changes due to global warming and/or climate change.

To address these challenges, long-term, systematic monitoring programs are essential to provide data that allow for improved evaluation of water resources conditions and availability to facilitate effective water resources management. Previously established groundwater and surface water monitoring networks have resulted in the collection of data necessary to distinguish trends from short-term fluctuations, anticipate unintended consequences due to historical land uses, identify emerging issues, and design water resources management strategies. Napa County embarked on updating the countywide monitoring program with an initial emphasis on understanding groundwater conditions based on available data, and implementing an expanded groundwater monitoring and data management program as a framework for coordinated, integrated water resources management and dissemination of water resources information.

This project addresses the initial goal of the County to understand current and historical groundwater conditions based on available data, developing an expanded data management system to store monitoring data from different county, state, and federal sources, and develop recommendations for expanded groundwater monitoring and water resources management. Broad project goals included gathering available groundwater-related data, cross-correlating ancillary data, evaluating historical groundwater level and quality data, and developing a centralized data management system that provides the data necessary to manage regional water resources and enable long-term protection of the County's surface and groundwater resources. This project led to a broader awareness of available groundwater data and how those data can be better used to assess current groundwater conditions and trends and also identify factors related to future assessment of groundwater availability. The project also led to an awareness of data security issues, data gaps, and actions needed to continue efforts to "qualify," organize, store, and disseminate water-related data to enhance the long-term value of the data. The County has been divided into 17 subareas based on geographic, geologic, and political boundaries. Spatial data coverage was good for some County subareas; however, for other subareas, monitoring network enhancements are needed. The project includes recommendations to enhance and expand countywide monitoring in order to facilitate understanding of groundwater availability and integrated regional water management and planning efforts.

1.1 Background

The main steps of the Napa County countywide project included:

1. Collecting existing data and developing a countywide data management system
2. Evaluating data collection procedures and making recommendations for improvement;
3. Preparing hydrogeologic descriptions of countywide basins/subareas and evaluating groundwater conditions; and
4. Developing a comprehensive groundwater monitoring network and program.

As part of the first task, a Data Management System (DMS) was developed for the County to establish a centralized repository for recording and archiving countywide well construction data (as related to groundwater monitoring wells), historical groundwater level and quality measurements, and pumpage, and developing procedures for analyzing data on a programmatic basis (LSCE, 2010a). The current DMS focuses on groundwater-related data; however, some surface water information has been incorporated. In the future, the database could be expanded to include additional surface water data and other information.

The objective of the second task was to review and assess the groundwater data that are in the DMS, along with DWR drillers' reports by subarea. The quality of current groundwater data (2005 to present) was evaluated and recommendations were presented to improve reliability, accuracy, and usability.

The report herein builds upon these foundational tasks and completes items 3 and 4 above. The regional assessment of groundwater conditions was structured to provide a comprehensive perspective on the County's groundwater resources, with emphasis on evaluation of the data available to identify groundwater conditions in specific local areas, i.e., County subareas. As a result of groundwater data compilation and organization efforts, construction of the countywide DMS, and evaluation of groundwater level and quality data on a subarea basis, the breadth of existing groundwater monitoring programs were identified, current data were examined, and groundwater conditions as known from available data were summarized. These efforts led to the identification of groundwater data gaps, and recommendations have been developed to enhance countywide groundwater monitoring to better track groundwater level and quality trends and conditions on subarea and regional bases.

1.2 Project Purpose

LSCE has prepared this initial report on groundwater conditions based on the reconnaissance evaluation completed in Tasks 1 and 2. This report documents the results of the existing knowledge of countywide groundwater conditions and establishes the framework for the reporting of water levels and water quality on a periodic basis. This report includes: spatial and vertical descriptions and illustrations of geologic units and the occurrence of groundwater; groundwater elevation hydrographs throughout the county; historical and current contours of equal groundwater elevations for some subareas; time-series plots and illustrations of the distribution of key groundwater quality constituents. Historical trends or occurrences are described to explain historical groundwater levels and/or quality in relation to the current condition.

An updated hydrogeologic picture has been developed to describe the occurrence and movement of groundwater beneath Napa County, especially key subareas of the county. As additional data become available, "layers" of detail can be added to describe and illustrate various hydrologic, groundwater quality and other related items of pertinence or interest (i.e., response of groundwater levels to changes in pumping stresses and/or existing or new recharge activities).

It is intended that this report will serve as a basis for future periodic reports that expand on the existing knowledge of countywide groundwater conditions; provide an update on groundwater conditions (including groundwater level and quality trends and variations); and recommends enhancements and/or modifications to the framework for future reporting of groundwater conditions.

1.3 Project Area

The area of interest for this project is all of Napa County. Because of the emphasis on groundwater data, conditions, and future monitoring, this section describes how the California Department of Water Resources (DWR) has defined the major groundwater basins and subbasins in and around Napa County, including the Suisun-Fairfield Valley, Napa-Sonoma Valley (divided into Napa Valley, Sonoma Valley, and Napa-Sonoma Lowlands Subbasins), Napa-Sonoma Volcanic Highlands, Berryessa Valley, Pope Valley, and Clear Lake Pleistocene Volcanic Area Basins (**Figure 1.1**). These basins and subbasins are generally defined based on boundaries to groundwater flow and the presence of water-bearing geologic units. The groundwater basins defined by DWR are not confined by county boundaries, may span multiple counties, and DWR-designated "basin" or "subbasin" designations do not cover all of Napa County. For purpose of this report and other related technical memorandums, the county has been subdivided into a series of subareas (**Figure 1.2**). These subareas were delineated based on the main watersheds, groundwater basins, and the County's planning areas.

1.4 Project Goals and Objectives

The County's broad goals for this project included gathering available water-related data from local, state and federal entities, cross-correlating ancillary data (e.g., well construction information and subsurface hydrogeologic features) to enhance the value of basic data, evaluating historical water level and water quality data to assess area groundwater conditions, and developing a centralized water resources data management system that provides the data necessary to effectively manage area water resources and enables long-term protection of the county's groundwater resources.

The project objectives included:

- Collecting available historical monitoring data (including water level records and selected groundwater quality records). Data collection for purposes of this program focused on overall groundwater quality conditions, i.e., point source data for local contamination investigations were generally not a focus of this project.

- Developing and implementing a DMS for ongoing, centralized storage of water resources data that would be annually updated with data from cooperating entities, exchanged with area cooperators, state and federal agencies, and (with appropriate security tiers) accessible to the public.

- Reviewing the existing groundwater level and quality monitoring network(s) and initially "qualifying" the wells such that the collected data are representative of the portion of the aquifer system of interest.

- Performing a critical review and evaluation of selected available data (particularly groundwater data) to determine adequacy and accuracy of the data for desired assessments of groundwater conditions. Data gaps would be identified and recommendations provided for the ongoing countywide monitoring program to facilitate effective interpretation and understanding of groundwater conditions.

- Developing recommendations to enhance the countywide groundwater level and quality monitoring program (parameters, monitoring frequency, data management, and evaluation) that provides the data needed to describe current groundwater conditions.

- Providing a comprehensive report (the report herein) that includes an evaluation of the historical and current groundwater level and quality data and recommendations for a countywide groundwater monitoring program.

1.5 Report Organization

This report includes:

- **Geology and Water Resources of Napa County**
  - Complete hydrostratigraphic characterization of the County's basins/subbasins/subareas based on existing data and information.

- **Data Management System**
  - Data collection and security
  - Database construction
  - Data quality

- **Groundwater Conditions**
  - Groundwater levels
    - Napa Valley Floor Subareas

    - Subareas south of the Valley Floor
    - Subareas east of the Valley Floor
  - Groundwater contours
  - Summary of groundwater level conditions and available data
  - Groundwater quality
    - Napa Valley Floor
    - Subareas south of the Valley Floor
    - Subareas east and west of the Valley Floor
  - Summary of groundwater quality conditions and available data

- **Historical and Future Groundwater Monitoring**
  - Summary of historical to current (2005 to present) groundwater monitoring
    - Groundwater level monitoring
    - Groundwater quality monitoring
    - Summary of current groundwater monitoring locations
  - Future recommended groundwater level monitoring network and program
  - Future recommended groundwater quality monitoring network and program

- **Findings and Recommendations**
  - Data management system
  - CASGEM groundwater elevation monitoring program
  - Groundwater monitoring program (and next steps)
  - Regional and local physical conceptualization

2.0 GEOLOGY AND WATER RESOURCES OF NAPA COUNTY

2.1 Introduction

Napa County is located within the northern Coast Ranges Geologic Province of California, north of the San Francisco Bay area. The geology of the county can be divided generally into three broad geologic units based on their ages and geologic nature. The oldest unit is comprised of Mesozoic Basement rocks. These are overlain by the older Cenozoic sedimentary and volcanic rocks. Younger Cenozoic sedimentary and volcanic deposits overlie the older Cenozoic rocks. Napa County can be divided into four areas (eastern, western, Napa Valley Floor and southern) (**Figure 2.1**) based on the dominant geologic units exposed.

2.2 Previous Studies

Previous studies of Napa County are divisible into geologic studies and groundwater studies. The more significant studies are mentioned in this section. Weaver (1949) presented geologic maps which covered the southern portion of the county and provided a listing of older geologic studies. Kunkel and Upson (1960) examined the groundwater and geology of the northern portion of the Napa Valley. California Department of Water Resources (DWR) (Bulletin 99, 1962) presented a reconnaissance report on the geology and water resources of the eastern area of the County; Koenig (1963) compiled a regional geologic map which encompasses Napa County. Fox and others (1973) and Sims and others (1973) presented more detailed geologic mapping of Napa County. Faye (1973) reported on the groundwater of the northern Napa Valley. Johnson (1977) examined the groundwater hydrology of the Milliken-Sacro-Tulucay (MST) Creeks area.

Helley and others (1979) summarized the flatland deposits of the San Francisco Bay Region, including Napa County. Fox (1983) examined the tectonic setting of Cenozoic rocks, including Napa County. Farrar and Metzger (2003) continued the study of groundwater conditions in the MST area.

Wagner and Bortugno (1982) compiled and revised the regional geologic map of Koenig (1963). Graymer and others (2002) presented detailed geologic mapping of the southern and portions of the eastern areas of the County, while Graymer and others (2007) compiled geologic mapping of the rest of Napa County.

Additional geologic maps, groundwater studies, and reports are listed in the references of this report.

2.3 A Brief Geologic History of Napa County

More than 100 million years ago, the western edge of North America collided with the Farallon oceanic plate forming a large subduction zone (oceanic plate slides beneath the more “buoyant” continental plate). Magma from the subducting Farallon plate bubbled toward the land surface forming a large volcanic arc. The mountains and volcanoes of the volcanic arc were eroded and deposited in the Pacific Ocean along the edge of the continent, forming the Great Valley Sequence. The modern Sierra Nevada are the exposed roots of this volcanic arc (pre-Sierra Nevada) (**Figure 2.2**).

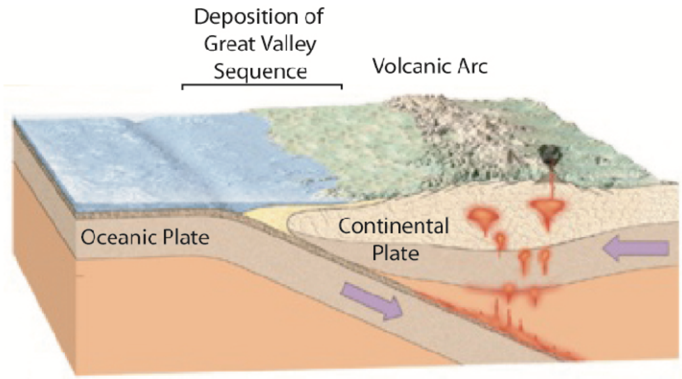

Figure 2.2 – Mesozoic to mid-Cenozoic landscape showing subduction of the Farallon Oceanic Plate beneath the North American Continental plate (Adapted from Tasa, 2010).

At the suture of the two plates, oceanic sediments and rocks were scraped from the surface of the Farallon plate and piled high along the western edge of the North American plate. As these sediments continued to pile up higher and higher, dry land appeared (10-20 mya) forming the Coast Range with an interior sea where the Central Valley is today (**Figure 2.3**),. The oceanic sediments and rocks of the Coast Range are known today as the Franciscan Complex and Coast Range Ophiolite, respectively. The extreme forces involved in the collision and subduction of the Farallon plate folded and faulted the Franciscan Complex, Coast Range Ophiolite, and Great Valley Sequence, producing steep bedding angles (**Figure 2.4**, **Plate 1**).

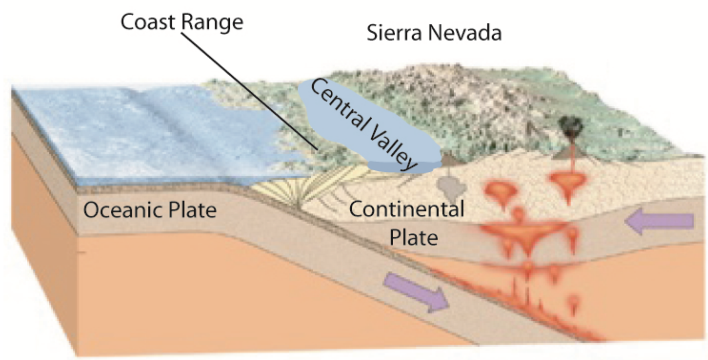

Figure 2.3 – 10-20 mya (Miocene) landscape showing formation of the Coast Range (Franciscan Complex and Coast Range Ophiolite (Adapted from Tasa, 2010).

From 8.5-2.5 mya violent eruptions blanketed Napa County and the surrounding areas (the volcanic field stretched over a 350 square mile area between Fairfield and Petaluma) with ash, which was sometimes followed by lava flows. These ash and lava flow deposits, known today as the Sonoma Volcanics, overlie the older Franciscan Complex, Coast Range Ophiolite, and Great Valley Sequence. Erosion of these units, including the Sonoma Volcanics, has filled the valleys of Napa County with alluvium while the remnants of active volcanism form the surrounding hills and mountains.

2.4 General Description of Geologic Units

2.4.1 Mesozoic Basement Rocks

The oldest rocks in Napa County are the Mesozoic (pre-65 million years) basement rocks. The Mesozoic basement rocks are complexly deformed by folding and faulting and are well lithified. The Mesozoic basement rocks are divisible into three subunits: the Great Valley Sequence, the Coast Range Ophiolite, and the Franciscan Complex. As discussed above, the basement rocks are believed to have been structurally assembled by plate tectonic processes in a sequence of subduction zones as the Farallon oceanic plate and overlying sedimentary and volcanic deposits were carried below the North American continental plate. Fragments of the oceanic crust formed volcanic zones (Coast Range Ophiolite), while oceanic crust volcanic and sedimentary rocks of the subducted oceanic plate were tectonically mixed forming the Franciscan Complex. The Franciscan Complex aggregated with the Great Valley Sequence to result in the bands of basement rocks exposed in Napa County. The contacts between the Great Valley Sequence and the Franciscan Complex are not depositional, but they are always faulted together or faulted against Coast Range ophiolites (oceanic crust).

2.4.1.1 Great Valley Sequence

The Great Valley Sequence is a coherent, depositional, sedimentary sequence of deep-marine origin consisting of shale, mudstone, sandstone, and conglomerate. The sedimentary rocks are moderately to well consolidated and lithified. Bedding within the Great Valley Sequence generally dips steeply having been strongly and complexly folded.

2.4.1.2 Coast Range Ophiolite

The Coast Range Ophiolite is composed of serpentinized igneous intrusive and extrusive rocks. The mapped serpentine bodies are believed to be bodies of the oceanic crust faulted and mixed with the other basement rocks by tectonic processes.

2.4.1.3 Franciscan Complex

The Franciscan Complex is composed of low-grade metamorphosed bodies of greywacke (sandstone with a matrix of finer-grained material), shale, chert, and bodies of mélange composed of mixed-sized blocks of various rock types in a matrix of sheared shale and mudstone formed in subduction zones by submarine landslides and tectonic processes.

2.4.1.4 Groundwater Occurrence in Basement Rocks

Previous groundwater studies (Kunkel and Upson, 1960; DWR, 1962; and Faye, 1973) considered the Mesozoic Basement rocks to be non-water bearing, although they conceded that small quantities of water were yielded to wells sufficient for domestic and stock watering needs. Groundwater yield from the Mesozoic Basement rocks is probably from secondary porosity (fractures, weathered zones, and jointing) due to their great age and fine-grained, highly deformed, well-consolidated nature.

Review of water well drillers' reports for the wells and test holes of record in the Mesozoic Basement rocks indicate low yields which are at best several tens of gallons per minute (gpm), with most wells yielding less than 10 gpm. There appear to be a higher proportion of dry test holes in the Mesozoic Basement rocks than in the younger geologic units. Faye (1973) reports a specific capacity less than or equal to 0.1 gallon per minute per foot of drawdown. Most water well drillers' reports indicate a yield in gpm by airlift, or bailing methods, but typically a drawdown water level is not reported. Some reports indicate complete evacuation of water from the well casing. Historically, drilling methods for wells and test holes in the Mesozoic Basement rocks tended to be by cable tool methods. However, in the last 30 years wells have been drilled largely by air-rotary methods.

Based on the geologic nature of the various Mesozoic basement rocks and on review of water well drillers' reports, the units are rated based on probability of successful well completion from more to less likely as: Great Valley Sequence, Franciscan Complex, and Coast Range Ophiolite. This rating may be partially biased by the higher proportion of wells and test holes drilled in the Great Valley Sequence than the other two units.

2.4.2 Older Cenozoic Volcanic and Sedimentary Deposits

The older Cenozoic (65my - 2.5my) sedimentary and volcanic rocks are subdivided into the older Tertiary (65my to pre-10my) marine sedimentary rocks and the younger Tertiary (Miocene and Pliocene; 10my to 2.5my) volcanic rocks of the Sonoma Volcanics. The Tertiary marine sedimentary rocks have the most limited exposure area of the various rock types within the county (they are confined to the southern area of the County) although extensive exposures exist to the west in Sonoma County.

2.4.2.1 Tertiary Marine Sedimentary Rocks

The Tertiary marine sedimentary units are found in three small areas, one in the Carneros Valley, and two in the southern County area (Congress Valley and Jameson Canyon). These units are composed of various formations, including, from the oldest to youngest: the Domengine, Markley, Neroly and Cierbo sandstones.

2.4.2.2 Tertiary Volcanic Rocks (Sonoma Volcanics)

The Sonoma Volcanics are a complex sequence of inter-layered lava flows and tuff beds with some interbedded sedimentary deposits of sandstone, gravel, and conglomerates (Weaver, 1949). The lava flows are composed of a variety of volcanic rocks types, including basalt, andesite, and rhyolite. Individual lava flows vary in thickness from a few feet to several hundred feet over short distances. The textures of the flows also vary from dense and fine-grained to vesicular (containing many small cavities) and agglomeratic (volcanic rock consisting of large fragments fused together), consisting of fragments of larger than 32 millimeters. The tuff beds are of pyroclastic origin formed by explosive or aerial ejection from a volcanic source vent. A variety of geologic units have been mapped based on their texture and origin, such as tuff, tuff breccias, ash flow tuff, and others (Graymer and others, 2007).

2.4.2.3 Groundwater Occurrence

Groundwater occurs in the Sonoma Volcanics in Napa County and yields water to wells. Well yields are highly variable from less than 10 to several hundred gpm. The most common yields are between 10 to 100 gpm. Faye (1973) reported well-test information which showed an average yield of 32 gpm and an average specific capacity of 0.6 gallons per minute per foot of drawdown. From the available well log data, the Tertiary marine sedimentary rocks are poor groundwater producers either for a lack of water or poor water quality (high salinity). At great depths, groundwater quality in the Tertiary marine sedimentary rocks is generally poor due to elevated chloride concentrations.

According to Kunkel and Upson (1960), groundwater in the Sonoma Volcanics is generally of good quality except in three areas. The first area with poor groundwater quality, the Tulucay Creek drainage basin, east of Napa, contains groundwater with elevated iron, sulfate, and boron. The Suscol area, south of Napa, is the second area where some wells suffer from poor quality groundwater due to elevated chloride concentrations, possibly from leakage from salty water in the Napa River, alluvial material above, or the existence of zones of unusually saline connate water deep within the Sonoma Volcanics. The third area of poor groundwater quality, the Calistoga area in the northern end of the Napa Valley, contains isolated wells with elevated chloride and boron concentrations.

Kunkel and Upson (1960) reported that the principal water yielding units of the Sonoma Volcanics are the tuffs, ash-type beds, and agglomerates. The lava flows were reported to be generally non-water bearing. However, it may be possible that fractured, fragmental, or weathered lava flows could yield water to wells. The hydrogeologic properties of the volcanic-sourced sedimentary deposits of the Sonoma Volcanics are poorly understood.

2.4.3 Younger Cenozoic Volcanic and Sedimentary Deposits

The Younger Cenozoic geologic unit is divisible into three categories: the Huichica Formation; the Clear Lake Volcanics, and the Quaternary surficial sedimentary deposits. The Huichica Formation, as used here, is exposed only in the southern area of the County, and the Clear Lake Volcanics occur only in the eastern area of the County. Surficial sedimentary deposits occur across the county and overlie all of the older geologic units.

2.4.3.1 Huichica Formation

The Huichica Formation was named by Weaver (1949) for exposures along Huichica Creek in the southern area of the County. The unit is composed of stratified gravel, sand, reworked tuff, clay and conglomerate. A tuff bed inter-layered with these deposits was dated at about 4 million years old. The age of the Huichica Formation is considered late Tertiary (Pliocene) and early Quaternary (post 2.6 my; Pleistocene). The unit overlies the Sonoma Volcanics, Tertiary marine sedimentary rocks, and Mesozoic basement rocks. Small exposures of Huichica Formation occur east of the Napa River in the southern area of the County as small hillocks and knobs. The exposed area of the Huichica Formation with visible layering is characterized by gentle southward dips. Most of the groundwater in this formation is suitable for irrigation and domestic uses, with minor occurrences of elevated chloride and nitrate (Kunkel and Upson, 1960).

2.4.3.2 Clear Lake Volcanics

The Clear Lake Volcanics are exposed in a linear band along the Putah Creek drainage north of Lake Berryessa in the eastern area of the County (**Plate 1**). The unit consists of basaltic lava flows of fairly wide extent. Southward, the Clear Lake Volcanics become more isolated, with smaller exposures in ridge-top locations underlain by thin sedimentary sand and gravel deposits (Cache Formation). Small patches of basaltic lava flows occur scattered across the northern part of the eastern area of the County. The Clear Lake Volcanics overlie the Mesozoic basement rocks. The age of the Clearlake Volcanics in Napa County range from about 2 to 1.3 my (Pleistocene).

2.4.3.3 Quaternary Sedimentary Deposits

The youngest geologic unit in Napa County is collectively termed alluvium, though it consists of sedimentary deposits of unconsolidated gravel, sand, silt, and clay. The alluvium is Quaternary in age (Pleistocene 2.6 my- 11,000 years and Holocene 11,000 years to present). Depositional environments include alluvial fans, stream channels, flood plains, lacustrine, basinal, and landslides. The Quaternary alluvium occurs in all four areas of the county.

2.4.3.4 Groundwater Occurrence

Several hundred wells and testholes of record have been drilled into the exposed Huichica Formation. Well yields tend to be low to modest (< 10 gpm to tens of gpm). Only a few known wells of record are completed in the Clear Lake Volcanics near the northern County line. Three wells report high yields of 400 to 600 gpm. Much of the Clear Lake Volcanics to the south appear to be thinner, limited in extent, and in ridge-top locations where possible groundwater production appears to be less likely.

Groundwater production from Quaternary alluvium is variable, with yields ranging from <10 gpm in the East and West mountainous areas to 3,000 gpm along the Napa Valley floor where the alluvium is thickest (>200 feet). According to Faye (1973), average yield of wells completed in the alluvium is 220 gpm. Many wells drilled in the alluvium within the last 30 years extend beyond the alluvium and into the underlying Cenozoic units. Kunkel and Upson (1960) report that groundwater in the alluvium is generally of good quality. The groundwater is somewhat hard and of the bicarbonate type, with small concentrations of sulfate, chloride, and total dissolved solids. A few isolated areas have increased chloride and boron concentrations.

2.5 Geology by Subarea

As mentioned above, Napa County was divided into four areas based on the dominant geologic units exposed (**Figure 2.1**). The eastern area of the County is dominated by the Mesozoic Basement rocks which are overlain by small areas of the younger geologic units. The western area of the County is dominated by the exposed older Cenozoic rocks. Smaller regions of Mesozoic Basement rocks occur in the mountainous upland areas. While the Napa Valley Floor is technically contained within the western area, it differs from the rest of the area in that it is predominantly younger Cenozoic sedimentary deposits overlying the older Cenozoic Sonoma Volcanics. The southern area is dominated by younger Cenozoic sedimentary deposits overlying older Cenozoic sedimentary rocks with small exposures of Mesozoic basement rocks.

2.5.1 Eastern Area

In the eastern area of the County, the three Mesozoic basement rock subunits are exposed as linear bands, largely separated from each other by faults. This relationship is best shown on regional scale maps, for example: Graymer and others (2001); Wagner and Bortugno (1982); and Graymer and others (2007) (**Figure 2.4**, **Plate 1**). The latter two references contain geologic cross-sections which show subsurface relationships. Approximately 500 wells and test wells of record occur in the Mesozoic basement rocks in the eastern area, the majority of which are located in the Pope Valley, Capell Valley, and Wooden Valley areas.

The Clear Lake Volcanics overlie the Mesozoic basement rocks in the eastern area. The Clear Lake Volcanics are primarily exposed in a linear band along the Putah Creek drainage north of Lake Berryessa in the eastern area. In this area, the unit consists of basaltic lava flows of fairly wide extent. Southward, the Clear Lake Volcanics become more isolated, with smaller exposures on ridge top locations, underlain by thin sedimentary sand and gravel deposits (Cache Formation). Small patches of basaltic lava flows occur scattered across the northern part of the eastern area of the County.

In the eastern area, the alluvium occurs as relatively narrow linear bands along the floor of stream valleys. Broader valley areas occur in Pope Valley, Chiles Valley, Wooden Valley, Capell Valley, and probably submerged beneath Lake Berryessa. The alluvium in the eastern County area appears to be relatively thin, generally less than 100 feet thick and more commonly less than 50 feet thick. The alluvium also appears to be largely fine-grained (clays or clays with sand and gravel), possibly caused by low stream gradients, influx of unsorted landslide debris, and possible drainage blockage by landslides. Early groundwater development in the eastern County area occurred from the alluvium in shallow hand-dug and drilled wells. More recent wells appear to generally extend through the alluvium into the underlying basement rocks, but the wells are screened to produce water from both units. Well yields range from low to modest (less than 10 gpm to a few tens of gpm) for wells completed in either the alluvium only or both alluvium and basement rock. It appears that the proportion of dry test holes is lower in the alluvium compared to those drilled only in the Mesozoic basement rock.

Many landslides of all styles and sizes occur in the eastern area, indeed throughout the county's hillslope areas. In the southwest corner of the eastern area from the county line northward to beyond Wooden Valley, the Green Valley Fault Zone occurs along what are mapped as large landslides (Qls, **Plate 1**). Some domestic wells of record have been drilled on these landslides and report low well yields of less than 10 gpm. Generally, landslide deposits are considered poor water well sites because of the fine-grained and mixed characteristics caused by landslide processes.

2.5.2 Western Area

2.5.2.1 Basement Rocks

In the western area of the County, the basement rocks are exposed in the central Eastern Mountains above Lake Hennessey. This area is dominated by a large area of Franciscan Complex metamorphosed greywacke along with smaller areas of Great Valley Sequence and serpentinite. In the Western Mountains, the basement rock is exposed in the southern three-quarters and is composed of Franciscan Complex and Great Valley Sequence rocks.

In these areas of basement rock exposures, less than 100 wells and test holes have occurred in the central Eastern Mountains, while approximately 500 wells and test holes occur in the Western Mountains.

2.5.2.2 Sonoma Volcanics

The Sonoma Volcanics occur largely in the western area, essentially the Napa Valley drainage area. Following the usage of Fox (1983), the Sonoma Volcanics are divided informally into lower and upper members. The lower member extends south of Sage Canyon and is dominated by andesite to basalt lava flows with subordinate interlayered tuff beds. To the north, the upper member is dominated by thick ash flows, a variety of tuff beds, and rhyolite lava flows. Capped by basalt lava flows, the upper beds of the upper member appear to interfinger with stream-laid, volcanic-sourced sandstone and conglomerates which are exposed west of Calistoga and just north of the mouth of Sage Canyon.

In the Eastern Mountains, the lower member of the Sonoma Volcanics are penetrated by possibly up to a thousand wells and test holes of record. Water yields appear to be low, from less than ten gpm to a few tens of gpm, with a few, rare higher yields. It appears a lower proportion of dry test holes are encountered than in the older Mesozoic basement rocks.

In the area north of Calistoga in the Western Mountains, underlain by the upper member of the Sonoma Volcanics, well yields appear to be similar, from less than 10 to a few tens of gpm, with a few, rare higher yields. The proportion of the dry test holes to constructed wells appears to be similar, or slightly less than the lower Sonoma Volcanics areas. The number of wells or test holes of record in the upper Sonoma Volcanics in the western area is about 800.

2.5.3 Napa Valley Floor

Within the Napa Valley Floor, the Mesozoic Basement complex is present as relatively small exposures of Great Valley Sequence to the east of Yountville. Along the western side of the Napa Valley Floor, the Sonoma Volcanics are exposed as steeply dipping beds separated from the Mesozoic basement rocks by the West Napa fault zone. The nature, configuration, and relationships of the Sonoma Volcanics that underlie the Napa Valley Floor to the adjacent areas with exposures of Sonoma Volcanics are poorly known and unclear. Weaver (1949) mapped small exposures as Huichica Formation along the Napa Valley floor. The Napa Valley Floor is divided into three subareas (Napa Valley (including Calistoga, St. Helena, Yountville, and Napa), MST, and Carneros) based on dominant aquifer materials for discussion purposes below.

2.5.3.1 Napa Valley Floor

The Napa Valley Floor, comprised of the Calistoga, St. Helena, Yountville, and Napa Subareas, is primarily made up of younger Cenozoic alluvium overlying both permeable and impermeable Sonoma Volcanics (**Figure 2.5**). Alluvium occurs as a linear, variable width band which consists of unconsolidated, discontinuous, thin sand and gravel beds interstratified with thicker silt and clay beds. The sand and gravel beds seem to be less than 10 feet thick, and may contain some clay and silt. These sand and gravel beds are believed to represent stream channel deposits. The silt and clay beds represent floodplain deposits grading into alluvial fan deposits toward the valley sides. The silt and clay deposits containing sand and gravel may represent mud flow/debris flow running out into the valley or debris carried out by tributary stream floods.

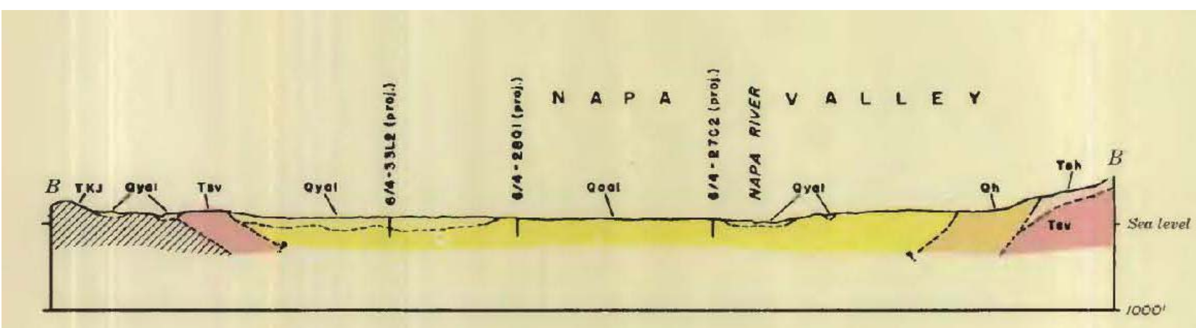

Figure 2.5 – Cross section north of the City of Napa (Figure 2.4 showing Quaternary Alluvium underlain by Sonoma Volcanics (B-B' in Kunkel and Upson, 1960)).

Faye (1973) presented maps showing the distribution of K values (**Figure 2.6**) and the thickness of alluvium (**Figure 2.7**) for the northern section of the Napa Valley. The thickness map shows the alluvium thickening from the edge of the valley to a band slightly down the center of the valley. Based on this map, the Napa Valley Floor underlain by alluvium can be divided into four areas. The upper valley north of St. Helena is narrow and underlain by thin alluvium (less than 100 feet thick). The central valley from St. Helena to just south of Oakville is broader and has thicker alluvium of up to 200 feet thick. South of Oakville to south of Yountville, the valley floor is narrow and knobs of Sonoma Volcanics and basement rocks are exposed above the valley floor. A narrow channel or valley filled with thick alluvium crosses this area in the center. This area is termed the Yountville Narrows. The lower Napa Valley extends southward as a broader wedge-shaped valley that narrows to the south where the Napa River passes into the South County area. The alluvium thickness in the lower Valley is poorly documented.

The alluvium has been the subject of study in previous reports as the most productive water yielding geologic unit (Kunkel and Upson, 1960; Faye, 1973). The alluvium of the Napa Valley Floor has the highest density of wells and test holes of record. Many of these wells, especially in the lower Napa Valley near the City of Napa, are shallow monitoring wells and heat exchange wells. In the upper Napa Valley, about 1000 wells and test holes of record occur. The Central Napa Valley has about 1500 wells of record. The Yountville Narrows area has about 300 wells of record. The lower Napa Valley, north of the City of Napa, has about 1200 wells of record but the majority of them are shallow monitoring wells.

Well yields from the alluvium were reported by Faye (1973) as ranging from 50 to 3,000 gpm. The average yield of wells is reported as 220 gpm, and the average specific capacity is about 10 gpm per foot of drawdown. Review of water well drillers' reports indicates yield may be more variable; many wells constructed in the alluvium have low to modest yields of less than 10 gpm to several tens of gpm. Many wells drilled on the Napa Valley Floor in the last 30 years have extended through the alluvium and into the underlying Sonoma Volcanics. These wells tend to have intake areas within both the alluvium and the Sonoma Volcanics.

2.5.3.2 Milliken-Sarco-Tulucay Creeks Subarea

The geology of the MST Subarea has been described by a number of authors, including Weaver (1949), Kunkel and Upson (1960), Johnson (1977), and Farrar and Metzger, (2003). Johnson (1977) describes the area as consisting of three volcanic members: the lower andesitic member (Tsa), the middle tuffaceous member (Tst), and the upper rhyolitic member (Tsr), separated by two subaqueous deposits: diatomaceous deposits (Tssd) and sedimentary deposits (Tss). This simplified description is helpful in developing a general understanding of the area, but the composition and distribution of units is more complicated than described in Johnson (1977). The Sonoma Volcanics of the MST are the result of the complex interaction of multiple volcanic vents with variable magma compositions which created a highly heterogeneous sequence of rock types and compositions. Although the simplified description of units will be used here to develop a general understanding of the area, the complexities of the system should be considered as later sections discuss groundwater levels and quality in the MST.

The andesitic member of the Sonoma Volcanics (Tsa), consisting of andesitic and basaltic lava flows, is found throughout the area, generally more than 500 feet below land surface. The tuffaceous member (volcanic ejecta consisting of pumice, tuff, ash, and scoria separated by irregular lava flows and low permeability clays) forms two aquifers (Tst), one located in the north (**Figure 2.8, A-A'**) and one in the south (**Figure 2.8, C-C'**) divided near the center of the MST where the andesitic member rises to within 100 feet of land surface (**Figure 2.8, B-B'**). The rhyolitic member (Tsr) overlies the andesitic member in a number of locations with the majority of outcrops located to the north in the Howell Mountains with one notable outcrop forming the peak of the "Cup and Saucer" area, located in the central portion of the MST (**Figure 2.8**). The diatomaceous deposits (Tssd) consist of diatomaceous clay and silt deposited in a lake or swamp environment with interbedded ash and pumice. These deposits are generally confined to the eastern half of the MST, thinning to the north and south from the central portion of the area. Interbedded within this unit are alluvial fan deposits of varying size and permeability (Johnson, 1977). Volcanic sedimentary deposits (Tss) overlie the tuffaceous member in the north surrounding Milliken and Sarco Creeks.

The Soda Creek Fault slices through the Sonoma Volcanics along the western edge of the MST (**Figure 2.8**). To the west of the fault the Sonoma Volcanics have been down dropped as much as 700 feet and covered by the younger Cenozoic alluvium (Qoal) described above. The Soda Creek Fault appears to limit flow from the MST into the Napa Valley, acting as a hydrologic barrier at depth.

The majority of groundwater in the MST comes from infiltration of precipitation which falls in the Howell Mountains. This precipitation is carried into the MST area by the Milliken, Sarco, and Tulucay Creeks. Johnson (1977) concluded that the infiltration rate from precipitation and runoff is greatest where tuffs are exposed or underlie shallow quaternary deposits. This occurs primarily along the lower elevations of the rim created by the Howell Mountains and where stream cuts in the eastern mountains reach the underlying tuff.

Johnson (1977) reports that there are at least 1,500 wells within the MST, roughly 400 of which have well records. The majority of wells are completed in the tuffaceous member and exhibit specific capacities from 0.0 to 42 gpm/ft.

2.5.3.3 Carneros Subarea

The Carneros Subarea is located at the southwestern end of the Napa Valley Floor. The primary units of interest, from oldest to youngest, are the Tertiary sedimentary and volcanic units, Sonoma Volcanics, Huichica Formation, Pleistocene terrace deposits and recent alluvium. Older units are assumed to be present at depth although hydrogeologic data for these and the younger units is limited for the area. In the Carneros Valley, the Tertiary sedimentary/volcanic rocks are in fault contact with Mesozoic basement rock to the east. Several formations are present in this area, including the Kirker Tuff (volcanic deposit), unnamed sandstone, the Ciebro sandstone, and the Neroly sandstone. These units appear to dip steeply southwestward and are overlain by Sonoma Volcanics. Sonoma Volcanics are exposed in the southwest and northeast of the Carneros Subarea, although it is believed that they underlie most, if not all, of the subarea. The Huichica Formation is the primary aquifer unit and consists of stratified gravel, sand, reworked tuff, clay and conglomerate. It is upwards of 900 feet thick (Napa County Flood Control and Water Conservation District, 1991) with reworked pumice from the underlying Sonoma Volcanics in the lower 200-300 feet. A few small exposures of the Huichica Formation exist along the southern rim of the area, although it is generally overlain by young alluvium and Pleistocene terrace deposits.

While the Huichica Formation is the primary aquifer for the Carneros Subarea, it is considered a low permeability unit with well yields generally less than 5 gpm. The underlying Sonoma

Volcanics do not contribute significantly to pumping, although local variations may exist. Recent alluvium and terrace deposits are also not significant aquifers as they are thin and generally lie above the water table. In the Carneros Valley only about 10 wells or test holes of record exist with low yield shallow domestic wells and dry test holes prevalent.

2.5.4 Southern Area

In the southern area of the County, the Great Valley Sequence is exposed in small faulted knobs and as part of a larger body of Mesozoic basement rocks to the southwest toward Benicia.

The Tertiary marine sedimentary rocks are exposed in two small areas of the southern area. The largest exposure is to the east in the Jameson Canyon Subarea where the rocks appear to overlie the Mesozoic basement rocks to the south, and are overlain to the north by the Sonoma Volcanics. A second, smaller exposure is present in the Congress Valley area where the Domengine sandstone is in fault contact with the Mesozoic basement rocks to the west and overlain by Sonoma Volcanics to the east. In the rest of the southern area, the extent and configuration of the Tertiary sedimentary rocks are not clear since they are covered by younger Cenozoic sedimentary deposits.

South of the larger exposed areas of Huichica Formation and East of the Napa River in the southern area, it is difficult to separate the Huichica Formation from the younger overlying sedimentary deposits due to the similarity of the lithology reported on the water well drillers reports.

The alluvium in the southern area is dominated by the estuarine and marshland deposits exposed at the surface. Alluvial fan deposits extend outward into the marshlands, especially from the east. The nature of the alluvium in the subsurface is poorly known due to a lack of well control, especially further south. The alluvium appears to be dominated by thick silt and clay beds a with few thin sand and gravel beds.

There are only about 200 wells or test holes of record occur in the southern area and most of these are located north of the marshlands or east of the Napa River. Well yields are generally low to modest, although a few higher yields are reported. In the Jameson Canyon Subarea, only about ten wells and test holes of record occur; these are dominantly shallow domestic wells of low yield (1 gpm or less) or dry test holes. It appears from the available wells and test holes of record that the Tertiary marine sedimentary rocks are poor groundwater producers either because of low yields (a result of the consolidated and/or fine-grained nature of these rocks) or poor water quality (saline).

2.6 Recharge Areas

The distribution and quantity of groundwater recharge occurring in Napa County is primarily a function of the geologic units which precipitation encounters, either as rainfall or runoff. Johnson (1977) performed a series of seepage experiments on the major creeks and tributaries in and around the MST Subarea to determine the primary mechanisms of groundwater recharge. A seepage experiment consists of several streamflow measurements taken along the length of a stream to quantify streamflow gains and losses. The stream is considered losing where streamflow decreases between measurements, and gaining where streamflow increases. He concluded that the infiltration rate from precipitation and runoff is greatest where tuffs are exposed or underlie shallow Quaternary deposits. Additionally, only a small percentage of groundwater recharge was found to come from direct precipitation, but instead it is greatest where streams and tributaries come in contact with tuffs. Farrar and Metzger (2003) similarly analyzed seepage gains/losses for various creeks and tributaries in the MST. They concluded that significant streambed infiltration also occurs where streamflow passes over unconsolidated, highly permeable, alluvial deposits.

Based on the findings of Johnson (1977) and Farrar and Metzger (2003), a map was created to locate areas of greatest recharge potential. This map shows the location of exposed tuffs throughout the county (**Figure 2.9**). Sonoma Volcanics sedimentary deposits and various alluvial units found countywide were also included in the map following findings by Farrar and Metzger (2003). Areas in which the slope of the land surface exceeds 30 degrees, beyond which recharge potential is significantly reduced, were also added to the map.

Two sizeable exposures of rhyolitic ash-flow tuff and related alluvium occur in the northern portion of the Eastern and Western Mountains near Calistoga. The eastern exposure covers roughly 30 square miles with tuff in the north and Sonoma Volcanics sedimentary deposits to the south. Following Johnson (1977), the greatest recharge would be expected along Bell Creek, which traverses much of the northern tuffs, and Conn Creek, which passes over large Sonoma Volcanic sedimentary deposits in Conn Valley, some of which are covered by younger alluvium. The Western Mountains exposure, which covers roughly 18 square miles, is almost entirely tuff, with a single Sonoma Volcanics sedimentary deposit in the north at Cyrus Creek. Again, following Johnson (1977), the greatest recharge potential would be expected along York, Mill, Richie, Nash, and Cyrus Creeks (**Figure 2.9**). Although concealed below the Napa Valley Floor, it is likely that the two exposures are connected at depth. It is expected that much of the water recharged through these two exposures eventually reaches the aquifer units of the Napa Valley Floor and flows to the south.

Another significant tuff exposure occurs to the east of the MST, which is discussed in depth in a later section. Other isolated exposures are found throughout the western portion of the county, including one in the Western Mountains along Redwood Creek, which may significantly influence local groundwater conditions. Additional local recharge occurs in the various alluvium filled valleys in the eastern portion of the county. The most significant area of groundwater recharge for the entire county occurs along the Napa Valley Floor in the Calistoga, St. Helena, Yountville, and Napa Subareas.

2.6.1 Napa Valley Floor

Groundwater recharge to the alluvium of the Napa Valley Floor (Calistoga, St. Helena, Yountville, and Napa Subareas) occurs by infiltration of precipitation, percolation from streams/rivers, and subsurface inflow from the surrounding subareas (**Figure 2.9**). The high permeability of the alluvial sediments permits precipitation and surface water to readily infiltrate and recharge groundwater throughout the majority of the valley. These high permeability soils combined with the large volume of water that flows through the Napa River create the potential for significant recharge to occur.

According to Faye (1973), this potential is restricted by high groundwater levels around the Napa River. According to the *Napa Baseline Data Report* (2005), recharge in the northern Napa Valley occurs primarily from direct infiltration of precipitation, and to a lesser extent, from irrigation and streambed percolation.

Data relating to groundwater inflow to the Napa Valley from surrounding subareas is limited to the MST. Johnson (1977) estimated that outflow from the MST into the Napa Valley was roughly 2,050 acre-feet per year (afy). Subsequently, Farrar and Metzger (2003) estimated that 600 acre-ft/yr of groundwater was entering the Napa Valley from the MST; they noted that the difference between their estimate and Johnson’s closely matches the increase in groundwater pumping in the MST between 1975 and 2000.

2.6.2 Milliken-Sarco-Tulucay

To the east of the MST Subarea a series of tuff exposures occur along Milliken, Sarco, Hagan, and Tulucay Creeks (**Figure 2.10**). Milliken, Sarco and Hagan Creeks flow into the MST Subarea where each crosses a large body of Sonoma Volcanics sedimentary deposits. Farrar and Metzger (2003) measured the greatest stream losses (16.5 acre-feet per day, (afd)) along Milliken Creek where alluvial fan and Sonoma Volcanics sedimentary deposits overlie a thick tuff deposit (**Figure 2.8, A-A’**). Streambed infiltration was significantly lower in the Sarco and Tulucay Creeks (0.1-1.1 afd), where low permeability diatomaceous deposits are either found in place of or covering tuff deposits (**Figure 2.8, B-B’ and C-C’**).

2.6.3 Carneros

The Carneros Subarea is predominantly low permeability Huichica Formation with only minor tuff and alluvial deposits (**Figure 2.11**). The tuff deposits, located along the eastern and westernmost borders of the area are not expected to be significant sources of groundwater recharge, primarily due to their limited size and lack of proximity to surface water. Recharge within alluvial deposits along the Huichica and Carneros Creeks, as well as other nameless tributaries, is a significant source of recharge (Jones & Stokes et al., 2005), although this is most likely restricted by the underlying low permeability Huichica Formation and Sonoma Volcanics. Other sources of recharge may include inflow from the Western Mountains, Napa Valley or infiltration through local concentrations of coarse-grained materials within the Huichica Formations. More data would be necessary to determine where and to what extent recharge is occurring within the Carneros Subarea.

2.6.4 Recommendations

Understanding the volume of and mechanisms driving groundwater recharge in the county will be essential in determining where and how much groundwater can be produced without incurring negative impacts. Currently, evaluation of recharge mechanisms and volumes within Napa County has been limited to the Napa Valley (Faye, 1973) and MST Subarea (Johnson, 1977; Farrar and Metzger, 2003). With the exception of Farrar and Metzger (2003), these studies are not able to account for the significant increase in groundwater pumping and accompanying geologic data available since the 1970s. Developing a comprehensive understanding of recharge within Napa County will require:

- Updating the current geologic conceptualization to include more recent data;
- Refining and further characterizing those areas of greatest recharge potential, with priority given to those areas with the greatest short- and long-term growth potential;
- Continued monitoring and analysis of precipitation, streamflow, and groundwater levels;
- Expanding current monitoring to include a greater portion of Napa County;
- Analyzing groundwater/surface water interactions and the influence of increased pumping on groundwater recharge from surface water; and
- Estimating the contribution of infiltration along fractures and joints to local and regional groundwater.

In addition to the tasks outlined above, a complete analysis of the Carneros Subarea, similar to those of Johnson (1977) and Farrar and Metzger (2003) in the MST, should be performed. Presently, very little data are available describing the hydrogeologic setting of the Carneros Subarea. The available data, though limited, suggest that groundwater resources are limited and may be susceptible to development. Future planning decisions will require knowledge of current groundwater conditions and the possible impacts that may result from additional pumping. Current conditions, including groundwater levels, water quality, recharge/discharge estimates, extent of aquifer materials, and the influence of natural and induced hydrologic stresses occurring in neighboring subareas should be investigated since little is currently understood. With time, similar studies should be completed for the Pope Valley, Angwin, Napa River Marshes, and Jameson/American Canyon Subareas where development exists or is planned.

2.7 Identification of Saltwater Intrusion Areas

Maximum observed chloride, total dissolved solids (TDS), and sodium concentrations for Napa County are shown in **Figures 2.12, 2.13, and 2.14**. Colors are assigned based on California drinking water standards with the highest concentration category corresponding to the maximum contamination level (MCL) for that constituent. The highest concentrations of each constituent are observed in the Napa River Marshes, Jameson/American Canyon, and Carneros Subareas. The highest observed chloride (3,020 milligram per liter (mg/L)) and sodium (956 mg/L) values occur in well 004N004W04C003M, which is located roughly 2 miles west from the Napa County Airport, near the divide between the Carneros and Napa River Marshes Subareas. Other wells of interest occur along the eastern edge of the Carneros Subarea, close to the Napa River Marsh Subarea, and about 1 mile southeast of the Napa County Airport. One well at the southern end of Lake Berryessa and another well in the southeastern section of the Central Interior Valleys Subarea also exhibit MCL exceedances for chloride and TDS, although it is not likely that these values are related to saltwater intrusion.

Groundwater quality and well construction data for the three subareas of interest are very limited, making it difficult to conclusively determine the source and distribution of observed salinity. For example, it is not clear whether high salinity groundwater in the Carneros Subarea is a result of saltwater intrusion or interaction of groundwater with the geologic units present in and around the subarea. Also, geophysical logs for two oil and gas wells located directly to the south of Napa County on San Pablo Bay do not show any conclusive saltwater occurrence between 80 and 1,500 feet below ground surface. More data will need to be collected for this area to determine if, and to what extent saltwater intrusion may be occurring. A series of multi-level monitoring well clusters should be installed stepping south from Napa to the southern extreme of the county, with geophysical logs, to more properly define the nature of groundwater in this area.

2.8 Summary and Recommendations

The geology of Napa County can be divided into three broad geologic units based on their ages and geologic nature. These units, with their corresponding subunits are:

- **Mesozoic Basement Rocks** (pre-65 my) – underlie all of Napa County, primarily exposed in the Eastern County area and the Western Mountains Subarea.
  - <u>Great Valley Sequence</u>
  - <u>Coast Ranges Ophiolite</u>
  - <u>Franciscan Complex</u>

- **Older Cenozoic Volcanic and Sedimentary Deposits** (65 my to 2.5 my)
  - <u>Tertiary Marine Sedimentary Rocks</u> (65 my to pre-10 my) – very limited exposures; confined to the southern portion of the County
  - <u>Tertiary Sonoma Volcanics</u> (Miocene and Pliocene; 10 my to 2.5 my) – found throughout the County, especially in the mountains surrounding Napa Valley

- **Younger Cenozoic Volcanic and Sedimentary Deposits** (post 2.6 my to present)
  - <u>Huichica Formation</u> (Plio-Pleistocene, post 2.6 my) – confined to the southern area of the County
  - <u>Clear Lake Volcanics</u> (Pleistocene, 2 to 1.3 my) – confined to northern section of the eastern area of the County
  - <u>Quaternary Sedimentary Deposits</u> (Pleistocene to Holocene, 2.6 my to present) – found in valleys throughout the County

The two primary water-bearing units for Napa County are the tuffaceous member of the Sonoma Volcanics and the Quaternary alluvium, although water is extracted from all of the units mentioned above. It is not generally possible to separate pumping of the tuffaceous member of the Sonoma Volcanics from the other units since well construction data is typically sparse. Yields for wells completed in the Sonoma Volcanics range from <10 gpm to several hundred gpm in some rare locations. Faye (1973) reported well-test information which showed an average yield of 32 gpm and an average specific capacity of 0.6 gallons per minute per foot of drawdown. Groundwater production from Quaternary alluvium is variable, with yields ranging from <10 gpm in the Eastern and Western Mountains, to as much as 3,000 gpm along the Napa Valley Floor where the alluvium is thickest (>200 feet). The average yield of wells completed in the alluvium is 220 gpm with an average specific capacity of around 10 gallons per minute per foot of drawdown (Faye, 1973). Many wells drilled in the alluvium within the last 30 years extend beyond the alluvium and into the underlying materials (typically Sonoma Volcanics). Yields from other water-bearing units tend to be <10 gpm, with highly variable specific capacities, although exceptions do exist.

Outside of the Napa Valley Floor, percolation of surface water appears to be the primary source of recharge. The rate of recharge within the MST has been shown to be significantly higher where streams and tributaries cross highly permeable outcrops, like the tuffaceous member of the Sonoma Volcanics, or shallow alluvium overlying highly permeable aquifer units. Direct infiltration of precipitation is a major component of recharge in the main Napa Valley. Recharge throughout much of the county is generally limited by underlying shallow bedrock of low permeability. An additional component of groundwater recharge, which has not been accounted for in previous studies, is deep percolation through joints, fractures, and faults. This type of recharge can be very difficult to quantify due to the highly variable size and distribution of faults, fractures, and joints in a given area.

Maximum measured chloride, TDS, and sodium concentrations were plotted (**Figures 2.12, 2.13, and, 2.14**) to identify those areas where salt water intrusion may be occurring. The highest concentrations of each constituent are observed in the Napa River Marshes, Jameson/American Canyon, and Carneros Subareas. A lack of groundwater quality and well construction data for these areas is a limiting factor in determining the source and distribution of salinity. Geophysical logs for two oil and gas wells located directly to the south of Napa County on San Pablo Bay, which do not show any conclusive saltwater occurrence between 80 and 1,500 feet below ground surface, introduce some uncertainty concerning the vertical distribution of salinity in groundwater.

Understanding the hydrogeology of Napa County is essential to determine how much water is available and to what extent it can be sustainably produced. To develop a more complete and current understanding of the hydrogeology of Napa County, the following is recommended:

- Cross sections from Kunkel and Upson (1960) for the Napa Valley should be updated, applying 50 years of new log data and plate tectonics theory;
- New cross sections be added throughout the County with priority given to those areas with the greatest short- and long-term growth potential;
- Both mass balance and streamflow infiltration methods be used to estimate regional and local recharge; and

- Groundwater/surface water interactions and the influence of increased pumping on groundwater recharge from surface water should be analyzed.

The geology of the MST Subarea has been studied in depth, both previously (Johnson, 1977) and more currently (Farrar and Metzger, 2003), and is therefore not in urgent need of further attention to define subsurface structural features.

3.0 DATA MANAGEMENT SYSTEM (DMS)

The Napa County DMS was recently developed to establish a centralized repository for recording and archiving countywide well construction data (as related to groundwater monitoring wells), historical groundwater level and quality measurements, and pumping data. In addition, a technical memorandum was prepared (LSCE, 2010b) that summarized the data in the DMS and included procedures for analyzing data on a programmatic basis. The current composition of the DMS focuses on groundwater-related data; however, some surface water information has been incorporated. In the future, the database could be expanded to include additional surface water data or other data that are currently located in other Napa County agency databases.

The DMS has five key attributes, including: 1) flexibility for importing data from and exporting data to other systems, 2) sufficient capacity to store existing (qualified) historical data, 3) ability to export data to numerous kinds of commercially available software, 4) ability to transition to a larger data management system in the future, and 5) a widely available interactive platform. It is anticipated that the County will, in the future, be able to export data from the core database to software programs that allow three-dimensional or animated depiction of the data in addition to accessing the well information and data via a geographic information system (GIS) based interface.

At this stage, the emphasis has been to establish the DMS structure, ensure the quality of the historical and baseline water quality data that have been and/or will in the future be entered by the County, establish procedures for the ongoing quality control of future data compilation and entry into the core database, and develop procedures for preliminary data evaluation. In addition, procedures can be developed to enable the transfer of data to the DWR as part of the California Statewide Groundwater Elevation Monitoring (CASGEM) Program mandated by Senate Bill SBX7- 6, or other central data repositories, as applicable.

The work to develop the DMS included the following items:

- **Data Collection:** Groundwater data available in electronic form was collected from such sources as DWR, U.S. Geological Survey, California Department of Public Health, State Water Resources Control Board, and Napa County.

- **Data Management System:** Provided details on database structure and format, types of data entered and suggestions for additional entries, procedures for data entry and customized output, and quality control.

- **Current Groundwater Monitoring:** Provided an overview of the groundwater monitoring currently being conducted by federal, state, local, and two public wastewater treatment entities in Napa County.

- **Data Security:** Described data confidentiality and security issues that need to be recognized when using, displaying, and exchanging data.

- **Recommendations:** Summarized recommendations for future actions, including reconciling data discrepancies; addressing data information needs (e.g., actual or more accurate sampling locations); expanding the historical data set, including data from other entities having less accessible information or data that exist in a hard copy format; collaboration and cooperation with other County departments to build the DMS as a centralized County data repository; and facilitating use of the DMS by non-database users through additional software that provides a GIS map-interface tool.

3.1 Data Collection

Several different public agencies collect and maintain groundwater data, including the DWR, the U.S. Geological Survey (USGS), the California Department of Public Health (DPH; GeoTracker-GAMA), and the State Water Resources Control Board (SWRCB; GeoTracker). These sources can be accessed through the SWRCB website that summarizes the current data and databases available on the web at www.waterboards.ca.gov/resources/data_databases/. These programs and publicly available databases are continually evolving to expand and merge to create a more useful and powerful network of information. Data collection methods and sources will likely change in the future, but the current methods and sources are summarized below.

These data sources were combined with Napa County's own records in order to populate the Napa County DMS. **Table 3.1** lists the agencies and data accumulated along with the number of wells and period of record in the DMS. Generally, well construction, well location, groundwater levels, and groundwater quality results were obtained and entered into the database, where available, from the agencies described. Additionally, surface water quality data were incorporated into the DMS, where readily available; however, surface water data were not a focus for this project. Key sources of data for development of the DMS are described below.

Table 3.1
Current Groundwater Monitoring, Napa County

Agencies	Last Measured WQ	Current Number of Water Quality Sites	Last Measured WL	Current Number of Water Level Sites
DWR	2008	5	2009	29
DPH	2009	114	NA	NA
SWRCB	2010	793	2010	476
USGS	2002	0	2001	0
Napa County	2009	8	2009	110

3.1.1 California Department of Water Resources

DWR maintains a variety of databases that contain hydrologic data for the State of California, including the Water Data Library (WDL), the Water Data Information System (WDIS) and the WellMA database. For Napa County, the WDL consists of water level measurements (1918 to present) and the WDIS consists of water quality results (1944 to present). Water level data in the WDL have been through DWR's quality assurance/quality control (QA/QC) checks, while no such process is in place for the WDIS, and these data are included 'as is' without the usual corresponding analytical information. No additional QA/QC was conducted during the incorporation of the WDL and the WDIS data into the DMS. Out of 166 wells with water levels from DWR in the database, 135 have some construction information (at least well depth) provided through a special request to DWR's Central District. 23 of those 135 wells with construction information have associated water quality data from the DWR WDIS.

In addition to water level and quality data, well log data from DWR were also obtained in different formats. One format was in the form of a compact disc which contained over 7,700 scanned and indexed well logs for wells located in Napa County. These scanned images are not included in the physical DMS, however, they are available for Napa County as a separate index file and collection of images. Incorporation of information from the scanned well logs into the database could be done in the future. However, the data contained on many of these well logs are already entered into a formatted data table by DWR's Central District in the form of their "WellMA" database. The WellMA database included well construction, well use, yield, owner, and some location information for 6,231 wells in Napa County. These data are currently incorporated into the DMS as a separate table unrelated to the water level and water quality records. Most of the WellMA data do not include specific locations (detailed latitude and longitude coordinates) or an official State Well Number which would allow the well data to be linked to water level and quality data obtained from the WDL and WDIS databases or other agency databases.

3.1.2 U.S. Geological Survey

The USGS maintains a publicly accessible database of water quality and groundwater level information (National Water Information System, or NWIS database). The NWIS database has water quality and/or water level data for 396 groundwater sites in the Napa region. Sites and related data were queried and downloaded from NWIS based on a latitude/longitude coordinate box of 38º00'00"N /122º00'00"W - 38º50'00"N /122º47'00"W. Of those 396 sites, 176 are located outside Napa County and 220 are located within Napa County according to the latitude/longitude coordinates provided by the USGS. These locations have not been verified, but they are believed to be generally accurate. All 220 sites within Napa County have historical groundwater level and/or groundwater quality data. Of the 220 groundwater sites in Napa County, the NWIS database provides some well construction information, including construction date, well depth, and/or borehole depth information on 198 of the sites. All USGS NWIS data have undergone QA/QC by the USGS. The NWIS groundwater level data included in the DMS span from 1920 to 2007 while the groundwater quality data range from 1949 to 2008. However, within the County, no direct monitoring by the USGS has occurred since 2002. Data reported by the USGS since 2002 have been collected by other agencies and shared with the USGS.

Additionally, there are 98 surface water sites with associated historical water quality data; 30 of those sites are located outside of Napa County based on the coordinates supplied by the USGS.

3.1.3 California Department of Public Health

DPH's Drinking Water Program is within the Division of Drinking Water and Environmental Management. The Drinking Water Program regulates all public drinking water systems in the state. Water quality information for public drinking water systems in California is stored in a database for large (>199 connections) and small (five to 199 connections) public drinking water systems. Many local agencies at the county level regulate smaller public drinking water systems, including Napa County's Environmental Management Department. Water quality data that are collected by the public drinking water systems are reported to DPH and entered into the DPH database. Records for Napa County were exported from DPH's statewide water quality database and incorporated into the DMS (LSCE, 2010a).

These records include data for 433 sites in Napa County, and they are identified in the DMS by the DPH Primary Station Code. Each site has a corresponding System Number and Source Name and other site specific information and related data that were incorporated in the DMS from the DPH database. The sites have been interpreted as a groundwater (290 sites), surface water (21 sites), or other unknown type (122 sites) based on the DPH designated Source Name and Status. Some of the currently 'unknown' types may represent a groundwater or surface water source, and therefore, are still included in the DMS. Of the 290 groundwater sites, 197 sites have related water quality data.

Current versions of the DPH database do not include site x-y coordinate information as had been previously included prior to September 2001. However, most of the groundwater sites have been assigned a latitude/longitude from two additional sources, the SWRCB GeoTracker-GAMA website (newly available as of November 2009 and currently in beta testing) and an older version of the DPH database. Similar to the GeoTracker-GAMA coordinates' level of precision, the coordinates from the older DPH database that have been incorporated in the DMS, have been sufficiently generalized (to the nearest 0.001 of a degree) so that exact well/facility location cannot be determined to within 350 feet.

3.1.4 State Water Resources Control Board

The SWRCB stores environmental data for regulated facilities in California in their GeoTracker database, including groundwater levels and groundwater quality. Data from these regulated facilities usually consist of data from groundwater monitoring wells (typically shallow) associated with each site location. In Napa County, there are 101 GeoTracker sites with 1,715 wells (including extraction and monitoring wells). 1,667 of these wells have water level or water quality data between 1998 and 2010. Out of the 1,715 wells, 414 have well construction information. The identifier for each well is the concatenated text string of the Global ID and the

Field Point Name. These well and site identifiers, and well construction information, where available, have been incorporated in the DMS.

3.1.5 Napa County

Napa County's groundwater level records from 1949 to 2009 were incorporated into the DMS. 148 wells of various uses (domestic, irrigation, public, or unknown) are included in this data set. Well construction information is available for 52 of the sites. Several wells have well diameter and well yield information. The historical records contained in the County's dataset are from the DWR and/or USGS monitoring programs. They are associated by their common State Well Number (SWN) and can to be grouped in the DMS on the SWN field.

3.2 Current Groundwater Monitoring

Currently in Napa County, groundwater monitoring is being conducted in over 300 wells (**Table 3.1**). These data are being collected either directly by or are being submitted to DWR, DPH, SWRCB, and the County. Since 2007, most groundwater level monitoring has been conducted by regulated facilities that submit data to the SWRCB/RWQCB and also by Napa County. Some limited groundwater level monitoring also occurs by the DWR. Since 2008, most groundwater quality monitoring has been conducted for community water systems, and those data are submitted to DPH. Very limited groundwater quality monitoring has been conducted by DWR.

Groundwater level monitoring is primarily conducted in the Napa Valley Floor portion of Napa County as shown in **Figure 3.1**. Within the Napa Valley Floor Subarea, the majority of the monitoring is conducted in the southern portion of the subarea.

Groundwater quality monitoring is more dispersed in Napa County as compared to the groundwater level monitoring locations (**Figure 3.2**). Most groundwater quality monitoring occurs in the Napa Valley Floor; some monitoring also occurs in the Eastern Mountains, Western Mountains, Carneros, Knoxville and the Berryessa Subareas.

3.3 Data Security

Several components of the DMS contain confidential information and should, therefore, not be made publicly available. For example, well owner information, private and public well construction information, particularly drillers' reports, received from DWR are confidential. Similarly, well location information for wells from the DPH database should remain confidential for the necessary security of these public water supplies. Any maps prepared from data in the DMS should represent well locations with large symbols without local roads as a reference. Well construction information should only be discussed or displayed in general terms by assigning a well to an aquifer zone based on well construction information. Individual well construction information should not be disclosed to the public.

3.4 Summary and Recommendations

As part of the program to establish the core DMS, LSCE entered historical groundwater level data available from DWR, the USGS, the SWRCB and the County. Groundwater quality data as available from these entities as well as from the SWRCB GeoTracker program and DPH were also incorporated. A previous technical memorandum (Task 1; LSCE, 2010a) includes additional details on the DMS including the following:

- Details on database format, types of data incorporated in the DMS, procedures for data entry, and information on the QA/QC of existing data.
- Summary of monitoring programs currently conducted by state, local, and private entities in Napa County.
- Preparation of automated data queries, tabular and graphical output, and report formats in the DMS.

At the outset of the development of the DMS, it was recognized that the County would assist with the entry of other historical groundwater level and groundwater quality data which were not readily available in electronic format. It was anticipated that future County staff time would be needed for this effort and also to incorporate well construction information for wells historically monitored in the County, recent surface water delivery information (as desired) and municipal pumping data, and especially for checking the functionality of the system. Other recommendations for refinements to the DMS are provided below:

- It is important to remove redundancy in the groundwater level and groundwater quality data. This can occur when two sources of information provide identical or similar data for the same well. The wells with redundant data need to be identified and flagged as such. Then the duplicated data (water level or quality) need to be examined and appropriate steps taken to remove the redundancy. Several wells and their related data are reported by more than one agency. **Table 3.2** is a list of 180 wells that are reported by all or one of the following agencies: DWR, Napa County, or USGS. The historical data from the various entities need to be merged and one Well ID should remain for each physical well.

- Currently, the WellMA table is not linked to wells in the main database tables. This is due to the lack of a complete SWN in the WellMA table. SWNs need to be determined or, where driller's report numbers are provided, the wells in the well table {T_Well} in the DMS need to be linked with the wells in the WellMA table.

- The monitoring agency and/or schedule of monitoring for water quality and groundwater levels of each well should be indicated in Monitoring Table {T_Monitor} for each well.

- Location data for several DPH and GeoTracker wells were unavailable at the time of download and entry to the DMS. These data should be requested from the respective source agencies and appropriate measures taken to ensure data security.

- Locate wells that have water level or water quality measurements but do not yet have x-y coordinates and assign them to their applicable geographic subareas. Additionally, verify coordinates to confirm the location of a site as in or outside of Napa County. Upon verification that coordinates for a site are correct and that the site is located outside of Napa County, that site and the related data may be removed from the DMS.

- Continue to fill in the Water Quality Parameter table with abbreviated (short) parameter names as necessary.

- Some groundwater level data contain measuring point discrepancies. These differences may arise when a well gets surveyed and the measuring point changes. There also might be errors in the reference point elevations; in this case, the reporting agency should be notified to resolve the error. For example, one well, 05N03W06M001M with water level data from DWR, has reference point elevations of 130.6 feet and 280 feet. This type of difference is significant and unacceptable. Other differences in reference point elevations are smaller, several are less than one foot, but the differences should be considered when making interpretations of water level changes and should, therefore, be rectified.

- To enhance DMS data viewing and retrieval by non-database users, it is suggested that a map-interface be established that allows for the display of well locations and the ability to click on the well location on the map to view or retrieve its various properties (for example a hydrograph of water levels, water quality tables, construction information, etc.).

- In the future, data entry is anticipated to be a cooperative effort overseen and managed by the County. The County would have overall responsibility for the centralized DMS; however, other entities (e.g., other County departments and potentially other entities in the County) could assist with the creation of data sets to be imported to the main database. Quality control protocols for merging newly entered data into the core database are recommended to avoid duplication.

Table 3.2
Well List by State Well Number that are reported by more than one entity.

SWN	DWR	Napa County	USGS
004N004W02L001M	04N04W02L001M		381316122162401
004N004W04C001M	04N04W04C001M		381348122183601
004N004W05B001M	04N04W05B001M		381348122190901
004N004W05D002M	04N04W05D002M		381338122194801
004N004W12M001M	04N04W12M001M		381225122154301
004N004W14C002M	04N04W14C002M		381153122162801
004N004W25K001M			380945122150301
005N003W05M001M	05N03W05M001M		381818122133201
005N003W06A001M	05N03W06A001M		381858122132601
005N003W06B002M	05N03W06B002M		381831122140501
005N003W06E002M		NapaCounty-104	381842122142901
005N003W06J002M		NapaCounty-9	381821122134001

Table 3.2 (cont.)
Well List by State Well Number that are reported by more than one entity.

005N003W06J003M		NapaCounty-10	381819122134001
005N003W06K002M		NapaCounty-6	381819122135301
005N003W06L001M		NapaCounty-90	381830122141201
005N003W06L002M		NapaCounty-94	381824122140801
005N003W06M003M		NapaCounty-74	381820122144001
005N003W06N004M		NapaCounty-63	381814122142901
005N003W06N005M		NapaCounty-73	381807122143401
005N003W06N006M		NapaCounty-61	381814122143101
005N003W06P002M		NapaCounty-89	381815122141901
005N003W06P003M		NapaCounty-62	381809122141401
005N003W06Q003M		NapaCounty-7	381815122135201
005N003W06Q004M		NapaCounty-105	381815122135101
005N003W06R001M		NapaCounty-8	381817122134901
005N003W06R002M		NapaCounty-17	381813122133701
005N003W06R003M		NapaCounty-106	381813122134101
005N003W07C003M	05N03W07C003M	NapaCounty-20	381744122141901
005N003W07C004M		NapaCounty-85	381802122142001
005N003W07C005M		NapaCounty-86	381804122141501
005N003W07D003M		NapaCounty-72	381801122144201
005N003W07D004M		NapaCounty-71	381753122143901
005N003W07E004M		NapaCounty-78	381744122142801
005N003W07E005M		NapaCounty-70	381748122143601
005N003W07E006M		NapaCounty-77	381744122143201
005N003W07E007M		NapaCounty-79	381746122143301
005N003W07E008M		NapaCounty-16	381744122142701
005N003W07F001M		NapaCounty-24	381749122141801
005N003W07F002M		NapaCounty-84	381751122142001
005N003W07F003M		NapaCounty-81	381748122142401
005N003W07F004M		NapaCounty-82	381748122142402
005N003W07F005M		NapaCounty-83	381749122142501
005N003W07F006M		NapaCounty-80	381748122142501
005N003W07M004M		NapaCounty-32	381732122142801
005N003W07N002M		NapaCounty-34	381717122143501
005N003W07N003M		NapaCounty-33	381720122143601
005N003W07P001M	05N03W07P001M		381700122141301
005N003W08E001M		NapaCounty-22	381746122133101
005N003W18D001M		NapaCounty-35	381712122144101
005N004W01F002M		NapaCounty-27	381831122153001
005N004W01F003M		NapaCounty-29	381841122152401
005N004W01L001M		NapaCounty-28	381830122152001
005N004W01R002M		NapaCounty-60	381809122145101
005N004W03G001M	05N04W03G001M		381837122170901
005N004W04G001M	05N04W04G001M		381833122181901
005N004W04Q001M	05N04W04Q001M		381813122181601
005N004W05P001M	05N04W05P001M		381814122193601

Table 3.2 (cont.)
Well List by State Well Number that are reported by more than one entity.

005N004W05P002M	05N04W05P002M		381815122193701
005N004W11F003M	05N04W11F003M		381742122162601
005N004W12B004M		NapaCounty-25	381753122151001
005N004W12B005M		NapaCounty-26	381755122151001
005N004W12F001M	05N04W12F001M		381746122151901
005N004W12G001M		NapaCounty-14	381740122150201
005N004W12H001M	05N04W12H001M		381747122144501
005N004W12H002M		NapaCounty-15	381744122145001
005N004W12J002M		NapaCounty-13	381738122145701
005N004W13G004M		NapaCounty-18	381648122151501
005N004W13H001M	05N04W13H001M	NapaCounty-137	381700122145001
005N004W13H003M		NapaCounty-36	381649122144901
005N004W13J001M		NapaCounty-19	381646122145601
005N004W14C001M	05N04W14C001M		381710122162501
005N004W14J003M	05N04W14J003M		381644122154601
005N004W15C002M	05N04W15C002M		381702122173501
005N004W15E001M	05N04W15E001M		381652122174901
005N004W19R002M	05N04W19R002M		381538122201801
005N004W20R002M	05N04W20R002M		381532122191101
005N004W21B001M	05N04W21B001M		381616122181701
005N004W22M001M	05N04W22M001M		381550122175501
005N004W28R001M	05N04W28R001M		381442122180401
005N004W29H001M	05N04W29H001M		381513122191101
006N003W30P001M		NapaCounty-58	381958122141601
006N003W31B001M	06N03W31B001M		381942122135301
006N003W31D001M		NapaCounty-65	381941122143201
006N003W31H001M	06N03W31H001M		381926122134501
006N003W31N002M	06N03W31N002M		381910122143401
006N003W31N003M		NapaCounty-39	381904122143001
006N004W05R001M	06N04W05R001M		382323122190101
006N004W06L002M	06N04W06L002M	NapaCounty-134	382342122205501
006N004W06N001M	06N04W06N001M		382318122205801
006N004W07N001M	06N04W07N001M		382230122211001
006N004W09Q001M	06N04W09Q001M	NapaCounty-125	
006N004W09Q002M	06N04W09Q002M	NapaCounty-126	
006N004W14Q001M		NapaCounty-4	382143122160301
006N004W15Q001M	06N04W15Q001M		382134122171301
006N004W17A001M	06N04W17A001M		382218122190101
006N004W17R002M	06N04W17R002M	NapaCounty-139	382138122191001
006N004W19B001M	06N04W19B001M	NapaCounty-135	382121122203401
006N004W21G001M	06N04W21G001M		382113122182101
006N004W22R001M	06N04W22R001M		382047122170501
006N004W23B001M		NapaCounty-3	382128122161001
006N004W23J001M	06N04W23J001M		382053122154701
006N004W23Q003M	06N04W23Q003M		382050122160901

Table 3.2 (cont.)
Well List by State Well Number that are reported by more than one entity.

006N004W25E003M		NapaCounty-99	382019122153201
006N004W25G001M		NapaCounty-51	382016122145801
006N004W25J001M		NapaCounty-52	382003122145001
006N004W26B002M		NapaCounty-23	382035122160601
006N004W26F002M		NapaCounty-55	382022122162601
006N004W26G001M	06N04W26G001M	NapaCounty-56	382035122161101
006N004W26G002M		NapaCounty-47	382021122161401
006N004W26G003M		NapaCounty-45	382018122161301
006N004W26R003M		NapaCounty-102	381956122155101
006N004W27N001M	06N04W27N001M	NapaCounty-136	381953122175401
006N004W28K001M	06N04W28K001M		382010122182501
006N004W29B001M	06N04W29B001M		382039122192901
006N004W30C001M	06N04W30C001M		382037122204301
006N004W32J006M	06N04W32J006M		381924122191101
006N004W32L002M	06N04W32L002M		381921122194301
006N004W35G003M	06N04W35G003M		381927122160901
006N004W35G005M		NapaCounty-69	381929122160701
006N004W36A001M		NapaCounty-98	381947122145401
006N004W36E001M		NapaCounty-37	381927122154001
006N004W36G001M	06N04W36G001M		381939122150401
006N004W36H001M	06N04W36H001M		381926122144301
006N004W36H004M		NapaCounty-40	381926122144201
006N004W36H006M		NapaCounty-97	381935122145501
006N004W36H007M		NapaCounty-108	381935122145401
006N004W36K002M		NapaCounty-54	381910122150101
006N004W36P001M		NapaCounty-31	381907122152301
006N004W36R001M		NapaCounty-53	381905122145601
006N005W12R001M	06N05W12R001M		382231122211501
007N004W30L001M	07N04W30L001M		382530122204701
007N004W30M001M	07N04W30M001M		382533122210001
007N004W31M001M	07N04W31M001M	NapaCounty-133	382442122210501
007N004W32B002M	07N04W32B002M		382502122192701
007N005W04E001M	07N05W04E001M	NapaCounty-130	383746122254001
007N005W04R002M	07N05W04R002M		382856122243801
007N005W05A001M	07N05W05A001M		382933122255201
007N005W06J001M	07N05W06J001M		382902122270701
007N005W08A001M	07N05W08A001M		382837122260001
007N005W08M001M	07N05W08M001M		382812122265201
007N005W09Q003M	07N05W09Q003M		382749122250801
007N005W10C001M	07N05W10C001M		382837122241001
007N005W14B002M	07N05W14B002M	NapaCounty-132	382742122224901
007N005W14J001M	07N05W14J001M		382720122222301
007N005W15A001M	07N05W15A001M		382743122233501
007N005W15F001M	07N05W15F001M		382738122241601
007N005W16L001M	07N05W16L001M	NapaCounty-131	382721122251701

Table 3.2 (cont.)
Well List by State Well Number that are reported by more than one entity.

007N005W16N002M	07N05W16N002M	NapaCounty-138	382707122254201
007N005W17B002M	07N05W17B002M		382753122261001
007N005W21G001M	07N05W21G001M		382646122245301
007N005W22E003M	07N05W22E003M		382637122242201
007N005W22H001M	07N05W22H001M		382642122234201
007N005W23D002M	07N05W23D002M		382658122231901
007N005W24P001M	07N05W24P001M		382612122215401
007N005W25A001M	07N05W25A001M		382606122211601
007N005W26D002M	07N05W26D002M		382604122232701
007N005W34C002M	07N05W34C002M		382513122241201
007N005W35F002M	07N05W35F002M		382455122230401
007N006W01A001M	07N06W01A001M		382954122281101
008N005W31H001M	08N05W31H001M		383011122270001
008N005W31P002M	08N05W31P002M		382944122273501
008N005W32K004M	08N05W32K004M		382954122260701
008N006W03M001M	08N06W03M001M		383418122310301
008N006W04F001M	08N06W04F001M		383432122315501
008N006W06L004M	08N06W06L004M	NapaCounty-129	383418122340201
008N006W09D002M	08N06W09D002M		383353122321201
008N006W09H001M	08N06W09H001M		383335122311401
008N006W09H002M	08N06W09H002M		383334122311501
008N006W10Q001M	08N06W10Q001M		383326122311801
008N006W14N001M	08N06W14N001M		383219122295201
008N006W14Q001M	08N06W14Q001M		383219122192001
008N006W23M001M	08N06W23M001M		383146122300201
008N006W24B001M	08N06W24B001M		383212122282901
008N006W25G002M	08N06W25G002M		383103122282601
008N006W26B004M	08N06W26B004M		383122122291601
009N006W31Q001M	09N06W31Q001M	NapaCounty-128	383446122334301
009N007W24L001M	09N07W24L001M		383641122350601
009N007W25N001M	09N07W25N001M	NapaCounty-127	383536122352901
009N007W25N002M	09N07W25N002M		383535122352801
009N007W35K001M	09N07W35K001M		383505122360601

4.0 GROUNDWATER CONDITIONS

Groundwater data availability in Napa County varies widely among the subareas. The bulk of the historical and current groundwater level and quality data is located in the Napa Valley Floor Subarea with limited to no data in the other Napa County subareas. This section presents two separate discussions of groundwater levels and quality, with a focus on groundwater level and quality characteristics by subarea.

4.1 Groundwater Levels

Figure 4.1 illustrates all the well locations in Napa County from which historical groundwater level data are available. Historical groundwater level records from these wells were reviewed to select representative (currently or historically) monitored wells for purposes of illustrating groundwater level trends in each subarea. The locations of these wells are shown in **Figures 4.2, 4.3, 4.4, 4.5, 4.6, and 4.7** along with inset hydrographs. The following discussion of groundwater levels is organized by subarea.

Groundwater level monitoring in Napa County has occurred since the early 1900s at more than 350 sites containing one or more wells. This monitoring has generally been on a semiannual frequency with measurements taken in the spring and the fall. All groundwater elevations are referenced to the NGVD 1929 vertical datum, also commonly referred to as 'mean sea level' (msl).

4.1.1 Napa Valley Floor Subareas

The Napa Valley Floor Subarea is subdivided into five smaller subareas. From north to south these areas are Calistoga, St. Helena, Yountville, Napa, and the MST. The groundwater level conditions in each of these areas are described below.

4.1.1.1 Napa Valley Floor – Calistoga and St. Helena Subareas

The hydrographs for the wells illustrated on **Figure 4.2** show representative groundwater elevations and corresponding depth to groundwater from 1950 to present, as available. Groundwater levels have been generally stable over time and do not exhibit any long-term trends. Groundwater levels are shallow at less than ten feet below the ground surface in the spring. Minor seasonal declines of about 10 feet occur in the fall in the Calistoga and northern portion of the St. Helena Subareas. Elsewhere in the St. Helena Subarea, groundwater levels exhibit greater seasonal declines of about 25 feet. Groundwater levels near the southwestern boundary of the St. Helena Subarea with the Western Mountains Subarea show the greatest seasonal declines on the order of 100 feet.

4.1.1.2 Napa Valley Floor –Yountville and Napa Subareas

The hydrographs shown in **Figure 4.3** show representative groundwater elevations and corresponding depths to water in the Yountville and Napa Subareas. Long-term groundwater elevations have remained for the most part stable in the Yountville Subarea with the exception of the southeastern portion of the subarea where groundwater elevations showed a decline in 2007 and 2008. This decline may be the result of dry climatic conditions that were experienced between 2006 through 2008. In the Yountville Subarea, the depth to groundwater in the spring is generally less than ten feet, similar in nature to the Calistoga and St. Helena Subareas to the north. Seasonal fluctuations vary by proximity to the center of the valley. Along the western and eastern edges of the subarea, levels are more subject to larger seasonal fluctuations. Groundwater elevations in the center of the valley fluctuate seasonally approximately 10 to 25 feet, and near the edge of the valley fluctuate approximately 25 to 35 feet.

In the Napa Subarea, depth to water ranges from about 20 to 50 feet below ground surface during the spring. Long-term trends have been generally stable with the exception of the northeastern area where there has been a 10 to 30 foot decline over the past 10 years. Seasonal groundwater elevations in this subarea generally fluctuate from 10 to 40 feet.

4.1.1.3 Napa Valley Floor – MST Subarea

Several investigators have stated that the primary source of groundwater produced in the MST is the tuffaceous member of the Sonoma Volcanics which is primarily situated in the northern and southern parts of the MST on the eastern side of the Soda Creek Fault (Johnson, 1977; Farrar and Metzger, 2003). Beneath the tuff, and underlying the entire MST, are the andesitic and basaltic lava flows of the Sonoma Volcanics that provide small amounts of water to wells. The northern and southern parts of the MST are separated by the central area that is underlain by the volcanic bedrock at a relatively shallow depth of 100 feet (Farrar and Metzger, 2003).

Representative hydrographs of the MST are illustrated on **Figures 4.4 and 4.5** show representative groundwater elevations and corresponding depth to groundwater since 1950 in the northern (**Figure 4.4**) and central/southern parts of the MST (**Figure 4.5**). In the northern MST, groundwater levels were stable throughout the late seventies until the mid-1980s (1986), at which time a decline of about 10 to 40 feet occurred. Following this decline, groundwater levels stabilized until the late 1990s to early 2000s. Since this time, groundwater levels have experienced a gradual decline of about 10 to 30 feet. Depth to groundwater in the northern part of the MST Subarea currently ranges from about 60 to 200 feet.

An important feature within the northern part of the MST is the Soda Creek Fault that several previous investigators have described as an occasional barrier to groundwater flow. It is described by Weaver (1949) as a normal fault with more than 700 feet vertical displacement downward on the western side. Johnson (1977) and Farrar and Metzger (2003) describe groundwater elevations were about 10 feet higher on the eastern side of the fault during their respective study periods. Recent measurements (post-2000) indicate that groundwater levels are about 10 feet higher on the eastern side of the fault. Long-term data are limited for wells located on either side of the Soda Creek Fault; therefore, trends on either side of the fault over time cannot be identified.

Along Hagen Road, located between the northern and central areas of the MST, groundwater level records are insufficient to make conclusions about long-term trends. Recent data show declining groundwater levels in this area of the MST. Along Sarco Creek/Hagen Road, land surface gradually rises in an eastward direction. In this area, the depth to groundwater in multiple wells along Hagen Road (and along First Avenue) is currently greater than 200 feet, where previously it was about 20 feet below ground surface in the 1960s and 1970s (see hydrograph for 6N/3W-36H1). With limited available data, it appears that there is a constant rate of groundwater level decline of about 5 feet per year over the last eight years.

In **Figure 4.5**, groundwater elevations in the central portion of the MST and near North Avenue show a greater rate of decline and total decline of groundwater elevations over time as compared to wells located further south. The groundwater elevations in the central portion of the MST began to decline in the 1950s and currently have declined up to 250 feet in some locations. The central portion of the MST also corresponds to an area in which the primary aquifer of the Sonoma Volcanics, the tuffaceous member of that unit, is not present. Groundwater levels in the southern portion of the MST, especially south of Coombsville Road, have generally been stable until the late 1990s and early 2000s, when a decline of about 10 to 30 feet in some locations has occurred.

The recent trends in the central MST are similar to those described above in the northern MST along Hagen Road. Based on the groundwater level trends and local geologic conditions, some of these trends may be the result of variations in geologic conditions. To fully evaluate the nature of the trends, additional geologic characterization is recommended.

4.1.2 Subareas South of the Valley Floor

The Carneros, Napa River Marshes, and Jameson/American Canyon Subareas are located south of the Napa Valley Floor. Seven wells have water level data from DWR and the USGS in the CarnerosSubarea, dating back to June 1918 and reaching into March 1978. The Napa River Marshes Subarea has 55 wells from two regulated facility sites with water level data from GeoTracker, having a recent period of record from June 2000 to April 2009. In the Jameson/American Canyon Subarea, 23 wells have water level data from DWR, USGS, and GeoTracker, with a period of record from March 1930 to November 2009. Shallow wells in these subareas are anticipated to be susceptible to tidal fluctuations based on their proximity to the San Pablo Bay, but without higher frequency measurements, these effects are not quantifiable with the dataset available. Groundwater level data from GeoTracker is measured in wells from regulated facilities which can be assumed to be completed at shallow depths.

4.1.2.1 Carneros Subarea

Although the Carneros Subarea does not have recent (post-2005) groundwater level data, the records available in this area indicate that water levels have been generally stable in the 1960s and 1970s with a decline of about 20 to 40 feet in the mid-1970s (**Figure 4.6**). Groundwater elevations in these two decades indicate groundwater moving from higher elevation areas toward the Carneros Creek and to the southeast and east toward the Napa River. Due to the lack of recent groundwater level data in this subarea, these flow directions may have changed due to possible increases in pumping stresses in the Rincon de Los Carneros area.

4.1.2.2 Napa River Marshes Subarea

Groundwater level data in the Napa River Marshes Subarea are limited to the extreme northern portion of the subarea. For the available period of record, groundwater levels are stable between 2000 and 2003, as well as between 2005 and 2009 (**Figure 4.6**). Groundwater levels remain a few feet above sea level. Two sites with monitoring data are not adequate to discuss groundwater flow directions in the entire subarea, but based on topography and assuming that groundwater elevations generally follow topography, groundwater likely flows toward the Napa River and south towards the Bay.

4.1.2.3 Jameson/American Canyon Subarea

Although groundwater level data in the Jameson/American Canyon Subarea spans almost eighty years, the data records are not continuous over that period. Three out of five wells monitored by the USGS or DWR have records of about twenty years ending in the late 1970s, the other two have very early water level measurements in the 1930s then skip to the 1950s or 1960s to continue their records. Three regulated facilities provide groundwater level data from 2002 to 2009 from 18 monitoring wells. As seen in the representative hydrographs in **Figure 4.6**, groundwater levels have been very stable, fluctuating less than ten feet in most cases over the period of record. The groundwater levels indicate a general westward groundwater flow direction out of the Jameson and American Canyons toward the Napa River, and south.

4.1.3 Subareas East of the Valley Floor

Due to the limited amount of sites with groundwater level data, subareas east of the Napa Valley Floor are grouped together in this section. The Eastern Mountains, Angwin, Pope Valley, Central Interior Valleys, Knoxville, and Berryessa Subareas are included in this section, as the Livermore Ranch and the Southern Interior Valleys Subareas do not have any groundwater level information.

The Eastern Mountains Subarea has seven wells with groundwater level data from DWR, USGS, and Napa County, spanning from January 1930 to October 2008. There are two occurrences where two wells, one reported by the USGS and one reported by Napa County, have almost the same latitudes and longitudes and appear to have identical water level records, even though their state well numbers are slightly different. This effectively reduces the number of wells with water level data to five. The five wells are all located on the western edge of the Eastern Mountains Subarea, very close to the Napa Valley Floor. Historical groundwater records from the 1930s to the early 1970s for a well in this subarea, located west of Lake Hennessey, show long-term stable levels. One well monitored by the County (NapaCounty-92), located just east of the MST Subarea boundary (**Figure 4.7**), has a more recent period of record from 1999 to 2008, showing water level declines similar to those seen in the MST Subarea to the west. The eastern groundwater elevations are higher than levels to the west indicating a westward flow direction towards the Valley Floor.

The Angwin Subarea has water level data solely from GeoTracker, consisting of ten wells from one regulated facility with semiannual water level data for three years between April 2002 and October 2004. Groundwater levels were stable within this time period with seasonal fluctuations of less than five feet as seen in one representative well from facility site ID T0605500038 in **Figure 4.7**.

The Pope Valley Subarea also has data solely from GeoTracker, consisting of nine wells from two regulated facility sites with groundwater level data between February 2002 and March 2009. The two groups of wells are located on the western edge of the Pope Valley floor. Both groups of wells show stable water levels within their period of record with seasonal fluctuations around ten feet as seen in their representative hydrographs in **Figure 4.7** (facility site ID T10000000436 and T0605593602).

The Central Interior Valleys Subarea also has data solely from GeotTracker, consisting of 31 wells from three regulated facility sites with groundwater level data between January 2002 and September 2009. The regulated facility sites are all located at the southern end of the subarea around the southern portion of Capell Valley. The groundwater level records indicate that levels have been stable during the period of record, with seasonal fluctuations up to twenty feet. Representative hydrographs for each facility (site ID T0605592744 and T0605500279) are seen in **Figure 4.7**.

The Knoxville Subarea contains five wells with groundwater level data between June 2006 and January 2009 from Napa County. These wells are identified as “LBRID” monitoring wells located on the southern side of Corral Creek, southwest of Putah Creek and east of Spanish Valley. Groundwater levels are relatively stable during the short period of record as seen in LBRID_MW1 and MW5 (**Figure 4.7**).

The Berryessa Subarea contains a total of 52 wells with groundwater level data between January 2002 and October 2009. Water level data from three wells are collected by Napa County, and 49 wells have data from three regulated facility sites from GeotTracker. All of the wells with groundwater level data in this subarea are located along the western coast of Lake Berryessa, and most have stable levels for their periods of record (**Figure 4.7**).

4.2 Groundwater Contours

Previous investigations have created contours of groundwater levels for the main Napa Valley and the MST to indicate the direction of groundwater flow. Contour maps indicate flow from areas of recharge and higher head to areas of discharge and lower head. Kunkel and Upson (1960) published contours for 1949/1950 for the entire Napa Valley and the MST. In the MST Subarea, Johnson (1977) published contour maps for the Spring and Fall of 1975, and Farrar and Metzger (2003) published contour maps for Fall 2001 and Spring 2002. These historical interpretations serve as a basis for comparing flow directions and gradients over different time periods. The 1949/1950 effort represents conditions during the early era of groundwater development in Napa Valley, while 1975 and 2002 efforts illustrate two periods of increasing groundwater development and extraction regimes. These previous investigation efforts are supplemented by more recent contours of equal groundwater elevation in this report.

Over the length of the Napa Valley, groundwater is contained in and moves primarily through the older and younger alluvium from Calistoga to San Pablo Bay, and is assumed for purposes of contouring groundwater data on a regional basis, to represent a single aquifer. In the MST, however, the aquifer system is composed primarily of the Sonoma Volcanics and associated sedimentary deposits. These aquifer materials have different hydraulic properties than the Napa Valley alluvial deposits and the level of communication and connectivity between the two areas is limited. Therefore, the contours of groundwater elevations presented in this report do not connect the contours between the MST and the Napa Valley Floor Subareas. In the future, refinement of these assumptions are recommended as part of future efforts to further characterize groundwater level data and associated geologic information which may result in the identification of multiple aquifers within the same subarea to gain a more accurate depiction of groundwater conditions.

4.2.1 Napa Valley

As discussed in the previous section, groundwater levels have remained mostly stable throughout the main Napa Valley. Flow directions are also mostly unchanged over the last 60 years. **Figure 4.8 and 4.9** show contours of equal groundwater elevations in 1949/1950 and Spring 2008, respectively. In Spring 2008, the groundwater flow direction is southward toward San Pablo Bay, except for certain areas near the MST, where local pumping depressions alter the groundwater flow directions.

Since the 1950s through Spring 2008, groundwater elevations have been between 300 to 400 feet msl in the Calistoga Subarea and remained essentially unchanged over that 60-year period (**Figures 4.8 and 4.9**). Slightly farther south near St. Helena, at Rutherford Road, groundwater elevations are at about 140 feet msl and generally have also remained essentially unchanged over this time period.

In the Yountville and Napa Subareas, groundwater flow is generally toward the south and the east in the direction of the Napa River and toward the southern portion of Napa Valley. Coverage of wells with water level measurements in Spring 2008 was not sufficient for determining if stretches of the Napa River have changed from gaining conditions to losing conditions where pumping depressions are most pronounced, particularly along the Silverado Trail between Soda Creek Road and Hardman Avenue.

4.2.2 MST

Previously, contours of equal groundwater elevations have been published for the MST for measurements collected in the Spring of 1949/1950, 1975, and 2002. Authors of these contouring efforts have recognized the problem of analyzing and summarizing trends for a composite groundwater system, i.e., the groundwater level measurements represent multiple depths or zones within the aquifer system. This is particularly important (and has generally been unable to be addressed) within the MST Subarea. Complete well construction information is necessary for correct interpretation of groundwater level data. As Farrar and Metzger (2003) reported, "The correct interpretation of ground-water level data is, in part, dependent upon complete well-construction information, including total depth, perforation intervals, seals, and gravel-pack depth. Complete construction information, however, was not available for several of the wells in the 2000-2002 network, which limited analysis and interpretation of the data."

Historically, groundwater flow directions in the MST were generally from the Howell Mountains in the east toward the Napa River to the west. **Figure 4.10** illustrates contours of equal groundwater elevations for 1949/1950 presented by Kunkel and Upson (1960). Groundwater elevations in the alluvium, west of the Soda Creek Fault, ranged from approximately 5 to 20 feet msl. Groundwater elevations in the Sonoma Volcanics, east of the Soda Creek Fault, ranged from approximately 40 to 160 feet msl.

Johnson (1977) incorporated measurements from more than 140 wells to create contours of equal groundwater elevations for Spring and Fall of 1975. He concluded that groundwater movement is in a general east to west direction during both periods in 1975 (**Figures 4.11 and 4.12**) in the area east of the Soda Creek Fault with some alteration by local pumping centers. In the vicinity of and west of the Soda Creek Fault, in the main alluvial aquifer of the Napa Valley, groundwater flow is generally southward and parallel to the Soda Creek Fault. The effect of the Soda Creek Fault as an apparent barrier to groundwater flow is seen in the northern part of the MST Subarea in Fall 1975 where water levels are offset 20 to 30 feet higher on the eastern side of the fault. This apparent barrier effect is not evident in Spring 1975. Notably, Johnson recognized that the contours of equal groundwater elevations he prepared for 1975 were based on composite potentiometric heads. Specifically, the groundwater level configurations depicted are "derived from heads measured in wells, some of which are in the shallow unconfined parts of the aquifer system and others are in the deeper confined parts of the system." As Farrar and Metzger (2003) subsequently note, the lack of well construction information for the monitored wells and the compositing of the measurements, limits the analysis and interpretation of the data.

Farrar and Metzger (2003) evaluated data from as many as 120 wells between Spring 2000 and Spring 2002. They described a general movement of groundwater from the mountains around the eastern perimeter of their study area toward three pumping depressions in the northern, central, and southern parts of the MST (**Figures 4.13 and 4.14**). They indicated the presence (since Johnson (1975)) of a new depression in the south, the continued deepening of the depression located in the central portion of the MST, and the stabilization of the pumping depression in the north. They also indicated a fourth area west of the Soda Creek Fault contains another pumping depression that had shifted location and depths since the Johnson study period.

As discussed in Section 4.1, water levels have generally continued to decline in the MST in varying degrees and the three local pumping depressions that are observed in the contours of equal groundwater elevations in the spring and fall in 1975 and 2001/2002 (**Figures 4.11 through 4.14**) are also observed in Fall 2008 (**Figure 4.15**). The fourth depression, west of the

Soda Creek Fault, is illustrated in the Fall 2008 contour map (**Figure 4.15**), where it has continued to deepen nearest the fault along McKinley Road. Available groundwater elevation data for Spring 2008 were contoured (**Figure 4.16**), but spatial coverage is insufficient to identify the major pumping centers during this period.

Well coverage for both Spring and Fall 2008 contouring efforts was lacking as compared to previous years' contouring efforts. Therefore, it is recommended that additional sites be monitored to increase spatial coverage. Most importantly, future monitoring efforts should specify the monitored zones, correct discrepancies for well locations, reconcile reference point elevation discrepancies, and reconcile naming in order to improve coverage in certain areas and help to identify the extents of the cones of depression.

4.2.3 Summary of Groundwater Level Conditions

Groundwater levels in the county are generally stable, with the exception of the MST Subarea. **Table 4.1** summarizes groundwater findings, including data availability and groundwater conditions for each County subarea.

Groundwater in the Napa Valley Floor generally flows toward the axis of the valley and south when not influenced by local pumping depressions. The MST Subarea, however, has shown significant declines in groundwater elevations, especially in the central portion of the subarea. Contemporaneous changes in water level trends are possible to discern throughout the MST. The variation and timing of groundwater level declines and trends in the northern, central, and southern areas of the MST that have historically occurred may be attributable to increased pumping and/or variation in geologic conditions. Wells in the immediate vicinity of the MST Subarea may be vulnerable to these variations as well, as seen from limited data in the eastern portion of the NVF-Napa Subarea and the southwestern part of the Eastern Mountains Subarea. Most wells elsewhere in the valley with a sufficient record indicate that groundwater levels are more affected by climatic conditions, are within historic levels, and seem to recover from dry periods during subsequent wet or normal periods.

Groundwater levels outside of the Napa Valley Floor are much less known. Subareas south of the Valley have very little groundwater level data, making it difficult to impossible to assess any trends in groundwater levels or potential for saltwater intrusion from San Pablo Bay. Subareas east and west of the Napa Valley Floor all have limited data or are lacking groundwater level data entirely (as seen in Livermore Ranch, Southern Interior Valleys, and Western Mountains Subareas). Where data are available, most records are short, spanning a few years at most, and it seems that groundwater level conditions are stable.

The findings on groundwater levels in the County have been used to develop the recommendations presented in the next section for the ongoing countywide groundwater level monitoring program.

Table 4.1 Findings: Groundwater Level Conditions and Available Data

Subarea	Summary Comments on Groundwater Conditions
Napa Valley Floor-Calistoga	Water levels are generally stable and depths to groundwater are shallow; 156 wells provide data, about 3/4 of the wells have limited records.
Napa Valley Floor-MST	Wells with records show long term declining water levels; some have a repeating pattern of declining then stabilizing (plateauing) and never recovering, while others have a recent steady continuous decline; 286 wells provide data, half with limited records and more than half measured recently.
Napa Valley Floor-Napa	Water levels are generally stable except toward the east where declines of 20 feet have been observed close to the northern MST; 273 wells provide data, most with limited records.
Napa Valley Floor-St. Helena	Water levels are generally stable and depths to water are shallow; 70 wells provide data, most wells have good records.
Napa Valley Floor-Yountville	Water levels are generally stable with seasonal fluctuations; fewer wells have data (31 wells) compared to the rest of the Valley Floor, and fewer wells have good records or recent data.
Carneros	No current groundwater level data, but a good record exists for 7 wells with data between 1962 and 1978.
Jameson/American Canyon	Limited groundwater level data; all recent data are from regulated facility monitoring wells.
Napa River Marshes	Limited groundwater level data; all data are from regulated facility monitoring wells; no historical data pre-2000.
Angwin	No current groundwater level data; 10 wells are from one regulated facility site with data over three years; no historical data pre-2002.
Berryessa	Limited record and spatial distribution; most wells with data are monitoring wells on three different regulated facilities; no historic data pre-2002.
Central Interior Valleys	Limited data; all data from three regulated facilities' monitoring wells; no historical data pre-2002
Eastern Mountains	Limited data and spatial distribution; one well near the MST shows recent declines similar to those found in the MST.
Knoxville	Limited record and spatial distribution; no historic groundwater level data and a very short period of record.
Livermore Ranch	No data.
Pope Valley	Limited groundwater level data; all data are from two regulated facilities' monitoring wells; no historical data pre-2002.
Southern Interior Valleys	No data.
Western Mountains	No data.

4.3 Groundwater Quality

Figure 4.17 illustrates all the sites in Napa County from which historical groundwater quality data are available. Historical groundwater quality records from these sites (some with multiple wells) were reviewed to select representative (currently or historically) monitored wells for purposes of illustrating groundwater quality information in Napa County and in each subarea. Some important constituents whose concentrations influence the quality of water for irrigation are TDS, electrical conductivity (EC), sodium, bicarbonate, and boron. Constituents of interest in water used for human consumption include chloride, nitrate, sulfate, fluoride, iron, and sodium. Notably, many of these chemical constituents are not represented in the subarea groundwater quality datasets. Therefore, the lack of data limits the ability to develop a comprehensive understanding of groundwater quality conditions and trends.

Appendices B through F summarize and plot the groundwater quality data for wells grouped by subarea. **Appendix B** contains a summary of all of the chemical analytes for each subarea, including any drinking water or agricultural standards, the number of wells, the number of measurements, the range of dates for those measurements, and the average value of each constituent. **Appendices C and D** contain general mineral and trace elements data for each well grouped by subarea. **Appendix E** contains plots of EC, TDS, chloride, and nitrate for wells that have either been classified as having recent (2005 to present) data or having more than five measurements in their record. **Appendix F** contains trilinear plots that were used to help classify each subarea's groundwater type. **Figures 4.18, 4.19, 4.20, 4.21, 4.22, 4.23, and 4.24** show the maximum measured concentration of arsenic, boron, chloride, EC, nitrate, sodium, and TDS for all wells with a water quality record. These figures help identify areas where higher values of those constituents have been measured.

4.3.1 Napa Valley Floor

Groundwater in the Napa Valley Floor (NVF) Subareas (including Calistoga, MST, Napa, Saint Helena, and Yountville) all have experienced elevated concentrations of arsenic, iron, manganese, and pH. Elevated levels of nitrate, sulfate, EC, and TDS are also prevalent in the groundwater of many Valley Floor Subareas. **Table 4-2** below summarizes the groundwater quality data for the key constituents of chloride, EC, nitrate, and TDS.

Table 4-2 Summary of Groundwater Quality for Selected Constituents – Napa Valley Floor Subareas

Analyte	Primary / Secondary Drinking Water Standard	Units	Range of Dates	No. of Wells	No. of Meas.	Range of Values	Average
Napa Valley Floor-Calistoga							
Cl	250/500 [b]	mg/L	9/30/1949-2/11/2009	23	154	3.9-360	59.25
EC	900/1600 [b]	µS/cm	9/30/1949-8/20/2008	13	81	109-992	508.85
NO_3	45 [a]	mg/L	10/10/1951-7/22/2009	36	155	<0.4-57.6	5.48
TDS	500/1000 [b]	mg /L	4/4/1962-2/11/2009	20	100	90-1600	654.79
Napa Valley Floor-MST							
Cl	250/500 [b]	mg /L	2/7/1944-10/21/2008	21	90	4.8-175	54.42
EC	900/1600 [b]	µS/cm	12/2/1949-10/29/2003	19	99	124-1230	467.24
NO_3	45 [a]	mg /L	2/12/1951-9/1/2009	34	138	<0.2-44.3	4.08
TDS	500/1000 [b]	mg /L	4/4/1962-9/28/2006	23	46	144-732	323.28
Napa Valley Floor-Napa							
Cl	250/500 [b]	mg /L	11/1/1949-9/4/2007	13	140	5.9-111	27.61
EC	900/1600 [b]	µS/cm	11/1/1949-9/4/2007	13	143	212-738	401.12
NO_3	45 [a]	mg /L	3/1/1951-4/8/2009	35	116	<0.2-49	7.28
TDS	500/1000 [b]	mg /L	4/4/1962-9/4/2007	10	29	176-740	263.34
Napa Valley Floor-St. Helena							
Cl	250/500 [b]	mg /L	10/21/1949-10/15/2008	9	42	4-151	22.43
EC	900/1600 [b]	µS/cm	10/21/1949-3/11/2009	8	43	288-902	450.81
NO_3	45 [a]	mg /L	8/27/1958-8/10/2009	35	238	<0.04-163.8	15.15
TDS	500/1000 [b]	mg /L	4/4/1962-3/11/2009	6	21	177-483	308.62
Napa Valley Floor-Yountville							
Cl	250/500 [b]	mg /L	1/20/1949-2/13/2008	15	52	4.1-140	21.23
EC	900/1600 [b]	µS/cm	1/20/1949-6/14/2006	12	50	77-1010	386.42
NO_3	45 a	mg /L	8/27/1958-4/13/2009	25	62	<2-50	8.16
TDS	500/1000 [b]	mg /L	5/8/1963-2/13/2008	12	13	72-814	369.31

a. Primary Maximum Contaminant Level Drinking Water Standard, California EPA and/or US EPA

b. Secondary Maximum Contaminant Level Drinking Water Standard, California EPA or US EPA
mg/L = milligrams per liter
µS/cm = microsiemens per centimeter

4.3.1.1 NVF Calistoga Subarea

Groundwater quality data from 38 wells in the NVF Calistoga Subarea indicates mixed types of water, varying in type between sodium bicarbonate, calcium bicarbonate, and sodium chloride. Sodium bicarbonate and sodium chloride water can sometimes be unsuitable for irrigation, posing a possible sodium hazard (Faye, 1973). Sodium chloride water is associated with hydrothermal waters and possibly faults in this area of the Napa Valley (Faye, 1973). Groundwater temperature measurements are not available in this subarea, but the nature of the volcanic and geothermal geologic setting indicates that groundwater temperature generally increases with depth at a greater rate than naturally would occur. Available boron concentrations in four wells range from non-detected to 14,000 micrograms per liter (ug/L), exceeding the 1,000 ug/L California State Notification Level for Drinking Water standard. Arsenic concentrations range from non-detect to 220 ug/L, with concentrations in seven wells above the primary drinking water maximum contaminant level (MCL) of 10 ug/L in this subarea. Chloride values range between 3.9 and 360 mg/L, only exceeding the MCL of 250 mg/L in two wells. Ten wells have exceeded the TDS secondary MCL of 500mg/L; the maximum measured TDS is 1,600 mg/L. Elevated sulfate occurs in this subarea as well, with a maximum concentration of 958 mg/L. Five wells exceed the primary MCL for fluoride and two wells exceed the secondary MCL for EC. A few occurrences of concentrations exceeding the MCLs, notification levels, or agricultural water quality limits for aluminum, chromium, iron, manganese, molybdenum, nitrate, lead, pH, sodium, and antimony also occur in this subarea (**Appendices B, C, and D**). As illustrated in **Figures 4.18 through 4.24**, most of the groundwater with poorer quality exists in the northern part of the subarea and along the flanks of the valley. There are three wells in this subarea that have a sufficient record for illustrating and evaluating water quality trends (SWN: 8N/6W-10Q3, 9N/7W-25N1, and 9N/7W-36H4). Plots of EC, TDS, chloride, and nitrate concentrations in these wells are included in **Appendix E**. Two of the three wells indicate groundwater quality being stable or improving, while one well (10Q3) shows increasing chloride, TDS, and EC between the late 1980s and early 2000s.

4.3.1.2 NVF MST Subarea

The MST Subarea groundwater quality was organized into three groups by Farrar and Metzger (2003) based on chemical composition. The first group contained wells close to creeks, many of these wells had completion depths greater than 350 feet. This group exhibited mixed cation bicarbonate type water with relatively low ionic concentrations and dissolved solids, with sodium dominating the cations. The second group of wells consisted of three shallower wells (less than 250 feet deep) in the southeastern subarea with a calcium-magnesium bicarbonate or calcium-magnesium mixed anion type of water, and slightly higher concentrations of dissolved solids. The third group described by Farrar and Metzger (2003) is made up of six wells located near the hilly central region of the MST known as the Cup and Saucer, and consists of sodium bicarbonate type water with relatively high dissolved solids, chloride, fluoride, and sulfate concentrations as compared to the northern and southern areas of the MST. 46 wells have groundwater quality data in this subarea. Boron values range from non-detect to 11,000 ug/L, with four wells exceeding the state notification level for drinking water of 1,000 ug/L. Arsenic concentrations range from <2 to 67 ug/L; six wells have data that exceed the primary MCL for drinking water of 10 ug/L. Five and eleven wells exceed the secondary MCL for drinking water for iron and manganese (300 and 50 ug/L) respectively, reaching concentrations of 2,290 ug/L for iron and 831 ug/L for manganese. Sodium ranges from 10 to 247 mg/L; seven wells have data that exceed the agricultural water quality limit of 69 mg/L. TDS values for 23 wells range from144 to 732 mg/L. Groundwater quality in the MST Subarea has exceeded the drinking water standards for EC, TDS, sulfate, chromium, fluoride, pH, and barium. Most of the groundwater with elevated concentrations of these constituents are scattered throughout the subarea (**Figures 4.18 through 4.24**). Although well completion depths are not entirely known, Farrar and Metzger (2003) suggest that wells completed in the aquifers underlying the diatomaceous deposits of the Sonoma Volcanics yield poor quality water. Only one well has a sufficient groundwater quality data record to observe any trends (SWN 5N/4W-11F3), as seen in **Appendix E**. Chloride and nitrate concentrations in this well have been stable at around 100 mg/L and <1 mg/L, respectively, with a slight increase in TDS and EC between the late 1980s and late 1990s.

4.3.1.3 NVF Napa Subarea

Groundwater quality data from 42 wells in this subarea can be described as being mostly sodium bicarbonate type water. Groundwater quality is generally good, with very few exceedances for arsenic, iron, manganese, nitrate, lead, pH, sulfate, and TDS. Sodium ranges from 11 to 124 mg/L. Five wells have sodium concentrations which exceed the agricultural water quality limit of 69 mg/L. Boron concentrations in this subarea remain below the secondary MCL of 1,000 ug/L; values range from non-detected to 990 ug/L. Three wells exceeded the primary MCL for arsenic of 10 ug/L; arsenic concentrations range from less than 2 to 21 ug/L. TDS concentrations (as measured in ten wells) range from 176 to 740 mg/L . Higher levels of nitrate and boron can be found outside the city of Napa, while arsenic exceedances mostly occur near the boundaries of the subarea (**Figures 4.18, 4.19, and 4.22**). Two wells have a sufficient water quality record in this subarea (SWN 5N/4W-09Q2 and 5N/4W-15E1) for EC, TDS, chloride, and nitrate to evaluate trends (**Appendix E**). Both wells show mostly stable levels of EC and nitrate, while TDS and chloride levels have decreased from high values observed in the 1960s to the late 1990s (well 09Q2) and more recently (well 15E1).

4.3.1.4 NVF St. Helena Subarea

Groundwater quality data from 44 wells indicate that most of the water in this subarea can be described as either magnesium or calcium bicarbonate type. Groundwater quality is generally good, with some standards being exceeded for arsenic, boron, chromium, EC, iron, manganese, nickel, nitrate, sodium, lead, pH, antimony, and sulfate. No pattern is visible to spatially relate the existence of elevated values of these constituents, although the higher nitrate values may be found where agriculture dominates land use (**Figures 4.18 through 4.24**). TDS concentrations are generally low in this subarea; six wells exhibit TDS values that range from 177 to 483 mg/L. Three wells have sufficient groundwater quality records to evaluate trends in TDS, EC, nitrate, and chloride (7N/5W-06F1, and Stonebridge Wells 1 and 2). These four analytes have been generally stable between the 1970s and late 2000s (**Appendix E**).

4.3.1.5 NVF Yountville Subarea

Groundwater quality data from 25 wells generally indicate the water is of the mixed cation bicarbonate type or magnesium bicarbonate type in this subarea. Higher levels than drinking water or agricultural standards have been measured for the following constituents: arsenic, boron, EC, fluoride, iron, manganese, nitrate, sodium, pH, antimony, vanadium, and TDS. Arsenic concentrations range between non-detectable levels to 830 ug/L; concentrations are above the primary drinking water MCL in five wells. EC and TDS are generally low in most wells; only one regulated facility site has wells with values that exceed drinking water standards. There is no spatial pattern to relate elevated levels of these constituents (**Figures 4.18 through 4.24**). Groundwater quality records spanning more than ten years are sparse in this subarea. Two wells have groundwater quality records for EC, TDS, chloride, and nitrate that span more than ten years (6N/4W-06P1 and 7N/5W-27A1), although both records do not have data in the 1990s or more recently. Trends for EC, TDS, and chloride appear to be stable, while the nitrate data are insufficient to determine any trends (**Appendix E**).

4.3.2 Subareas South of the Valley Floor

Subareas south of the Napa Valley Floor may be susceptible to seawater intrusion originating from San Pablo Bay. This may be observed in wells with elevated chloride, EC, and TDS levels as seen in the **Table 4-3** below which summarizes the chloride, EC, nitrate, and TDS levels. EC and TDS levels in these subareas are much higher on average than those in the Napa Valley Floor.

Table 4-3 Summary of Groundwater Quality for Selected Constituents – Subareas South of the Napa Valley Floor

Analyte	Primary / Secondary Drinking Water Standard	Units	Range of Dates	No. of Wells	No. of Meas.	Range of Values	Average
Carneros							
Cl	250/500 [b]	mg/L	3/9/1951-9/24/2008	10	156	21-3020	215.76
EC	900/1600 [b]	µS/cm	3/9/1951-9/24/2008	10	157	268-9560	1,097.43
NO3	45 [a]	mg /L	3/26/1952-2/10/2009	12	62	ND-98.4	19.28
TDS	500/1000 [b]	mg /L	4/4/1962-9/24/2008	9	33	184-1520	652.21
Jameson/American Canyon							
Cl	250/500 [b]	mg /L	10/9/1950-8/19/1998	6	91	8.2-656	214.2
EC	900/1600 [b]	µS/cm	10/9/1950-8/19/1998	6	92	225-3670	1307.48
NO3	45 [a]	mg /L	8/28/1958-8/6/1985	6	30	0.2-255	43.07
TDS	500/1000 [b]	mg /L	4/4/1962-8/6/1985	6	11	259-1280	763.36
Napa River Marshes							
Cl	250/500 [b]	mg /L	7/23/1949-4/22/2009	20	137	4.3-3900	554.43
EC	900/1600 [b]	µS/cm	1/24/1950-9/23/2007	3	9	352-2800	1482.44
NO3	45 [a]	mg /L	5/19/1954-4/22/2009	24	117	ND-230	12.19
TDS	500/1000 [b]	mg /L	6/18/2002-9/23/2007	2	4	720-1700	1157.5

a. Primary Maximum Contaminant Level Drinking Water Standard, California EPA and/or US EPA

b. Secondary Maximum Contaminant Level Drinking Water Standard, California EPA or US EPA

4.3.2.1 Carneros Subarea

Groundwater quality data from 13 wells indicate that water in this subarea is generally of the sodium bicarbonate or sodium chloride type. Groundwater has exceeded water quality standards in aluminum, arsenic, chloride, EC, iron, manganese, nitrate, lead, pH, sodium, and TDS. EC ranges from 268 to 9,560 microsiemens per centimeter (µS/cm); eight wells have values that exceed the secondary MCL of 900 µS/cm. TDS ranges from 184 to 1520 mg/L; sixteen wells have values that exceed the secondary MCL of 500 mg/L. Sodium ranges from 27 to 956 mg/L; twelve wells have values that exceed the agricultural water quality limit of 69 mg/L. Chloride ranges from 21 to 3,020 mg/L; seven wells have concentrations that exceed the secondary MCL (recommended concentration) of 250 mg/L. No apparent spatial pattern is evident to correlate elevated levels of these constituents in groundwater (**Figures 4.18 through 4.24**). Five wells in this subarea have a sufficient record of water quality measurements (4N/4W-05C1, 4N/4W-05D2, 5N/4W-20R2, 5N/4W-21P2, 5N/4W-29H1) to evaluate trends for EC, TDS, chloride, and nitrate (**Appendix E**). The EC records show fluctuations over the years and three wells have increasing EC levels between the 1960s and late 2000s. These three wells also have increasing TDS levels, although that record is less complete. Two wells have increasing chloride concentrations, approaching or surpassing the 250 mg/L secondary MCL in recent years (post 2000). Nitrate concentrations can be seen to increase in one well, while the other wells show stability from 1960 to present.

4.3.2.2 Jameson/American Canyon Subarea

Groundwater quality data from six wells generally indicate that the water is of the sodium chloride or magnesium bicarbonate type in this subarea. Although the number of wells with data is quite limited in this subarea (**Figures 4.18 to 4.24**), groundwater measurements have exceeded water quality standards and/or limits for boron, chloride, EC, nitrate, pH, sodium, sulfate, and TDS. EC concentrations range from 225 to 3,670 µS/CM, with five wells exceeding the secondary MCL of 900 µS/CM. TDS ranges from 259 to 1,280 mg/L, with five wells exceeding the secondary MCL (upper range) of 500 mg/L. Sodium ranges from 7.7 to 326 mg/L, with all wells exceeding the agricultural water quality limit of 69 mg/L. Chloride ranges from 8.2 to 656 mg/L, with two wells exceeding the lower limit of the secondary MCL of 250 mg/L. All wells sampled in this subarea are located in the western half of the subarea, limiting the spatial coverage. All six wells have water quality data that span over ten years; three wells in particular have the best records for observing trends in EC, TDS, chloride, and nitrate (4N/4W-12M2, 4N/4W-13E1, and 4N/4W-14C2) (**Appendix E**). Although there are no recent data in this data set (post 1998), chloride and EC records all show increasing values over the span of record between 1960 and 1998 while TDS and nitrate records show stability or are insufficient to evaluate trends.

4.3.2.3 Napa River Marshes Subarea

Groundwater quality data from 28 wells indicate that water is generally of the sodium bicarbonate or chloride type in this subarea. 21 of these wells are from one regulated facility site. Groundwater exceeds water quality standards in arsenic, barium, chloride, EC, iron, manganese, nitrate, lead, sodium, sulfate, and TDS. EC concentrations were measured in three wells; values range between 352 and 2,800 µS/CM. All three wells have measurements that exceed the secondary MCL of 900 µS/cm. TDS concentrations were measured in two wells, ranging from 720 to 1700 mg/L; all exceed the secondary MCL of 500 mg/L. Sodium ranges from 75 to 240 mg/L; all wells exceed the agricultural water quality limit of 69 mg/L. Chloride concentrations range from 4.3 to 3,900 mg/L; 13 wells have values that exceed the lower limit of the secondary MCL of 250 mg/L. There is no spatial correlation to elevated levels of these constituents. There are no wells that have a groundwater quality record with more than 5 years of data, so no trends can be interpreted for this subarea.

4.3.3 Subareas East and West of the Valley Floor

From the limited amount of groundwater quality data in subareas east and west of the Napa Valley Floor, the groundwater is generally of good quality. Elevated levels of iron and manganese occur, along with lower than average pH values indicating more acidity than the Napa Valley Floor. Livermore Ranch Subarea has no available groundwater quality data. For comparison, **Table 4-4** below summarizes the available chloride, EC, nitrate, and TDS values in the eight subareas east and west of the valley.

Table 4-4 Summary of Groundwater Quality for Selected Constituents – Subareas East and West of the Napa Valley Floor

Analyte	Primary / Secondary Drinking Water Standard	Units	Range of Dates	No. of Wells	No. of Meas.	Range of Values	Average
Angwin							
Cl	250/500 [b]	mg/L	2/10/1988-9/8/2008	9	35	2.9-12	6.32
EC	900/1600 [b]	µS/cm	2/10/1988-9/8/2008	9	35	90-280	156.46
NO3	45 a	mg/L	2/10/1988-3/9/2009	10	71	<0.5-15	7.09
TDS	500/1000 [b]	mg/L	2/10/1988-9/8/2008	9	35	120-200	157.71
Berryessa							
Cl	250/500 [b]	mg/L	11/25/2003-2/6/2009	7	17	21-93	55.88
EC	900/1600 [b]	µS/cm	11/25/2003-2/6/2009	6	20	776-3000	1572.4
NO3	45 [a]	mg/L	11/25/2003-2/6/2009	7	15	ND-1151	232.18
TDS	500/1000 [b]	mg/L	11/25/2003-2/6/2009	13	27	300-1200	782.96
Central Interior Valleys							
Cl	250/500 [b]	mg/L	4/30/2001-6/18/2007	13	27	0.5-730	75.98
EC	900/1600 [b]	µS/cm	4/30/2001-6/18/2007	4	9	150-740	554.44
NO3	45 [a]	mg/L	4/30/2001-12/31/2008	18	63	<0.4-27.4	5.92
TDS	500/1000 [b]	mg/L	4/30/2001-6/18/2007	13	27	150-1300	538.52
Eastern Mountains							
Cl	250/500 [b]	mg/L	3/8/1963-6/18/2008	12	34	3.5-33.7	6.77

Analyte	Primary / Secondary Drinking Water Standard	Units	Range of Dates	No. of Wells	No. of Meas.	Range of Values	Average
EC	900/1600 [b]	µS/cm	3/8/1963-3/24/2009	12	158	97-422	210.44
NO3	45 [a]	mg/L	3/8/1963-4/22/2009	31	224	<1-28	6.48
TDS	500/1000 [b]	mg/L	3/8/1963-3/24/2009	12	161	120-347	190.01
Knoxville							
Cl	250/500 [b]	mg/L	9/20/2006-1/28/2009	5	44	11-1500	263.89
EC	900/1600 [b]	µS/cm	6/27/2006-1/28/2009	5	51	ND-6900	1307.86
NO3	45 [a]	mg/L	6/27/2006-1/28/2009	5	49	ND-23	9.41
TDS	500/1000 [b]	mg/L	6/27/2006-1/28/2009	5	50	92-5600	1312.24
Pope Valley							
NO3	45 [a]	mg/L	6/21/2006	1	1	ND	
Southern Interior Valleys							
Cl	250/500 [b]	mg/L	5/29/2002-8/16/2006	1	3	8-18	13.67
EC	900/1600 [b]	µS/cm	5/29/2002-8/16/2006	1	3	230-750	560
NO3	45 [a]	mg/L	5/29/2002-2/27/2008	3	8	ND-10	7.7
TDS	500/1000 [b]	mg/L	5/29/2002-8/16/2006	1	3	180-460	363.33
Western Mountains							
Cl	250/500 [b]	mg/L	8/5/1971-6/14/2007	8	22	3-10	6.53
EC	900/1600 [b]	µS/cm	8/5/1971-6/14/2007	8	22	87-320	207.95
NO3	45 [a]	mg/L	8/5/1971-4/17/2009	12	48	<0.4-32	6.35
TDS	500/1000 [b]	mg/L	8/5/1971-6/14/2007	8	14	79-230	136.71

a. Primary Maximum Contaminant Level Drinking Water Standard, California EPA and/or US EPA

b. Secondary Maximum Contaminant Level Drinking Water Standard, California EPA or US EPA

4.3.3.1 Angwin Subarea

Groundwater quality data from eleven wells indicates that water is generally of the bicarbonate or calcium bicarbonate type. Groundwater quality measurements are limited in spatial coverage to two sites with data. TDS concentrations are low, between 120 and 200 mg/L (**Figure 4.24**). Groundwater is generally of good quality except for occasional samples with iron and manganese levels above drinking water standards. Six wells have a sufficient record of EC, TDS, chloride, and nitrate to evaluate trends (**Appendix E**) (Linda Falls Terrace Mutual Well 1, Linda Vista Mutual Water Company Well 1, Pacific Union College Wells 3, 4, 5, and 6). These wells generally show decreases in EC and TDS concentrations and increasing chloride and nitrate concentrations. These constituent concentrations have all been below 16 mg/L between the early 1990s to present.

4.3.3.2 Berryessa Subarea

Groundwater quality data from 18 wells indicate that water in this subarea is of the sodium bicarbonate type. There is poor coverage for the majority of chemical constituents in this subarea, but groundwater quality results exhibit levels exceeding water quality standards for aluminum, boron, EC, iron, manganese, nitrate, sodium, and TDS. There are three clusters of wells with groundwater quality data, all located on the western bank of Lake Berryessa (**Figures 4.18 through 4.24**). EC concentrations are available at one regulated facility site, with values ranging between 2,500 and 3,000 µS/cm from four wells; all values exceed the secondary MCL of 900 µS/cm. In 13 other wells, TDS values range between 300 and 1,200 mg/L, with eight wells exceeding the secondary MCL of 500 mg/L. Insufficient data records exist in this subarea to discuss trends.

4.3.3.3 Central Interior Valleys Subarea

Groundwater quality data from 40 wells indicate that water in this subarea is of the mixed cation bicarbonate or magnesium bicarbonate type. Although there is poor coverage for the majority of constituents in this subarea, levels above water quality standards have been measured in arsenic, cadmium, chloride, chromium, fluoride, iron, manganese, nickel, lead, sodium, sulfate, and TDS. TDS concentrations range from 150 to 1,300 mg/L. Nine wells at one regulated facility have data that exceed the secondary MCL of 500 mg/L. Chloride concentrations were measured in 13 wells; values ranged from 0.5 to 730 mg/L, where only one well exceeded the secondary MCL of 250 mg/L. Sodium concentrations ranged from 4.9 to 90 mg/L, with only one well barely exceeding the agricultural water quality limit of 69 mg/L. There seems to be no relationship between exceedances of water quality standards and location (**Figures 4.18 through 4.24**). There are insufficient water quality records in this subarea to discuss trends.

4.3.3.4 Eastern Mountains Subarea

Groundwater quality data from 31 wells indicate that water is of mixed cation bicarbonate or sodium bicarbonate type in the subarea. Groundwater is of generally good quality, with few exceedances of water quality standards in iron, manganese, sodium, lead, and pH. TDS concentrations range from 120 to 347 mg/L. Sodium ranges from 9.9 to 110 mg/L; three wells have values that exceed the agricultural water quality limit of 69 mg/L. All but five of the wells with water quality data are located on the western edge of the subarea, close to the Napa Valley Floor. Due to a lack of constituents sampled for each well, there appears to be no relationship between location and concentration of constituents (**Figures 4.18 through 4.24**). Three wells have sufficient records for EC, TDS, chloride, and nitrate (Appendix E; St. Helena Hospital's Liparita Well, Ballentine Well 3, and Hillcrest Well 1). Although these records are all post 1990, they show a decrease in EC concentrations, stable TDS levels, and stable to slightly increasing chloride and nitrate concentrations (chloride and nitrate levels remain below 25 mg/L from the mid-1990s to present).

4.3.3.5 Knoxville Subarea

Groundwater quality data from five LBRID monitoring wells indicate that groundwater is of the magnesium bicarbonate or sodium chloride type in this subarea. The monitoring wells are all located in the Stone Corral area near Stone Creek, in a southern pocket of the subarea (**Figures 4.18 through 4.24**). Groundwater quality measurements have exceeded standards in the following constituents: arsenic, boron, chloride, EC, iron, manganese, molybdenum, sodium, pH, sulfate, and TDS. EC and TDS concentrations range from 243 to 6,900 µS/cm and 92 to 5,600 mg/L, respectively. The TDS secondary MCL of 500 mg/L is exceeded by four of the five monitoring wells. Four of the five wells exceed the agricultural water quality limit for sodium of 69 mg/L; sodium concentrations are as high as 1,300 mg/L. Three of the five wells exceed the secondary drinking water standard for boron of 1,000 ug/L; concentrations range between non-detect and 15,000 ug/L. No trends can be determined from groundwater quality data in this subarea, as there are only about three years of records, and the records are variable for EC, TDS, chloride, and nitrate (**Appendix E**).

4.3.3.6 Pope Valley Subarea

Groundwater quality data is available from seven wells in this subarea. The data are limited and inadequate to determine the water type. Groundwater quality data are limited to two sites: one public supply well and six monitoring wells from a regulated facility with very limited water quality analyses. From the limited amount of data, however, it appears that groundwater quality is generally very good, with the exception of iron, manganese, and a slightly acidic pH (6.45 pH units). No TDS or EC measurements are available. There are insufficient data to determine water quality trends in this subarea.

4.3.3.7 Southern Interior Valleys Subarea

Groundwater is of the sodium bicarbonate type. Spatial groundwater quality data coverage is limited. Only three wells have water quality data in this subarea. These wells are located on the western edge of the subarea (**Figures 4.18 through 4.24**). Groundwater quality seems to be good, but many constituents exceed water quality standards, including arsenic, iron, manganese, sodium, and lead. Sodium concentrations range from 12 to 160 mg/L and exceed the agricultural water quality limit of 69 mg/L in one well. EC and TDS levels are low; they range from 230 to 750 µS/cm and 180 to 460 mg/L, respectively. There are insufficient data to determine any water quality trends in this subarea.

4.3.3.8 Western Mountains Subarea

Most of the groundwater in this subarea is of the sodium bicarbonate type, based on public supply well data. Groundwater quality has been measured in 12 wells scattered throughout the subarea. Many constituent concentrations have exceeded water quality standards, including arsenic, chromium, iron, manganese, lead, sodium, and pH. The pH is again slightly more acidic than the Valley Floor (5.9 pH units). Sodium concentrations range from <8.4 to 87 mg/L; only one well has concentrations that exceed the agricultural water quality limit of 69 mg/L. EC and

TDS levels are low and range from 87 to 320 µS/cm and 79 to 230 mg/L, respectively. Very few wells in this subarea have a groundwater quality data record longer than a few years. One well that has measurements of EC, TDS, chloride, and nitrate between 1970 and 1990 (8N/6W-06L5) indicates stability in chloride and nitrate, while EC and TDS exhibit slight increases.

4.3.4 Summary of Groundwater Quality Conditions

Historical groundwater quality records are typically lacking in Napa County. Groundwater is generally of good quality throughout most subareas. Poor groundwater quality exists in the south and the north-central parts of the County. The poor groundwater quality includes concentrations of metals such as arsenic, iron, and manganese that exceed drinking water standards throughout the county. Elevated levels of boron are also prevalent in most subareas. Subareas south of the Napa Valley Floor, such as the Carneros, Napa River Marshes, and Jameson/American Canyons Subareas, have poor quality water due to high levels of EC, TDS, and chloride. The Calistoga Subarea of the Napa Valley Floor also has poor quality water in many wells due to hydrothermal conditions resulting in higher concentrations of metals. Nitrate concentrations are not a concern throughout the county, but tend to be higher in agricultural areas in the Napa Valley Floor.

Available groundwater quality data in the County are incomplete in regards to spatial distribution, number, and record. Many subareas do not have sufficient spatial coverage to gain a full understanding of groundwater quality throughout the area. Six subareas have ten or less wells with available groundwater quality data, which limits the ability to determine representative quality. Groundwater quality records in many subareas are lacking, as some subareas have no historical data, some subareas have little to no recent data, and very few wells have more than ten years worth of data. As a result, without sufficient records of quality data, it is impossible to determine any trends in many subareas.

Table 4.5 summarizes findings about groundwater quality conditions in the County. These findings have been used to guide the recommendations presented in the next section for an ongoing countywide groundwater quality monitoring program.

Table 4.5 Findings: Groundwater Quality Conditions and Available Data

Subarea	Constituents of Concern	WQ Comment
Napa Valley Floor-Calistoga	As, B	Limited data record, minimal historical record
Napa Valley Floor-MST	As, B, Fe, Mn, Na	Very limited long-term records
Napa Valley Floor-Napa	Na, As, NO3	Generally good water quality; most wells have limited data records and very little historical data
Napa Valley Floor-St. Helena	As, NO3	Generally good water quality; most wells have limited data records and very little historical data
Napa Valley Floor-Yountville	As, NO3	Generally good water quality; most wells have limited data records and very little historical data
Carneros	Cl, EC, TDS	Limited data record; minimal historic and recent records; poor water quality common; possible increasing recent trend seen in EC, chloride, and TDS
Jameson/American Canyon	Cl, EC, Na, NO3, TDS	No recent data post-1998; generally poor water quality from a very limited data set; increasing chloride and EC levels
Napa River Marshes	Cl, EC, Na, NO3, TDS	Very limited long-term records; one well with historic data; generally poor water quality
Angwin	Fe, Mn	No historic records; all measurements from two sites (ten wells total); generally good water quality
Berryessa	EC, TDS	Poor coverage for majority of constituents; no long-term records
Central Interior Valleys	TDS	No historic records pre-2001; poor coverage for majority of constituents; no long-term data
Eastern Mountains	Fe, Mn	Limited historic records; poor spatial distribution; generally good water quality
Knoxville	B, Cl, EC, Na, TDS	Limited to one site with five monitoring wells; generally poor quality and no long-term records
Livermore Ranch	unknown	No groundwater quality data available
Pope Valley	Fe, Mn	No historic records; all measurements from two sites (seven wells total); generally good water quality from constituents with data
Southern Interior Valleys	As, Na	No historic records; poor spatial coverage (only three wells with data); generally good quality
Western Mountains	Fe, Mn	Very limited historic and current records (12 wells total); generally good quality

5.0 HISTORICAL AND FUTURE GROUNDWATER MONITORING

As part of the overall Napa County countywide groundwater project *(*Comprehensive Groundwater Monitoring Program*)*, the DMS was developed for the County to establish a centralized repository for countywide historical groundwater level and quality measurements and provide a foundation for programs that enhance integrated water resources management and planning. The countywide data can be expanded upon to better understand available water resources (e.g., in the future, additional information is needed on water withdrawals; and surface water allocations and diversions should be recorded on a continuing basis). Future applications of the DMS will lead to identification and improved understanding of the issues that may affect the quantity/quality of the County's water resources (climate change, human stresses due to withdrawal, or land use).

The tasks included in the overall Napa County groundwater conditions evaluation and monitoring project complement statewide monitoring program interests. Development of the countywide DMS, groundwater data quality evaluation, and the recommended groundwater monitoring program presented below provide a means for further coordination with statewide monitoring program interests, particularly groundwater elevation monitoring being implemented in response to adoption of SBX7-6 in 2009. DWR is facilitating the statewide program where local entities can apply to DWR to assume the function of regularly and systematically collecting groundwater level data to determine seasonal and long-term trends in the state's groundwater basins and subbasins. Napa County's overall project covers the continuation and expansion of countywide groundwater level and also quality monitoring efforts (including many basins, subbasins and/or subareas throughout the county) for the purpose of understanding groundwater conditions (i.e., seasonal and long-term groundwater level trends and also quality trends) and availability to enable integrated water resources management and planning to meet future water supply demands.

Another aspect of SBX7-6 is to make the groundwater level information available to the public. Napa County's combined efforts through the Comprehensive Groundwater Monitoring Program along with the related AB 303 Public Outreach Project create a framework for applying the findings and recommendations from these programs to the County's continued efforts to increase public outreach. An informed public enables support of planned water resources projects and programs proposed by the County and others.

As part of the County's overall Comprehensive Groundwater Monitoring Program, the quality of the historical to present groundwater level and quality data in the DMS have been examined and groundwater data gaps have been identified according to county subareas. The groundwater data generated as part of historical to current (2005 to present) groundwater monitoring programs are summarized below. There are many areas in the county where further efforts to establish groundwater monitoring, using existing or new monitoring facilities, will improve the understanding of groundwater conditions and availability. Recommendations for expanded monitoring efforts are discussed below for each subarea.

5.1 Summary of Historical to Current (2005 to Present) Groundwater Monitoring

The DMS data were grouped by type (including groundwater levels and groundwater quality) and by subarea in order to evaluate the spatial distribution of historical and current data collection sites.

5.1.1 Groundwater Level Monitoring

Historical groundwater level data (data collected prior to 2005) have primarily been collected from the five subareas of the Napa Valley Floor in Napa County, including: Calistoga, St. Helena, Yountville, Napa, and the Milliken-Sarco-Tulucay Creeks (MST) Subareas (**Table 5.1**). These subareas account for about 83 percent of the historically monitored wells in Napa County (816 out of 985 wells) (LSCE, 2010b). The large number of wells includes wells at regulated facilities or sites that monitor more than one well; therefore, the number of sites where monitoring has been conducted is much less1. Subareas which have not had any historical groundwater level monitoring include the Western Mountains, Livermore Ranch, and Southern Interior Valleys. The other subareas (Knoxville, Angwin, Pope Valley, Eastern Mountains, Carneros, and Jameson/American Canyon) each had 20 or fewer historical monitoring locations. The period of record for historical groundwater level data ranges from 1918 to 2010.

Figure 5.1 illustrates the distribution of current groundwater level monitoring locations, which is similar to the distribution of historical data discussed above and primarily located in the Napa Valley Floor-Napa and MST Subareas. Very little groundwater level monitoring is currently conducted elsewhere in Napa County outside these two subareas. A few scattered locations of groundwater level monitoring occur in the Berryessa, Pope Valley, the southern portion of the Central Interior Valleys, Jameson/American Canyon, and in the NVF-Calistoga, NVF-St. Helena, and NVF-Yountville Subareas. Groundwater level monitoring is not currently conducted in the Carneros, Livermore Ranch, Angwin, Southern Interior Valleys, and Western Mountains Subareas. **Table 5.1** summarizes the number of wells in each subarea that are currently monitored for groundwater levels. Groundwater level measurements have been recorded in a total of 676 wells (at 173 sites) through at least 2005. Of these sites where groundwater levels are measured, some type of well construction information (depth and/or perforated interval(s)) is readily available for 118 sites. Most current groundwater level monitoring occurs on a semi-annual frequency.

---

1 Where GeoTracker includes data for multiple wells monitored at a regulated facility, only one well per facility location is included in the number of “sites” monitored in the County.

Table 5.1
Summary of Historical and Current[1] Groundwater Level Monitoring Wells

Subarea	No. Wells with Historical and Current WL Data (post 2005 and >5 years of data)[2]	No. Wells with Current but Limited WL Data (post 2005 and <5 years of data)	No. Wells with Historical WL Data (pre-2005 and >5 years of data)	No. Wells with Historical but Limited WL Data (pre-2005 and <5 years of data)
Napa Valley Floor-Calistoga	28	55	14	59
Napa Valley Floor-MST	126	56	17	87
Napa Valley Floor-Napa	77	150	20	26
Napa Valley Floor-St. Helena	23	12	27	8
Napa Valley Floor-Yountville	7	4	19	1
Carneros			7	
Jameson/American Canyon		15	5	
Napa River Marshes		49		1
Angwin				10
Berryessa	13	19		4
Central Interior Valleys	21	6		
Eastern Mountains	1		1	3
Knoxville		5		
Livermore Ranch				
Pope Valley		9		
Southern Interior Valleys				
Western Mountains				
Total	**296**	**380**	**110**	**199**

[1] "Current" refers to monitored wells for levels and/or any water quality parameter with a period of record extending to 2005 or later.
[2] This column includes wells with historical data and also data collected since 2005.

5.1.2 Groundwater Quality Monitoring

Historical groundwater quality data have been collected from all the Napa County subareas with the exception of Livermore Ranch (**Table 5.2** and **Figure 5.2**). Compared to groundwater level data, historical groundwater quality data are more spatially distributed among the subareas. Most historical groundwater quality data have been collected from wells located in the Napa Valley Floor Subarea (195 out of 368 wells) (**Table 5.2**). The period of record for historical groundwater quality data ranges from 1930 to 2010.

Current groundwater quality monitoring locations are also more spatially distributed in Napa County than groundwater level monitoring locations (**Figures 5.1 and 5.2**). Current groundwater quality monitoring is conducted in all the subareas except for the Livermore Ranch Subarea. **Table 5.2 s**ummarizes the number of wells in each subarea that are currently monitored for groundwater quality. Groundwater quality monitoring has been conducted at a total of 283 wells (at 153 sites) through at least 2005. Of these sites where groundwater quality samples are collected, some type of well construction information (depth and/or perforated interval(s)) is readily available for 15 sites (LSCE, 2010b). With the exception of GeoTracker contaminated sites, current groundwater quality monitoring for TDS and/or EC typically occurs on a less frequent than annual basis. Nitrate monitoring on an annual or more frequent basis has occurred more often than monitoring for TDS, EC, and chloride (LSCE, 2010b).

Table 5.2
Summary of Historical and Current[1] Groundwater Quality Monitoring Wells

Subarea	No. Wells with Historical and Current WQ Data (post 2005 and >5 years of data)[2]	No. Wells with Current but Limited WQ Data (post 2005 and <5 years of data)	No. Wells with Historical WQ Data (pre-2005 and >5 years of data)	No. Wells with Historical but Limited WQ Data (pre-2005 and <5 years of data)
Napa Valley Floor-Calistoga	4	25	5	4
Napa Valley Floor-MST	16	10	4	16
Napa Valley Floor-Napa	3	28	6	5
Napa Valley Floor-St. Helena	4	33	2	5
Napa Valley Floor-Yountville	5	13	4	3
Carneros	3	4	5	1
Jameson/American Canyon			6	
Napa River Marshes	1	26	1	
Angwin	8	2		
Berryessa		9		9
Central Interior Valleys	13	26		1
Eastern Mountains	15	10		6
Knoxville		5		
Livermore Ranch				
Pope Valley		7		
Southern Interior Valleys	1	2		
Western Mountains	6	4	1	1
Total	**79**	**204**	**34**	**51**

[1] "Current" refers to monitored wells for levels and/or any water quality parameter with a period of record extending to 2005 or later.
[2] This column includes wells with historical data and also data collected since 2005.

5.2 Future Recommended Groundwater Level Monitoring Network and Program

The focus of the countywide groundwater level monitoring program includes the following objectives.

- Evaluate groundwater levels in key county subareas to describe the occurrence and movement of groundwater and identify vertical hydraulic head differences in the aquifer system. This report provides an initial evaluation of the occurrence and movement of groundwater in the various subareas where data is available. Expanded data collection and ongoing evaluation will enable the County to expand on this effort and focus on key subareas where short- and long-term development of groundwater resources are planned, assess any changes in groundwater conditions, identify aquifer specific groundwater conditions, and identify vertical hydraulic head differences that may exist in those key subareas;
- Identify and investigate natural (e.g., direct infiltration of precipitation, surface water seepage to groundwater, groundwater discharge to streams) or induced (e.g., pumping, purposeful recharge operations) factors that affect groundwater conditions and trends;
- Identify where data gaps occur in the key subareas and provide infill, replacement, and/or project-specific monitoring (e.g., such as may occur for planned projects or expansion of existing projects) as needed;
- Develop and/or refine estimates of groundwater inflows (subsurface groundwater inflow, recharge from rainfall, streamflow, and irrigation, etc.), groundwater outflows (groundwater pumping, evapotranspiration, subsurface groundwater outflow, etc.) and change in groundwater storage (groundwater budget) for key subareas; and
- Employ methods to better estimate groundwater basin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

5.2.1 Groundwater Level Monitoring Network

Currently, groundwater level measurements have been recorded at a total of 676 wells (173 sites) through at least 2005.

Table 5.3 and **Figure 5.3** summarize the currently conducted monitoring in each subarea. Also shown in **Table 5.3** and **Figure 5.3** are the preliminary ranking and priorities for improving or expanding groundwater level monitoring in each of the designated subareas. Seven subareas (including the NVF-Calistoga, NVF-MST, NVF-Napa, NVF-St. Helena, NVF-Yountville, Carneros, and Pope Valley Subareas) are given a higher priority based on factors of current and/or projected land and water use (WYA, 2005). Groundwater level monitoring needs (**Table 5.3**) include improved spatial distribution of groundwater level monitoring, additional characterization of subsurface geologic conditions in each subarea to identify and aquifer characteristics, further examination of well construction information to define which portion of the aquifer system is represented by water levels measured in the currently monitored wells (and in many cases to link construction information to the monitored wells), and improve the understanding of surface water –groundwater relationships.

Table 5.3
Groundwater Level Monitoring Wells, Napa County
(Current[1] and Future)

Subarea	No. Wells with Historical and Current WL Data (post 2005 and >5 years of data)	No. Wells with Current but Limited WL Data (post 2005 and <5 years of data)	Future Groundwater Level Monitoring	Monitoring Needs
Napa Valley Floor-Calistoga	28	55	HE	SP, SW
Napa Valley Floor-MST	126	56	HR	SP, SW
Napa Valley Floor-Napa	77	150	HR	SP, SW
Napa Valley Floor-St. Helena	23	12	HE	SP, SW
Napa Valley Floor-Yountville	7	4	HE	SP, SW
Carneros			HE	B
Jameson/American Canyon		15	ME	B
Napa River Marshes		49	ME	SP, SW
Angwin			ME	B
Berryessa	13	19	ME	B
Central Interior Valleys	21	6	ME	B
Eastern Mountains	1		ME	B
Knoxville		5	ME	B
Livermore Ranch			LE	B
Pope Valley		9	HE	B
Southern Interior Valleys			LE	B
Western Mountains			LE	B
Total	**296**	**380**		

[1] "Current" refers to monitored wells for levels and/or any water quality parameter with a period of record extending to 2005 or later."Future" refers to recommended monitoring locations.
L = Low Priority; add groundwater level monitoring based on areas of planned future groundwater development
M = Medium Priority; add groundwater level monitoring

H = High Priority; add groundwater level monitoring

E = Expand current monitoring network; possible alternatives for additional monitoring wells include 1) wells historically monitored by DWR/USGS/Others, preferably with

well construction information and as the well may be available for monitoring; 2) existing water supply wells (e.g., private/commercial) with well construction information; 3) new dedicated monitoring wells (coordinate with potential geologic investigations that may be conducted in selected areas)
R = Refine current monitoring network (link well construction information to all monitored wells, as possible)
Monitoring Needs: SP = Improve horizontal and/or vertical spatial distribution of data; SW =identify appropriate monitoring site to evaluate surface water -groundwater recharge/discharge mechanisms; B = Basic data needed to accomplish groundwater level monitoring objectives

The individual wells (and sites in the case of GeoTracker regulated facility sites) in the current groundwater level monitoring network for programs conducted by the County, DWR, and others are included in **Table 5.4.** Wells that were historically monitored are included in **Appendix G.** As further discussed in the next section, this latter group can be further examined for the purpose of filling data gaps. Specifically, previously monitored wells that have a good historical data record, have well construction information, and are available for monitoring, are desirable for addressing data gaps.

Table 5.4 Current Groundwater Level Monitoring Network

Subarea	Well/Site	Source	Date Range			No. of Meas.	Desc.	Constr. Data Available
Berryessa	T0605500257	Geotracker	1/30/2002	-	1/17/2006	15	CurrLim	
	T0605500298	Geotracker	1/23/2004	-	3/25/2009	12	CurrHist	Yes
	T0605500312	Geotracker	10/18/2002	-	5/18/2009	24	CurrHist	
	T0605591908	Geotracker	6/20/2006	-	10/26/2009	10	CurrLim	Yes
Central Interior Valleys	T0605500279	Geotracker	1/23/2002	-	9/10/2009	24	CurrHist	
	T0605592744	Geotracker	1/10/2002	-	9/10/2009	21	CurrHist	Yes
Eastern Mountains	006N003W32N001M	NapaCounty	4/1/1999	-	10/7/2008	799	CurrHist	
Jameson/American Canyons	T0605500077	Geotracker	5/20/2003	-	5/5/2008	21	CurrLim	
	T0605500097	Geotracker	4/29/2002	-	11/2/2006	12	CurrLim	Yes
	T0605500240	Geotracker	12/6/2007	-	11/10/2009	8	CurrLim	Yes
Knoxville	LBRID_MW1	NapaCounty	6/27/2006	-	1/28/2009	12	CurrLim	Yes
	LBRID_MW2	NapaCounty	6/27/2006	-	1/28/2009	11	CurrLim	Yes
	LBRID_MW3	NapaCounty	9/20/2006	-	1/28/2009	11	CurrLim	Yes
	LBRID_MW4	NapaCounty	9/20/2006	-	1/28/2009	11	CurrLim	Yes
	LBRID_MW5	NapaCounty	2/1/2007	-	1/28/2009	10	CurrLim	Yes
NVF-Calistoga	008N006W06L004M	DWR	7/19/1962	-	10/6/2008	212	CurrHist	Yes
	008N006W10Q001M	DWR	9/30/1949	-	4/1/2009	625	CurrHist	Yes

Table 5.4 Current Groundwater Level Monitoring Network (cont.)

	009N006W31Q001M	DWR	7/14/1925	-	10/6/2008	236	CurrHist	Yes
	009N007W25N001M	DWR	10/6/1949	-	10/6/2008	240	CurrHist	Yes
	T0605500029	Geotracker	7/23/2002	-	4/3/2006	10	CurrLim	Yes
	T0605500037	Geotracker	1/15/2002	-	10/6/2006	29	CurrLim	Yes
	T0605500136	Geotracker	11/2/2001	-	7/16/2009	32	CurrHist	
	T0605500250	Geotracker	11/17/2005	-	7/22/2009	16	CurrLim	Yes
	T0605500253	Geotracker	10/28/2003	-	7/16/2009	20	CurrLim	
	T0605500272	Geotracker	9/25/2008	-	6/11/2009	4	CurrLim	
NVF-MST	005N003W05M001M	USGS	6/15/1949	-	4/22/2008	130	CurrHist	Yes
	005N003W06A001M	USGS	10/20/2000	-	4/22/2008	18	CurrHist	Yes
	005N003W06B002M	USGS	11/9/1992	-	4/22/2008	45	CurrHist	Yes
	005N003W06E002M	NapaCounty	4/21/2000	-	10/20/2008	13	CurrHist	Yes
	005N003W06J003M	USGS	4/10/1979	-	10/7/2008	64	CurrHist	Yes
	005N003W06K001M	NapaCounty	11/9/1992	-	10/7/2008	44	CurrHist	Yes
	005N003W06L002M	NapaCounty	4/13/2000	-	10/14/2008	13	CurrHist	Yes
	005N003W06M001M	DWR	4/7/2003	-	4/22/2008	11	CurrHist	
	005N003W06M003M	USGS	10/15/1999	-	10/7/2008	609	CurrHist	Yes
	005N003W06N004M	USGS	4/13/2000	-	10/20/2008	14	CurrHist	Yes
	005N003W06P00_M	NapaCounty	10/24/2001	-	10/21/2008	4	CurrHist	
	005N003W06P002M	USGS	4/13/2000	-	10/14/2008	8	CurrHist	Yes
	005N003W06Q003M	NapaCounty	4/17/2000	-	10/15/2008	11	CurrHist	Yes
	005N003W06Q004M	USGS	4/17/2000	-	10/14/2008	14	CurrHist	Yes
	005N003W06R001M	NapaCounty	4/17/2000	-	10/14/2008	14	CurrHist	Yes
	005N003W06R002M	NapaCounty	10/13/2000	-	10/16/2008	11	CurrHist	Yes
	005N003W06R003M	USGS	8/4/2000	-	10/16/2008	11	CurrHist	Yes
	005N003W07B00_Mx	NapaCounty	5/21/2001	-	10/16/2008	5	CurrHist	
	005N003W07B00_My	NapaCounty	5/23/2001	-	10/13/2008	16	CurrHist	
	005N003W07C003M	USGS	10/17/1978	-	10/7/2008	119	CurrHist	Yes
	005N003W07C005M	NapaCounty	4/13/2000	-	10/15/2008	14	CurrHist	Yes
	005N003W07D003M	NapaCounty	4/14/2000	-	10/13/2008	25	CurrHist	Yes
	005N003W07D004M	NapaCounty	8/4/2000	-	10/20/2008	12	CurrHist	Yes
	005N003W07E004M	NapaCounty	8/7/2000	-	10/15/2008	13	CurrHist	Yes
	005N003W07E005M	NapaCounty	4/14/2000	-	10/20/2008	36	CurrHist	Yes
	005N003W07E006M	NapaCounty	4/13/2000	-	10/20/2008	35	CurrHist	Yes
	005N003W07E007M	USGS	4/13/2000	-	10/15/2008	13	CurrHist	Yes
	005N003W07E008M	USGS	4/11/2000	-	10/16/2008	14	CurrHist	Yes
	005N003W07F001M	USGS	4/12/2000	-	10/16/2008	14	CurrHist	
	005N003W07F002M	NapaCounty	4/13/2000	-	10/15/2008	15	CurrHist	
	005N003W07F003M	NapaCounty	4/13/2000	-	10/13/2008	25	CurrHist	Yes
	005N003W07F004M	NapaCounty	4/13/2000	-	10/15/2008	14	CurrHist	Yes

Table 5.4 Current Groundwater Level Monitoring Network (cont.)

005N003W07F005M	NapaCounty	4/13/2000	-	10/15/2008	14	CurrHist	Yes
005N003W07G00_Mx	NapaCounty	10/26/2001	-	10/16/2008	4	CurrHist	
005N003W07G00_My	NapaCounty	5/23/2001	-	10/16/2008	5	CurrHist	
005N003W07G001M	NapaCounty	4/13/2000	-	10/16/2008	7	CurrHist	
005N003W07H003M	NapaCounty	10/25/2000	-	10/16/2008	6	CurrHist	
005N003W07M00_M	NapaCounty	5/23/2001	-	10/15/2008	5	CurrHist	
005N003W07M004M	NapaCounty	4/14/2000	-	10/24/2008	14	CurrHist	
005N003W07N002M	NapaCounty	4/14/2000	-	10/22/2008	14	CurrHist	Yes
005N003W07N003M	USGS	4/14/2000	-	10/22/2008	14	CurrHist	Yes
005N003W07Q001M	NapaCounty	4/14/2000	-	10/22/2008	7	CurrHist	
005N003W08E001M	NapaCounty	4/17/2000	-	10/13/2008	513	CurrHist	Yes
005N003W08L00_M	NapaCounty	5/25/2001	-	10/15/2008	5	CurrHist	
005N003W18D001M	USGS	4/14/2000	-	10/13/2008	25	CurrHist	Yes
005N004W01C001M	NapaCounty	4/12/2000	-	10/21/2008	7	CurrHist	
005N004W01F003M	NapaCounty	4/11/2000	-	11/5/2008	27	CurrHist	Yes
005N004W01J00_My	NapaCounty	10/23/2001	-	11/17/2008	4	CurrHist	
005N004W01R00_M	NapaCounty	10/24/2001	-	10/20/2008	14	CurrHist	
005N004W02Q00_M	NapaCounty	4/10/2001	-	10/17/2008	5	CurrHist	
005N004W12B003M	NapaCounty	4/11/2000	-	10/20/2008	7	CurrHist	
005N004W12B004M	USGS	4/11/2000	-	10/20/2008	14	CurrHist	Yes
005N004W12B005M	NapaCounty	4/11/2000	-	4/13/2005	29	CurrHist	Yes
005N004W12G001M	NapaCounty	4/11/2000	-	10/16/2008	15	CurrHist	Yes
005N004W13C00_M	NapaCounty	10/29/2001	-	10/22/2008	4	CurrHist	
005N004W13G004M	USGS	4/26/2000	-	10/13/2008	47	CurrHist	Yes
005N004W13H001M	USGS	7/16/1962	-	10/7/2008	168	CurrHist	Yes
005N004W13H003M	USGS	4/19/2000	-	10/22/2008	15	CurrHist	Yes
005N004W13J001M	USGS	4/18/2000	-	10/21/2008	15	CurrHist	Yes
005N004W14J003M	DWR	7/1/1920	-	4/24/2008	207	CurrHist	Yes
005N004W14J004M	NapaCounty	5/25/1989	-	10/7/2008	736	CurrHist	Yes
006N003W31D001M	USGS	4/18/2000	-	10/17/2008	14	CurrHist	Yes
006N003W31D002M	NapaCounty	4/20/2000	-	10/17/2008	7	CurrHist	Yes
006N003W31E001M	NapaCounty	4/18/2000	-	10/17/2008	7	CurrHist	Yes
006N003W31E002M	NapaCounty	4/12/2000	-	10/23/2008	10	CurrHist	Yes
006N003W31E003M	NapaCounty	4/18/2000	-	10/17/2008	786	CurrHist	
006N004W14Q001M	USGS	4/26/2000	-	10/13/2008	25	CurrHist	Yes
006N004W23J001M	USGS	11/18/1952	-	4/21/2008	166	CurrHist	Yes
006N004W23J005M	NapaCounty	4/9/1979	-	10/6/2008	504	CurrHist	Yes
006N004W23K001M	NapaCounty	4/20/2000	-	10/14/2008	8	CurrHist	Yes
006N004W23Q003M	USGS	10/17/1978	-	4/21/2008	79	CurrHist	Yes
006N004W23Q004M	NapaCounty	3/9/1978	-	10/6/2008	66	CurrHist	

Table 5.4 Current Groundwater Level Monitoring Network (cont.)

	006N004W25G00_M	NapaCounty	10/5/2001	-	10/13/2008	17	CurrHist	
	006N004W25G001M	USGS	4/18/2000	-	4/23/2008	44	CurrHist	Yes
	006N004W25J001M	USGS	4/18/2000	-	10/17/2008	14	CurrHist	Yes
	006N004W26B002M	NapaCounty	4/20/2000	-	10/14/2008	14	CurrHist	Yes
	006N004W26F002M	NapaCounty	4/18/2000	-	10/14/2008	14	CurrHist	Yes
	006N004W26G001M	NapaCounty	10/13/1978	-	10/7/2008	159	CurrHist	Yes
	006N004W26G002M	NapaCounty	8/4/2000	-	10/14/2008	14	CurrHist	Yes
	006N004W26G003M	USGS	4/18/2000	-	10/14/2008	15	CurrHist	Yes
	006N004W26L00_M	NapaCounty	5/23/2001	-	10/13/2008	16	CurrHist	Yes
	006N004W26R003M	USGS	6/23/2000	-	10/21/2008	14	CurrHist	Yes
	006N004W35G005M	NapaCounty	4/17/2000	-	10/13/2008	25	CurrHist	
	006N004W35H00_M	NapaCounty	5/21/2001	-	10/21/2008	5	CurrHist	
	006N004W36A001M	USGS	4/18/2000	-	10/13/2008	25	CurrHist	Yes
	006N004W36B003M	NapaCounty	4/18/2000	-	10/14/2008	7	CurrHist	
	006N004W36G001M	USGS	10/17/1978	-	4/22/2008	74	CurrHist	Yes
	006N004W36G002M	NapaCounty	4/9/1979	-	10/7/2008	68	CurrHist	
	006N004W36H004M	NapaCounty	4/12/2000	-	10/22/2008	12	CurrHist	Yes
	006N004W36P001M	NapaCounty	4/12/2000	-	10/23/2008	14	CurrHist	Yes
	006N004W36R00_M	NapaCounty	5/21/2001	-	10/17/2008	5	CurrHist	
	L1000280448	Geotracker	5/3/2005	-	4/20/2009	9	CurrLim	
	T0605500007	Geotracker	8/28/2001	-	9/3/2009	30	CurrHist	Yes
	T0605500045	Geotracker	1/2/2002	-	10/10/2006	19	CurrLim	Yes
	T0605500135	Geotracker	11/16/2001	-	1/26/2006	18	CurrLim	
	T0605500138	Geotracker	1/16/2002	-	8/17/2009	31	CurrHist	
	T0605500140	Geotracker	3/23/2000	-	9/1/2009	17	CurrHist	Yes
	T0605500150	Geotracker	8/20/2004	-	5/3/2005	4	CurrLim	
	T0605500166	Geotracker	1/18/2001	-	3/19/2008	17	CurrLim	Yes
	T0605500284	Geotracker	3/13/2002	-	8/30/2006	18	CurrLim	Yes
	T1000000041	Geotracker	12/31/2008	-	6/15/2009	3	CurrLim	
NVF-Napa	006N004W15R003M	NapaCounty	4/26/2000	-	10/13/2008	18	CurrHist	
	006N004W22R001M	DWR	9/27/1959	-	4/21/2008	67	CurrHist	Yes
	006N004W22R002M	NapaCounty	10/13/1978	-	10/6/2008	56	CurrHist	Yes
	006N004W27L002M	DWR	7/22/1966	-	4/1/2009	336	CurrHist	Yes
	006N004W27N001M	NapaCounty	2/14/1930	-	10/6/2008	187	CurrHist	Yes
	SL060553668	Geotracker	3/10/2005	-	9/9/2009	19	CurrLim	Yes
	SL060558972	Geotracker	5/23/2005	-	12/4/2007	10	CurrLim	Yes
	T0605500006	Geotracker	1/22/2004	-	1/31/2006	6	CurrLim	Yes
	T0605500008	Geotracker	12/6/2001	-	7/16/2009	31	CurrHist	Yes
	T0605500013	Geotracker	4/30/2003	-	6/14/2006	10	CurrLim	
	T0605500044	Geotracker	1/24/2002	-	8/27/2009	31	CurrHist	Yes

Table 5.4 Current Groundwater Level Monitoring Network (cont.)

	T0605500110	Geotracker	2/22/2002	-	8/20/2009	30	CurrLim	Yes
	T0605500124	Geotracker	3/22/2002	-	11/24/2008	27	CurrHist	Yes
	T0605500153	Geotracker	2/22/2002	-	8/11/2005	5	CurrLim	Yes
	T0605500164	Geotracker	7/22/2003	-	1/26/2009	23	CurrHist	
	T0605500165	Geotracker	3/6/2006	-	1/4/2010	15	CurrLim	
	T0605500205	Geotracker	2/4/2005	-	9/12/2005	3	CurrLim	
	T0605500206	Geotracker	2/12/2002	-	11/2/2005	16	CurrLim	
	T0605500212	Geotracker	3/25/2003	-	11/23/2009	20	CurrHist	Yes
	T0605500241	Geotracker	11/13/2002	-	8/24/2005	10	CurrLim	Yes
	T0605500244	Geotracker	1/16/2002	-	2/15/2006	17	CurrLim	Yes
	T0605500256	Geotracker	3/13/2003	-	7/30/2009	26	CurrHist	
	T0605500262	Geotracker	12/6/2001	-	10/5/2007	22	CurrHist	Yes
	T0605500283	Geotracker	3/26/2003	-	9/15/2005	5	CurrLim	Yes
	T0605514064	Geotracker	6/6/2005	-	8/26/2009	18	CurrLim	
	T0605522317	Geotracker	1/15/2008	-	9/21/2009	6	CurrLim	
	T0605547200	Geotracker	9/30/2008	-	6/9/2009	4	CurrLim	
	T0605554740	Geotracker	12/11/2003	-	9/8/2005	8	CurrLim	
	T0605575085	Geotracker	6/18/2009	-	9/23/2009	2	CurrLim	
	T0605591205	Geotracker	8/5/2005	-	4/29/2009	14	CurrLim	
	T0605598080	Geotracker	4/7/2005	-	4/28/2009	14	CurrLim	
NVF-Saint Helena	007N005W09Q002M	DWR	10/21/1949	-	4/1/2009	484	CurrHist	Yes
	007N005W14B002M	NapaCounty	7/17/1962	-	10/6/2008	212	CurrHist	Yes
	007N005W16L001M	USGS	10/4/1949	-	10/6/2008	211	CurrHist	Yes
	007N005W16N002M	NapaCounty	10/4/1949	-	10/6/2008	214	CurrHist	Yes
	SL060550637	Geotracker	12/10/2008	-	2/24/2009	2	CurrLim	Yes
	T0605500061	Geotracker	1/31/2005	-	12/1/2009	18	CurrLim	Yes
	T0605500143	Geotracker	3/4/2002	-	9/8/2009	24	CurrHist	Yes
	T0605500168	Geotracker	6/27/1998	-	9/15/2009	27	CurrHist	
	T0605500190	Geotracker	3/4/2002	-	9/21/2009	15	CurrHist	Yes
NVF-Yountville	006N004W06L002M	USGS	4/11/1963	-	10/6/2008	208	CurrHist	Yes
	006N004W09Q001M	DWR	4/9/1979	-	10/6/2008	105	CurrHist	Yes
	006N004W09Q002M	DWR	5/24/1984	-	10/6/2008	97	CurrHist	Yes
	006N004W17A001M	DWR	10/13/1949	-	11/25/2008	391	CurrHist	Yes
	006N004W17R002M	DWR	10/13/1978	-	10/6/2008	133	CurrHist	Yes
	006N004W19B001M	DWR	3/27/1952	-	10/6/2008	181	CurrHist	Yes
	007N004W31M001M	DWR	10/17/1978	-	10/6/2008	131	CurrHist	Yes
	T0605500293	Geotracker	12/28/2005	-	6/27/2006	3	CurrLim	Yes
Pope Valley	T0605593602	Geotracker	2/26/2002	-	2/23/2006	17	CurrLim	
	T1000000043	Geotracker	4/19/2007	-	3/12/2009	8	CurrLim	

5.2.1 Groundwater Level Monitoring Program

As indicated above, most current groundwater level monitoring occurs on a semi-annual frequency. As the County embarks on expanding and/or refining groundwater level monitoring in various county subareas, it is recommended that, initially, measurements occur on at least a quarterly basis to establish current conditions and responses to seasonal trends. For wells selected to improve understanding of surface water – groundwater interactions, monthly measurements, at least initially, would be desirable.

5.3 Future Recommended Groundwater Quality Monitoring Network and Program

The primary objectives of the countywide groundwater quality monitoring program include:

- Evaluate groundwater quality conditions in the various county subareas and identify differences in water quality spatially between areas and vertically in the aquifer system within a subarea;
- Identify where data gaps occur and provide infill, replacement, and/or project-specific monitoring (e.g., such as may occur for planned projects or expansion of existing projects) as needed;
- Detect the occurrence of and factors attributable to natural or "emerging" constituents that are a concern;
- Assess the changes and trends in groundwater quality; and
- Identify the natural and human factors that affect changes in water quality.

5.3.1 Groundwater Quality Monitoring Network

The current groundwater quality monitoring network consists of 283 wells (at 153 monitoring sites) (**Table 5.5**). Of the sites, 41 have some level of well construction information. Current groundwater quality monitoring sites are fairly well distributed throughout the Napa Valley Floor Subarea. As illustrated on **Figure 5.1**, some of these have a longer-term record than others. In other subareas, current groundwater quality monitoring (e.g., sites with shorter or longer term records) is more limited. Recommended improvements to the groundwater quality monitoring program, and priority timelines for improvements, are summarized in **Table 5.5** and discussed below.

Table 5.5 and **Figure 5.4** summarize current groundwater quality monitoring wells/sites. **Table 5.5** includes a preliminary ranking and prioritization for improving or expanding groundwater quality monitoring in each of the designated subareas. Four subareas (including NVF-MST, Carneros, Jameson/American Canyon, and Pope Valley Subareas) are given a higher priority based on factors of current and /or projected land uses and also the lack of spatially distributed groundwater quality monitoring. Three subareas, including Livermore Ranch, Southern Interior Valleys, and Western Mountains, are preliminarily assigned lower priorities for groundwater quality monitoring due to the likely lower levels of projected land and groundwater use. The eleven remaining subareas are designated as medium priorities for groundwater quality monitoring (**Table 5.5**). Many of these areas have current monitoring programs, so the emphasis in these areas is to further examine land use with respect to monitoring locations and the units(s) of the aquifer system represented by this monitoring.

Table 5.5 also includes key factors related to monitoring needs. Many subareas outside the Napa Valley Floor have limited spatial distribution of the current groundwater quality monitoring wells/sites. Basic data are described as a key monitoring need to accomplish groundwater quality objectives. Importantly, expansion and/or refinement of groundwater quality monitoring conducted in all subareas should be coordinated with efforts to expand or refine groundwater level monitoring.

The individual wells (and sites in the case of GeoTracker regulated facility sites) in the current groundwater quality monitoring programs conducted by DWR and others are included in **Table 5.6.** Wells that were historically monitored are included in **Appendix H.** As further discussed in the next section, this latter group can be further examined for the purpose of filling data gaps. Specifically, previously monitored wells that have a good historical data record, have well construction information, and are available for monitoring could be considered for addressing data gaps.

Table 5.5
Groundwater Quality Monitoring Wells, Napa County
(Current[1] and Future)

Subarea	No. Wells with Historical and Current WQ Data (post 2005 and >5 years of data)	No. Wells with Current but Limited WQ Data (post 2005 and <5 years of data)	Future Groundwater Quality Monitoring	Monitoring Needs
Napa Valley Floor-Calistoga	4	25	MR	SP,C
Napa Valley Floor-MST	16	10	HR	SP,C
Napa Valley Floor-Napa	3	28	MR	SP,C
Napa Valley Floor-St. Helena	4	33	MR	SP,C
Napa Valley Floor-Yountville	5	13	MR	SP,C
Carneros	3	4	HR	SP,C
Jameson/American Canyon			HE	B,SP,C
Napa River Marshes	1	26	ME	B,SP,C
Angwin	8	2	ME	B,C
Berryessa		9	ME	B,C
Central Interior Valleys	13	26	MR	B,SP,C

Table 5.5 (cont.)
Groundwater Quality Monitoring Wells, Napa County
(Current[1] and Future)

Eastern Mountains	15	10	ME	B,C
Knoxville		5	ME	B,C
Livermore Ranch			LE	B,C
Pope Valley		7	HE	B,C
Southern Interior Valleys	1	2	LE	B,C
Western Mountains	6	4	LR	B,C
Total	**79**	**204**		

[1] "Current" refers to monitored wells for levels and/or any water quality parameter with a period of record extending to 2005 or later.“Future” refers to recommended monitoring locations.
L = Low Priority; add groundwater level monitoring based on areas of planned future groundwater development
M = Medium Priority; add groundwater level monitoring

H = High Priority; add groundwater level monitoring

E = Expand current monitoring network; possible alternatives for additional monitoring wells include 1) wells historically monitored by DWR/USGS/Others, preferably with well construction information and as the well may be available for monitoring; 2) existing water supply wells (e.g., private/commercial) with well construction information; 3) new dedicated monitoring wells (coordinate with potential geologic investigations that may be conducted in selected areas)
R = Refine current monitoring network (link well construction information to all monitored wells, as possible)
Monitoring Needs: SP = Improve horizontal and/or vertical spatial distribution of data; B = Basic data needed to accomplish groundwater level monitoring objectives; C = Coordinate with groundwater level monitoring

Table 5.6 Current Groundwater Quality Monitoring Network

Subarea	Name	Source	Date Range			No. of Meas	Description	Construction Data Available
Angwin	2800527-001	DPH	6/12/2000	-	3/9/2009	141	CurrHist	
	2800528-001	DPH	9/17/2001	-	9/8/2008	108	CurrHist	
	2800528-002	DPH	10/4/2004	-	6/16/2008	68	CurrLim	
	2801936-001	DPH	5/17/2004	-	6/29/2005	36	CurrLim	
	2810001-002	DPH	2/10/1988	-	12/19/2007	91	CurrHist	
	2810001-003	DPH	5/17/1989	-	12/19/2007	91	CurrHist	
	2810012-003	DPH	4/15/1992	-	8/22/2008	176	CurrHist	
	2810012-004	DPH	4/1/1992	-	8/22/2008	175	CurrHist	
	2810012-005	DPH	4/15/1992	-	8/22/2008	176	CurrHist	

Table 5.6 Current Groundwater Quality Monitoring Network (cont.)

	2810012-006	DPH	4/1/1992	-	8/22/2008	178	CurrHist	
Berryessa	NBRID_MW2	NapaCounty	5/9/2007	-	2/6/2009	69	CurrLim	Yes
	NBRID_MW3	NapaCounty	5/9/2007	-	2/6/2009	69	CurrLim	Yes
	T0605500257	Geotracker	9/28/2007	-	9/28/2007	2	CurrLim	
Carneros	004N004W05C001 M	DWR	8/28/1958	-	9/24/2008	318	CurrHist	
	005N004W20R002 M	USGS	5/8/1963	-	8/22/2005	165	CurrHist	
	2800538-001	DPH	10/20/2003	-	2/11/2005	36	CurrLim	
	2800538-002	DPH	2/11/2005	-	2/11/2005	35	CurrLim	
	2800847-001	DPH	5/18/2004	-	9/23/2008	53	CurrLim	
	2801011-002	DPH	6/17/2002	-	6/13/2007	55	CurrLim	
	2801089-001	DPH	4/30/2002	-	2/10/2009	7	CurrHist	
Central Interior Valleys	2800186-001	DPH	6/14/2007	-	6/14/2007	14	CurrLim	
	2800297-001	DPH	9/2/2008	-	9/2/2008	25	CurrLim	
	2800521-002	DPH	5/29/2002	-	8/6/2008	73	CurrHist	
	2800593-001	DPH	4/30/2001	-	11/14/2008	106	CurrHist	
	2800593-002	DPH	5/26/2004	-	11/14/2008	73	CurrLim	
	2800593-003	DPH	5/26/2004	-	11/14/2008	73	CurrLim	
	2800593-004	DPH	5/22/2008	-	10/1/2008	2	CurrLim	
	2800844-001	DPH	9/23/2008	-	9/23/2008	1	CurrLim	
	L10003756160	Geotracker	6/2/2005	-	12/29/2005	14	CurrLim	
	T0605500279	Geotracker	10/1/2002	-	9/30/2008	13	CurrHist	
	T0605592744	Geotracker	4/16/2007	-	12/31/2008	28	CurrLim	Yes
Eastern Mountains	2800023-001	DPH	7/31/2007	-	1/21/2009	29	CurrLim	
	2800023-002	DPH	8/18/2006	-	10/27/2008	29	CurrLim	
	2800024-001	DPH	4/24/2002	-	8/27/2008	68	CurrHist	
	2800029-001	DPH	7/15/2008	-	1/14/2009	2	CurrLim	
	2800298-001	DPH	1/20/2004	-	4/9/2008	72	CurrLim	
	2800521-001	DPH	5/29/2002	-	8/19/2008	91	CurrHist	
	2800525-001	DPH	2/4/2000	-	10/2/2006	69	CurrHist	
	2800532-001	DPH	8/6/2003	-	12/23/2008	74	CurrHist	
	2800583-001	DPH	3/6/2002	-	3/15/2006	31	CurrLim	
	2800625-002	DPH	3/31/1994	-	10/18/2007	143	CurrHist	
	2800625-003	DPH	3/31/1994	-	3/24/2009	467	CurrHist	
	2800625-004	DPH	3/31/1994	-	3/24/2009	474	CurrHist	
	2800625-006	DPH	7/30/1997	-	3/24/2009	358	CurrHist	
	2800625-007	DPH	4/29/2002	-	3/24/2009	250	CurrHist	
	2801033-002	DPH	12/1/2008	-	12/1/2008	1	CurrLim	

Table 5.6 Current Groundwater Quality Monitoring Network (cont.)

	2801035-002	DPH	2/5/2007	-	2/5/2007	25	CurrLim	
	2801043-002	DPH	11/18/2002	-	4/22/2009	54	CurrHist	
	2801076-001	DPH	1/23/2003	-	2/10/2009	5	CurrHist	
	2801076-002	DPH	2/10/2009	-	2/10/2009	1	CurrLim	
	2801084-002	DPH	3/31/2004	-	9/17/2008	79	CurrLim	
	2801086-001	DPH	4/11/2000	-	5/21/2008	50	CurrHist	
	2803697-001	DPH	4/24/2002	-	6/12/2007	54	CurrHist	
	2803879-001	DPH	3/20/2006	-	4/6/2009	3	CurrLim	
	2803907-001	DPH	6/28/2002	-	1/6/2009	57	CurrHist	
	2810305-001	DPH	6/7/2000	-	9/10/2008	27	CurrHist	
Knoxville	LBRID_MW1	NapaCounty	6/27/2006	-	1/28/2009	149	CurrLim	Yes
	LBRID_MW2	NapaCounty	6/27/2006	-	1/28/2009	153	CurrLim	Yes
	LBRID_MW3	NapaCounty	9/20/2006	-	1/28/2009	136	CurrLim	Yes
	LBRID_MW4	NapaCounty	9/20/2006	-	1/28/2009	136	CurrLim	Yes
	LBRID_MW5	NapaCounty	2/1/2007	-	1/28/2009	119	CurrLim	Yes
Napa River Marshes	2800530-001	DPH	12/17/2002	-	9/23/2007	89	CurrLim	
	2800531-001	DPH	4/14/2004	-	6/21/2006	25	CurrLim	
	2800811-001	DPH	9/4/2002	-	10/3/2007	41	CurrHist	
	2800811-002	DPH	9/4/2002	-	7/5/2006	17	CurrLim	
	2800811-003	DPH	9/4/2002	-	7/5/2006	17	CurrLim	
	2801080-001	DPH	6/18/2002	-	7/29/2005	69	CurrLim	
NVF-Calistoga	008N006W10Q003M	DWR	8/16/1972	-	9/5/2007	137	CurrHist	
	2800026-001	DPH	1/17/2005	-	11/25/2008	11	CurrLim	
	2800026-002	DPH	1/17/2005	-	8/20/2008	37	CurrLim	
	2800030-001	DPH	12/11/2008	-	12/11/2008	1	CurrLim	
	2800129-001	DPH	3/15/2000	-	8/27/2008	85	CurrHist	
	2800129-002	DPH	2/18/2004	-	8/27/2008	44	CurrLim	
	2800508-002	DPH	2/11/2009	-	2/11/2009	26	CurrLim	
	2800516-001	DPH	2/13/2007	-	2/13/2007	34	CurrLim	
	2800516-002	DPH	2/13/2007	-	9/27/2007	35	CurrLim	
	2800561-002	DPH	12/6/2004	-	11/21/2008	54	CurrLim	
	2800742-002	DPH	6/19/2003	-	11/10/2008	23	CurrHist	
	2801007-003	DPH	11/29/2005	-	11/29/2005	6	CurrLim	
	2810300-001	DPH	5/22/1987	-	6/18/2008	66	CurrHist	
	L10001344067	Geotracker	2/23/2005	-	2/11/2009	69	CurrLim	Yes
	T0605500250	Geotracker	7/22/2009	-	7/22/2009	3	CurrLim	Yes
NVF-MST	2800025-001	DPH	5/10/2004	-	4/7/2009	4	CurrLim	
	2800548-001	DPH	10/11/2000	-	7/30/2008	70	CurrHist	
	2800580-001	DPH	8/18/2003	-	8/28/2008	44	CurrHist	

Table 5.6 Current Groundwater Quality Monitoring Network (cont.)

	2800848-001	DPH	5/18/2004	-	9/23/2008	27	CurrLim	
	T0605500135	Geotracker	7/16/2003	-	6/2/2009	7	CurrLim	
	T0605500140	Geotracker	6/29/2002	-	9/1/2009	26	CurrHist	Yes
NVF-Napa	005N004W15E001 M	USGS	8/28/1958	-	8/21/2006	263	CurrHist	
	006N004W27L002 M	DWR	8/16/1972	-	9/4/2007	145	CurrHist	
	2800546-001	DPH	4/26/2000	-	7/13/2005	69	CurrHist	
	2800635-002	DPH	1/24/2008	-	1/7/2009	29	CurrLim	
	2800635-005	DPH	11/8/2005	-	4/8/2009	80	CurrLim	
	T0605522317	Geotracker	1/15/2008	-	1/15/2008	17	CurrLim	
	T0605597251	Geotracker	8/7/2007	-	4/28/2008	5	CurrLim	
NVF-Saint Helena	2800027-001	DPH	6/28/2006	-	2/24/2009	29	CurrLim	
	2800035-001	DPH	10/8/2004	-	2/10/2009	43	CurrLim	
	2800561-003	DPH	11/16/2004	-	11/19/2008	46	CurrLim	
	2800609-002	DPH	10/22/2003	-	9/5/2008	59	CurrLim	
	2801012-001	DPH	10/4/2005	-	2/15/2009	50	CurrLim	
	2801046-002	DPH	4/5/2007	-	2/4/2009	27	CurrLim	
	2801049-002	DPH	7/14/2004	-	1/5/2009	45	CurrLim	
	2801070-001	DPH	5/19/2004	-	3/25/2009	45	CurrLim	
	2801070-002	DPH	5/19/2004	-	7/23/2008	32	CurrLim	
	2801073-001	DPH	9/4/2008	-	3/23/2009	3	CurrLim	
	2801073-003	DPH	4/15/2008	-	9/18/2008	3	CurrLim	
	2801075-001	DPH	4/15/2002	-	2/4/2009	87	CurrHist	
	2801075-002	DPH	6/23/2004	-	4/18/2007	50	CurrLim	
	2801075-003	DPH	6/23/2004	-	2/4/2009	113	CurrLim	
	2803892-001	DPH	6/12/2002	-	6/20/2005	3	CurrLim	
	2803912-001	DPH	6/21/2002	-	9/11/2008	78	CurrHist	
	2810004-006	DPH	2/20/1991	-	12/3/2008	286	CurrHist	
	2810004-007	DPH	11/20/1996	-	3/11/2009	207	CurrHist	
	L10003472156	Geotracker	2/16/2005	-	8/10/2009	60	CurrLim	Yes
	SL0605506371	Geotracker	7/31/2008	-	5/6/2009	20	CurrLim	Yes
	T0605500143	Geotracker	2/21/2008	-	2/21/2008	1	CurrLim	Yes
	T0605500190	Geotracker	7/12/2007	-	3/3/2009	8	CurrLim	Yes
NVF-Yountville	2800299-001	DPH	4/25/2002	-	8/4/2008	107	CurrHist	
	2800299-002	DPH	6/24/2003	-	8/4/2008	63	CurrHist	
	2800302-001	DPH	4/18/2002	-	4/28/2008	25	CurrHist	
	2800302-003	DPH	4/2/2009	-	4/2/2009	1	CurrLim	
	2800736-002	DPH	11/13/2006	-	11/13/2006	24	CurrLim	
	2801029-002	DPH	1/4/2005	-	5/7/2008	60	CurrLim	

Table 5.6 Current Groundwater Quality Monitoring Network (cont.)

	2801029-003	DPH	1/4/2005	-	5/7/2008	63	CurrLim
	2801029-004	DPH	1/4/2005	-	5/7/2008	62	CurrLim
	2801042-002	DPH	10/29/2008	-	10/29/2008	18	CurrLim
	2801042-003	DPH	6/16/2004	-	12/3/2008	23	CurrLim
	2801042-004	DPH	10/29/2008	-	10/29/2008	25	CurrLim
	2801047-001	DPH	3/6/2002	-	12/10/2008	65	CurrHist
	2803911-001	DPH	4/19/2002	-	4/13/2009	18	CurrHist
	2810007-002	DPH	6/14/2006	-	9/29/2008	40	CurrLim
	T0605500058	Geotracker	9/13/2005	-	9/13/2005	17	CurrLim
Pope Valley	2800569-002	DPH	6/21/2006	-	5/21/2008	34	CurrLim
	T0605593602	Geotracker	11/17/2003	-	11/30/2005	3	CurrLim
Southern Interior Valleys	2800521-003	DPH	5/29/2002	-	7/19/2007	104	CurrHist
	2800680-002	DPH	6/15/2004	-	11/20/2006	27	CurrLim
	2800845-001	DPH	5/19/2004	-	9/23/2008	53	CurrLim
Western Mountains	2800301-001	DPH	5/1/2002	-	4/13/2009	88	CurrHist
	2800579-002	DPH	8/8/2007	-	8/8/2007	1	CurrLim
	2800613-001	DPH	3/2/2004	-	2/12/2009	71	CurrLim
	2801008-002	DPH	2/18/2003	-	4/17/2009	65	CurrHist
	2801016-001	DPH	8/7/2002	-	8/26/2008	74	CurrHist
	2801016-002	DPH	8/7/2002	-	8/26/2008	75	CurrHist
	2801016-003	DPH	8/7/2002	-	8/26/2008	75	CurrHist
	2801016-004	DPH	8/7/2002	-	5/17/2006	72	CurrLim
	2801025-001	DPH	3/25/2003	-	11/14/2006	37	CurrLim
	2810301-001	DPH	9/24/1992	-	6/18/2008	38	CurrHist

5.3.2 Groundwater Quality Monitoring Program

As indicated above, with the exception of GeoTracker regulated facility contaminated sites, current groundwater quality monitoring for TDS and/or EC typically occurs on a less frequent than annual basis. Nitrate monitoring on an annual or more frequent basis has occurred more often than monitoring for TDS, EC, and chloride. As the County embarks on expanding or refining groundwater quality monitoring in various subareas, it is recommended that, initially, samples from "new" locations (previously monitored wells, existing supply wells or new dedicated monitoring facilities) be monitored annually for general minerals and metals for at least two years. Pending subarea-specific land uses and further examination of the available groundwater quality data in that area, along with additional attention to the aquifer unit(s) that these data represent, it may also be desirable to monitor selected constituents more often. For example, available groundwater quality data indicate elevated arsenic concentrations in the southern portion of the county, particularly in the NVF-MST Subarea. It is unclear whether the elevated arsenic concentrations exhibit a correlation with one or more rock types common to this area and/or if other factors (e.g., turbid samples) have also influenced historical results. To further examine the source of the exceedances, an area-specific investigation and focused sampling plan may be warranted.

6.0 FINDINGS AND RECOMMENDATIONS

Groundwater and surface water resources are highly important natural resources in Napa County. The Napa County community actively supports and invests in its water resources to sustain agricultural productivity. Concurrently, municipal and private stakeholders are actively engaged in assessing the potential for the development of additional water supplies, both groundwater and surface water of good quality, to meet future urban and rural water demands.

Long-term, systematic monitoring programs are essential to provide data that allow improved evaluation of water resources conditions and availability and facilitate effective water resources management. Napa County embarked on this countywide project with emphasis on understanding groundwater conditions based on available data, and implementing an expanded groundwater monitoring and data management program as a framework for coordinated, integrated water resources management and dissemination of water resources information.

This project led to a broader awareness of available groundwater data and an assessment of current groundwater conditions and trends and also identified factors related to future assessment of groundwater availability. Spatial data coverage was good for some County subareas; however, for other subareas, monitoring network enhancements are needed. Findings from this project and recommendations for enhancing and expanding the countywide groundwater monitoring program to facilitate understanding of groundwater availability and integrated regional water management and planning efforts are summarized in this section. A table that summarizes the recommended implementation steps, including the implementation time frame, a relative estimated budget and the relative priority for implementation, is presented at the end of this section.

6.1 Data Management System

At the outset of the development of the DMS, it was recognized that the County would assist with the entry of other historical groundwater level and groundwater quality data. It was anticipated that future County staff time would be needed for this effort and also to incorporate well construction information for wells historically monitored in the County, recent surface water delivery information (as desired), and municipal pumping data. Other recommendations are provided below:

- It is important to remove redundancy in the groundwater level and groundwater quality data. This can occur when two sources of information provide identical or similar data for the same well. The wells with redundant data need to be identified and flagged as such. Then the duplicated data (water level or quality) need to be examined and appropriate steps taken to remove the redundancy. Several wells and their related data are reported by more than one agency. The historical data from the various entities need to be merged and one Well ID should remain for each physical well.

- Currently, the WellMA table is not linked to wells in the main database tables. This is due to the lack of a complete SWN in the WellMA table. SWNs need to be determined or, where driller's report numbers are provided, the wells in the well table {T_Well} in the DMS need to be linked with the wells in the WellMA table.

- The monitoring agency and/or schedule of monitoring for water quality and groundwater levels of each well should be indicated in Monitoring Table {T_Monitor} for each well.

- Location data for several DPH and GeoTracker wells were unavailable at the time of download and entry to the DMS. These data should be requested from the respective source agencies and appropriate measures taken to ensure data security.

- Locate wells that have water level or water quality measurements but do not yet have x-y coordinates and assign them to their applicable geographic subareas. Additionally, verify coordinates to confirm the location of a site as in or outside of Napa County. Upon verification that coordinates for a site are correct and that the site is located outside of Napa County, that site and the related data may be removed from the DMS.

- Continue to fill in the Water Quality Parameter table with abbreviated (short) parameter names as necessary.

- Some groundwater level data contain measuring point discrepancies. These differences may arise when a well gets surveyed and the measuring point changes. There also might be errors in the reference point elevations; in this case, the reporting agency should be notified to resolve the error. For example, one well, 05N03W06M001M with water level data from DWR, has reference point elevations of 130.6 feet and 280 feet. This type of difference is significant and unacceptable. Other differences in reference point elevations are smaller, several are less than one foot, but the differences should be considered when making interpretations of water level changes and should, therefore, be rectified.

- To enhance DMS data viewing and retrieval by non-database users, it is suggested that a map-interface be established that allows for the display of well locations and the ability to click on the well location on the map to view or retrieve its various properties (for example a hydrograph of water levels, water quality tables, construction information, etc.).

- In the future, data entry is anticipated to be a cooperative effort overseen and managed by the County. The County would have overall responsibility for the centralized DMS; however, other entities (e.g., other County departments and potentially other entities in the County) could assist with the creation of data sets to be imported to the main database. Quality control protocols for merging newly entered data into the core database are recommended to avoid duplication.

6.2 CASGEM Groundwater Elevation Monitoring Program

Development of the countywide DMS, groundwater data quality evaluation, and the recommended groundwater level monitoring program presented in this report provide a means for further coordination with statewide monitoring program interests, particularly the CASGEM program. As described in Section 5, DWR is facilitating the statewide program where local entities can apply to DWR to assume the function of regularly and systematically collecting and reporting groundwater level data to determine seasonal and long-term trends in the state's groundwater basins and subbasins. Napa County's overall Comprehensive Groundwater Monitoring Program covers the continuation and expansion of countywide groundwater level monitoring efforts (including many basins, subbasins and/or subareas throughout the county) for the purpose of understanding groundwater conditions (i.e., seasonal and long-term groundwater level trends and also quality trends) and availability to enable integrated water resources management and planning to meet future water supply demands.

Another aspect of the CSGEM program is to make the groundwater level information available to the public. Napa County's combined efforts through the Comprehensive Groundwater Monitoring Program along with the related AB 303 Public Outreach Project create a framework for applying the findings and recommendations from these programs to the County's continued efforts to increase public outreach. An informed public enables support of planned water resources projects and programs proposed by the County and others. Recommendations for furthering County participation in this program are summarized below.

6.2.1 Recommendations

1. County establish its role as lead entity for the CASGEM program for groundwater basins located in Napa County. The County Board of Supervisors recently approved the County's plan to notify DWR that it intends to become the monitoring entity for Napa County (Napa County Board of Supervisors, meeting December 14, 2010).

2. Coordinate with other collaborators on participation in DWR's program.

3. Coordinate current groundwater level monitoring network and program discussed herein with DWR objectives to identify groundwater monitoring wells suited to representing groundwater conditions in the "DWR-designated" basins and subbasins (i.e., link DWR basin/subbasin designations to subarea delineation).

4. Establish a CASGEM subset of groundwater level monitoring wells from the current groundwater level monitoring network. Specific monitoring objectives (in addition to over-arching objectives described in Section 5) should then be developed for these wells.

5. Coordinate groundwater level measurement frequency with other local entities for CASGEM-designated monitoring wells such that measurements are collected at least semi-annually.

6. Import groundwater level data into the DMS.

7. Establish data format in accordance with DWR guidelines for electronic transfer of data as requested by DWR.

6.3 Groundwater Monitoring Program

The County's Comprehensive Groundwater Monitoring Program project has resulted in recommendations for continuation of current monitoring programs and expansion and/or refinement of the programs conducted by the County and others. A DMS has also been developed that creates a central repository for these data, as well as other data necessary to accomplish groundwater level, groundwater quality, and other objectives to protect the County's water resources. For the overall groundwater level and quality monitoring program to be successful, coordination with other cooperating entities, such as City representatives and numerous other entities is required. A successful program will also require interest by and the cooperation of landowner participants who have already authorized use of their wells for current monitoring programs and also those that express an interest in being an active participant in the County's efforts to expand the countywide groundwater level and quality monitoring programs.

6.3.1 Groundwater Level Monitoring Network

Groundwater level measurements have been recorded at a total of 676 wells (173 sites) through at least 2005. Of these sites where levels are measured, some type of well construction information (depth and/or perforated interval(s)) is readily available for 118 sites. Below are recommendations to implement the expansion and improvement of countywide groundwater level monitoring activities by the County and others.

6.3.2 Recommendations

1. Replace water level monitoring wells that are completed in more than one aquifer with wells completed in (or representative of) a single aquifer (a phased approach is recommended for this effort that considers the historical record for existing wells in the network, i.e., **Appendix G**).

2. Continue groundwater level monitoring on at least a semi-annual basis; increase the spatial and vertical distribution of wells for monthly water level measurements as described in Section 5 to allow more comprehensive evaluation of groundwater conditions and stream-aquifer relationships.

3. Perform GPS surveys with higher accuracy instrumentation, as may be needed, to establish reference point elevation data.

4. Communicate County groundwater level monitoring objectives to private and commercial landowners and invite participation in the ongoing program (i.e., access to suitable wells with construction information located in areas of interest to meet subarea-specific monitoring objectives).

6.3.3 Groundwater Quality Monitoring Network

Groundwater quality monitoring has been conducted at a total of 283 wells (or 153 sites) through at least 2005. Of these sites where groundwater quality samples are collected, some type of well construction information (depth and/or perforated interval(s)) is readily available for only 15 sites. Below are recommendations to implement the expansion and improvement of countywide groundwater quality monitoring activities.

6.3.3.1 Recommendations

1. Implement efforts to expand and/or refine groundwater quality monitoring program such that more wells can be “qualified” with well construction information.

2. Review the historically monitored wells in **Appendix H** to determine whether some of these may be suited to the objectives of gathering basic data and/or expanding groundwater quality monitoring in the various county subareas.

3. Coordinate expansion of the groundwater quality monitoring program with the expansion/refinement of subarea groundwater level monitoring.

4. Communicate County groundwater quality monitoring objectives to private and commercial landowners and invite participation in the ongoing program (i.e., access to suitable wells with construction information located in areas of interest to meet subarea-specific monitoring objectives).

5. As feasible, replace monitoring wells that are completed in more than one zone or aquifer with wells completed in a single unit that meets regional and subarea-specific groundwater quality monitoring objectives.

6.3.4 Groundwater Monitoring Program – Next Steps

6.3.4.1 Recommendations

1. County establish its role as lead agency for ongoing groundwater monitoring program coordination and database oversight and management.

2. Establish plan for pertinent County departments (e.g., Groundwater Advisory Group representatives and others as appropriate, including County GIS persons(s)) to coordinate data collection, storage, and analysis efforts.

3. Identify potential collaborators (including local, federal, and state agency representatives) and interested stakeholders for the ongoing program.

4. Annually update the DMS (e.g., groundwater levels and quality and other water-related data), assess network and findings, and make changes to the program where necessary.

5. Discuss monitoring parameters of special interest with collaborators.

6. Review groundwater data annually and revise or make recommendations to revise data collection accordingly pending changes to network wells and/or specific program objectives.

7. Identify locations for construction of dedicated monitoring wells for water level and quality monitoring (e.g., county subareas where more subsurface information is required to better quantify groundwater availability and quality, recharge areas where aquifer-specific monitoring is lacking, surface water-groundwater interaction, etc.).

8. Replace (over time) wells in the monitoring network that have no well construction information (or are perforated in more than one zone) to improve the understanding of aquifer-specific conditions.

9. Coordinate efforts being conducted for water supply investigation work (e.g., test hole construction) with opportunities for constructing zone-specific dedicated monitoring facilities for countywide water level and/or water quality monitoring.

10. Communicate program results to the cooperating entities.

11. Provide an overview of program objectives, benefits and results to general public via web information and other communication vehicles.

12. Seek funding to support program continuation, including DMS, data evaluation, and implementation of priority recommendations.

13. Explore the need to develop guidelines for testing private wells to evaluate potential water quality issues.

6.4 Regional and Local Physical Conceptualization

Understanding the hydrogeology of Napa County is essential to determine how much water is available and to what extent it can be sustainably produced. Previous hydrogeologic studies have focused on the MST Subarea and northern portion of the Napa Valley without much attention to the other areas within the County. With the exception of the Farrar and Metzger (2003) study, which looked at the MST, all of these studies are more than 30 years old. In the last 30+ years hundreds of new wells have been drilled to greater depths than previously reached, supplying an abundance of new data. Also, pumping of these new wells has influenced groundwater conditions throughout much of the County.

Due in part to the scarcity of hydrogeologic data available for the majority of Napa County, data collection and analysis will need to be prioritized, with the most urgent attention given to those areas of greatest short- and long- term development potential. Although current agricultural and domestic groundwater and surface water consumption are not necessarily set to expand significantly, what little data are available for this area suggests that current use may not be sustainable.

6.4.1 Napa Valley Geology and Groundwater Conditions

Currently, analysis of the Napa Valley has been limited to two studies, one by Kunkel and Upson (1960) which included preliminary cross sections through the lower portion of the Valley, and one by Faye (1973), which focused on the valley alluvium occurring in the northern section of Napa Valley. Since the Kunkel and Upson (1960) study, plate tectonics theory was introduced, significantly expanding our understanding of the relationship between individual geologic units within the County and the structures (faults, folds, and fractures) that accompany these relationships. Also, since the 1960s and 1970s, a significant number of new wells (and therefore new well logs) have been added to the Valley, with an ever increasing number reaching beyond the Napa Valley alluvium and into the underlying Sonoma Volcanics.

Kunkel and Upson’s cross sections should be updated and expanded to include the last 50 years of new log data and plate tectonics theory. New cross sections should also be created throughout the valley and into the surrounding foothills to better delineate the vertical/horizontal extent of the alluvium and underlying Sonoma Volcanics. Faye’s isopach map of the alluvium (**Figure 2.6**) and hydraulic conductivity distribution map (**Figure 2.7**) should be updated to include the new well log data and be extended to the southern end of the Valley. As data become available, similar maps could be produced for the Sonoma Volcanics within the Napa Valley. Delineation and description of the primary aquifer units is essential to determine how much available groundwater is present within the Valley and how the aquifers may react to future water management policies.

Faye (1973) identified direct infiltration of precipitation and percolation of surface water as the primary mechanisms for groundwater recharge in the Valley. He also concluded that the contribution of percolating surface water was significantly limited by high groundwater levels. Farrar and Metzger (2003) note that subsurface inflow to the Napa Valley has been significantly decreased by increased pumping within the MST. It is similarly likely that increased pumping in the areas surrounding the Napa Valley has reduced recharge to the Valley, lowering groundwater levels and increasing the potential for streambed percolation. These groundwater surface water reactions and their response to changing stresses in the County should also be examined.

6.4.2 Pope Valley Subarea Hydrogeology

The Pope Valley Subarea is forecast to have an increase in development and with that an increase in groundwater pumping. Currently, subsurface geology has not been investigated and only limited hydrologic data is available. To determine the impact of current groundwater usage and enable informed decision making concerning future development within the Pope Valley Subarea (or other similar subareas), further analysis should include:

- Monitoring groundwater levels;
- Monitoring groundwater quality;
- Collection and interpretation of geologic data (primarily well logs);
- Analysis of stream flow and precipitation;
- Estimation of pumping and irrigation demand; and
- Estimation of groundwater recharge and discharge.

6.4.3 Carneros Subarea Hydrogeology

Presently, very few data are available that describe the hydrogeologic setting of the Carneros Subarea. The available data, though limited, suggest that groundwater resources are limited and may be susceptible to over development. Future planning decisions will require knowledge of current groundwater conditions and the possible impacts that may result from additional pumping. A complete analysis of the Carneros Subarea, similar to those of Johnson (1977) and Farrar and Metzger (2003) in the MST, should be performed, including:

- Monitoring groundwater levels;
- Monitoring groundwater quality;
- Estimation of recharge and discharge using both mass balance and streamflow infiltration methods;
- Determination of the extent and properties of aquifer materials; and
- Investigation of the influence of natural and induced hydrologic stresses occurring in neighboring subareas

This will likely require the addition of a number of monitoring wells for geologic and water level data.

6.4.4 Hydrogeology and Saltwater Intrusion Potential for the Jameson/American Canyon and Napa River Marshes Subareas

Similar to the Angwin and Carneros Subareas, very few data are available for the Jameson/American Canyons and Napa River Marshes Subareas. The two main issues facing this area are potential saltwater intrusion and the possibility that current water resources will not be sufficient to meet future demand (in the Jameson/American Canyon Subarea). To establish current conditions and obtain information necessary for future development planning, a local study should include:

- Collection and interpretation of geologic data (primarily well logs);
- Analysis of streamflow and precipitation;
- Estimation of recharge and discharge using both mass balance and streamflow infiltration methods; and
- Determination of the extent and properties of aquifer materials.

As mentioned in **Section 2.7** of this report, the current lack of groundwater data makes it difficult to determine the source and distribution of salinity in the southern area of the County with any certainty. Also, geophysical logs for two oil and gas wells located directly to the south of Napa County on San Pablo Bay do not show any conclusive saltwater occurrence between 80 and 1,500 feet below ground surface, suggesting freshwater may be present below the shallow subsurface. A series of multi-level monitoring well clusters installed stepping south from the City of Napa toward San Pablo Bay would help in determining the geology of the Napa River Marsh Subarea and distribution of high salinity groundwater. This study, in conjunction with efforts to estimate subsurface outflow from the Napa Valley would also help determine if fresh water within the Napa River Marshes Subarea could possibly be used to sustain increasing demand in the Jameson/American Canyon Subarea.

6.5 Summary of Recommendations and Priorities for Implementation

Table 6.1 summarizes the steps necessary to implement the above-described recommendations. The summary table includes the following:

- **Implementation time frames**: near term, mid term and long term (approximately 3, 5, and 10-year periods, respectively);
- **Relative estimated preliminary budgets:** "$ to $$$", where $ budget ranges up to $50,000; $$ budget ranges up to $500,00, and $$$ budget ranges up to $1,000,000;
- **Relative priorities for implementation**: the priority ranking is on a scale of 1 to 4, with 1 being the highest priority and 4 being the lowest priority, and
- **Related document for additional information**: indicates in which Technical Memorandum or Report related to the Comprehensive Groundwater Monitoring Program additional information is presented.

Table 6.1

Summary of Recommended Implementation Steps
Comprehensive Groundwater Monitoring Program

Item	Summary Description	Implementation Time Frame[1]	Relative Estimated Budget [2]	Relative Priority Ranking [3]
1. Data Management System				
1.1a	Entry of archived data not previously available, link WellMA table information, add well construction data from wells the County monitors, add recent surface water delivery information, add municipal pumping data, and other information along with development and implementation of quality control protocols for inputing new data and reviewing existing data discrepancies	**Near to Long Term**	**$**	**1**
1.1b	Establishment of a map-interface with the DMS to enhance the use of the database by non-database users	**Near Term to Mid Term**	**$**	**3**
2. CASGEM Groundwater Level Monitoring Program				
2.1a	Input CASGEM groundwater level data into the DMS	**Ongoing**	**$**	**1**
2.1b	Establish data format to meet DWR guidelines for electronic data transfer	**Near Term**	**$**	**1**
2.1c	Optimize CASGEM monitoring well network per DWR guidelines by filling in data gaps where identified (Note: high cost ($$$) is assuming new monitoring wells will be required to fill data gaps in those DWR basins which currently have minimal to no monitoring)	**Mid to Long Term**	**$$ to $$$**	**3**
3. Napa County Monitoring Program				
3.1a	Update County field procedures for measuring groundwater levels	**Near Term**	**$**	**1**

Table 6.1 (cont.)
Summary of Recommended Implementation Steps
Comprehensive Groundwater Monitoring Program

3.1b	Develop and/or expand aquifer-specific groundwater monitoring network in Napa Valley Floor, Pope Valley and Carneros Subareas by identifying existing wells with well construction data and constructing new aquifer-specific monitoring wells as needed where data gaps may exist (Note: cost is dependent on whether new facilities are required)	**Near to Mid Term**	**$ to $$$**	**2**
3.1c	Develop aquifer-specific groundwater monitoring network in the other Subareas (except for Napa Valley Floor, Carneros, and Pope Valley Subareas) by identifying existing monitored wells with well construction data and constructing new wells where data gaps may exist (Note: cost is dependent on whether new facilities are required)	**Mid to Long Term**	**$ to $$$**	**3**
4. Napa County Conceptualization of Hydrogeologic Conditions				
4.1a	Update geologic cross sections for the Napa Valley Floor and Carneros Subareas (previous ones are 50 years old)	**Near to Mid Term**	**$ to $$**	**2**
4.1b	Develop new geologic cross sections in those areas with the greatest short- and long-term growth and/or land use potential	**Near to Long Term**	**$**	**2**
4.1c	Investigate groundwater/surface water interactions and the affect of recharge and pumping on groundwater levels in the Napa Valley Floor Subareas, along with the Carneros Subarea to assess the sustainability of groundwater resources	**Near to Mid Term**	**$ to $$**	**1**

[1] Implementation schedule reflects relative multi-year time frames for completing or conducting the task. Near, Mid, and Long Terms are reflective of 3, 5, and 10 year periods.

[2] Relative estimated budget symbols: $, $$, and $$$ reflect preliminary budget ranges of up to $50,000 ($), up to $500,000 ($$), and up to $1,000,000 ($$$).

[3] Priority ranking is on a scale of 1 to 4 with 1 being the highest priority and 4 being the lowest.

7.0 References

Bezore, S., C.E. Randolph-Loar, and R.C. Witter (2002). Geologic map of the Cuttings Wharf 7.5' Quadrangle, Napa and Solano Counties, California: A Digital Database. California Geological Survey available from CGS website at ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Prelim_geo_pdf

Bezore, S., C.E. Randolph-Loar, and R.C. Witter. Geologic map of the Mt. George 7.5' Quadrangle, Napa and Solano Counties, California: A Digital Database. California Geological Survey available from CGS website at ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Prelim_geo_pdf

Bezore, S.P., K.B. Clahan, J.M. Sowers, and R.C. Wittier. 2005. Geologic map of the Yountville 7.5' Quadrangle, Napa and Solano Counties, California: A Digital Database. California Geological Survey available from CGS website at ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Prelim_geo_pdf

California Department of Water Resources. 1962. Reconnaissance Report on the Upper Putah Creek Basin Investigation, Bulletin No. 99.

Clahan, K.B., D.L. Wagner, G.L. Saucedo, C.E. Randolph-Loar, and J.M. Sowers.2004. Geologic Map of the Napa 7.5' Quadrangle, Napa County, California, California. California Geological Survey available from CGS website at, ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Prelim_geo_pdf/Napa_prelim.pdf

Delatree, M.P. & J .M. Sowers. 2006. Geologic map of the Capell Valley 7.5' quadrangle, Napa County, California: A digital database. California Geological Survey available from CGS website at ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/Prelim_geo_pdf

Farrar, C.D. and L. F. Metzger. 2003. Ground-water resources in the Lower Milliken-Sarco-Tulucay Creeks area, southeastern Napa County, California, 2000-2002. USGS. Water-Resources Investigations Report 03-4229.

Faye, R.E. 1973. Ground-water hydrology of northern Napa Valley California. Water Resources Investigations 13-73, US Geological Survey, Menlo Park, CA, 64 p.

Fox, K.F., Jr., J.D. Sims, J.A. Bartow, and E.J. Helley. 1973. Preliminary geologic map of eastern Sonoma County and western Napa County, California: U.S. Geological Survey Misc. Field Studies Map MF-483, 5 sheets, scale 1:62,500.

Fox, K. 1983. Tectonic setting of Late Miocene, Pliocene, and Pleistocene rocks in part of the Coast Ranges north of San Francisco, California, U.S. Geological Survey Professional Paper 1239. 33 pp.

Graymer, R.W., D.L. Jones, and E.E. Brabb. 2002, Geologic map and map database of northeastern San Francisco Bay region, California; most of Solano County and parts of Napa, Marin, Contra Costa, San Joaquin, Sacramento, Yolo, and Sonoma Counties: U.S Geological Survey Miscellaneous Field Studies Map MF-2403, 1 sheet, 1:100,000 scale, 28 p.

R.W. Graymer, B.C. Moring, G.J. Saucedo, C.M. Wentworth, E.E. Brabb, and K.L. Knudsen. 2006. Geologic Map of the San Francisco Bay Region. U.S. Geological Survey, Scientific Interpretations Map 2918, scale 1:275,000.

Graymer, R.W., E.E. Brabb, D.L. Jones, J. Barnes, R.S. Nicholson, and R.E. Stamski. Geologic map and map database of eastern Sonoma and western Napa Counties, California: U.S. Geological Survey Scientific Investigations Map 2956 [http://pubs.usgs.gov/sim/2007/2956/].

Helley, E.J. and others. 1979. Flatland deposits of the San Francisco Bat region, California – their geology and engineering properties, their importance to comprehensive planning. U.S. Geological Survey Professional Paper 943.

Jennings, C.W.1994. Fault activity map of California and adjacent areas. California Division of Mines Geological Data Map 6, scale 1:750,000.

Johnson, M.J. 1977. Ground-water hydrology of the Lower Milliken-Sarco-Tulucay Creeks Area, Napa County, California. USGS Water-Resources Investigations 77-82.

Jones and Stokes & EDAW. 2005. Napa County baseline data report. http://www.napawatersheds.org/app_folders/view/3666

Koenig, J.B. 1963. Geologic map of California, Olaf P. Jenkins edition, Santa Rosa Sheet. California Division of Mines and Geology. Scale 1:250,000.

Kunkel, F. and J.E. Upson. 1960. Geology and groundwater in Napa and Sonoma Valleys Napa and Sonoma Counties California. U.S. Geological Survey Water Supply Paper 1495.

Langenheim, V.E., R.W. Graymer, and R.C. Jachens. 2006a. Geophysical setting of the 2000 ML 5.2 Yountville, California, earthquake: implications for seismic hazard in Napa Valley, California. Bulletin of the Seismological Society of America 96, no. 3: 1192-1198.

Langenheim, V.E., C.W. Roberts, C.A. McCabe, D.K. McPhee, J.E. Tilden, and R.C. Jachens.2006b. Preliminary Isostatic Gravity Map of the Sonoma Volcanic Field and Vicinity, Sonoma and Napa Counties. California. U.S. Geol. Surv. Open-File Rpt. 2006-1056.

Luhdorff and Scalmanini, Consulting Engineers. 2010a. Task 1, Napa County data management system. Technical Memorandum prepared for Napa County.

Luhdorff & Scalmanini, Consulting Engineers. 2010b. Task 2, Review and evaluation of data collection procedures and recommendations for improvement. Technical Memorandum prepared for Napa County.

Napa County. 2005. Napa County baseline data report, Chapter 16: groundwater hydrology.

Sims, J.D., K.F. Fox, Jr., J.A. Bartow, and E.J. Helley. 1973. Preliminary geologic map of Solano County and parts of Napa, Contra Costa, Marin, and Yolo Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-484, 5 sheets, scale 1:62,500.

Tasa Graphic Arts, Inc. 2010. http://tasaclips.com/illustrations.html.

Wagner, D.L., and E.J. Bortugno. 1982. Geologic map of the Santa Rosa quadrangle: California Division of Mines and Geology Regional Geologic Map Series, Map 2A, scale 1:250,000.

Wagner, D.L., C.I. Gutierrez, and K.B. Calhan. 2006. Geologic map of the south half of the Napa 30' x 60' quadrangle, California. California Geological Survey.

Weaver, C.E., 1949. Geology of the Coast Ranges immediately north of the San Francisco Bay region, California. California Department of Natural Resoures, Division of Mines. Bulletin 149.

West Yost & Associates. 2005. 2050 Napa Valley water resources study, Napa County, California. Prepared for: Napa County Flood Control & Water Conservation District, City of Napa, City of American Canyon, Town of Yountville, City of St. Helena, and City of Calistoga.