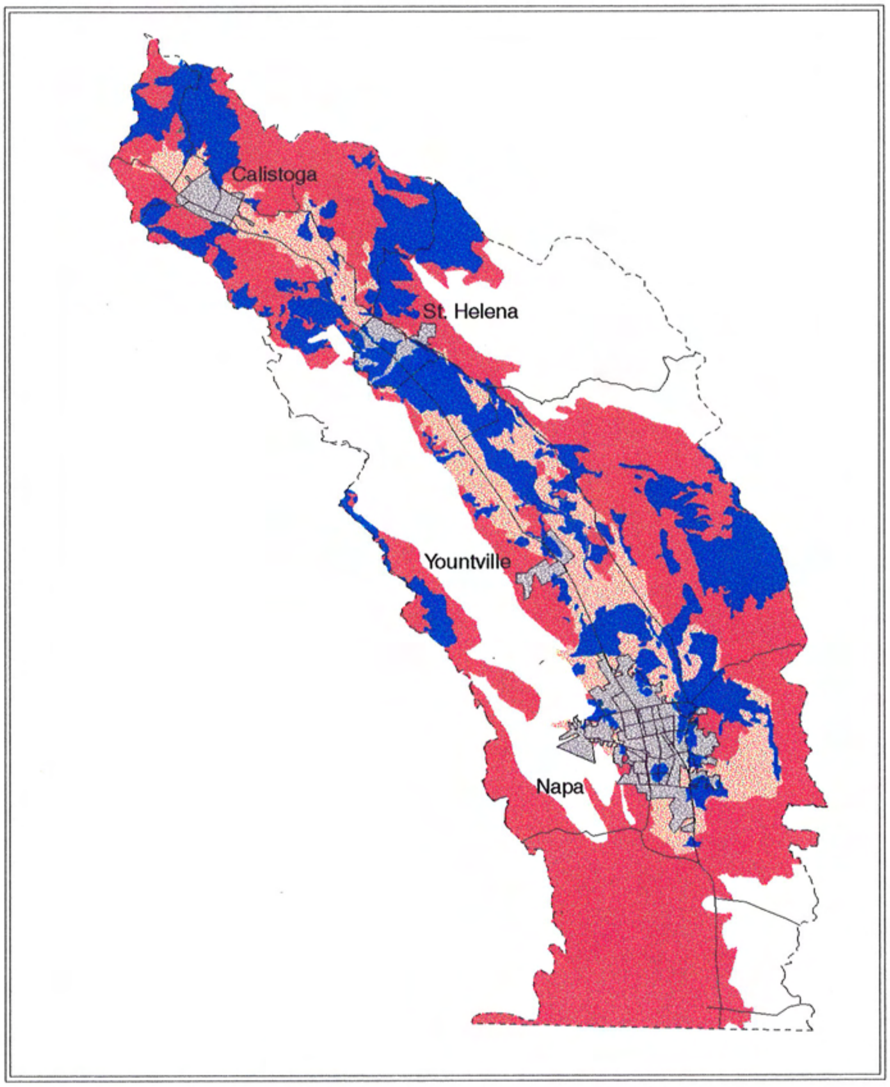
GROUNDWATER PROTECTION STRATEGY FOR THE NAPA RIVER WATERSHED



A GEOGRAPHIC INFORMATION SYSTEM DEMONSTRATION PROJECT

APRIL 1996

SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD

GROUNDWATER PROTECTION STRATEGY FOR THE NAPA RIVER WATERSHED

A GEOGRAPHIC INFORMATION SYSTEM DEMONSTRATION PROJECT

FINAL PROJECT REPORT
Volume 1

APRIL 1996

SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD

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EXECUTIVE SUMMARY

The enormous costs and technical challenges of restoring polluted groundwater have heightened awareness of the need to prevent pollution. The need to protect groundwater resources is now widely recognized. The San Francisco Bay Regional Water Quality Control Board (the Regional Board) received U.S.EPA funding, under Section 106 of the Clean Water Act, to develop a groundwater protection strategy. The Napa River watershed was chosen for this project because the groundwater is a relatively pristine resource and an important supply for agriculture, industry, and domestic use.

In order to develop a groundwater protection strategy, Regional Board staff designed a project that used geographical information systems (GIS) to identify specific priority areas within the watershed. In addition, the project design emphasized collaboration with local agencies within the watershed. The project proceeded in three phases. The first phase generated a comprehensive groundwater database, a monitoring program, and GIS hardware and software design. This phase is summarized in a report titled "Napa 106 Groundwater Demonstration Project" (Appendix D). The second and third phases, which are described in this final project report, produced a groundwater protection strategy for the Napa River Watershed (the Napa Strategy).

Development of the Napa Strategy began with identification of critical issues for groundwater protection. We identified critical issues by evaluating the threats to groundwater and reviewing the existing programs that protect groundwater from these threats. Effective pollution prevention efforts are already underway at the local level in Napa. However, these efforts are not strategically carried out to target groundwater where it is most vulnerable to pollution. The following critical issues were identified:

- Areas where groundwater is vulnerable to pollution from agricultural chemicals should be identified and targeted for additional protection efforts.
- Areas where groundwater is vulnerable to pollution from septic systems should be identified and targeted for a pilot permit program.
- A consistent groundwater monitoring program should be designed for wastewater ponds, and an investigation of older wastewater ponds should be undertaken.
- A comprehensive groundwater management plan should be developed to protect the groundwater basins from overdraft.
- A comprehensive groundwater monitoring program is needed.

With the critical issues identified and groundwater data collected, the project focused on analyzing the watershed using GIS. We chose to identify groundwater recharge areas, as they can be the most vulnerable part of a groundwater basin. The conceptual model for the analysis was that groundwater recharge is most likely to occur where permeable soils overlie permeable surficial geology within groundwater basins. The analysis revealed that recharge in the hills occurs mainly north of Calistoga and St. Helena, and northeast of Napa, and in the valley region primarily southeast of St. Helena, with other isolated areas north of Yountville and Napa.

The location of groundwater recharge areas in relationship to groundwater depth, aquifer yield, and water wells were analyzed. Our findings were:

- Most of the Napa Valley groundwater basin has shallow groundwater (less than 50 ft).
- Shallow groundwater underlies groundwater recharge areas between the cities of Yountville and St. Helena and north and east of the city of Napa.
- High well yield areas in the Napa Valley basin are in relatively small area between St. Helena and Yountville. Pollution within this area could have a significant impact on the availability of groundwater for municipal wells or high production agricultural or industrial wells.
- Areas that are particularly sensitive because of domestic well sites, are clustered in the town of Angwin and city of St. Helena, as well as the region northeast of the city of Napa, where domestic wells coincide with recharge areas.

Based on available data, the overall water quality in the watershed is excellent; however, our analysis of pollution sources indicates that the groundwater recharge areas are at risk. The primary areas of risk from septic system pollution are, the Angwin area, northeast and south of St. Helena, and northeast of Napa. Areas of concern from agricultural chemicals are located primarily between St. Helena and Yountville and around Napa. There are some leaking underground storage tanks within recharge areas near St. Helena, around Napa, within or near Yountville, and in the hills north of St. Helena.

We devised the Napa Strategy with the results from the GIS analysis and our local outreach efforts. The Strategy recognizes and encompasses existing agencies' efforts that were identified during the project and is intended to support ongoing local efforts for integrated watershed planning and protection. The goals of the Strategy are to:

- protect the existing high quality of groundwater,
- restore polluted groundwater,
- prevent further pollution from occurring, and
- disseminate groundwater resource information for decision-making.

The Strategy is organized into six components:

- pollution prevention
- monitoring
- restoration

- groundwater management
- information management/coordination, and
- funding

The Strategy outlines the goals, actions, and participants for each of these six components, many of which are already being implemented in Napa County. For example, one action is local GIS coordination. As a result our GIS workshops, a Napa-based GIS work group was formed, which is represented by county and city agencies within Napa. There is agreement to develop a strategy and to seek funding for a county-wide GIS infrastructure. Despite implementation successes such as this, a significant gap remains--the lack of a coordinated groundwater management plan to protect the basins from overdraft. Meetings were held in which this issue was discussed but no plan is currently in place. Other actions that the Strategy recommends are:

- The Department of Pesticide Regulation, Agricultural Commissioner's Office, and Regional Board should integrate the recharge area map into the County's programs for agricultural chemical management.

- The Department of Environmental Management and Regional Board staff should integrate the recharge area map into their programs for septic system permitting and leaking tank cleanup.

- The Regional Board should disseminate data layers to GIS work group agencies so that groundwater resource information will become part of the data available to decision makers.

- The Department of Water Resources, the Department of Pesticide Regulation, and the Regional Board should work towards a coordinated groundwater monitoring program.

This project successfully demonstrated the usefulness of GIS as a decision-making tool for groundwater protection. Although protection of all groundwater in the watershed is necessary, this project showed how GIS can delineate areas of groundwater recharge relative to pollution sources. These areas can then be targeted for priority protective action. With the advent of integrated watershed management in Napa county, many agencies want tools to support interdisciplinary problem-solving. Furthermore, both hardware and software costs have lowered to a level where most local agencies can realistically afford to purchase the necessary equipment. Thus, management decisions can increasingly be based more on in-depth and current information than ever before.

The project was a starting point for the use of GIS for groundwater protection within the Napa River watershed. As the application of GIS will grow in the future, this project will be useful as a road-map for similar projects. We characterized our challenges in developing GIS so that others can learn from our experience. Ongoing coordination efforts on the part of the Regional Board staff can help with implementation of the Napa Strategy. Ultimately, the success of groundwater protection hinges on the expansion of existing groundwater protection efforts by local agencies and the public within the Napa River watershed.

1. INTRODUCTION

Over the past fifteen years, members of the public and regulators alike have come to understand the need to protect groundwater resources. Limited water supplies and the existence of pollution have driven this interest in groundwater protection in California. There are enormous technical and financial burdens on society from restoring polluted groundwater. The San Francisco Bay Regional Water Quality Control Board (the Regional Board) has been involved in these restoration efforts for over 15 years. The magnitude of effort required for groundwater restoration has promoted our interest in groundwater protection. The Regional Board was awarded a $250,000 Clean Water Act, Section 106 grant from U.S. EPA in 1992 to pursue a groundwater protection demonstration project. Regional Board staff designed a three-year project with the goal of developing a groundwater protection strategy in one of our important groundwater basins.

We chose the Napa River watershed for this project because its groundwater basins are relatively pristine, which makes it a prime candidate for a groundwater protection demonstration project. Groundwater is an important resource to agriculture, industry, and individual homes. Groundwater and surface water qualities are very closely related, amplifying the need for integrated watershed management.

The Regional Board staff has been responsible for designing and managing the Napa project. Other agencies that assisted us are listed in Table 1.

Table 1. Participating Agencies

Alameda County Water District	Bay Conservation and Development Commission	City of Calistoga
City of Napa (planning, water)	Department of Pesticide Regulation	FUGRO-West
Napa County Agricultural Commission and Weights and Measures	Napa County Assessor	Napa County Department of Environmental Management
Napa County Flood Control & Water Conservation District	Napa County MIS	Napa County Office of Emergency Services
Napa County Planning	Napa County Public Works	Napa County Resource Conservation District
NASA Ames Research Center	Regional Water Board	San Mateo County Health Department
Santa Clara Valley Water District	State Water Resources Control Board	UC Berkeley Institute of Transportation Studies
UC Cooperative Extension	USDA Natural Resources Conservation Service	U.S. EPA
Wizard Associates		

1.A FINAL REPORT ORGANIZATION

This final project report details the steps taken to develop the Napa Groundwater Protection Strategy (the Napa Strategy). It is intended to be used as a reference for Napa citizens and agencies who are implementing the Napa Strategy. Although every watershed is unique, the final project report is also intended to provide other state, regional, and local agencies with a methodology for developing groundwater protection strategies. The final project consists of two volumes. Volume I documents work conducted as part of the second and third phases of the project, while Volume II includes supporting documents and technical appendices.

Chapter 1 describes the project's study area, goals and objectives, design, and setting. Chapter 2 summarizes existing groundwater protection programs at the local, federal, and state level. Chapter 3 identifies critical issues for groundwater protection. Chapter 4 contains our GIS analysis and the outcome of meetings held to cultivate local GIS development. Chapter 5 describes the Napa Strategy. Specific findings made as a result of the project are condensed into Chapter 6.

Volume II of the final project report includes four appendices. Appendix A documents all the digital data assembled for the report. A description of what GIS is and how it can be used as a decision-making tool is given in Appendix B. Appendix C documents all agency coordination and outreach activities. Appendix D is the Phase I final report.

1.B PROJECT GOALS AND OBJECTIVES

The Napa project consisted of three phases. The first phase of work, conducted between 1993 and 1994, resulted in a comprehensive groundwater database, a monitoring program, and GIS hardware/software design. The first phase is summarized in earlier reports (Whyte and Schwarz, 1994 and Whyte et al., 1993), which is included in Appendix D. The second and third phases of the project were conducted between 1994 and 1996. These final two phases are summarized in this final project report.

The primary goal of the second and third phases of work was to develop and implement a groundwater protection strategy within the study area. The objectives of the second and third phases are to:

1) Demonstrate the advantages and applicability of GIS technology as a decision-making and long-range planning tool for groundwater protection.

2) Demonstrate the significance and utility of forming collaborative relationships among state and local agencies, as well as with the concerned public.

3) Produce a final project report that will assist local agencies and the Regional Board in implementing the strategy.

4) Provide recommendations for the State Water Board and other Regional Boards to guide future groundwater protection efforts.

1.C PROJECT DESIGN

In order to develop the Napa Strategy, Regional Board staff designed the project to rely both on outreach and coordination efforts with local agencies and on GIS analyses. The flowchart on Figure 3 summarizes the steps we took to develop the Napa Strategy, namely: 1) background research 2) definition of critical issues, 3) GIS analysis, and 4) strategy development. Important aspects of these steps are described below.

Background research was conducted during the first phase of the project, and is summarized in detail in Appendix D. As part of this research, Regional Board staff identified and communicated with state and local agencies involved in groundwater protection. Data sources were obtained via telephone contact, literature searches, and repeated searched of the Internet. Data gathering was an ongoing process conducted throughout the project. In the end, our persistence paid off, as we were able to obtain key soil data from NASA that were vital to our final GIS analysis.

During this phase, a GIS was purchased and database system was designed. The GIS consists of a SUN workstation, digitizing tablet, color plotter, modem, and ethernet gray scale printer. For database management and graphics development, a high powered Macintosh Quadra 800 and color scanner were purchased. The Macintosh is linked to the workstation in a manner that allows rapid transfer of data files. Appendix B contains a complete description of the Regional Board's system.

Data acquisition also included the development of a groundwater monitoring program. The program was designed in accordance with protocol laid out in the U.S. EPA's "Definitions for the Minimum Set of Data Elements for Groundwater Quality" (U.S. EPA, 1992). Under this program, we sampled groundwater in 1991, 1993, and 1994.

The identification of critical issues for groundwater protection came from background research. Through data collected, agency interviews, and local workshops, Regional Board staff identified the potential sources of groundwater pollution as well as the existing programs to protect groundwater. Based on this preliminary understanding of what was needed for groundwater protection, Regional Board staff designed a conceptual GIS analysis and an outline of the components needed for the Napa Strategy.

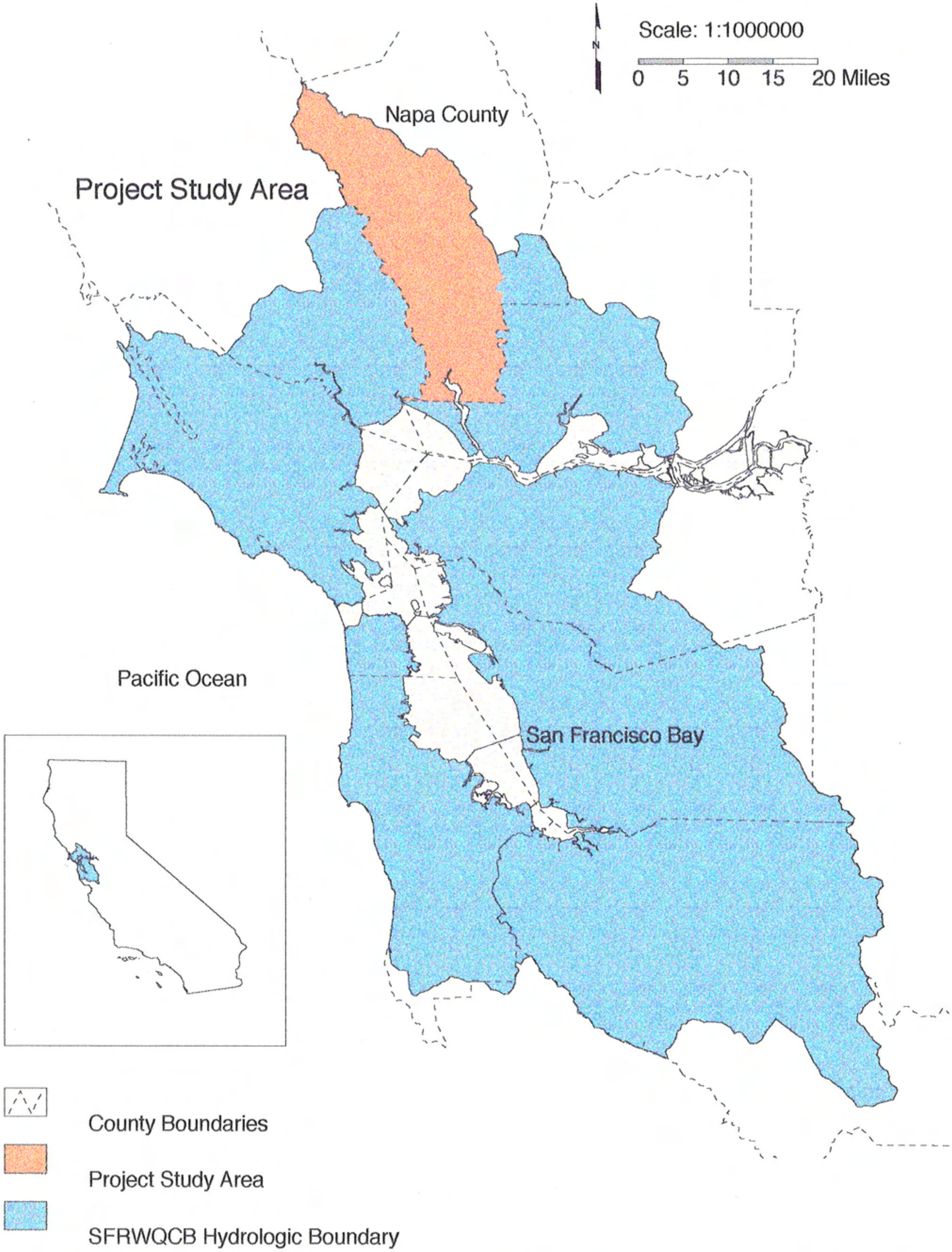


Figure 1. Location of Napa Project Study Area

Coverages: Basins, Nboundary, Counties SFRWQCB, April 1996

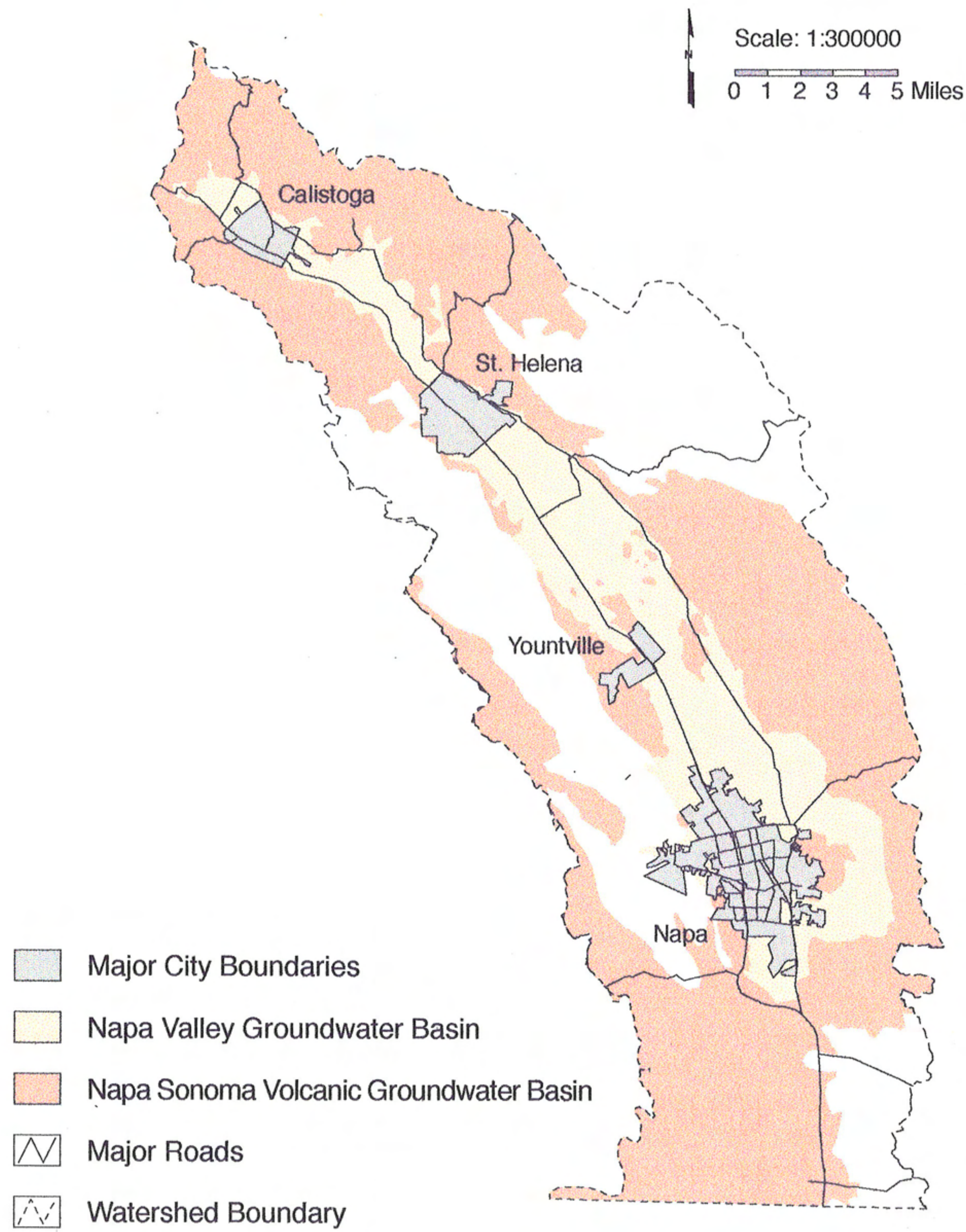


Figure 2. Napa Project Study Area

Coverages: Napagw, Naparoads, Nboundary, Np_city

SFRWQCB,April 1996

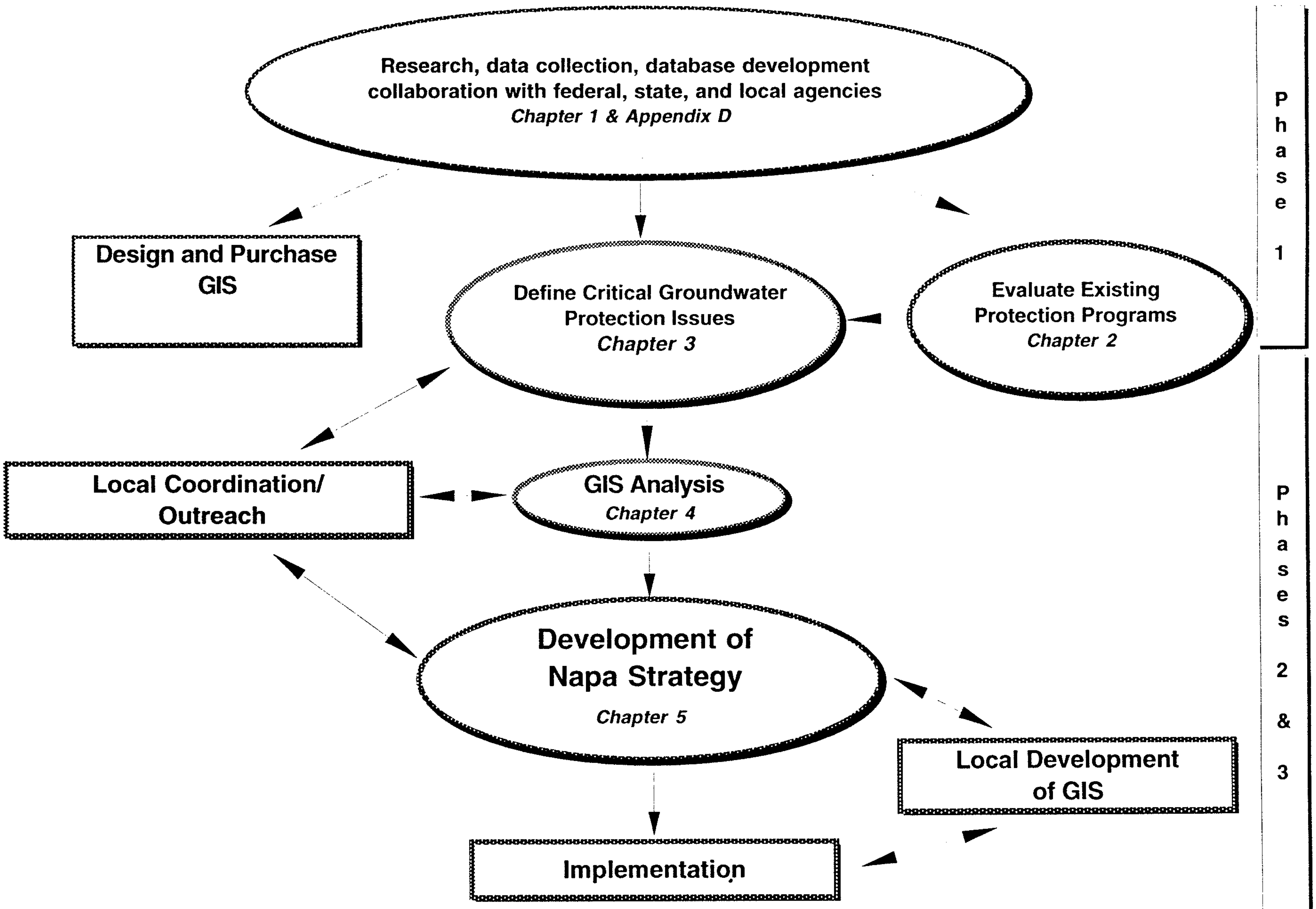


Figure 3. Project Design for the Napa Groundwater Protection Strategy

Based on the data gathered on the geology, soil type, hydrology, water quality, pollution sources, and land use, the Regional Board GIS specialist created data "coverages" used for the analyses. The coverages were evaluated for quality control by comparing them with other published maps. In addition, Regional Board geologists and local experts knowledgeable about the information contained in the coverages were consulted for verification purposes. The accuracy of the data was documented and compiled in the data dictionary (Appendix A).

Data analysis was greatly enhanced by the use of GIS. Specifically, GIS provided 1) increased speed for analyzing large amounts of information, 2) new analytical capabilities for determining the geographic locations of critical groundwater resources, and 3) a powerful foundation for examining alternative policy directives for Regional Board and local agency resource protection efforts. While conducting our own GIS analysis, we were also promoting GIS development locally. This was accomplished by organizing, participating in, and facilitating meetings and workshops among Napa resource and planning agencies.

Development of the Napa Strategy was accomplished during the third phase when both the GIS analysis and outreach efforts were merged together. The results of the GIS analysis provided the basis for the geographic components of the Strategy while the outreach efforts identified critical local issues and existing programs.

1.D PROJECT SETTING

The study area is located in the western portion of Napa County, just north of San Francisco Bay (Figure 1). It encompasses the Napa River Watershed, which constitutes all the surrounding lands and waterbodies draining into the Napa River. The Napa River flows through the Napa Valley, which encompasses an area of approximately 210 square miles. Situated north of Calistoga, Mount St. Helena forms the headwaters of the Napa River, which runs south toward the San Pablo Bay. The river is intermittent in the northern reach; it then becomes perennial due to groundwater discharge. The Napa River is a significant freshwater tributary to San Francisco Bay.

The valley consists of a low central alluvial plain, bordered by fairly distinct, low-lying terraces (particularly prominent in the southern region) and foothills and mountains, which rise rather abruptly to altitudes between 1,000 and 4,000 feet. The brush-covered slopes, hills, and mountains are unsuited for agriculture. Thus, the alluvial plains and adjoining terraces and foothills have been the lands used primarily for agricultural and urban development. Land surface elevations in the central plain of the valley range from about 400 feet above sea level near Calistoga to sea level south of Napa. The central alluvial plain of Napa Valley is about 32 miles long and ranges in width from less than one mile at the north end to nearly four miles just north of Napa. South of Napa, the plain narrows to about 2,000 feet between the encroaching valley sides at the head of the tidal marsh. The areas between these tidal marshlands and the alluvial plain are flat lands traversed by numerous winding tidal channels containing strongly brackish water. Most of these areas have been reclaimed through construction of levees and drainage ditches where some subsidence has occurred (Kunkel and Upson, 1960).

The average annual precipitation differs considerably from 23 inches in the south, to 32 inches at St. Helena to 60 inches at Mount St. Helena.

Hydrogeology

Within the study area are two groundwater basins identified by the Department of Water Resources (1980): the Napa-Sonoma Volcanics Groundwater Basin (Napa Volcanics basin) and the Napa Valley Groundwater Basin (Napa Valley basin) (Figure 2). Groundwater recharge to both basins occurs through infiltration of rain, irrigation water, and stream seepage. The Napa Valley basin may also receive a limited amount of recharge from the Napa Volcanics basin. Recharge to the Napa Sonoma volcanics basin is also through infiltration of rainfall and stream seepage, particularly within outcrop areas of tuff and coarse pumices (Kunkel and Upson, 1960). Distribution of these recharge areas, analyzed in more detail for the Napa project, is described in Chapter 4. Groundwater discharge occurs through groundwater pumpage, evapotranspiration, and outflow to the Napa River and San Pablo Bay. (DWR, 1995)

The primary water-bearing formations in the Napa Valley basin are the younger and older alluvium deposits, consisting of interbedded deposits of gravel, silt, sand, peat, and clay. These deposits extend along most of the Valley floor under the flood plains and channels of the river and its tributaries. These deposits generally increase in thickness from north to south with maximum thickness occurring under the Napa River. Underlying these alluvium formations are essentially non-water bearing, consolidated, older sedimentary and metamorphic rocks.

Bedrock in the Napa Volcanics Basin is comprised of Pliocene-age rocks of the Sonoma Volcanics and older, Cretaceous- to Jurassic-age rocks of the Franciscan Complex. These two units underlie the younger alluvial deposits of the Napa Valley basin and form outcrops in the surrounding mountains. Most of the small hills present in the valley are underlain by these two units. The Franciscan Complex generally yields limited quantities of groundwater to wells and contributes little to the overall water supply.

The Napa volcanics basin, composed of a highly variable series of volcanic rocks, underlie the valley floor's alluvial deposits along the eastern and western sides. This basin produces highly variable water yields, but is an important source of groundwater. There are three areas in the basin that have been identified as water producing: 1) Milliken and Tulucay Creeks east of Napa city, 2) the Soscol area south of Napa City, and 3) the vicinity of Calistoga. A lower andesite/basalt member with interbedded tuff yields sufficient water to a number of wells in the valley. Hydrothermal water is produced from the volcanics near Calistoga.

The Occurrence of Groundwater

Within the Napa Valley basin, groundwater is unconfined and occurs at relatively shallow depth, usually within 20 to 30 feet of the land surface. Based on wells monitored by DWR, annual fluctuations are small--5 to 10 feet per year. Long-term groundwater level fluctuations follow climatic trends, with the lowest levels more or less corresponding to the 1976-77 drought. In general, however, long-term groundwater levels in most of the valley have remained unchanged. (DWR, 1995)

Within the Napa Volcanics basin, groundwater often occurs under confined conditions. (DWR, 1995). The area east and northeast of Napa, the Milliken-Sarco-Tulucay creeks area, is a confined groundwater system. Groundwater in this area may be isolated from the unconfined groundwater system of the Napa Valley by the Soda Creek Fault (Johnson, 1977). Another confined groundwater system, south of the city of Napa, the "Soscol area", has been described by Kunkel and Upson (1960). Prior to 1940, this system supplied groundwater for Vallejo, Crockett, and Benecia. Napa State Hospital continued to operate several wells in this area until the mid-1950s.

In general, groundwater in the Napa Valley basin flows from the sides of the valley toward the Napa River and southward towards San Pablo Bay. This trend is interrupted by local pumping, but generally speaking, the groundwater surface follows that of the land surface (DWR, 1995). Groundwater levels vary seasonally and annually based on rainfall. Generally, water levels are highest in the spring, after the rainy season. They gradually decline through the summer, as groundwater is extracted or discharges to streams draining the valley, and usually reach their low point during September or October (DWR, 1995).

Water Supplies

The primary users of both surface water and groundwater in Napa County are agriculture and municipalities; secondary users are industry and individual homes. Figure 4 shows the relative percentages of total water consumed by each type of user. Figure 5 breaks down these totals into percentages of groundwater used by each user. As of 1989, groundwater supplied less than 5% of municipal and industrial demand, while 60% of the agricultural demand was supplied by groundwater. The rural community, representing approximately 19% of the total Napa County population, relies primarily on private wells and small purveyors for their water supply (JMM, 1991).

In 1991, the Napa County Flood Control and Water Conservation District (Napa Flood Control District) commissioned J.M. Montgomery Consulting Engineers to perform a Water Resource Study for the Napa County Region (JMM, 1991). This report identified certain water supply shortfalls by the year 2020. A Water Advisory Committee for Napa County (WAC), comprised of county and city agencies, reviewed these predicted water supply shortfalls and determined that the "major water supply deficiency in 2020 mostly likely will be in the municipal and industrial areas, followed closely by agriculture and rural residential" users. The agriculture and rural residential water users lie outside the jurisdictional boundaries of water service areas where "groundwater has long been viewed as the only reasonable, economical and reliable source of water supply for agriculture"(WAC, 1993).

Although the upper Napa Valley is reported by WAC to have an extremely reliable groundwater basin with levels that respond quickly to rainstorm activity, certain areas within the County suffer from declining groundwater levels. In addition, rural residential wells are usually older, shallower, and tend to have more fluctuating water levels. The WAC concluded that "additional information pertaining to the quantities of groundwater and divertible surface water are necessary to fully evaluate the local water supply potentials". As a very desirable and immediate source of water supply, groundwater development needs to be thoroughly evaluated in order to determine the long- and short- term effects of such development. One of the Committee's recommendations was that studies be performed to determine more accurate yield information in targeted sub-basins and to investigate the feasibility of a County-wide Groundwater Recharge and Management Program (WAC, 1993).

The Napa Volcanics basin has an estimated safe yield of 22,500 acre-feet per year (JMM, 1991). However, long-term changes indicate a decline in water levels throughout the Milliken Creek area and a gradual depletion of groundwater storage. Water levels in this area declined an average of approximately 1.5 feet per year during the years from 1965 to 1975 (Cooper, et.al., 1987), while water levels in the Tulucay Creek area do not appear to have changed significantly during this same time period.

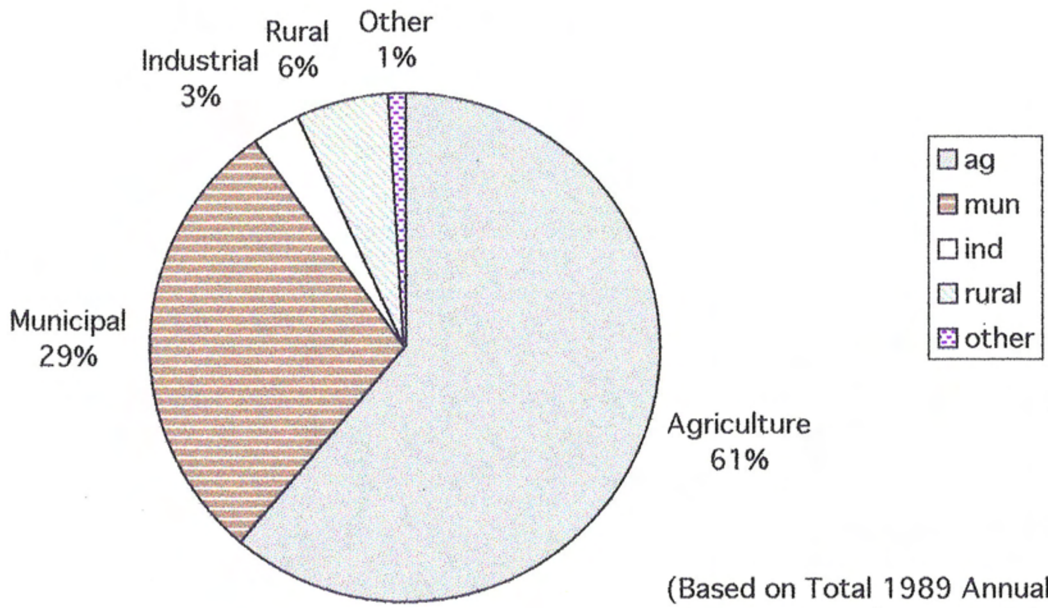
Groundwater Quality

Napa Valley groundwater quality data is fairly limited and dated. Kunkel and Upson (1960) reported that groundwater in the Napa Valley area was generally of satisfactory quality for domestic and irrigation uses, although the Calistoga area contained high levels of chloride and boron. Faye's USGS report (Faye, 1973) indicates that the groundwater quality in Napa County is generally good, although high levels of sodium, boron, chloride, and iron were found. In 1991, 1993, and 1994, the Regional Board sampled 12 agricultural and domestic wells in the watershed. The samples were analyzed for metals, coliform, minerals, pesticides, PCB's chlorinated herbicides, and extractable organics. No pesticides or organic compounds were detected (Regional Board, 1994). Nine monitoring wells in Napa Valley are sampled as part of DPR's statewide monitoring program. DPR reports that these wells have been pesticide-free as of 1994.

Unique Groundwater Resources

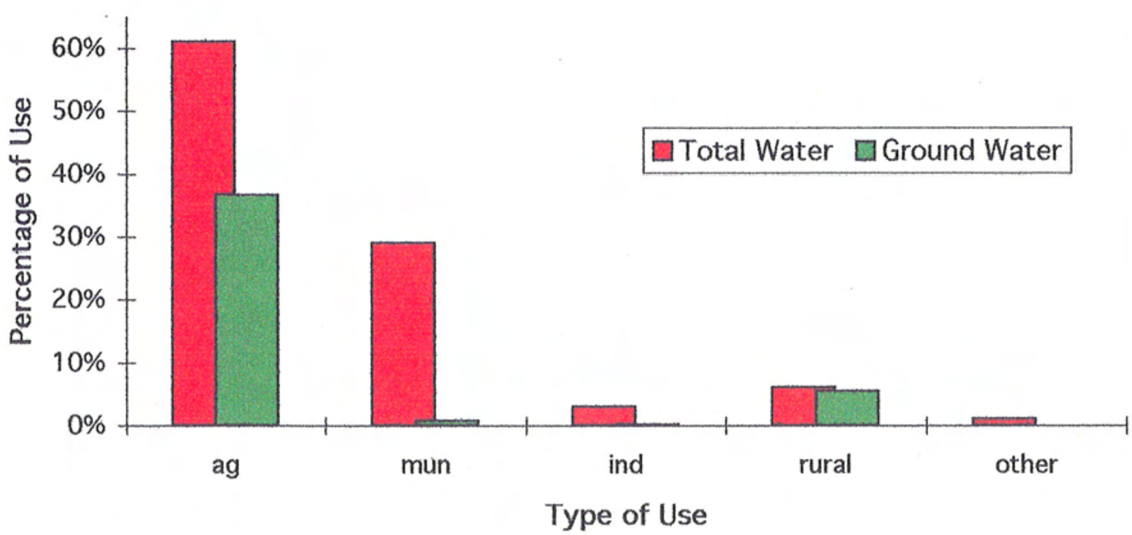
The northern Napa Valley town of Calistoga is a popular health resort known for its natural geysers, hot water mineral springs, and mineralized mud baths. Groundwater in the northern Napa Valley is also bottled and sold as natural spring water. Many of the wells in the vicinity of Calistoga extract groundwater from a shallow, moderate-temperature, confined geothermal system (DWR, 1995). This system is found at depths ranging from 50 to 100 feet below land surface and at temperatures of up to 275°F (Youngs, et.al., 1980). This area also has one of the few geothermal power plants operating in the country; this energy source is used for space heating. Hydrographs for wells monitored in the Calistoga area show that long-term groundwater levels are stable (DWR, 1995).

FIGURE 4
Percentages of Total (surface and ground) Water Used by Type of Use (JMM, 1991)



(Based on Total 1989 Annual Demand of 57,100 Acre-Ft)

FIGURE 5
Percentage Total Water Demand by Type of Use, and Percent of Total which is Ground Water (JMM, 1991)



2. GROUNDWATER PROTECTION EFFORTS

There are many pollution prevention and hazardous materials management programs within the Napa River Watershed. Although these programs are not coordinated as a comprehensive groundwater protection program, much is being accomplished. Napa agencies and citizens initiated a process to identify priority actions for groundwater in the Napa River watershed. In seeking to implement these actions, expand the existing programs, and foster more coordination in Napa, we looked at what has been done in the watershed and elsewhere. For example, the U.S.EPA has extensive information for local and state agencies seeking to create their own groundwater protection strategies. The following discussion highlights existing groundwater protection efforts by local, federal, and state agencies.

2.A LOCAL

Perhaps the most effective and interesting pollution prevention efforts exist at the local level. Each of the following Napa County agencies' programs related to groundwater protection are summarized below.

- Resource Conservation District (RCD),
- Department of Environmental Management (DEM),
- Office of Emergency Services (OES)
- Flood Control and Water Conservation District (Flood District), and
- Agricultural Commissioner's Office

Resource Conservation District (RCD)

Local RCDs, established by the state in 1945 and funded through county property taxes, were originally intended to aid farmers and ranchers in soil erosion control and water conservation efforts. They have expanded their services to include watershed projects and environmental improvement programs. The RCD provides technical information on soils, watersheds, and resource conservation methods to landowners, managers, and residents.

The RCD developed the *Napa River Watershed Owner's Manual* (RCD, 1994) to help citizens maintain a healthy, sustainable natural resource system. This endeavor was accomplished with the advice and participation of federal, state and local government agency representatives, as well as community representatives, private citizens, and local interest groups. The manual culminated from a significant amount of work by two committees formed in the early 1990's--the Technical Advisory and Educational Advisory Committees.

The Technical Advisory Committee (TAC) agreed upon a watershed protection approach designed to protect and preserve both natural and community resources by recommending land use practices and programs that target the entire watershed.

This approach integrates all facets of watershed protection into a comprehensive set of management recommendations. Table 2 lists the recommendations that directly address groundwater protection. Regional Board staff participated in the TAC and helped to develop and promote these recommendations.

Table 2. Napa River Owner's Manual Groundwater Recommendations (Napa County RCD, 1994)

Objective	Target	Groundwater-related Recommendations
Promote and improve water management for long-term availability of water supplies.	Encourage conjunctive use of groundwater and surface water in the watershed.	I1.2 Estimate groundwater recharge rates for tributaries.
		I2.1 Use groundwater during dry times when surface water is less available, and surface water during times of high availability in wetter months.
		I2.2 High winter surface water runoff should be directed into areas such as flood plain wetlands to encourage groundwater recharge in wet months, especially in the Tulocay-Coombsville area, and in the lower Milliken Creek area.
		I2.3 Assessment of the state of valley aquifers, particularly in and around St. Helena, should be made in order to determine rates and sites of renewable extraction (safe yield) of groundwater. Establish a long-term water budget and aquifer monitoring program based on this analysis.
		I2.4 Utilize the GIS database as a common reference for water use and development decisions in the watershed.
	Increase public awareness/ outreach and efficient water use and improve data management.	I5.5 Increase the use of permeable pavement surfaces to increase groundwater recharge.
		I6.3 In cooperation with the Regional Water Quality Control Board, establish a network of aquifer monitoring stations and begin a program of accurate determination of well head and well screen elevations of the monitored wells.
		I6.4 Cooperate with the Regional Water Quality Control Board in developing a voluntary, cooperative groundwater management strategy.
Protect and enhance the environmental underpinnings of agriculture.	Utilize sound management practices in protecting surface water and groundwater quality.	J3.1 Direct surface water flows away from well heads to avoid surface water movement into wells.
		J3.3 Continue monitoring of wells for pesticide and fertilizer residue in the Valley and be coordinate efforts with any aquifer level monitoring that may be established.
		J3.4 Provide a well head assessment program for all well users to assess well head protection status and provide recommendations for well head protection planning.

Department of Environmental Management (DEM)

The DEM plays a pivotal role in maintaining groundwater quality and reducing the likelihood of further pollution by requiring management of hazardous materials and by mandating cleanup of existing groundwater pollution. Three of their groundwater-related programs are described below.

1). <u>Hazardous Materials Management Program (HMMP)</u>.
Any facility that handles hazardous materials in amounts equal to or in excess of 55 gallons (liquids), 200 cubic feet (gases), or 500 pounds (solids), must prepare a business plan. This includes all facilities, except agricultural facilities which report to the Agricultural Commissioner. The business plan includes an inventory of

chemicals, facility site plan, emergency response plan and procedures (including employee training).

To ensure the effectiveness of the program the following checks are in place:
- Annual submittal of hazardous materials inventory.
- Inspections are conducted at least once every three years to ensure compliance.
- Business plans are reviewed by the DEM; if any deficiencies are identified, a notification is sent to the facility with a requirement for resubmittal of a corrected Business Plan within 30 days of notification.

A program report, published November 1994, provides basic information for facilities that are required under Chapter 6.95 of the California Health and Safety Code (DEM, 1994a). This includes development of a business plan for the safe handling of hazardous materials and emergency response measures in the case of accidental release or threatened release.

2). Local Oversight Program (LOP):
DEM oversees all aspects of discovery, investigation, and cleanup of individual underground tank cases and has their own guidelines for cleanup requirements (DEM, 1991). As of October 1995, there are a total of 174 active fuel cases under investigation by DEM. To date, all of the cases where free product phase is present in groundwater are being remediated with groundwater extraction systems. Approximately six percent of the cases with dissolved phase plumes have pump and treat systems in place. To date, there are three known cases where underground tanks have affected drinking water wells.

3). Water well permitting
A county ordinance adopted in 1974 empowered the DEM to permit wells. In-house guidelines for water well construction were developed in 1990. Monitoring well requirements are in the 1991 LOP Guidelines. The DEM inspects all new water well construction and abandoned well destruction.

Improperly constructed or abandoned wells can act as conduits, transmitting surface water runoff directly to aquifers. In addition, shallow drainage wells often become pathways for pollutants into shallow groundwater. If additional funding were available, the DEM has expressed interest in conducting a survey to locate abandoned wells. This project could become a key component of conduit management, thereby reducing the risk of groundwater pollution.

Office of Emergency Services (OES)

OES is in the final stages of completing the "Napa County Hazardous Material Incident Plan" (OES, 1995). In collaboration with many local cities, regional and state agencies, the plan addresses the emergency response to a release or threatened release of a hazardous material within Napa County. The plan covers hazardous material emergencies associated with transportation by highways, roads, streets, railroads, pipeline, aircraft or other means. In addition, releases from "fixed installation" facilities are covered by the plan.

Flood Control and Water Conservation District (Flood District)

The Flood District conducts groundwater level monitoring for the California Department of Water Resources (DWR). It also conducts and funds special studies, such as the *Water Resources Study for the Napa County Region* (JMM, 1991). This study provided a review of the water needs and supply issues for the county's rural, agricultural, and five major municipal areas. It also gave estimates of groundwater basin yields. Short-term recommended actions include well inventory monitoring. Long-term actions include additional investigation of smaller groundwater basins, tracking the exploration of new wells by municipalities and wineries, and encouraging the implementation of wastewater reclamation by the Napa Sanitation District for turf irrigation. In addition, adequate water supply and drainage retention should be demonstrated before County use-permits are issued, thus encouraging groundwater recharge.

The Flood District sponsored the *Napa River Draft Supplemental General Design Memorandum and EIR/EIS* (U.S. Army Corps of Engineers, 1995) conducted for flood control improvement along the Napa River. Part of this study presented the results of a Hazardous, Toxic and Radioactive Waste Investigation, which has been helpful in evaluating potential groundwater contaminant sources.

Agricultural Commissioner's Office

The Agricultural Commissioner's Office is responsible for enforcing state and federal pesticide laws, regulations, as well as enforcing compliance with pesticide labels. They issue permits for pesticides that the Department of Pesticide Regulation has identified as restricted materials. The restricted pesticide certificate exam provided by the Agricultural Commissioner's office asks specific groundwater pollution questions.

Pesticides are restricted based on their hazard to public health, applicators and field workers, domestic animals, and to crops from direct application or drift. In addition, pesticides that may present a hazard to the environment (from drift onto waterways or movement through soil to groundwater) are restricted. Staff conducts site specific evaluations of permitees for proper use of restricted materials; each application must be time specific to allow for environmental review. The largest percentage of pesticide applications in Napa County are non-restricted applications.

In addition to issuing permits, the Agricultural Commissioner's Office oversees programs that reduce the likelihood of accidental spills or improper chemical handling. A major part of the Agricultural Commissioner's program ties into their field inspection efforts. Programs exist for inspecting and auditing businesses and field worker protection. Inspection programs are in place for pesticides used in commercial agriculture, residential settings, parks, highways and other landscaped areas, as well as other locations where these materials are used.

"Mix and load" inspections cover the transfer of chemicals into sprayers. Licensed staff agricultural biologists, inspect the mix and load sites and procedures, the application sites, the storage areas, and the application equipment for compliance with California laws and regulations. Staff inspects the safe handling of the chemicals as well as the appropriate backflow devices.

As part of their audit program, the Agricultural Commissioner's office checks records and inspects chemical storage areas. Chemical application sites and storage areas are evaluated relative to the location of wellhead and creek areas. Overall, the inspection program provides the opportunity to discuss practices that are protective of groundwater. Because the Agricultural Commissioner's office has taken an aggressive role in identifying groundwater protection as an important part of agricultural stewardship, this one-on-one communication during inspection insures that proper practices are implemented.

The Agricultural Commissioner's Office has a program for wellhead protection related to agricultural chemical application. They developed guidelines and management practices for distribution to the agricultural community. The following guidelines apply to any production water wells, drainage wells, or wellhead protection areas wherever they may serve as a catchment for surface water runoff containing pesticide residues:
1) No well should serve as a catchment or receiving basin for surface water runoff containing pesticide residues or be contaminated by back-siphoning during pesticide mixing, rinsing, or chemigation;

2) Storage, handling, and disposal of pesticides, including mixing, loading, and cleaning practices, should not occur in the immediate vicinity of a wellhead; and

3) Pest control around a wellhead should be achieved, whenever possible, by non-chemical means. Soil-applied pesticides should be avoided when chemical controls must be considered.

2.B FEDERAL

U.S. EPA is the primary agency coordinating groundwater protection at the Federal level. U.S. EPA's focuses on providing guidance and financial incentives to promote state and local actions. In delineating the respective federal, state, and local responsibilities toward achieving groundwater protection, U.S. EPA's policy (U.S. EPA, 1991) states that:

- The primary responsibility for coordinating and implementing groundwater protection programs has been and should continue to be vested with the states. An effective groundwater protection program should link federal, state, and local activities into a **coherent and coordinated plan of action.**
- U.S. EPA should continue to improve coordination of groundwater protection efforts within the Agency and with other Federal agencies with groundwater responsibilities.

U.S. EPA has provided guidelines and objectives for state-wide groundwater protection efforts. These guidelines, listed in Table 3 are based on a list of elements commonly found in "mature" groundwater protection programs. Although intended for a State program, we incorporated many of the components into the Napa Strategy.

In 1992, U.S. EPA introduced the idea of a Comprehensive State Groundwater Protection Program (U.S. EPA, 1992a). The goal of this program is to foster more efficient and effective groundwater protection through greater coordination between all relevant federal, State, and local agencies. With this program, U.S. EPA recommended a shift from source-control programs that focus on contamination, toward a comprehensive resource-oriented protection program. As a result of this shift, U.S. EPA focuses on the larger-scale issues of watershed protection and management, of which groundwater protection is one segment. Several U.S. EPA grants are geared toward watershed protection, including the 205J, 604B, and 319 grants; and, as a segment of watershed management, groundwater projects are funded under these grants. In California, the well head protection programs, remain U.S. EPA's highest priority due to California's lack of an "adequate" Groundwater Protection Plan (Whichard, 1995).

U.S. EPA's coordination with State programs was evident during the course of the Napa project. In addition to providing partial funding for this project, U.S. EPA staff participated in all workshops. We received technical support regarding GIS and groundwater protection policies from U.S. EPA staff throughout the project. U.S. EPA staff loaned global positioning equipment early in the project to accurately locate monitoring wells.

Table 3. U.S. EPA's Elements Of Groundwater Protection Programs	
1. Setting Goals and Documenting Progress	
**	a. Groundwater protection goal that accounts for present and future uses of the resource.
	b. Yearly action plan for achieving the goal, which includes a mechanism for evaluating progress toward accomplishing the goal and provides for periodic review.
2. Characterizing the Resource and Setting Priorities for Actions	
**	a. Comprehensive assessment of aquifer systems and their associated recharge and discharge areas.
	b. Procedure for inventorying and ranking potential sources of contamination that may cause an adverse effect on human health or ecological systems.
**	c. Process used for setting priorities for actions taken to protect or remediate the resource, such as a use designation/classification scheme that considers use, value, vulnerability, yield, current quality, etc., including wellhead protection and cost-benefit analyses.
3. Developing and Implementing Prevention and Control Programs	
**	a. A coordinated pollution prevention and source reduction program aimed at eliminating and reducing the amount of pollution that could potentially affect groundwater, including wellhead and recharge area protection programs, siting criteria, improved management practices and technology standards, etc.
**	b. Enforceable quality standards that are health-based for drinking water supplies and ecologically based in areas where groundwater is closely connected to surface water.
**	c. Regulatory and non-regulatory authorities to control sources of contamination currently under State or local jurisdictions, e.g., permitting, siting, and zoning authorities on the state and local levels.
N/A	d. Remediation program that dovetails with RCRA and Superfund and sets priorities for action according to risk.
**	e. Monitoring, data collection, and data analysis activities to determine the extent of contamination, update control strategies, and assess any needed changes in order to meet the groundwater protection goal.
**	f. Compliance and enforcement authorities given to the appropriate state and local officials through legislative or administrative processes.
**	g. Water well programs, including private drinking water wells, covering areas such as well testing, driller certification, well construction, and plugging abandoned wells.
**	h. Statement of how federal, state, and local resources will be used to fund the program.
**	i. Public participation activities to involve the public in the development and implementation of the program.
4. Defining Roles Within the State and the Relationship to Federal Programs	
**	a. Delineation of state agencies' responsibilities in the groundwater program covering areas such as planning, implementation, enforcement, and coordination
**	b. Statement indicating how the state will or does provide local government with authorities to address local groundwater protection issues.
N/A	c. Statement of the state's role under groundwater-related U.S. EPA statutes, including RCRA, CERCLA, SDWA, CWA, and FIFRA, i.e., U.S. EPA-approved programs such as a RCRA authorization should be listed and integrated as part of the state's overall groundwater protection program yet continue operating as free-standing programs.
**	d. Mechanisms for dealing with other Federal agencies that affect state groundwater programs (e.g., MOUs or other arrangements with USDA, DOI, DOD).
**	e. Statement indicating how the state intends to integrate water quantity and quality management.
**	f. Coordination of groundwater programs with other relevant natural resource protection programs, including surface water management.

from: U.S. EPA, 1991. *Protecting the Nation's Groundwater: EPA's Strategy for the 1990's.*
**Components incorporated into the Napa Groundwater Protection Strategy.

2.C STATE

The programs of the State Water Board, the Department of Pesticide Regulation, the Regional Board, and the Department of Water Resources are described below.

State Water Board

The goals of California State Water Board's approach to groundwater pollution are to: 1) maintain groundwater quality for present and future drinking water needs and other beneficial uses, and 2) restore the quality of groundwater where feasible and appropriate. Policies to achieve these goals include the establishment of standards and programs for preventing the entry of pollutants into groundwater and restoring polluted aquifers where technically and economically feasible.

The State Water Board has programs to 1) control sources of pollution, 2) monitor and detect groundwater problems, and 3) mitigate groundwater problems that have already occurred. State Water Board staff compared existing California programs to U.S. EPA's "essential elements" of a groundwater protection program. Staff concluded that California's approach to groundwater protection is incomplete (SWRCB, 1993). The State Water Board does not have a comprehensive groundwater protection strategy. Staff prepared a draft Groundwater Protection Strategy (SWRCB, 1987), but it was never formally adopted. Nonetheless, individual state agencies are implementing various groundwater programs. The net effect of these programs has prevented further groundwater degradation and restored groundwater polluted from historic activities. Table 4 lists groundwater programs in California and the agencies that address them.

Table 4. California Groundwater Programs

	RWQCBs	DWR	CDFA	DHS	CDOC	CWMB
Land Disposal						
Municipal Landfill	X					X
Haz. Waste Disposal	X		X	X		X
Surface Impoundment	X	X		X		
Cleanup	X			X		
Underground Tanks	X			X		
Underground Injection	X			X	X	
Agricultural Practices	X	X	X			X
Individual Disposal Sys.	X			X		
Water Well Construction and Regulation	X	X		X		
Wtr. Reclam. & Recharge	X	X		X		
Sea Water Intrusion	X	X				
Poor Mat. Mgmt. Pract.	X		X	X	X	X

RWQCBS	Regional Water Quality Control Boards	DWR	Department of Water Resources
CDFA	CA Department of Food and Agriculture	DHS	Department of Health Services
CDOC	CA Department of Conservation	CWMB	Ca Waste Management Board

note - modified from : *State of California Groundwater Quality Protection Strategy*, 1987

Department of Pesticide Regulation (DPR)

DPR evaluates and mitigates environmental and human health impacts of pesticide use. DPR works closely with other State agencies, including the departments of Fish and Game and Health Services, as well as other agencies within Cal/EPA. DPR oversees pesticide registration and workplace safety and enforces state and federal pesticide laws.

A pesticide must be evaluated and registered by DPR before it can be sold or used in California. DPR's evaluation of testing data determines acceptability for registration. Testing includes the toxicology, efficacy, phytotoxicity, environmental fate, product chemistry, and residue of each product. Environmental fate testing includes pesticide adsorption, leaching potential in soil and groundwater, and its solubility in water. All chemicals are identified and categorized. Use restrictions are placed on those pesticides found to move through soil and groundwater. Although there are no restrictions on those chemicals that have not been found to leach, DPR does monitor for them. They also monitor for pesticides that have a propensity to migrate to the water table. In Napa County, nine wells were sampled in 1994, and one well was sampled in 1995. DPR reports that these wells are pesticide-free (DPR, 1994, 1995).

If chemicals are detected in groundwater as a result of legal use, a "Pesticide Management Zone" for that chemical is designated for an area of one square mile around the point of detection. Within these zones, pesticide use restrictions are mandated for crop use; non-crop use may be prohibited as well. Aldicarb, for example, cannot be used in certain counties because of high rainfall and shallow water table. This process for identifying Management Zones is under review to make the system more workable and prevention oriented. Toward this end, models are being developed to discover the triggering mechanism for movement through the soil (DPR, 1994a; DPR, 1994b; U.S. EPA, 1991a).

All entities which test for chemicals in groundwater are required to report their results to the DPR. Groundwater monitoring data sources include: USGS, State Water Board, Regional Boards, and consulting and chemical companies. DPR follows up on these reports to verify the presence of the pesticide in the groundwater and whether it has been registered.

Regional Board

The Regional Board implements groundwater cleanup programs. Groundwater protection programs are limited to protection of groundwater from waste disposal. However, with the award of two recent grants, the Regional Board has conducted groundwater protection studies. One study, *"Groundwater Basin Planning: Five South Bay Basins"* (CEDR, 1994), enabled the Regional Board to develop expertise in

GIS and to identify key analyses needed for groundwater protection planning. Another study funded by U.S. EPA 205j grants produced groundwater protection information. The "*San Francisco Bay Region Groundwater Resource Study, Napa Valley Groundwater Basin Characteristics*"(Cooper, et.al., 1987) provides background information on groundwater conditions within the study area. It is one of a series of 1987 reports by UC Berkeley and the Regional Board. The purpose of the series was to assist in gathering information on specific groundwater basins in the San Francisco Bay Region and to present this information in a format that could be used to help prioritize sites where groundwater pollution has been identified. The authors compiled information on well type, location, and number, basin hydrogeologic characteristics, land use characteristics, location of potential pollution sources, identification of local water purveyor and city boundaries, and basin populations.

Regional Board staff oversees cleanup of sites polluted with chemicals other than petroleum. Currently, there are four sites that are actively under investigation in Napa County. Of these sites, three have initiated active soil or groundwater remediation and have made significant restoration progress.

Table 5 lists the GIS resources for the twelve Regional Board offices throughout the state. This information was obtained via surveys to discover what the other Regional Boards had in terms of GIS. The table identifies contact people for those who want more information on the potential application of GIS by regulatory agencies. The results of the survey were quite surprising. Many Regional Boards' staff do not identify GIS technology as a tool for groundwater protection. The offices listed as having no current or future GIS are not considering the possibility of a GIS. Most were concerned with the overwhelming expense and the difficulty inherent in proposing and acquiring a GIS. While the Central Valley Regional Board staff and the Victorville Regional Board staff are both potential GIS users, the former is far more confident in the use of a GIS in groundwater protection as well as in all other office divisions. Also, some Regional Board's staff that did have a working GIS, did not feel it was very useful for groundwater protection. For example, the North Coast Regional Board uses GIS for timber harvest plans and non-point sources; they do not foresee it being used as a tool for groundwater protection.

TABLE 5. Survey of GIS Equipment and Use at RWQCBs

Level		RWQCB Office	System Administrator (Phone #)	Hardware	Software	Future System Upgrades	Coverages	GIS Usage	Use for GW Protection
GIS Users	High-End	Los Angeles Region (4)	Tom Siebels (213-266-7678)	Two Sparc 2 Sun Workstations, Three Tetong Sun Clones, two digitizers, plotter	Arc/Info, Arc/View, dbase IV	Color Tetronix Printer	A few common regional maps	Two high-end users	Well investigation, monwells locations, generating maps showing plumes
GIS Users	High-End	San Francisco Bay Region (2)	Carrie Salazar (510-286-0785)	Sparc 20 Sun Workstation, SiliconGraphics server, various PC's, HP Plotter, digitizer	Arc/Info, ArcView, Grass, MapInfo	IBM PC for digitizer	Various regional coverages	One high-end user; many other low-end MapInfo users	Recharge zones, water wells, pollution sources, geology, soils, regional resource planning
GIS Users	High-End	North Coast Region (1)	Naomie Owen (707-576-2377)	Sparc 10 Sun Workstation, IBM PC, Calcomp Plotter	Arc/Info, ArcView, dbase III	More memory, digitizer, HP Plotter	Partial watershed coverage	One high-end user	None
GIS Users	Low-End	San Diego Region (9)	Vicente Rodriguez (619-627-3940)	IBM PC	ArcView	None	Only those from Mary Tappel (1)	Minor	Creating San Diego Bay watershed maps
Non Users	Possible Future GIS	Central Valley Region (5S)	Bob Matteoli (916-255-3035)	None	None	Current Teal needs assessment; Sun Workstation, Arc/Info, Plotter	None	None	Hopeful use in all aspects of GW protection such as GW modeling and time based plume maps
Non Users	Possible Future GIS	Victorville Office(6V)	None	None	None	Possible GIS system	None	None	None
Non Users	No Current or Future GIS	Fresno Office (5F)	None	None	None	None	None	None	None
Non Users	No Current or Future GIS	Redding Office (5R)	None	None	None	None	None	None	None
Non Users	No Current or Future GIS	Lahontan Region (6SLT)	None	None	None	None	None	None	None
No Response		Central Coast Region (3)							
No Response		Colorado River Basin Region (7)							
No Response		Santa Anna Region (8)							

(1). There is extensive GIS mapping at EPA and Camp Pendleton for the Santa Margarita River Watershed.

The two Regional Boards which do use a GIS for groundwater protection, enjoy the ability to do advanced analyses on multiple layers and generate highly detailed two-dimensional maps. These maps can show the locations of various wells, pollution sources, and sensitive groundwater areas and, in this way, can be useful for groundwater protection. Although the Los Angeles Regional Board and the San Francisco Bay Regional Board have each had difficulty in acquiring their GISs, both feel that it is a valuable asset to implementation of an effective groundwater protection plan. Moreover, the two Regional Boards view three-dimensional subsurface characterization and time-based plume modeling as the "final frontier" of GIS and each are heading towards the effective use of these most advanced capabilities.

Department of Water Resources (DWR)

DWR develops well construction and destruction standards. In addition, DWR conducts studies of a few of California's 394 groundwater basins each year and determines current yield and water storage capacity. DWR staff have been outspoken advocates regarding the need for groundwater management to prevent overdraft. They have provided training and guidance to local entities seeking to develop management plans in accordance with Assembly Bill 3030. The DWR has monitored groundwater levels in Napa Valley wells since the early 1910s. DWR recently completed a summary of this data in *Historical Ground Water Levels in the Napa Valley* (DWR, 1995). Some of this well data were used by Regional Board staff to create GIS water table coverages for the Napa project.

3. CRITICAL ISSUES FOR GROUNDWATER PROTECTION

Maintaining the existing high quality and quantity of groundwater supplies requires continuance of the programs identified in Chapter 2. However, based on the information gathered to date, we find that additional efforts, identified here as "critical issues", are needed to preserve groundwater. This process was facilitated through input from local agencies. The critical issues are described below in the following sections:

- agricultural chemicals
- septic systems
- wastewater ponds
- water supply and groundwater demand
- groundwater monitoring

3.A AGRICULTURAL CHEMICALS

The dominant land use in Napa Valley has been and continues to be agriculture. In order for us to identify critical issues related to agricultural chemicals, an understanding of pesticide and fertilizer use practices was important. These use practices are described below. In the past, concern focused on surface water contamination. Now there is greater awareness of the dangers that pesticides and fertilizers pose to groundwater resources. Certain pesticides and fertilizers have the capability to infiltrate through the unsaturated zone to the water table, thus contributing to groundwater contamination.

Although orchards and crops predominated in the valley bottom-lands prior to the 1960's, agriculture in this region has increasingly become a monoculture of vineyards; greater than 90% of production is in grapes (RCD, 1992). Napa Valley is well known for its wineries and scenic vineyards, which have primarily been planted in the Napa Valley floor. An increasing number of vineyards have been planted on hillside terraces above the Valley in recent years. The number of vineyards has been projected to increase into the future. The county has recognized the importance of maintaining vineyard land and has been putting limits on urbanized growth. In fact, many local general plans focus on the need to balance agricultural resource preservation with urban development. Given the approximately 240 wineries in the area and a tourist industry that brings approximately 4.7 million visitors to the county each year (Visitors Center, 1996), there are growing concerns about maintaining this balance, both in terms of water quantity (supply and demand) and water quality issues (JMM, 1991).

The grape growers in this north coast area are fortunate that they experience less pressure from grape pests than other regions, and additionally need not comply with the strict cosmetic standards of traditional household consumed agricultural products.

During the dormant winter months, after vineyard pruning, preventative fungicide sprays like benomyl, copper formulations and lime sulfur are sometimes used. Except for benomyl, which is usually applied with hand-held equipment directly to pruning cuts, most applications are made using power spray equipment. Herbicide applications to control weeds in the vine row are also hand-applied using power spray equipment. Those used during winter include the pre-emergent herbicides simazine (Princep), diuron (karmex), oryzalin (Surflan), and oxyfluorfen (Goal); the post-emergent herbicides include glyphosate (Roundup) and oxyfluorfen. Glyphosate is also applied throughout the growing season to control problem weeds in the vineyards.

One pest for which the wine makers have strict standards is powdery mildew. Sulfur in both wettable (sprayed) and dust (duster applied) formulations is the most prevalent pesticide used in Napa County, accounting for between 85% - 90% of all pesticides applied (including insecticides, herbicides, etc.). Applications of sulfur begin in the spring and continue as the vine grows into summer. Other fungicides used for powdery mildew control include tradimefor (Bayleton), myclobutanil (Rally), and fenarimol (Rubigan). Insecticides are not routinely used in Napa County vineyards, although from time to time a problem with grape leafhoppers requires treatment. Historically, dimethoate (Cygon), an organophosphate, was used; however, there has been a recent trend toward managing this pest through a combination of cultural practices (leaf pulling) and lower toxicity insecticides such as fatty-acids (M-pede) and imidacloprid (Provado).

Table 6 gives a synopsis of information contained in EXTOXNET (Extension Toxicology Network, 1994) about some pesticide chemicals currently used in Napa County. Known or suspected groundwater pollutants are noted. As described in Chapter 2, there are programs in place to prevent spills and protect wellhead areas. However, **areas within the watershed that are especially vulnerable to pollution from agricultural chemicals should be identified and targeted for additional protection efforts.**

Table 6. Fate of Agricultural Chemicals Used In Napa County				
Pesticide	**Season of Application**	**Action**	**Breakdown in Soil and Groundwater**	**Breakdown in Water**
Copper Sulfate	Winter	Fungicide	Washes to GW, adsorbs to soil particles.	Highly soluble - toxic to fish/invertebrates.
Dicofol	Spring/Summer	Insecticide	Adsorbs to soil particles. Unlikely infiltration to GW.	Degrades when exposed to UV light or pH > 7. Adsorbs to sediment.
Dimethoate (B)	Spring/Summer	Insecticide	Considerable leaching. Broken down by soil organisms.	Does not adsorb or bioaccumulate. Microbial/chemical breakdown
Diuron (A)	Winter	Herbicide	Less residue in soils with low organic matter. Groundwater pollutant.	Stable in neutral water. Microbes primary degradation factor.
Glyphosate	Spring/Summer	Herbicide	Highly adsorbed to high organic matter soils. Little leaching to GW. Microbial breakdown.	Strongly adsorbed to organic matter and minerals. Microbial breakdown.
MANEB	Spring/Summer	Fungicide	Nearly insoluble. Adsorbs to soil particles. Aerobic /Anaerobic breakdown.	Complete degradation within one hour under anaerobic conditions.
Methyl Bromide	Fall (post-harvest)	Insecticide	[Br-] increases as soil organic matter increases. More leaching in sandy vs. loamy soil.	Runoff to surface waters rare due to application method (evap. rate).
Oryzalin (B)	Winter	Herbicide	Soluble. Does not adsorb to soil. Microbial breakdown	Low solubility in water.
Oxyfluorfen	Winter	Herbicide	Adsorbs to soil particles. Unlikely to leach to GW. Resistant to degradation.	Rapidly decomposed by light. Adsorbs to sediments..
Simazine (A)	Winter	Herbicide	Does not adsorb to soil. Adsorbs to clays/mucks. Persistent. Groundwater pollutant.	Avg. half-life 30 days, dependent on algae and weeds present.
Triadimefon	Spring/Summer	Fungicide	Breakdown varies with soil type. Unknown potential for contamination.	Very stable in water.

(A) Known groundwater pollutants as identified in CCR, Title 3, Cpt 4, Article 1, §6800(a).
(B) Potential groundwater pollutants as identified in CCR, Title 3, Cpt 4, Article 1, §6800(b).
from: EXTOXNET, Extension Toxicology Network, University of California, Davis, 1994

3.B SEPTIC SYSTEMS

People living in the rural areas of Napa County rely primarily on septic systems for sewage disposal. Because there are approximately 30,000 people living in rural areas, there is concern about the effect of these systems on groundwater. Domestic sewage typically adds minerals to groundwater. Bacteria and viruses normally breakdown in soils, while phosphorus is generally retained by the soil. However, significant quantities of nitrogen, typically in the form of nitrate, can readily leach into groundwater (Todd, 1976). Once groundwater is contaminated by nitrate, it is generally cost prohibitive to restore. The toxic effect of elevated levels of nitrates on young infants is well established. The critical need to protect groundwater from contamination from septic system leachate can not be overstated. Good septic system performance depends on proper site evaluation, system design and installation, and ongoing maintenance.

The Department of Environmental Management (DEM) oversees the permitting of septic systems in Napa County. There is not a large number of septic systems permitted on an annual basis. One estimate put the number permitted in 1995 at under 50 systems. The county's formal regulations for septic system practices are contained in an ordinance which dates back to 1969. This ordinance is out of date with respect to the county's actual current practices and local regulations in nearby counties (Sonoma and Marin). However, the DEM has begun writing an updated ordinance, which it plans to complete soon.

The DEM staff has developed their own internal guidance for site evaluation, which requires soil core sampling and evaluation. If they have concerns about the suitability of the soils, based on their professional judgment, they require percolation testing. In areas where limiting conditions (shallow groundwater, marginal soil conditions, shallow bedrock) are present, they have written guidelines for "alternative" systems (DEM, 1994b). Geographically speaking, problem areas for conventional systems are south of Napa, the Yountville area, and north of Calistoga. Alternative systems that DEM allows are: evapotranspiration, mound, and pressure distribution. Unlike Marin and Sonoma Counties, groundwater monitoring is not required for individual domestic alternative systems in Napa County. In addition, after the initial construction inspection, no follow-up inspections are conducted. However, for commercial alternative systems, groundwater monitoring is required, and annual inspections are conducted.

There is little site specific or regional monitoring data available to identify existing groundwater problems from septic systems. However, given the local reliance on septic systems for sewage disposal and the importance of groundwater as a drinking water source, pollution from septic systems is a critical issue. Overall, the DEM receives few reports on septic system failures, and has found that individual homeowners are "very good" at maintaining septic systems. However, Regional Board staff remains concerned that the monitoring and inspection program may not be adequate. As a starting point for designing a more rigorous permitting and monitoring program, **areas that are vulnerable to groundwater pollution should be identified. The DEM should initiate a pilot permit program for new and existing septic systems within these areas.**

3.C WASTEWATER PONDS

Wasteponds are frequently used by wineries to collect operational wastewater, particularly from crushers and drains which collect wash-down water from the tanks. The Regional Board issues permits for ponds that combine winery waste and sewage, while the DEM issues permits for ponds that contain just winery waste. The DEM submits annual reports to the Regional Board covering new permits issued, permit modifications, and existing permits (surface and subsurface disposal). The Regional Board issues Waste Discharge Requirements (WDRs) that specify monthly or quarterly reporting of pond water samples. Neither agency requires groundwater monitoring. The Regional Board staff is interested in developing a consistent, comprehensive monitoring program for these ponds, but has not been able to staff this effort.

Winery operation wastewater is usually high in organic material and therefore has a high biological oxygen demand; it also may contain soaps, oils, and pesticide residues. Before reaching the ponds, the wastewater is screened to remove any debris and coarse solids. The water is then treated by natural biological processes in the ponds. The water from the pond is then disposed of either through irrigation (drip or spray), evaporation, or percolation to groundwater.

Wastewater ponds are primarily a concern with regard to surface water contamination. Newer ponds are constructed with a low permeability (10^{-6} cm/sec) natural or artificial liner. During construction, either a soil scientist or geologist tests for soil compaction or conducts in situ testing of underlying soil characteristics, to verify acceptable permeability. However, older ponds are unlined and may pose a threat to groundwater. Regardless of the pond's age, there are no groundwater sampling or monitoring programs in place. Also, because of the greater ease in obtaining a septic permit over the "use-permit" required for a wastepond, there is a trend toward septic system disposal, which could pose greater threats to groundwater.

One concern regarding these waste ponds is the lack of storage capacity during the wet season due to poor design, incorrect operation, or insufficient disposal during the dry season. Other concerns include whether there is adequate treatment for the waste stream, adequate regulations on irrigation applications, and adequate inspection of the operations. The DEM staff consults with Regional Board staff on issues of design related to capacity and liner percolation rates for both winery and domestic ponds. Regional Board staff also provides guidance to insure wet weather reliability, although they do not specify design criteria regarding construction of the pond.

A critical issue is the need for a consistent groundwater monitoring program, and an investigation of older wastewater ponds. A groundwater monitoring program should include monitoring wells at each site, with samples taken quarterly. Appropriately placed drinking water wells could be used as monitoring wells. Factors that need assessment before a monitoring program can be implemented include the quantity of wells needed per pond, where the wells should be placed, what constituents need to be tested, and how often samples should be collected.

3.D WATER DEMANDS AND GROUNDWATER SUPPLIES

The Association of Bay Area Governments (ABAG, 1989) estimates that Napa County's land conversion to intensive agriculture will continue to be a significant trend to the year 2005. An increase in urban areas is also projected, particularly in the unincorporated community of American Canyon in southeast Napa County, as evidenced by the projected 17% population increase for this community between 1990 and 2000. There is local impetus to incorporate the community, which would remove it from the county's tight growth limits. If this effort prevails, projected growth rate for the 1990 - 2000 period would be 37% (ESA, 1991), more than twice the growth projected by ABAG (Whyte, et.al., 1992).

Groundwater predominately supplies rural demands, while urban demands are being met by local or imported surface water. Although an agreement for water allocation is not officially documented, many local sources publicly refer to a "gentleman's agreement" between urban and agricultural water users. This informal agreement is that groundwater is to be used for non-urban demands. Recently, however, there has been interest in developing additional groundwater resources for urban uses. As a result, future water supply planning is a subject of much debate.

In order to facilitate this discussion, the University of California, Cooperative Extension organized a broad-based group of Napa residents known as the Napa Water Educational Coalition. A professional facilitator and public policy analyst, Jim Reedy, is staffing the effort for the cooperative extension. The Coalition is currently in its formative stages and has held four meetings. The group is designed to lower the tension in the Napa County community regarding water supply, to cultivate a better information base, to promote informed discussion, and to develop alternative solutions to identified water issues. The mailing list of participants includes nearly 50 representatives from cities, the County, grape growers, environmental groups, citizens groups, contractors, and consultants. A subcommittee is preparing to analyze two preliminary questions: 1) Will there be enough water for future growth? and 2) Is water available for all water users presently?

The anticipated achievements of the coalition include:

- a lowering of tension in the community,
- an agreed upon information base,
- a consensus on values,
- a more informed discussion of the topic,
- involvement of a broad spectrum of the population,
- and an expanded list of possible new alternative solution.

The study area does not appear to be experiencing widespread problems from overpumpage of groundwater. However, the potential for future problems can not be ruled out, because 1) there is not a good understanding of the perennial yield of the basins, and 2) there is no formal agreement between water users about the amount and location of addition withdrawals. We find that **the lack of a comprehensive groundwater management plan is a critical issue.**

3.E GROUNDWATER MONITORING

In Chapter 2, the existing monitoring programs were identified. These efforts include water level monitoring by the County Flood District (31 wells), pesticide monitoring by the DPR (two wells in 1995), and Regional Water Board monitoring (discontinued after 1994). Groundwater monitoring data provides needed information regarding the current conditions, and provides baseline data for future comparisons. Without groundwater monitoring information, it is impossible to know how effective groundwater protection programs are. Given the reliance on septic systems and the intensity of agriculture, **the lack of ongoing groundwater monitoring is a critical issue.**

4. DEVELOPING A GEOGRAPHICAL INFORMATION SYSTEM FOR GROUNDWATER PROTECTION

This section describes the steps we took in developing a geographic information system (GIS) for the Napa River watershed. In Phase I of this project, we developed a conceptual framework for a comprehensive "groundwater resource information system". We then began constructing the system. This task involved purchasing the needed hardware and software, and creating a database from which pertinent data from a variety of sources could be easily accessed. During this phase we identified the type of data and analyses that were needed to develop a groundwater protection strategy for the Napa watershed. This task was essentially on-going throughout the project. In the second and third phases of this project we used the GIS to perform spatial analyses and coincidence tabulations of data layers and to produce graphical representations of our results (maps and charts).

We discuss our system design and our project analysis below. This includes how and where we obtained GIS coverages, the GIS analysis conducted, data gaps, and future uses of the GIS. This section concludes with a discussion of how we conducted interagency coordination and outreach to initiate local development of GIS.

4.A DATABASE DESIGN CHOICES

Development of a groundwater resource information system for the Napa River watershed involved a number of hardware and software decisions. In choosing components for our system we carefully considered cost, software and hardware compatibility, long term utility and adaptability, and staff training requirements. It was also important to have a system that would allow us to easily exchange data with other agencies. In considering costs, our aim was not only to stay within our project budget, but to demonstrate how a GIS could be constructed in a cost effective manner. We therefore set out to build a prototype system.

Hardware

The Phase I report (Appendix B) discusses in detail the equipment purchased for the project. These purchases included the following items:

- Macintosh Quadra 800, Mac OS
- Sun Workstation, UNIX platform
- modem
- color Scanner
- digitizing tablet
- gray scale printer
- Color plotter
- Geographical positioning system (GPS)

The Macintosh was primarily used for database development and data storage, report generation, graphics production, scanning, and telecommunications. A network was established whereby data from the Macintosh was transferred to the UNIX workstation for GIS analyses. The graphical output from the GIS was then transferred back to the Macintosh for image enhancement and slide production (if desired). Communication and information exchange among agencies and sources was facilitated by a high speed modem.

Software

A number of GIS software programs were used for this project. As this was a demonstration project, we felt it was appropriate to evaluate the strengths and weaknesses of the more commonly used GIS programs. The GIS software ArcInfo was purchased for use on the UNIX workstation. GRASS (Geographical Resources Analysis Support System) a freeware, UNIX based, raster GIS program was also used. On the Macintosh, we used MapInfo and ArcView, a companion program to the UNIX based ArcInfo. Both of these Macintosh programs are available in PC versions as well.

ArcInfo is the most robust of all of the programs used. However, it is also the most expensive and the most difficult to learn how to use. Nonetheless, it was essential for doing the type of analysis this project required. ArcInfo was chosen as our primary GIS analysis tool because 1) it has the largest user-base of any commercial GIS package on the market today, 2) U.S. EPA uses the ArcInfo package in their regional offices and provides support to agencies using ArcInfo for WHP programs, 3) ArcInfo appears to be flexible enough to adapt to any future GIS needs for the Napa region, 4) its analytical capabilities are both raster and vector based, and 5) its companion program, ArcView, runs on PCs and Macs, and allows users to access UNIX data on their desktop computers.

GRASS is a fairly robust UNIX based GIS software program that was designed by the U.S. Army Corps of Engineers and is available free of charge. Its strength is in its ability to quickly perform coincident tabulations of raster based coverages. This program was used to generate a number of our statistical reports. The major weakness of the program is its lack of output options. We therefore found ourselves turning more to ArcInfo so that we could produce higher quality maps.

MapInfo has more limiting capabilities than ArcInfo, but ease of use and low cost make this program attractive. The groundwater toxics division at the Regional Board was already using this program to display contamination site locations. One of MapInfo's strong points is its geocoding capabilities. As such we used this program to geocode contaminated sites from the Regional Board's site tracking databases and groundwater well locations obtained from the Napa County. The data was then transferred to the UNIX-based ArcInfo for analysis. An asset and a limitation of MapInfo is that it comes with its own set of base maps. While these are useful, the program does not easily allow the user to input large spatial polygon or vector data sets such as a geology coverage. Instead, it is designed more for importing site files.

Other software programs used for this project were databases, spreadsheets, drawing, and word processing programs. The database program, Filemaker Pro, was used to maintain a mailing list of stakeholders, interested parties, and agency contacts; to create field sampling data sheets; and for storage and manipulation of pertinent data on wells in the groundwater monitoring network. The spreadsheet program, Excel, was used to generate charts and graphs. The drawing program, Freehand, was used to graphically depict and store geologic well log information. Both Freehand and Illustrator were used to process the GIS maps into final report figures.

4.B GIS DATA LAYERS USED

Table 7 includes a description of each data set in terms of the type, coverage name, reference name, source, and scale. A more complete description of each coverage is found in Appendix A, the Data Dictionary.

4.C GIS ANALYSIS

The potential for a groundwater basin to become polluted is dependent on a number of factors. These factors can be grouped into two categories: (1) those pertaining to the pollutant, namely its stability and mobility in the subsurface, location in the basin, and type of discharge; and (2) those relating to the hydrogeologic properties of the basin, such as the geochemistry of the soils and bedrock, subsurface permeability, depth to the aquifer, precipitation, and the overall nature of the groundwater flow regime. In general, all of groundwater basins in the Napa River watershed need to be protected. However, analyses were conducted to determine whether discrete sensitive areas could be identified and targeted for protection. For example, if isolated recharge areas could be identified, additional priority for protection and cleanup of existing contamination sites could be placed in these areas.

A simple model was developed for identifying sensitive areas. A flowchart, Figure 6, illustrates our model. Using available digital maps and data sets, we first created, as accurately as possible, a coverage which depicts where the dominant recharge areas are in the Napa River watershed. Using this layer as a base map, we further evaluated the basin in terms of groundwater resource-related factors such as depth to the water table, existing well densities, and variability in aquifer yields. We then evaluated the basin in terms of existing and potential pollution sources as well as known contamination sites. It was during this phase of the project that the beauty of a GIS was fully realized. Once our base map and data layers were in place, numerous analyses were easily conducted and new coverages were created by combining relevant data from other coverages. As such, consideration of a variety of groundwater factors led to creation of a 'recharge areas' GIS coverage. Likewise, from a pollution perspective, various groundwater pollution factors were considered in the development of a 'Vulnerable Areas' GIS coverage. In the following sections we discuss the data we used in creating these GIS coverages, including maps from the GIS, and our decision making process.

Table 7. GIS Coverages

DATA TYPE	SPECIFIC COVERAGE	REFERENCE NAME	SOURCE	SCALE
Geology	Surficial geology	NAPAGEO	CEDR/USGS	1:100,000
Soils	Napa Soil Series	NAPASOIL	Napa Soil Survey	1:24,000
Groundwater	GW Basins	NAPAGW	DWR Bulletin 118	1:100,000
	Webster well yield	NAPAWEB	Webster Map 1972	1:250,000
	Depth to GW	NAPADWR	DWR	N/A
	Recharge Areas	RECHARGE2	Regional Board	1:100,000
Wells Data	Municipal	NAPAMUN	St. Helena Public Works Office	N/A
	County Domestic	NPAWELLS	Napa DEM	N/A
	Monitoring *DPR *DWR *RWQCB	NAPAMON	Trimbal GPS	N/A
Contaminant -related data	Napa County Septic Systems	NAPA_SEPTIC	Napa Cnty EHS	N/A
	Hazardous Material Storage Sites *LUSTIS sites *SLIC sites	NAPALUST NAPASLIC	Regional Board LUST and SLIC files.	N/A N/A
	Landfills American Canyon *Clover Flat *Abandoned	NAPA_LANDFIL LS	Regional Board and Napa DEM	dbf file & paper map
	Sewer Srvc. Areas *Napa/Am. Canyon *St. Helena/Calistoga	NAPA_SEWAGE	Regional Board and General Plans	Unknown
Land Use	Agricultural	NAPA_LANDUS E	Landsat Thematic Mapper data	30 meter resolution
	Cities	NAPA_CTY	1992 Census	1:100,000
	County	NAPA_CNTY	1992 Census	1:100,000

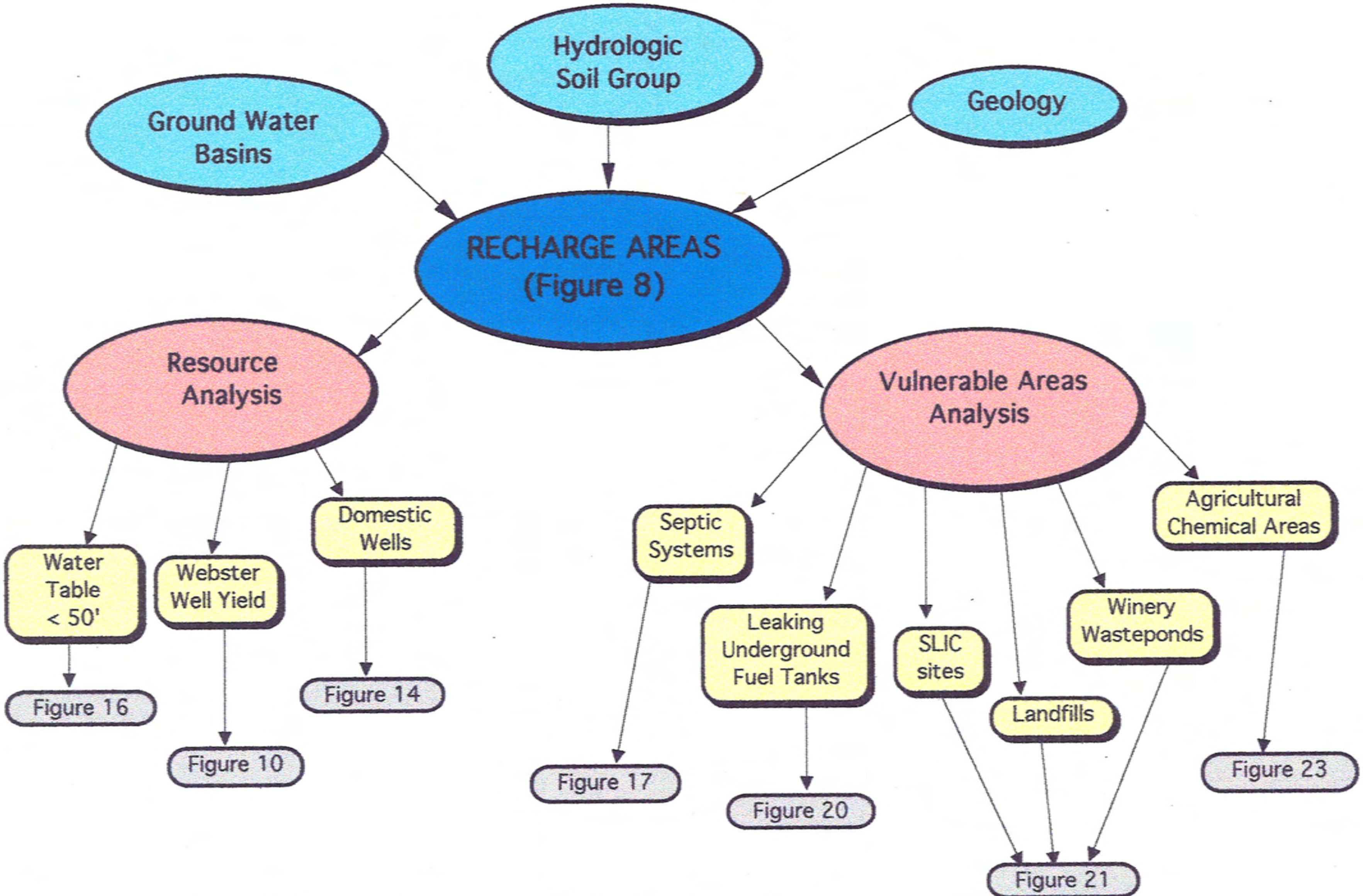


Figure 6. Flowchart of GIS Analysis

Creation of Recharge Areas

For the Napa project we developed a simple model for delineating groundwater recharge areas in the Napa watershed. As with most GIS projects, our analysis was limited by the availability and resolution of data. However, the analysis easily can be refined in the future if new or more accurate spatial data sets become available. The data layers that we used to create a new coverage called *Recharge2* contained information on soils types, surficial geology, and the areal extent of major groundwater basins. Using the GIS, we delineated recharge areas by identifying discreet areas located within groundwater basins where permeable soils coincided with permeable surficial geologic units.

A digital version of a portion of the Napa County Soil Survey was provided by NASA Ames Research laboratory. Next, we considered how best to group the soil units into permeability classes. We concluded that the existing USDA classification scheme of "soil hydrologic groups" was the best method. Each soil polygon then was tagged based on the USDA criteria. Traditionally, soil hydrologic groups are used to estimate runoff from precipitation. Soil types are assigned to a hydrologic soil group based on infiltration capacity under saturated conditions. Table 8 lists the four groups with a description of their hydrologic properties. For our analysis, we selected the more permeable soils, group A and B, for potential inclusion in recharge areas.

Table 8. Definitions of USDA's Hydrologic Soil Groups

Hydrologic Soil Group	Property
Group A	Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well-drained to excessively drained sands or grovels. These soils have a high rate of water transmission.
Group B	Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep to deep, moderately well-drained to well-drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
Group C	Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer which impedes the downward movement of water or soils that have moderately fine texture or fine texture. these soils have a slow rate of water transmission.
Group D	Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrinking-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. these oils have a very slow rate of water transmission.

The surfical geology map, *Napageo*, was combined with the soils map, *Napasoil*. The geologic units underlying the more permeable soils are listed on Table 9. The USGS evaluated the hydrogeology of the Napa area (Faye, 1973) and identified the geologic units in the basins which contribute most to the recharge of groundwater. Using this information, the few small areas with questionable geologic permeability (indicated in italics on Table 9), such as the serpentine and the Bay mud, were "clipped" out from the recharge area coverage. The areas called "unidentified units" are polygons that had attribute labels that were not translated over from the original coverage in GRASS. Most of these polygons were not closed (GRASS does not require polygon closure as does ARC/INFO). Each of the areas was evaluated individually to determine if they should be included. The vast majority of these polygons were Holocene colluvium.

Table 9. Geology Underlying Permeable Soils	
GEOLOGY IN RECHARGE AREAS	HYDROLOGIC SOIL UNIT
Qg 6589 (19) quat. gravel	B
Qhbm Qm 6526 (8) Holocene bay mud	B
Qpa 6537 (11)	B
Qpa 6537 (11)	A
Qpea 6539 (13) pleis alluvium	B
Qyf Qhac 6521 (4) Holocene coarse grained alluvium	B
Qyf Qhac 6521 (4) Holocene coarse grained alluvium	A
Tsa 6613 (64) son vol. andesite/basalt	A
Tsa 6613 (64) son vol. andesite/basalt	B
Tslt 6709 (72) PLIO. Sonoma vol.-tuff breccia	B
Tsr 6611 (59) Sonoma vol. rhyolite	A
Tsr 6611 (59) Sonoma vol. rhyolitic	B
Tsrp 6675 (62) Sonoma volcan./rhyolite	A
Tsrp 6675 (62) Sonoma volcan./rhyolite	B
Tssd 6711 (75) Plio. Sonoma vol.-diatomite	B
Tst 6615 (68) Sonoma vol. pumic.	A
Tst 6615 (68) Sonoma vol. pumic.	B
Tstx 6708 (70) Plio. Sonoma Vol.-tuff	B
fsr 6577 (252) francis. melange	B
sp 6578 (268) Jurassic serpentine	B
Unidentified units	B

Unfortunately, the GIS soils coverage did not encompass the entire study area. Areas outside of the digital soils coverage were evaluated using hard copy maps. Figure 7 illustrates the boundary of the soils coverage; the areas between the rectangular soil coverage boundary and the watershed boundary are the regions where the soil survey maps were inspected. In addition to visual map inspection we used air photo interpretation and geologic analysis to identify additional recharge areas in these regions.

In the final step, we used the groundwater basin coverage to complete the analysis. Areas of permeable soils and geology that are within the two groundwater basins were selected as the final recharge areas. Figure 8 illustrates the areal extent of the recharge areas that resulted from the analysis described above.

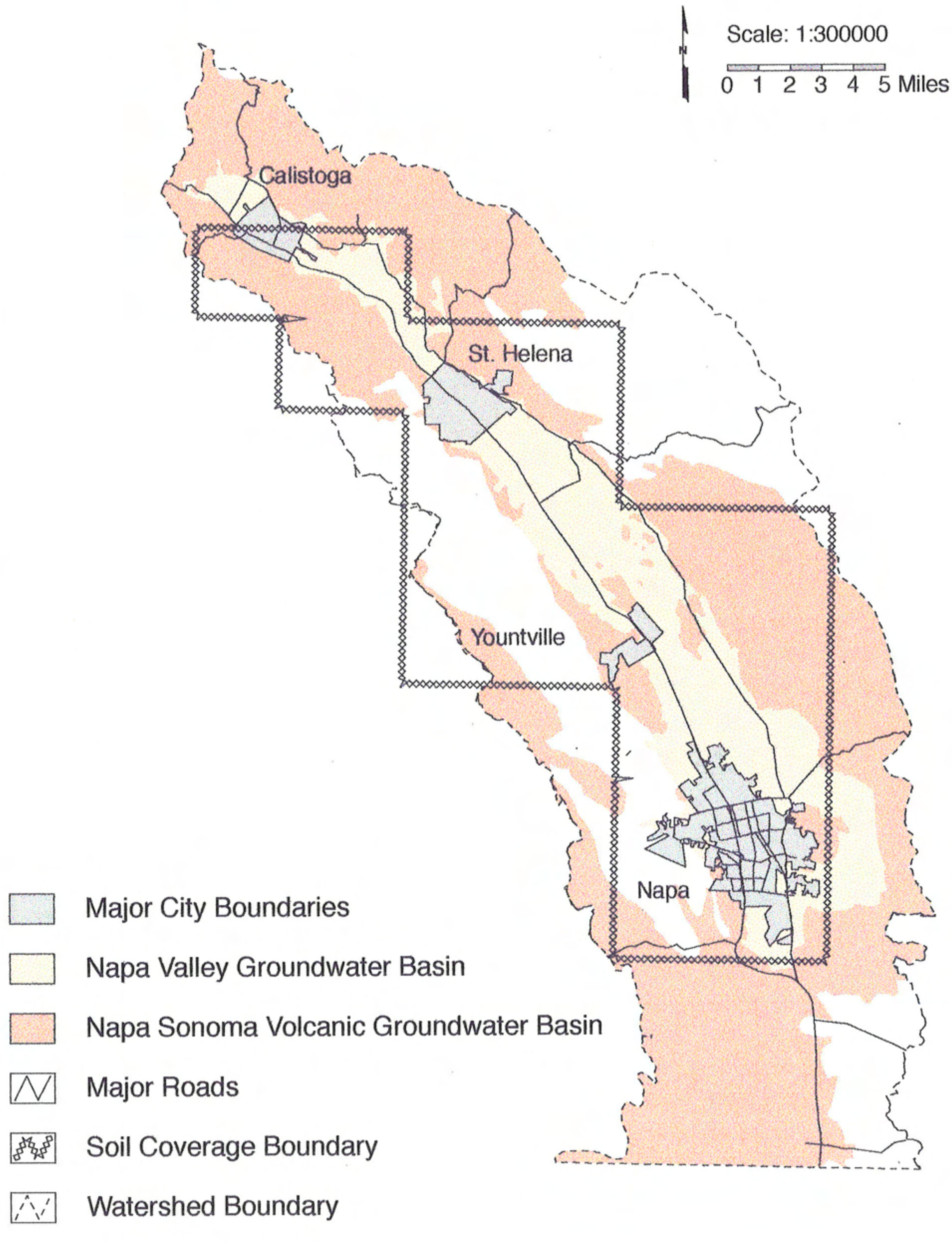


Figure 7. Extent of Soil Coverage

Coverages: Napagw, Napasoil, Nboundary

SFRWQCB, April 1996

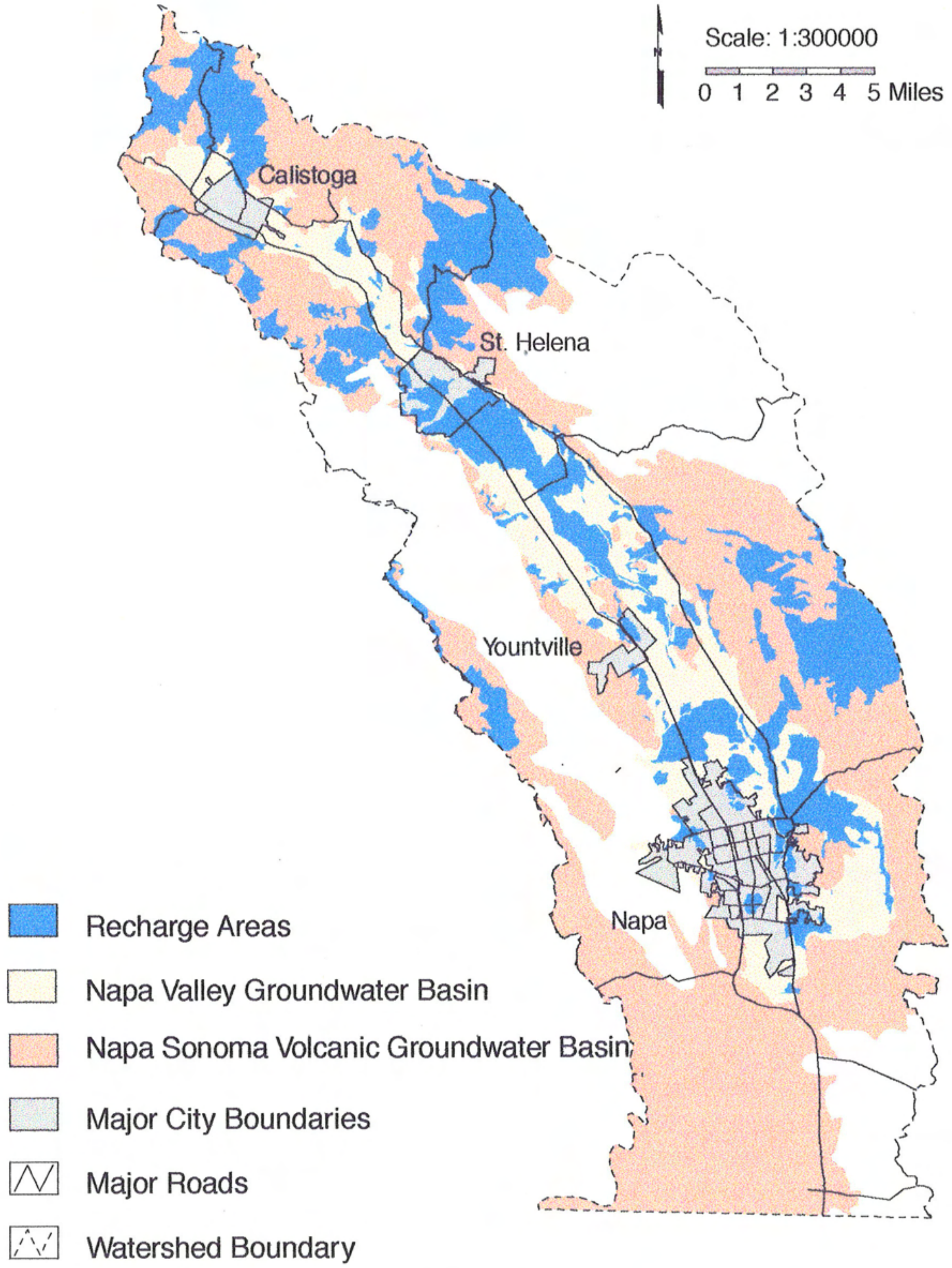


Figure 8. Napa Project Recharge Areas

Coverages: Naparoads, Nboundary, Np_city, Recharge2

SFRWQCB, April1996

Creation of a Recharge Area Coverage and Resource Evaluation

Using the above described process, we produced a GIS coverage delineating recharge areas. We then used this coverage as a base map to overlay or perform coincidence tabulations upon each of the following GIS coverages: Webster well yield, Napa County wells, and depth to the groundwater table.

The recharge areas coverage utilizes data from a limited depth below the actual ground surface. For a deeper look below the surficial geology, we overlaid a digitized map depicting aquifer/well yields (Webster, 1972). This GIS coverage illustrates ranges in the maximum probable well yield from water-bearing rocks in the San Francisco Bay Region. A description of the categories representing well yields is given in Table 10.

Table 10. Ranges in Probable Maximum Yield of Wells (Webster, 1972)

Map Symbol	Adequacy of Yield (at 68 % level of probability)	68 % probability that maximum yields will range from (in gpm)	95 % probability that maximum yields will range from (in gpm)
A	Marginal to adequate for stock or single family domestic use.	0.5 to 5	0.1 to 10
B	Adequate for stock or single family domestic use, but inadequate to marginal for light industrial use.	5 to 50	1 to 100
C	Adequate for light industry, but inadequate to marginal for irrigation, heavy industry, and municipal uses.	50 to 500	10 to 1,000
D	Marginal to adequate for irrigation, heavy industry, and municipal uses.	500 to 1,500	100 to 3,000

*Assuming operation without excessive draw down.

Note: Ranges in the probable maximum yield of wells are ranked in groups implying ±1 and ±2 standard deviations from the mean. This ranking is not intended to imply rigid statistical analyses of the data, which differ greatly in adequacy from place to place. The assignment of yield ranges to areas is based on available geologic and hydrologic data and on the professional judgment of the compiler (Webster, 1972).

An overlay of the Webster well yield coverage with the recharge areas coverage (*Napagw + Napasoil*) revealed that the highest well yielding areas are within the middle of the Napa Valley (Figure 9). Figure 10 illustrates the Webster well yields coverage when overlain by recharge areas. The percentages of yield by area are shown in Figure 11. Only 0.02% of the area is categorized as high yielding (Category D). The highest percentage, 63%, is within Category A which is marginal to adequate yield for stock or domestic use. It should be noted that these calculations are based on area, not volume. This analysis indicates that the total land surface area overlying the highest yielding aquifers is very small. Therefore, **contamination of this area would have a significant impact on the availability of groundwater for municipal wells or high production agricultural or industrial wells.**

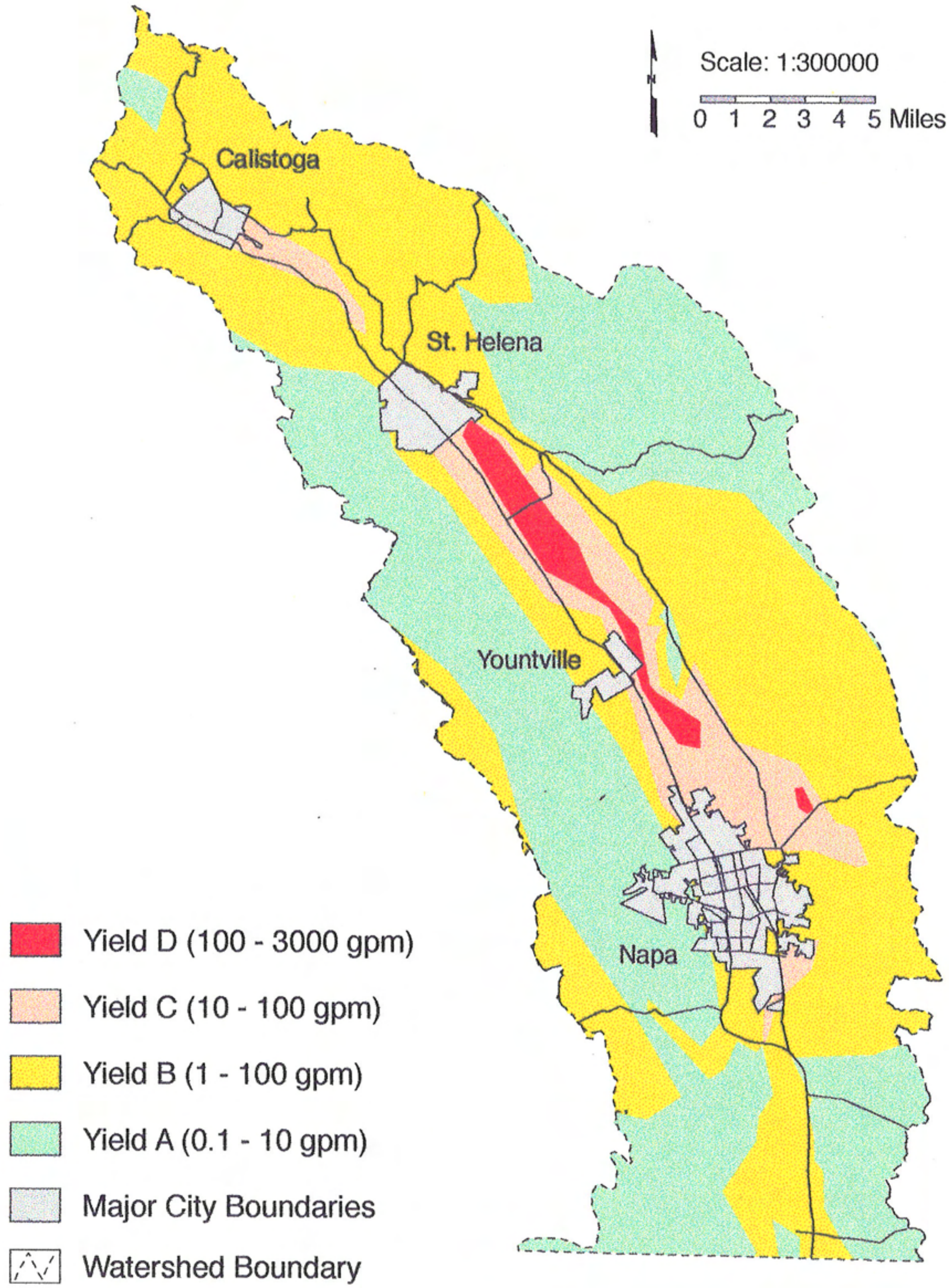


Figure 9. Webster Yields

Coverages: Napaweb

SFRWQCB, April 1996

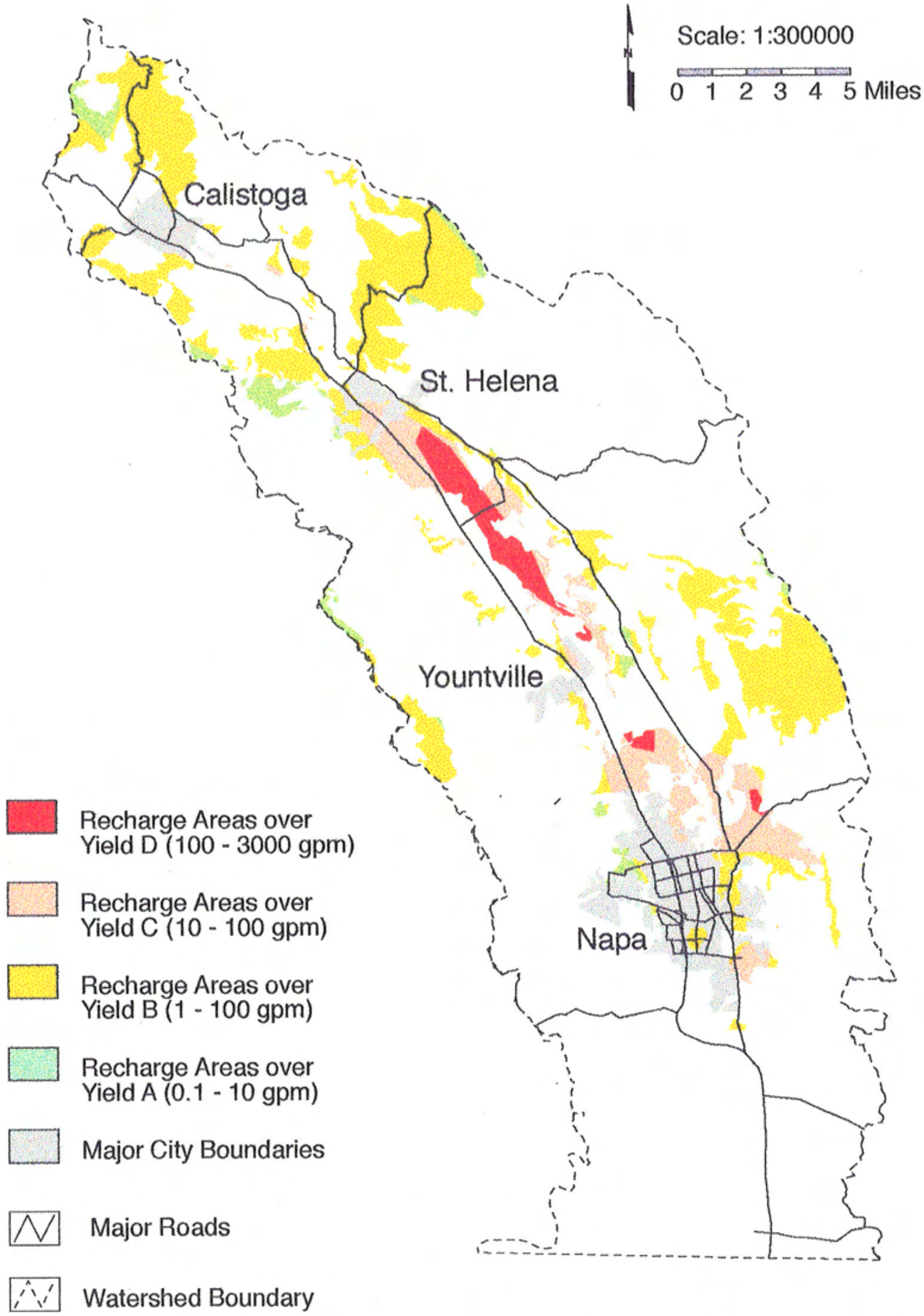


Figure 10. Webster Yields in Recharge Areas

Coverages: Napaweb, Naparoads, Np_city

SFRWQCB, April 1996

Figure 11. Percent by Area of Webster (1972) Groundwater Yield Categories for the Study Area

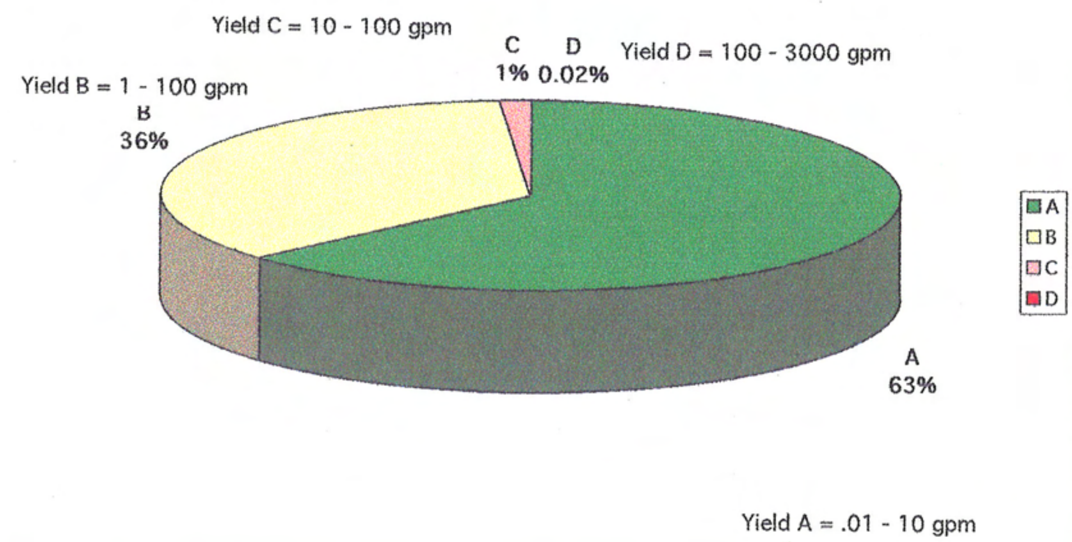
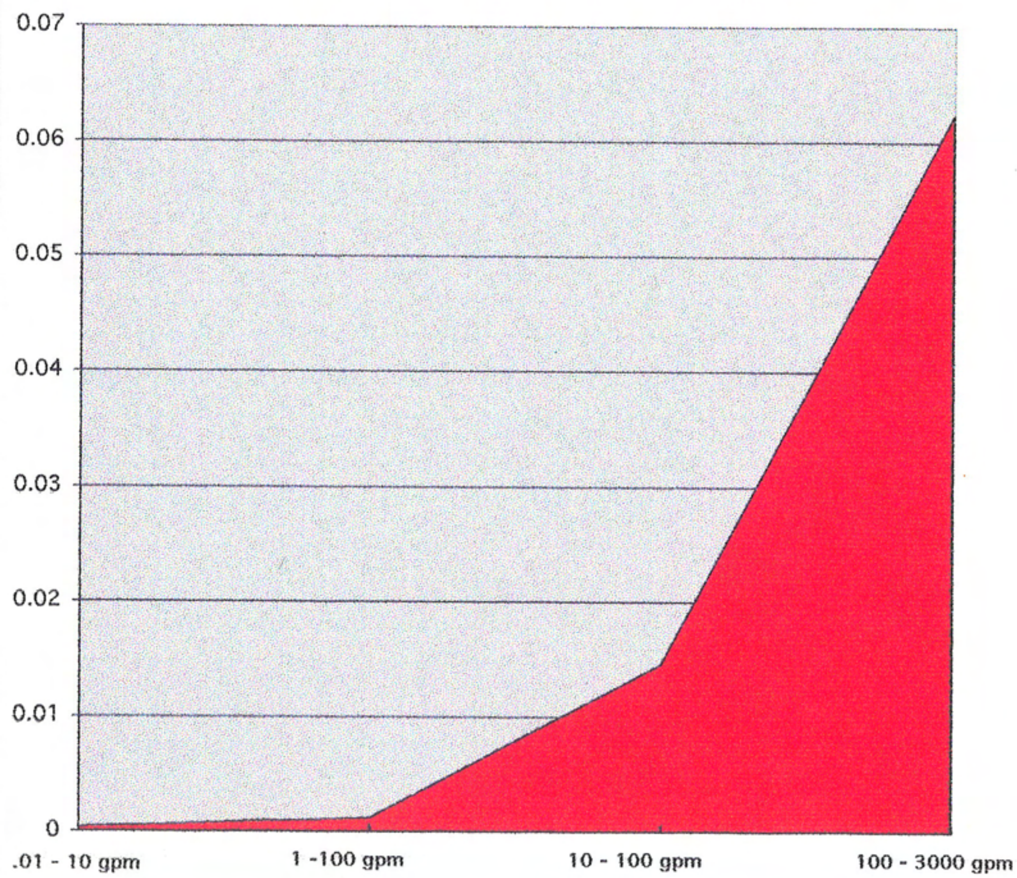


Figure 12. Well Density in Groundwater Yield Categories



The location of wells that could be accurately geocoded (only 53% of total wells in our database) is shown on Figure 13. Wells are distributed throughout the watershed indicating the need to protect the entire watershed. The density of wells in the study area was evaluated in relation to the distribution of groundwater well yields (Figure 12). Somewhat more surprising to us is the amount of domestic groundwater use outside of the highest yielding area, category D. We determined that only one quarter of the county's domestic wells are located in high-yield areas C and D. However, the density of wells rises significantly from the C to D category, because the County's municipal supply wells are located in area D and the areal extent is small. Unfortunately, the utility of the well density coverage is limited without knowing the extraction associated with each well.

The Department of Water Resources (DWR) provided us with groundwater information for 34 wells in Napa Valley. We realize that this data set is insufficient to characterize the entire study area. Nonetheless, we felt it would be useful to demonstrate how this type of information can be used. Using the DWR site data, we created a thiessen polygon coverage which we clipped over the Napa Valley GW basin. From this, a contour map (Figure 15) showing fall water table elevations was created. This map is consistent with the early work done by Kunkel and Upson (1960).

We used data on the depth to groundwater and the thiessen polygon coverage to create a coverage called *Napadwr*, which illustrates the polygons or areas where the water table is less than 50 feet below the surface. This coverage was then overlaid with the *recharge areas* coverage to delineate areas where the water table is relatively close to the surface (<50'). This coverage is shown in Figure 16.

Creation of the Vulnerable Areas Coverage

We developed a simple model for delineating areas vulnerable to groundwater pollution. Vulnerability was assessed based on hydrogeologic properties of the study area (*recharge areas*), and past and present landuses, and anthropogenic activities. For example, we combined our recharge areas coverage with six potential pollution source-related coverages that we developed. We created these coverages from Regional Board and local agency databases which contained site information on the following potential pollution sources: septic systems, leaking underground fuel tanks, toxic hotspots (SLIC sites), landfills, winery waste water ponds, and agricultural land use.

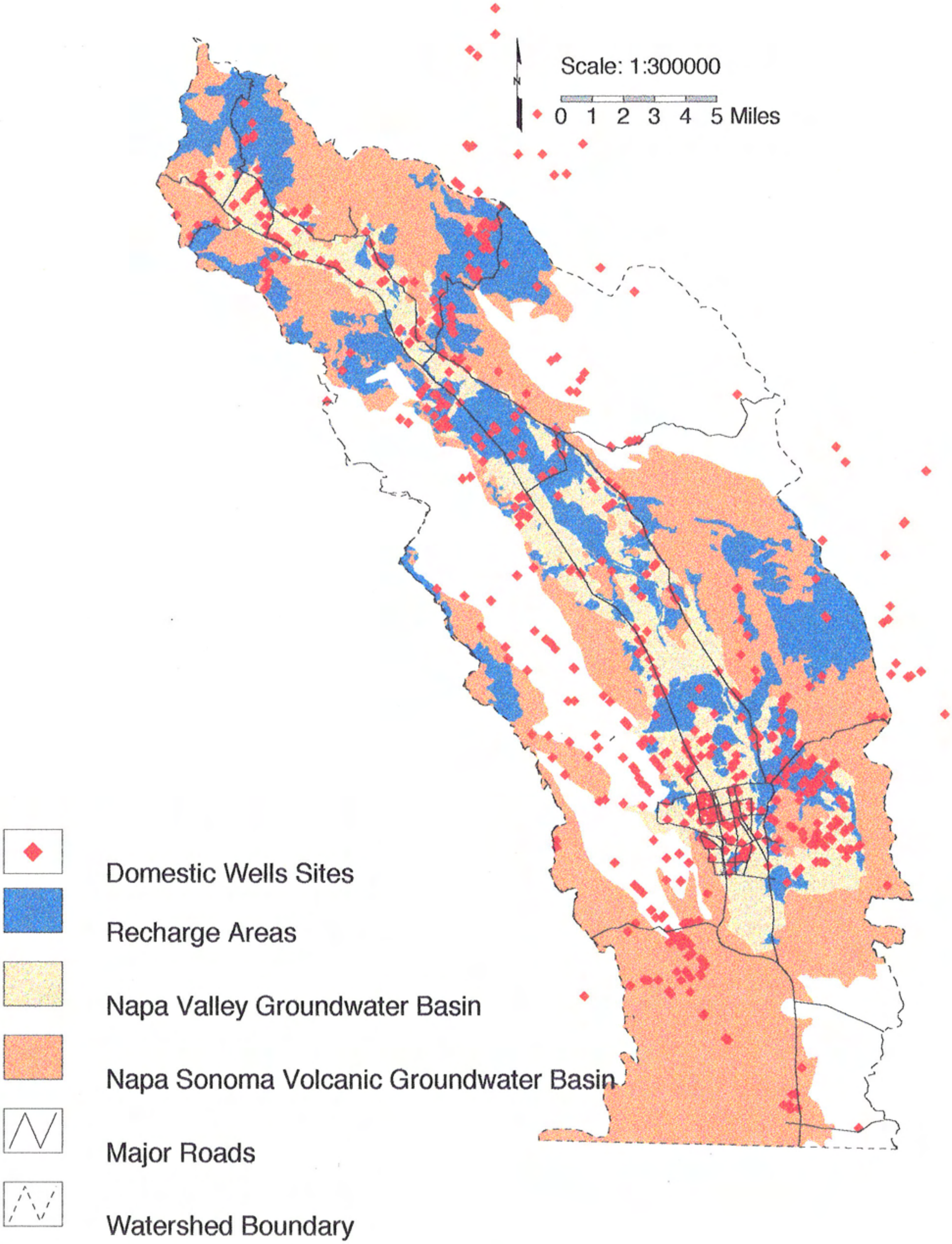


Figure 13. Domestic Well Sites

Coverages: Napagw, Well_rech, Nboundary

SFRWQCB, April 1996

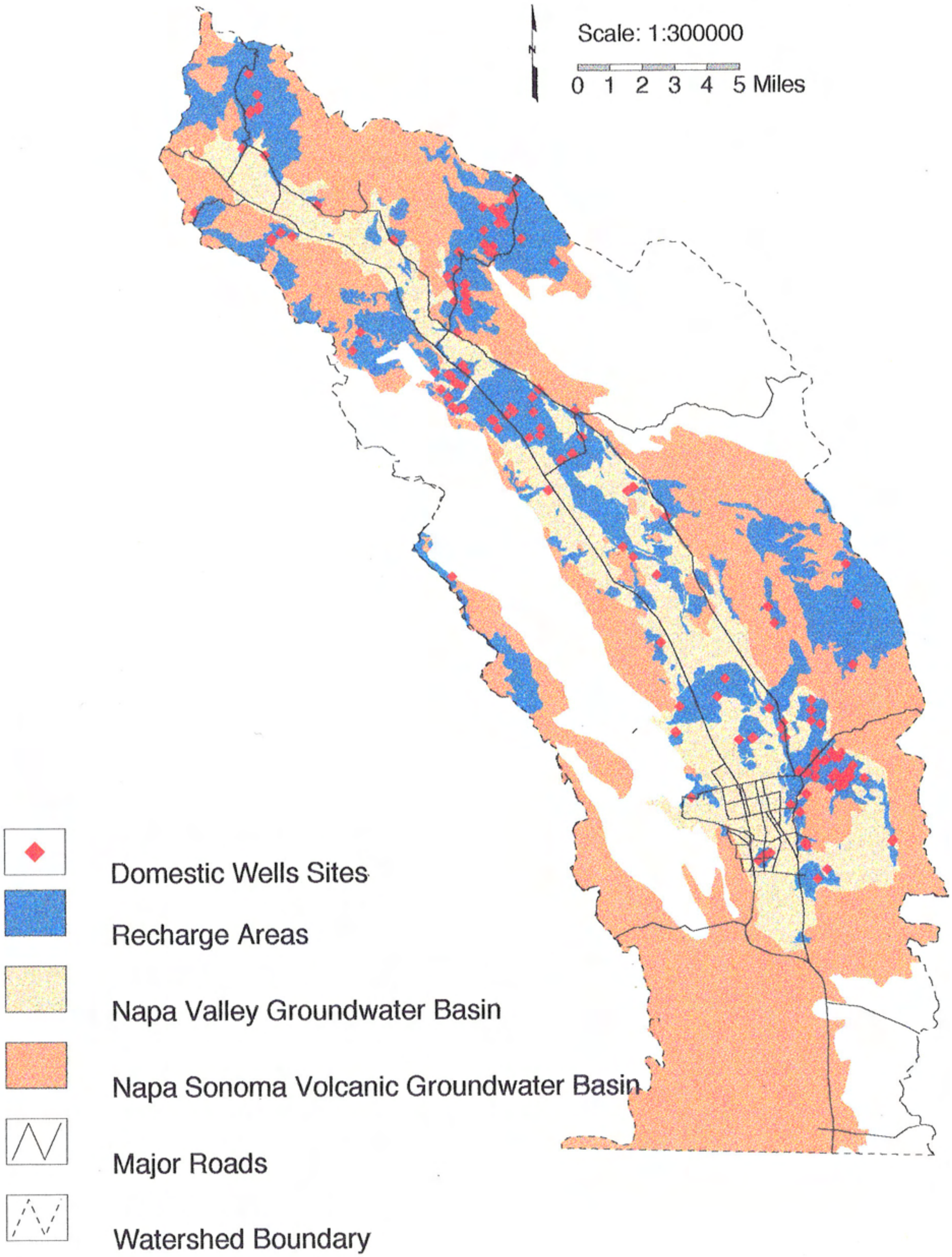
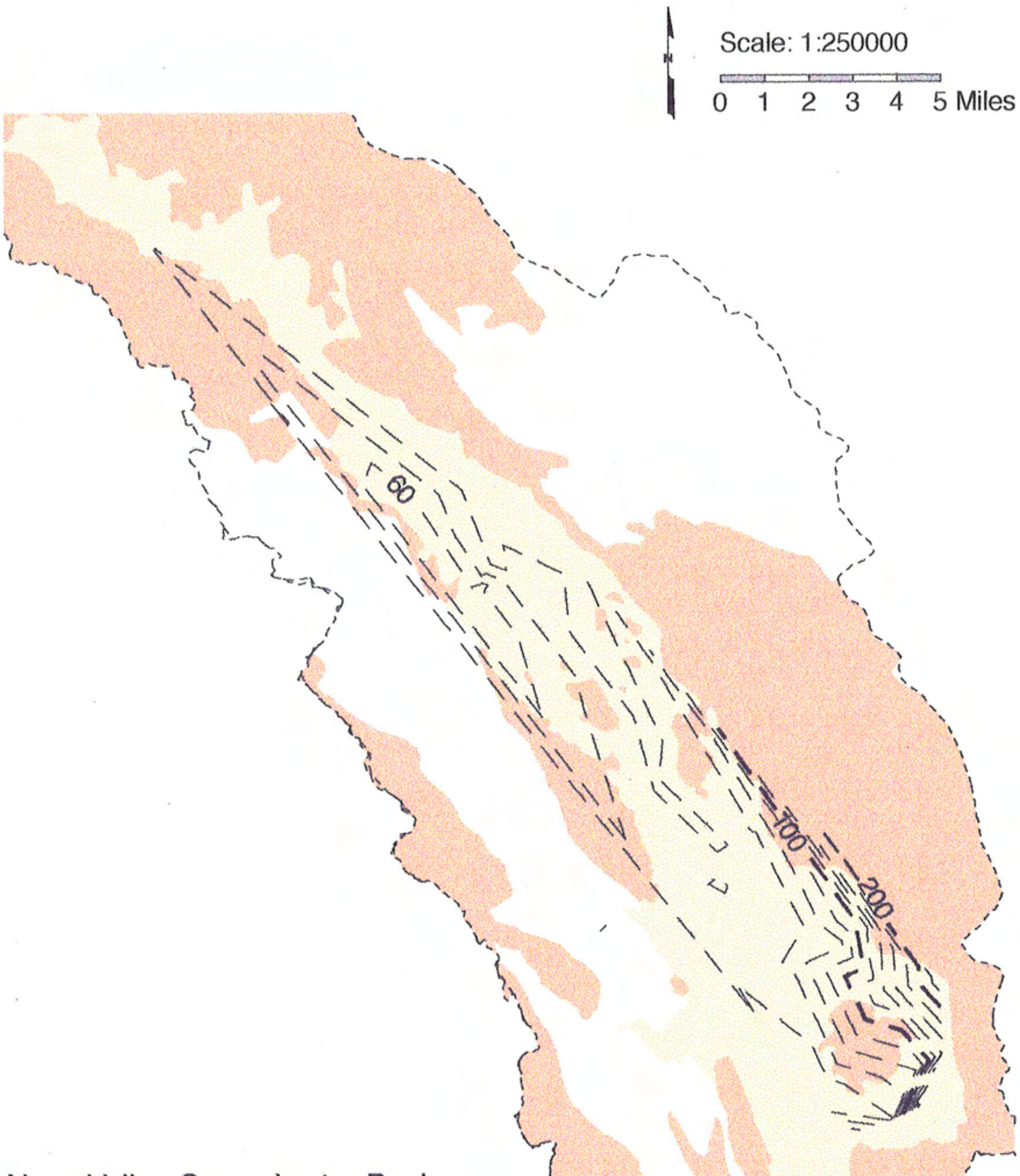


Figure 14. Domestic Well Sites over Recharge Areas

Coverages: Napagw, Well_rech, Nboundary

SFRWQCB, April 1996



Napa Valley Groundwater Basin

Napa Sonoma Volcanic Groundwater Basin

Contour LInes

Watershed Boundary

Figure 15. Groundwater Level Below Surface Contours

Coverages: Napagw, Napadwr, Nboundary

SFRWQCB, April 1996

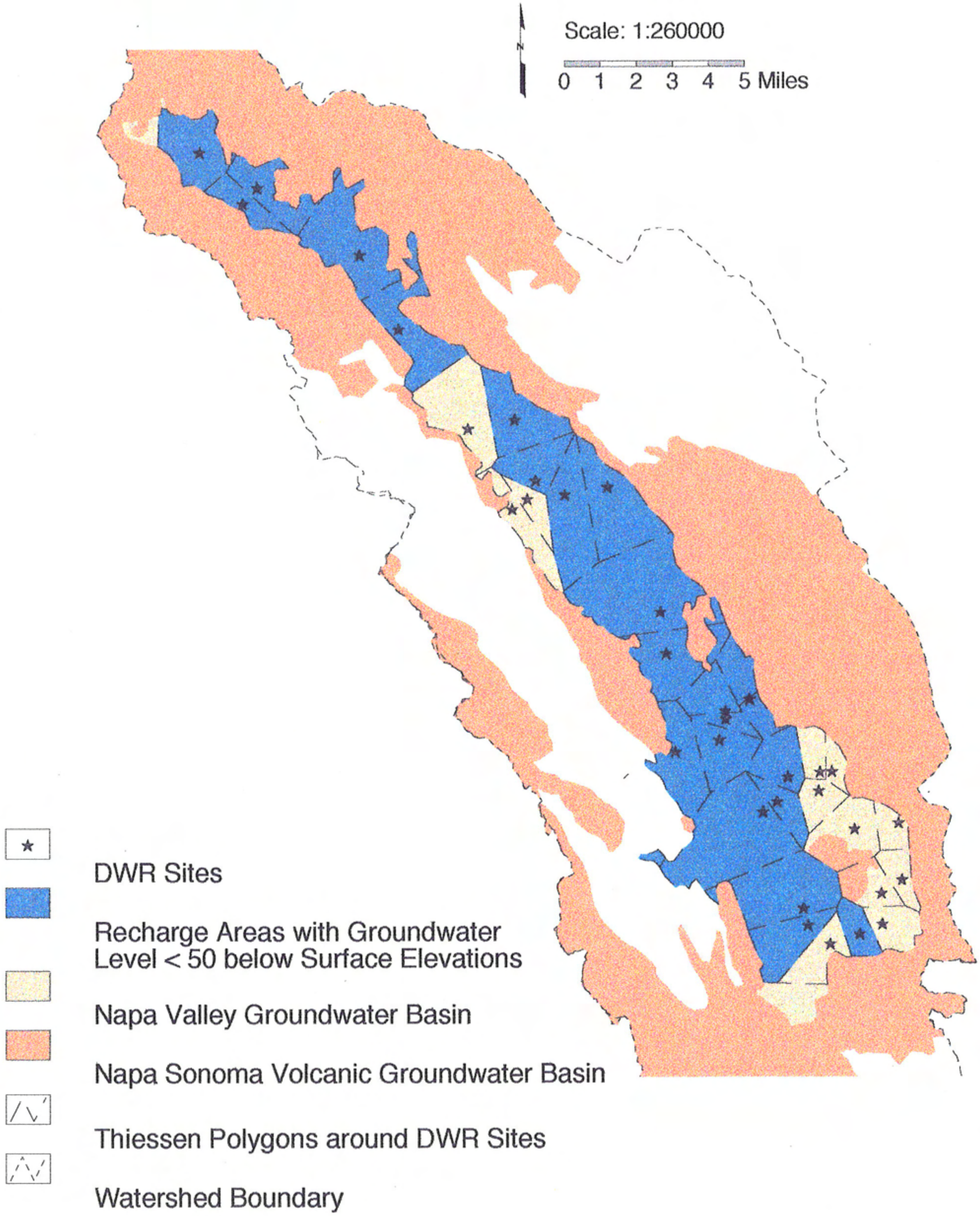


Figure 16. Groundwater Watertable < 50 feet

Coverages: Np_city, Napadwr_t, Napagw, Napasoil, Nbound SFRWQCB, April 1996

Septic Systems

The distribution of septic systems throughout the Napa River watershed are depicted in Figure 17. Figure 18 illustrates where septic systems are located within in recharge areas. This figure highlights several areas of clustered septic systems in recharge areas. Theoretically, in these areas there is a greater potential for the groundwater to be contaminated. The Angwin area exhibits the greatest vulnerability. Two other areas of high septic tank concentration are the St. Helena region and east of Napa.

Leaking Underground Storage Tanks

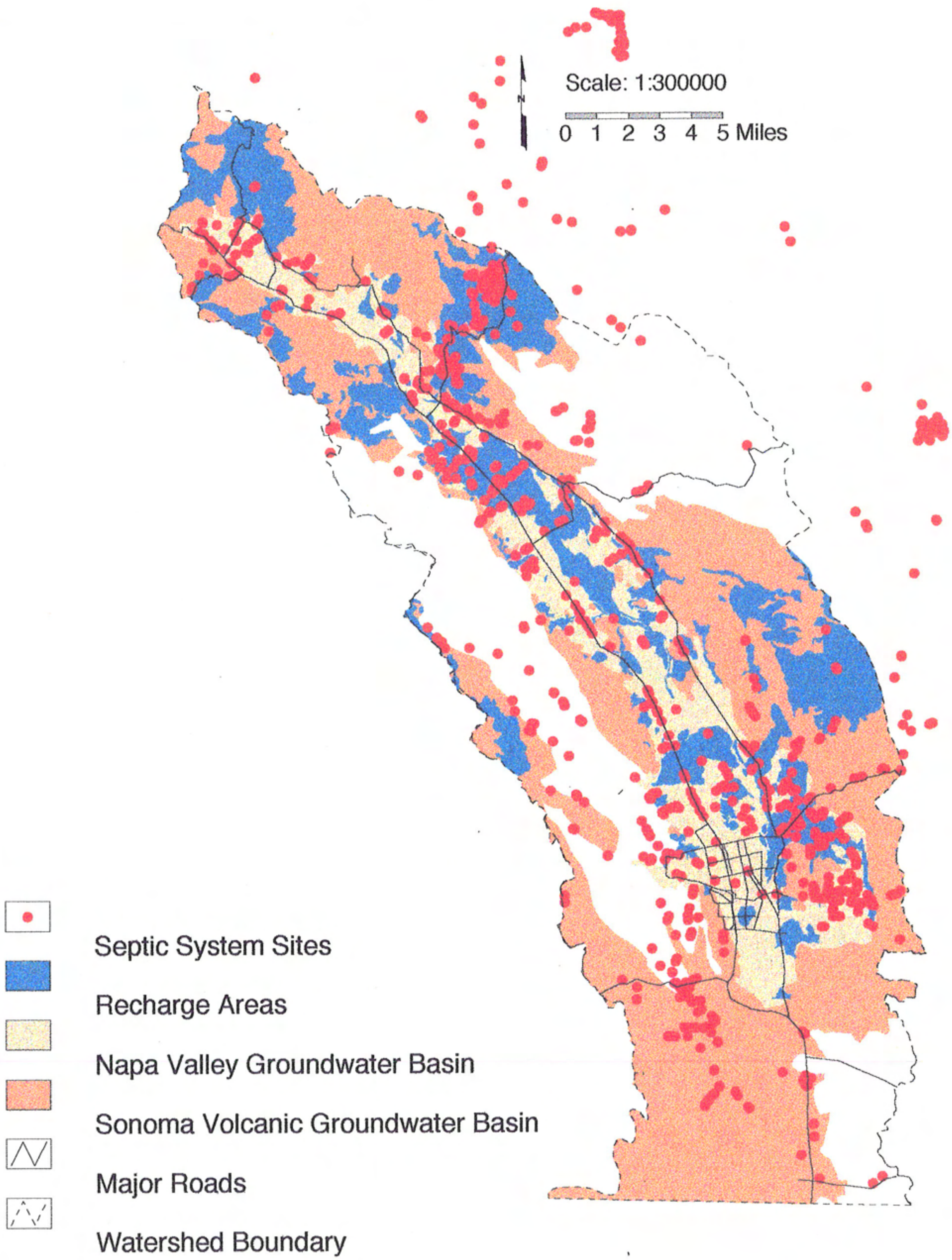
Figure 19 illustrates all the leaking underground storage tanks (UST) that could be geocoded. Figure 20 indicates those sites located in our designated recharge areas. The greatest concentrations of leaking underground storage tanks are in the vicinities of Calistoga, St. Helena, and Napa. Of the 174 fuel leak tank sites in the study area, 34 of these sites are located over recharge areas. The concentration of sites over St. Helena is cause for concern, since a cluster of sites appears directly over a recharge area. The greatest concentration of fuel sites are in the City of Napa; however, most of this area is fortuitously underlain by interbedded clays which may serve to protect the groundwater basin.

This analysis and subsequent future analysis of this type should prove useful to both Regional Board staff and local agencies in prioritizing site cleanups and evaluating closure requests.

Other Pollution Sources

As there were relatively few toxic hotspots (SLIC sites), landfill sites, and winery wasteponds, we combined these sites and overlaid them as one coverage with *recharge areas* coverage (Figure 21). Out of the four sites listed in the Regional Board Toxic Division's SLIC database, one site is located over a recharge area. This is shown in Figure 21 as the open triangle in the St. Helena area. There are a total of 15 permitted winery wasteponds in the study area, of which two are located in recharge areas. These are marked as filled-in triangles on Figure 21. The locations containing the highest density of these three potential groundwater pollutant sources indicates areas in which water quality should be monitored more closely. In the future, it may be beneficial to consult with the San Borne maps which identify historic pollution sites.

We identified agricultural areas from land use coverage obtained from NASA (Figure 22), and assumed that agricultural chemicals are used in these areas. We then overlaid this coverage with recharge areas (Figure 23). In the future, this evaluation could be further refined by incorporating more information such as the type and quantity of chemicals used. We also recognize that not all growers use chemicals; we would like to update this coverage to reflect for instance, areas where growers use organic or sustainable methods for growing crops.



Septic System Sites

Coverages: Napagw, Septic_rech, Nboundary

SFRWQCB, October 1995

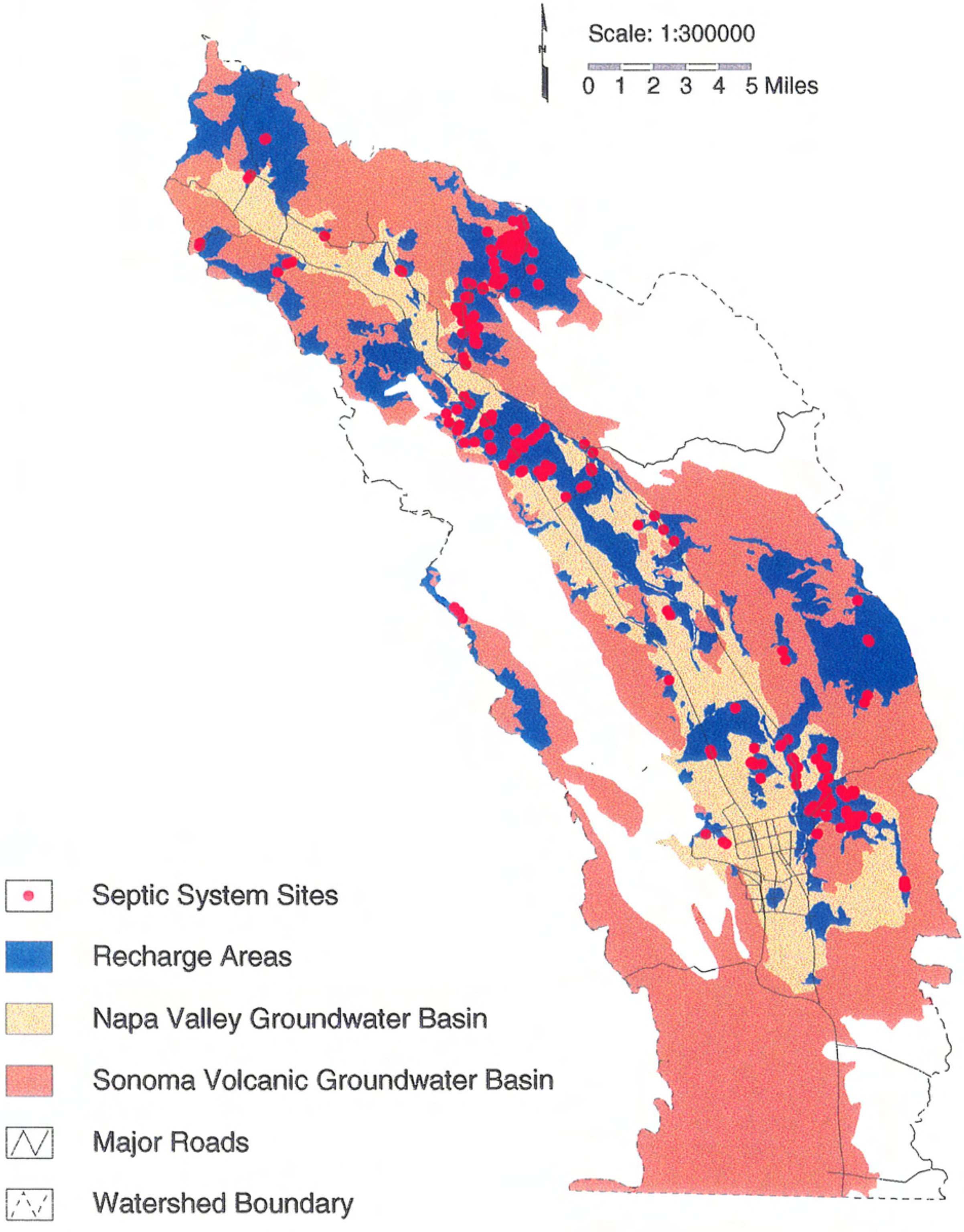


Figure 18: Septic System Sites over Recharge Areas

Coverages: Napagw, Septic_rech, Nboundary

SFRWQCB, October 1995

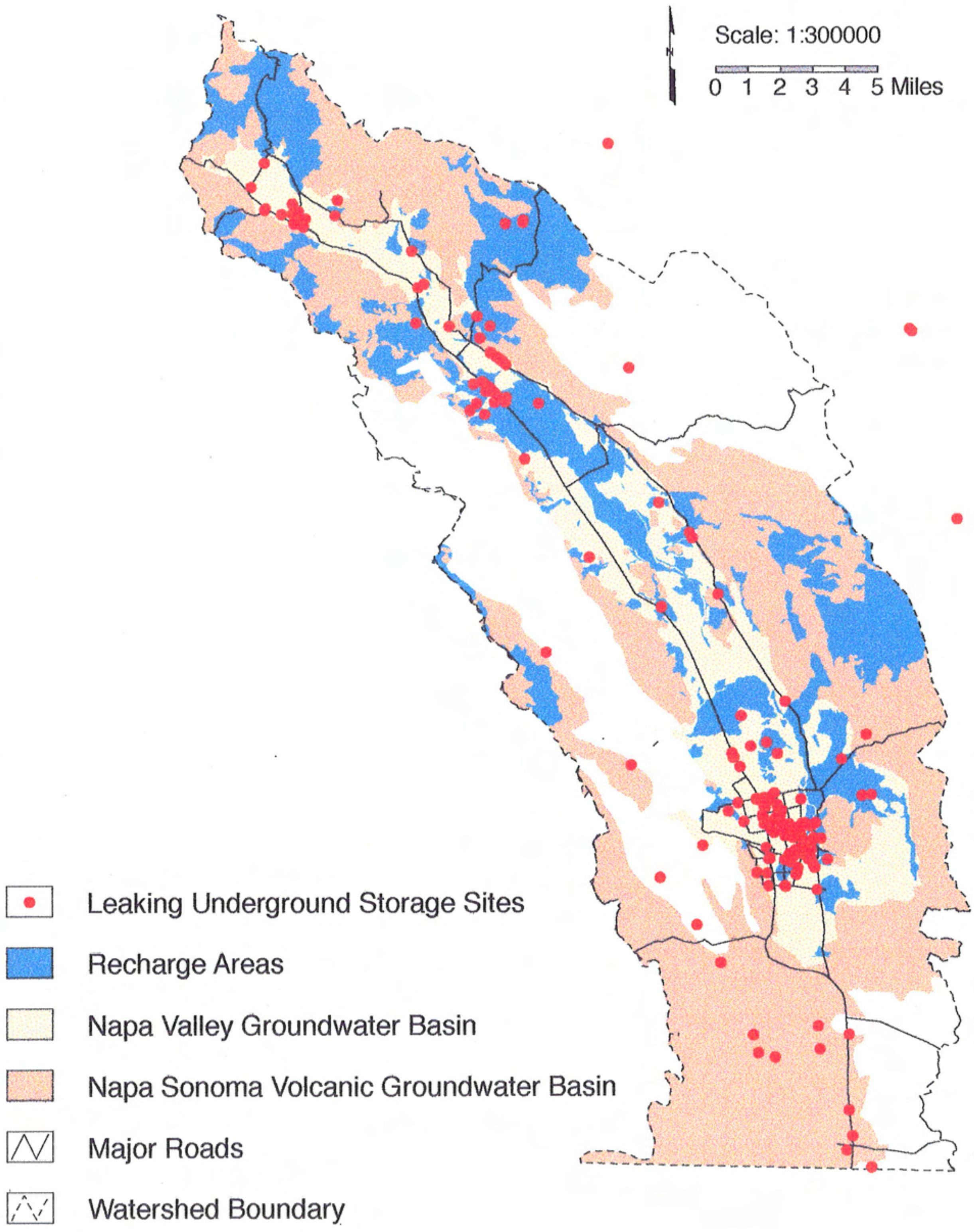


Figure 19. Leaking Underground Storage Sites

Coverages: Napagw, Lust_rech, Nboundary

SFRWQCB, April 1996

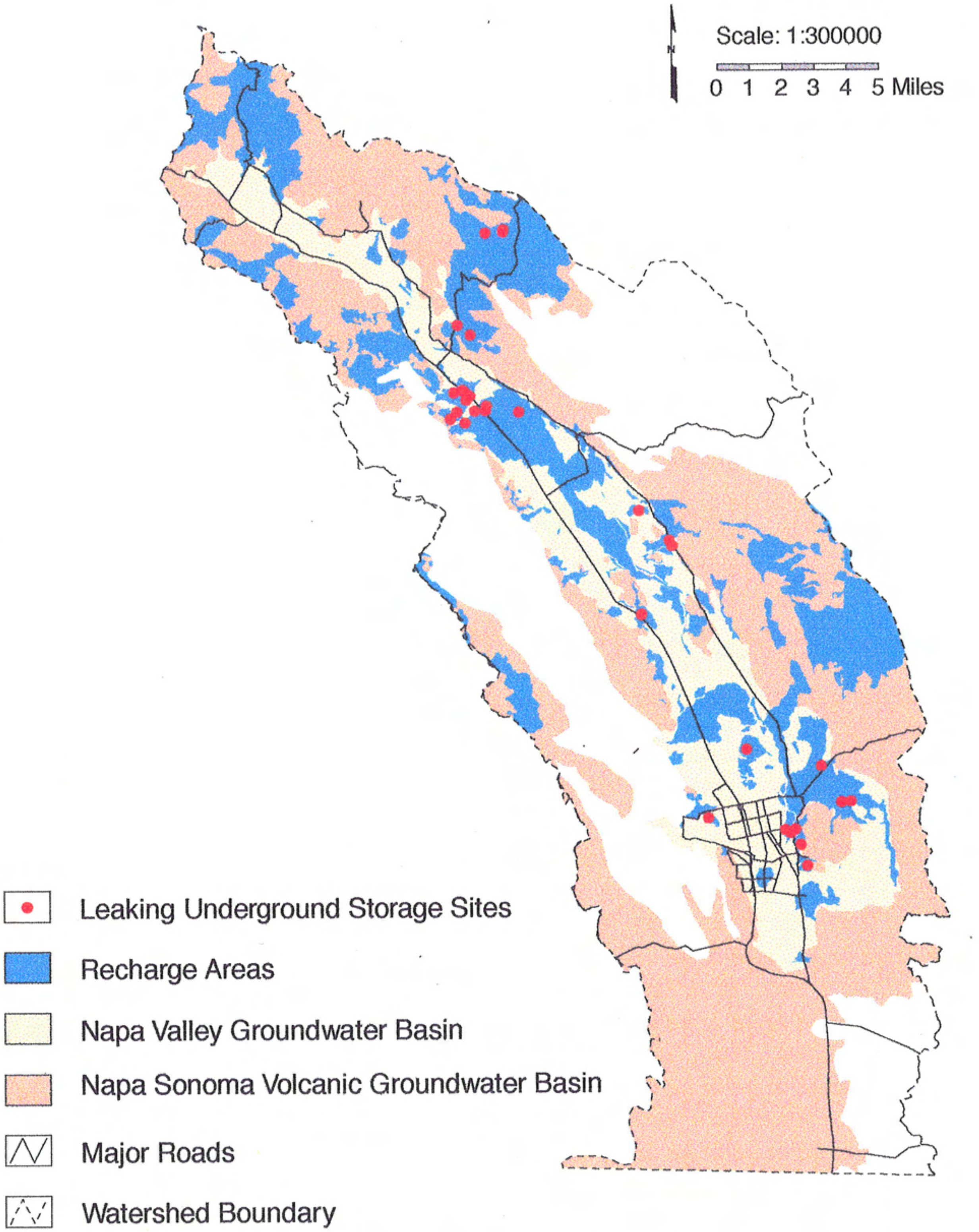


Figure 20. Leaking Underground Storage Sites over Recharge Areas

Coverages: Napagw, Lust_rech, Nboundary

SFRWQCB, April 1996

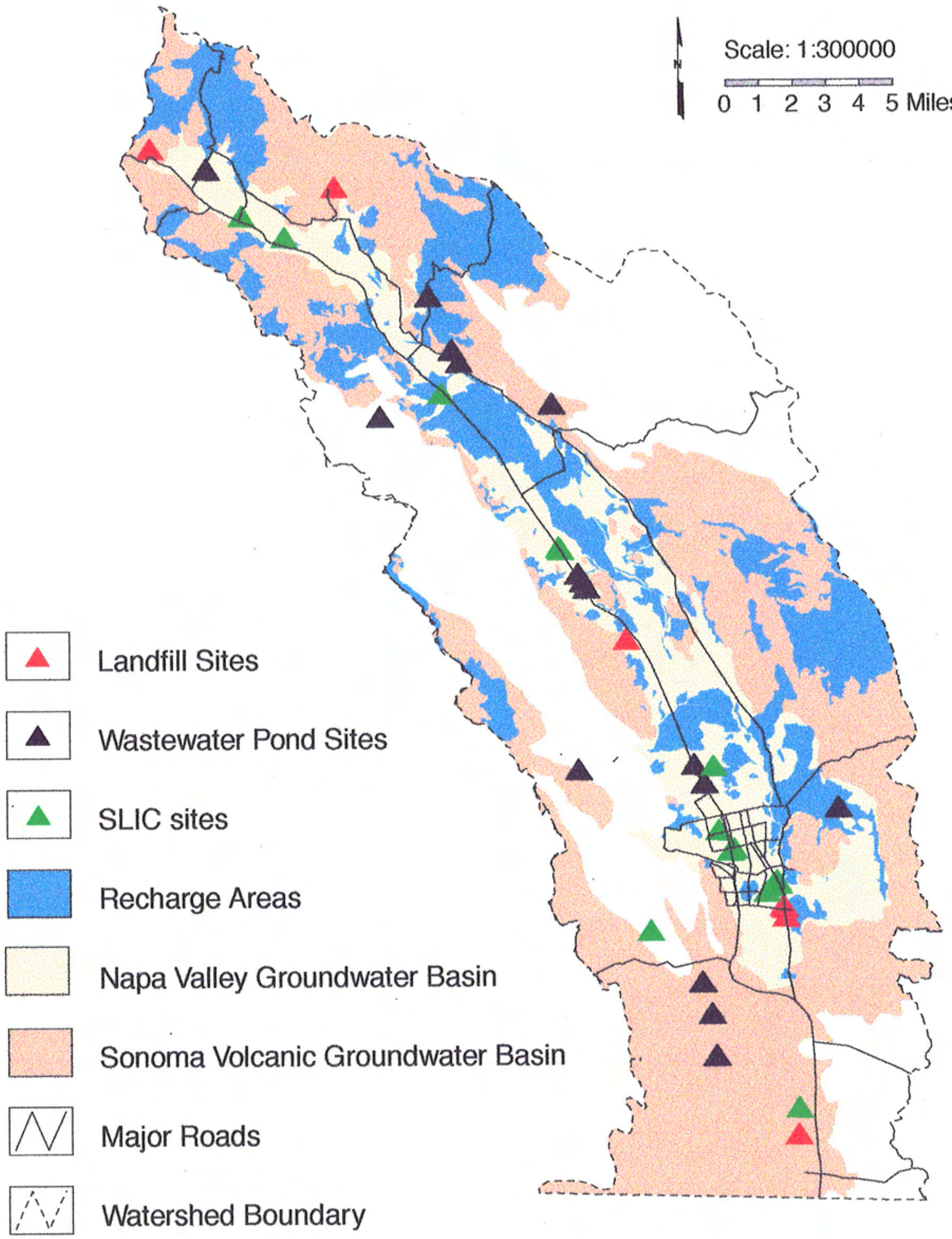


Figure 21. Other Potential Pollution Sources

Coverages: Napagw, Landf_rech, Pond_rech, Slic_rech, Nboundary

SFRWQCB, April 1996

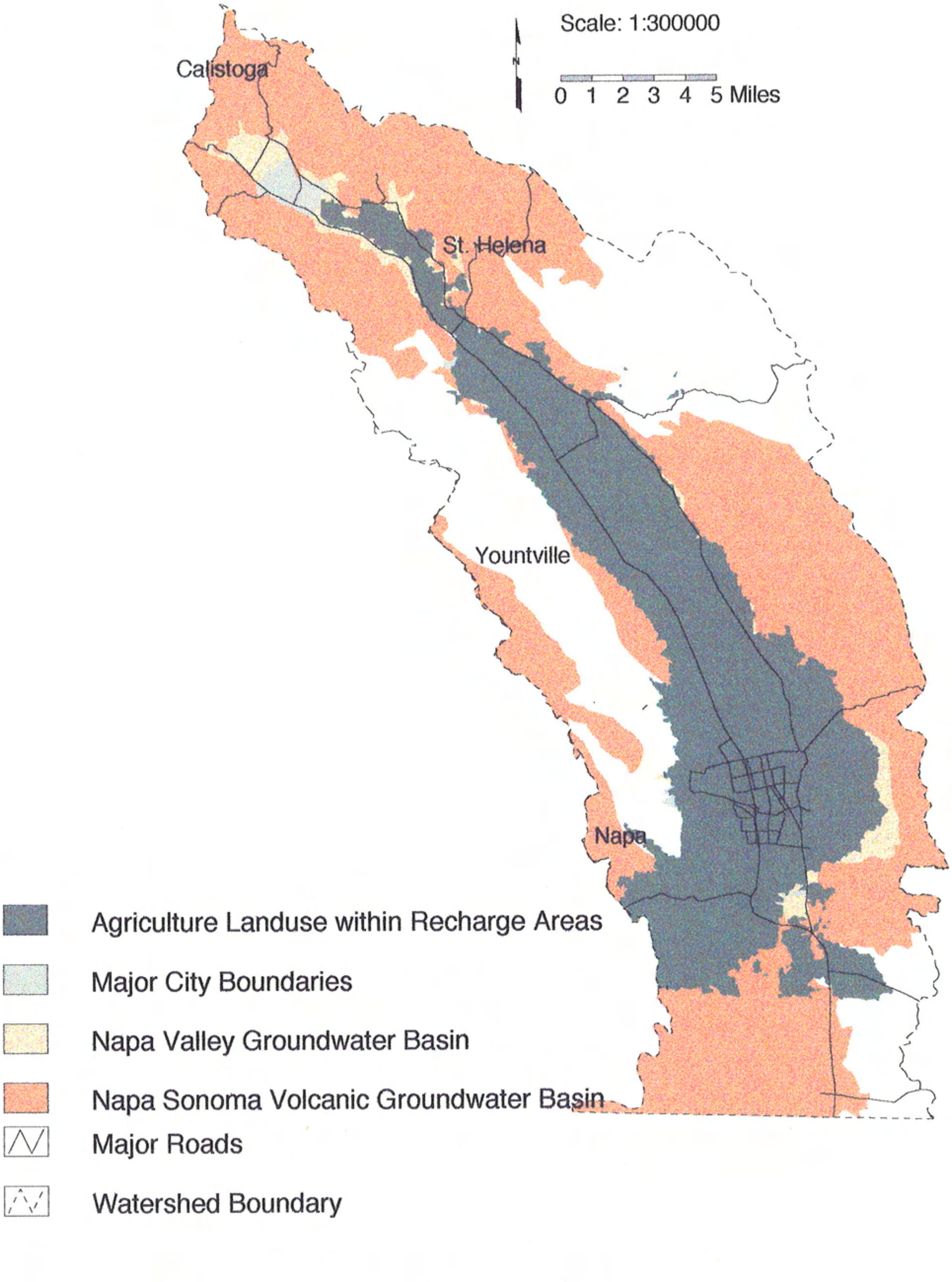


Figure 22. Agriculture Landuse

Coverages: Napagw, Agchem, Nboundary, Naparoads SFRWQCB, April1996

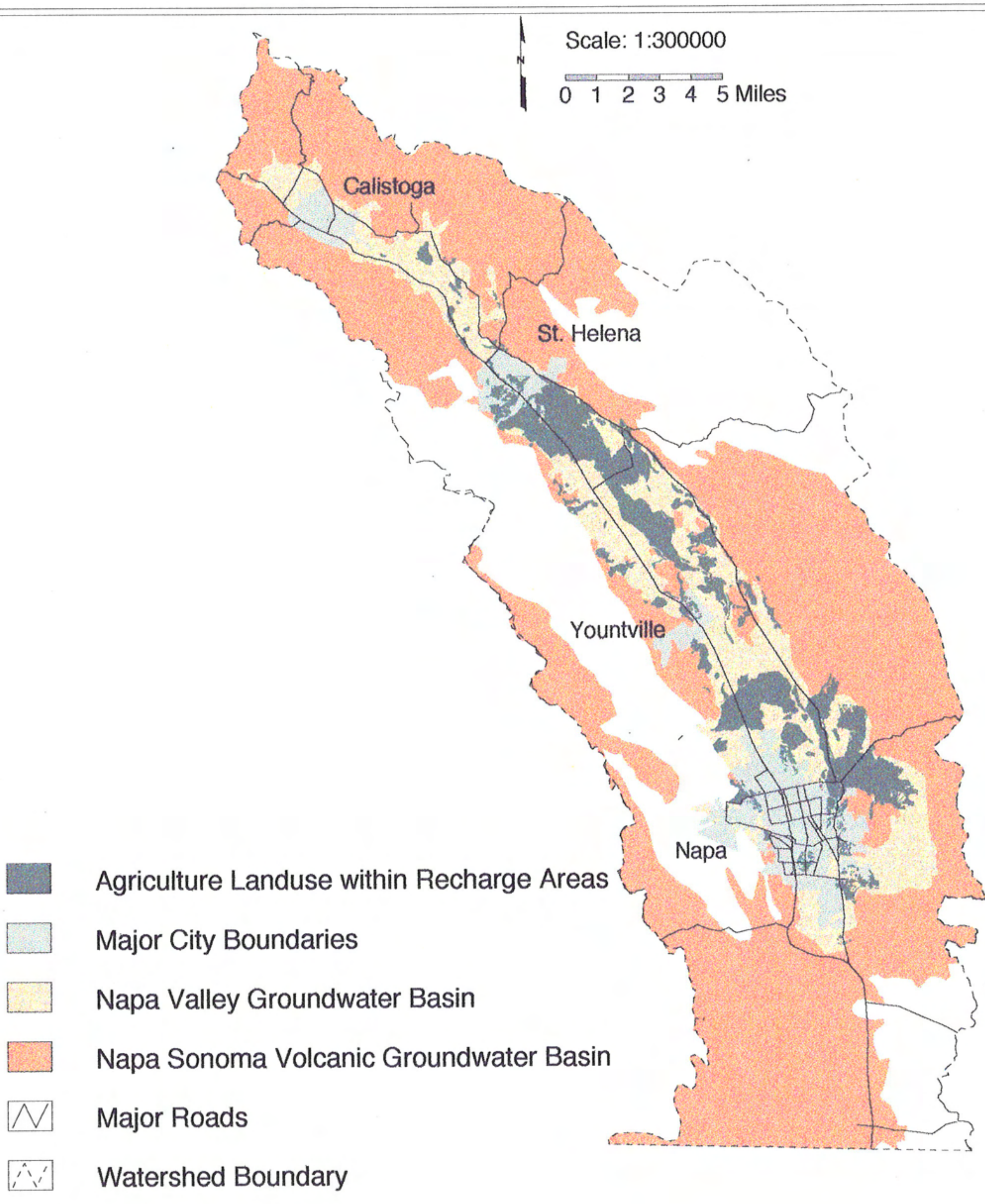


Figure 23. Agriculture Landuse in Recharge Areas

Coverages: Napagw, Agchem, Nboundary, Naparoads

SFRWQCB, April 1996

4.D IDENTIFICATION OF DATA GAPS and FUTURE ANALYSES NEEDED

As with most GIS projects, there is the need for more accurate and higher resolution data. Our intent in this section is to acknowledge key gaps in our data and identify future work needs. The largest problem we encountered in developing our own GIS coverages from site data files was in the geocoding process. These problems are detailed in this section. In addition, we identify coverages that could not be included in our analysis, but that would improve the reliability of our analyses. Finally, there are numerous analyses that could be conducted from different combinations of existing coverages; several examples are discussed.

Geocoding Problems

The process of geocoding site locations from street addresses using MapInfo is subject to a number of limitations. The process entails using MapInfo and its address files to match an address number with a geographic location. Unfortunately, for the Napa region, MapInfo files contain gaps in the address number series for many streets. In addition, there are street names that are not in the MapInfo file. Formatting existing data files for input and recognition by MapInfo was also a problem. For example, the number for the street address may be missing, a post office box may be used, or data entry errors such as an "I" in the number field instead of a "1" may exist. Interactive geocoding allowed for correction of some of these types of errors but was very time intensive.

Overall, geocoding county wells, septic systems, and LUSTIS sites yielded geographic positioning of from 53% to 76% of the total number of sites. This percentage needs to be improved. MapInfo is working on an updated version of its address file which may reduce the number of unmatched sites.

Another limitation of geocoding site data from addresses is that symbols associated with a particular site are geocoded to the edge of the street, rather than the actual geographic location. This may be overcome if the geographic coordinates are known or can be determined (e.g. using a Global Positioning System). Geocoding to the street may be of sufficient precision for regional scales of analysis, while more accurate locations are clearly required for site level analysis. For this project, we did use U.S.EPA's GPS to accurately locate monitoring wells for our monitoring network and do foresee using GPS to improve data layers in the future.

Coverages manually enhanced

The soils coverage from NASA Ames and the USGS maps only covered a portion of the study area (Figure 7). Soils outside the NASA coverage were evaluated for their potential as permeable areas by comparing hard copy soil survey maps with known permeable geologic units (surficial geology coverage). Map symbol numbers on the soil survey maps which correlated with A and B hydrologic soil groups were hand-shaded on the soils map. Permeable recharge areas outside the soil boundary were then determined based on whether or not these shaded areas were a significant enough portion of the permeable geology polygon to call it a recharge area. In some areas, such as in northern Napa county, recharge zones outside the coverage boundary were also determined by placing a buffer around the streams where permeable soils appeared to line the streams. The methodology used here was based on the most conservative approach; i.e., areas with any potential for recharge were included.

Figure 15 depicts groundwater elevation contours as determined from 34 wells (depicted by stars). The data used for this analysis was the most recent data from either currently monitored wells or wells monitored within the previous 4 years. Clearly, more data points will produce a more accurate contour map. However, the contours do coincide fairly well with what is known about the groundwater basins in this region.

Future Analysis

One of the main benefits of a GIS, if designed properly, is to allow for on-going analysis in response to both improvements or changes in baseline data, and shifts in management priorities and needs. With this in mind, we recommend further analyses using the location of surface water bodies and a digital elevation model. In the Napa watershed, surface water and groundwater are closely connected. Yet, we have not evaluated how this may effect water quality. In order to further delineate and pinpoint areas of maximum recharge we suggest:

- Using the digital elevation model and surface water coverages to evaluate the relationship between the location of streams and recharge areas, and
- Improving recharge area delineations by using more accurate geological source maps.

In addition, future analyses that could extend from this current work include the following various combinations of recharge and vulnerable areas (all a result of overlay with recharge areas):

- Domestic Wells + a combination of: Septic, waste ponds, agricultural chemical areas, and landfills; and
- Municipal Wells + leaking underground storage tanks and/or SLIC sites.

The ability of a GIS to produce maps should not be under estimated. High quality GIS maps depicting the location of sites have already proven useful to Regional Board staff in preparing presentations for Board Meetings, developing graphics for the Basin Plan, and evaluating site cleanups. With GIS, numerous other types of analyses can be conducted with coverages developed for this project. The limiting factor in GIS is and will always be the availability of high resolution, accurate data. This should not stop us from moving ahead and using the data we have, as analyses can always be further refined as the quality of available data improves.

4.E INTERAGENCY COORDINATION AND OUTREACH

Successful groundwater protection efforts using GIS in Napa hinges on local participation. In recognition of this, Regional Board staff focused considerable energy in working with local agencies. Interagency coordination and outreach was conducted through workshops and work groups. A complete synopsis of all these presentations, discussions, and follow-up tasks is provided in Appendix C.

Perhaps the greatest challenge regarding coordination efforts was spreading the word on the importance that GIS can play in groundwater protection. Although GIS technology is not new to most local agencies, many have not been interested due to financial or staff training limitations. However, the coordination efforts were well timed with increased interest in GIS locally. With the advent of integrated watershed management in Napa county, many agencies want tools to support interdisciplinary spatial problem-solving. Furthermore, both hardware and software costs have lowered to a level where most local agencies can realistically afford to purchase the necessary equipment.

There is widespread willingness among Napa agencies to collaborate on GIS. This collaborative effort, however, is difficult to accomplish in a computer-based environment. This section addresses some of these themes and discusses the various ways Regional Board staff chose to facilitate coordination and collaborative efforts between groups.

Workshops

Regional Board staff held two workshops in Napa for federal, state, county, and city agency staff. Paul Schwarz, a Regional Board intern, organized and ran the workshops. Paul's training and professional experience with facilitation and mediation was instrumental in the success of the workshops. The purpose of the workshops were twofold: 1) to inform local resource managers about how GIS could be implemented for decision-making, and 2) to focus on issues of importance to local agencies, thus encouraging participation in an area-wide strategy to coordinate and share data.

Paul conducted extensive one-on-one discussions with Regional Board staff and local, state, and federal officials before and after each workshop to cultivate attendance and participation. These efforts paid off, as both workshops were well attended. Representatives from all cities and county planning and public works departments, Department of Environmental Management, Assessor's office, Resource Conservation District, Agricultural Commissioner's Office, USDA Natural Resource Conservation Service, Department of Pesticide Regulation, U.S. EPA, Regional Board, State Water Board, as well as the San Francisco Bay Conservation and Development Commission and University of California Cooperative Extension were also in attendance.

a.) Workshop #1 - May 1995

This workshop provided an opportunity for Regional Board staff to spotlight the status of the groundwater related activities and GIS work conducted for the project. More importantly, however, it gave Regional Board staff the chance to hear what individuals from Napa wanted to pursue in regards to the GIS goals and development. As such, it was an opportunity to identify:

- what motivated people to attend the workshop,
- what specific analyses people want to perform with GIS,
- what types of data are needed,
- what are the constraints in pursuing GIS.

Regional Board staff invited staff from Santa Clara Valley Water District, Alameda County Water District, and San Mateo County Health Department to make presentations. Their examples provided tangible success stories on the application of GIS for groundwater protection purposes. These presentations demonstrated the different levels of software sophistication that exist, while showing the range of possibilities for data analysis depending on the goals and budget of the GIS project.

Follow-up interviews with attendees after the workshop indicated that they obtained a general sense of what GIS is, what some of its unique capabilities are, and various strategies for implementing a system. **It was very clear that while groundwater issues were of interest, the attendees had a much broader and more ambitious idea of the GIS they wanted to implement.** Regional Board staff realized that the groundwater coverages could become one small part of a county-wide GIS. As a result, our emphasis shifted from groundwater protection toward GIS itself. The second workshop was organized with the purpose of demonstrating how GIS can be used as a tool for decision-making.

b.) Workshop #2

The second workshop in June was well-attended by the majority of the participants from the May workshop. A panel of GIS experts provided insights into some of the issues which need to be addressed, or at least considered, when developing a GIS database. Specific issues noted were:

- Accuracy required,
- Availability of data,
- Cost of data, and
- Appropriateness of the data.

This second workshop also allowed vendors from two GIS software companies to describe general characteristics of GIS as well as give brief demonstrations of their products. Following the presentations, a group discussion ensued, allowing attendees to focus on particular items of concern that had been raised during the first two workshops. A number of issues surfaced:

- What is the best way to develop interagency connectivity?

- Who would take the lead in establishing protocols and setting standards?
- How can individual interests be integrated with group goals?
- A "blueprint for the future" is needed to set a desired condition for GIS, the steps necessary to get there, who would be involved and when.
- What metadata are required to document data attributes.
- Accuracy can be varied depending on need.

A core group of people interested agreed to participate in a GIS work group to pursue these issues. The Regional Board committed to assist by providing our facilitator, Paul Schwarz, to organize, run, and perform administrative tasks for the work group meetings.

GIS Work Group

To date there have been three work group meetings. The general response has been positive, participation is strong, and significant progress towards a county-wide GIS has been made. The following agencies have participated: City of Napa, U.C. Berkeley Institute of Transportation Studies, Napa County Planning Department, Napa County Management Information Systems (MIS), Napa County Assessor, Napa County RCD, Napa County Public Works, City of Napa Water Division, City of Napa Planning Department, City of Napa Water Division, U.S. EPA, and Regional Board.

At the initial meeting three areas were identified as requiring priority follow-up:

1. A written statement of purpose would be useful to make progress toward a definite goal that all can support.
2. A strategy needs to be created for producing a comprehensive, seamless basemap with some number of layers tied to a coordinate grid map, having assessor's data pulled to it.
3. There needs to be close communication among the various entities developing or planning to develop GISs to assure system interconnectivity for data transfer with the greatest of ease. A technical person should speak to the group about data transfer.

At the second work group meeting on September 29, 1995, the following directions were developed:

- To develop a coordinated approach to data management,
- To discuss funding options for developing a basemap (cost ~$2 - $8 per parcel),
- To develop a way of linking GIS-based information to a mainframe database,
- To share basemap and resources (funding, and equipment).

Several options for basemap development were identified, including, orthophotographs, digital line graphs (DLG) from USGS, hand digitizing, and scanned images. The idea of forming a basemap task force was agreed upon. This task force would develop a Request For Proposal (RFP) in order to solicit bids for basemap generation. A list of entities to have input into the drafting of the RFP document was brainstormed and included the following groups: Napa Sanitation District upper management, City/County Public Works, City/County Planning, Private Surveyor, PG&E, Pacific Bell, and Cablevision. City involvement would also be important in drawing up the scope of the RFP, particularly the following cities and towns: American Canyon, St. Helena, Calistoga and Yountville.

The Bay Area Interagency Data Standards Committee is an existing group which was formed to discuss many of the same issues that the Napa group are confronted with. It may be advisable to have a representative from the Napa group attend an upcoming Data Standards Committee meeting in order to benefit from the experience of others and be able to apply the information to Napa.

In order to follow-up on this second work group meeting and to plan for the next meeting, the work group devised the following strategy, listed in order of priority:

1.) Introductory presentation on GIS for upper managers
2.) Develop basemap RFP.
3.) Upgrade infrastructure.

The third workgroup meeting accomplished priority one of the strategy. Mike Smith, City of Oakland, was invited to present a GIS success story to Napa managers and politicians. We expended considerable time and effort to ensure that key decision makers were in attendance. At the close of the meeting, the workgroup introduced the idea of items 2 and 3 of the strategy. The workgroup stated that a RPF would be forthcoming, and local funding from agencies represented by those at the meeting would be sought.

5. THE NAPA GROUNDWATER PROTECTION STRATEGY

The Napa Groundwater Protection Strategy (Napa Strategy) is a culmination of the information described in the previous four chapters. In developing the Strategy, we began with an understanding of the necessary components for comprehensive groundwater protection (Chapter 2). We identified existing local programs (Chapter 2) and critical issues for groundwater protection (Chapter 3). Using GIS, we defined areas that are vulnerable to pollution (Chapter 4).

The Strategy recognizes and encompasses existing agencies' efforts that were identified during the project and is intended to support ongoing efforts for integrated watershed planning and protection. The goals of the Strategy are to:

- protect the existing high quality of groundwater,
- restore polluted groundwater,
- prevent further pollution from occurring, and
- to disseminate groundwater resource information for decision-making.

The Strategy is organized into six components: pollution prevention, restoration, monitoring, groundwater management, GIS coordination, and funding. Some of these have been subdivided into implementation elements. Table 11 summarizes the strategy that is described below. Wherever possible, the specific implementing agencies are identified.

5.A POLLUTION PREVENTION:

Pollution prevention is the most fundamental component of groundwater protection. **The goal is to limit inputs and prevent accidental releases.** It is necessary to protect groundwater from legally permitted inputs such as agricultural chemicals and septic system effluent, as well as to prevent accidental releases of fuels and other toxic chemicals. **The actions for pollution prevention are:**

- **Prevention of Hazardous Materials Releases**
- **Agricultural Chemical Spills Prevention**
- **Septic System Design Review**
- **Waste Water Control**
- **Conduit Management**
- **Septic System Management Areas**
- **Agricultural Chemical Management Areas**

COMPONENT	GOAL	ACTIONS	PARTICIPANTS
1) Pollution Prevention	To limit inputs and prevent accidental releases.	Prevention of Hazardous Material Releases	County Dept. of Environmental Mgmt. (DEM); County Office of Emergency Services (OES)
		Agricultural Chemical Spills Prevention	Agricultural Commissioners office (Ag. Comm.)
		Agricultural Chemical Management Areas	Ag. Comm.; DPR; RWQCB
		Septic System Design Review	DEM; RWQCB
		Waste Water Control	DEM; RWQCB
		Conduit Management	DEM
		Septic System Management Areas	DEM; RWQCB
2) Monitoring	To demonstrate progress and verify source control	Coordination of Existing Programs	RWQCB; DPR; DWR; Co Flood Control Dst: Ag Comm.
3) Restoration	To return polluted GW to productive use and prevent further degradation	Cleanup of Leaking UST	RWQCB; County DEM
		Cleanup of Other Pollution Sources	RWQCB; County DEM
		Focus Effort in Recharge Areas	RWQCB; County DEM
4) Ground Water Management	To protect basin from overdraft and associated detrimental affects to water quality	Facilitate Dialogue between Water User Community	UC Cooperative Extension; Napa Water Education Coalition
		Determine safe yield of GW basins	unknown
		Develop a management strategy	unknown
5) Information Management/Coordination	To manage information efficiently and provide information to decision-makers	Data Management	Co RCD; City of Napa; County Public Works
		GIS Coordination	Napa GIS Workgroup
6) Funding	To ensure adequate funds are available to implement the Strategy	Grant Writing	RWQCB, U.S.EPA, local agencies

Table 11. Groundwater Protection Strategy for the Napa River Watershed

There are many aspects of pollution prevention and hazardous materials management that are part of existing programs, described in Chapter 2. The Department of Environmental Management (DEM) and the Office of Emergency Services, manage programs that address both the routine handling of hazardous chemicals and emergency releases. Agricultural chemical spill prevention program is managed by the Agricultural Commissioner's Office. Their program also has a component of wellhead protection. Septic system design review, waste water control, and conduit management are the responsibility of the Regional Board and the DEM.

It should be noted, as discussed previously in Chapter 4, that the GIS analysis is regional in nature and not appropriate for site-specific case consideration. The implementing agencies should continue to use site-specific conditions when evaluating individual permits or chemical applications. The best use of the GIS is to evaluate potential areas for cumulative impacts, aligning staff efforts with areas of elevated importance, and conducting field inspections and monitoring programs.

Based on the GIS analysis, the following **new actions** are recommended as part of the Strategy:

<u>Septic systems management areas</u>: Figure 18 illustrates septic systems that overlie groundwater recharge areas. The DEM should evaluate new septic system proposals within these areas for further potential groundwater impacts. Based on the clustering of septic systems in several areas, tracking of the proper ongoing maintenance and monitoring should be a priority for the DEM within the following areas: Angwin, St. Helena, and east of Napa. Furthermore, in evaluating new proposals for non-standard systems, the DEM should consider monitoring requirements in these "cluster" areas.

<u>Agricultural chemical management areas:</u> The coincidence of agricultural areas and groundwater recharge areas is indicated on Figure 23. The Agricultural Commissioner's office, together with the DPR, should evaluate the need for any additional notices or restrictions of pesticide applications within these areas. Consideration should be given to prioritizing the existing inspection program within these areas. The need for coordination of monitoring programs within these areas is described below under "Monitoring".

<u>Location of Abandoned Wells:</u> The DEM should begin a program to locate and properly destroy abandoned wells. In addition, the identification of shallow drainage or injection wells that may serve as conduits is important. In April 1996, the U.S. EPA announced a grant program for local agencies to enhance groundwater protection efforts. A well destruction program could be partially funded under a U.S. EPA grant. In addition to seeking grant funds for this work, a volunteer program to find abandoned wells may be appropriate. According to U.S. EPA staff, the city of Anaheim has been using a national volunteer senior citizen's group for locating abandoned wells.

5.B MONITORING

As described in Chapter 2, there are currently three state agencies monitoring regional groundwater conditions within the Napa River watershed. In addition, there is ongoing monitoring at pollution sites regulated by the Regional Board and DEM. The existing data suggests that there is no known widespread pollution problems. **The goal of monitoring is to demonstrate progress and verify source control.** The ongoing monitoring provides basic data for agencies that are assessing the overall quality of the aquifers, to document that groundwater protection measures are indeed working, and to serve as a early warning indicator of pollution problems that may not be detected by site specific monitoring programs. The challenge of maintaining a monitoring network in Napa River watershed, is to coordinate and consolidate existing programs so that costs can be shared.

The Regional Board's monitoring program was specifically designed for evaluation of ambient water quality and together with DPR's pesticide monitoring, provides a baseline of the "current condition" of Napa groundwater. DWR's data likewise provides both a current picture as well as a historical record of water levels. The three agencies should discuss how to coordinate field sampling and lab analysis to make the best use of limited agency resources. For example, the Regional Board may not have staffing to conduct field sampling in the future, but could provide laboratory services to another agency that samples the wells.

Results of compliance monitoring at pollution sites is reviewed by DEM. The Regional Board and DEM should evaluate the feasibility of requiring the submittal of this data into a format which can be utilized for GIS analysis. Evaluation of this data over time will indicate whether ongoing restoration efforts have had a net improvement in water quality.

The action for monitoring is the coordination of existing programs.

5.C RESTORATION

The goal of restoration is to return polluted groundwater to productive use and prevent further degradation. The action items are:

- **cleanup of leaking underground storage tank pollution**
- **cleanup of pollution from other sources**
- **focused staff efforts in recharge areas**

Because of the widespread domestic groundwater use, all groundwater in Napa is potentially a source of drinking water. Furthermore, there is interest in using additional groundwater resources for urban supplies. Cleanup of polluted sites should reflect the need to restore as much groundwater as is reasonably possible. Staff from the Regional Board and the DEM should focus their efforts in recharge areas (Figure 20). Napa County has been extremely fortunate to date in that only three of the over 170 cases of leaking underground storage tanks have affected drinking water wells. Regional Board staff have observed that one of the reasons for this is that most of the fuel cases are within the City of Napa, which has relatively low permeability soils. Likewise, there are no known incidence of other pollution sources, including septic systems, chemical spills, or waste water ponds that have impacted water supply wells. Currently, there are four solvent leak sites that are actively under investigation in Napa County. Of these sites, three have initiated active soil or groundwater remediation and have made significant restoration progress.

5.D GROUNDWATER MANAGEMENT

Groundwater management refers to the need for coordinated planning between various water users that are extracting groundwater in Napa Valley. **The goal of this effort is to protect groundwater basins from overdraft with its associated detrimental effects to water quality.** Traditionally, Regional Boards have not had to address water supply management issues. Likewise, the State Water Board Water Rights Division does not enter into the arena of groundwater extraction. However, a comprehensive groundwater protection strategy must address the issue of water extraction impacts on water quality. In Napa County, the need for a management strategy has been formally recognized (RCD, 1994) and steps are being taken to bring water extractors together to reach consensus on future water development and protection. **Action items for groundwater management are:**

- **Facilitate Dialogue Between the Water User Community**

Chapter 3 describes the efforts of the Napa Water Education Coalition in accomplishing this action. This work of the Coalition should be continued with participation from all agencies, groundwater users, and interested members of the public. Although this dialogue must take place at the local level, Regional Board staff should stay informed of their progress and provide technical support if requested.

- **Determine safe yield of the groundwater basins**

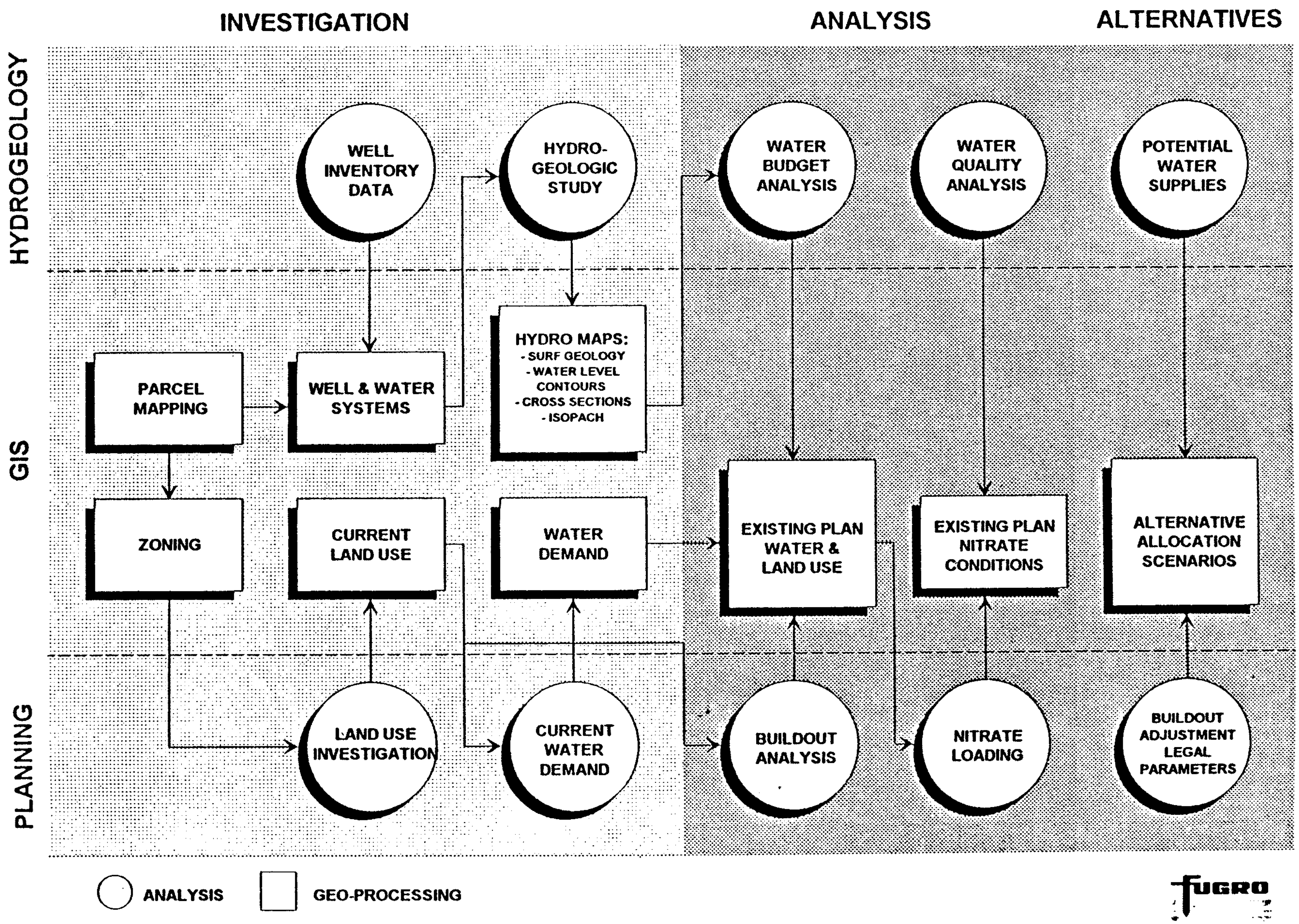
This component was recommended in the Napa River Owner's Manual. As discussed in Chapter 1, several background studies have been completed. However, a detailed investigation of aquifer yield is necessary in order to effectively evaluate both existing extraction and future planned extraction. Some areas are believed to be in a state of overdraft, while other areas are not fully utilized. The Water Coalition may be the organization that could sponsor this type of evaluation.

- **Develop a management strategy**

This component was a recommendation in the Napa River Owner's Manual. The specific suggestion was that interested parties should work together with the Regional Board to develop the strategy. In order to move ahead with this concept, the Regional Board submitted a grant proposal to the U.S. EPA in September 1995 for funding for this project, under section 106 of the Clean Water Act. If funded, Regional Board staff could work with the Napa Water Coalition, to move from consensus building phases to developing a groundwater management plan. If the Regional Board does not receive the grant funding, staff can monitor the progress of the Water Coalition meetings and participate in meetings as resources allow.

One vehicle, spelled out in Assembly Bill 3030, for developing management plans is beginning to be used around the State. DWR is tracking the statewide progress of groundwater basins that have gone ahead with this process. At the first workshop in May of 1995, examples were presented of other basins that have developed management plans. Figure 24, illustrates a flowchart that was utilized for developing plans in North County, Monterey (Fugro, 1995). The flowchart illustrates how planning, GIS, and hydrogeology are integrated into three phases: investigation, analysis, and alternatives. Utilizing the basic components from AB3030, as well as examples from other groundwater basins, could be used for developing a specific approach for Napa.

Figure 24 GROUND WATER MANAGEMENT APPROACH



5.E INFORMATION MANAGEMENT

The goal of information management is to efficiently manage and provide information to decision-makers. The actions are:

Data Management

The point coverages used in the GIS analysis (wells, septic systems, fuel sites) are all based on Regional Board database files. As these files are updated, they must be periodically transferred into the GIS. Because the GIS is becoming such a vital decision-making tool for the Regional Board, it is imperative that databases be maintained and updated. In addition, as was discussed in Chapter 4, the accuracy of many of the point locations needs to be improved.

The DEM maintains current listings, maps, and files on all of the sites within the County known to be or suspected of being contaminated with hazardous substances. The DEM keeps the name, address, and Assessor's parcel number of each affected site. The information is stored on a UNIX-based computer system. The DEM has a private contractor which does their programming for the UNIX system. As presently configured, the DEM does not interface with computer data files at the Regional Board. The Regional Board maintains some of the information on the fuel sites using the DOS-based LUSTIS database. This database was the source of the fuel site locations illustrated on Figure 19.

GIS Coordination

The purpose of GIS coordination is to:

- to make the best use of limited agencies' resources,
- to promote public awareness,
- to prevent redundancy (duplication of efforts), and
- integrate resource information directly into decision-making.

Several agencies are pursing GIS in Napa County. Some have already purchased equipment and have GIS staff (RCD), others plan on developing their capabilities in the very near future (City of Napa), and the remainder of agencies are keenly interested in developing a system, yet have no specific plans for moving ahead. As a direct result of this project, interested agencies have gotten together to develop a plan for a coordinated GIS for Napa County. The workshops and meetings that have lead up to this outcome were discussed in Chapter 4. The need for coordination stems from the large costs involved, as well as the fact that the needed information resides within a multitude of agencies. All the agencies are well aware of the problems that have arisen from failure to coordinate on hardware, software, and database design and are anxious to move forward.

system management. In addition, considerable staff time has been spent training and orienting new students. Consequently, we face a challenge to keep our GIS operational. Fortunately, many graduate student applicants have had some GIS training. However, few students have the ability to deal with the combination of hardware and software troubleshooting, project planning, data conversion, and GIS analysis.

In order to justify a permanent GIS staff person, the Regional Board should conduct an office-wide needs assessment and develop a GIS utilization plan. Although we have not accomplished this yet, we would recommend it to other Regional Boards. In conducting this assessment, the mapping needs of each Division should be identified. Management should weigh the enhanced efficiencies and cost savings from GIS. If cost savings can be demonstrated, then this may justify the need to hire GIS staff.

License Maintenance, and Technical Support Agreements

The hardware, software, and equipment for the Napa project were ultimately purchased by the State Board. As a result, all license, maintenance, and technical support agreements were in the State Board's name as well. Since the Regional Board was the user of these products, we encountered difficulties in resolving a number of software and hardware problems in a timely manner. Even though State Board project staff were immensely helpful in providing assistance at every step of the way, for practical reasons **it would be much more efficient for the Regional Board to hold all license and maintenance agreements.** This would ensure, for example, that all periodic manufacturer software revisions are sent directly the Regional Board. Also, when the Regional Board staff seek technical support, they can go directly to the manufacturer. In addition, if budgetary limitations at the State Board level preclude continuance of maintenance agreements or updates, the Regional Board may have the resources.

Equipment Delays

Delays in receiving computer equipment were major obstacles in getting our GIS up and running Delays were caused by purchasing and funds transfer procedures. For example, with the Napa project, a project workplan and budget (staff and equipment) had been approved by the State Board and U.S. EPA. Nonetheless, State and Regional Board staff were required to prepare a feasibility study report to justify the computer equipment purchase. This report then had to be approved by the Office of Information Technology before equipment could be purchased. It is our understanding that this system has been streamlined as GIS is no longer considered a 'new technology' and more Regional Boards have purchased both software and hardware. We encourage the State Board to continue to work in this direction.

As a result of the delays, the arrival of essential computer equipment for the Napa project did not coincide with the timeline for work tasks. During this time our State

Board project officer was very helpful in resolving problems. Many tasks had to be put off until equipment arrived. In the meantime, we used another Regional Board GIS on a part-time basis to get the project going in the second year. The lesson learned is that **considerable flexibility in project planning is necessary and that contingency plans are imperative.** Also, it is noteworthy that delays are much less likely now that Regional Boards can purchase equipment directly from vendors.

Obtaining Data

A GIS is only as good as the data it uses; unfortunately, sometimes it is difficult to acquire accurate data. **Project managers should scope data acquisition work with caution.** Both staff time and expenses can be hard to estimate in advance. Many times we found the sources for a particular data set to be inaccurate or were not traceable. In addition, many private sector companies charge a high price for the privilege of using their data. When an existing data set could not be obtained, or if the cost of that data was too high, a new data set was created. For example, this time intensive effort included digitizing maps and geocoding street addresses.

The use of existing GIS data sets can be hampered by compatibility problems. For example, when one file format, such as MapInfo, must be used by a different program, such as ArcInfo, the conversion may be time consuming, data integrity may be compromised, and the purchase of translation software may be necessary. In our case, the Napa project was initially developed on GRASS, and later transferred onto ArcInfo. This translation went smoothly thanks to the expertise of our GIS student, who wrote a number of specific translation programs for us.

On a positive note, more data is becoming available free of charge. The Regional Boards could benefit greatly by having access to the Internet, both to locate new sources of data and to transfer existing datasets. For example, key Napa project data from the USGS and NASA were downloaded free of charge off the Internet. Likewise, we have been able to make a number of our own GIS layers available to interested agencies. The Internet is extremely useful for transferring many large files which are typical for GIS.

Obtaining high quality data will always be a source of concern and frustration to GIS users. Regional Boards can minimize this frustration by creating an atmosphere in which data and metadata can be accurately stored and more easily exchanged with other Regional Boards and institutions. The importance of full documentation should continue to be emphasized.

Despite these challenges, Regional Board staff generally consider our GIS to be running quite smoothly. Through development and rigorous documentation of file conversion methods, the problem of file format incompatibility has mostly been resolved. The equipment ordered was of high quality, which has resulted in relatively few system breakdowns. In addition, the procurement process through the State Board is now much easier. Problems using the GIS are resolved rather

It is anticipated that in the future, the GIS coverages created during this project will become an integral part of decision-making by all the agencies participating in the development of a county-wide GIS.

5.F FUNDING

The Regional Board will continue to work on securing additional grant funds. As described previously, the Regional Board has submitted one proposal for additional funding in September 1995 to the U.S. EPA for developing a groundwater management study. Federal watershed protection grant dollars could be applicable to groundwater protection efforts as well. In addition, local agencies in Napa County could pursue Groundwater Protection Grant funds from the U.S. EPA. The Regional Board could assist interested agencies in preparing their proposals. In the past, grants of $30,000 to $75,000 have been awarded to local agencies.

6. FINDINGS: THE CHALLENGES OF GIS

The Regional Board's funding sources have been largely tied to groundwater restoration programs. Recently the U.S. EPA's groundwater program emphasizes that **there is a need to shift emphasis from restoration to protection efforts.** The Napa Groundwater Protection Strategy provides the State and Regional Boards with a prototype. One of U.S. EPA's (1991) groundwater protection principles is that "an effective groundwater protection program should link Federal, State, and local activities into a coherent and coordinated plan of action" (U.S. EPA, 1991). As an example of a coordinated plan of action, **the Napa Strategy has demonstrated the benefits of a cooperative approach between resource management agencies.** The continuation of cooperative efforts are crucial for the implementation of the Napa strategy.

The Napa Project has succeeded in showing that **GIS is an important and very useful decision-making tool** in developing a groundwater protection strategy. However, a GIS housed at the Regional Board offices is only part of the Napa Strategy. The most important decisions regarding groundwater protection take place at the local level. Ultimately, **it will be through the success of a locally-based GIS that the Napa Strategy will reach full implementation.** One outcome of the project was the formation of a local GIS work group which is working towards development of a county-wide GIS infrastructure.

Development of GIS at the Regional Board posed challenges, many of which we overcame. In documenting these challenges, our aim is to provide constructive comments that will enhance GIS development at both the local and state level. When this project was first conceived no other Region Boards had implemented GIS. Therefore some of the problems we encountered in part can be attributed to 'breaking new ground', and **we hope other Regional Boards will be able to learn from our mistakes and benefit from our achievements.** Our findings fall into three categories:

- in house staffing
- license, maintenance, and technical support agreements
- equipment delays
- obtaining good data

In House Staffing Issues

The Regional Board would benefit greatly from a full-time, staff member experienced in GIS to work with the system. While technical staff are fully capable, with proper training, of utilizing GIS, a well trained GIS support staff are needed to maintain, update, and oversee a GIS. Without the proper support staff, our experience is that GIS can become a burdensome exercise of troubleshooting. We have been fortunate to have competent, temporary students to setup and manage our system. The major drawback to this arrangement is the potential for gaps in quickly, once technical support representatives are contacted. At this time we only have a small number of GIS users. This keeps the strain on the system low, and consequently, we have encountered relatively few breakdowns of the system and minimal losses of data or deletion of important files.

At the close of the Napa project, our challenge, with limited staff and funds, will be to maintain the GIS, to continue to perform analysis, and to support local agencies who are developing GIS for the Napa River watershed.

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