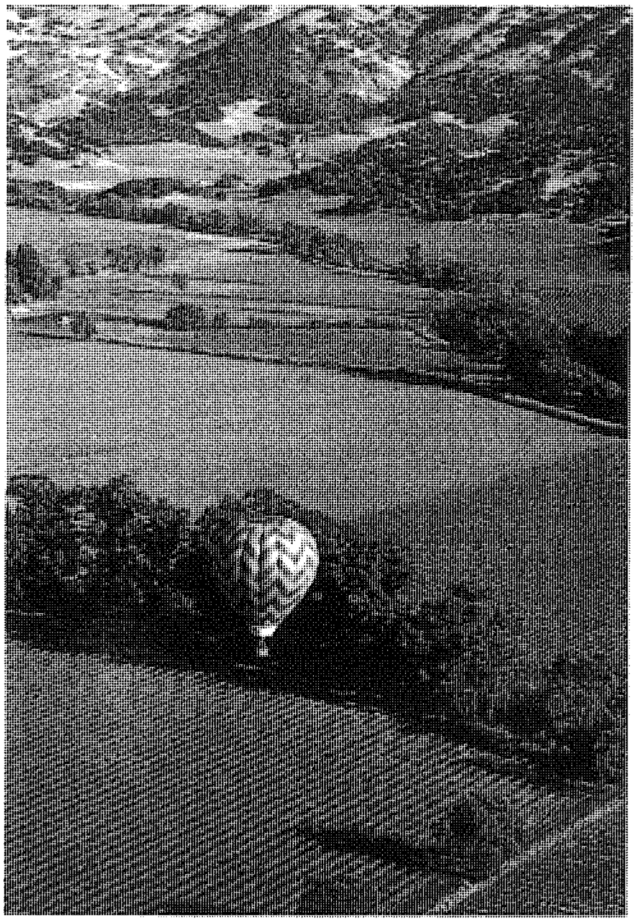

Napa County Flood Control and Water Conservation District

Water Resource Study for the Napa County Region

January 1991

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Consulting Engineers Inc.

Napa County Flood Control and Water Conservation District
WATER RESOURCE STUDY FOR THE NAPA COUNTY REGION

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Napa County Flood Control and Water Conservation District
WATER RESOURCE STUDY FOR THE NAPA COUNTY REGION

STUDY SUMMARY

STUDY OBJECTIVE

Provide an in-depth review of the water need/supply relationship for the County's five major municipal areas - American Canyon, City of Napa, Yountville, St. Helena, and Calistoga; rural areas; and agriculture. Based on this review, recommend a program for balancing water needs and supply.

STUDY SCOPE OF WORK

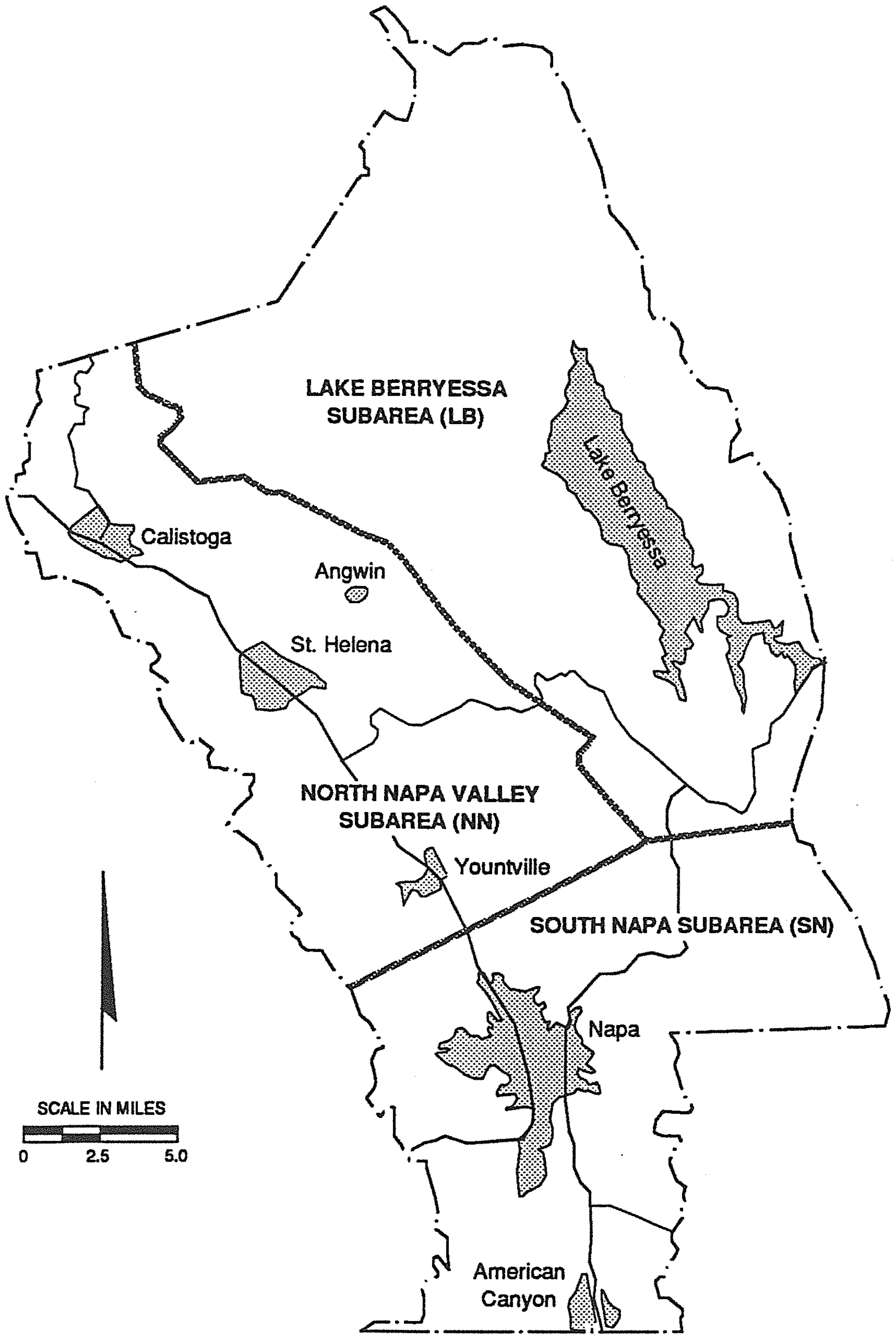
The scope of work contained in Agreement No. 2893-Contract for Engineering Services for Napa County Water Resources Study, approved by the County Board of Supervisors on February 27, 1990, can be summarized as follows:

- Analyze and characterize existing (1989) water use by principal user categories.
- Estimate future water needs to the year 2020 in five-year increments.
- Summarize water quality requirements of users and quality of supplies.
- Analyze the availability of existing water supplies, including groundwater, river diversion, local reservoirs, imported water, and reclamation.
- Discuss the water need/supply relationship and recommend a program for balancing water needs and supplies.

WATER NEEDS

Water use in Napa County primarily satisfies agricultural and municipal needs, with a small percentage of use by industry and rural areas. To facilitate balancing water needs and supplies, existing water use and future needs were established at several levels - by user; by subarea; and County-wide. Users include the five major municipal areas, rural (Angwin and remainder), and agricultural (vineyards and other). Three subareas were defined - North Napa Valley (NN); South Napa (SN); and Lake Berryessa (LB). The subareas and user groups are shown in Figure S-1, along with the water needs methodology.

An extensive data collection effort was undertaken in association with members of an Advisory Committee. The effort consisted of a review of general plans, master water supply plans, water management plans, and previous investigations; a review of agricultural water and land use practices; acquisition of historical water production and metered water sales



NAPA COUNTY MUNICIPALITIES AND SUBAREAS

RECENT HISTORICAL USE (1985-89)

HOW MUCH PER YEAR?

- Municipalities
  Production Records for:
  - American Canyon CWD
  - City of Napa
  - Town of Yountville
  - City of St. Helena
  - City of Calistoga
- Rural
  - Angwin Area: Production Records
  - Remainder: Estimate based on population x per capita use
- Agricultural
  - Vineyards
    - Irrigation requirements = 1987 DWR acreage x applied water based on region (Ac-Ft/Ac/Yr)
      - South Napa Subarea = 0.4
      - North Napa Valley Subarea = 0.5
      - Lake Berryessa Subarea = 0.6
    - Frost Protection = DWR acreage x 0.33 Ac-Ft/Ac/Yr
    - Heat Protection = DWR acreage x 0.17 Ac-Ft/Ac/Yr
  - Other Agriculture
    - Pasture - 4.0 Ac-Ft/Ac/Yr
    - Deciduous - 2.0 Ac-Ft/Ac/Yr
    - Truck Crops - 2.4 Ac-Ft/Ac/Yr
    - Grain - 1.2 Ac-Ft/Ac/Yr

UNIT WATER USE

CHARACTERISTICS?

- Variation in Use
- Unit Use
  - Per Capita
  - Per Acre
- Extent of Conservation

WILL CURRENT CHARACTERISTICS CONTINUE?

- Greater Density
- More Conservation
- Change in Industry
- Change in Crops
- System Improvements

FUTURE WATER NEED

How do local and regional planning entities envision future distribution of population and land use within Napa County?

- Reflection of Policies
- Regional Economy
- Land Capabilities

Municipalities

- Residential/Commercial/Public
  To year 2005, ABAG population projections x per capita use.
  To year 2020, California Department of Finance population projections x per capita use.
- Industrial
  General/Specific Land Use Plans for years 2000/10. Acreage of water use category x unit use (Ac-Ft/Ac/Yr)

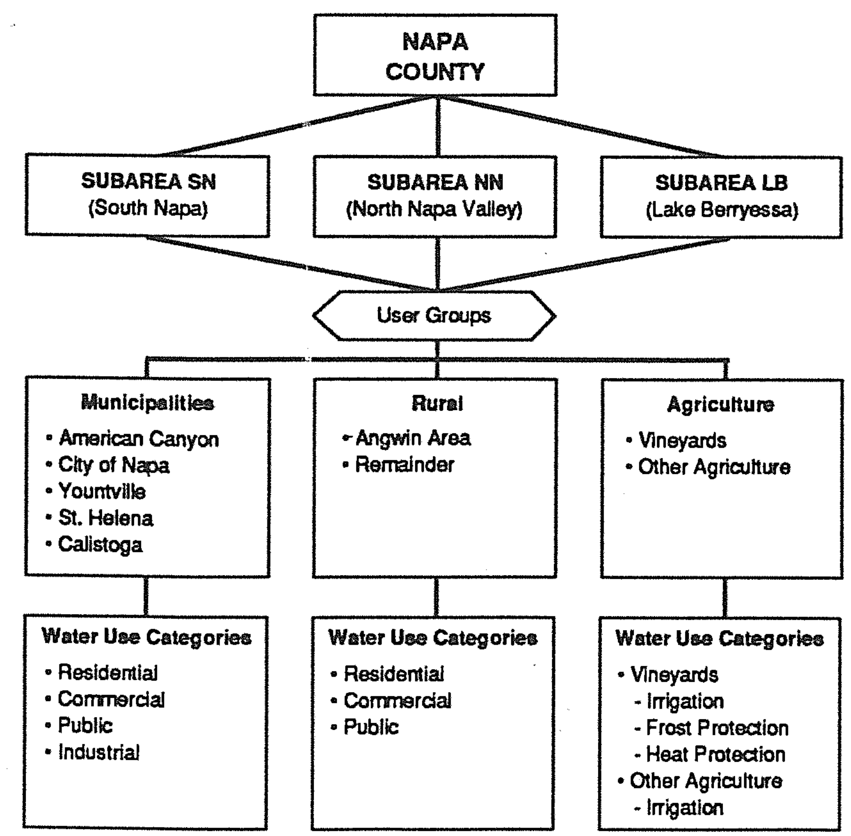
Rural

To year 2005, ABAG population projections x estimated per capita use.
To year 2020, California Department of Finance population projections x estimated per capita use.

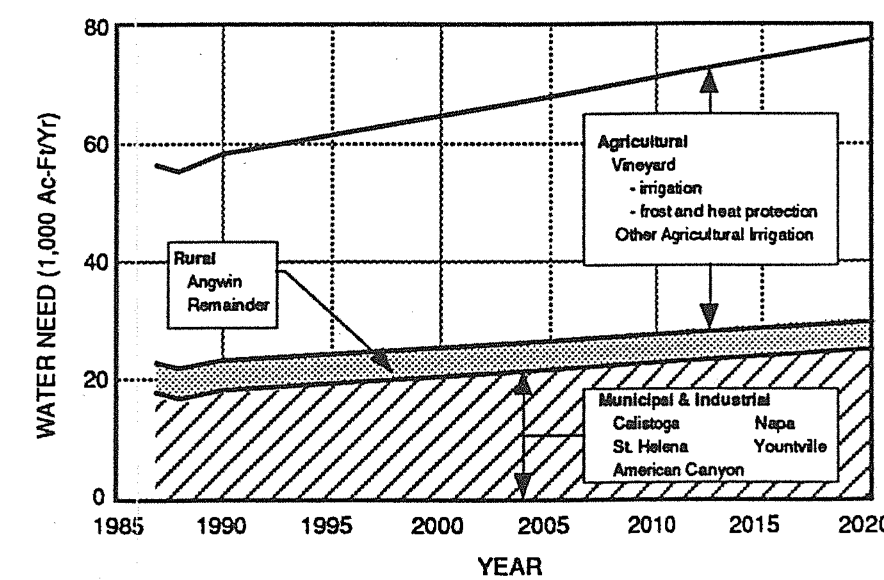
Agriculture

- Vineyards:
  In year 2020, 53,000 Ac (based on Agricultural Resource acreage of County General Plan) x applied water requirement for irrigation and frost and heat protection.
- Other Agriculture: Constant water demand.

WATER USE CALCULATIONS



WATER USER CLASSIFICATIONS



NAPA COUNTY WATER NEEDS

OVERVIEW OF WATER NEEDS METHODOLOGY

FIGURE S-1

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records; collection of historical and projected population data; acquisition of land use maps and data; and consultation with the County Agricultural Commissioner's Office, the U.C. Davis Cooperative Extension, the Farm Bureau, and the Napa County Planning Department. The type of data available was a key factor in establishing the water need methodology.

Future municipal and industrial water needs were based on per capita water consumption factors obtained from 1985-89 water production and sales data applied to population projections made by Napa County, the Association of Bay Area Governments (ABAG), and the California Department of Finance (CDOF). The industrial use component of the per capita factor was reviewed and separated where required to insure that the per capita estimate would be representative of future water use. The adopted per capita factors were also reviewed for extent of in-place conservation and impact of recent drought conditions. The seasonal variation of municipal and industrial water use was also established from the 1985-89 production data. The variation was required to perform operational runs for reservoir yield analyses.

Future rural water needs were based on an estimate of per capita use and population projections. Per capita use was obtained from Howell Mountain Mutual Water Company data and generally-available information for similar rural areas in northern California. The adopted values were 135 and 150 gallons per capita per day for the Angwin area and remainder of Napa County, respectively.

Since records of well pumping and stream diversion are not maintained for public use, an alternative "water duty" approach was utilized to estimate agricultural water needs. Agricultural water use practices have a unique requirement for vineyards, supplemental to vineyard irrigation, from the threat of severe frost and heat conditions. In this study, individual average annual water consumption factors were determined for frost and heat protection, 0.33 and 0.17 Acre-Feet per Acre per Year, respectively. These factors were then added to the irrigation-applied water requirement which varied from 0.4 to 0.6 Acre-Feet per Acre per Year depending upon location (climate), being highest in the warmer Lake Berryessa Subarea. Factors were also established for other irrigated use such as pasture, grain, deciduous, and truck crops. The future agricultural water need was obtained by applying the "water duty" to the acreage by specific crop.

Because of the uncertainty involved in making any projection of future water needs which are based on population and land use, a baseline water need projection and alternative demand scenarios were developed. These scenarios are based on per capita use factors, water duties, population, and land acreage shown in Table S-1. Key scenario conditions are summarized below.

TABLE S-1

NAPA COUNTY WATER NEEDS SCENARIO CHARACTERISTICS

Characteristics	Baseline Projection	Alternative Scenario 1	Alternative Scenario 2
PER CAPITA (gpcd)			
Calistoga	151	136	151
St. Helena	233	209	233
Yountville	223	201	223
Napa	179	161	179
American Canyon	164	148	164
Angwin	135	135	135
Remainder	150	150	150
VINEYARD WATER REQUIREMENTS (ac-ft/ac/yr) (1)			
Frost Protection	0.33	(2)	0.33
Heat Protection	0.17	(2)	0.17
IRRIGATED VINEYARD LAND USE ACREAGE (1)			
South Napa Subarea			
1990	8121	8121	8121
2005	10581	10581	13041
2020	13041	13041	13041
Napa Valley Subarea			
1990	22181	22181	22181
2005	26883	26883	26883
2020	31586	31586	31586
Lake Berryessa Subarea			
1990	2236	2236	2236
2005	3443	2236	5611
2020	4650	2236	8986
POPULATION			
Napa County			
1990	108900	108900	108900
2005	127350	127350	138900
2020	147500	147500	169900

(1) For Alternate Scenarios 1 and 2, the Other Irrigated Agriculture water requirements and land use acreage are the same as the Baseline Projection (see Table 3-2 and Figure 3-3). Vineyard irrigation requirements, also not shown, are not changed for the analysis of Alternative Scenarios 1 and 2 (see Table 3-2).

(2) Conversion from sprinkler systems to wind machines is assumed to occur linearly at a rate such that in the year 2020 sprinkler systems for frost and heat protection are used on 50 percent of the vineyard lands in the North Napa Valley and Lake Berryessa Subareas, with the remaining lands in these subareas utilizing wind machines and other alternatives.

- **Baseline Projection**

  - Per capita use for municipal areas based on the average consumption during the 1985-89 period. The per capita factor for this period of predominantly dry years reflects a conservation - oriented attitude (inherent conservation) deemed to be representative of future use.

  - Population projections from ABAG and CDOF.

  - "Water Duties" for crop irrigation and protection as discussed above.

  - Irrigated crop acreage from Napa County 1989-2005 General Plan Land Use Map, with area dedicated to Agricultural Resource fully developed as vineyards by year 2020 for South Napa and North Napa Valley Subareas, and 50 percent developed in the Lake Berryessa Subarea due to restricted water availability. Frost and heat protection not required for 50 percent of future vineyard lands in the North Napa Valley and Lake Berryessa Subareas due to hillside location.

- **Alternative Scenario 1**

  - Per capita use factors reduced by 10 percent from potential additional water conservation in the incorporated communities and American Canyon.

  - No further growth in current vineyard acreage in the Lake Berryessa Subarea due to limited water availability.

  - Wind machines will replace sprinkler systems for frost and heat protection in 50 percent of vineyards in the North Napa Valley and Lake Berryessa Subareas by year 2020.

- **Alternative Scenario 2**

  - A greater projected population than the ABAG and CDOF estimates based on the 1980-2000 growth rates used in the Napa County General Plan, assuming that the growth rates remain in effect until year 2020.

  - Due to potential rapid development of Carneros vineyards, the acreage designated as Agricultural Resource in the South Napa Subarea is assumed to be fully developed by year 2005, instead of year 2020.

The resultant total County water needs for these scenarios are shown in Figure S-2.

WATER QUALITY

User water quality requirements for municipalities (drinking water), industries, and vineyard irrigation, and quality of sources (local reservoirs, North Bay Aqueduct, Lake Berryessa, Napa River, and four groundwater basins) were summarized. Source quality issues were discussed based on a comparison of source quality parameters with user requirements. The parameters of concern are summarized below by user:

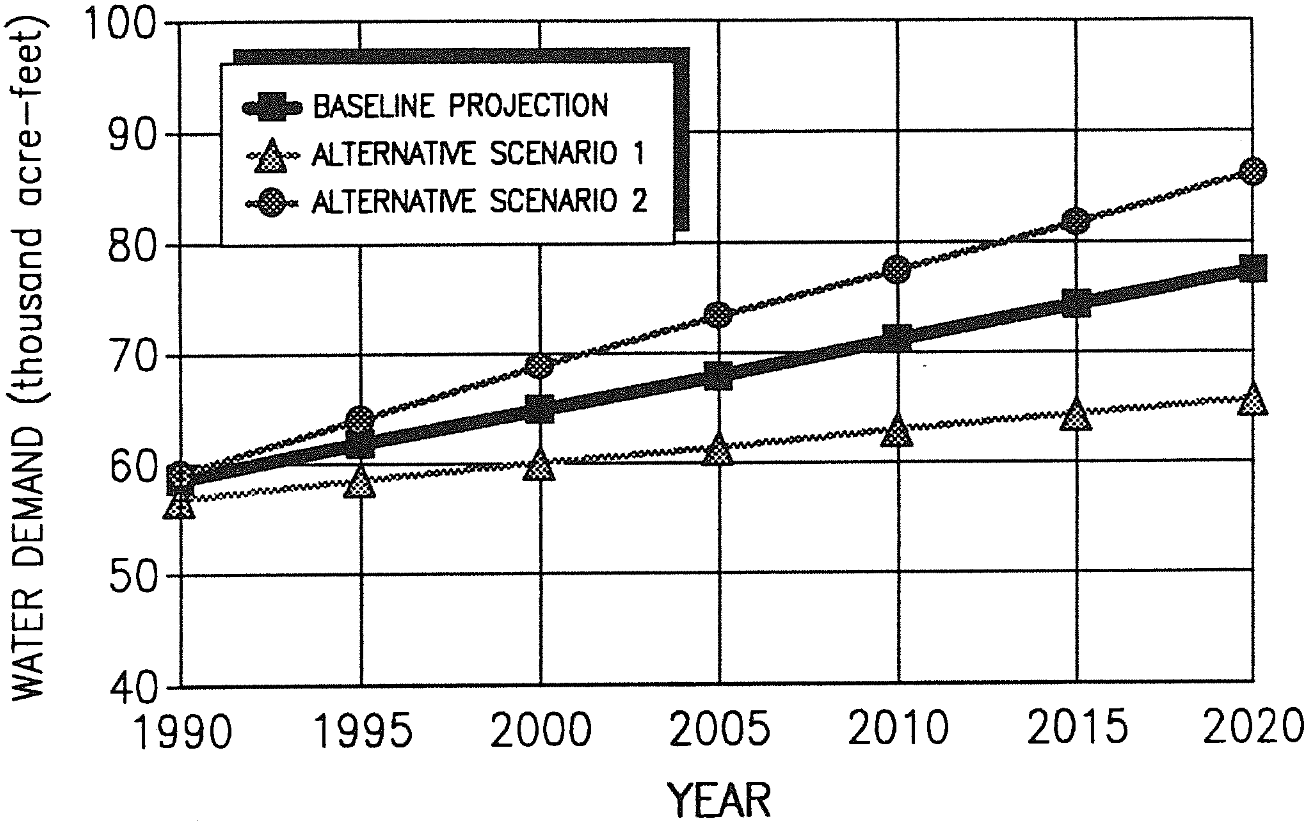
	User		
Water Quality Parameter	**Municipal**	**Industrial**	**Agricultural**
Turbidity	X		
Color			
Odor	X		
Iron and Manganese	X		
Hardness		X	
Nitrates	X		X
Total Dissolved Solids		X	X
Sodium	X		X
Chlorides			X
Boron			X

EXISTING WATER SUPPLIES

Napa County's agriculture, municipalities, and rural areas satisfy their current water needs from five supplies:

- Groundwater
- River Diversion
- Reservoirs
- Imported Water
- Reclamation

The quantity, its buildup (if any) with time, and availability (reliability) of these supplies were analyzed, with a focus of effort on estimating the safe yield of the main Napa (North Napa Valley) groundwater basin and the yield-frequency relationship for the five major municipal water supply reservoirs - Milliken, Rector, Hennessey, Bell Canyon, and Kimball. In the case of groundwater, where three additional basins were also reviewed (Milliken-Sarco-Tulucay, Carneros, and Lake Berryessa), the safe yield represents a long-range amount



TOTAL PROJECTED WATER NEEDS OF THE BASELINE PROJECTION AND ALTERNATIVE DEMAND SCENARIOS - NAPA COUNTY, CALIFORNIA

FIGURE S-2

of well pumpage that can be sustained by recharge, avoiding economic hardship (deep pumping) and water quality degradation. In the case of river diversion, the variation in flow from year to year and seasonally for the Napa River were related to the timing of water need for vineyard irrigation and frost and heat protection. For the major local reservoirs, the variation of inflow from their respective watersheds and variation of consumption played key roles in arriving at a yield-frequency relationship. For Lake Berryessa, the water rights and Napa-Solano negotiations were reviewed. For the North Bay Aqueduct (imported) water supply, contract buildup and potential drought cutbacks were summarized. And for reclamation, the plans by the Napa Sanitation District were reviewed.

The yield of existing water supplies resulting from the above analyses and reviews are as summarized in Table S-2.

BALANCING WATER NEEDS AND SUPPLIES

The study estimated the likely range of future water needs through development of a baseline projection and low- and high-demand alternative scenarios, and the availability of individual existing supplies - groundwater, river diversion, reservoirs, imported water, and reclamation. The relationship between year 1990 and 2020 water need and existing supplies was established by user, subarea, and for the County using the baseline water need projection and the following assumptions regarding supplies:

- **Groundwater.** Safe yield extraction rate.

- **River Diversion.** Napa River above Oak Knoll Ave - 10,000 Ac-Ft/Yr. Others - estimated.

- **Reservoirs.** Rector and Hennessey at firm yield (100 percent frequency) rate; Milliken, Bell Canyon, and Kimball at 80 percent frequency yield. Lake Berryessa-1,500 Ac-Ft/Yr based on existing agreement for lakeside use.

- **Imported Water.** North Bay Aqueduct maximum contract entitlement of 6,475 Ac-Ft/Yr in 1990 to 13,695 Ac-Ft/Yr in 2020, with the latter based on a reduced entitlement at 55 percent of the ultimate amount (State delivery capability with existing facilities).

- **Reclamation.** Current reclamation capacity of 200, 314, and 1,622 Ac-Ft/Yr for Calistoga, Yountville, and Napa Sanitation District, respectively.

From a review of the water need/supply relationship for Napa County water users, its three subareas, and the County as a whole, as shown in Table S-3 and Figure S-3, the following observations can be made:

TABLE S-2

YIELD OF EXISTING WATER SUPPLIES

Source	Safe or Firm Yield (Ac-Ft/Yr)	Based on Record Period
<u>Groundwater</u>		
North Napa Valley Basin	22,500	1962-89
Milliken-Sarco-Tulucay Basin	<5,400	---
Lake Berryessa Basin	< 400	---
Carneros Area Basin	< 300	---
Total Groundwater	**28,600 max**	**---**
<u>River Diversion</u>		
Napa River above Oak Knoll	10,000	1960-88
<u>Reservoirs</u>		
Major Municipal		
Milliken	400	1940-89
Rector	1,200	1940-89
Lake Hennessey	5,000	1940-89
Bell Canyon	480	1940-89
Kimball	110	1949-89
Subtotal Reservoirs	7,190	
Lake Berryessa	1,500	---
<u>Imported Water (North Bay Aqueduct)</u>		
Maximum - 1990	6,745	---
- 2020	24,900	---
Minimum - 1990	5,060	---
- 2020	13,695	---
<u>Reclamation</u>		
Minimum	3,103	---
Maximum	5,943	---

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TABLE S-3
NAPA COUNTY WATER NEED/SUPPLY RELATIONSHIP

	Baseline Water Need (Ac-Ft/Yr)							Safe/Firm Yield from Existing Water Supplies: Ground-Water	River Diversion		Reservoirs			Imported (NBA)		Recla-mation	Total		Supply-Need (Ac-Ft/Yr)	
Water User	1990	1995	2000	2005	2010	2015	2020		Napa	Others	Muni-cipal	Berryessa	Misc.	1990	2020		1990	2020	1990	2020
North Napa Valley (NN) Subarea																				
Muncipal & Industrial (M&I) Calistoga	990	1060	1190	1340	1405	1460	1515	75	0	0	400	NA	0	272	275	200	947	950	-43	-565
St. Helena	1935	2195	2275	2380	2495	2595	2690	0	0	0	1200	NA	0	0	0	0	1100	1200	-835	-1490
Yountville	450	490	515	540	570	595	625	0	0	0	325	NA	0	272	275	0	597	600	147	-25
Subtotal M&I	3375	3745	3980	4260	4470	4650	4830	75	0	0	1925	0	0	544	550	200	2744	2747	-631	-2083
Rural(1)	2438	2506	2623	2745	2882	2996	3111	*	*	*	875	NA	*	NA	NA	0	—	—	—	—
								22500*	10,000*								35175	35175	9762	2034
Agricultural-Vineyard	22181	23356	24532	25708	26883	28059	29235													
Agricultural-Other	797	797	797	797	797	797	797													
Agricultural-Total	22978	24153	25329	26505	27680	28856	30032	*	*	*	1500**	NA	*	NA	NA	300	—	—	—	—
Total for Subarea NN	**28791**	**30404**	**31932**	**33510**	**35032**	**36502**	**37973**	**22575**	**10000**	**0**	**4300**	**0**	**0**	**544**	**550**	**500**	**37919**	**37922**	**9128**	**-51**
South Napa (SN) Subarea																				
Municipal & Industrial (M&I) City of Napa	13825	14675	15305	15685	16625	17410	18195	0	0	0	6150	NA	NA	4000	10285	0	10150	16435	-3675	-1760
American Canyon	1591	1721	1846	2031	2136	2226	2316	0	0	0	NA	NA	NA	2200	2860	0	2200	2860	609	544
Subtotal M&I	15416	16396	17151	17716	18761	19636	20511	0	0	0	6150	0	0	6200	13145	0	12350	19295	-3066	-1216
Rural	1705	1732	1811	1903	2017	2112	2207	*	*	*	NA	NA	*	NA	NA	0	—	—	—	—
								5700*	1000**	500**			500**				9300	9300	841	-1629
Arigcultural-Vineyard	3248	3576	3904	4232	4560	4888	5216													
Agricultural-Other	3506	3506	3506	3506	3506	3506	3506													
Agricultural-Total	6754	7082	7410	7738	8066	8394	8722	*	*	*	NA	NA	*	NA	NA	1600	—	—	—	—
Total for Subarea SN	**23875**	**25210**	**26372**	**27357**	**28844**	**30142**	**31440**	**5700**	**1000**	**500**	**6150**	**0**	**500**	**6200**	**13145**	**1600**	**21650**	**28595**	**-2225**	**-2845**
Lake Berryessa (LB) Subarea																				
Municipal & Industrial (M&I)	0	0	0	0	0	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—
Rural	95	96	101	106	112	117	123	*	NA	*	NA	*	*	NA	NA	0	—	—	—	—
								400*		100*		1500*	250*				2250	2250	-3664	-5744
Agricultural-Vineyard	2460	2802	3144	3486	3828	4170	4512													
Agricultural-Other	3359	3359	3359	3359	3359	3359	3359													
Agricultural-Total	5819	6161	6503	6845	7187	7529	7871	*	NA	*	NA	0	*	NA	NA	0	—	—	—	—
Total for Subarea LB	**5914**	**6257**	**6604**	**6951**	**7299**	**7646**	**7994**	**400**	**0**	**100**	**0**	**1500**	**250**	**0**	**0**	**0**	**2250**	**2250**	**-3664**	**-5744**
Total All Subareas	**58580**	**61871**	**64908**	**67818**	**71175**	**74290**	**77407**	**28675**	**11000**	**600**	**10450**	**1500**	**750**	**6744**	**13695**	**2100**	**61819**	**68770**	**3239**	**-8637**

NOTES: * Supply available to rural and agricultural, combined - ** Assumed (no detailed information available) - NA - Not available to user - (1) Includes Veterans Home at Yountville.

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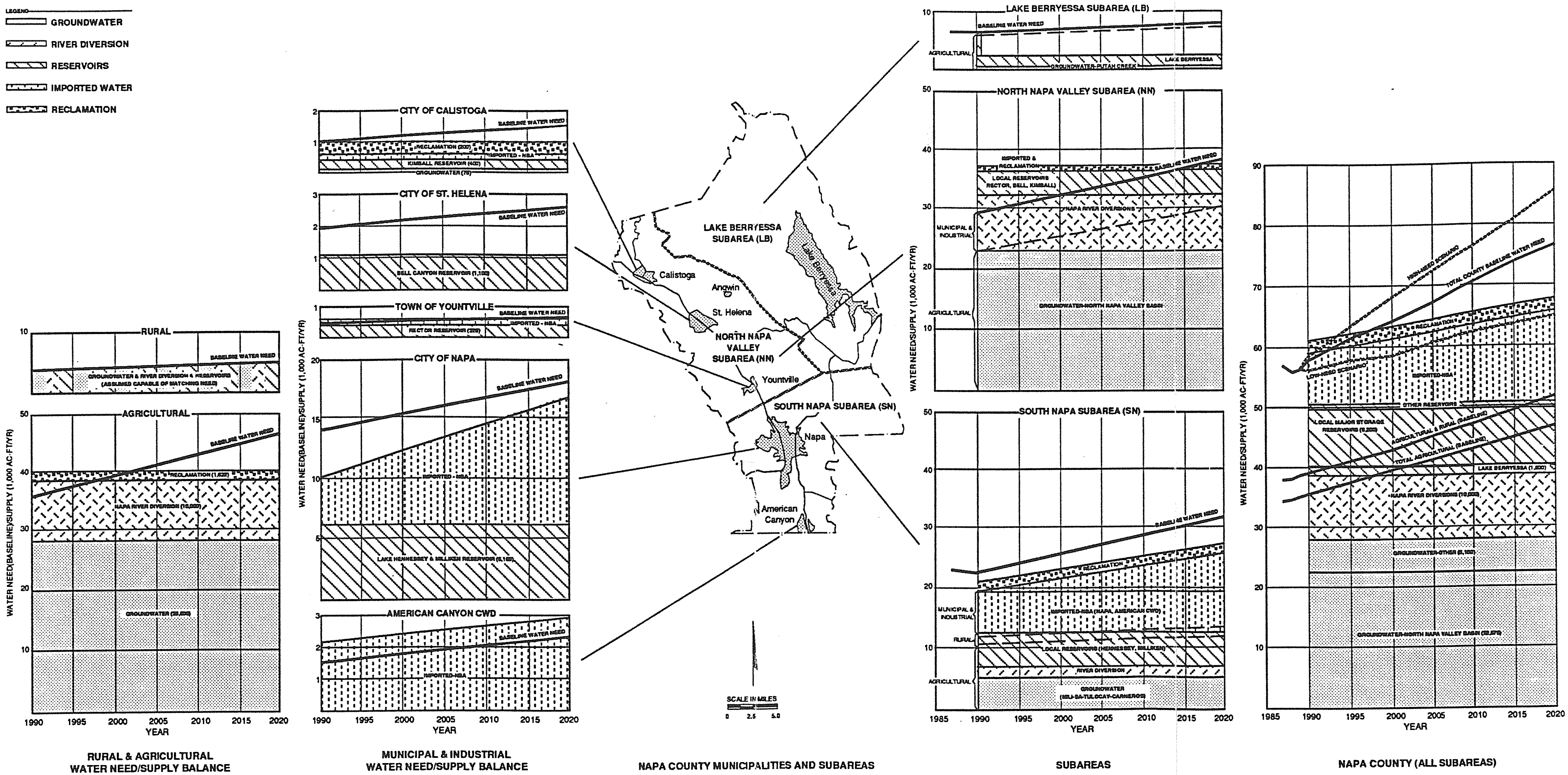

WATER NEED/ SUPPLY RELATIONSHIPS

FIGURE S-3

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User Group	Adequacy of Existing Supplies 1990	Adequacy of Existing Supplies 2020
Individual User:		
Municipal and Industrial		
City of Calistoga	Barely Adequate	Inadequate
City of St. Helena	Inadequate	Inadequate
Town of Yountville	Adequate	Barely Adequate
City of Napa	Inadequate	Inadequate
American Canyon CWD	Adequate	Adequate
Rural	Probably Adequate	Probably Adequate
Agricultural	Adequate	Inadequate
Subareas:		
Lake Berryessa (LB)	Adequate*	Inadequate
North Napa Valley (NN)	Adequate	Inadequate
South Napa (SN)	Inadequate	Inadequate
Napa County:	Adequate	Inadequate

* Due to the SWRCB depletion reservation for the Putah Creek area, the right to develop any water supply has been available.

Certain water management issues were addressed in balancing the County's water needs and supplies, as summarized below:

- What is a realistic short-term drought-period cutback in the future water need?
- Can groundwater serve as a potential alternate supply to municipalities, especially during drought periods?
- Have river diversions been maximized through the development of storage?
- Are local municipal reservoirs developed such as to derive the maximum yield from tributary watersheds?
- What supply should be anticipated from Lake Berryessa and who would it serve?

- What can be done about firming up the North Bay Aqueduct supply?
- Can any additional in-County water transfers be implemented?
- What supplemental water supplies might be considered?

Incremental water supplies available from these water management measures are summarized in Table S-4.

WATER MANAGEMENT PLAN

Based upon the water need/supply balance (surplus or deficit for 1990 and 2020,) as shown in Table S-3, and the incremental supply available from alternative water management measures, as shown in Table S-4, it is recommended that the Napa County Water Management Plan consist of the following elements (See summary in Figure S-4):

- <u>Public Information Element.</u> Develop, maintain, and distribute information to County water users regarding:

  - the source of the County's water supplies.
  - current hydrologic conditions in the County and those pertinent to its imported supply.
  - status of State's efforts to meet its North Bay Aqueduct contract entitlements.
  - status of municipal, industrial, and agricultural water conservation efforts.
  - status of wastewater reclamation efforts.

  Consideration should be given to establishing a water deficiency (drought) index that would trigger certain actions to restrain water use and preserve or enhance supplies through transfers or short-term supplemental supplies.

- <u>Water Need Element.</u> At five-year intervals, update the County-wide water needs analysis to track the baseline water use. In addition, encourage discussion on optimum beneficial use; compliance by municipalities with the conservation commitments contained in their urban water management plans and introduction of incentives for water conservation; the use of advanced water-saving vineyard development and irrigation methods; and facilitate increased wastewater reclamation by identifying potential users.

TABLE S-4
INCREMENTAL SUPPLY FROM WATER MANAGEMENT MEASURES

Water Management Measure	Incremental Supply (Ac-Ft/Yr) 1990	2020
Drought-Period Water Use Cutback (25%)		
Calistoga	248	379
St. Helena	484	672
Yountville	112	156
City of Napa	3,456	4,549
American Canyon	398	579
Rural (Total)	947	1,245
Agricultural (Total)	8,888	11,656
Total	14,533	19,236
Groundwater as Municipal Supply		
Calistoga	---	---
St. Helena	---	---
Yountville	---	---
City of Napa	---	---
American Canyon	Not Available	
Total	9,776	2,048
Maximizing River Diversions		
Napa River above Oak Knoll Avenue	---	
Other Streams	---	
Total	5,000	
Maximizing Municipal Reservoir Yield		
Milliken (20-ft dam height increase)	600	
Rector	Minimal	
Lake Hennessey (15-ft dam height increase)	1,500	
Bell Canyon (20-ft dam height increase)	700	
Kimball (40-ft dam height increase)	500	
Total	3,300	
Lake Berryessa Supply	Indeterminate	
Firming Up North Bay Aqueduct Supply (45%)		
Calistoga	0	225
Yountville	0	225
City of Napa	0	8,415
American Canyon	0	2,340
Total	0	11,205

TABLE S-4
INCREMENTAL SUPPLY FROM WATER MANAGEMENT MEASURES
(CONTINUED)

Water Management Measure	Incremental Supply (Ac-Ft/Yr) 1990	2020
In-County Water Transfers		
American Canyon NBA Entitlement	610	546
North Napa Valley Groundwater	9,776	2,048
Total	10,386	2,594
Additional Wastewater Reclamation		
Napa Sanitation District	4,321	
Calistoga	200	
St. Helena	500	
Yountville	100	
Total	5,121	
New Supplemental Water Supplies		
Local Storage Reservoirs		
Napa River, Off-stream	10,000	
Others	1,000	
Imported		
Central Valley Project	10,000	
Total	21,000	

PUBLIC INFORMATION ELEMENT

Develop, maintain, and distribute information regarding the water resources of Napa County:

- ☐ Supplies - groundwater, river diversion, local reservoir storage, imported water, wastewater reclamation.
- ☐ Current Hydrologic Conditions - Drought Index
- ☐ Status of North Bay Aqueduct Entitlements
- ☐ Status of Water Conservation Efforts
- ☐ Status of Wastewater Reclamation Efforts

WATER NEED ELEMENT

Update County-wide water needs analysis periodically and encourage the continuation of existing and implementation of additional water conservation measures.

- ☐ At five-year intervals update baseline water needs estimate and alternative demand scenarios.
- ☐ Analyze optimum beneficial use of stored, imported, and groundwater.
- ☐ Encourage compliance with State-mandated urban water management plan commitments on water conservation.
- ☐ Encourage implementation of incentives to promote conservation with a focus on urban turf and landscaping.
- ☐ Encourage agriculture to use advanced vineyard layout and water-saving methods such as moisture tracking and drip irrigation.

WATER SUPPLY ELEMENT

Take the lead role in making arrangements and pursuing opportunities in resolving the County's near-term and long-term water need-supply imbalances

NEAR TERM ACTIONS (Next Five Years)

- ☐ Develop an automatic drought action triggering mechanism (drought index) that would signal a staged program to restrain water use and enhance supplies.
- ☐ Inventory wells or well sites which could be used to supplement municipal water supplies during droughts.
- ☐ Inventory non-municipal water storage capacity along the Napa River to establish diversion capability. Review and summarize existing Napa River diversion water rights.
- ☐ Confirm potential transfers among North Bay Aqueduct contractors within the County.
- ☐ Negotiate multi-year agreement with water surplus-agency to supplement NorthBay Aqueduct entitlement through 1995.
- ☐ Summarize and update the cost of potential existing municipal reservoir enlargements previously studied.

LONG-TERM ACTIONS

- ☐ Sponsor additional investigation of County's smaller groundwater basins to refine yield estimate.
- ☐ Track exploration of new wells by municipalities and wineries.
- ☐ Insure that County use permits demonstrate the adequacy of water supply and retain drainage on site to encourage groundwater recharge.
- ☐ Negotiate with Solano County to resolve Lake Berryessa water allocation.
- ☐ Serve as lead agency in firming up the North Bay Aqueduct supply through a long-term contract with surplus water-agency and extension of supplemental Central Valley Project water into Napa County. Review North Bay Aqueduct conveyance capacity and feasibility of additional terminal storage.
- ☐ Encourage the implementation of wastewater reclamation by the Napa Sanitation District for turf irrigation in the south-Napa and American Canyon area.
- ☐ Review offstream storage potential if unused Napa River flows are available.
- ☐ Investigate the advantages of conversion of the Flood Control and Water Conservation District into a County Water Agency.

NAPA COUNTY
WATER MANAGEMENT PLAN

FIGURE S-4

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- Water Supply Element. Based on the Water Resource Study, the following guidelines are offered to the District in resolving near-term and short-term imbalances between County water needs and supplies:

  - Water conservation has a very significant impact on getting through drought periods.

  - Adequate groundwater reserve is available in the North Napa Valley Basin for short-term municipal use during drought periods.

  - Off-stream storage is the key to Napa River diversion capability. The total current storage capacity is not well documented.

  - Some opportunities exist for near-term transfers of water among the County's North Bay Aqueduct contractors.

  - Near-term, multi-year arrangements for water are needed to supplement the County's current North Bay Aqueduct entitlements.

  - There are opportunities at Kimball, Bell Canyon, and Milliken to enhance the existing water supply by dam enlargement, although such enlargements would be very costly.

  As far as future activities with regard to water supply, it is recommended that the District consider the following:

  - refine the safe yield estimates of the smaller groundwater basins (Milliken-Sarco-Tulucay, Pipe/Capell Valleys, and the Carneros area.

  - track exploration for new wells by municipalities and wineries.

  - undertake an inventory of non-municipal storage facilities with special emphasis on Napa River diverters, using a follow-up on the winery questionnaire conducted during the current study. Summarize riparian and appropriative river water rights. Review offstream storage potential if unused Napa River flows are available.

  - for County development use permits, insure that drainage is retained on site to encourage groundwater recharge, and that adequacy of the water supply is fully demonstrated.

- negotiate with Solano County for allocation of the Lake Berryessa water rights considering the needs and supplies of the Lake Berryessa Subarea as discussed in this study.

- serve as the lead agency in firming up the North Bay Aqueduct supply so that full entitlement will be available.

- encourage the implementation of Napa Sanitation/American Canyon Water District's reclamation plans at the joint Soscol Wastewater Plant.

- investigate the advantages of conversion of the District into a county water agency as water supply consumes an ever-increasing share of the District's activities.

SECTION 1

STUDY OBJECTIVE AND SCOPE

As the existing water supplies of Napa County reach full utilization, and the water needs of the County's municipalities and agriculture continue to go up, formulating practical solutions to the water needs - supply balance is best achieved by a regional, County-wide review of longer-range water needs and alternative water management strategies. Napa County Flood Control and Water Conservation District (County) has evolved as the sponsor of the study since it is the prime regional contractor for supplemental water from the State via the North Bay Aqueduct. Further, the County is the negotiating agency for Solano Project (Lake Berryessa) water, and is the logical requestor of potential uncommitted Central Valley Project (CVP) from the Bureau of Reclamation.

Specifically, the objective of this study is to provide an in-depth review and future projection of water demands and supplies for all of Napa County, with incremental 5-year projections between the years 1990 and 2020 for municipal, industrial, and agricultural users. Although numerous studies have been conducted over the years on various aspects of water needs and supplies, the last comprehensive, County-wide assessment was conducted nearly 30 years ago.

The scope of work of Agreement #2893 - Contract for Engineering Services for Napa County Water Resources Study, approved by the County Board of Supervisors on February 27, 1990, consists of the following series of tasks:

Task	Description
1	Summarize Existing Water Use
2	Characterize Existing Water Use
3	Estimate Water Needs to Year 2020
4	Summarize Existing County Water Supplies
5	Analyze Demand - Supply Relationship
7	Discuss Plans for Supplemental Water Sources
8	Recommend a Program for Balancing Water Needs and Supply
9	Meetings and Reports

Section 1

Study Objective and Scope

Report Section	Title	Task Covered
2	Description of Study Area	----
3	Water Needs	1,2,3,4
4	Existing Water Supplies	5
5	Water Quality	4,5
6	Balancing Water Needs and Supplies	6,7,8

In order to coordinate the study work with the County's primary water users, an Advisory Committee was formed, consisting of the following:

- City of Calistoga
- American Canyon County Water District
- City of Napa
- City of St. Helena
- Town of Yountville
- County of Napa
- Farm Bureau
- Vintners Association
- United Napa Valley Associates/Sierra Club

The input of Advisory Committee members is hereby acknowledged.

SECTION 2

DESCRIPTION OF STUDY AREA

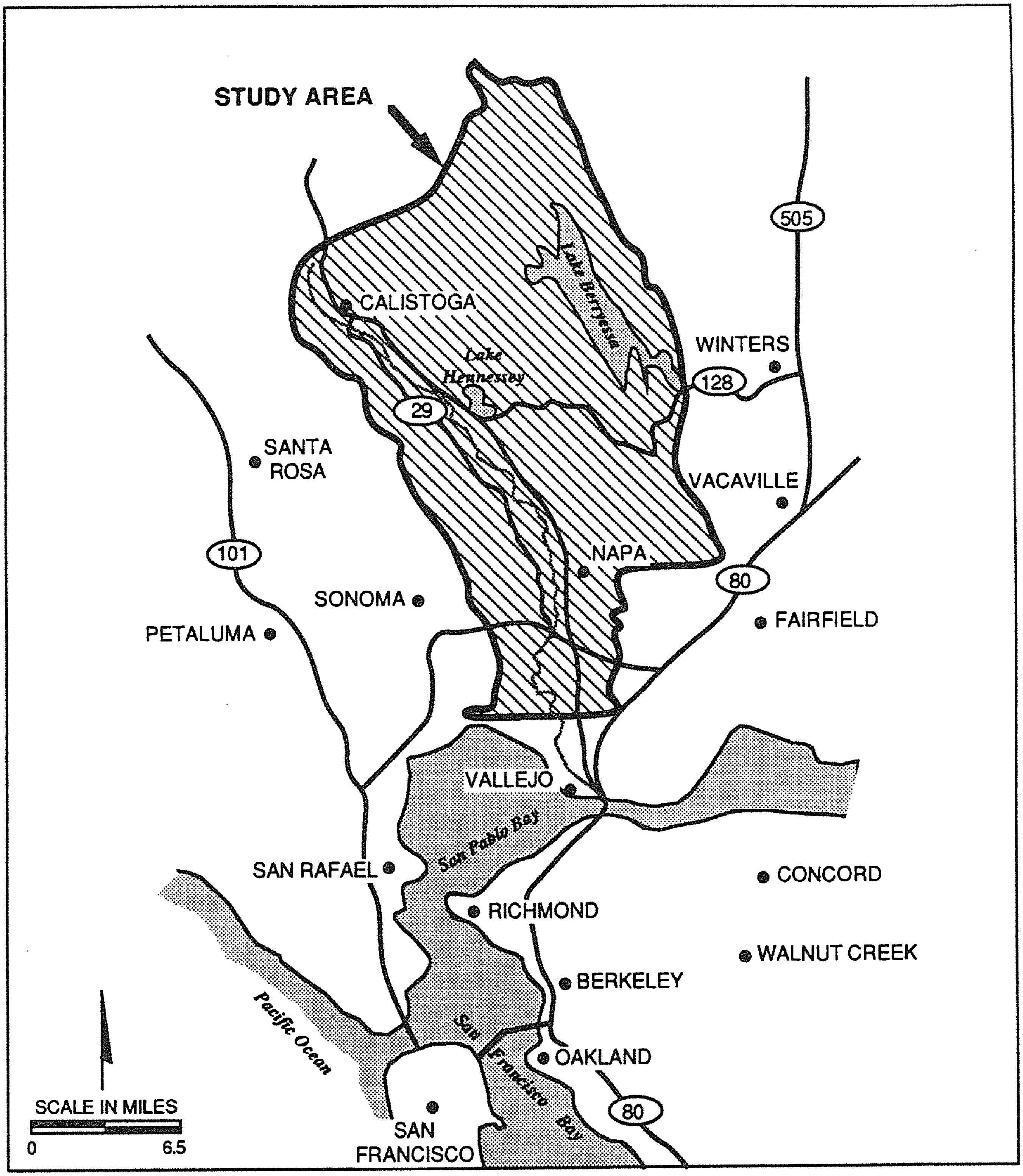
Napa Valley, the key, most well-known portion of Napa County, extends about 35 miles in a gentle northwesterly arc from the shores of San Pablo Bay to the hills above Calistoga, culminating in 4,000 foot-high Mount St. Helena. At the foot of the valley lies the City of Napa; to the southwest, the Carneros region; and to the southeast, the American Canyon area. The valley is surrounded on both sides by mountains, with the Mayacamas on the west side separating Napa from Sonoma County. Beyond the eastside hills lie a series of smaller valleys from Pope Valley in the north to Wooden Valley in the south. Further east lies the large man-made reservoir, Lake Berryessa. (See Figure 2-1 for study area location.)

Napa County is now recognized world-wide for its premium wines and as a popular tour goal based on its scenic vineyards and wineries. It is the Napa Valley floor, between Highway 29 and the Silverado Trail, that dominates as vineyard area, with, however, more and more hillside plantings in recent years. Napa Valley's towns of Napa, Yountville, Oakville, Rutherford, St. Helena, and Calistoga are well known as a result of the valley's wine reputation, with the latter town further recognized as a health resort with natural hot-water geysers, mineral springs and mineralized mud baths. The climate of the valley varies from the cooler, Bay-influenced southern portion such as the Carneros area, to the hotter northern end at Calistoga. The valleys to the east and Lake Berryessa are still hotter. At the southeast end of the County lies the unincorporated community of American Canyon, located adjacent to the City of Vallejo on the border of Napa and Solano Counties.

The County has long recognized the importance of maintaining vineyard land, creating in 1968 the agricultural preserve designation. It is the proper balance between requirements for resource preservation and urban development needs of the County that has occupied many general plan formulations and updates. With 1.5 million County visitors a year and approximately 240 wineries in business or in the approval state, concern about traffic and water recently resulted in new County regulations imposing strict limits on the size and scope of winery expansions and public events. At the southern end of the County, 3,000 acres have been set aside for commercial development including manufacturing, distribution warehouses and office space. Recent announcements indicate a growing commercial and industrial zone. The County and its towns are generally governed by population growth goals, with the greatest urbanization currently taking place in the American Canyon area due to its proximity to Highway 80, the booming city of Vallejo and the recently-relocated Marine World.

For purposes of this study, Napa County has been divided into three subareas:

- North Napa Valley (NN)
- South Napa (SN)
- Lake Berryessa (LB)



STUDY AREA LOCATION

FIGURE 2-1

These subareas were established to facilitate development of the water need and supply balance. For example, the NN Subarea, covering the main Napa Valley north of Oak Knoll Avenue, just outside of the City of Napa, was used by the U.S. Geological Survey in its 1973 groundwater model. The subarea's groundwater basin and the Napa River, which is the main stream within the area, provide a dominant water supply for subarea agriculture. In the case of the Lake Berryessa Subarea, the lake's watershed is the basis of water right reservations associated with construction of Lake Berryessa.

Within each subarea, water needs by user group (agriculture, municipal and industrial, and rural) and appropriate supplies will be brought into balance, to the greatest extent possible, before inter-subarea water transfers are considered.

SECTION 3

WATER NEEDS

Water use in Napa County primarily satisfies agricultural and municipal needs, with a small percentage of use by industry and rural areas. The purpose of this section is to present existing water use (1989) and projections of future water needs to the year 2020 for Napa County. The uses are separated into four primary categories:

- Municipal and Industrial
- Rural
- Vineyard
- Other Irrigated Agriculture

Municipal and industrial users rely primarily on local reservoirs and the North Bay Aqueduct, with a small percentage of supply coming from groundwater. Groundwater pumping and diversions from the Napa River and its tributaries, as well as numerous streams and creeks in the Lake Berryessa watershed, supply water to the other three user categories.

The remainder of this section is organized as follows:

- **Data Collection**. This section discusses the data collection effort conducted for the water needs analysis.

- **Methodology**. This section provides a description of how existing water use and future water needs are estimated for this report.

- **Analysis of Existing (1989) Water Use**. This section presents the existing water needs (1989) for the four major water use categories. The characteristics of water use are also presented for each group; this provides the basis for projecting future water needs, and conducting operations studies of supply sources

- **Future Water Needs**. This section presents estimates of water needs projected to the year 2020. Projections are made in five-year increments according to the water user groups mentioned above. In addition, alternative scenarios are considered which provide a range of likely water needs, accounting for potential variations in the adopted water use characteristics, population growth, and land use development.

DATA COLLECTION

An extensive effort was made to collect data pertaining to water use practices and requirements, population projections, and existing and future land use plans, all of which are desirable for a water needs evaluation. The data collection effort consisted of: a review of general plans, master water supply plans, water management plans, and previous investigations; a review of agricultural water and land use practices; acquisition of historical water production records and metered water sales records; collection of historical and projected population data; acquisition of land use maps and data; and consultation with the Agricultural Commissioner's Office, the U.C Davis Cooperative Extension, the Farm Bureau, the Napa County Planning Department and the Advisory Committee, a panel consisting of experts in the areas of water and land use in Napa County.

As is common with these types of studies, the available data is not as complete as would be desired and it is not always in a consistent format. From inspection of the database, the following observations were made:

- Historical water production data for the City of Calistoga, the City of St. Helena, the City of Napa, the Town of Yountville, and American Canyon area are available. Recent data for the community of Angwin is not readily available;

- Metered water sales records are not readily available for the entire historical period 1985 through 1989, nor for all the communities; this is a reflection of the water rate structure of the communities;

- Industrial water use supplied by municipal sources is available for some communities, however historical information is limited and the format is not consistent from area to area. Production of water from private sources for industrial uses is not readily available; some information is reported in investigations conducted by the California Department of Water Resources (DWR);

- Very limited data is available for water use by customers served by small water purveyors or water use by rural users on private wells for the historical period 1985 through 1989;

- No measurements of groundwater pumping or surface water diversions for crop irrigation are readily available for the historical period 1985 through 1989;

- Historical and projected population data is available for Napa County from the California Department of Finance (CDOF) for 1985 through 2020. The Association of Bay Area Governments (ABAG) publishes population projections for Napa County, the incorporated areas, and the American Canyon area for 1985 through 2005;

- Existing land use maps/data (1989) for Napa County and for the communities have not been compiled recently. General Plan land use maps are available;

- Detailed land use maps and land use acreage are available from DWR Land Use Study #88-62. This study, completed in 1988, delineates existing land use (1987) for Napa County on U.S. Geological Survey (USGS) quadrangles; land use is divided into 26 groups -- ten agricultural classifications, six native classifications, six urban classifications, and four recreational classifications. Corresponding acreage for each quadrangle and classifications are also available.

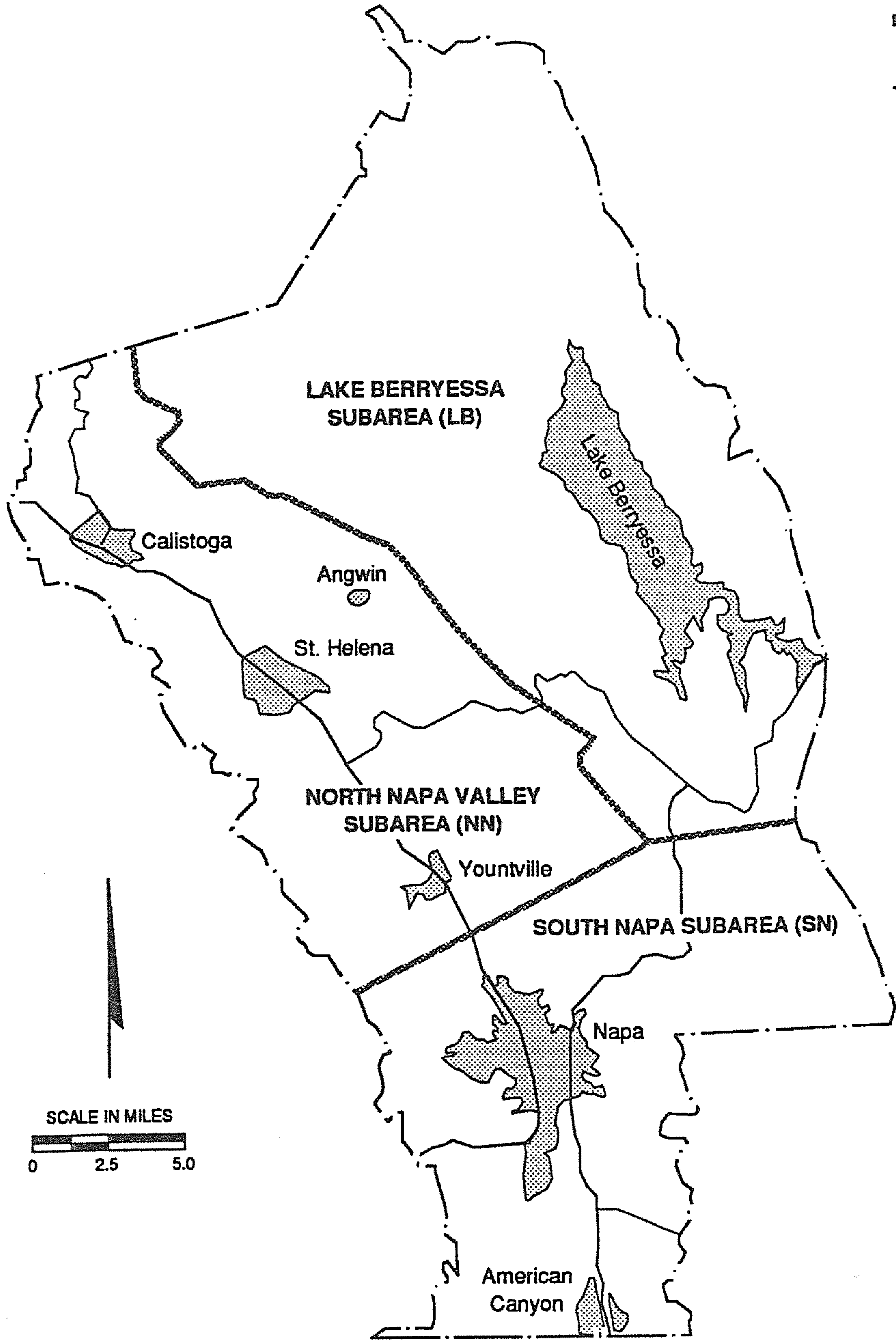
METHODOLOGY

To determine existing and future water needs in Napa County, unit water consumption was analyzed or developed by user group, as discussed below. See Figure 3-1 for an overview of the water needs methodology.

Municipal and Industrial Water Needs Analysis

Municipal and industrial water use for 1989 were determined from an analysis of water production records and metered water sales data maintained by the water service agencies serving communities discussed above.

The most common approach for estimating future water needs of the municipal and industrial sector is the per capita consumption factor. The per capita method is ideal for areas that do not expect dramatic changes in the current composition of the city and its water use characteristics. The data required for this method is the annual water consumed for a service area and the corresponding number of customers served. In this study, water production records for a city, together with historical population data, provided the information necessary to estimate an average annual per capita use for the city. (This assumes the geographic delineation of the water service agency boundary is coincident with the geographic area used for the population estimate). The per capita consumption factor is then used with projected future population data to estimate the corresponding future water need.



NAPA COUNTY MUNICIPALITIES AND SUBAREAS

RECENT HISTORICAL USE (1985-89)

HOW MUCH PER YEAR?

- **Municipalities**
  Production Records for:
  - American Canyon CWD
  - City of Napa
  - Town of Yountville
  - City of St. Helena
  - City of Calistoga
- **Rural**
  - Angwin Area: Production Records
  - Remainder: Estimate based on population x per capita use
- **Agricultural**
  - Vineyards
    - Irrigation requirements = 1987 DWR acreage x applied water based on region (Ac-Ft/Ac/Yr)
      - South Napa Subarea = 0.4
      - North Napa Valley Subarea = 0.5
      - Lake Berryessa Subarea = 0.6
    - Frost Protection = DWR acreage x 0.33 Ac-Ft/Ac/Yr
    - Heat Protection = DWR acreage x 0.17 Ac-Ft/Ac/Yr
  - Other Agriculture
    - Pasture - 4.0 Ac-Ft/Ac/Yr
    - Deciduous - 2.0 Ac-Ft/Ac/Yr
    - Truck Crops - 2.4 Ac-Ft/Ac/Yr
    - Grain - 1.2 Ac-Ft/Ac/Yr

UNIT WATER USE

CHARACTERISTICS?

- Variation in Use
- Unit Use
  - Per Capita
  - Per Acre
- Extent of Conservation

WILL CURRENT CHARACTERISTICS CONTINUE?

- Greater Density
- More Conservation
- Change in Industry
- Change in Crops
- System Improvements

FUTURE WATER NEED

How do local and regional planning entities envision future distribution of population and land use within Napa County?

- Reflection of Policies
- Regional Economy
- Land Capabilities

Municipalities

- Residential/Commercial/Public
  To year 2005, ABAG population projections x per capita use.
  To year 2020, California Department of Finance population projections x per capita use.
- Industrial
  General/Specific Land Use Plans for years 2000/10. Acreage of water use category x unit use (Ac-Ft/Ac/Yr)

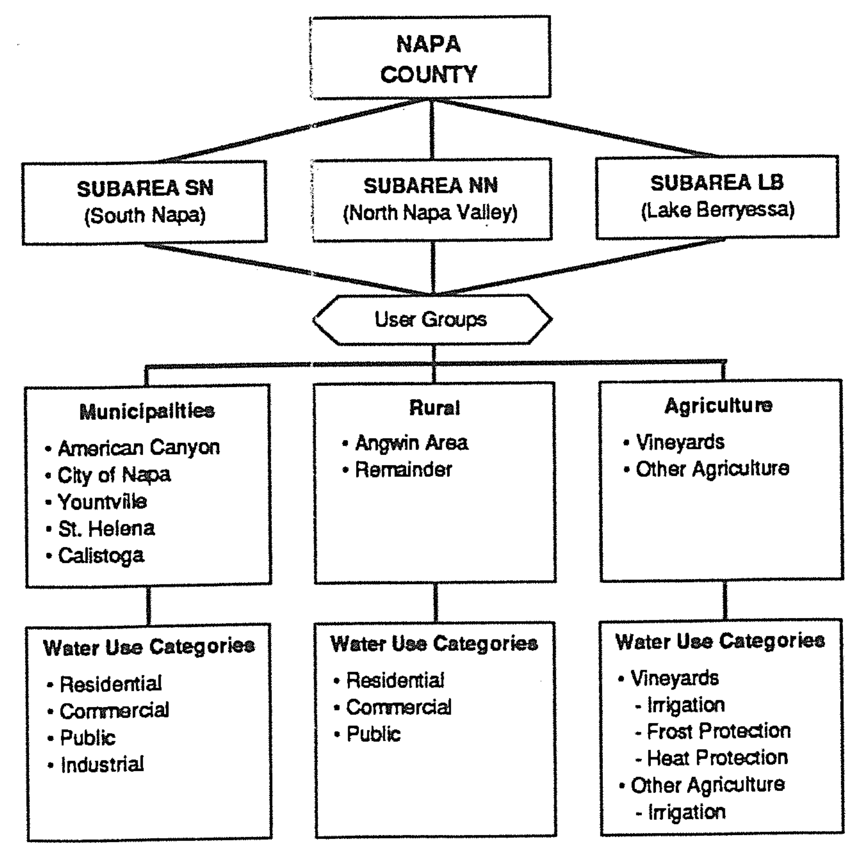
Rural

To year 2005, ABAG population projections x estimated per capita use.
To year 2020, California Department of Finance population projections x estimated per capita use.

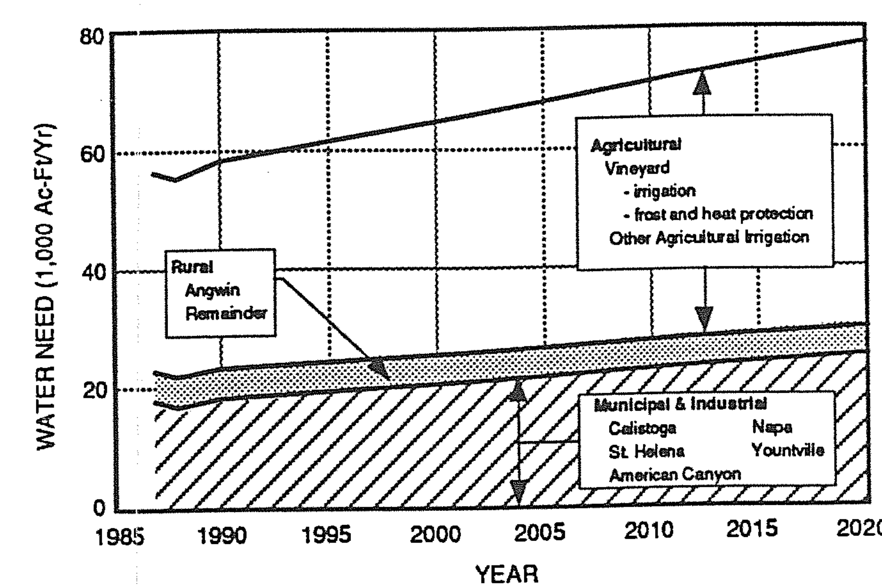
Agriculture

- Vineyards:
  In year 2020, 53,000 Ac (based on Agricultural Resource acreage of County General Plan) x applied water requirement for irrigation and frost and heat protection.
- Other Agriculture: Constant water demand.

WATER USE CALCULATIONS



WATER USER CLASSIFICATIONS



NAPA COUNTY WATER NEEDS

OVERVIEW OF WATER NEEDS METHODOLOGY

FIGURE 3-1

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Section 3

Water Needs

In order for the unit consumption approach to yield valid estimates of future water needs, existing and probable future water use practices must be reviewed. The review considered the current effectiveness of water conservation practices of the municipal and industrial groups, and the likelihood of additional conservation driven by governmental regulation, economics, or technical advancements. The water management plans, mandated by the State, cover a community's goals as far as conservation is concerned. In addition, adjustments were made to the per capita estimates to account for: recent hydrologic conditions; anticipated changes in population density; commercial development; large industrial uses, and tourism.

The characteristics of municipal use in Napa County, consisting of residential, commercial, and public water needs, are not expected to change dramatically over the planning horizon. However, the industrial use component can vary dramatically as a result of the unique water requirements of certain kinds of industrial processes. To guarantee the accurate representation of future water use characteristics, the per capita method was enhanced to accommodate this possibility. The industrial component was separated from the total municipal and industrial water needs prior to calculating the per capita consumption factor.

Future industrial water needs were estimated in one of two ways, based on data availability. If metered water sales records were available, together with corresponding existing land use maps, a water duty for the industrial portion was determined. (A water duty represents the amount of water required per unit area occupied by a particular land use category, expressed in units of acre-feet per acre per year). Estimates of future industrial water needs were then determined by applying the water duty to future land use acreage reserved for industrial development, as stated in the general plans. Alternatively, relying on previous investigations and/or recommendations from Advisory Committee panelists, industrial water use was expressed as a percentage of the total water use. Water needs in the future were then assumed to reflect this same percentage. Any error induced from the special treatment of this industrial factor was presumed to be small since industrial use in Napa County is a relatively small component of the total water needs.

Rural Water Needs Analysis

Existing water use of the rural population can also be determined from a compilation of water production records. However, such records of rural water use are not regularly maintained on a public level. Hence, an estimate of per capita water consumption was used together with historical population data.

A large component of the rural population is made up of individuals associated with wineries situated primarily throughout the Napa Valley. This industry has a water use component consisting of needs for domestic purposes, bottle washing, tourism, and other incidental uses for processing of wine. A survey revealed that winery operations required relatively little water, with domestic needs requiring the largest percentage. This domestic need was already accounted for in the rural per capita estimate. From the survey, the remaining uses were averaged over the rural population and an additional per capita component included with the overall rural per capita estimate.

The same per capita estimate was used with projected population data to determine future water needs of the rural population. No adjustments were made to the per capita use estimate for calculating future water needs. This assumes that water use characteristics of the rural population will remain constant over the planning horizon.

Agricultural Water Needs Analysis

Generally, irrigation for agricultural purposes is met by pumpage of groundwater, surface water diversions from local streams and creeks, and to a lesser extent water service agencies. Typically, records of agricultural water consumption are not maintained and/or are not easily obtained. The most common approach used to estimate existing agricultural water needs makes use of an applied water requirement factor, expressed in units of acre-feet of water required annually per acre of crop for a particular crop type. The annual water requirement is based on the amount of water needed to meet the evapotranspirative needs of the crop as well as losses incurred in conveyance systems.

Agricultural water use practices in Napa County have a unique requirement for vineyards posed by the threat of severe frost and heat conditions. Water is commonly sprayed over the vineyard to protect the vines from potential damage. If adequate protection against these two factors is not provided, significant economic loss can be incurred. Numerous studies conducted in the past have estimated the seasonal and annual water needs required for frost and heat protection. However, determining an annual average water application for these purposes has been difficult because of the unpredictability due to erratic climatic conditions. In this study, individual average annual water consumption factors were determined for frost and heat respectively based on previous studies. These factors were then added to the irrigation-applied water requirement.

The applied water requirement determined for a particular crop was used, together with crop acreage determined from existing detailed land use maps prepared by DWR, to estimate the existing water needs of a particular crop.

To calculate future irrigated crop water needs, the growth patterns of the different crop types were evaluated, as well as future irrigation practices that may alter the water consumption factor. Crop development depends on the Napa County general plan land use element, economics, land availability, and water availability. The applied water requirement for each crop was evaluated and adjusted according to potential changes in irrigation practice and irrigation efficiency. Water demand projections were calculated by applying this adjusted applied water requirement to the projected future crop acreage as designated in the Napa County General Plan.

Alternative Scenarios

In addition to the above estimates, alternative scenarios were developed to consider the possibility of changes in projected populations, land use development, and to account for changes in general water use characteristics.

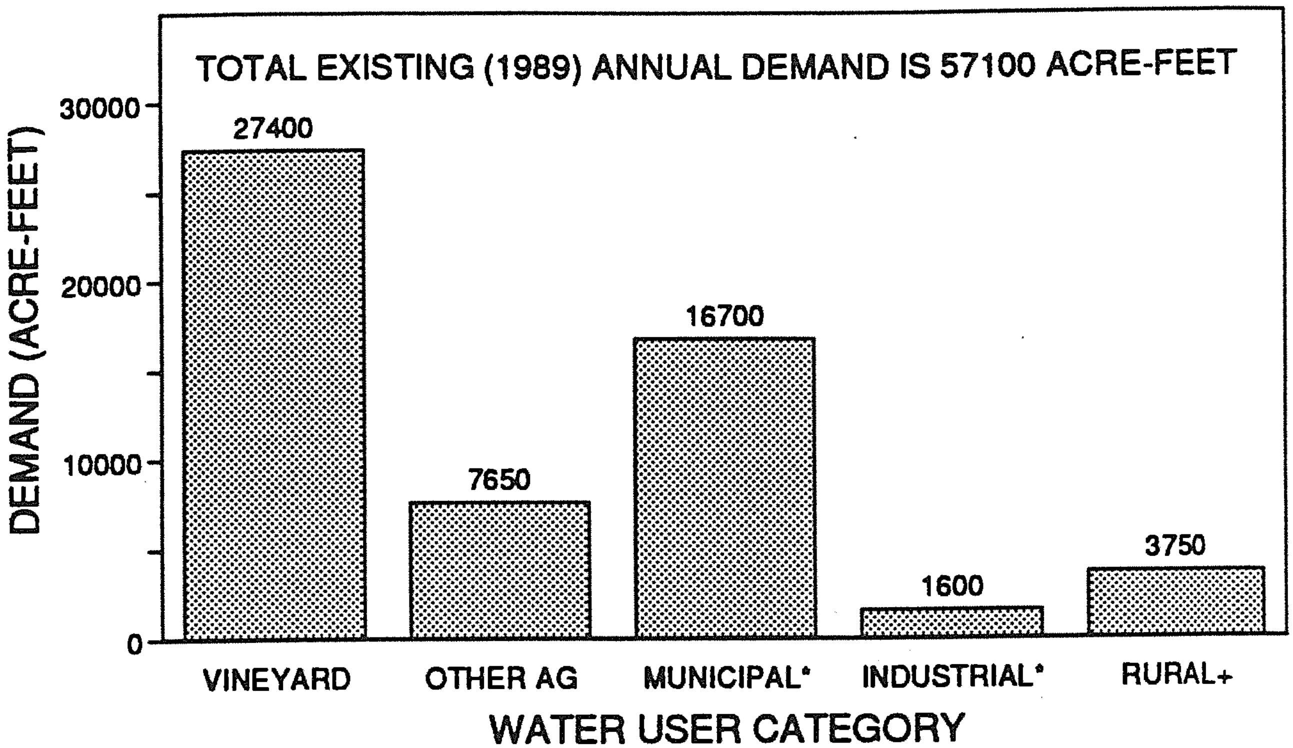
ANALYSIS OF EXISTING (1989) WATER USE

As discussed previously, water use in Napa County has been separated into four categories: Municipal and Industrial; Rural; Vineyard; and Other Irrigated Agriculture. The total current (1989) water use for Napa County is 57,100 acre-feet. The distribution of this total by water use category is shown in Figure 3-2.

Municipal and Industrial Water Demand

The focus of municipal and industrial use is in the urban areas of Calistoga, St. Helena, Yountville, Napa, American Canyon, and Angwin. The residents of these areas make up 81 percent of the total population in Napa County, and are located in the North Napa Valley and South Napa Subareas. Each of these communities, with the exception of Angwin, is served by a single water service agency. The Angwin area receives its water primarily from the Howell Mountain Mutual Water Company, Pacific Union College, and St. Helena Hospital. The water agency boundaries generally coincide with the urban limit lines defined in the general plans, although in some cases a small number of residential and industrial customers exist outside the service area boundaries.

Existing Municipal and Industrial Water Use. Existing municipal and industrial water use was determined using water production records from the individual water service agencies. Additional metered water sales records were available for some cities, though the use of this data is limited since records are incomplete. However, this additional information serves to check and validate the water production data. Each community, as mentioned previously, is treated individually, accounting for the variations in water use practices of the distinctive communities. The total current (1989) combined municipal and industrial use is 18,300 acre-feet (Figure 3-2).



* Includes the cities of Calistoga, St.Helena, and Napa, the Town of Yountville (including the group quarters), and American Canyon.

\+ Includes the rural population, the Angwin area, and winery usage.

EXISTING (1989) WATER USE
NAPA COUNTY, CALIFORNIA

FIGURE 3-2

Section 3

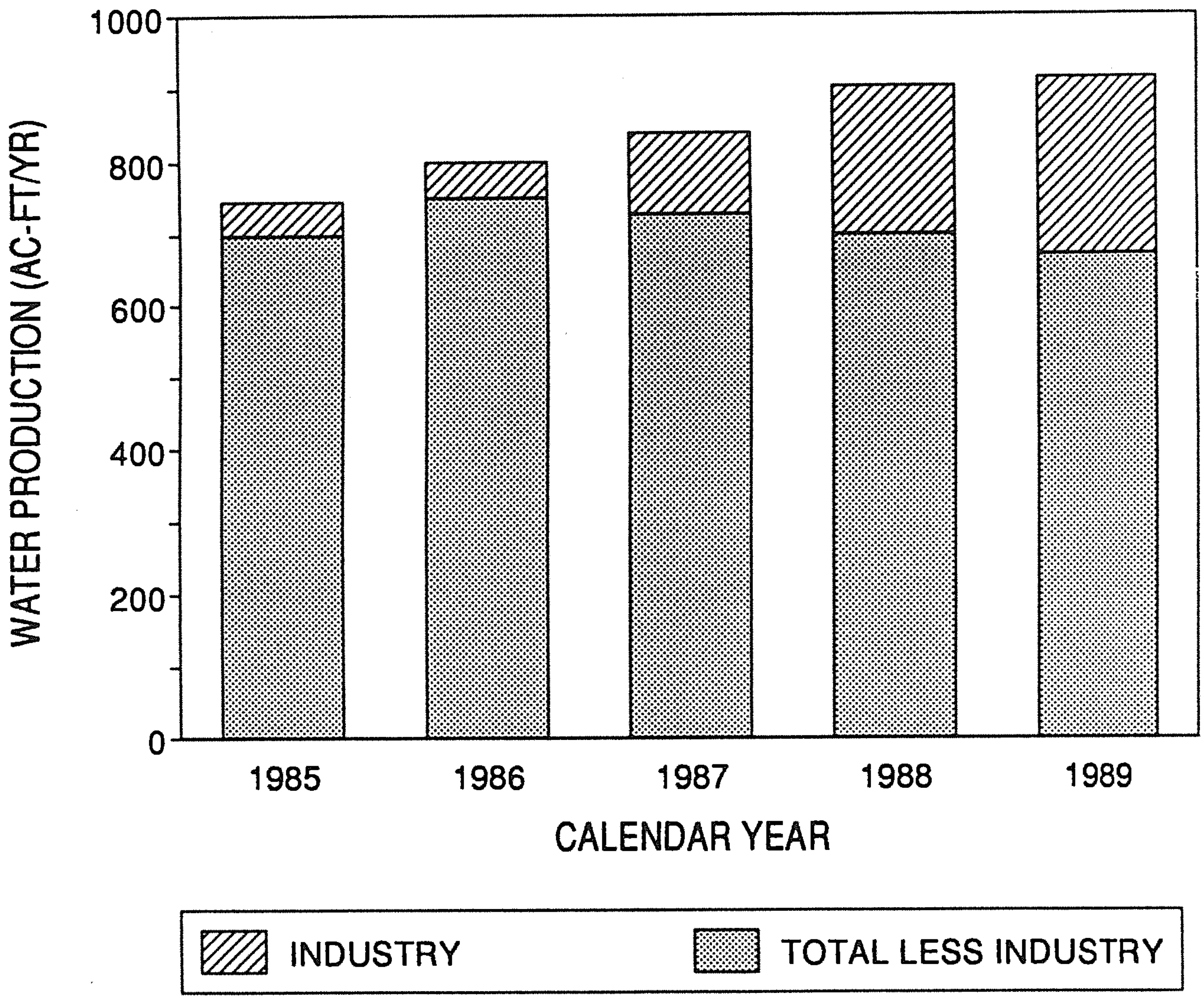
Water Needs

The City of Calistoga, located in the extreme north end of Napa Valley, provides water for residential, commercial, industrial, and public uses within its city limits. The city's water needs are supplied from Kimball Reservoir, the North Bay Aqueduct, and the Fiege well field. The most significant industrial use is for Calistoga bottling works, responsible for producing sparkling mineral water. In recent years this industry has grown tremendously, as is reflected in Figure 3-3 which depicts historical total water production, with industrial use segregated from the total use, and the remainder consisting of residential, commercial, and public uses. The industrial use was determined from 1989 metered water sales records. For 1985 through 1988, industrial water use was estimated from previous work (Heuser, 1989).

The City of St. Helena, located south of Calistoga, near the center of Napa Valley, is served by the Water Enterprise of St. Helena. Water is supplied by Bell Canyon Reservoir, and in recent years, additional water, as needed, has been imported from outside sources according to temporary short term contracts. Currently, groundwater does not provide any supply, though investigation of wells located within the service area are ongoing. The Water Enterprise sells approximately 79 percent of its water within the St. Helena city limits, with the remainder being distributed to residential and commercial use, as well as wineries for wine production outside the service area (Hanson, 1987). In addition, restaurants and overnight accommodations for tourists represent a significant water use. Recent historical use, according to water production records collected from the Louis Stralla Water Treatment Plant, are presented in Figure 3-4. Industrial use was 440 acre-feet in 1987 (Hanson, 1987). The use was assumed to be an average use and was separated from the remaining years as well.

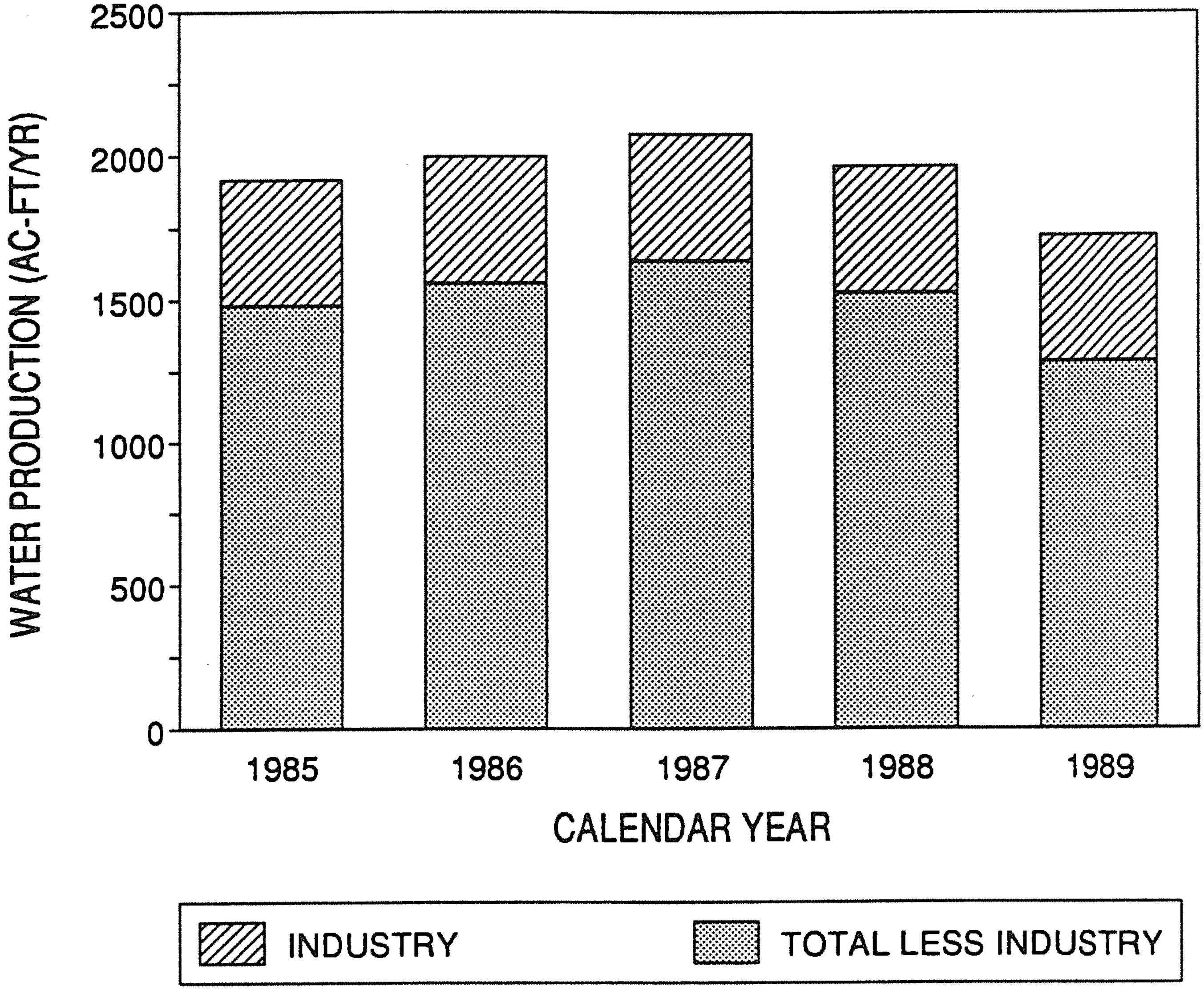
Another residential community within Napa Valley, located north of the City of Napa, is the Town of Yountville. The water service area serving Yountville includes residents in the town limits and excludes those people living in the California Veterans Home. The water supply comes from two sources, the North Bay Aqueduct and Rector Reservoir, through contractual agreements with DWR and the California Department of Veteran Affairs, respectively. The water use in Yountville is dominated by residential and commercial needs; no industrial uses are reported. However, like St. Helena, restaurants and overnight accommodations for tourists represent a significant water use. Water production records for the Yountville water service area are presented in Figure 3-5.

The largest community of Napa County, the City of Napa, is located near the southern-most end of Napa Valley. With a population of approximately 64,500 in 1989, the City of Napa is home to over 60 percent of the total Napa County population. Water needs are currently met by three primary supplies: Lake Hennessey, Milliken Reservoir, and the North Bay Aqueduct. With the exception of two large industrial operations (Napa Pipe and Syar Rock),



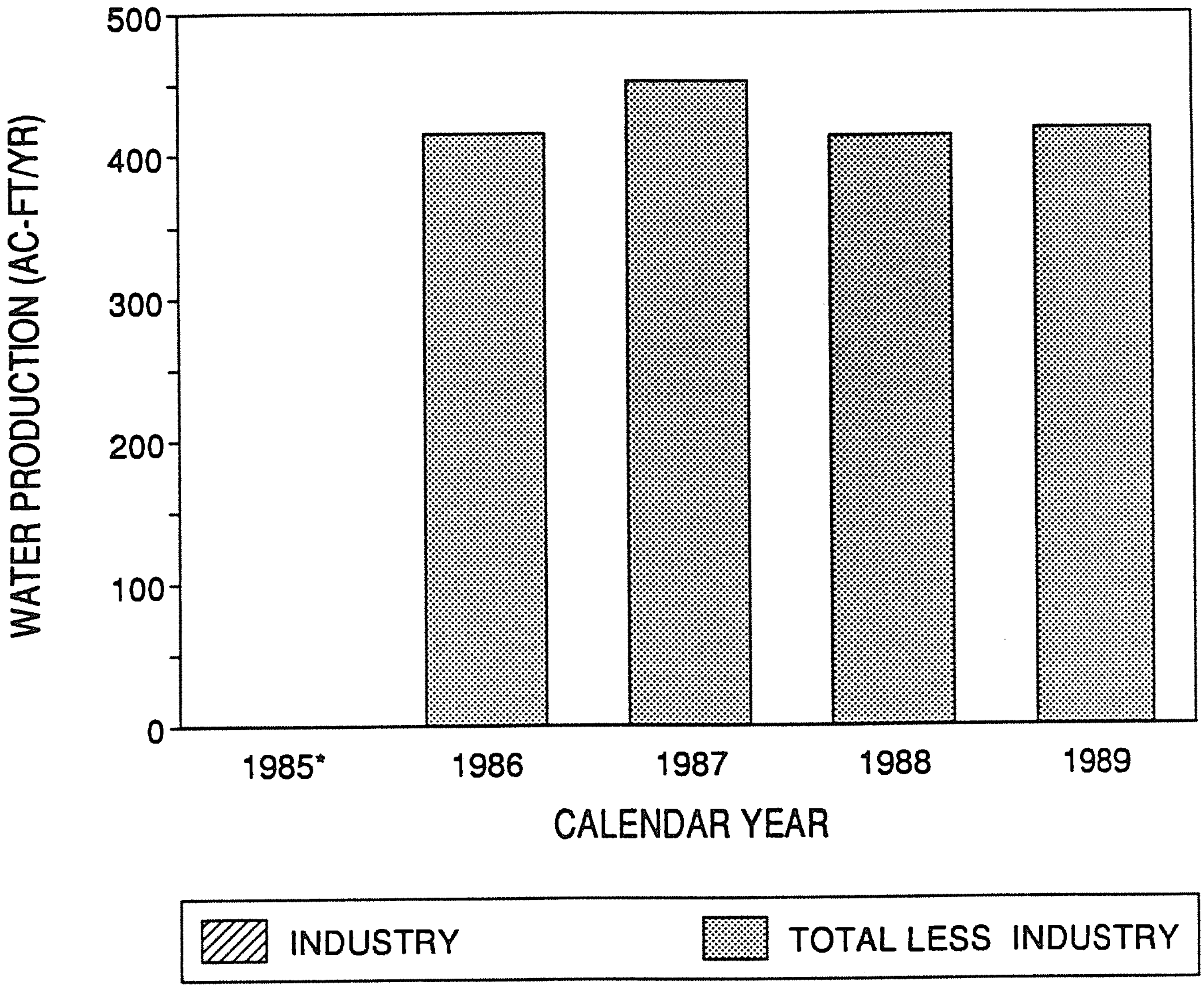
HISTORICAL WATER PRODUCTION FOR THE CITY OF CALISTOGA, NAPA COUNTY, CALIFORNIA

FIGURE 3-3



HISTORICAL WATER PRODUCTION FOR THE CITY OF ST. HELENA, NAPA COUNTY, CALIFORNIA

FIGURE 3-4



* Water Production data not available for 1985

HISTORICAL WATER PRODUCTION FOR THE TOWN OF YOUNTVILLE, NAPA COUNTY, CALIFORNIA

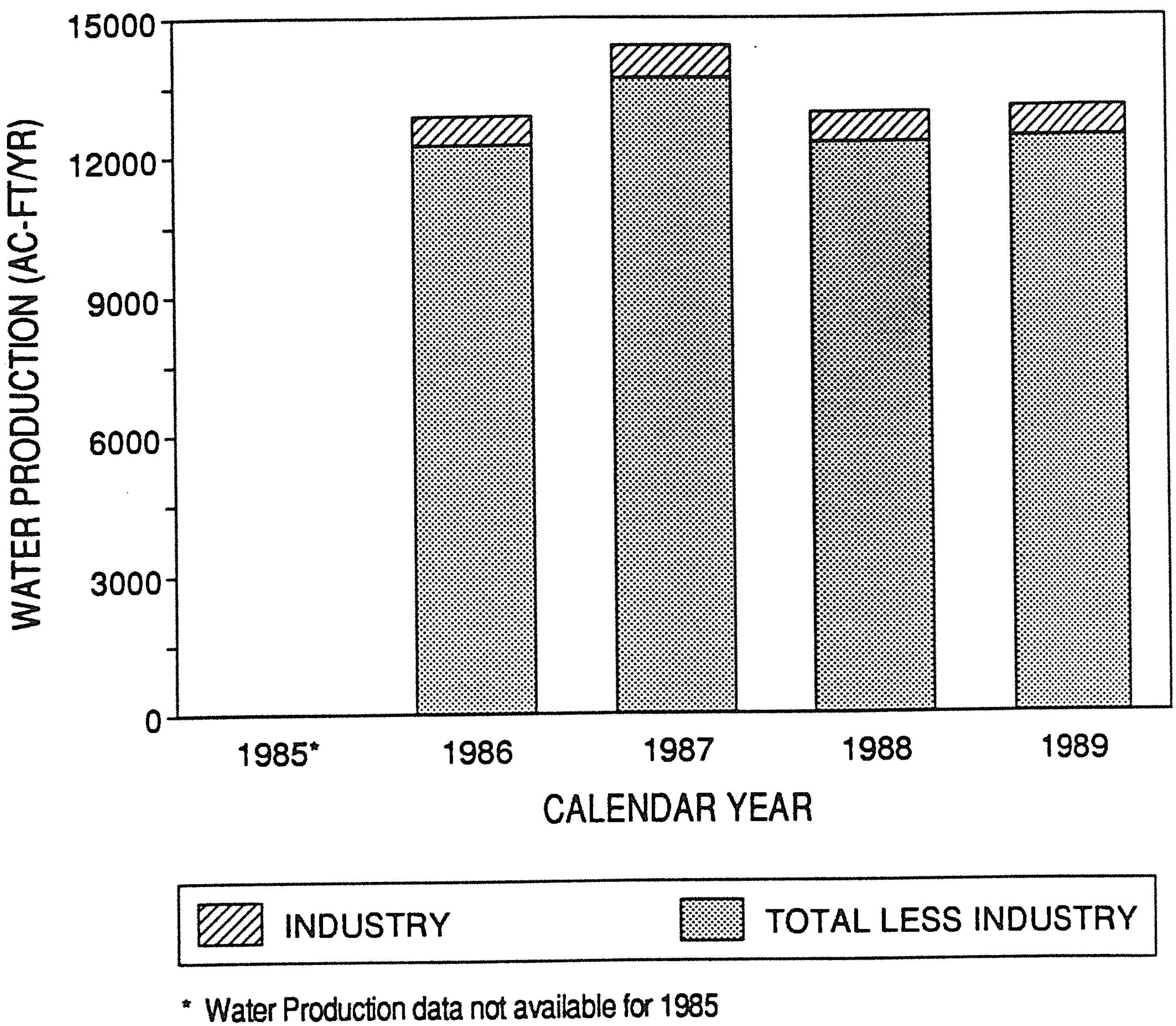
FIGURE 3-5

industrial activity is limited to small operations. The City sells surplus water to agricultural customers, primarily vineyards, when the municipal and industrial requirements have been met. This service is provided on a contract basis and is interruptible. The combined recent historical water production records of the three water treatment plants (Hennessey, Milliken, and Jameson) supporting the City of Napa are shown in Figure 3-6. The segregation of industrial use from the total use was based on an estimate that five percent of the total use was for industrial needs. Data from metered water sales records were used to derive this estimate. Industrial use could not be directly extracted from the records due to the water rate structure used by the city of Napa. Consultation with the Advisory Committee enabled the five percent estimate to be determined (City of Napa, 1990).

The American Canyon County Water District (ACCWD) serves a rapidly developing unincorporated community referred to as American Canyon, located in the southern end of Napa County. The Local Area Formation Committee (LAFCOM) has identified a boundary for the area congruent with the ACCWD service area. The service district receives its water supply principally from the State Water Project via the North Bay Aqueduct with minor supplemental supplies from the City of Vallejo and a connection to the City of Napa distribution system. The area is predominantly residential. The steady upward trend of water production, as shown in Figure 3-7, is an indication of recent growth. Figure 3-7 reflects the initiation of a 5-year contract serving an agricultural interest, which, for purposes of this study, was treated as an industrial demand (assumed constant for 1987 through 1989) and separated from the municipal demand. No other industrial uses were reported.

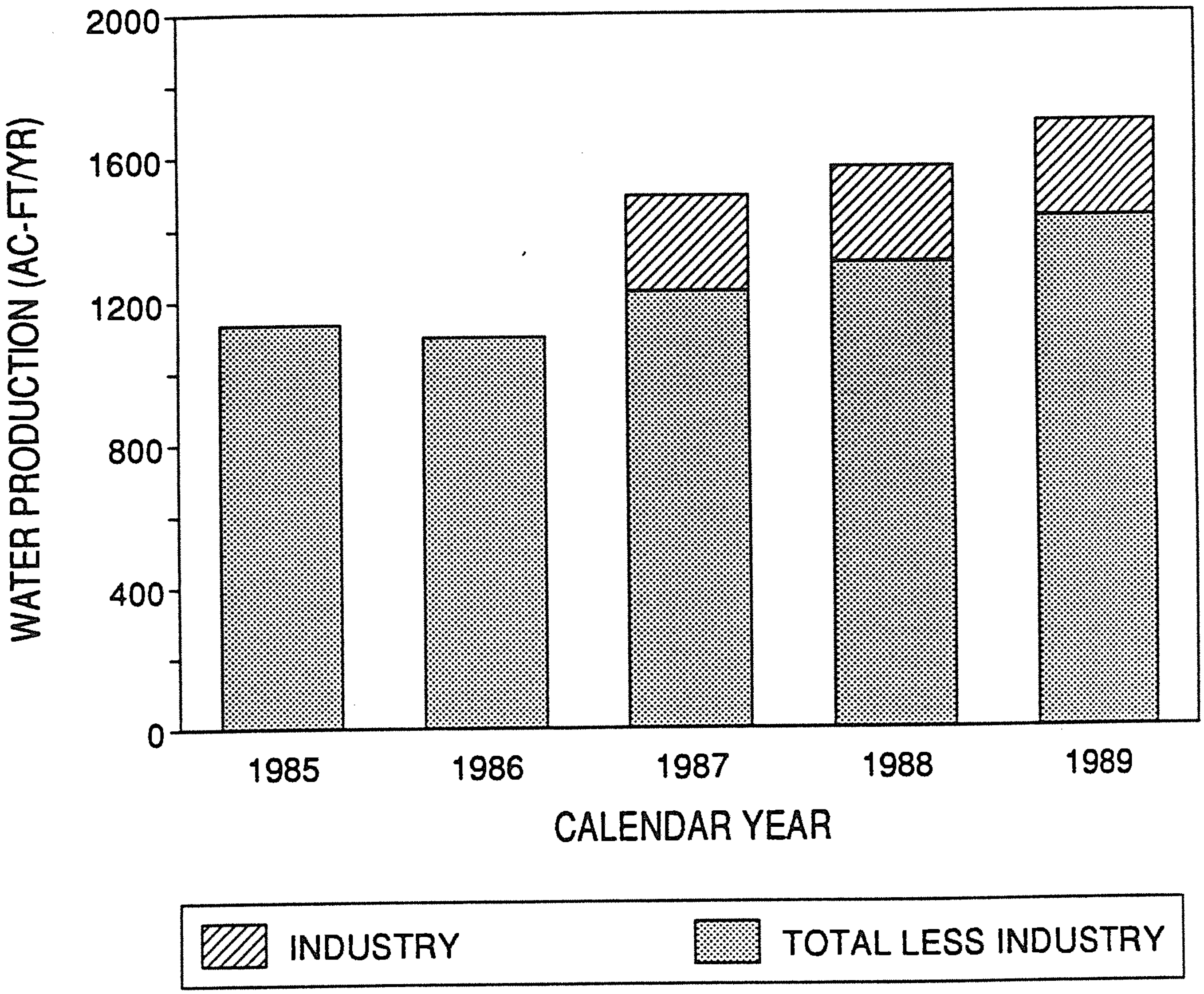
Recent water production data for the Angwin area was not readily available. Instead, estimates of per capita consumption and population were used to determine existing water use. The per capita estimate was taken from a previous investigation conducted for the Howell Mountain Mutual Water Company (Winzler & Kelly, 1985).

Characteristics of Municipal and Industrial Water Use. For projections to be made of future municipal and industrial water needs, an analysis of the existing water use was conducted, deriving unit consumption factors for each municipality. The historical water production data for each water service agency, together with historical population data obtained from the CDOF and the ABAG, was used to obtain annual per capita consumption in units of gallons per capita per day. The recent drought conditions have affected water use practices in Napa County. To evaluate this impact, data was collected for the period 1985 through 1989. The per capita method is sensitive to large non-residential water use components that have a tendency to fluctuate. For this reason it is important to address any sizable current use that may change dramatically and separate it from the data. The potential for industrial water demands to change independently of population, for example, is accounted for in this case. With the industrial component removed, the per capita method



HISTORICAL WATER PRODUCTION FOR THE CITY OF NAPA, NAPA COUNTY, CALIFORNIA

FIGURE 3-6



HISTORICAL WATER PRODUCTION FOR THE AMERICAN CANYON COUNTY WATER DISTRICT, NAPA COUNTY, CALIFORNIA

FIGURE 3-7

is ideal for projecting future water needs of municipalities in Napa County, since water use characteristics of the various cities are expected to remain relatively constant over the planning horizon. The characteristics of recent water use patterns for municipal needs were determined for each of the Napa County communities. These characteristics, expressed as annual per capita water consumption factors, are given in Table 3-1.

Calistoga water production data was adjusted for the recent trend of increased water demand for the bottling works industry. This industrial water use was reflected in metered water sales records for 1989. Per capita use was calculated after this industrial use was removed.

St. Helena also serves a share of its water to nearby wineries during production phases. Based on a recent study, it was assumed that the 1987 industrial use would remain constant over the planning horizon (Hanson, 1987). This community's per capita use is the largest of the group. Two reasons account for this: (1) Tourism is a major component of this area. St. Helena showed the second largest percentage increase in the number of lodging rooms during the 1980 decade (Napa County Conservation, Development and Planning Department, 1990); and (2) delivery system losses are reported as high as 20 to 30 percent (Hanson, 1987). Because the analysis relies on water production data, these losses comprise part of the per capita estimate.

The industrial sector of Yountville is assumed insignificant (Yountville Water Management Plan, 1986), and no adjustment accounting for industrial use was made to the water production data. Like St. Helena, this community also portrayed a high per capita water use estimate relative to the other municipalities. This is primarily due to the large tourist activity in the area, which showed the greatest increase in Napa County during the 1980 decade (Napa County Conservation, Development and Planning Department, 1990).

In the City of Napa, industrial use has historically been a small component of total water needs. It was difficult to separate the industrial water needs due to the water rate structure since industrial contracts were not always distinguished from residential and commercial contracts. A review of data available, reinforced by recommendations from Advisory Committee panelists, resulted in an assumption of a five percent industrial water use. Future land use plans indicate that the composition of the city of Napa's water use characteristics will not change significantly over the planning horizon (City of Napa, 1990).

American Canyon also supports little industry, however in 1987 the service district initiated a single contract for delivering water for vineyard irrigation to the Chardonnay Golf Club (ACCWD, 1990). This use was placed in the industrial use category and, as stated previously, was assumed constant for the years 1987 through 1989.

TABLE 3-1

CHARACTERISTICS OF CURRENT WATER USE

CALENDAR YEAR	CALISTOGA gpcd	NAPA gpcd	ST. HELENA gpcd	YOUNTVILLE gpcd	ACCWD gpcd	ANGWIN gpcd	REMAINDER gpcd
1985	154	N/A	230	N/A	158	N/A	
1986	163	177	242	226	150	N/A	
1987	155	195	254	240	163	N/A	
1988	146	173	237	215	169	N/A	
1989	139	172	200	213	181	N/A	
AVERAGE	151	179	233	223	164	135	150

NOTES:

gpcd = gallons per capita per day
N/A = Not available

CALISTOGA: Production data was adjusted for industrial use. This was necessary due to the rapid growth of "bottling works" which significantly increased overall water use. The resulting per capita estimates reflects a conservation-minded community. Industrial demands were handled by the "Water Duty" approach. A water duty was calculated using existing land use data; this was then applied to future land use acreage provided in the general plan.

ST. HELENA: St. Helena serves a large portion of its water to the wineries during production phases. Based on previous studies (Master Water Plan of 1987 - Hanson) it was assumed that the industrial use of 1987 represented an average annual use. To calculate per capita, this industrial component was separated from the production data; for future projections it was then added back (assuming no future demand increase in this use category).

NAPA: Production data was also adjusted for industrial use in Napa. However, because of limited data it was assumed that five percent of the production data went to industry (based on fiscal year sales data). Industrial use was assumed to make up five percent of future demands as well.

YOUNTVILLE: It was assumed that industry was an insignificant portion of Yountville's annual production. The only adjustment necessary was the separation of the "Group Quarters" population from the rest of the town. Per capita was calculated using the estimates of Town population. A per capita of 50 gpcd was assumed for the Group Quarters indoor use; water duty of 1.5 Ac-Ft/Ac/Yr was applied to 150 acres used by the Veteran's Home (DWR 1987 land use).

ACCWD (AMERICAN CANYON COUNTY WATER DISTRICT): American Canyon also supports little industry, and therefore was not adjusted accordingly. However, in 1986-1987 ACCWD began supplying Chardonnay Golf Course with irrigation water. An estimate of 266 Ac-Ft was then removed from years 1987-1989. Per capita use was then calculated, and the irrigation was carried along as a separate component for future demand calculations.

ANGWIN: Data was not available for the Angwin area, with the exception of a report performed by Winzler and Kelly in 1985 for Howell Mountain Mutual Water Company. A per capita estimate of 135 gpcd was taken from here (119 gpcd for residential use; 12 percent of total use for commercial - 16 gpcd).

REMAINDER (rural): Assumed the per capita use of the rural population of Napa County was 150 gpcd.

As is apparent in Table 3-1, the dry conditions that have prevailed in recent years are partly responsible for the downward trend in the annual per capita use. To evaluate the significance of this on the average per capita use estimate, an average of the period spanning 1985 through 1987 was considered. The net impact is less than a 5 percent increase in future water demands. This is not enough evidence to warrant an adjustment to the per capita use estimates. On the contrary, state wide trends indicate that future per capita use estimates will decline as a result of increased water conservation. This slightly lower per capita estimate inherently reflects this attitude. The primary reasons for historical differences in the individual per capita use estimates was due to large tourism components associated with St. Helena and Yountville relative to the other communities. Calistoga, on the other hand, tends to be lower than the other communities due to a large percentage of trailer parks, which generally have a low per capita use (STA Planning, Inc., 1989). The Napa County General Plan calls for urban development to be restricted to those areas within the urban limit lines. In addition, there are currently no future plans for extending urban limit lines associated with any of the incorporated areas. Thus, the composition of the water user categories should remain relatively constant over the planning horizon warranting the use of the per capita estimate. The average per capita use estimate derived from historical use during the 1985 to 1989 period has been used as the basis for projecting future municipal and industrial water needs.

Production data for the period 1985-89 was reviewed for the five municipal entities to establish the seasonal variation of use. This variation is required for the yield analysis of local reservoirs (See Table 5-5).

Rural Water Use

The rural community represents approximately 19 percent of the total Napa County population, and relies primarily on private wells and small water purveyors for their water supply.

The primary water use is for domestic purposes. However, it is possible that some incidental use occurs as a result of commercial, industrial, and agricultural needs. For purposes of this study it was assumed that a per capita consumption factor would be used to account for these rural water needs. A review of previous investigations indicated an annual per capita use of 150 gallons per capita per day has been calculated in the past (Engineering-Science, Inc., 1971). Using historical population data, the total existing water use for 1989 was calculated (see Figure 3-2). The estimated water use supports an earlier assumption that the rural water use category represented only a small percentage of the total water needs of Napa County -- approximately 6 percent. This reinforces the idea that the same per capita estimate can be used for projecting the future water needs of this category, with little chance of significant error based on these estimates.

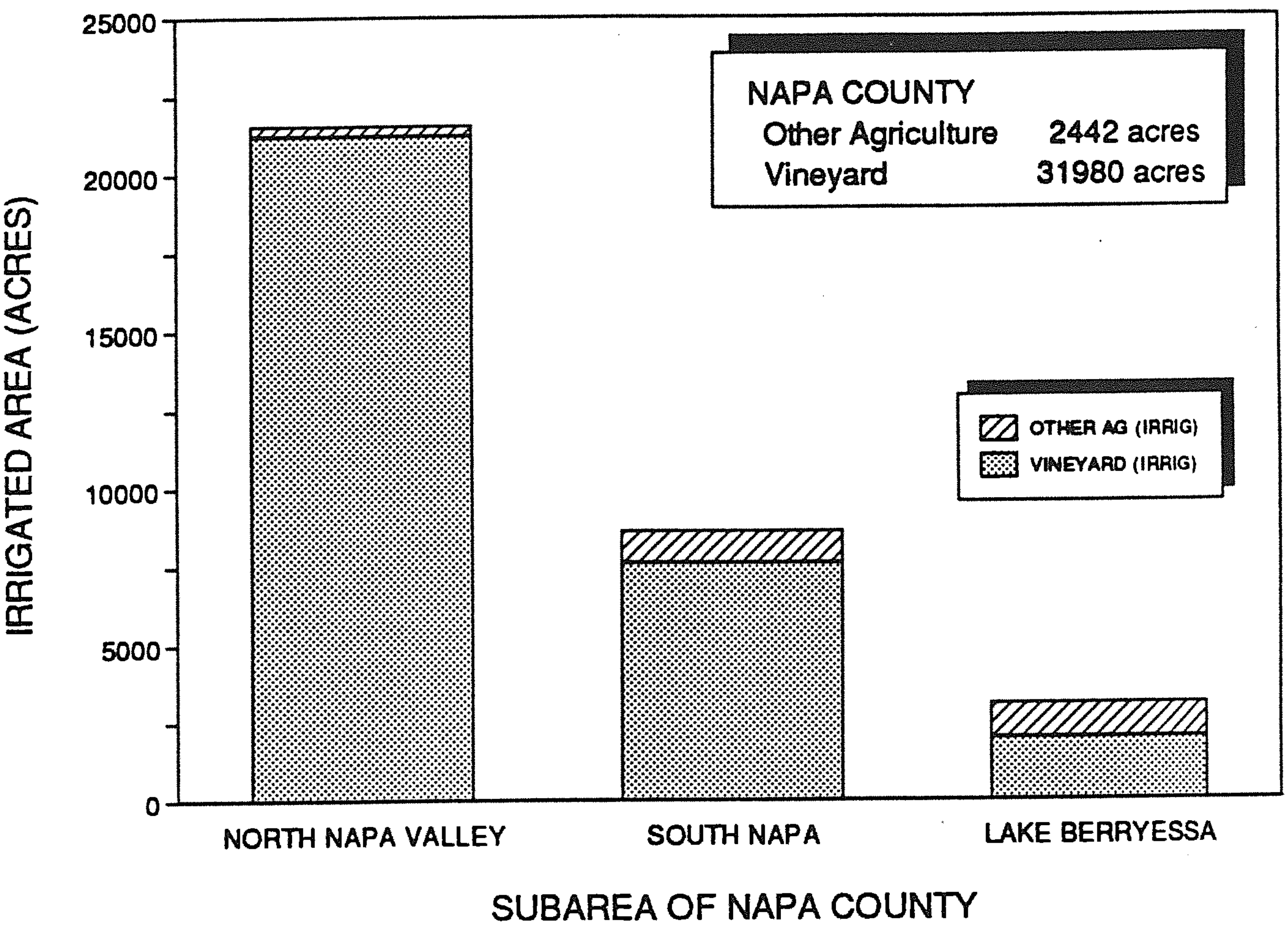
Agricultural Water Use

The largest component of existing water use is the agricultural base of Napa County. The primary crop grown is wine grapes, which account for 92 percent of the irrigated agriculture (1989). Other irrigated crops consist of pasture, grain, deciduous, and truck crops. The irrigated agricultural land use acreage distribution by subarea is shown in Figure 3-8. Crops are irrigated using both groundwater and diversions of Napa River water and its tributaries, as well as a number of small streams and creeks in the Lake Berryessa watershed. A very small percentage of crop water requirements are met by municipal water agencies, on an as-available basis.

Agricultural water use in Napa County is largely devoted to vineyards covering the Napa Valley floor, and increasingly the hillsides, as well as the Carneros area, Jameson and American Canyons, and Chiles and Pope Valley. The annual current water requirements for vineyard is composed of water for irrigation, protection of the vines from spring frost damage, and protection of maturing grapes from heat damage during extremely hot summer temperatures. Several references have addressed vineyard development in Napa County and its water requirements. The key sources of information used in this study included: the Napa County Department of Agriculture, DWR, and the University of California Cooperative Extension Service.

Existing Land Use. A breakdown of crop patterns is the first step in developing estimates of existing and future agricultural water needs. Agricultural land use practices in Napa County were analyzed to identify crop-mix and crop acreage. Significant detail of Napa County agricultural development was made available from a DWR land use survey conducted in 1987 (DWR Land Use Study #88-62). DWR conducts such surveys for California counties approximately every seven years. The maps and data are developed from aerial photographs, supported by frequent spot field checks for accuracy. The survey separates land use into agricultural, native, urban, and recreational classes, with further division within each class. The agricultural class includes ten subclasses, of which Napa County has five:

- Vineyard
- Pasture
- Grain
- Deciduous
- Truck Crops



EXISTING (1989) SUBAREA IRRIGATED AGRICULTURE
NAPA COUNTY, CALIFORNIA

FIGURE 3-8

Section 3

Water Needs

Because of the dominant presence of vineyards in Napa County, pasture, grain, deciduous, and truck crops were assigned to one group, previously identified as Other Irrigated Agriculture. The land use survey also identifies whether the crop is irrigated or not. By identifying the irrigated acreage for each crop, water requirements can be estimated based on water use characteristics shown in Table 3-2.

As of 1987, the North Napa Valley Subarea contained nearly 70 percent of all developed vineyard land in Napa County (or 21,240 acres). Development is concentrated on the Napa Valley floor, with additional vineyards recently spreading to the hillsides and smaller upper elevation areas such as Chiles and Foss Valleys. Other irrigated agriculture is relatively small, occupying less than 2 percent of the developed irrigated agricultural land in this subarea (or 320 acres).

The eastern portion of Napa County, designated as the Lake Berryessa Subarea, supports a mixture of vineyard and other irrigated agriculture. Existing vineyards are currently limited primarily to Pope and Capell Valley, totaling 1995 acres in 1987. Other irrigated agriculture is approximately 1115 acres.

In the South Napa Subarea rapid vineyard development has occurred in the Carneros Valley, with additional vineyards spread thinly among the Jameson and American Canyon areas, and Wooden and Gordon Valleys. Total lands occupied by vineyards in 1987 was 7630 acres, with 1010 acres devoted to other irrigated agriculture.

Characteristics of Vineyard Water Requirements. In general, irrigated agricultural land requires enough applied water to satisfy the consumptive use requirements not met by precipitation (the consumptive use of a crop is the amount of water required to satisfy the evapotranspirative demands of the crop including evaporation loss from crop foliage and adjacent soils). Annual water requirements for vineyards are unique, however, and consist of three distinctive water use components: (1) irrigation; (2) frost protection; and (3) heat protection. A summary of these applied water demands for each particular crop is given in Table 3-2.

Vineyard irrigation varies geographically and annually depending on climatic conditions. The water requirements for irrigation are commonly expressed in units of acre-feet per acre. Based on a review of previous investigations and consultation with Advisory Committee panel members, an applied water requirement for each subarea was estimated (see Table 3-2). It was assumed that this water requirement was constant over a given subregion.

During the 1970s, not all vineyards were irrigated, depending mostly on grower preference (Metcalf and Eddy, 1973). However, the increased demand for higher yielding vineyards

TABLE 3-2

UNIT WATER REQUIREMENTS BY CROP CATEGORY

Crop Category	Average Annual Crop Water Demand (Ac-Ft/Ac/Yr) North Napa Valley[1]	South Napa[1]	Lake Berryessa[1]	Crops Included[2]
Vineyard[3]				Black and White grapes
Irrigation	0.50	0.40	0.60	
Frost Protection	0.33	0.33	0.33	
Heat Protection	0.17	0.17	0.17	
Total	1.00	0.90	1.10	
Pasture				
Irrigation	4.00	4.00	4.00	Alfalfa, Mixed Pasture, Irrigated Native Pasture
Grain				
Irrigation	1.70	1.70	1.70	Oats, Wheat, Barley
Deciduous				
Irrigation	2.00	2.00	2.00	Apples, Apricots, Bushberries Citrus, Prunes, Nut Crops
Truck Crops				
Irrigation	1.70	1.70	1.70	Flowers and Nursery

(1) Other than Vineyards, the Average Annual Crop Water Demand was assumed constant for each subarea.

(2) Incidental crops not included are Subtropical Fruits and Field Crops - irrigated acreage was insignificant.

(3) Average Annual Crop Water demand is assumed to be the same for Black and White grapes.

coupled with improved irrigation technology has resulted in a majority of vineyards utilizing irrigation water. For purposes of this study, irrigated vineyards acreage was based on irrigated vineyard lands identified by the DWR Land Use Study #88-62.

Between March 15 and May 15, potential frost conditions in the low-lying valleys threaten vineyard development. To combat this problem, sprinkler systems have been installed, and to a lesser extent other systems such as wind machines are also used. Sprinkler systems accomplish the task by coating the leaves, shoots, and clusters with a thin layer of ice which holds the enclosed area at 32°F, as the surrounding temperature continues to drop. A review of previous investigations indicated that water requirements for frost protection varied dramatically from year to year. A rate of 55 gpm per acre has been reported (Metcalf and Eddy, 1973). There is no general agreement of the average number of hours of frost protection required per year. Based on consultation with Advisory Committee members, an agreement of an average 32 hours per year was reached. This translates to approximately .33 acre-feet per acre required annually for frost protection. It was also assumed that frost protection was only a requirement in the low lying-valleys of the North Napa Valley and Lake Berryessa Subareas; the South Napa Subareas proximity to coastal climatic conditions prevents frost from occurring in this region.

The need of water for heat protection occurs primarily in August, to prevent damage to maturing crops for high summer temperatures. The purpose of the water, also commonly applied by sprinkler systems, is to create a cooling action by its evaporative processes. For purposes of this study it was assumed that previous estimates of .17 acre-feet per acre was required on an annual basis. And like frost protection, heat protection was assumed only to be required in the North Napa Valley and Lake Berryessa Subareas.

The three components of water requirements for vineyards in Napa County are based on average annual estimates. The sum of these components represents the total annual water requirement per acre of vineyard, as presented by subarea in Table 3-2. These estimates of water consumption were based on existing (1989) irrigation practices. Currently irrigation is accomplished with sprinkler or drip systems. Trends indicate that conversion to the drip system is occurring throughout Napa County (Farm Bureau, 1990). However, differences in water requirements for sprinkler systems and of drip systems are marginal. Since no significant changes in irrigation practices were foreseen, the total applied water consumption factor was assumed to apply to future conditions.

Characteristics of Other Irrigated Agriculture. Water requirements for the other irrigated agricultural lands consist only of irrigation water used to satisfy the needs of crop consumptive use. Each of the crop classes in this category (pasture, grain, deciduous, and truck crops) has an irrigation-applied water requirement published by DWR (DWR Bulletins

113-3 and 113-4). These factors are presented in Table 3-2, and are assumed to be constant for all of Napa County. Like vineyard irrigation practices, no significant changes in water use practices are expected that would warrant an adjustment to future irrigation water consumption factors.

Existing Agricultural Water Use. The annual water use of a crop can be determined by multiplying the unit water requirement by the irrigated acreage of that crop. A rate of 1.25 acre-feet per acre per year has been previously developed for vineyard crops, and most recently used in the District's 1988 application for supplemental Central Valley Project (CVP) water. Our analysis indicates a net annual average vineyard water requirement of 1.0 acre-feet per acre for North Napa Valley Subarea, and 1.1 acre-feet per acre for Lake Berryessa Subarea, and .9 acre-feet per acre for South Napa Subarea. Applying the factors shown in Table 3-2 to the acreage shown in Figure 3-3 results in a total vineyard requirement of 27,400 acre-feet in 1989 and 7,650 acre-feet for Other Irrigated Agriculture (see Figure 3-2).

FUTURE WATER NEEDS

Water needs to the year 2020 have been determined for Napa County and three subareas: North Napa Valley, South Napa, and Lake Berryessa. The conditions and assumptions relative to future land use and population growth were reviewed in Advisory Committee meetings held throughout the study. The future water need projection made under these conditions and assumptions is referred to as the Baseline Projection. Because of the uncertainty involved in making any projection, alternatives to the Baseline Projection were also developed and are called Alternative Scenario 1 and Alternative Scenario 2. The purpose of these alternatives is to provide a range of likely future water needs, accounting for the possibility of variations in water use characteristics, population growth, and land use development.

The year 2020 was requested by the County as the planning horizon for this study. The 30-year period, from 1990 to 2020, represents a reasonable period for planning and implementing any measures to bring the County's water needs and supplies into balance.

ABAG and CDOF population projections and the Napa County General Plan, along with the community General Plans, were used to establish the population and acreage of specific land use categories to the year 2020. The demand at year 2020 and at five year increments from 1990 were established through application of the unit consumption factors for municipal, industrial, and rural water needs, and the unit water requirement for agriculture.

Section 3

Water Needs

The conditions underlying the baseline projection and the two alternative scenarios are summarized below. Refer to Table 3-3 for a summary of the characteristics.

Conditions of Baseline Projection

The conditions agreed upon for projecting water needs for Napa County to the year 2020 are described for each water use category below.

Municipal/Industrial and Rural Water Needs. Municipal/industrial and rural water needs were calculated using per capita use estimates (gallons per capita per day) and projected population data. Estimates of per capita use were developed from an analysis of production and population data collected for the historical period 1985 to 1989. Population projections were obtained from ABAG and the CDOF (see Figure 3-9). The following conditions are a result of deliberations carried out with the Advisory Committee panel:

- Characteristics of current water use estimates (i.e. per capita estimates based on an average of the calculated annual per capita use for the historical period 1985 through 1989) were assumed to represent characteristics of future water use conditions.

- The proportionate use of the municipal components (residential, commercial, and public) remains unchanged for the duration of the study period.

- The production data collected for each municipality represents all contracted use (i.e. no major unmetered uses or illegal uses). (It is noted that other uses not metered include fire protection, miscellaneous city use, and system losses).

- Projected population estimates (based primarily on sphere of influence boundaries designated by LAFCOM) are consistent with populations served according to municipal water district boundaries.

Irrigated Agricultural Water Needs. Irrigated agricultural water needs were calculated using irrigation-applied water requirements (acre-feet per acre) and land use acreage for each crop type. Estimates of irrigation-applied water requirements were based on a thorough review of previous investigations focusing on crop water use in the region and recommendations from Advisory Committee members. Existing irrigated crop acreage was determined from a DWR land use survey conducted for Napa County in 1987 (DWR Land Use Study #88-62). Future irrigated crop acreage was determined from the Napa County 1989-2005 General Plan Land Use Map. Figure 3-10 depicts future acreage for vineyard

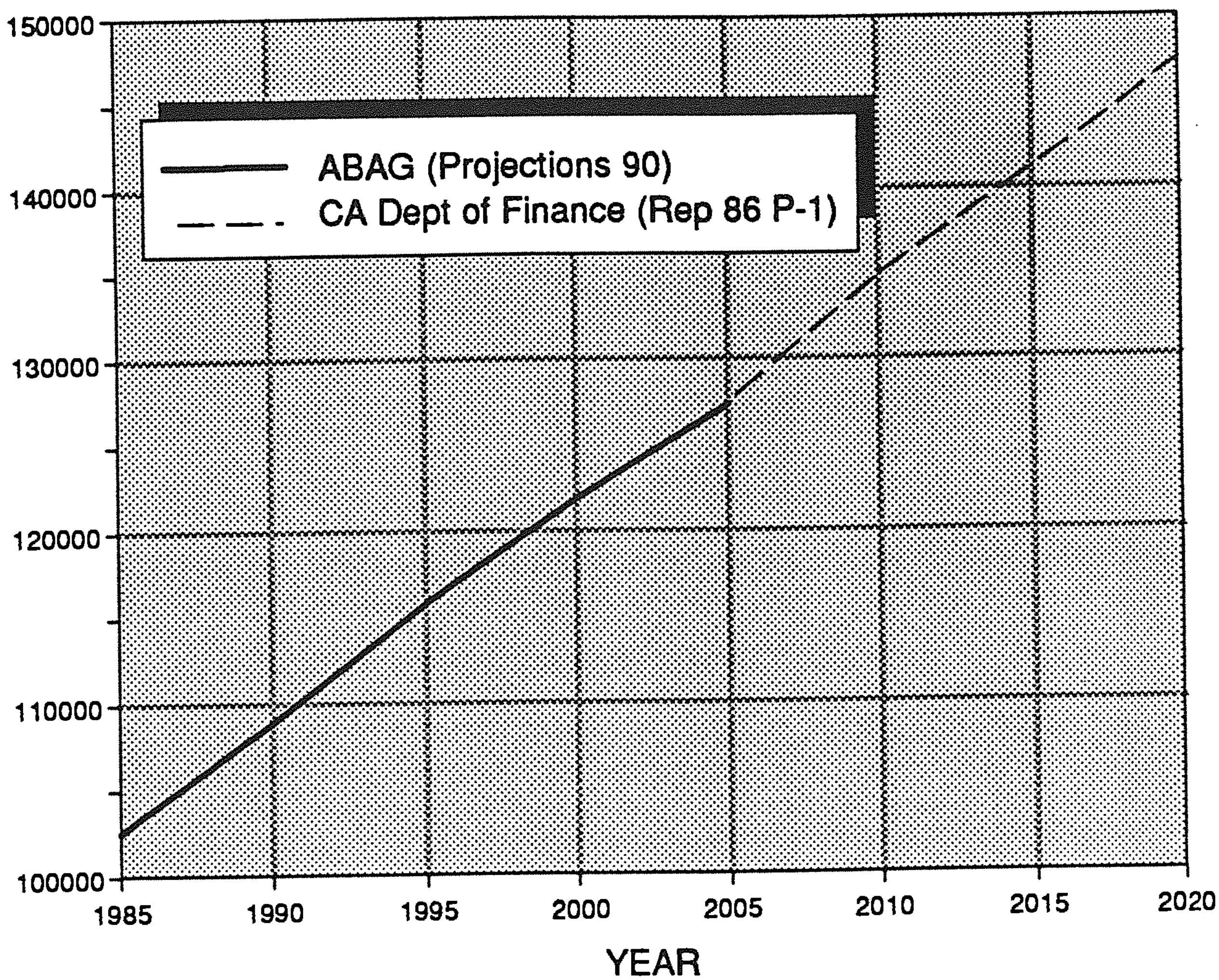
TABLE 3-3

NAPA COUNTY WATER NEEDS SCENARIO CHARACTERISTICS

Characteristics	Baseline Projection	Alternative Scenario 1	Alternative Scenario 2
PER CAPITA (gpcd)			
Calistoga	151	136	151
St. Helena	233	209	233
Yountville	223	201	223
Napa	179	161	179
American Canyon	164	148	164
Angwin	135	135	135
Remainder	150	150	150
VINEYARD WATER REQUIREMENTS (ac-ft/ac/yr) (1)			
Frost Protection	0.33	(2)	0.33
Heat Protection	0.17	(2)	0.17
IRRIGATED VINEYARD LAND USE ACREAGE (1)			
South Napa Subarea			
1990	8121	8121	8121
2005	10581	10581	13041
2020	13041	13041	13041
Napa Valley Subarea			
1990	22181	22181	22181
2005	26883	26883	26883
2020	31586	31586	31586
Lake Berryessa Subarea			
1990	2236	2236	2236
2005	3443	2236	5611
2020	4650	2236	8986
POPULATION			
Napa County			
1990	108900	108900	108900
2005	127350	127350	138900
2020	147500	147500	169900

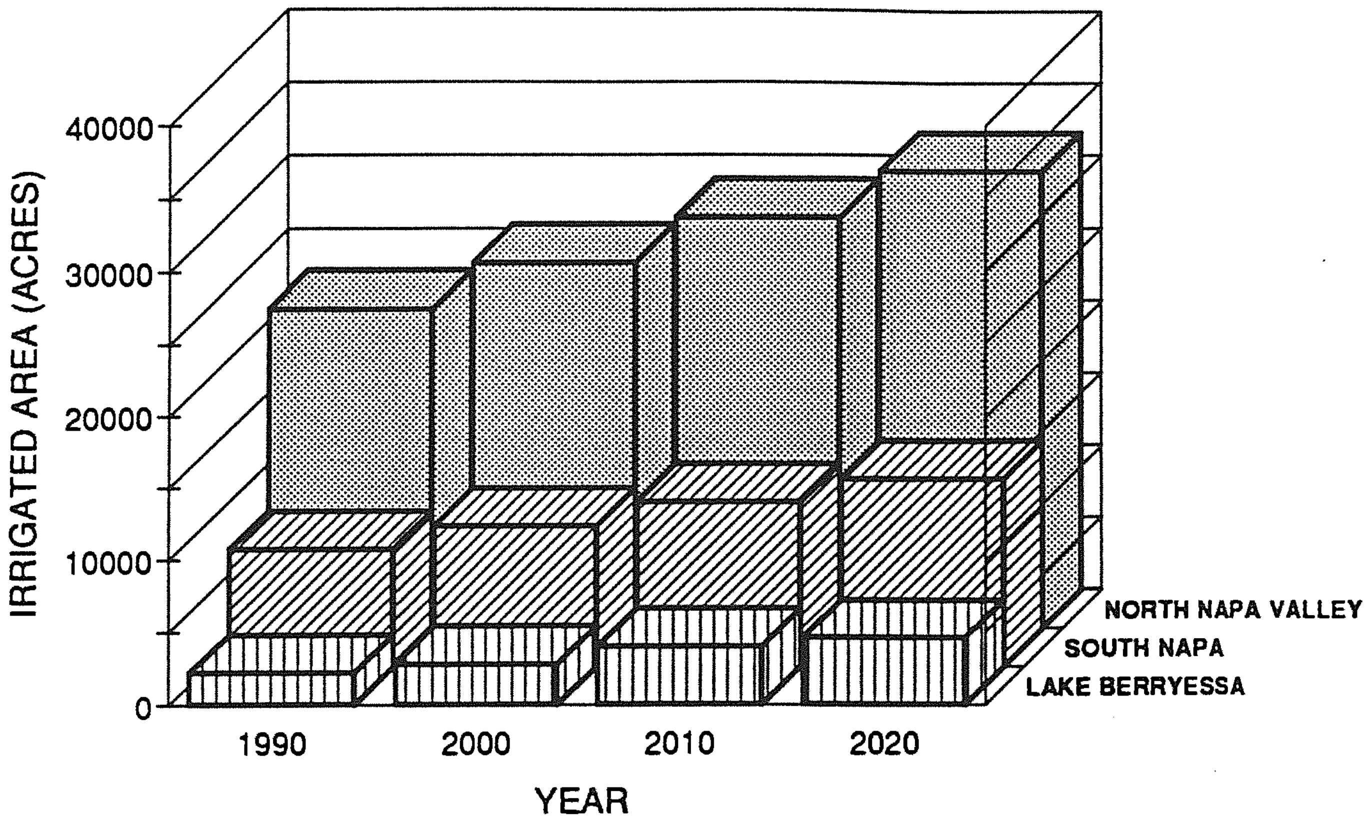
(1) For Alternate Scenarios 1 and 2, the Other Irrigated Agriculture water requirements and land use acreage are the same as the Baseline Projection (see Table 3-2 and Figure 3-3). Vineyard irrigation requirements, also not shown, are not changed for the analysis of Alternative Scenarios 1 and 2 (see Table 3-2).

(2) Conversion from sprinkler systems to wind machines is assumed to occur linearly at a rate such that in the year 2020 sprinkler systems for frost and heat protection are used on 50 percent of the vineyard lands in the North Napa Valley and Lake Berryessa Subareas, with the remaining lands in these subareas utilizing wind machines and other alternatives.



HISTORICAL AND PROJECTED POPULATION, NAPA COUNTY, CALIFORNIA

FIGURE 3-9



**PROJECTED IRRIGATED VINEYARD ACREAGE BY SUBAREA,
NAPA COUNTY, CALIFORNIA**

FIGURE 3-10

lands by subarea. For purposes of this study, it is assumed that the area dedicated to Agricultural Resource would be fully developed as vineyards by 2020 for the South Napa and North Napa Valley, and 50 percent developed in the Lake Berryessa Subarea (special treatment in the Lake Berryessa subarea is a result of restrictions in water availability and recommendations by the Advisory Committee). Vineyard land development was assumed to occur at a linear rate from 1987 to 2020. Acreage devoted to other irrigated crops is assumed to remain constant in each subarea for the duration of the planning period. Irrigated vineyard area, as designated by the DWR 1987 Napa County Land Use Study (Study #88-62), represents lands requiring frost and heat protection (North Napa Valley and Lake Berryessa Subareas only), as well as irrigation. The irrigation-applied water requirement for vineyards is the same over a given subarea. The irrigation-applied water requirement for Other Irrigated Agriculture is the same over the entire county for a given crop type.

Frost and Heat Protection Water Needs. Frost and heat protection of vineyards, assumed to be required in the North Napa Valley and Lake Berryessa Subareas only, is most commonly accomplished with the use of sprinkler systems or wind machines. Application rates for sprinkler systems are based on a thorough review of previous investigations and recommendations from Advisory Committee members. A review of existing vineyard land use indicated that much of the future vineyard development in these subareas will occur on hillsides, regions generally requiring little or no protection from frost and heat. It was assumed that 50 percent of the future land developed as vineyards in the North Napa Valley and Lake Berryessa Subareas will not require frost and heat protection. This is based on a comparison of DWR land use survey maps (DWR, 1987) together with USGS topographic maps and soil classifications identified in the Napa County Soil Survey (Soil Conservation Service, 1977).

Conditions of Alternative Scenario 1

Alternative Scenario 1 incorporated potential changes in water use patterns due to conservation activities and reduction in land use development. The departure from the conditions stated in the Baseline Projection for each water use category is described below.

Municipal/Industrial and Rural Water Need. The communities of Calistoga, Yountville, Napa, and American Canyon have developed water management plans in an attempt to improve overall water conservation. Given full implementation of these plans, water savings in the municipal and industrial sectors are estimated in the range of five to fifteen percent. Since it is not known to what extent these plans have been executed, it was assumed that the per capita estimate for the municipal/industrial water use categories is reduced by ten percent for the incorporated communities and American Canyon. The water demands were then calculated using the population projections from the Baseline Projection. This reduction does not apply to any of the rural communities in Napa County (refer to Table 3-3). It should be noted that the ten percent reduction in water use is in addition to the five percent reduction inherent in the per capita estimates previously discussed. It was assumed that no reductions in the rural and industrial categories would occur from conservation; because of their relatively small magnitude, any change would be minimal.

Irrigated Agricultural Water Needs. Most vineyard development in the Lake Berryessa Subarea is expected to occur in Pope Valley (Napa County General Plan, November 1986). However, because of extremely limited water rights in this subarea, water needed to support this growth may not be available. Therefore, it was assumed that the estimated vineyard acreage for 1990 in the Lake Berryessa Subarea will remain unchanged for the duration of the study period. The South Napa and North Napa Valley Subareas follow the conditions stated in the Baseline Projection (refer to Table 3-3).

Frost and Heat Protection Water Needs. From numerous discussions with experts involved in the Napa Valley wine industry, a recent trend of conversions from sprinkler systems to wind machines for frost and heat protection has been observed. One key factor contributing to this change is water availability. In regions where frost and heat protection are required (primarily the valley areas of the North Napa Valley and Lake Berryessa Subareas) as much as one-half of the total annual vineyard water requirement may be used for this purpose alone. To evaluate this potential change in agricultural water use characteristics, it was assumed the conversion will occur at a rate such that in the year 2020 sprinkler systems for frost and heat protection are used on 50 percent of the vineyard lands in the North Napa Valley and Lake Berryessa Subareas, with the remaining vineyard lands in these subareas utilizing wind machines.

Conditions of Alternative Scenario 2

Alternative Scenario 2 was developed to focus on the possibility of increased population growth and land use development from those rates stated previously for the Baseline Projection. The departure from the Baseline Conditions for each water use category is described below.

Municipal/Industrial and Rural Water Needs. As part of the planning process, the Napa County General Plan has reported estimates of projected population growth through the year 2000. There is some discrepancy between these projections and those developed by ABAG and the CDOF, the General Plan estimating a greater projected population. Hence, as a part of this scenario, the 1980-2000 growth rates used in the General Plan were used to calculate the population projections (it was assumed that these growth rates remain in effect through

2020). The water demands were then calculated using the per capita estimates from the Baseline Projection (refer to Table 3-3).

Irrigated Agricultural Water Needs. Based on discussions with experts in the Napa Valley wine industry, it is possible that the Carneros area will grow at a faster pace than any other region in Napa County. Several reasons support this observation, including: less expensive land; abundance of good quality land; and frost and heat protection are not usually required. Therefore, acreage designated as Agricultural Resource in the South Napa Subarea is assumed to be fully developed as vineyards by 2005, with vineyard land development occurring at a linear rate from 1987 to 2005. It was also assumed that the entire area in the Lake Berryessa Subarea designated as Agricultural Resource by the Napa County General Plan would be fully developed as vineyards by the year 2020. Vineyard development in the North Napa Valley Subarea followed the conditions previously stated in the Baseline Projection (refer to Table 3-3).

Frost and Heat Protection Water Needs. Frost and heat protection water needs follow the conditions stated in the Baseline Projection.

Baseline Projection Water Needs

The municipal, industrial, and rural projected water needs are presented for each community in Table 3-4. As stated earlier, the municipal and rural projections are based on derived average annual per capita estimates and projected population data. The industrial component was separated and treated independently (refer to Table 3-1 for further explanation of projected industrial water needs).

The annual projected water needs by water user category are presented in Table 3-5. Projected water needs were grouped by each subarea and totaled for Napa County. Figures 3-11 through 3-14 depict the projected water needs graphically. From the figures it is apparent that the South Napa Subarea contains the majority of the municipal and industrial water use (which accounts for approximately 65 percent of the total water use in this subarea). On the contrary, water use in the North Napa Valley and Lake Berryessa Subareas is dominated by agricultural requirements.

As can be seen in Figure 3-14, the change in composition of future water uses is relatively small from existing conditions. Currently municipal and industrial water uses are approximately 32 percent of total, rural seven percent, and agricultural requirements accounting for the remaining 61 percent. Future conditions indicate that municipal and industrial use will require approximately 34 percent, rural six percent, and agricultural 60 percent of the total water needs for Napa County in the year 2020.

TABLE 3-4

MUNICIPAL AND INDUSTRIAL WATER NEEDS
NAPA COUNTY, CALIFORNIA

AREA OF USE	1989	1990	1995	2000	2005	2010	2015	2020
CALISTOGA								
Municipal	670	745	810	930	1070	1130	1185	1240
Industrial	245	245	250	260	270	275	275	275
ST. HELENA								
Municipal	1285	1495	1755	1835	1940	2055	2155	2250
Industrial	440	440	440	440	440	440	440	440
YOUNTVILLE-TOWN								
Municipal (1)	420	450	490	515	540	570	595	625
Industrial	0	0	0	0	0	0	0	0
YOUNTVILLE-V.H.								
Municipal (1)	450	450	450	455	460	460	460	460
Industrial	0	0	0	0	0	0	0	0
NAPA								
Municipal	12405	13135	13940	14540	14900	15795	16540	17285
Industrial	655	690	735	765	785	830	870	910
AMERICAN CANYON								
Municipal	1430	1325	1455	1580	1765	1870	1960	2050
Industrial	266	266	266	266	266	266	266	266
ANGWIN AREA								
Munipical	620	630	675	725	770	815	855	895
Industrial	0	0	0	0	0	0	0	0
RURAL (2)								
Municipal	3150	3155	3205	3355	3525	3735	3910	4090
Industrial	---	---	---	---	---	---	---	---

(1) Yountville was separated into two components:
Town - water use within the Town Limits
V.H. - Water use by the Veterans Home

(2) Includes rural population and winery use.

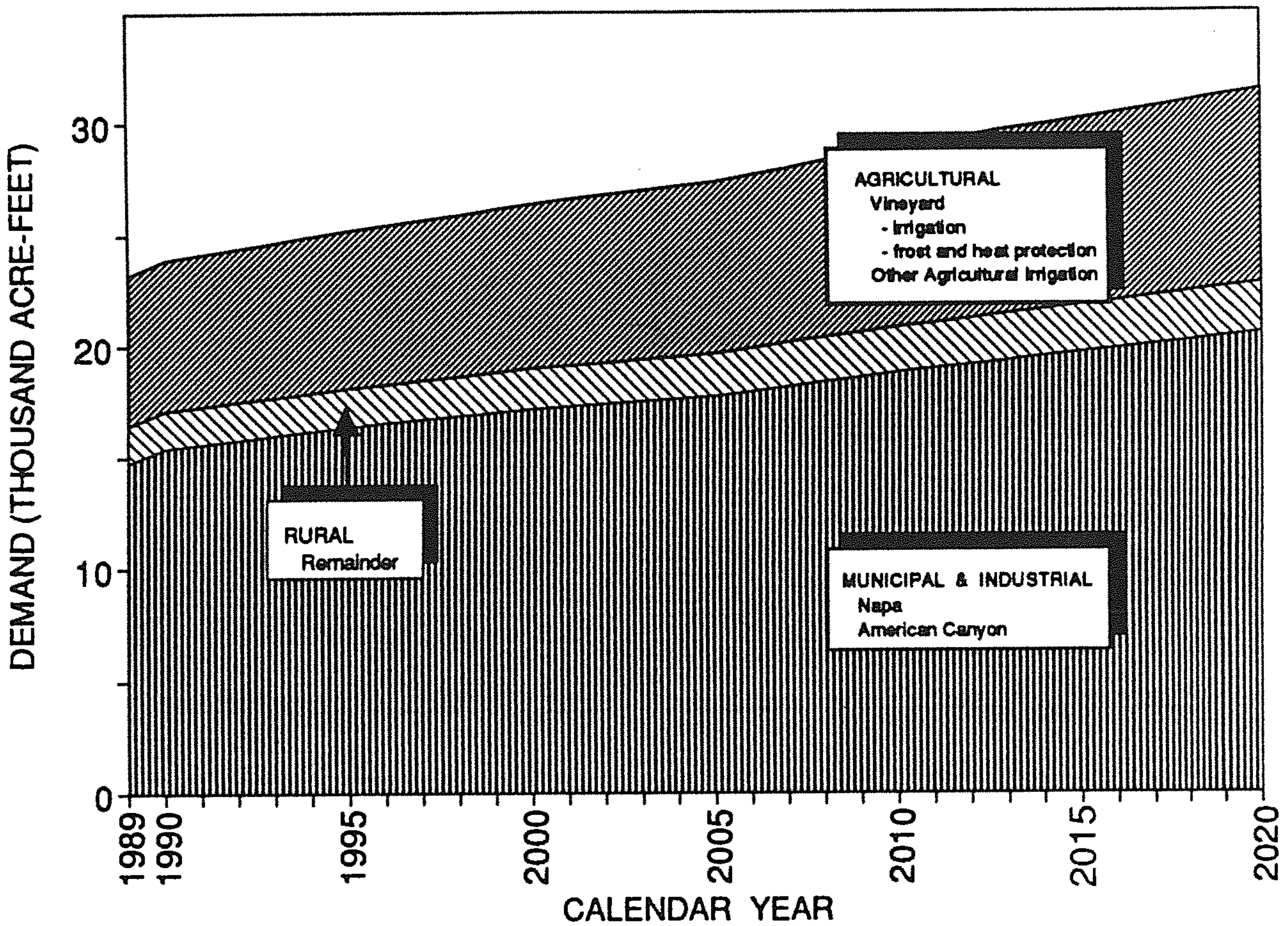
TABLE 3-5

ANNUAL PROJECTED WATER NEEDS BY WATER USER CATEGORY NAPA COUNTY, CALIFORNIA

WATER USE CATEGORY	1989	1990	1995	2000	2005	2010	2015	2020
NORTH NAPA VALLEY SUBAREA								
Municipal(1)	2825	3140	3505	3735	4010	4215	4395	4575
Industrial	685	685	690	700	710	715	715	715
Rural	1976	1988	2056	2168	2285	2422	2536	2651
Vineyard	21867	22181	23356	24532	25708	26883	28059	29235
Other Irrigated Agriculture	797	797	797	797	797	797	797	797
Subtotal	28150	28791	30404	31932	33510	35032	36502	37973
SOUTH NAPA SUBAREA								
Municipal	13835	14460	15395	16120	16665	17665	18500	19335
Industrial	921	956	1001	1031	1051	1096	1136	1176
Rural	1702	1705	1732	1811	1903	2017	2112	2207
Vineyard	3183	3248	3576	3904	4232	4560	4888	5216
Other Irrigated Agriculture	3506	3506	3506	3506	3506	3506	3506	3506
Subtotal	23147	23875	25210	26372	27357	28844	30142	31440
LAKE BERRYESSA SUBAREA								
Municipal	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0
Rural	95	95	96	101	106	112	117	123
Vineyard	2372	2460	2802	3144	3486	3828	4170	4512
Other Irrigated Agriculture	3359	3359	3359	3359	3359	3359	3359	3359
Subtotal	5826	5914	6257	6604	6951	7299	7646	7994
NAPA COUNTY								
Municipal	16660	17600	18900	19855	20675	21880	22895	23910
Industrial	1606	1641	1691	1731	1761	1811	1851	1891
Rural	3773	3788	3884	4080	4294	4551	4765	4981
Vineyard	27422	27889	29734	31580	33426	35271	37117	38963
Other Irrigated Agriculture	7662	7662	7662	7662	7662	7662	7662	7662
Subtotal	57123	58580	61871	64908	67818	71175	74290	77407

Notes:

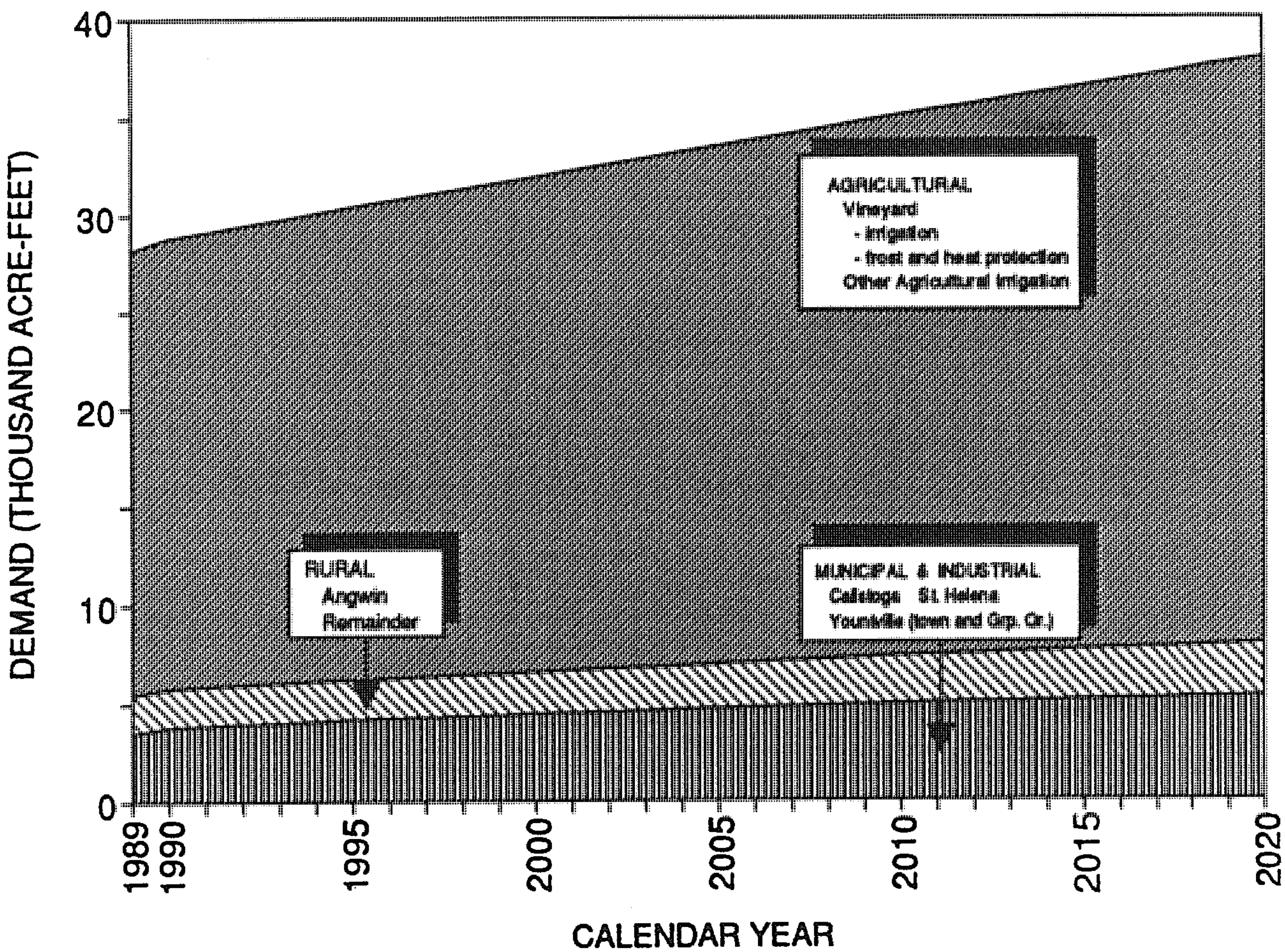
1) Includes Veterans Home at Yountville



PROJECTED WATER NEEDS - SOUTH NAPA SUBAREA, NAPA COUNTY, CALIFORNIA

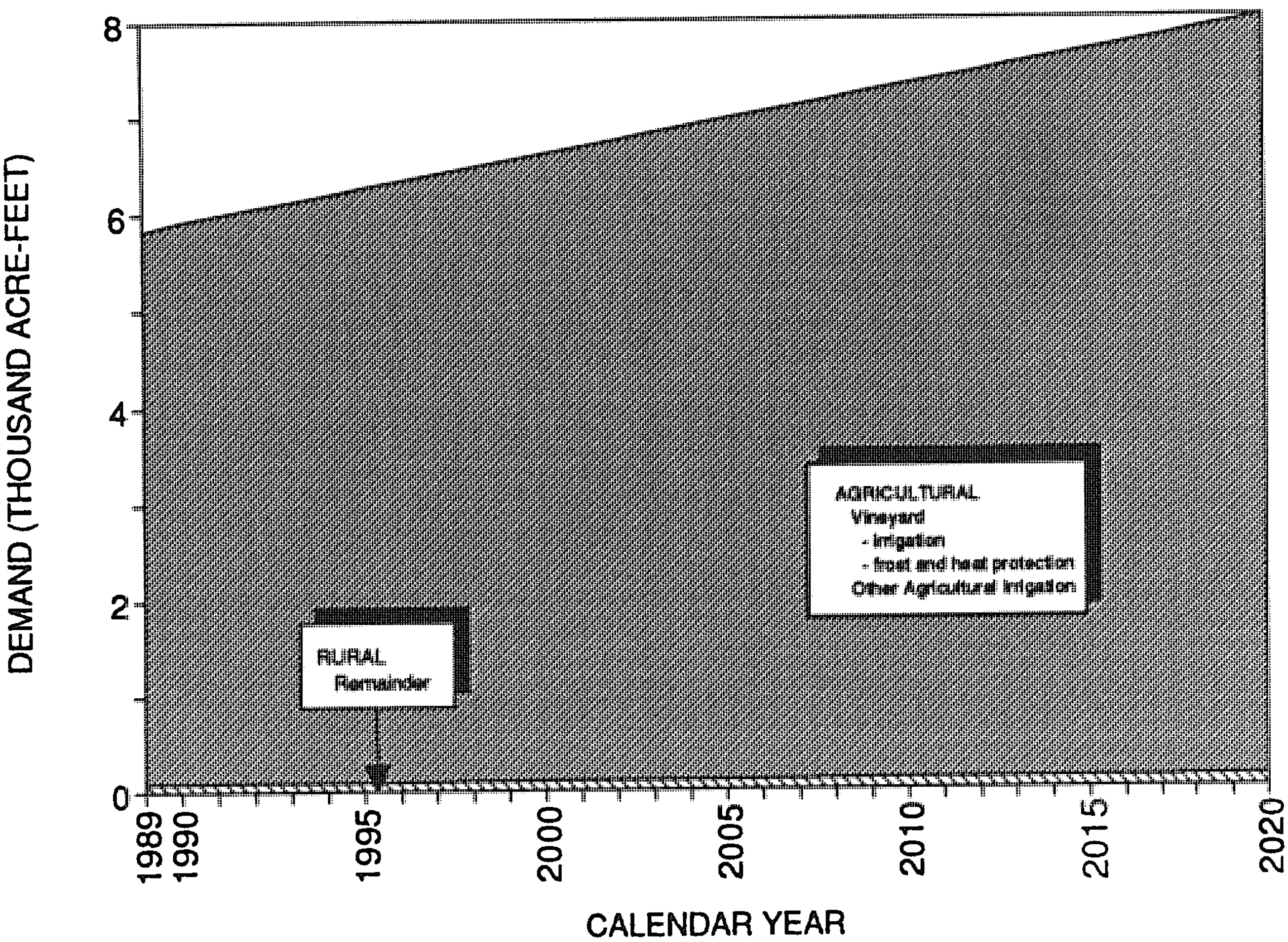
FIGURE 3-11

JMM



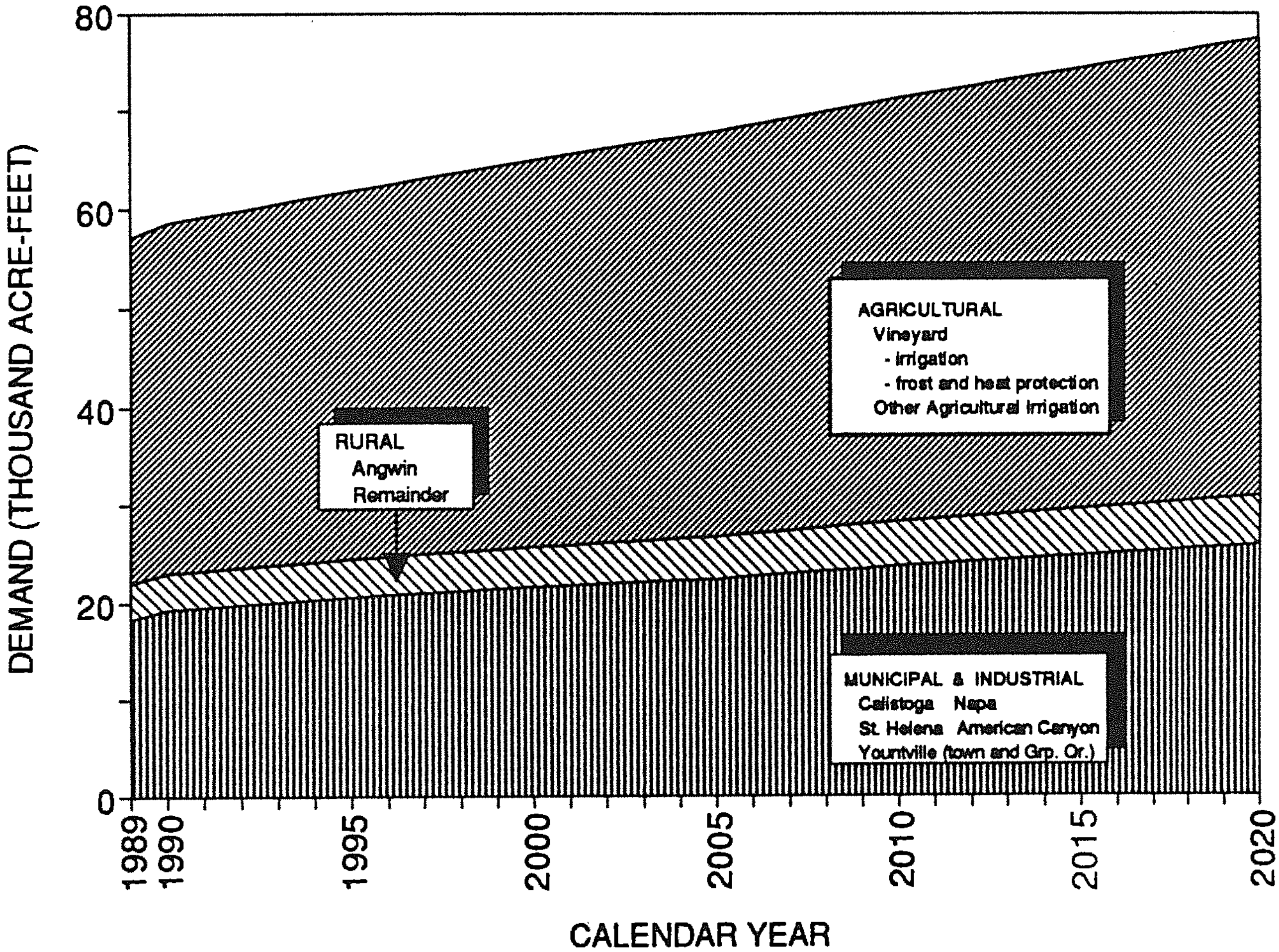
PROJECTED WATER NEEDS - NORTH NAPA SUBAREA, NAPA COUNTY, CALIFORNIA

FIGURE 3-12



PROJECTED WATER NEEDS - LAKE BERRYESSA SUBAREA, NAPA COUNTY, CALIFORNIA

FIGURE 3-13



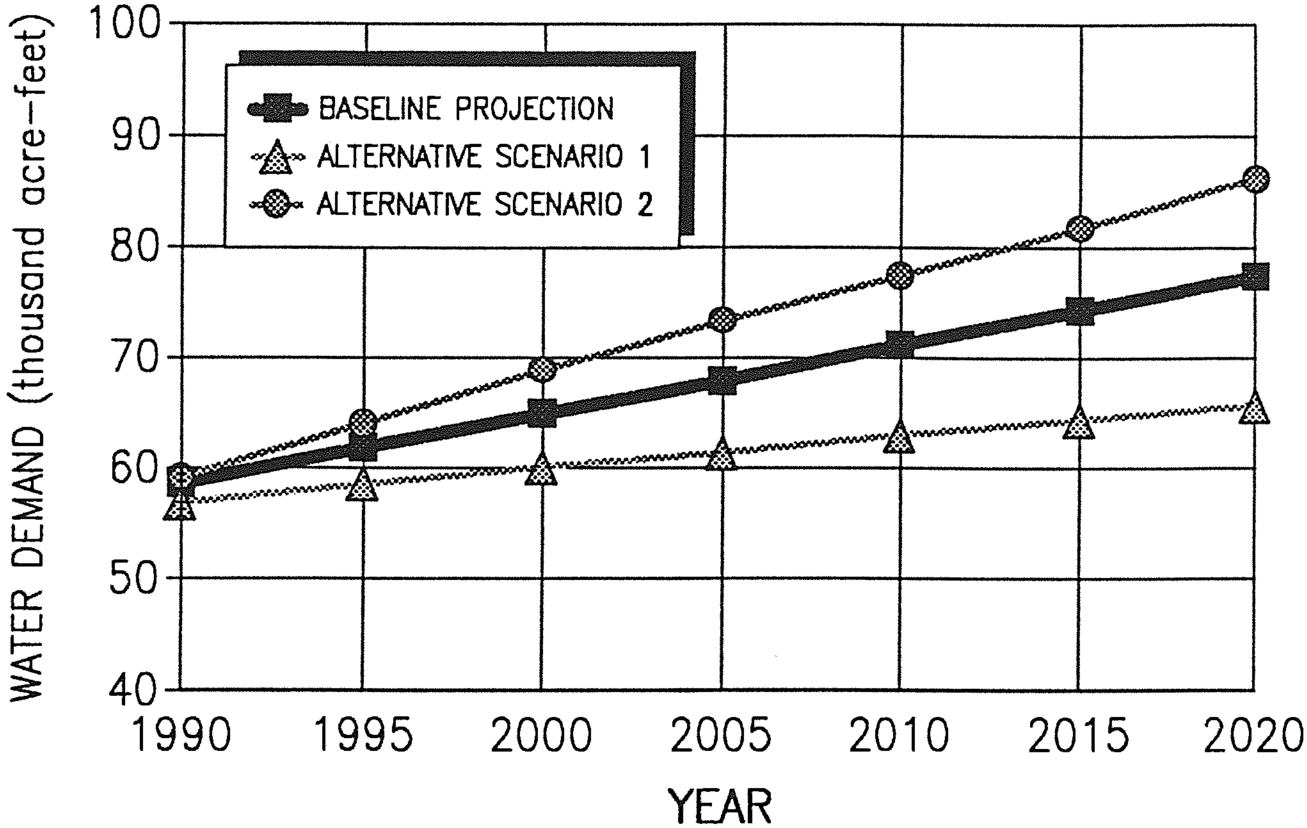
PROJECTED WATER NEEDS - NAPA COUNTY, CALIFORNIA

FIGURE 3-14

Alternative Scenario Water Needs

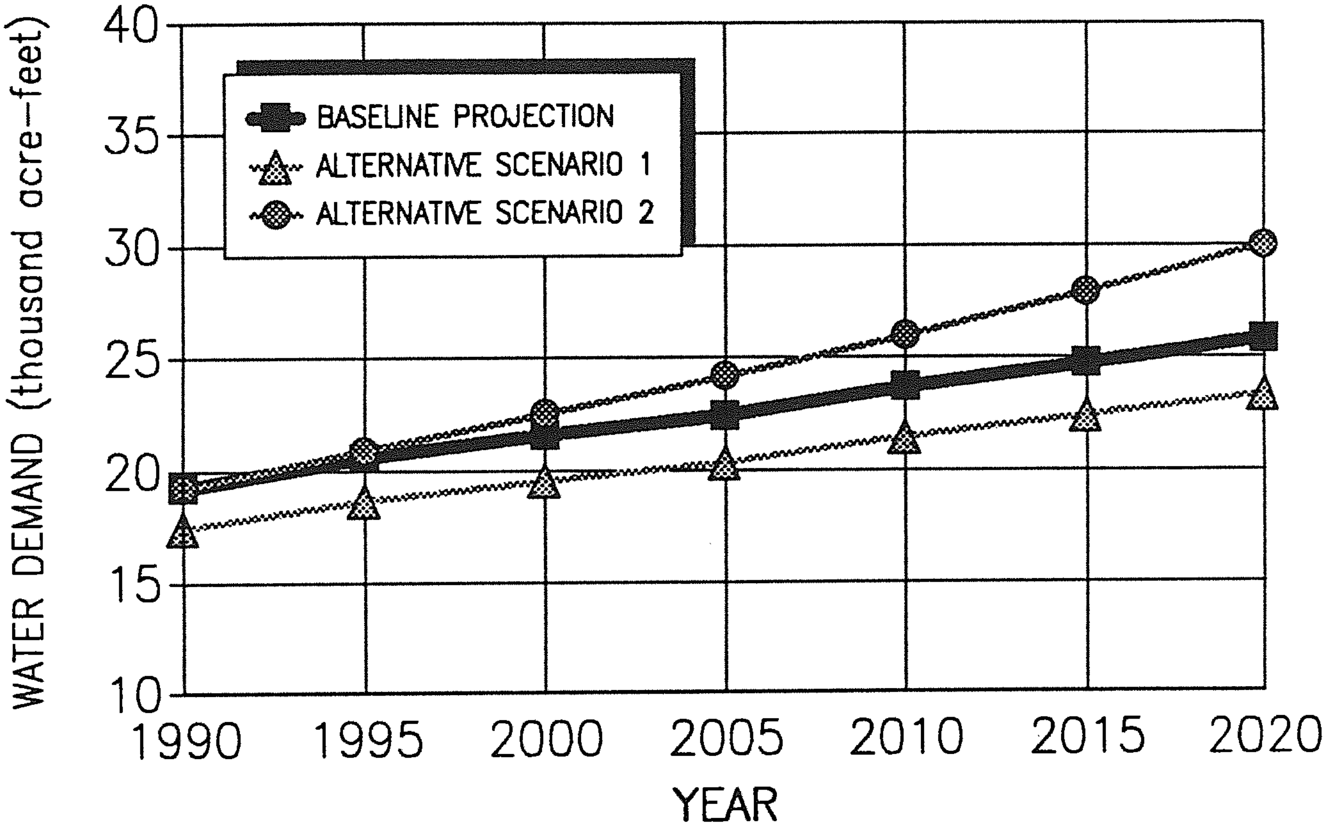
The impacts of potential changes in future water use characteristics, population projections, and land use development, from those used in the Baseline Projection, are reflected in Figures 3-15 through 3-17. Alternative Scenario 1 would result in a reduction of approximately fifteen percent in total water needs for Napa County by the year 2020. This is due primarily to the changes in vineyard water use practices, and to a lesser extent the increased water conservation effort by municipalities.

Alternative Scenario 2 shows a potential for an increase of projected water needs from the Baseline Projection of approximately 11 percent. This increase is due to the accelerated population growth (see Figure 3-16) and the additional land use development (see Figure 3-17).



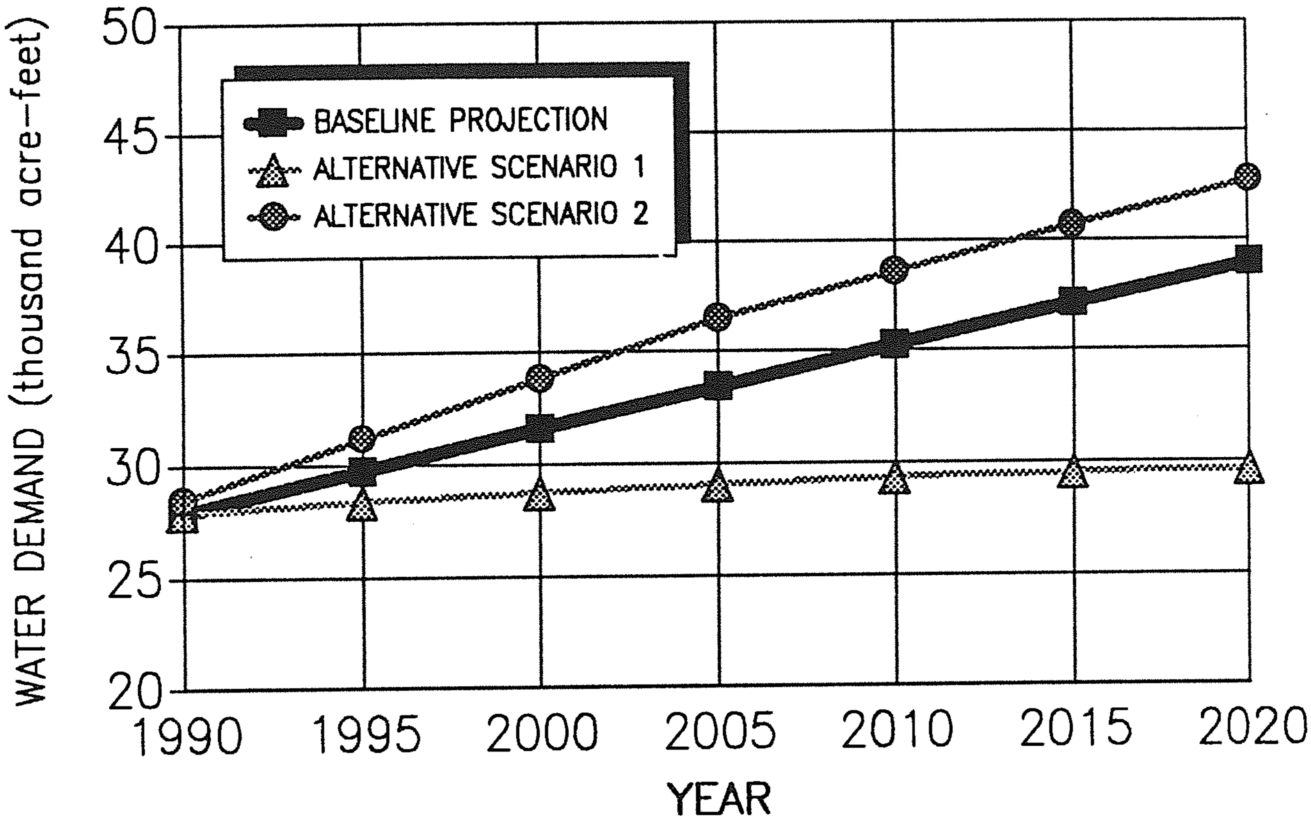
TOTAL PROJECTED WATER NEEDS OF THE BASELINE PROJECTION AND ALTERNATIVE DEMAND SCENARIOS - NAPA COUNTY, CALIFORNIA

FIGURE 3-15



MUNICIPAL AND INDUSTRIAL PROJECTED WATER NEEDS OF THE BASELINE PROJECTION AND ALTERNATIVE DEMAND SCENARIOS - NAPA COUNTY, CALIFORNIA

FIGURE 3-16



VINEYARD PROJECTED WATER NEEDS OF THE BASELINE PROJECTION AND ALTERNATIVE DEMAND SCENARIOS - NAPA COUNTY, CALIFORNIA

FIGURE 3-17

SECTION 4

WATER QUALITY

This section discusses the quality of surface and groundwaters of Napa County. Data sources are described first. Standards for drinking water and requirements for industrial and agricultural water uses of Napa County are summarized next. This is followed by a review of the historical and existing quality of surface and groundwaters of Napa County. The review is limited to inorganic and physical parameters exceeding the drinking water standards, and requirements for industrial and agricultural supply.

DATA SOURCES

Water quality data were obtained from the California Department of Health Services (DOHS), California Department of Water Resources (DWR), and published reports. Available data for different source waters varied considerably. Where data for source water was limited or unavailable, raw water quality measurements at the treatment plants were used.

The quality of Bell Canyon Reservoir water is described using six raw and six treated water samples collected between September 1974 and May 1990. Rector Reservoir water quality is based on three raw and five treated water samples obtained between January 1986 and July 1987. Kimball Reservoir water quality is based on two raw and ten treated water samples measured between May 1982 and March 1990. The quality of Lake Hennessey and Milliken Reservoir waters were characterized from average monthly raw and treated samples measured at the respective treatment plants. At the Hennessey Water Treatment Plant, seventy five monthly measurements of average values were recorded between January 1983 and July 1990, and at the Milliken Water Treatment Plant, during the same period, forty monthly measurements were recorded. Between December 1985 and May 1986, the Milliken plant was not in service.

The quality of North Bay Aqueduct water was obtained from average monthly raw and treated samples measured at the Jameson Water Treatment Plant. Sixty three monthly measurements were recorded between November 1983 and July 1990.

Lake Berryessa water quality was described from Putah Creek measurements recorded at Winters, Yolo County, by DWR between 1985 and 1987.

Water quality data for the Napa River was obtained from DWR, consisting of 216 measurements made at St. Helena between December 1951 and April 1989.

Napa County groundwater quality data was obtained from USGS and DWR reports. Much of the available information on Northern Napa, Milliken-Sarco-Tulucay, Carneros and Putah Creek groundwaters was collected between January 1948 and July 1972.

USER QUALITY REQUIREMENTS

Water quality requirements, in general, depend upon the potential beneficial use of water. Napa County's current water demand (1989) generated by municipal, industrial and agricultural uses is estimated to be 57,100 Ac-Ft/Yr. Other beneficial uses of Napa County surface waters include recreation, fish spawning and warm fresh water habitat as well as migration route and temporary environment for anadromous fish species. In this report, however, only water quality issues related to municipa, industrial and agricultural uses are described. Municipal demand constitutes about 29 percent of the total water demand; industrial demand about 3 percent; and agriculture about 61 percent. Surface water, including from the local reservoirs and imported water, supplies more than 95 percent of the total municipal and industrial demand. Surface water from the local reservoirs and Napa River also supplies about 40 percent of the total agricultural demand. Groundwater supplies less than 5 percent of the municipal and industrial demand and about 60 percent of the agricultural demand.

Quality Requirements for Municipal Supply

Table 4-1 lists the primary and secondary water quality standards for inorganic and physical parameters in drinking water supplies established by DOHS. Primary standards have been established as Maximum Contaminant Levels (MCLs) for parameters that are known to adversely affect human health and are enforceable by law. Secondary standards are set as recommended concentration limits for some parameters and are based mainly on aesthetic considerations.

Primary drinking water quality standards have been exceeded for turbidity in raw waters of all local reservoirs as well as the North Bay Aqueduct, and for nitrates in the Napa River and groundwaters of the Northern Napa, and Carneros basins. Secondary drinking water quality standards have been exceeded for color, odor, iron, and manganese in various surface and groundwater sources.

Quality Requirements for Industrial Supply

Quality requirements for industrial water vary over a wide range depending on the type of industry and the industrial process or equipment installed in a particular facility. Because the variance is so great it is unlikely that most domestic supplies will be of the proper quality without further treatment. Drinking water standards would apply to the wine-making industry. Table 4-2 lists values for selective water quality parameters that may be of relevance to other Napa County industries.

TABLE 4-1

CALIFORNIA DRINKING WATER QUALITY STANDARDS

		California Title 22	
Parameter	Unit	Primary MCL(1)	Secondary (2)
Physical/Aesthetic			
Color	unit	-	15
Corrosivity	-	-	relatively low
Odor	TON	-	3
pH	unit	-	-
Specific Conductance	µmho/cm	-	900
Turbidity	TU	1	-
Total Dissolved Solids	mg/l	-	500
Inorganic Chemicals			
Aluminium	mg/l	1	-
Arsenic	mg/l	0.05	-
Barium	mg/l	-	-
Cadmium	mg/l	0.01	-
Chlorides	mg/l	-	250
Chromium (total)	mg/l	0.05	-
Copper	mg/l	-	1
Fluoride	mg/l	1.4-2.4(3)	-
Iron	mg/l	-	0.03
Lead	mg/l	0.05	-
Manganese	mg/l	-	0.05
Mercury	mg/l	0.002	-
Nitrate (as NO3)	mg/l	45	-
Selenium	mg/l	0.01	-
Silver	mg/l	0.05	-
Zinc	mg/l	-	5

Note: (1) Standards are enforceable
(2) Standards are recommended
(3) Temperature dependent

TABLE 4-2

SUMMARY OF INDUSTRIAL WATER QUALITY PREFERENCE

Parameter	Preferred Value
Chlorides (mg/l)	200
Color (color units)	25
Iron (mg/l)	0.3
Bicarbonate (mg/l)	480
Manganese (mg/l)	1
Nitrate (mg/l)	8
Total Dissolved Solids (mg/l)	150
Total Hardness (mg/l)	120

* Interpreted from California Department of Water Resources (1989: 8)

In addition to the parameters that exceed the drinking water standards, total dissolved solids and total hardness values in various surface and groundwaters exceed the preferred industrial water quality levels.

Quality Requirements for Agricultural Supply

Water quality constraints for agriculture are generally less stringent than those for municipal supply, and as such, agricultural water quality requirements, rather than standards, have been established for irrigation. Since Napa County agriculture is dominated by grape growing, only the water quality requirements for irrigation of vineyards are discussed. Table 4-3 lists the water quality requirement for irrigation for vineyards. The suitability of water for irrigation depends upon the effects of chemical constituents in the water on the plants and the soil. Permissible salt concentrations for irrigation water depend on the salinity tolerance of the plant, soil types, climatic conditions, and irrigation practices.

Potential water quality constraints for agricultural supply in Napa County include high levels of dissolved solids, boron, nitrate, sodium, and chloride.

SOURCE QUALITY ISSUES

Table 4-4 lists the concentration range for parameters that have exceeded the drinking, industrial or agricultural water quality requirements in the local reservoirs of Napa County and the North Bay Aqueduct. Raw water quality data for local reservoirs including Hennessey, Milliken, Rector, Bell Canyon, and Kimball, and for the North Bay Aqueduct, indicate that the following parameters have exceeded drinking water quality standards at different times: turbidity, color, odor, iron and manganese. In some of these sources even the industrial preference levels for total dissolved solids and total hardness have been exceeded.

Table 4-5 lists the concentration range for parameters that have exceeded the drinking, industrial or agricultural water quality requirements in Lake Berryessa, Napa River and four groundwater basins in Napa County. The constituents listed in Tables 4-4 and 4-5 are elaborated below with regard to each surface and groundwater source.

Turbidity

Turbidity is attributed to suspended and colloidal material such as microorganisms, organic debris, silica or other mineral substances, clay or silt. Turbidity reduces the clarity of the water and diminishes the penetration of light. It is commonly analyzed

TABLE 4-3

WATER QUALITY REQUIREMENTS FOR IRRIGATION OF VINEYARDS

Parameter	Value		
	No problems	Increasing problems	Usually unsatisfactory
Total Dissolved Solids (mg/l)	0 - 500	500 - 2000	2000+
Sodium (mg/l)	0 - 69	69 - 184	184+
Sodium Adsorption Ratio	0 - 6	6 - 9	9+
Chlorides (mg/l)	0 - 106	106 - 284	284+
Bicarbonate (mg/l)	0 - 76	76 - 152	152+
Boron (mg/l)	0 - 1	1 - 3	3+
Nitrate-Nitrogen (mg/l)	0 - 5	5 - 30	30+
Biochemical Oxygen Demand (mg/l)	0 - 10	10 - 20	20+
pH	6.5 - 8.4		
Coliform, Most Probable Number	2.2*		

* For sprinkler irrigation of produce.

Source: University of California, Agriculture Extension Service

Table 4-4

Water Quality* in Local Reservoirs and North Bay Aqueduct

Source	Hennessey	Milliken	Kimball	Rector	Bell Canyon	NBA
Parameter						
Turbidity (TU)	3 - 26	2.3 - 18	8 - 11	0.5 - 8	1.6 - 2.5	2 - 68
Color (color unit)	0 - 100	2.5 - >70	20 - 35	35 - 50	1 - 30	2 - 77
Odor (TON)	2 - 4	<3**	3 - 6	<3**	1 - 8	<3 - 8
Iron (mg/l)	0 - 0.49	0.05 - 1.63	<0.1 - 0.83	0.09 - 0.65	0.1 - 0.61	<0.3**
Manganese (mg/l)	0.01 - 1.2	0.01 - 0.15	0.01 - 0.055	<0.05**	<0.05**	0.01 - 0.63
Hardness (mg/l)	100 - 147	<120**	83 - 150	37 - 42	21 - 125	90 -186
Total Dissolved Solids (mg/l)	<150 - 180	<150**	100 - 180	46 - 150	61 - 220	<150 -283

* Only concentration ranges of parameters exceeding beneficial use requirements are listed
** All records below stated value

Table 4-5

Water Quality* in Lake Berryessa, Napa River and Napa County Groundwater

Source			Groundwater Basins			
	Lake Berryessa	Napa River	Northern Napa	Milliken-Sarco Tulocay	Carneros	Putah Creek
Parameter						
Iron (mg/l)	-	-	0 - 5.1	0 - 67	-	-
Hardness (mg/l)	139 - 178	33 - 182	0 - 315	-	-	-
Nitrates (mg/l)	-	0.44 - 53	0.06 - 50	-	>45	-
Total Dissolved Solids (mg/l)	170 - 262	<150	98 - 1000	500 - >1000	500 - >2000	>2000
Sodium (mg/l)	8 - 23	4 - 36	7.7 - 644	-	-	-
Chloride (mg/l)	4 - 20	4 - 45	50 - 300	-	-	-
Boron (mg/l)	0.1 - 0.3	0.05 - 1.9	4.2 - 32	>1	-	1 - 10
Sodium Adsorption Ratio	-	0.4 - 1.3	1 - 56	-	-	23.6

* Only concentration ranges of parameters exceeding beneficial use requirements are listed
\- Records not available

by measuring the amount of light scattered by particulate matter, higher turbidity readings, measured as turbidity units (TU), indicate an increase in particulate matter and light scattering, and a corresponding decrease in clarity.

High turbidity levels in drinking water pose a potential health risk and are aesthetically undesirable, causing consumer dissatisfaction. Turbidity can interfere with disinfection-the particulate matter, which causes turbidity, shielding bacteria and viruses from destruction by the disinfecting agent. Water-borne microorganisms, if not destroyed by disinfection, are capable of causing gastroenteritis, infectious hepatitis or other diseases.

Turbidity also degrades the aesthetic quality of drinking water. Most consumers judge their water supply initially by taste and appearance. Turbidity reduces the clarity of water and makes it aesthetically less desirable. Also, particulates associated with turbidity may adsorb or be comprised of organic material which has undesirable tastes or odors. When particulate material settles in distribution reservoirs it can later be decomposed or resuspended, either of which can intensify tastes and odors.

The DOHS requires that surface supplies exposed to significant sewage hazard or significant recreational use shall receive, as a minimum, pretreatment, filtration and disinfection, and that filtered water turbidity be maintained at less than 0.5 TU, as compared to surface supplies not exposed to microbiological contamination, where a standard of 1 TU applies.

All monthly average turbidity levels in raw waters of Hennessey, Milliken and Jameson Water Treatment Plants (North Bay Aqueduct) exceeded 0.5 TU, and they ranged between 3 and 26 TU, 2.3 and 18 TU, and 2 and 68 TU, respectively. All monthly average turbidity levels in treated waters of each plant was below 0.5 TU.

Turbidity levels in two raw water samples from Kimball Reservoir were 8 and 11 TU. Turbidity levels in four treated samples were less than 0.5 TU; in two treated samples between 0.5 and 1 TU; and in one treated sample it was 8.7 TU. The high turbidity level noted in the last sample may have been because it was taken from a faucet that was not used often. This sample also had high iron concentration and color values.

Three raw water samples from Bell Canyon Reservoir had turbidity levels between 1.6 and 2.5. One treated water sample exceeded the 1 TU level (2.2 TU), another one was between 0.5 and 1 TU (0.71 TU), and two others were below the 0.5 TU level.

One raw sample from Rector Reservoir had a turbidity level greater than 1 TU (8 TU) and another raw sample was below 0.5 TU. Two treated water samples exceeded the 1 TU level (1.6 and 2.5 TU).

Water Quality

Color

Color in water results from the presence of metallic ions such as iron and manganese, or the presence of organic material such as humus or peat, plankton, and weeds. The DOHS recommends a drinking water standard of 15 color units. Although aesthetically color may be objectionable, it does not pose a health hazard.

In Hennessey, Milliken and Jameson Treatment Plants, color levels in the raw water ranged between 0 and 100 color units, 2.5 and over 70 color units, and 2 and 77 color units, respectively. Drinking water standards in raw waters of these plants were exceeded twenty eight, twenty seven and twenty nine times, respectively. Color values in all treated samples of the three plants were below the standard.

Two raw water samples from Rector Reservoir had values of 35 and 50 color units. All five treated samples met the standard.

Two raw water samples from Kimball Reservoir had values of 20 and 35 color units. Eight treated samples had color levels below the standard. High color value (30 color units) in one particular sample may be attributed to infrequent use of the faucet from which the sample was obtained.

Raw water samples in Bell Canyon Reservoir had values between 1 and 30 color units. Two samples had values of 20 and 30 color units. Color levels in all treated samples were below the standard.

Odor

Odor is an important aesthetic quality of water. Its intensity is measured as the "threshold odor number" (TON). For drinking supplies, the recommended threshold odor number is 3 units. At the Hennessey Treatment Plant, odor values in the raw water ranged between 2 and 4 TON, and exceeded the recommended standard four times. At Jameson Treatment Plant, the standard was exceeded once at 8 TON. All treated samples at both Hennessey and Jameson Treatment Plants had odor values below the standard.

Drinking water quality standard for odor was exceeded in one raw water sample from Bell Canyon Reservoir, and in one raw and two treated water samples from Kimball Reservoir.

Iron and Manganese

High levels of iron in water imparts an unattractive appearance and taste. High concentrations of manganese result in disagreeable taste and discolors laundry. Iron and manganese concentrations can be caused by anaerobic conditions resulting from reservoir stratification. The DOHS recommended drinking water standard for iron and manganese are 0.3 mg/l and 0.05 mg/l, respectively.

Iron concentrations in raw waters of Hennessey and Milliken Treatment Plants were between 0 and 0.46 mg/l, and 0.05 and 1.63 mg/l, respectively. Drinking water standards in raw waters of these two plants were exceeded two and four times, respectively. All the treated samples met the drinking water standards.

In raw waters of Bell Canyon Reservoir, iron concentration ranged from less than 0.1 to 0.61 mg/l, and the standard was exceeded twice. All treated samples met the standards.

One raw water sample from Kimball Reservoir had iron concentration of 0.83 mg/l. All treated samples, except one, had values below the drinking water standard. The high iron concentration of 1 mg/l in one treated sample was attributed to the infrequently-used faucet.

In raw waters of Rector Reservoir, iron concentration ranged from 0.085 to 0.65 mg/l, the standard was exceeded once. All treated samples met the standards.

Northern Napa groundwaters exhibit high iron concentrations. Four wells northwest of St. Helena had iron concentrations from 0.88 to 5.1 mg/l. One well south east of St. Helena had an iron level of 3.8 mg/l. One well, measured in 1915, north of the Milliken-Sarco-Tulucay basin, had an iron level of 67 mg/l, and another well in the northern part of Milliken-Sarco-Tulucay basin contained an iron concentration of 15 mg/l.

Manganese concentrations in raw waters of Hennessey, Milliken and Jameson Treatment Plants ranged from 0.01 to 1.2 mg/l, 0.01 to 0.15 mg/l, and 0.01 to 0.63 mg/l, respectively. Drinking water standards at these plants were exceeded forty eight, eleven and twenty five times, respectively. At the Hennessey plant, manganese levels in treated water samples exceeded the standard nine times. At Milliken and Jameson plants, all treated samples had manganese values below the standard.

All of the raw and treated samples collected from Kimball and Bell Canyon waters had manganese values below the standard. Raw water from Rector Reservoir had manganese levels ranging from less than 0.05 to 0.27 mg/l. They exceeded the drinking water standards twice. All of the treated samples met the standard.

Hardness

Hardness is a term applied to the soap-consuming power of a water. Any substance that will form an insoluble curd or scum with soap causes hardness. In natural water, hardness is caused mainly by calcium and magnesium ions. Other ions which cause hardness such as iron, manganese, copper, barium, lead or zinc, are normally present in trace quantities and do not contribute significantly to hardness. Hardness is traditionally reported in milligrams per liter as calcium carbonate.

Although hardness is not regulated in drinking water supplies, the historical concern has been its aesthetic and economic impact. According to Davis and DeWeist (1966), water hardness, measured as calcium carbonate, can be classified as follows: up to 60 mg/l classified as soft; between 60-120 mg/l as moderately hard; between 120-180 mg/l as hard; and greater than 180 as very hard. Moderately hard levels require consumers to use more soap and detergent, even with the use of synthetic detergents. Hardness can also lead to the formation of scale in plumbing fixtures, mainly in boilers and other heat exchange equipment, and the precipitation of scum in laundry equipment and cooking utensils. Thus, higher hardness levels would require consumers to spend more in purchase of cleaning materials and repair or replacement of plumbing or hot water heating equipment. In industrial supplies, in general, a hardness level of 120 mg/l or less is preferred.

Hardness in the raw water of Hennessey, Milliken and Jameson Water Treatment Plants ranged from 100 to 147 mg/l, below 120 mg/l, and 90 to 186 mg/l, respectively. The 120 mg/l hardness level was exceeded forty six and forty three times at Hennessey and Jameson plants, respectively.

Bell Canyon and Rector Reservoir waters are soft. Hardness in Kimball Reservoir water is between 69 and 150 mg/l. The 120 mg/l level was exceeded twice.

Lake Berryessa water exceeds the 120 mg/l level all the time. Hardness values range between 139 and 178 mg/l.

Hardness levels in the Napa River are between 33 and 182 mg/l. Eighty six samples exceeded 120 mg/l level and two samples exceeded 180 mg/l level.

Hardness values in the Northern Napa groundwater basin ranges between 0 and 315 mg/l. Seventeen wells had levels above 120 mg/l.

Nitrates

Nitrates are common contaminants in surface and groundwaters in many rural communities in California and are becoming increasingly widespread because of agricultural activities and disposal of sewage on or below the land surface. Nitrates can enter the groundwater through either the conversion of naturally-occurring or introduced organic nitrogen or ammonia. The primary drinking water quality standard for nitrates is 45 mg/l as nitrate (10 mg/l as nitrogen). Excess nitrates cause methemoglobinemia in infants (the blue baby syndrome). Nitrates are converted to nitrites in the intestines and inhibit the body's ability to ingest oxygen. Water quality requirements for irrigation of vineyards as well as for industrial supply espouse more stringent nitrate limits than drinking water standards. In irrigation supplies, nitrate levels exceeding 5 mg/l up to 30 mg/l cause increasing problems, and values over 30 mg/l are usually unsatisfactory. In industrial supplies, values below 8 mg/l are preferred, and over 30 mg/l are not recommended.

Nitrate levels in the Napa River (reported as nitrogen) range between 0.44 and 53 mg/l as nitrate. Drinking water standards were exceeded once (in May 1962). Forty samples had nitrate levels within the "increasing problem" category for irrigation requirements for vineyards and fifteen fell in the "usually unsatisfactory" category. Thirty seven samples had values above the preferred requirements for industrial supply, and fifteen above the recommended limits.

High nitrate levels in groundwaters have been noted in several areas of Napa County. Nitrate levels in Northern Napa groundwaters (measured between December 1955 and July 1971) ranged from 0.06 to 50 mg/l. Two Northern Napa wells, located northwest of the City of Napa, had levels exceeding the drinking water standard. Six wells had nitrate values that were within the "increasing problem" category for irrigation requirements and above the preferred requirements for industrial supply. In the Carneros basin, 2 wells, one located in the northern part of the basin and the other west of Cuttings Wharf, had nitrate levels above the drinking water standard.

Total Dissolved Solids (TDS)

Surface and groundwater contains a variety of dissolved inorganic constituents as a result of chemical and biochemical interactions with geological materials. The major constituents in TDS - sodium, magnesium, calcium, chloride, bicarbonate, and sulfates, occur in ionic form and normally comprise more than 90 percent of the TDS. The DOHS recommended TDS concentration for municipal supply is 500 mg/l, which is also the limit for the "no problem" category for irrigation requirements for vineyards. For industrial supply, TDS levels of 150 mg/l or less are preferred.

TDS concentration in the Napa River is between 99 and 256 mg/l. Fifty six samples had concentrations above the preferred industrial supply requirement.

Northern Napa groundwaters have TDS values between 98 and 1000 mg/l. High TDS concentrations (greater than 500 mg/l) are found northwest of Calistoga. Thirty two wells had TDS values above the preferred industrial supply requirements. Groundwaters in the Carneros basin have TDS concentrations between 500 to over 2000 mg/l. TDS concentrations between 500 and 1000 mg/l are found in the eastern and southern boundaries of the Carneros basin. The northeastern part of the basin had values between 1000 and 2000 mg/l. Two wells, one in the eastern part of the basin and another in the southern part of the basin, had values exceeding 2000 mg/l. In the Milliken-Sarco-Tulucay groundwater basin, east of Napa, TDS concentrations range between 500 and 1000 mg/l, and south of Napa, they exceed 1000 mg/l. One well in Pope Valley (in the Putah Creek basin) had TDS levels exceeding 2000 mg/l.

Sodium

Although sodium is not regulated in drinking water supplies, the Environmental Protection Agency (EPA) has recommended that a 20 mg/l be used as a goal for public water systems. The American Heart Association has suggested the same level (20 mg/l) to afford protection to those individuals with heart or kidney disease who require a low sodium diet. In supplies for vineyard irrigation, sodium concentrations above 69 and up to 184 mg/l cause increasing permeability problems, and those above 184 mg/l are usually unsatisfactory.

Northern Napa groundwaters had sodium concentrations ranging from 7.7 to 644 mg/l. Thirty two wells have values above 20 mg/l, the EPA recommended value for public drinking supplies. Eighteen wells had sodium concentrations above 69 mg/l, the increasing problem category for vineyard irrigation, and seven above 184 mg/l, the unsatisfactory category.

Sodium adsorption ratio (SAR) provides an indicator of the salt balance between the major cations (sodium, calcium and magnesium). For irrigation of vineyards, SAR values greater than 6 to 9 could cause permeability problems in shrinking-swelling types of soils. SAR values greater than 9 are usually unsatisfactory for vineyard irrigation. SAR values in Northern Napa groundwaters range from less than 1 to over 56. Eleven wells had SAR values above 6, nine of which had values greater than 9. One well in Pope Valley had a SAR of 23.6.

Water Quality

Chlorides

Chlorides in excess of 100 mg/l impart a salty taste to drinking water. The recommended drinking water standard for chlorides is 250 mg/l. Industrial users prefer a concentration of 200 mg/l or less. For vineyard irrigation, levels above 106 mg/l may cause increasing problems and those above 284 mg/l are usually unsatisfactory.

Groundwaters of Northern Napa have chloride concentrations between 50 and 300 mg/l, with thirteen wells having levels above 106 mg/l, six above 200 mg/l, three above 250 mg/l, and one over 284 mg/l.

Much of Northern Napa groundwater is classified as sodium-chloride waters.

Boron

Boron is an essential element for plant growth but is needed in relatively small amounts. If excessive, boron becomes toxic. The recommended boron level for vineyard irrigation is 1 mg/l; concentrations above 1 mg/l causing increasing problems and those above 3 mg/l are usually unsatisfactory for vineyard irrigation.

Boron levels in the Napa River are between 0.05 and 1.9 mg/l. Concentrations in five samples exceeded 1.0 mg/l.

Boron levels in groundwaters of Napa County are high. They range between 4.2 and 12 mg/l in groundwaters around and north west of Calistoga, and between 1.6 and 32 mg/l in groundwaters west of St. Helena, north of Oakville and North of Yountville. In the Milliken-Sarco-Tulucay basin, especially south and south east of Napa, boron levels exceed 1 mg/l.

Boron levels in three wells in the Putah Creek basin, (in Pope Valley) exceeded 1 mg/l with one well having as much as 10 mg/l.

Boron levels in groundwaters of Napa County are high. They range between 4.2 and 12 mg/l in groundwaters around and north west of Calistoga, and between 1.6 and 32 mg/l in groundwaters west of St. Helena, north of Oakville and North of Yountville. In the Milliken-Sarco-Tulucay basin, especially south and south east of Napa, boron levels exceed 1 mg/l. Boron levels in three wells in the Putah Creek basin, (in Pope Valley) exceeded 1 mg/l with one well having as much as 10 mg/l.

SECTION 5

EXISTING WATER SUPPLIES

Napa County's agriculture and municipalities satisfy their current water needs from five supplies:

- Groundwater
- River Diversion
- Reservoirs
- Imported Water
- Reclamation

In assessing the balance between County water needs and supplies, the quantity and its availability must be considered in determining how effective and reliable a given supply can be. In the case of groundwater, a safe yield estimate must be obtained which represents a long-range amount of pumping that can be sustained by recharge of the groundwater basin. In the case of river diversion, with the focus on the Napa River, the variations of flow, seasonally and year-to-year, must be related to the timing of water need. For the major local reservoirs, the variation of inflow from their respective watersheds and variation of consumption play major roles in arriving at a yield-frequency relationship. For imported water, contract entitlement buildup and dry-period cutbacks are the major considerations. For reclamation, the quality of the treated effluent is a key determinant of usability.

The above existing County water supplies are discussed in detail below.

GROUNDWATER

The objective of this section is to address water supply availability in groundwater basins located in Napa County. Napa County is located within the northern half of the Coast Ranges geomorphic province. In general, the Northern Coast Ranges are composed of marine sedimentary sandstones and shales that have been folded and faulted for millions of years creating the northwest-southeast trending valley-ridge topography. More recently, volcanic activity and erosion have assisted in the landscape process. It is these later geologic events which created the water bearing units of interest in and around the Napa Valley. Many of the faults which originally created the Coast Ranges are not presently active (an active fault has had surface displacement within the last 11,000 years), but some have shown evidence of faulting within the last 2 million years. Some of the faults in Napa County include: Carneros Fault, Cordelia Fault Zone, Green Valley Fault Zone (active), Soda Creek Fault, West Napa Fault Zone (active), Wilson Fault and the Wragg Fault.

Section 5

Existing Water Supplies

The focus of this analysis is on four key areas with potential for feasible extraction of groundwater. These areas, as shown in Figure 5-1, are: (1) North Napa Valley Groundwater Basin; (2) Milliken-Sarco-Tulucay Groundwater Basins; (3) Carneros; and (4) Lake Berryessa Basin (Pope and Capell Valleys).

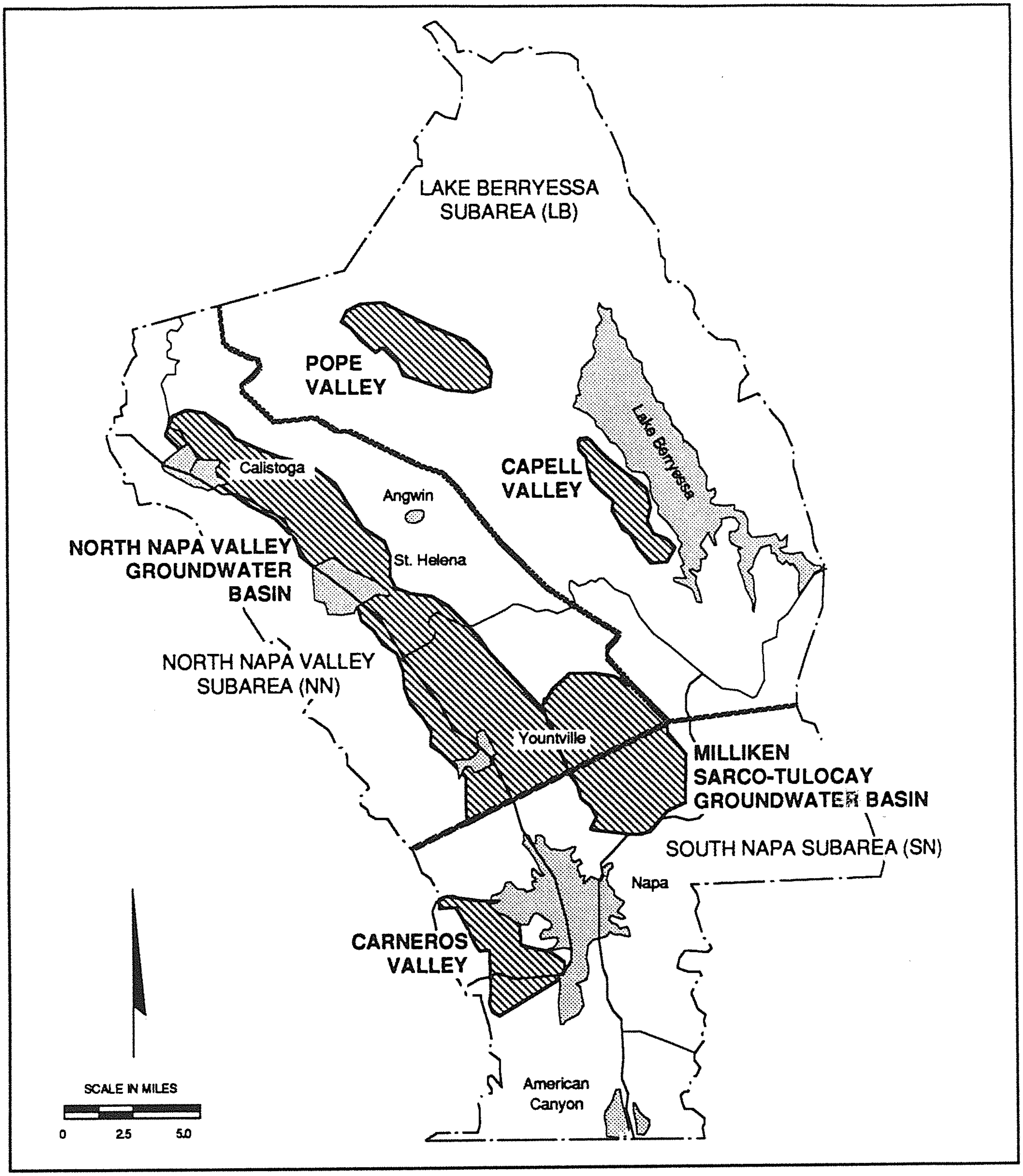
The primary aquifer depended upon in Napa County is that of the North Napa Valley Groundwater basin. Formed by the alluvium found in the Napa Valley east of the City of Napa, and extending north of the City of Calistoga, this aquifer provides water for irrigation and frost and heat protection for the highly valued grapes in the region. To a lesser extent, it is used for domestic purposes as well. Because of the importance of this aquifer as a source of supply, sources of recharge were analyzed facilitating the calculation of the safe yield of the groundwater basin. To validate the recharge estimates, a hydrologic budget was performed as well.

The other basins mentioned above are discussed in less detail. Existing information is reviewed together with additional insight provided by the Advisory Committee panel members, providing a summary of the basin characteristics and the potential water supply.

North Napa Valley Groundwater Basin

Napa Valley is located 40 miles northeast of San Francisco. The North Napa Valley groundwater basin lies beneath the valley floor. The boundaries of the basin, as described by the U.S. Geological Society (USGS) in 1973 (USGS, 1973), extends from Oak Knoll Avenue (just north of the City of Napa) to the northwestern end of the valley just beyond the City of Calistoga. The boundary encompasses approximately 60 square miles of valley floor.

The valley floor is drained by the Napa River which extends longitudinally through the study area, starting in the northwestern section and proceeding south past Oak Knoll to San Pablo Bay. Tributary flows occur along the western and eastern boundaries; the primary regulated watersheds are situated on the east side and consist of Bell Canyon, Conn, Moore, Chiles, and Sage Creeks supplying Lake Hennessey, and Rector Creek. Along the west side there are numerous creeks, mostly unregulated, with a total watershed area of approximately 71 miles adjacent to the study area. Water use in the North Napa Valley region is dominated by agricultural needs, mostly for vineyards established in the basin. Of the total water use in 1989 in this region, 82 percent was needed to support 19,100 acres of land dedicated to vineyards. As discussed in the previous sections, water for vineyards is needed both for irrigation and frost and heat protection. There are small acreages of other agriculture that for purposes of this



GROUNDWATER HYDROLOGIC STUDY AREAS

FIGURE 5-1

analysis were assumed negligible. In addition to agriculture, municipal and industrial needs in the North Napa Valley were 12 percent of the total water use in 1989 and domestic use by the rural population was approximately 6 percent.

The North Napa Valley Groundwater basin has been studied numerous times in the past. The most relevant work of this present study includes four previous investigations: (1) a joint study by the USGS and the California Department of Water Resources (DWR) completed in 1960 involving an analysis of groundwater characteristics in Napa Sonoma Valleys; (2) a U.S. Bureau of Reclamation (USBR) study in 1966 as part of the Knights Valley unit investigation; (3) a study by the Napa County Flood Control and Water Conservation Service in 1972 evaluating the potential for increased groundwater use for vineyard irrigation and frost protection; and (4) the most recent work by the USGS in which North Napa Valley groundwater hydrology was studied in detail and analyzed for its groundwater yielding capabilities (USGS, 1973).

In the Northern Napa Valley Groundwater Basin, the hydrogeologic units of interest include the water bearing Quaternary Alluvium and Pliocene Sonoma Volcanics, and the non-water bearing Cretaceous-Jurrassic Franciscan Formation and Great Valley Sequence.

Most of the valley floor is composed of alluvium which occurs as poorly sorted lenticular stream deposits of sand and gravel surrounded by silts and clays of the floodplain deposits. Alluvial deposits vary in thickness from more than 300 feet in the south end of the Napa Valley near San Pablo Bay to less than 50 feet near Calistoga. The alluvium tends to be thicker in the center of the valley near the Napa River.

The Sonoma Volcanics provide additional water to wells penetrating through the alluvium on the valley floor or located on the foothills surrounding the valley. The Sonoma Volcanics are a thick highly variable series of 4 different volcanic members. Only a tuffaceous member in the upper half of the volcanic deposit yields moderate amounts of water to wells. The Sonoma Volcanics which underlie most of the valley floor are believed to reach up to 2000 feet thick. The entire east side of the valley floor is flanked by the volcanics, as is most of the west side north of St. Helena.

The Franciscan Formation and The Great Valley Sequence flank most of the west side of the valley south of St. Helena. This is important to local groundwater users because these two deposits yield even less water to wells than the adjacent volcanics.

During pre-development conditions, groundwater generally flowed from the valley's edges toward the valley axis, and then south to San Pablo Bay. Some of the faults located within the valley floor modify these general flow patterns. The Soda Creek Fault is the only fault documented to obstruct the flow of groundwater. It appears to restrict the westward flow of groundwater just north of Milliken Creek, but only during times of low water levels.

Most of the groundwater in the Napa Valley is pumped from the Quaternary Alluvium which is considered the best aquifer in the area. Most water produced from the alluvium is pumped from unconfined aquifers; and the yields from wells depend on the number of gravel beds penetrated and screened by the well. Individual sand and gravel lenses tend to be less than 10 feet thick. Well production averages 223 gpm, but ranges from 50-3000 gpm at a specific capacity of 10 gpm per foot of drawdown. Storage capacity of the alluvium in the north Napa Valley is estimated at 190,000 Acre-Feet.

The Sonoma Volcanics are the other main source of groundwater in and around the Napa Valley. Few wells penetrate the alluvium on the valley floor to pump water from the lower producing volcanic deposits. Water in the Sonoma Volcanics commonly is confined though a few wells actually do produce flowing water. Most of the flowing wells occur near Calistoga, and many of these produce hydrothermal water. Hydrothermal water is described as having a temperature equal to or greater than 20.5°C (69°F). Wells tapping the Sonoma Volcanics produce an average of 32 gpm at a specific capacity of 0.6 gpm/ft of drawdown. No estimate of the storage capacity of the Sonoma Volcanics was found, but one report stated that the 230 square mile Napa Valley Basin contained 300,000 AF of water in all the units between 10-200 feet below the ground surface.

Wells tapping the Franciscan Formation and the Great Valley Sequence yield an average of 19 gpm at a specific capacity of 0.1 gpm/ft of drawdown. Most wells tapping these formations produce less than 10 gpm. The few wells that do produce more water extract it from the highly fractured zone at depth.

The main objective of this analysis was to estimate groundwater yield, which is comprised of groundwater recharge from deep percolation of direct precipitation and irrigation-applied water and other inflows including recharge from neighboring tributaries and subsurface inflows from adjacent areas.

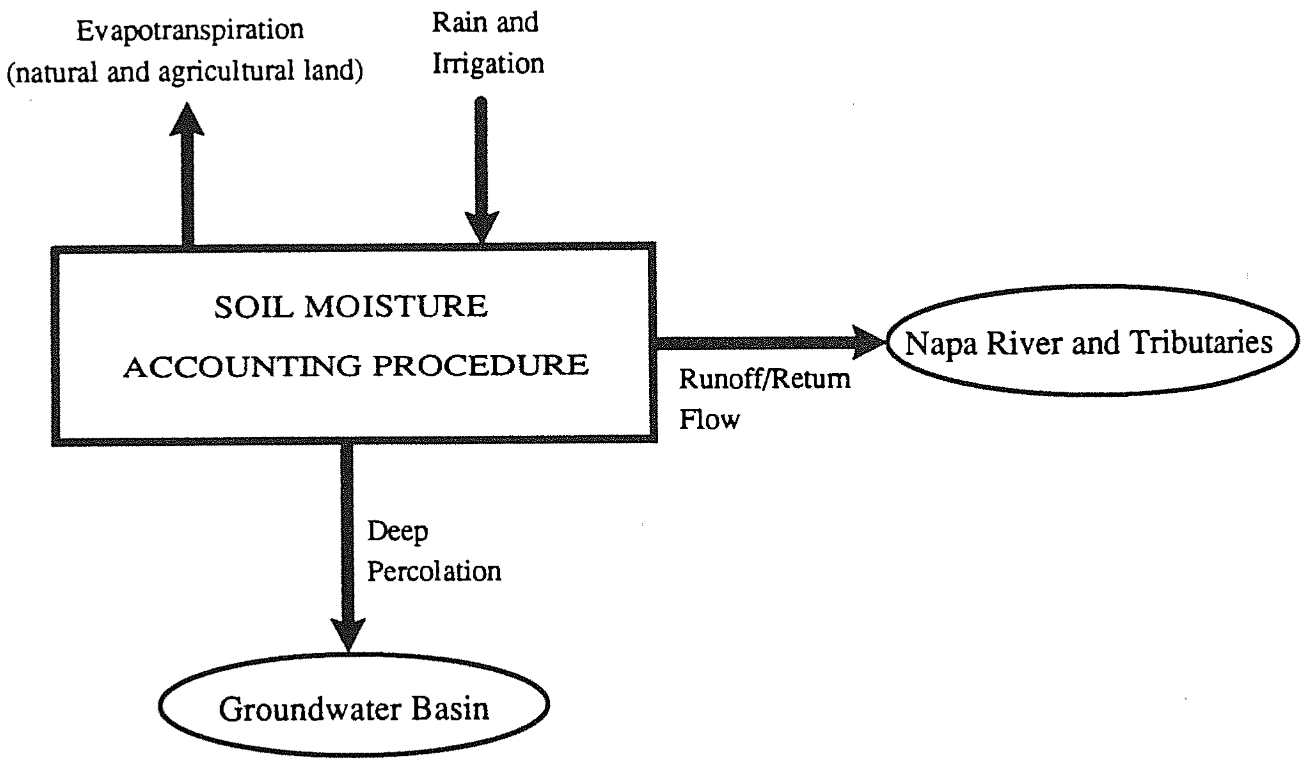
To estimate the groundwater yield of the North Napa Valley Groundwater basin, the individual components of recharge to and discharge from the basin were computed by independent methods. The results were then employed in an analysis of the hydrologic balance represented by the equation of hydrologic equilibrium stating that inflow less outflow is equal to the change in storage. The estimated change in storage was then compared with known groundwater level data for the purpose of validating or refining the initial estimates of inflow and outflow components. The methodology used in estimating the groundwater inflow and outflow components are discussed further below.

An aquifer may be replenished by several different sources, both natural and artificial. Deep percolation of precipitation, stream flow, or water in lakes and reservoirs exemplifies natural recharge. Seepage from irrigation applied-water and canals, and water purposely applied in spreading grounds or injected via wells can be classified as artificial recharge.

Deep percolation can be calculated by considering the natural processes occurring when precipitation and irrigation-applied water proceed through the hydrologic cycle. The most important factors to consider are surface runoff, evapotranspiration, and soil moisture retention. Deep percolation takes place when water reaching the soil exceeds these factors and infiltrates past the root zone depth, and eventually into the groundwater aquifer below. Recharge also occurs when streams cross regions where the pervious nature of the channel allows seepage to the groundwater system below. The amount of recharge is a function of stream flow, channel characteristics, and soil properties. Another possible source of recharge is from subsurface flow originating in adjacent groundwater systems.

To calculate annual deep percolation for the North Napa Valley Groundwater basin, a soil moisture accounting procedure was employed. This procedure, depicted in Figure 5-2, calculates the deep percolation resulting from precipitation and irrigation-applied water. This is accomplished on a monthly basis by solving a mass balance equation which relates the change in soil water content to precipitation, direct runoff, irrigation-applied water, evapotranspiration (actual), and deep percolation. Direct runoff was computed by the Soil Conservation Service (SCS) runoff curve number method. Curve numbers for the Napa Valley are available in the Soil Survey Report for Napa Valley (SCS, 1977). The curve number is a function of vegetative cover and soil group. Deep percolation is a function of rainfall (in excess of direct runoff) combined with irrigation-applied water (less the return flow) that infiltrates into the soil. As this excess water seeps down, some of the infiltrated water percolates due to gravity, contributing to an increase in groundwater storage, while the remainder is held in the soil moisture zone and subject to evapotranspiration.

The main input data required for this program includes historical monthly rainfall, existing land use acreage and its respective evapotranspiration, average monthly



CALCULATION OF DEEP PERCOLATION IN THE NORTH NAPA VALLEY GROUNDWATER BASIN

FIGURE 5-2

irrigation applied-water, and two soil parameters (SCS curve number and field capacity).

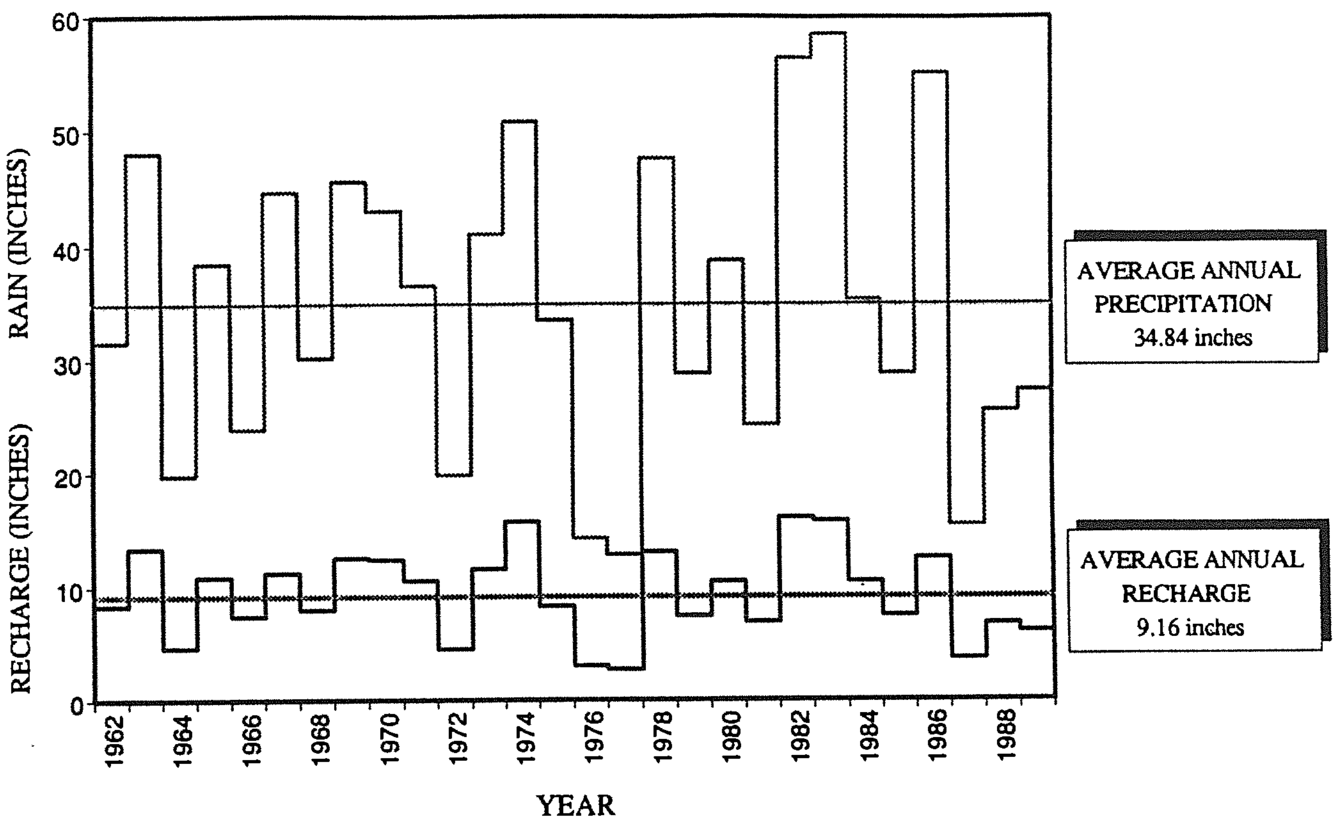
Applying this program to the North Napa Valley resulted in monthly values of deep percolation recharging the groundwater basin from natural, agricultural, and urban areas.

Recharge from the percolation of tributary streamflow is also mostly dependent on precipitation patterns. Percolation occurs as the tributaries enter the basin boundary passing from older impermeable geologic formations to permeable channel deposits in the alluvium. To fully understand the tributary interaction with the underlying groundwater basin on a monthly basis would require a sophisticated modeling approach based on simulation of the hydrologic cycle. For purposes of this study, an estimate of the average annual recharge from the percolation of tributary streams was determined using an average infiltration rate and the total wetted perimeter. The infiltration rate was taken from the Soil Survey of Napa County report (SCS, 1977), and the wetted perimeter was estimated from DWR land use-type classification maps (DWR, 1987).

Subsurface inflow occurs from adjacent groundwater bodies along the periphery of the North Napa Valley Groundwater basin. It is possible to estimate this recharge component using Darcy's Law and information concerning the hydraulic gradient across the adjoining basins. However, USGS reported that this component was relatively insignificant, occurring primarily east and southeast of St. Helena where Sonoma volcanics are known to exist (USGS, 1973). For purposes of this study, the subsurface inflow was taken to be that estimated by USGS in the 1973 investigation.

The estimated annual recharge in inches was plotted along with annual precipitation recorded at St. Helena. This is shown in Figure 5-3. The period chosen for the analysis, 1962 through 1989, is consistent with available well levels monitored by the Napa County Flood Control and Water Conservation District. As was stated earlier, the natural recharge occurring in the North Napa Valley Groundwater basin follows a pattern largely dependent on the precipitation patterns in the basin. Average annual recharge for the entire basin, which consists of deep percolation, tributary recharge, and subsurface inflow, from 1962 to 1989 was approximately 26,800 acre-feet per year.

A groundwater hydrologic budget considers the change in storage of the aquifer as a result of inflows into, and outflows out of, the basin. The change in storage is reflected in recorded well level fluctuations; an estimated change in storage can be computed from the inflow and outflow components and compared to recorded values. This provides a means for validating and refining the estimates of inflow and outflow.



ANNUAL PRECIPITATION AND RECHARGE IN NORTH NAPA VALLEY GROUNDWATER BASIN

FIGURE 5-3

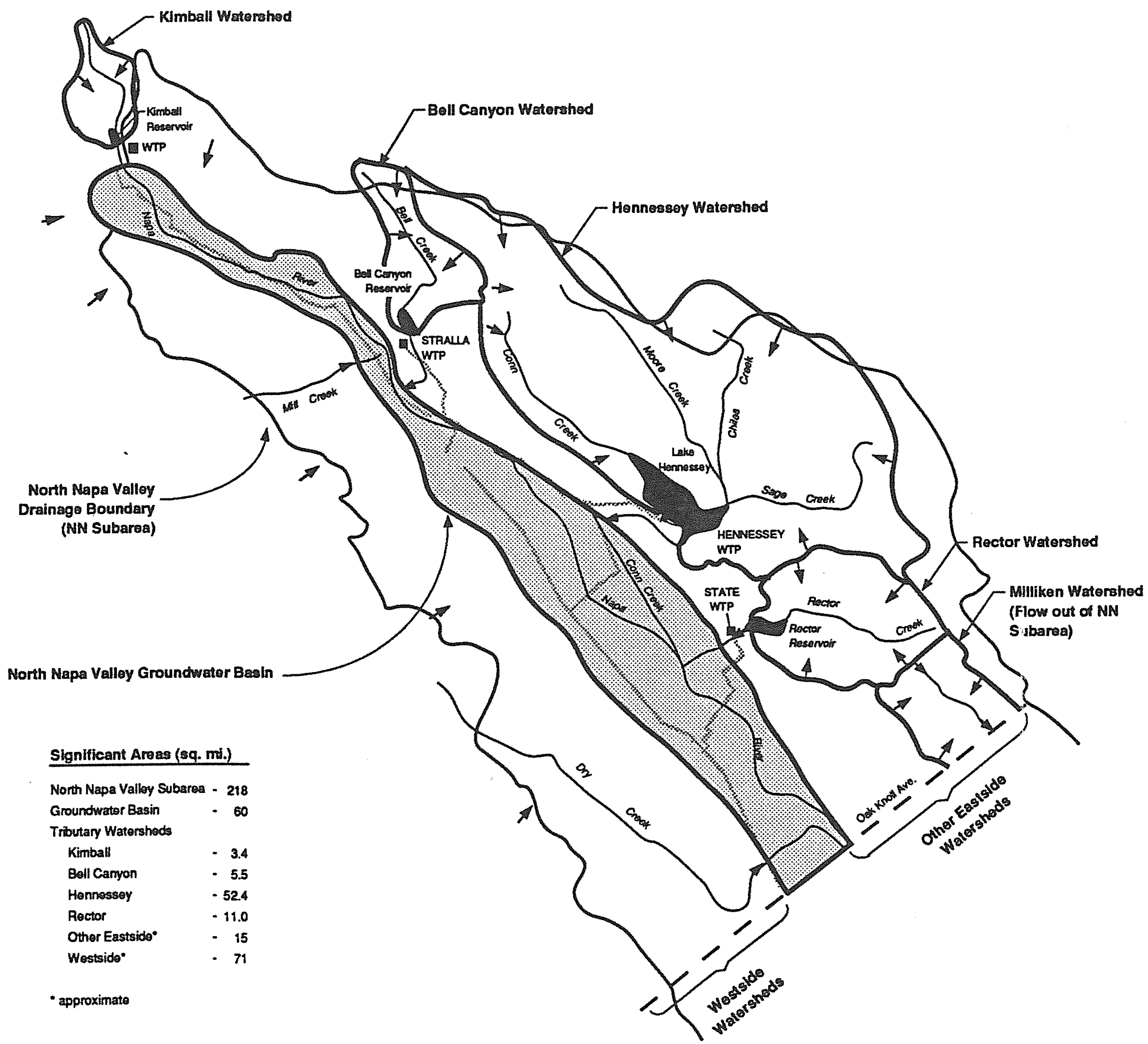
The surface/groundwater system interaction is depicted in Figure 5-4, and below this schematic the inflow and outflow components are shown. Inflow to the basin includes rain, irrigation-applied water, tributary recharge, and subsurface inflow. These components were discussed previously. The unit rate (inches/year) and average volume (acre-feet/year) are given in Table 5-1. These values are averaged over the historical period 1962 through 1989.

Outflow from the North Napa Valley Groundwater basin can be separated into the following categories: groundwater pumpage; net discharge to Napa River; evapotranspiration; irrigation return flow; surface runoff; and subsurface outflow.

Groundwater pumping for agricultural purposes can be estimated from an analysis of the annual crop consumptive use of applied water and irrigation efficiency. Annual consumptive use of applied water as the portion of crop consumptive use that is met by irrigation water for an average year. The annual consumptive use of applied water was determined from crop acreage data (DWR, 1987) and crop evapotranspiration (DWR, 1975). The annual consumptive use of applied water divided by irrigation efficiency provides an estimate of total agricultural groundwater pumping. Groundwater pumpage for domestic uses was estimated based on historical rural population data in the North Napa Valley and a per capita consumption factor developed in Section 3.

In the 1973 USGS investigation, the Napa River was reported as a gaining stream. On a local scale, some regions of the Napa River may be recharging the aquifer below, and other reaches may gain water from the aquifer. However, an analysis of the recorded streamflow of Napa River at the outlet of the basin (Oak Knoll Avenue) indicates that on an annual average, the Napa River receives a net gain from the groundwater system below. This is reflected graphically in Figure 5-5. This figure indicates that even during months of little or no precipitation, flow persists. It should also be noted that on the average, tributary streams are intermittent. Hence, flows during the dry periods are a result of groundwater discharge. Using baseflow separation techniques, the average annual net gain to the Napa River was determined to be 12,700 acre-feet per year. This is in good agreement with the USGS estimate of 13,200 acre-feet per year.

Evapotranspiration, irrigation return flow, and surface runoff are direct outputs from the soil moisture accounting routine shown previously in Figure 5-2. The results are tabulated in Table 5-1 Subsurface outflow can be estimated using the same techniques, employed for calculating subsurface inflow. However, because of the lack of detailed information regarding the hydraulic gradient across the southern boundary, the estimate developed by USGS in 1973 was used.

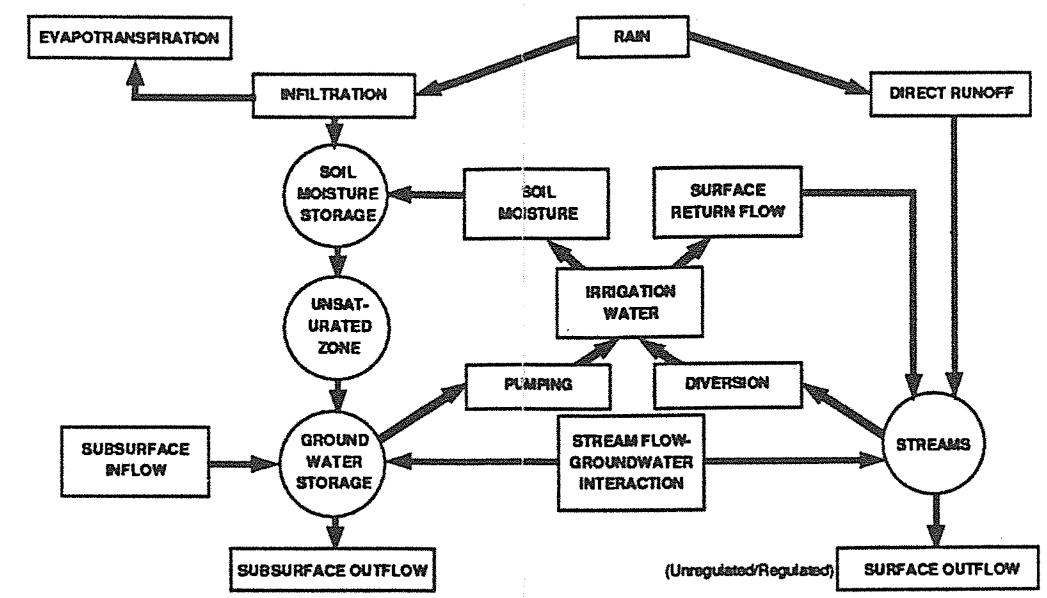


Significant Areas (sq. mi.)

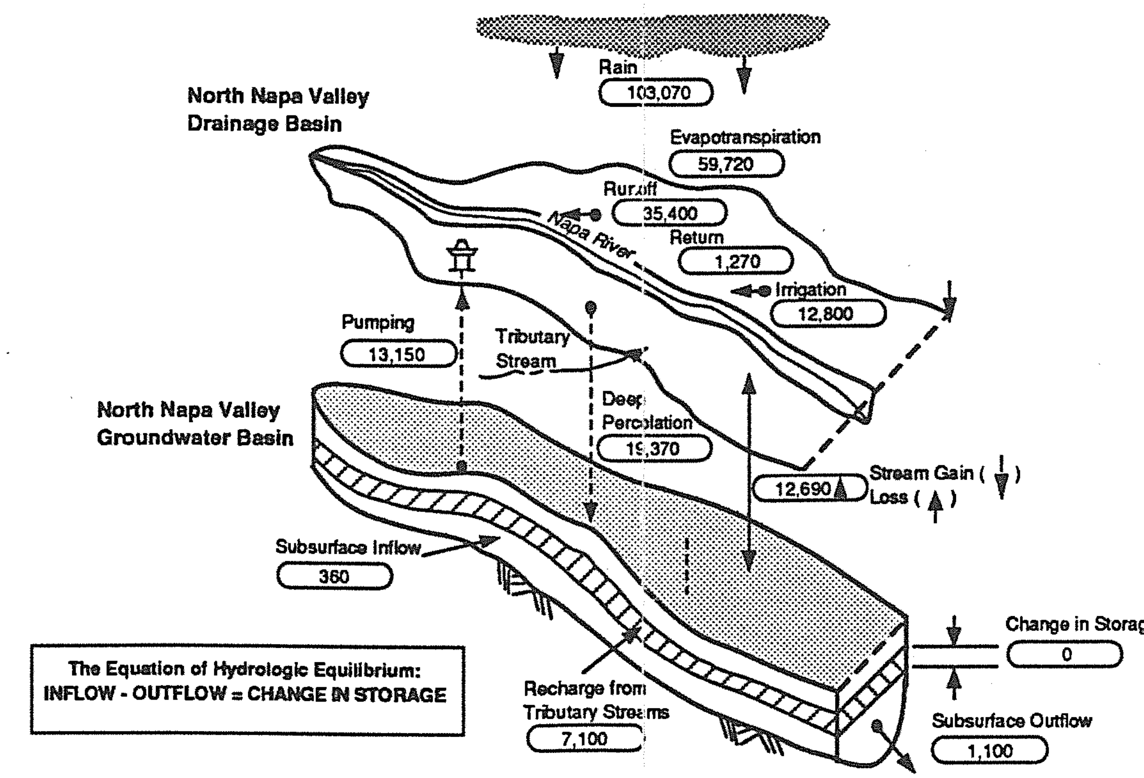
North Napa Valley Subarea	218
Groundwater Basin	60
Tributary Watersheds	
Kimball	3.4
Bell Canyon	5.5
Hennessey	52.4
Rector	11.0
Other Eastside*	15
Westside*	71

* approximate

LOCATION OF GROUNDWATER BASIN AND TRIBUTARY SURFACE WATER INFLOWS



SURFACE/GROUNDWATER SYSTEM INTERACTION



GROUNDWATER BUDGET DURING 1962 TO 1989 (Ac-Ft/Yr)

DETERMINATION OF GROUNDWATER BASIN YIELD

FIGURE 5-4

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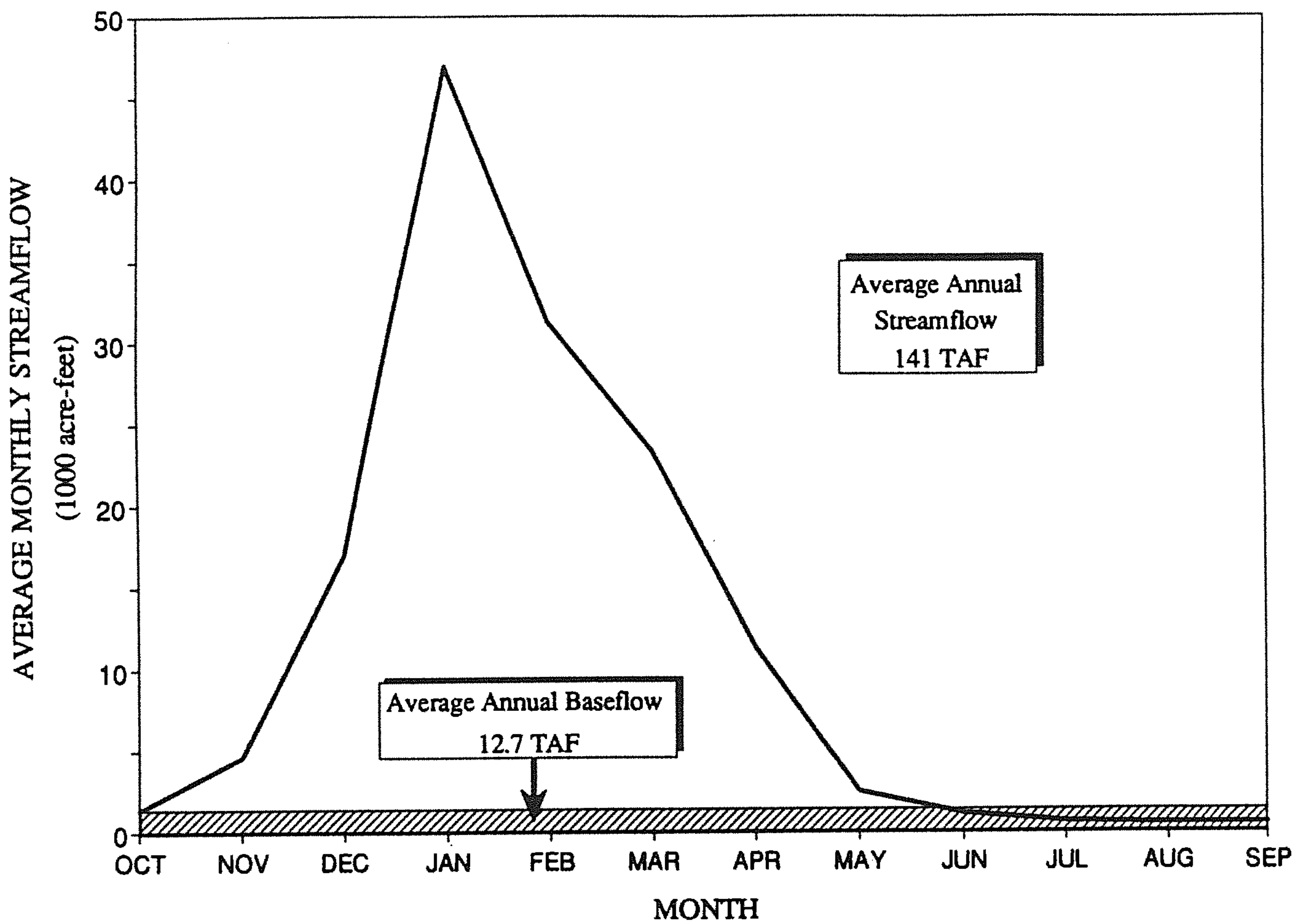
TABLE 5-1

GROUNDWATER HYDROLOGIC BUDGET
NORTH NAPA VALLEY GROUNDWATER BASIN
(PERIOD OF RECORD: 1962 TO 1989)

PARAMETER	UNIT RATE (1) (inches/yr)	AVERAGE VOLUME (acre-feet/yr)
Inflow to Basin		
Rain	34.84	103070
Irrigation-Applied Water	4.33	12800
Tributary Recharge	2.40	7100
Subsurface Inflow (2)	.12	360
Outflow from Basin:		
Evapotranspiration - Natural Land	18.59	22460
Evapotranspiration - Agricultural Land	21.56	34320
Evapotranspiration - Pervious Rural/Urban Land	18.59	2940
Groundwater Pumpage	4.45	13150
Irrigation Return Flow	.43	1270
Surface Runoff - Natural Land	10.58	12780
Surface Runoff - Agricultural Land	13.16	20950
Surface Runoff - Previous Rural/Urban Land	10.58	1670
Net Discharge to Napa River	4.30	12690
Subsurface Outflow (2)	.37	1100
Total for Basin:		
Inflow	41.69	12330
Outflow	41.69	12330
Net Change in Groundwater Storage	0.00	0

(1) Unless land type is specified, unit rate is averaged over entire basin. Basin land use areas are:
Natural Land - 14500 acres
Agricultural Land - 19100 acres
Pervious Rural/Urban Land - 1900 acres

(2) Estimate developed by USGS, 1973.



**STREAMFLOW HYDROGRAPH - NAPA RIVER NEAR NAPA
(PERIOD OF RECORD: 1962-1989)**

FIGURE 5-5

A complete tabulation of the inflow and outflow components is given in Table 5-1. A review of well level data collected by the County over the period 1962 through 1989 indicates that no net change of storage has occurred. This was reinforced by panel members associated with the Advisory Committee. This indicates that the groundwater basin has been in a state of equilibrium, and has not been exploited beyond the safe yield of the aquifer.

The average annual yield of an aquifer can be equated to the average annual recharge to the groundwater system. However, this definition does not factor in the reliability of the aquifer as a source of supply. If pumping were practiced such that it equalled the average annual recharge, in years of low rainfall the groundwater level would decline. For example, in recent years annual recharge has been less than 50 percent of normal (See Figure 5-3). Pumping according to average conditions would cause serious drawdown resulting in local overdraft and potential failing of wells.

The safe yield of an aquifer is defined as that amount of water that can be pumped from the groundwater which does not result in degradation to the aquifer, (such as poor water quality or causes economic hardship due to failure of wells. With this in mind, the groundwater system was evaluated in much the same way as the surface water reservoirs were in this study. Using historical precipitation recorded in St. Helena for the period 1940 through 1989, the soil moisture accounting routine was employed to estimate monthly deep percolation.

The average annual recharge from tributary watersheds was distributed on a monthly basis by relating it directly to precipitation patterns. The subsurface inflow was assumed to be constant annually and distributed equally over the months. The sum of these three components provided recharge to the groundwater basin on a monthly basis. This recharge is equivalent in definition to the inflow associated with a surface water reservoir. The criteria used in operating the groundwater reservoir was to ensure that shortages occurred no more than one year over the simulated 50 year period. Using RESSIM (discussed further in the reservoir safe yield section), a safe yield that provides reliable groundwater extraction was determined to be 22,500 acre-feet per year. This estimated safe yield resulted in a shortage of six percent in 1950; the late 1940s experienced low rainfall and was the critical period of the simulated planning horizon.

Milliken-Sarco-Tulucay Creeks Area

The Milliken-Sarco-Tulucay Creeks Basin was specifically defined by the USGS in an investigation conducted in the later 1970s (USGS 1977). The area, approximately 15 square miles, is located adjacent to the City of Napa along the eastern boundary of the Napa Valley floor. The area is distinguished from the Napa Valley because of its high-yielding Sonoma Volcanics east of the Soda Creek Fault. The heaviest precipitation occurs in the upper Milliken Creek basin. The area is drained primarily by Milliken, Sarco, and Tulucay Creeks. The 1977 USGS investigation estimated surface water outflow at an average of 24,100 acre-feet per year. However, records of streamflow were only available for several years in the 1970s. The primary use of water is for domestic and agricultural purposes. In addition, two golf courses report the use of well water. Groundwater availability was evaluated in two studies by the USGS, one published in 1960 and the more recent in 1977. The first study was of a regional nature considering the entire Napa Valley; the 1977 study focused only on this area and investigated the groundwater hydrology in detail.

In the Milliken-Sarco-Tulucay Creeks area, both the Sonoma Volcanics and alluvium yielded water to wells. Geographic location of the well dictates the source of water. The largest groundwater reserves exist east of the Soda Creek Fault in the Sonoma Volcanics. West of the Soda Creek Fault, alluvium is the primary source of groundwater. The fault is a normal fault, down-dropped to the west with as much as 700 feet of vertical displacement. The water-bearing characteristics of the alluvial aquifer were described in the section on North Napa Valley so they will not be repeated. The description of the water-bearing properties of the Sonoma Volcanics is similar to that previously mentioned in the North Napa Valley section, but there are some additions.

As before, the tuffaceous deposits are the most permeable unit in the Sonoma Volcanics. In this area, the specific yield of the tuff is estimated at 4 percent. Although the tuff is continuous throughout the area east of the Soda Creek Fault, the tuff in the Milliken and Sarco Creeks area is not believed to be hydraulically connected to the tuff near Tulucay Creek. A high point in the underlying impermeable material splits the continuous tuff into two subbasins. The north subbasin contains the Milliken and Sarco Creeks, and the southern basin contains Tulucay Creek. In the Milliken-Sarco Creek area, sedimentary deposits of low permeability previously described as the Huichica Formation overlie portions of the more permeable tuff. It is estimated that 196,000 Acre-Feet of water is stored in the Sonoma Volcanics in the 15 square mile area around the Milliken-Sarco-Tulucay Creeks area between 10- 500 feet below the ground surface. Of this, only 20,000 Acre-Feet is considered to be economically feasible to extract.

Natural recharge to the underlying groundwater formations is reported to occur primarily from Milliken, Sarco, and Tulucay Creeks, and geologic outcrop areas.

Subsurface inflow is reported to occur from Wild Horse Valley east of the area (USGS, 1977). Groundwater is primarily obtained from the Sonoma Volcanic Formations, a confined aquifer. Wells generally penetrate this aquifer at depths of 100 feet or greater. The average annual natural recharge was estimated at 5,400 acre-feet per year; the natural discharge was estimated at 2,650 acre-feet per year; and the pumping in 1977 was estimated to be 3,000 acre-feet (USGS, 1977). The USGS reported a gradual decline of the groundwater level occurring under these conditions. For purposes of this report it was assumed that the yield of the groundwater in this area is equivalent to the total recharge of 5,400 acre-feet per year. This number should be used with caution, however, since pumping at this rate would cause an initial significant drawdown possibly requiring wells to be deepened. Ideally, the aquifer would again stabilize when equilibrium was met. In addition, the safe yield is most likely less than this amount.

Carneros Area

The Carneros Valley is located in the southwestern portion of Napa County. The Carneros region has seen tremendous growth in vineyard acreage in recent years due to its prime suitability for providing high quality vine grapes. The primary surface water source is Carneros Creek which crosses through the Carneros Valley in a south by southeast direction. Carneros Creek is approximately 12 square miles; no streamflow records were available for Carneros Creek, but it has been reported as being ephemeral. Agricultural and domestic water needs rely primarily on surface water diversions and, to a lesser extent, pumping of groundwater.

Very little information is available concerning the hydrology of the Carneros Valley. The valley floor was described as Pleistocene terrace deposits and Recent alluvium with some Pleistocene Huichica Formation flanking the sides of the south end of the valley. A later report incorporates the terrace deposits into the alluvium.

The Huichica Formation contains fluvial deposits of gravel, silt, sand, and clay with an interbedded tuff. The basal 200-300 feet of the formation contains reworked pumice from the underlying Sonoma Volcanics. The Huichica Formation attains a maximum thickness of about 900 feet, but no information is available for the Carneros Valley area. The limited information available describes the Huichica Formation as having a low permeability with well yields less than 5 gpm. Extended pumping of wells screened in this unit often require several days to fully recover.

The younger alluvium, including the previously mentioned terrace deposits, are generally thin with much of their volume above the saturated zone. This unit also has a low permeability. Available information stated that only a few wells tap this unit, and no additional well information was available.

Precipitation in the area is similar to the City of Napa, and is estimated to be approximately 23 inches. Natural recharge to the underlying groundwater formations is reported to occur primarily from geologic outcrop areas (mostly in the hillsides bordering he Carneros Valley) and infiltration from streambeds where they cross the geologic formations (USGS 1960). No extensive studies of the region concerning groundwater availability have been conducted, making accurate determination of the safe yield difficult. According to the Advisory Committee, there are reports of recent successful well development in this area. For purposes of this report, based on an assessment of existing geologic formations, the safe yield of the groundwater is estimated at less than 300 acre-feet per year.

Putah Creek Basin

Two regions in the Putah Creek Basin were of interest in this study: (1) Pope Valley; and (2) Capell Valley. Pope Valley is located west of the north portion of Lake Berryessa. It is drained by Pope Creek and Maxwell Creek and has an average annual precipitation of approximately 34 inches. Water is required primarily for agricultural purposes (vineyards and other irrigated agriculture). Direct diversion of surface is a key source, and pumping of groundwater is also practiced. Capell Valley, located in the southern most area of the upper Putah Creek watershed, is drained primarily by Capell Creek with some additional minor tributaries. Precipitation in this region averages approximately 31 inches. Like Pope Valley, the soil and climate conditions provide a very suitable environment for vineyard development. Previous investigations of groundwater hydrology in this area are contained in two key reports: (1) a reconnaissance report by DWR in 1962 which investigated the upper Putah Creek basin; and (2) a report on water supply alternatives prepared by the County in 1977.

Limited information is available regarding the hydrogeology of this area. Most of the information is from a reconnaissance level investigation. This report is only interested with the part of the Putah Creek Basin in Napa County. Within the Putah Creek Basin, only the alluvium is considered a significant water bearing deposit. Within Napa County, only the Pope Valley and the Capell Valley are large enough to be described here.

Stream development in the Pope Valley has been limited to small creeks with low flows. The lack of large streams prevented thick accumulations of alluvium from being deposited on the valley floor. This resulted in a limited groundwater storage capacity in the alluvium of the Pope Valley. The only other source of groundwater in the Pope Valley comes from a pervious unit in the Sonoma Volcanics near Aetna Springs.

Most of the groundwater extracted in the Pope Valley comes from the alluvium The alluvium averages 25-30 feet thick and consists of silty clayey sands and gravel. With an assumed specific yield of 3 percent, the alluvium in the basin is estimated to contain 7000 Acre-Feet of water. Infiltration of winter precipitation recharges the basin. With most wells yielding less than 100 gpm, there is little opportunity for additional groundwater development.

Like the Pope Valley, the Capell Valley is also a structural basin surrounded by Pre-Cretaceous marine rocks. The thin alluvium cover on the valley floor is estimated to store only 700 Acre-Feet of water. No wells in the valley produce more than 15 gpm. Water in the alluvium is stored in small local sand and gravel lenses limiting well yields to less than 15 gpm. A few wells tap the fractured Pre-Cretaceous rocks that surround the valley. These wells yield 10-12 gpm with a drawdown of about 100 feet. Little opportunity exists for further development of groundwater in the Capell Valley.

Groundwater resources in the Pope and Capell Valleys are relatively limited. It was reported by DWR that the best source of groundwater is in the shallow alluvium and to some extent the Sonoma Volcanics along the hillside of the valley floor. Pope Valley has been estimated to have approximately 7,000 acre-feet of usable storage. Capell Valley has a less well defined alluvial aquifer from which groundwater can be extracted. It has been estimated that less than 700 acre-feet of storage exist in this region. Historically, well yields in Pope Valley have been limited to less than 100 gpm, while in Capell Valley well yields greater than 15 gpm are rare. These low yields are due to the nature of the alluvium, consisting of silt and fine grain sands derived from adjacent hillsides. In a memorandum released by DWR in 1980, a groundwater yield estimate was reported as 400 acre-feet per year for Pope, Capell, and Chiles Valleys combined (DWR, 1980). For purposes of this study, it was assumed that the safe yield for Pope and Capell Valleys was less than 400 acre-feet. Further revision of this estimate was not possible given the available information.

A summary of the estimated safe yields and usable storage of the groundwater supplies discussed above is provided in Table 5-2.

RIVER DIVERSION

The Napa River, which flows through the entire Napa Valley, from its uppermost northwestern end above Calistoga, to San Pablo Bay, offers a potential for direct

TABLE 5-2

SUMMARY OF GROUNDWATER BASIN SUPPLY

Basin	Safe Yield (acre-feet/yr)	Usable Storage (acre-feet)
North Napa Valley GWB	22500	190000
Milliken-Sarco-Tulucay GWB	<5400	20000
Lake Berryessa Basin (Pope and Capell Valleys)	< 400	7700
Carneros Area	< 300	<3000

diversion for the prime valley vineyards located between Highway 29 and the Silverado Trail. As a review of Napa River flows at Oak Knoll Avenue for the period 1962 to 1989 indicates (See Figure 5-5), a well-defined seasonal pattern is present, with flows predominantly occurring in the period December through March and minimum flows in the summer and early fall. Yearly variations are significant as can be seen from Table 5-3, and consecutive dry years, are not uncommon, as is the case in the current four-year drought period. Water quality may impact divertability in the winter due to high turbidity.

Without storage, river diversion capability is mainly determined by the match of seasonal variation of water need and river flow. For vineyards there are three water uses:

- Irrigation
- Frost Protection
- Heat Protection

Although some irrigation may occur in the winter, the months May to September form the principal irrigation season. Frost protection by sprinklers is generally needed between mid-March and mid-May, while heat protection by sprinklers would occur most likely during July and August. Clearly there is no real match between seasonal supply and need variation, except for some potential for frost protection. A 1973 estimate by Metcalf and Eddy ("Napa County Water Resources Development Study-Phase II") put the spring frost season Napa River diversion at approximately 2,000 Ac-Ft above St. Helena and 4,500 Ac-Ft above Oak Knoll Avenue with an 80 percent reliability, assuming a 60 percent capture rate and a 10 cubic feet per second fish release. The 1973 Metcalf and Eddy analysis of Napa River diversions also determined that 10,000 Ac-Ft/Yr could be obtained from the river if storage were constructed in Spring Valley (10,000 Ac-Ft) and from on-site vineyard reservoirs (3,000 Ac-Ft), assuming some portion of this reservoir storage is unavailable due to carryover storage or is supplied from groundwater. Review of the more extensive Napa River flow data for the period 1960-88 shows that mid-March to mid-May flows available for frost protection probably do not exceed 10,000 Ac-Ft/Yr during the drier years.

RESERVOIRS

Local County reservoirs include five major facilities serving basically municipal drinking water needs. These facilities including the City of Napa's Milliken Reservoir and Lake Hennessey; the State of California's Rector Reservoir; St. Helena's Bell Canyon Reservoir; and Calistoga's Kimball Reservoir. Lake Berryessa, owned by the U.S.

TABLE 5-3

MONTHLY FLOW, 1960-88, NAPA RIVER NEAR NAPA

									Irrigation				
						Frost Protection				Heat Protection			
Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Year Total**
1960	44	82	192	2306	42620	19910	4211	1708	308	12	0	0	71393
1961	0	261	3066	6935	14490	9826	3667	1447	201	0	0	0	39893
1962	0	209	4719	3918	56880	34080	4187	1377	208	2	0	0	105580
1963	20770	1680	14020	31350	59830	22840	51620	6891	1697	320	105	96	211219
1964	449	6129	2116	16160	3546	2089	1101	320	149	23	0	4	32086
1965	40	3527	60250	77930	9110	3854	16290	3209	736	191	218	119	175474
1966	146	3362	8069	53500	25870	7976	2785	1055	206	24	36	12	103041
1967	26	7734	37040	101000	23190	32720	42240	7377	3306	1120	274	187	256214
1968	298	443	3275	26150	35560	27320	5792	1664	373	156	165	63	101259
1969	224	591	19680	114400	90900	32300	7236	2596	986	396	219	41	269569
1970	344	487	31320	164300	28490	22500	4070	1525	345	111	64	66	253622
1971	118	12840	74870	28100	6760	14370	6315	2307	807	276	136	177	147076
1972	189	481	5378	5147	8795	3463	2110	829	146	12	0	34	26584
1973	437	7816	9594	100000	69240	35520	6657	2412	569	136	97	156	232634
1974	233	36630	31980	60470	16730	69090	30710	4005	1400	838	474	496	253056
1975	415	444	1979	2844	56860	60740	12410	3574	1184	561	306	397	141714
1976	631	815	682	650	374	1242	889	151	6	0	3	10	5453
1977	35	71	45	179	24	160	12	0	0	0	0	0	526
1978	0	4472	14370	95830	45450	44080	13190	3906	1119	502	266	182	223367
1979	155	278	358	18726	35907	18006	6568	3406	783	371	250	154	84963
1980	759	1268	12762	72372	93484	28924	6558	2627	862	345	242	202	220405
1981	174	207	4835	21766	9966	13433	4527	1580	421	135	169	86	57300
1982	445	32042	81185	90227	56776	49801	79973	5673	2307	1063	562	639	400694
1983	699	14707	31781	74152	101025	160069	22867	13948	3108	1192	581	450	424581
1984	722	30249	90823	19363	9072	9789	3492	2065	803	341	281	222	167221
1985	371	10570	6466	4433	21758	10343	5560	1872	686	252	215	252	62779
1986	310	815	3019	13290	227501	75019	7092	2786	970	525	315	320	331962
1987	295	301	475	1248	11329	11959	2744	1027	345	211	132	60	30127
1988	84	301	14284	28043	4505	1802	1395	1099	459	159	108	76	52316
Total	28413	178813	568635	1234791	1166041	823226	356267	82437	24490	9274	5218	4502	4482107
Average	980	6166	19608	42579	40208	28387	12285	2843	844	320	180	155	154555
Maximum	20770	36630	90823	164300	227501	160069	79973	13948	3306	1192	581	639	424581
Minimum	0	71	45	179	24	160	12	0	0	0	0	0	526

Bureau of Reclamation, is the key feature of eastern Napa County. Numerous smaller reservoirs or ponds exist throughout the County, including those in the Angwin and eastern valley (Pope, Chiles, Capell) areas. Lake Curry, whose supply goes to the City of Vallejo, is not considered part of Napa County's supply. The supplies available from the reservoirs are discussed below under three headings:

- Major Municipal Reservoirs
- Lake Berryessa
- Miscellaneous Reservoirs

Major Municipal Reservoirs

An analysis was conducted for each of the five major municipal reservoirs in Napa County to determine the firm surface water yield and develop yield-frequency curves (See Figure 5-6). The reservoirs studied were Lake Hennessey, Milliken Reservoir, Rector Reservoir, Bell Canyon Reservoir, and Kimball Reservoir. The reservoirs are located in the mountains on the east and north sides of the Napa Valley.

The yield analysis provides a measure of the water quantity available from each reservoir, and the reliability of that supply under varying hydrologic conditions. The timing and volume of the natural seasonal streamflow is different from year to year because of varying seasonal weather conditions. The availability of water may not coincide with the seasonal timing of municipal and agricultural demands. Thus, the function of a reservoir is to redistribute the streamflow with respect to time so that water demands can be satisfied on a dependable long term basis.

The yield of a reservoir is that amount of water that can be reliably supplied to meet demands over time. The firm yield of a reservoir is defined as the amount of water that can be supplied, without any shortage, during a specific critical time interval, usually the driest period of years on record.

The yield analysis was divided into two tasks. The first task was to extend the existing streamflow record in order to analyze the operation of each reservoir over a longer hydrologic period. The second task was to use the streamflow values, developed in task one, as input to a reservoir simulation model in order to evaluate the yield of each reservoir under varying hydrologic conditions.

Streamflow Generation. Of the five reservoirs in the analysis, historical reservoir inflow data was available only for a 10 year period for Lake Hennessey. This inflow data, for the period 1980 to 1989, was too short a period of record to allow an adequate analysis

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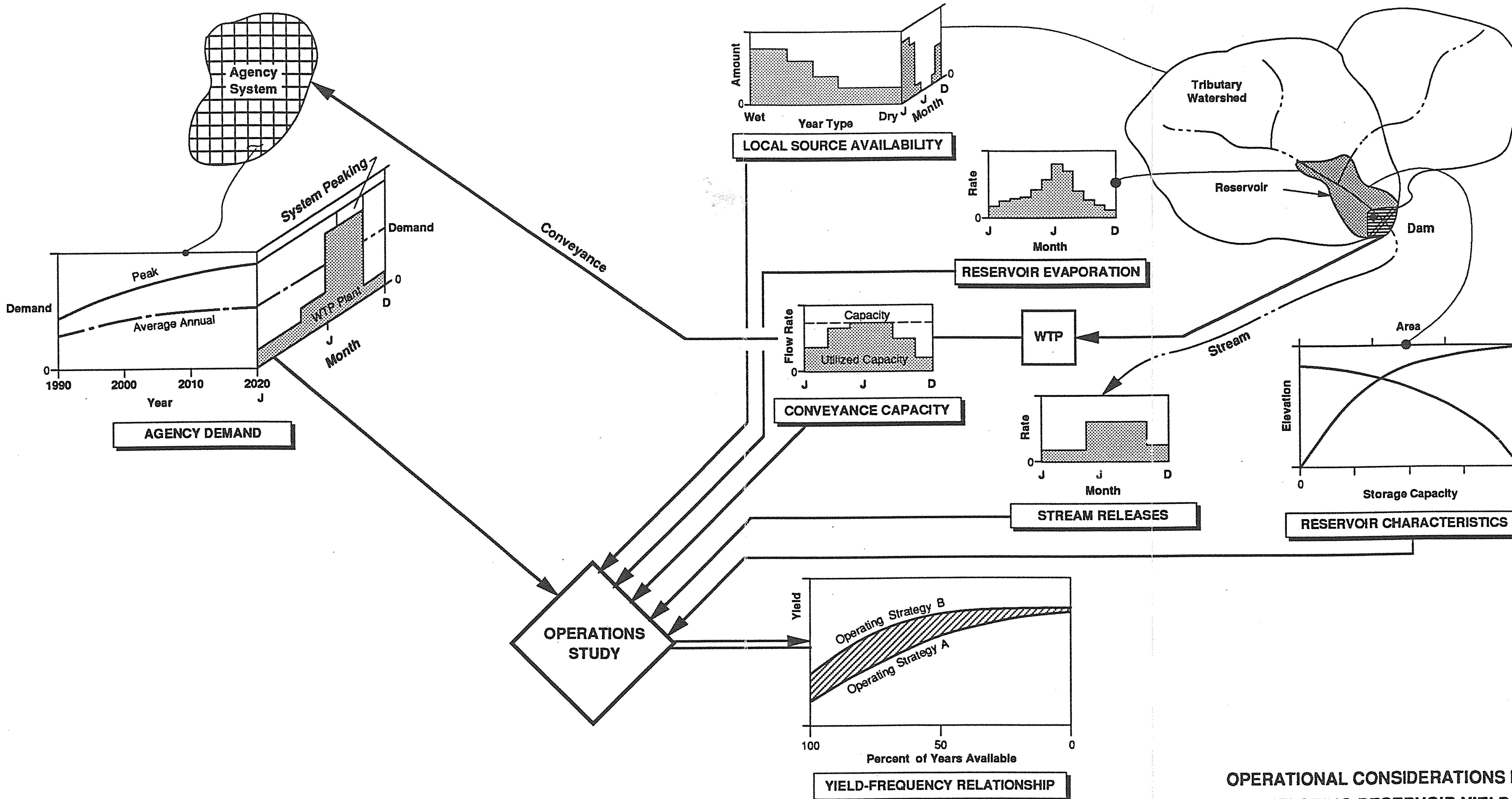

OPERATIONAL CONSIDERATIONS IN
DEVELOPING RESERVOIR YIELD

FIGURE 5-6

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under a range of different hydrologic conditions. In order to provide a longer period of record that includes a wider variety of tributary streamflows for the yield analysis, the 10 years of historical inflow data for Lake Hennessey was used to calibrate a Runoff Simulation Model (RUNOFF), and generate streamflows for the period of available rainfall data between 1940 and 1989.

The RUNOFF model was used to generate the extended streamflow record because it performs a soil moisture accounting and unsaturated flow simulation for the watershed based on actual historical rainfall data. Standard rainfall-streamflow correlation techniques were inadequate due to the number of variables affecting the generation of runoff, including soil type and antecedent soil moisture conditions. Input data for the RUNOFF model includes monthly precipitation data for the period of record from a rain gauge representative of the watershed. Monthly average evaporation and evapotranspiration data and an appropriate Soil Conservation Service (SCS) curve number are also required. The SCS curve represents the runoff potential of the watershed based on soil group, vegetative ground cover, and amount of impervious area in the watershed. Model output includes direct runoff from the watershed, evapotranspiration, and groundwater flow for each month in the simulation period.

Precipitation data was obtained from rain gauges at Napa, Angwin, and Calistoga and adjusted to represent rainfall in each watershed. The Napa gauge was used to generate the streamflows for the Milliken and Rector Reservoirs, and the Angwin gauge was used for Lake Hennessey and Bell Canyon Reservoir. The Calistoga gauge was used for Kimball Reservoir streamflow.

Average monthly evaporation data was obtained from DWR Bulletin 73-79, "Evaporation From Water Surfaces in California". This data, for a Type A evaporation pan in Yountville-Gamble, was adjusted to a free water surface by applying a pan coefficient of 0.74. This data was assumed to be representative of the evaporation at each of the five reservoir locations. Average monthly evapotranspiration data representative of the natural vegetative cover in the watersheds was taken from DWR Bulletin 113-3, "Vegetative Water Use In California". SCS curve number 82 was selected based on the hydrologic soil group, vegetative cover, and amount of impervious area contained in the watersheds.

The RUNOFF model was calibrated using historical streamflow data for the Lake Hennessey watershed for the period 1980 to 1989. Based on similar physical characteristics between the reservoir watersheds, the calibrated model was then used to generate streamflows for the watersheds tributary to each reservoir for the period of record between 1940 and 1989. Streamflow from the watershed tributary to Kimball

Reservoir was generated for the period 1949 to 1989 due to the shorter record of rainfall data available at the Calistoga rain gauge.

Table 5-4 presents a summary of the streamflows generated for each of the five reservoirs. The table includes the watershed drainage area and the maximum, average, and minimum yearly inflow for each reservoir.

Reservoir Yield Analysis. The yield analysis provides a measure of the quantity of water available from a reservoir and the reliability of that supply under varying hydrologic conditions. The Reservoir Simulation Model (RESSIM) was used to evaluate the yield of each of the five reservoirs based on the 50 years of monthly streamflow generated by the RUNOFF model.

The Reservoir Simulation Model was adapted from the SIMYLD2 model developed in 1972 by the Texas Water Development Board. RESSIM is a computer program designed to simulate the monthly operation of a reservoir subject to a sequence of reservoir inflows and demands. The model can also determine the maximum firm yield of the reservoir for the period of inflow record. RESSIM accounts for reservoir inflow, evaporation, releases, spills, and changes in storage on a monthly time step. The model incorporates a reservoir operating rule and allows the user to specify the desired amount of water held in storage at the end of each month.

For each reservoir yield analysis, input data for RESSIM included the monthly streamflow record generated for each of the reservoirs along with the same average monthly evaporation data used with the RUNOFF model. Reservoir capacity versus surface area data was obtained from reservoir capacity curves for each reservoir. Monthly reservoir storage goals were approximated based on a general monthly operations rule curve that was applied to each reservoir.

The monthly municipal demand distribution for each reservoir was taken from work done in the Water Needs Analysis (Section 3) of this study. The demand distribution was based on an analysis of monthly water production data for the period 1985-1989. Table 5-5 shows the monthly demand distribution used for each reservoir.

The yield analysis was conducted without allowing water transfers between water suppliers in order to determine the yield and supply reliability of each reservoir on an individual basis. For both Lake Hennessey and Milliken Reservoir, water rights documents and operational records were reviewed to evaluate the effect of water rights and instream-flow requirements on reservoir yield and reliability.

TABLE 5-4
RESERVOIR INFLOW SUMMARY

Reservoir	Drainage Area (Sq. Mile)	Annual Inflow (AF/YR)		
		Maximum	Average	Minimum
Milliken	9.6	14,154	3,656	0
Rector	11.0	13,800	3,354	0
Lake Hennessey	52.4	82,890	19,692	0
Bell Canyon	5.5	12,166	3,133	4
Kimball	3.4	8,904	2,817	3

TABLE 5-5
MONTHLY MUNICIPAL DEMAND DISTRIBUTION
(Percent of Annual)

Reservoirs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Milliken	5.2	4.9	5.8	7.4	10.1	12.0	13.1	12.1	9.8	8.3	5.9	5.5
Rector	4.2	5.3	4.9	6.5	9.7	14.0	11.0	11.4	11.1	8.9	5.9	5.1
Lake Hennessey	5.2	4.9	5.8	7.4	10.1	12.0	13.1	12.1	9.8	8.3	5.9	5.5
Bell Canyon	4.5	4.3	5.4	7.6	10.0	12.1	13.2	13.4	10.7	8.4	5.5	4.7
Kimball	6.6	6.1	6.9	7.8	9.2	10.4	11.7	10.9	8.8	7.9	6.7	6.9

Note: Percentages based on 1985-1989 production data.

Section 5

Existing Water Supplies

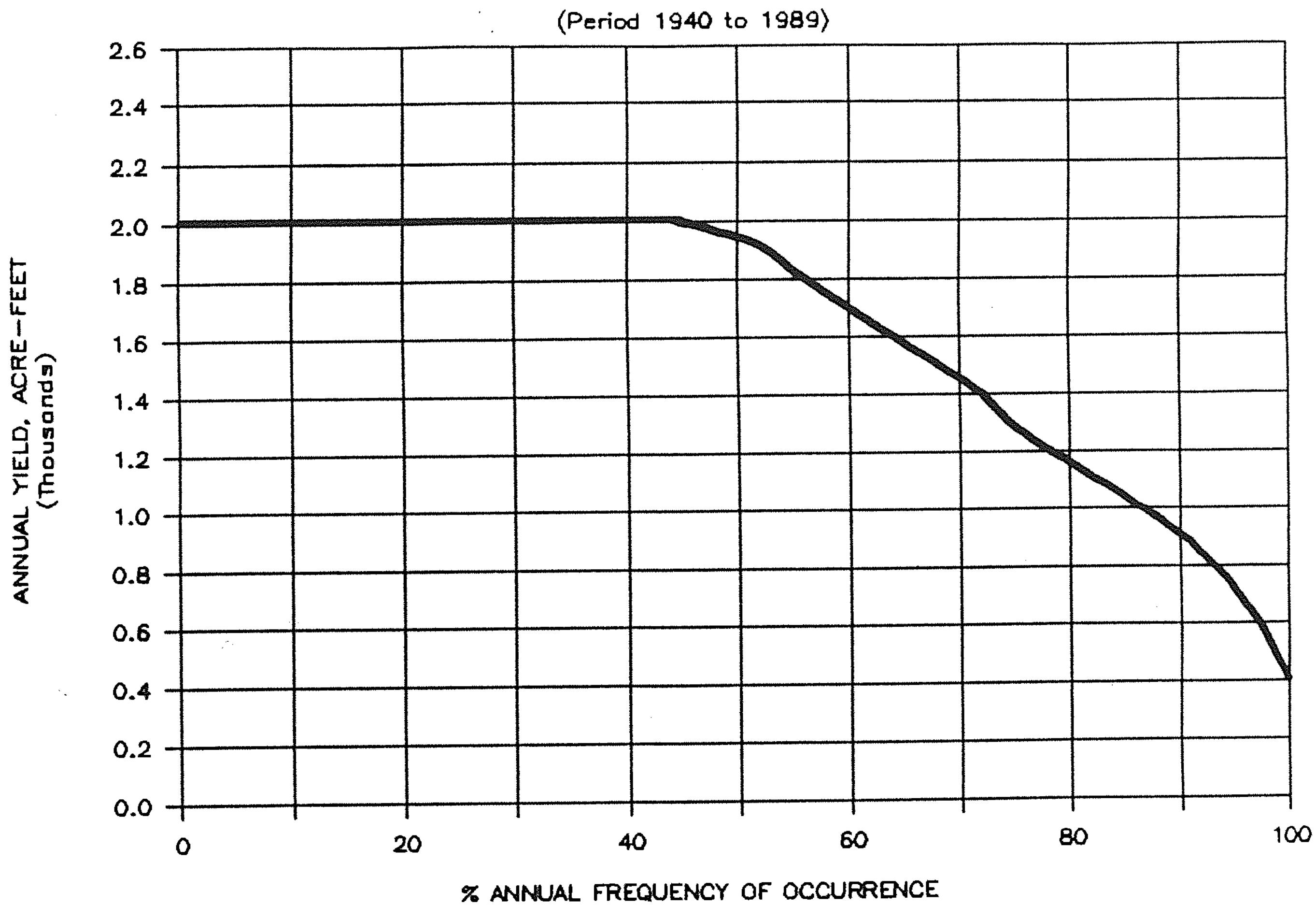
For this study, firm yield was defined as the reservoir yield that could be supplied for the 50 years of record, between 1940 and 1989, without any shortage. The Kimball Reservoir analysis used a 40 year period of record, from 1949 to 1989, due to the shorter period of data available at the Calistoga rain gauge. Thus, the firm yield for each reservoir is the largest annual volume of water that can be supplied during the driest critical period in the historical record, without any shortage.

The yield frequency curve developed for each reservoir is shown in Figures 5-7 through 5-11. The shape of each curve is a function of the annual streamflow, reservoir storage capacity, and the water supply demand distribution. The frequency curves provide an estimate of the reliability of each reservoir for different levels of annual yield. The frequency curve shows the percent of the time that a given level of annual yield can be supplied, without any shortage, based on the period of record for the RESSIM simulations. The firm yield is shown as the annual yield that can be supplied 100 percent of the time. As an example, Milliken Reservoir can supply a yield of 1,150 acre-feet per year 80 percent of the time. This means that there were 10 years out of the 50 year simulation period when this yield could not be met. The firm yield for Milliken Reservoir or the yield that could be supplied 100 percent of the time, in all 50 years without any shortage,is about 400 acre-feet.

The firm yield of the smaller reservoirs with little carry-over storage, such as Kimball and Bell Canyon, was determined by the short, but very dry period from 1976-1977, whereas the firm yield for Lake Hennessey, the largest reservoir at 31,000 acre-feet, was determined by the longer drought period from 1945-1949. The longer drought period used up the carry-over storage that allowed Lake Hennessey to provide a larger reliable quantity of water during the 1976-1977 drought.

Table 5-6 presents a summary of the results of the yield analysis for each of the five reservoirs. The table includes the reservoir storage capacity and reservoir yield reliability levels at 50, 80, 90 and 100 percent. The firm yield is shown in the 100 percent column and represents the yield that can be supplied every year without shortage based on the reservoir simulations for the period of record. The reservoir storage utilized in the yield analysis does not include surcharge storage created by flashboards in the spillway. Flashboard use is regulated by the State Division of Safety of Dams and would only be allowed late in the rainy season to avoid any danger from storms.

The reservoir yields shown in Table 5-6 are significantly lower than the yields estimated in previous studies. Since the background data and period of record used for these previous estimates are unknown, it is impossible to make any kind of valid comparison.



MILLIKEN RESERVOIR ANNUAL YIELD

FIGURE 5-7

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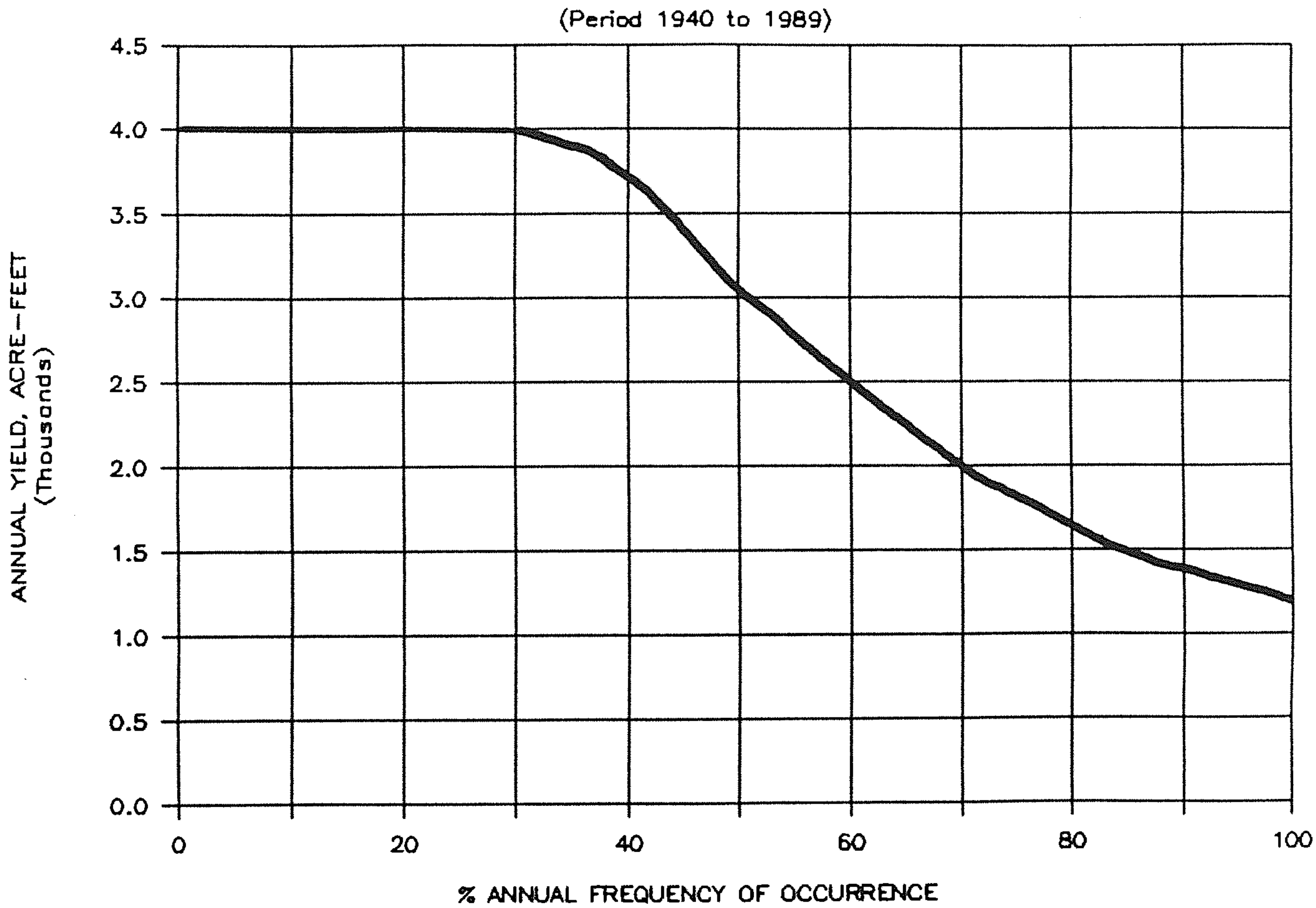

RECTOR RESERVOIR ANNUAL YIELD

FIGURE 5-8

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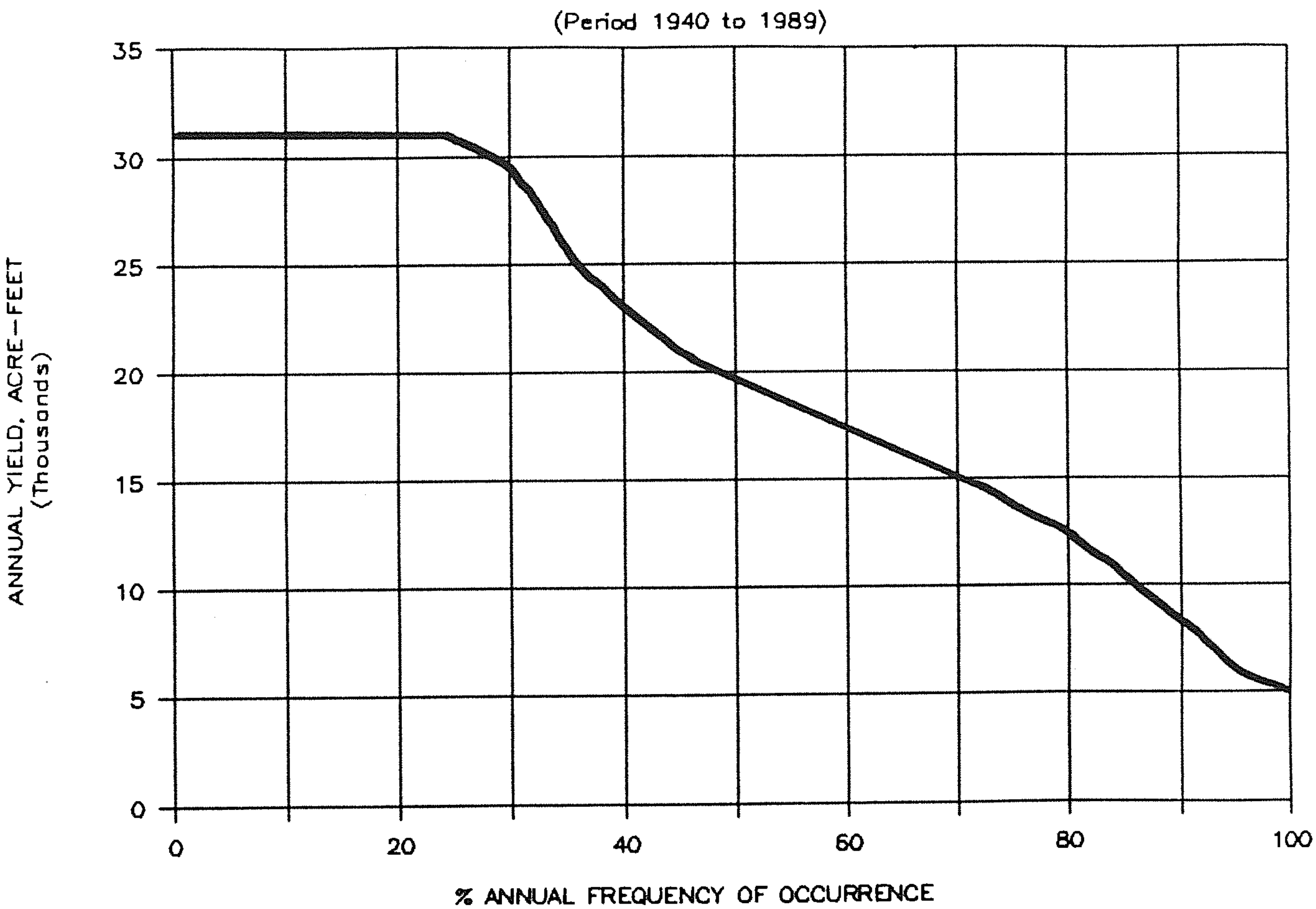
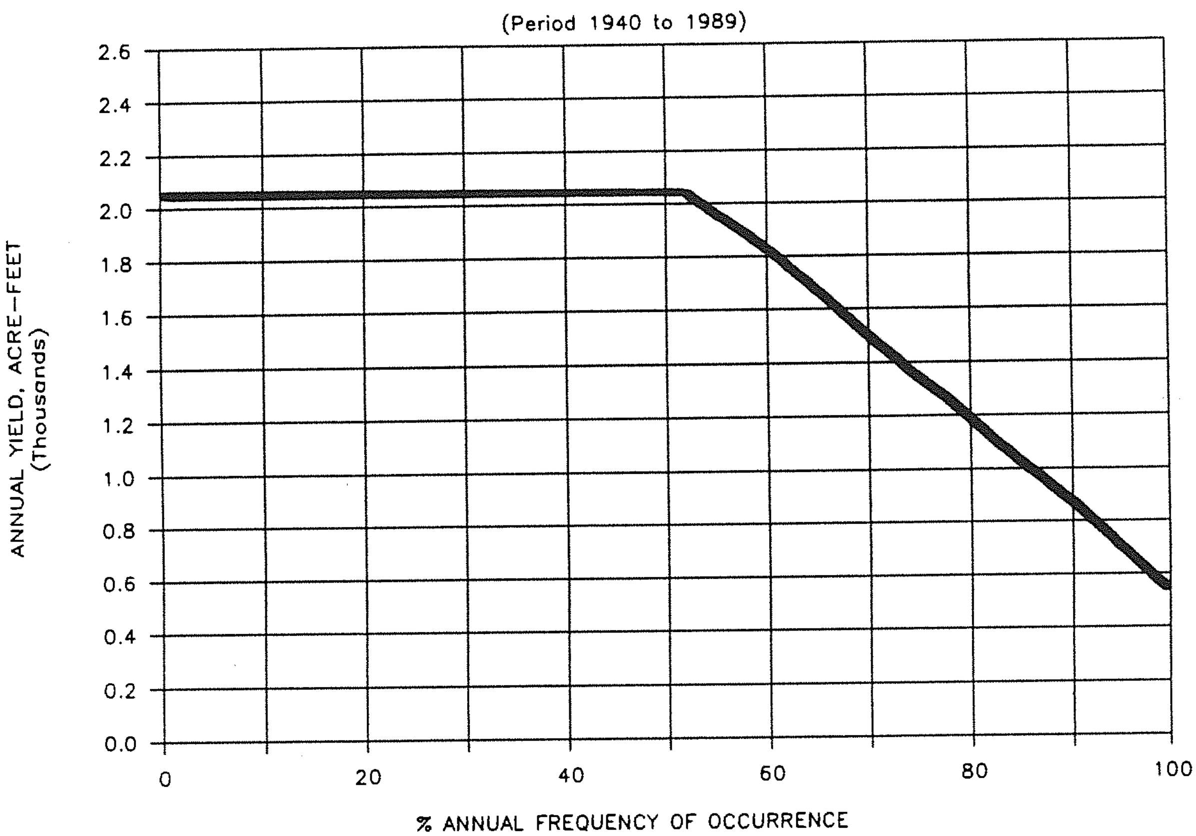


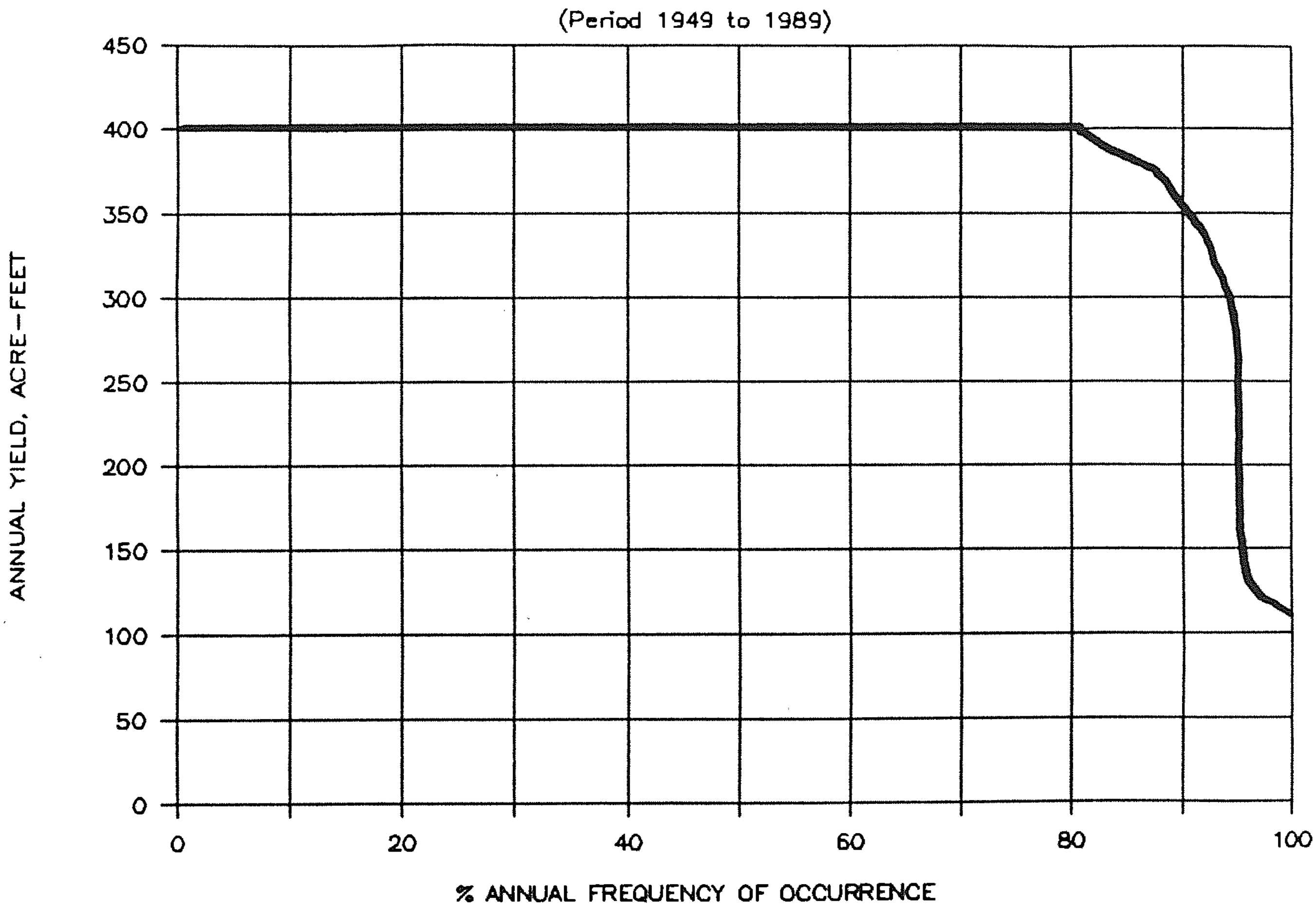
LAKE HENNESSEY ANNUAL YIELD

FIGURE 5-9



BELL CANYON RESERVOIR ANNUAL YIELD

FIGURE 5-10



KIMBALL RESERVOIR ANNUAL YIELD

FIGURE 5-11

TABLE 5-6
RESERVOIR YIELD ANALYSIS SUMMARY

Reservoir	Storage Capacity (AF)	Reservoir Yield Reliability (AF/YR)[1]			
		100%	90%	80%	50%
Milliken	2,000	400	900	1,150	1,950
Rector[2]	4,000	1,200	1,400	1,650	3,000
Lake Hennessey	31,000	5,000	8,300	12,000	19,500
Bell Canyon	2,050	530	870	1,200	2,050
Kimball[3]	335	110	350	400	400

(1) Reservoir yield was computed for a range of reliability levels. Firm yield (yield that can be supplied every year without any shortage) is shown in the 100 percent column. Other columns show the percent of the time the specific yield can be supplied, based on the period of record 1940-1989.

(2) Rector provides 325 Ac-Ft/Yr of yield to the Town of Yountville; the remainder to the State for the Veterans Home and Napa State Hospital.

(3) Kimball yields and average inflow based on period 1949-1989.

But the probable primary differences are that the RESSIM model allows a much more detailed level of analysis then was used previously, and that the present analysis was based on an extended streamflow record that included three major droughts that were not previously analyzed. These three droughts include the periods 1945-1949, 1976-1977, and 1987-1989.

Lake Berryessa

In the eastern part of Napa County, the 1.6-million-acre-feet Lake Berryessa dominates the landscape. This 15-mile-long reservoir was created in the 1950s by the U.S. Bureau of Reclamation by constructing Monticello Dam which is located at the junction of Napa, Solano, and Yolo Counties. The lake itself is entirely within Napa County. On March 7, 1955, the Bureau of Reclamation entered into a 40-year contract with the Solano County Flood Control and Water Conservation District for Lake Berryessa's full yield of 247,000 Ac-Ft/Yr for agricultural and municipal and industrial water. To deliver that water, Solano County residents constructed the required regulating reservoirs, canals, pipelines, and pumping stations. The key water users are farmers and such municipalities as the City of Fairfield and Vacaville. At the time of construction of Lake Berryessa, the California State Water Resources Control Board said that an Upper Putah Creek "depletion reservation" of 33,000 Ac-Ft/Yr must be set aside from the 247,000 Ac-Ft/Yr yield for future use upstream of the lake-namely for Lake and Napa Counties, and further required a downstream release of an additional 20,000 Ac-Ft/yr.

The key issue with water rights is that such rights are often reserved only as they relate to a proposed beneficial use implemented within a date specified by the Board. Over the years, the water need has developed in Solano County so that today it is actually using some of the Upper Putah Creek "depletion reservation". Of that 33,000 Ac-Ft/yr reservation, Lake County was allocated 7,500 Ac-Ft/yr for the proposed Dry Creek Dam, a project that has not been built. The State now has applications for some 80,000 Ac-Ft/Yr of the unused portion of the "depletion reservation".

Solano County's growth and presence of a delivery system from Lake Berryessa have facilitated its use of the unused portion of the reservation. It is permitted to do so by the Board on a year-to-year basis. In 1993, when the permit goes to license, and actual beneficial use has to be demonstrated, Solano County could most likely point to its needs and capability to deliver that water through an existing distribution system. However, the State Board would consider Lake, Napa, and Yolo Counties' protests in making any decision, and would prefer that a negotiated allocation of the unused water be achieved between the counties. An agreement between Napa County and Solano

County now provides that 1,500 Ac-Ft of Lake Berryessa water will be available for lakeside use. The desire of Solano County to purchase Monticello Dam from the Bureau has further complicated the water rights issue in that the Bureau would prefer that such an unresolved issue be taken care of before any potential sale which must be approved by Congress. As a result, negotiations were begun in 1988 between Napa and Solano Counties, with Napa requesting 15,000 Ac-Ft/Yr, and in 1989 with Lake County which requested 10,000 Ac-Ft/Yr. In the case of Napa County, Solano offered approximately 10,000 Ac-Ft/Yr. During the 1988 Napa election period, talks between the two counties were put on hold after three new supervisors were elected to the Napa board. In February 1989, the board voted to go back to the negotiating table. At this time, the water rights issue has not been resolved.

The issue was further complicated by recent legal action of several Solano County agencies who are requesting court adjudication of the Putah Creek water supply.

As a Napa County supply, water would most likely be restricted to use within the lake's watershed, a consideration that was incorporated in establishing the Lake Berryessa Subarea (LB) boundaries for the current water resource study. Key users of this water would be residents and visitors of Lake Berryessa, and irrigation of vineyards such as in Pope and Capell Valley from storage of winter stream flows in the upper Berryessa watershed.

The amount of Lake Berryessa water that will be permanently available to Napa County is indeterminate at this time.

IMPORTED WATER

Napa County is a contractor with the State of California Department of Water Resources for water for municipal and industrial water from the State Water Project via the North Bay Aqueduct. This facility derives its water from the Delta at Barker Slough and delivers it to cities in Solano County via conduit and then by supplemental pumping into the Jameson Canyon area of southeast Napa County. For many years, an interim supply source was provided from Lake Berryessa via the Putah South Canal until the recent completion of Phase II of the aqueduct. The master water supply contract between the County and the State was signed on December 19, 1963 with subsequent amendments revising contract repayment and entitlement buildup.

The current contract buildup schedule is shown in Table 5-7, derived from Contract Amendment No. 12 of February 11, 1986. The entitlement culminates with a total of 25,000 Ac-Ft/Yr in the year 2021, allocated as follows:

Contractor	Entitlement (Ac-Ft/Yr)
City of Napa	18,800
American Canyon CWD	5,200
Town of Yountville	500
City of Calistoga	500
Total	25,000

The City of St. Helena is not a participant in the contract.

A plot of the entitlement (Figure 5-12) shows an approximate linear buildup to year 2020 (24,900 Ac-Ft/Yr) from year 1990 (6,745 Ac-Ft/Yr). The current (1990) allocation among the County water supply entities is Napa (4,000), American Canyon CWD (2200), and Yountville/Calistoga (545). The contract states that the specified water quantities are based on a "minimum project yield" defined as an ultimate dependable State Water Project supply of 4,230,000 Ac-Ft/Yr (when all required facilities are in place). The contract also provides for "allowable reduction" in the contract quantity due to drought, with agricultural cutbacks coming first in an amount up to 50 percent in any one year, and additional cutbacks distributed equally among agricultural and municipal and industrial users. (Thus a 65 percent agricultural use cutback translates to a 15 percent municipal and industrial use cutback.) Napa County's contract is for municipal and industrial use exclusively.

The reliability of the North Bay Aqueduct water supply thus comes down to two issues:

- the potential cutbacks during droughts
- the inability of the State to deliver its ultimate contract entitlement with current State Water Project Facilities.

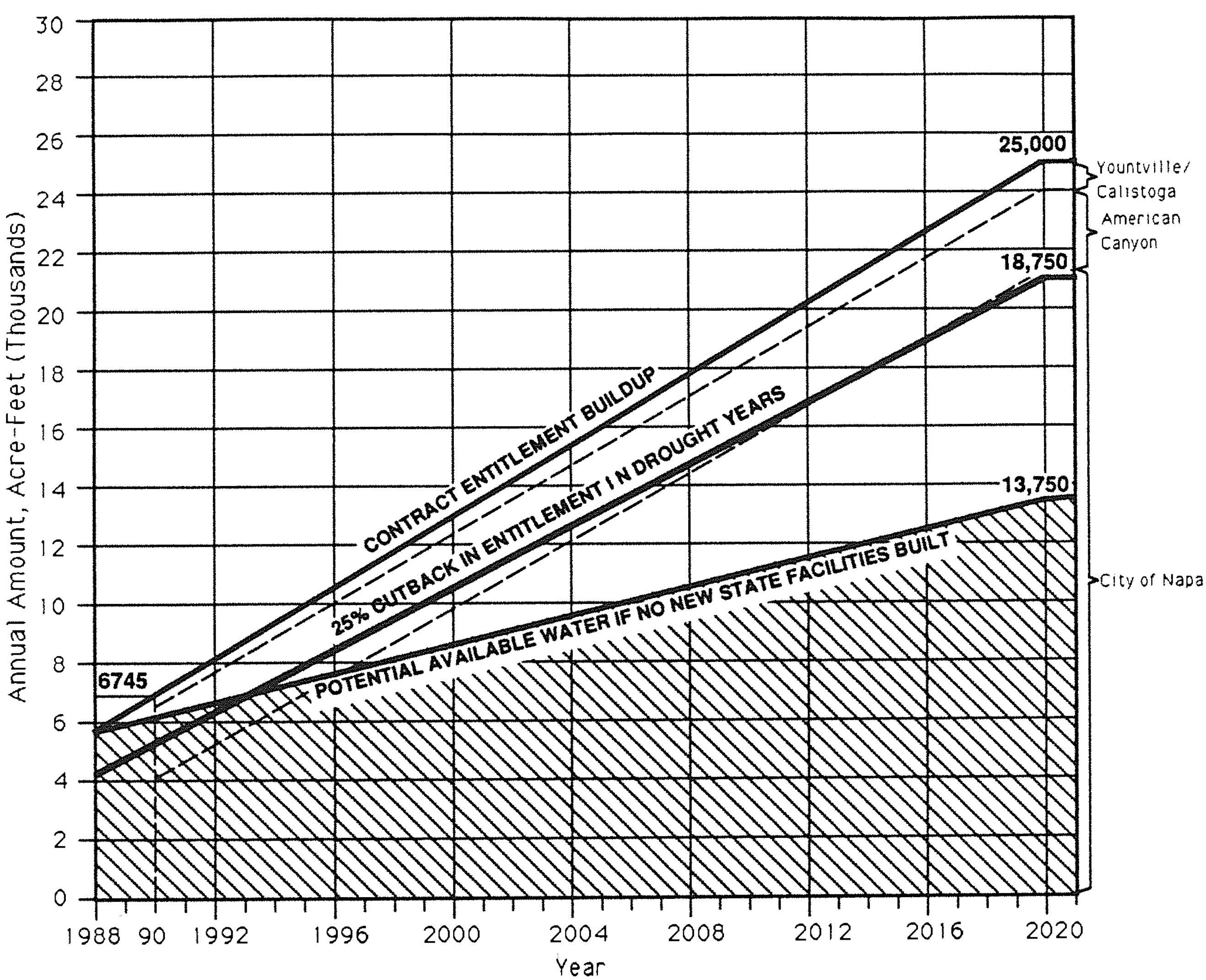
If we look at Figure 5-12, then it can be said that if State facilities are built (such as additional Banks Pumping Plant units, Delta channel modifications, Los Banos Grandes, Kern Water Bank, etc.), then in any year, the entitlement for that year can be reduced due to drought, such as the current four-year period (1987-90). Such cutbacks have been kept to a maximum of about 10 percent for municipal and industrial users, such as in 1977. It is conceivable that such cutbacks could approach 25 percent (when

TABLE 5-7

NORTH BAY AQUEDUCT ENTITLEMENTS
NAPA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

Year	Total Annual Amount (Acre-Feet)
1988	5,745
1989	6,195
1990	6,745
1991	7,290
1992	7,840
1993	8,490
1994	9,135
1995	9,780
1996	10,425
1997	11,065
1998	11,710
1999	12,330
2000	13,050
2001	13,665
2002	14,185
2003	14,800
2004	15,400
2005	16,000
2006	16,450
2007	17,000
2008	17,650
2009	18,200
2010	18,750
2011	19,400
2012	19,950
2013	20,600
2014	21,250
2016	22,500
2017	23,100
2018	23,700
2019	24,300
2020	24,900
2021	25,000*

NOTE: * and each succeeding year thereafter for the term of the contract as a maximum entitlement.



NORTH BAY AQUEDUCT CONTRACT BUILDUP

FIGURE 5-12

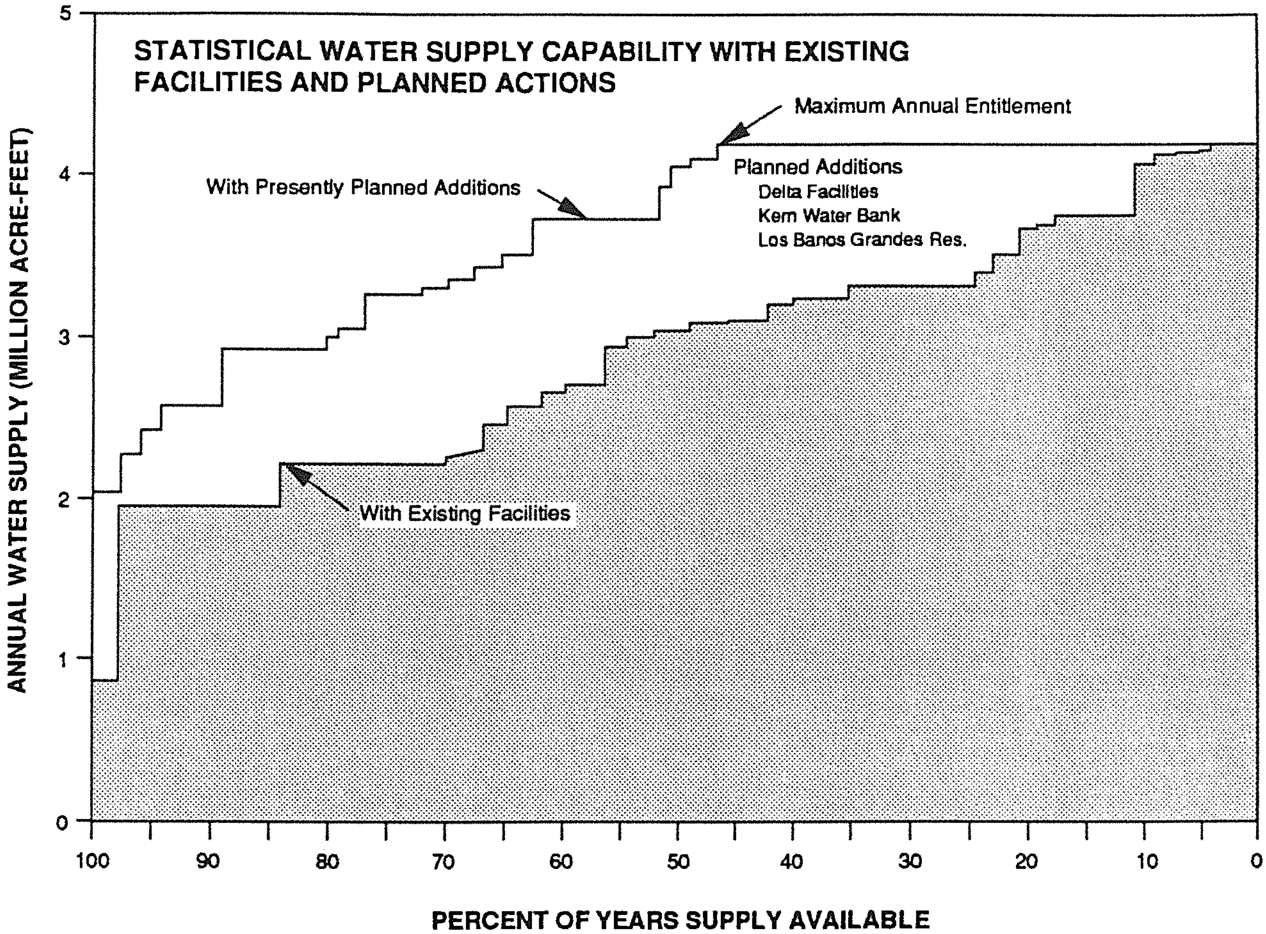
agriculture is cut back by 75 percent). So in any year, depending upon uncontrollable hydrologic events (rainfall), the County's supply could be cut back to 75 percent of its entitlement for that year.

The second aspect of reliability can also be shown on Figure 5-12. The State has said that with current State Water Project Facilities it is capable of delivering a dependable yield of 2,300,000 to 2,400,000 Ac-Ft/Yr, approximately 55 percent of its contracted-for ultimate dependable yield of 4,230,000 Ac-Ft/Yr. What this means is that if the State builds no new project facilities it would have to cut back its deliveries by 45 percent of ultimate contract entitlement. If distributed uniformly to all State water contractors, then Napa County could count on only 13,750 Ac-Ft/Yr of its 25,000 Ac-Ft/Yr contract. The situation could possibly be even slightly worse since Sierra "area of origin" Counties' water rights might further reduce the State project's supplies. Because municipal and industrial demand has not built up as rapidly as originally envisioned (slower growth and conservation), cutbacks of contract entitlement are not yet imminent. As demand grows, however, the State Water Project reliability will further deteriorate from its current level of 65 percent (percent of years supply is available, according to Figure 5-13), a level which is not acceptable for any municipality dependent on such a source as its only supply.

It should be pointed out that surplus water has been and would be available in the future during wetter years, with North Bay Aqueduct delivery capacity becoming the chief limitation.

RECLAMATION

Reclamation of municipal wastewater effluent is currently being accomplished in Calistoga, Yountville, and at Napa Sanitation District plants. For Calistoga and Yountville, turf areas such as parks, sport fields, and a golf course are being irrigated by approximately 200 and 300 Ac-Ft/Yr of treated effluent, respectively. The Sanitation District currently disposes approximately 1600 Ac-Ft/Yr of effluent by irrigation of 590 acres of ranch pasture in the Soscol area during the summer months. The District's current reclamation practice is very restricted as to use due to the level of wastewater treatment provided - oxidation ponds, with no additional disinfection. The key reason for current reclamation here is due to an annual Napa River effluent discharge prohibition between May 1 and October 31.



SOURCE: DWR BROCHURE (1989) "THE CALIFORNIA STATE WATER PROJECT"

NORTH BAY AQUEDUCT SUPPLY RELIABILITY

FIGURE 5-13

SECTION 6

BALANCING WATER NEEDS AND SUPPLIES

The goal of the current water resources study is to find the best mix of supplies that can satisfy the County's water needs to the year 2020. The study's effort has focused on estimating the likely range of water needs through development of a baseline projection and alternative demand scenarios. The water needs projection methodology is well documented in this report and based to the greatest extent possible on local and regional planning agency land use and population estimates. On the supply side, this study has strived to establish the reliability of the individual supplies - groundwater, river diversion, reservoirs, and imported water. This reliability aspect points up that all supplies vary in availability by season (month) and by year. Such supply variation can be unpredictable to a large degree depending on weather. Yet, long-term historical records of rainfall and streamflow make statistical analysis possible that gives some indication of what supplies are available in the future. With longer and longer historical records, more extreme hydrologic events become incorporated, and the supply reliability estimate becomes somewhat better. In other cases, such as the imported water from the North Bay Aqueduct and the Lake Berryessa supply, both hydrologic and political factors impact supply availability. For example, construction of additional State Water Project facilities to insure that Napa County's full, ultimate contract entitlement becomes available, depends on the outcome of the Bay-Delta Hearings being conducted by the California State Water Resources Control Board, environmental organizations, State and Federal fisheries policies, the north-south water controversy, governmental actions, voter approval of initiatives and bonds, etc. Yet one can arrive at some estimate of the range of water supply availability and consider that in balancing water needs and supplies.

WATER NEED/SUPPLY RELATIONSHIP

The balancing of water needs and supplies must be approached from several levels:

- By User
- By Subarea
- County-wide

The user assessment is necessary based on individual reliability requirements, as well as water quality concerns.

The subarea assessment is necessary based on legal requirements-Lake Berryessa "depletion reservation" for "reasonable beneficial use within the watershed of Putah Creek above said reservoir", and on obtaining economic supplies based on proximity to user. As an example of the latter, Napa River diversions and groundwater in the North Napa Valley Basin made available to vineyards in the Napa Valley.

Balancing Water Needs and Supplies

The County-wide assessment is necessary since State and Federal water contracts and water rights often are placed into county hands for allocation to in-county water supply entities. The county acts as the umbrella organization, minimizing the number of potential contracts with the State or Federal government. Such is the case with the North Bay Aqueduct contract and the recent request for supplemental Central Valley Project water from the Bureau of Reclamation. It is also the case with the Lake Berryessa water, where Napa County has been involved in agreements and negotiations to resolve the water supply issues.

Using the water need projections presented in Section 3, and existing supply availability as discussed in Section 5, water need/supply relationships were developed for individual water users, subareas, and Napa County as a whole, as shown in Table 6-1 and Figure 6-1. The key assumptions underlying these relationships are summarized below.

- **Water Needs**

  - Total County baseline water need projection for the period 1990 through 2020 with breakdown by user-agricultural (total crop requirement for vineyards and other), rural, and municipal and industrial. The alternative demand scenarios for total County water need are also shown.

  - Subarea baseline water need projection for the same period and breakdown by user.

- **Water Supplies**

  - Supplies are "stacked" from bottom to top in the following order: groundwater, river diversion, reservoirs, and imported supply, in order to correspond to water need "stacking" and allow review of need/supply balance by user.

  - The groundwater supply shown in Figure 6-1 represents safe yield, which is that amount of pumping that can be sustained in the long term based on natural basin recharge. Pumping extractions may be more in certain years, but would have to be balanced by reduced pumping in other years. The allocation to subarea and safe yield is as follows:

TABLE 6-1
NAPA COUNTY WATER NEED/SUPPLY RELATIONSHIP

	Baseline Water Need (Ac-Ft/Yr)							Safe/Firm Yield from Existing Water Supplies											Supply-Need (Ac-Ft/Yr)	
								Ground-Water	River Diversion		Reservoirs			Imported (NBA)		Recla-mation	Total			
Water User	1990	1995	2000	2005	2010	2015	2020		Napa	Others	Muni-cipal	Berryessa	Misc.	1990	2020		1990	2020	1990	2020
North Napa Valley (NN) Subarea																				
Muncipal & Industrial (M&I) Calistoga	990	1060	1190	1340	1405	1460	1515	75	0	0	400	NA	0	272	275	200	947	950	-43	-565
St. Helena	1935	2195	2275	2380	2495	2595	2690	0	0	0	1200	NA	0	0	0	0	1100	1200	-835	-1490
Yountville	450	490	515	540	570	595	625	0	0	0	325	NA	0	272	275	0	597	600	147	-25
Subtotal M&I	3375	3745	3980	4260	4470	4650	4830	75	0	0	1925	0	0	544	550	200	2744	2747	-631	-2083
Rural(1)	2438	2506	2623	2745	2882	2996	3111	*	*	*	875	NA	*	NA	NA	0	—	—	—	—
								22500*	10,000*								35175	35175	9762	2034
Agricultural-Vineyard	22181	23356	24532	25708	26883	28059	29235													
Agricultural-Other	797	797	797	797	797	797	797													
Agricultural-Total	22978	24153	25329	26505	27680	28856	30032	*	*	*	1500**	NA	*	NA	NA	300	—	—	—	—
Total for Subarea NN	**28791**	**30404**	**31932**	**33510**	**35032**	**36502**	**37973**	**22575**	**10000**	**0**	**4300**	**0**	**0**	**544**	**550**	**500**	**37919**	**37922**	**9128**	**-51**
South Napa (SN) Subarea																				
Municipal & Industrial (M&I) City of Napa	13825	14675	15305	15685	16625	17410	18195	0	0	0	6150	NA	NA	4000	10285	0	10150	16435	-3675	-1760
American Canyon	1591	1721	1846	2031	2136	2226	2316	0	0	0	NA	NA	NA	2200	2860	0	2200	2860	609	544
Subtotal M&I	15416	16396	17151	17716	18761	19636	20511	0	0	0	6150	0	0	6200	13145	0	12350	19295	-3066	-1216
Rural	1705	1732	1811	1903	2017	2112	2207	*	*	*	NA	NA	*	NA	NA	0	—	—	—	—
								5700*	1000**	500**			500**				9300	9300	841	-1629
Arigcultural-Vineyard	3248	3576	3904	4232	4560	4888	5216													
Agricultural-Other	3506	3506	3506	3506	3506	3506	3506													
Agricultural-Total	6754	7082	7410	7738	8066	8394	8722	*	*	*	NA	NA	*	NA	NA	1600	—	—	—	—
Total for Subarea SN	**23875**	**25210**	**26372**	**27357**	**28844**	**30142**	**31440**	**5700**	**1000**	**500**	**6150**	**0**	**500**	**6200**	**13145**	**1600**	**21650**	**28595**	**-2225**	**-2845**
Lake Berryessa (LB) Subarea																				
Municipal & Industrial (M&I)	0	0	0	0	0	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—
Rural	95	96	101	106	112	117	123	*	NA	*	NA	*	*	NA	NA	0	—	—	—	—
								400*		100*		1500*	250*				2250	2250	-3664	-5744
Agricultural-Vineyard	2460	2802	3144	3486	3828	4170	4512													
Agricultural-Other	3359	3359	3359	3359	3359	3359	3359													
Agricultural-Total	5819	6161	6503	6845	7187	7529	7871	*	NA	*	NA	0	*	NA	NA	0	—	—	—	—
Total for Subarea LB	**5914**	**6257**	**6604**	**6951**	**7299**	**7646**	**7994**	**400**	**0**	**100**	**0**	**1500**	**250**	**0**	**0**	**0**	**2250**	**2250**	**-3664**	**-5744**
Total All Subareas	**58580**	**61871**	**64908**	**67818**	**71175**	**74290**	**77407**	**28675**	**11000**	**600**	**10450**	**1500**	**750**	**6744**	**13695**	**2100**	**61819**	**68770**	**3239**	**-8637**

NOTES: * Supply available to rural and agricultural, combined - ** Assumed (no detailed information available) - NA - Not available to user - (1) Includes Veterans Home at Yountville.

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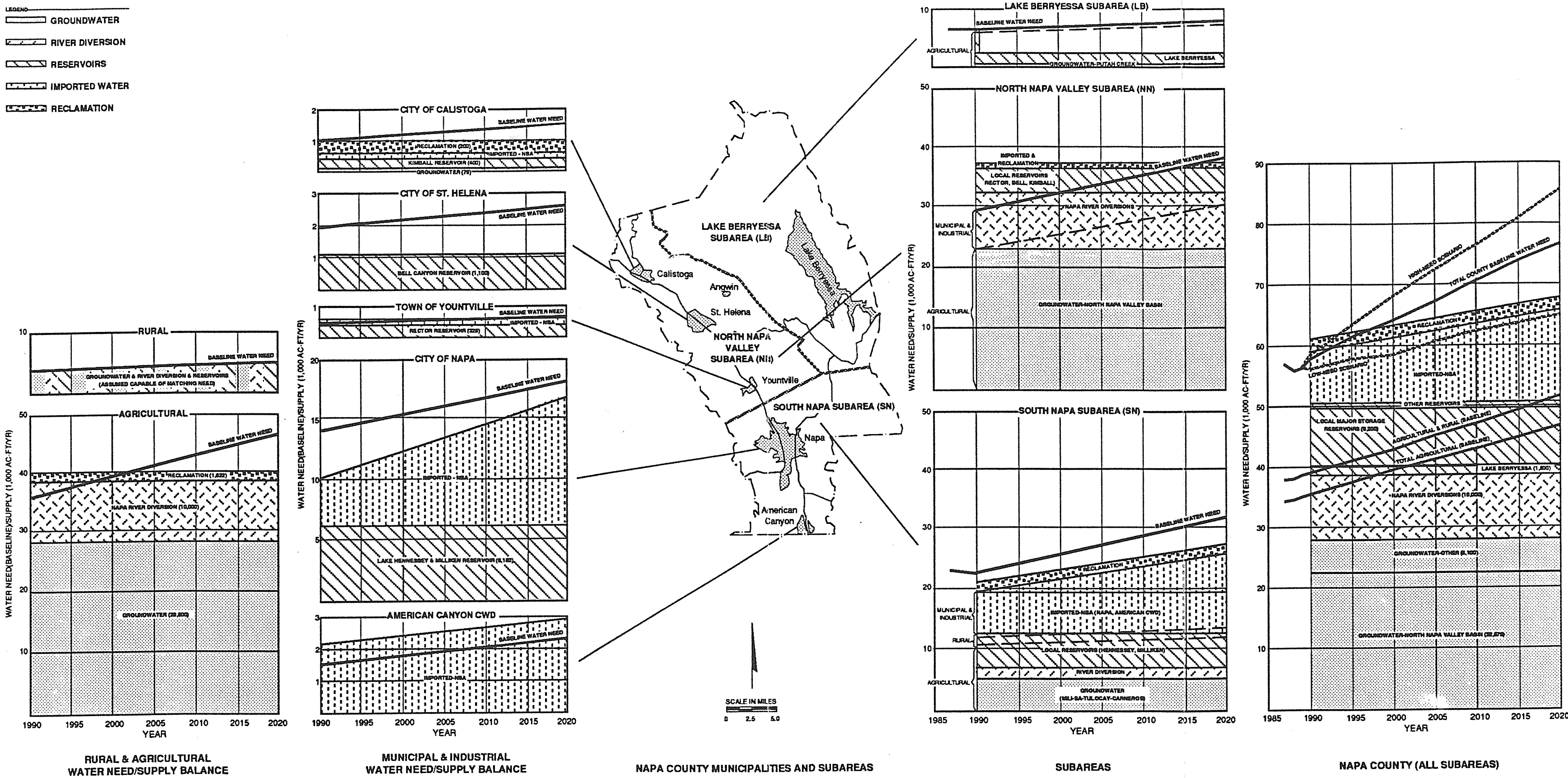

WATER NEED/ SUPPLY RELATIONSHIPS

FIGURE 6-1

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Groundwater Basin (Ac-Ft/Yr)	Subarea	Safe Yield
Northern Napa Valley	NN	22,500
NN Subarea Total		22,500
Carneros	SN	300
Milliken-Sarco-Tulucay	SN	5,400
SN Subarea Total		5,700
Putah Creek	LB	400
Total for all Subareas		28,600

- Potential river diversions for vineyards are estimated at up to 10,000 Ac-Ft/Yr based on review of prior work and Napa River flows during the mid-March to mid-May frost protection season.

- The supply from local reservoirs is dependent on the minimum level of reliability (lowest frequency of occurrence) that is acceptable for that reservoir based on hydrologic availability and the likelihood that short-term supplemental alternate supplies could be obtained if a reservoir were operated to get more water most of the time. That is, to get a larger, long-term yield from a given reservoir, one must back off the "firm yield" operating strategy (100 percent frequency yield) and be willing to accept running low during infrequent critically-dry periods. This risk is acceptable if short-term water rationing can be imposed or an alternate short-term supply can be obtained. A review of actual 1989 local reservoir deliveries shows that the three smallest reservoirs - Kimball, Bell Canyon and Milliken, were operated at an 80 percent reliability level, whereas Hennessey and Rector were operated near the "firm yield" level. A purchase of 7,000 Ac-Ft for 1989 and 1990 from the Yuba County Water Agency, delivered via the North Bay Aqueduct, served as a short-term supplemental supply. Reservoir size plays an important role here in that Lake Hennessey, and Rector to a lesser extent, are carry-over reservoirs, and their "firm yield" is determined by multi-year drought periods, such as the current one, while the smaller reservoirs, with little carry-over storage, are impacted by single-year extreme hydrologic conditions, such as 1977. In Table 6-1 and Figure 6-1, local reservoir supply yield is based on the 80 percent frequency level for Kimball, Bell Canyon, and Milliken, and the 100 percent level for Hennessey and Rector. The allocation of reservoirs by subarea and their 80 percent and 100 percent-level yields are as follows:

Section 6

Balancing Water Needs and Supplies

Storage Reservoir	Subarea	Yield (Ac-Ft/Yr) 80%	100%
Lake Hennessey	SN	12,000	5,000*
Milliken	SN	1,500*	400
SN Subarea Total		13,150	5,400
Kimball	NN	400*	110
Bell Canyon	NN	1,200*	530
Rector	NN	1,650	1,200*
NN Subarea Total		3,250	1,840
Total for all Subareas		16,400	7,240

NOTE: Asterisk indicates yield selected for use in Table 6-1 and Figure 6-1.

As of this date (November 1990), no final allocation of the Lake Berryessa water between Napa and Solano Counties has been established beyond a 1981 agreement which specified 1500 Ac-Ft/Yr for lakeside municipal and industrial use.

- The imported supply represents the North Bay Aqueduct contract entitlement buildup from a total of 6,745 Ac-Ft/Yr in 1990 to 24,900 Ac-Ft/Yr in 2020. This supply is allocated as follows to the subareas with contract entitlement at a reduced 55 percent of the ultimate amount based on the delivery capability of existing State Water Project Facilities.

		Yield (Ac-Ft/Yr)	2020	
Subarea	User	1990	100%	55%*
SN	City of Napa	4,000	18,700	10,285
	American Canyon	2,200	5,200	2,860
	SN Subarea Subtotal	6,200	23,900	13,145
NN	Calistoga	---	500	275
	Yountville	---	500	275
	NN Subarea Total	545	1,000	550
	---		0	00
LB	Total All Subareas	6,745	24,900	13,695

NOTE: Asterisk indicates yield selected for use in Table 6-1 and Figure 6-1.

Section 6

Balancing Water Needs and Supplies

- The current reclamation supply is distributed as follows:

Source	Use	Amount (Ac-Ft/Yr)
City of Calistoga	Turf-Parks/Sport Fields	200
Town of Yountville	Turf-Golf Courses	300
Napa Sanitation District	Ranch Pasture	1,600

From a review of the baseline water need/existing supply relationship for Napa County water users, its three subareas, and County as a whole, as shown in Table 6-1 and Figure 6-1, the following observations can be made regarding the adequacy of existing water supplies:

	Adequacy of Existing Supplies	
User Group	1990	2020
<u>**Individual User:**</u>		
Municipal and Industrial		
City of Calistoga	Barley Adequate	Inadequate
City of St. Helena	Inadequate	Inadequate
Town of Yountville	Adequate	Barely Adequate
City of Napa	Inadequate	Inadequate
American Canyon CWD	Adequate	Adequate
Rural	Probably Adequate	Probably Adequate
Agricultural	Adequate	Inadequate
<u>**Subareas:**</u>		
Lake Berryessa (LB)	Adequate*	Inadequate
North Napa Valley (NN)	Adequate	Inadequate
South Napa (SN)	Inadequate	Inadequate
<u>**Napa County:**</u>	Adequate	Inadequate

* Due to the SWRCB depletion reservation for the Putah Creek area, the right to develop any water supply has been available.

Section 6

Balancing Water Needs and Supplies

A review of municipal and industrial production records for the recent drought years, 1987 to 1989, indicates that the smaller municipal reservoirs have been yielding close to their storage capacity, with however some yield declines in 1989, as the drought period lengthened. In the case of Lake Hennessey, however, there is a definite reduction in yield year by year, with current production near the firm-yield rate (100 percent frequency).

Current Napa County deliveries from its imported supply-the North Bay Aqueduct, have exceeded contract entitlements by over 60 percent. That extra water has come from the Yuba County Water Agency in a separate agreement negotiated between the City of Napa and the Agency for 7,000 Ac-Ft/Yr. The water is obtained from New Bullards Bar Reservoir via the Sacramento River and picked up at the Barker Slough intake of the North Bay Aqueduct. The City of Napa plays a key role in delivering the imported supply to the three up-valley water users - Calistoga, St. Helena and Yountville, by exchanging imported water for Lake Hennessey water. The latter can be delivered via the City's Conn Transmission Main and main extensions that have been established by Calistoga and St. Helena. In the case of St. Helena, which is not a contract participant for North Bay Aqueduct water, the non-State Water Project Yuba supply has been provided. Individual North Bay Aqueduct contract entitlements have been exceeded for Calistoga and the City of Napa, while Yountville's and American Canyon's entitlements have not been exceeded. It is the imported supply that has clearly made up for the reduced local reservoir yields.

Certain data and information inadequacies must be considered when reflecting on the water need/supply relationships shown in Table 6-1 and Figure 6-1:

- The lack of publicly-available groundwater pumping rates for agricultural and rural water users requires an indirect approach to estimate water use through land use acreage and crop unit water consumption.

- Sparse hydrogeological information for some of the smaller groundwater basins, such as the Carneros area.

- Little information on actual direct river and stream diversions, and available reservoir storage capacity for capturing direct diversions. Due to the timing mismatch between water need and river/stream flows, it is the amount of storage that really establishes direct river diversion capability.

Although some additional data and information may be available upon more intensive effort, the scope of this County-wide water resource study was not focused on specific individual water users. It is believed, however, that the water need/supply relationships for the major County water users has been established with a satisfactory level of confidence.

Section 6

Balancing Water Needs and Supplies

BALANCING WATER NEEDS AND SUPPLIES

In attempting to balance Napa County's water needs and supplies for the period 1990 through 2020, certain issues must be addressed:

- Hydrologic uncertainty is a way of life in semi-arid California, impacting virtually all supplies that Napa County water users have available - groundwater, river diversion, local reservoirs, and the imported North Bay Aqueduct supply. A key point here is whether the hydrologic uncertainty is concurrent for the different sources and what the shape of their yield-frequency curves is. Note that hydrologic uncertainty may decrease as the years go on since a longer-term hydrologic database becomes available. However, it does not appear likely that the hydrologic conditions for this coming water year, nor any subsequent years, will become known in advance so that supply operations could be adjusted accordingly. The reservoir yield that one seeks to operate at reflects the required dependability (reliability) and the availability of alternate supply sources. Municipal and industrial use generally requires a higher level of dependability than agricultural use.

- Political uncertainty may also be a way of life with respect to tying down supplies in water-deficient California as the state's population continues to expand. Such uncertainty clearly is a factor in the Lake Berryessa supply and the State Water Project North Bay Aqueduct supply. In the Berryessa case, approximately 35 years after construction of the Monticello Dam, no final allocation of water from the Solano Project (Lake Berryessa) among Napa, Solano, Lake and Yolo Counties has been established. Although several agreements exist between Napa, Solano, and the U.S. Bureau of Reclamation, the actual water rights have not been established. If putting water to beneficial use is a key criteria for developing water rights, then Solano County is much further along in establishing water need from Lake Berryessa. As to the State Water Project supply, its dependability will continue to decline as the years go on if no additional facilities are constructed. The implementation of such facilities are highly dependent on political solutions reached in Sate and Federal legislative bodies, with Delta and north-south issues predominating.

- Groundwater and direct river and stream diversions within Napa County are essentially dedicated to agriculture and rural domestic water needs. At present, Calistoga's Fiege well field is the only municipal groundwater supply.

Balancing Water Needs and Supplies

- The City of Napa's water transmission system, supplied by three sources - Lake Hennessey, Milliken Reservoir, and the North Bay Aqueduct, provides an extensive interconnecting conveyance system among the five major County municipal water agencies and the State of California's Rector Reservoir.

- Opportunities exist for expansion of reclamation within the County, especially in the South Napa Subarea from the Napa Sanitation/American Canyon wastewater treatment facilities. The timing of such reclamation is, however, dependent on economics and institutional arrangements. The economic aspects are significantly influenced by alternative supplies available to potential reclaimed water users. The existing reclaimed water use in this area does not really satisfy a true water need, but actually reflects a developed a use (ranch pasture irrigation) driven by the order to comply with Napa River effluent discharge limitations.

- The baseline water need projection and the alternative demand scenarios depict a likely range of future water needs. Such projections do not include additional short-term management of water demand during droughts. Voluntary and mandatory demand cutbacks for municipalities of 25 percent have become common in northern California since the 1976-77 drought. Agricultural-use cutbacks of up to 60 percent have occurred in deliveries from the State Water Project and the Federal Central Valley Project. But, those cutbacks become increasingly difficult as water system efficiencies are increased and as conservation becomes imbedded; and as people tire of too-frequent emergencies.

Based on the current water needs and supply analyses, and the issues described above, the following issues in balancing the County's water needs and supplies must be addressed:

- What is a realistic short-term drought-period cutback in the future water need?

- Can groundwater serve as a potential alternate supply to municipalities, especially during drought periods?

- Have river diversions been maximized through the development of storage?

- Are local municipal reservoirs developed such as to derive the maximum yield from tributary watersheds?

- What supply should be anticipated from Lake Berryessa and who would it serve?

- What can be done about firming up the North Bay Aqueduct supply?
- Can any additional in-County water transfers be implemented?
- What supplemental water supplies might be considered?

Each of these issues is discussed in the following paragraphs.

Drought-Period Water Use Cutbacks

On a short-term basis, supply and water need can be brought into balance by asking for voluntary cutbacks or imposing mandatory water rationing during critical drought periods. Although 1976-77 demand cutbacks in the Bay Area approached 40 and 50 percent for municipal users, future cutbacks probably should not exceed about 25 percent.

Groundwater as Municipal Supply

Water quality is an important consideration in the suitability of groundwater as a municipal water supply. The greatest need would come from the Cities of Calistoga, St. Helena, and Napa. According to Table 4-5, quality parameters of concern to these municipalities in obtaining groundwater from the Northern Napa basin would be high levels of iron and manganese, nitrates, TDS, sodium, chlorides, and boron. Although many of these parameters are represented by secondary standards, nitrates could pose a health risk to children, and sodium could be a problem for persons with restricted sodium diets. Treatment would be mandatory for nitrate control.

Development of municipal groundwater would require the availability of municipally-owned property located suitably. Such suitability would include proximity to water-bearing strata and distance to any potential contaminant source. A recent search for groundwater near St. Helena by Beckstoffer Vineyards produced 7 gpm at 400 feet instead of the hoped-for 150 gpm. Clearly there is no easy way to predict well production, especially for larger-capacity municipal wells. For short-term groundwater extraction by municipalities the major concern would not be the impact on basin safe yield but rather the effects on adjacent well owners.

Maximizing River Diversions

The State Water Resources Control Board's decision on Napa River diversions during the frost protection period emphasizes the value of storage so that winter flows can be captured. The existing annual diversion rate of 10,000 Ac-Ft that the current study uses in the water need/supply balance is not based on an inventory of actual storage but on an estimate. Any refinement of this estimate would require a detailed storage inventory.

Maximizing Municipal Reservoir Yield

In connection with the reservoir yield analysis detailed in Section 5, the potential for increasing yield by reservoir enlargement was reviewed and is summarized below.

- **Milliken Reservoir.** A one foot increase in dam height would produce 39 Ac-Ft of new storage capacity. Road relocation and diversion limits impact consideration of enlargement. A 20-foot increase in dam height (792 Ac-Ft of new capacity) would produce 615 Ac-Ft of new yield.

- **Rector Reservoir.** Every foot of increased dam height produces 68 Ac-Ft of new capacity. Need saddle dams. Spillway enlargement may be difficult. Appears to be inadequate annual inflow to increase yield.

- **Lake Hennessey.** 1000 Ac-Ft of new capacity per foot of increased dam height. Highway relocation and spillway of concern. A 15-foot increase in dam height (15,000 Ac-Ft capacity change) would produce 1,500 Ac-Ft of new yield; not a very efficient yield/capacity ratio.

- **Bell Canyon Reservoir.** Every foot of dam height increase would produce 73 Ac-Ft of new capacity. Road relocation and dikes required. Based on an average annual inflow, additional yield appears to be available.

- **Kimball Reservoir.** A one-foot increase in dam height would produce 12 Ac-ft of new storage. Extensive physical works required for enlargement. An additional 500 to 1,000 Ac-Ft of yield could be developed based on average annual inflow.

In summary, several thousand acre-feet of new yield could be developed from the existing municipal reservoirs, however the cost of dam expansions are high based on previous studies by the individual agencies.

Lake Berryessa Supply

A maximum Lake Berryessa Subarea water need of 11,801 Ac-Ft/Yr (high-demand scenario) can be anticipated by the year 2020, excluding lakeside use. Any negotiations for Lake Berryessa water rights should consider this water need projection.

Section 6

Balancing Water Needs and Supplies

Firming Up North Bay Aqueduct Supply

The current reliability of about 65 percent (frequency of entitlement availability) and likely decline in future reliability as State-wide entitlements build up, is not acceptable for municipal supplies. Obviously, support for the State's program of development of additional facilities to increase yield, such as the Delta Facilities, Los Banos Grandes Reservoir, and the Kern Water Bank are a way to assure North Bay Aqueduct yield. For Napa County as a whole, a more rapid buildup of contract entitlement would be desirable. A more permanent agreement with agencies that have surplus water, such as the Yuba County Water Agency, might be obtained under sponsorship of the Department of Water Resources, rather than obtaining year-by-year individual agreements with the Agency. Another possibility is to evaluate participation in such future facilities as Contra Costa Water District's Los Vaqueros Project, as was done for the Solano Water Authority. Further, supplemental water recently offered by the Central Valley Project (requests now on hold based on concerns regarding availability of water and environmental impacts) could be used to firm up the North Bay Aqueduct supply since it could be picked up from the Sacramento River.

In-County Water Transfers

Two County water users have current water supply surpluses - the American Canyon CWD (North Bay Aqueduct contract entitlement) and agriculture (groundwater). The former supply excess will be maintained to year 2020, while the latter excess will turn into a deficiency in ten years. The American Canyon supply could be transferred to other Napa County municipal entities via the City of Napa transmission system. Use of the groundwater surplus would require development of municipal wells and probably some well-head treatment facilities.

Additional Wastewater Reclamation

An engineering study currently being conducted for the Napa Sanitation District states that there are opportunities for additional reclamation in the South Napa Subarea from the jointly owned Napa Sanitation District/American Canyon CWD Soscol Wastewater Plant. These opportunities are proposed for staged implementation as follows:

Reclaimed Water Use	Date in Place	Quantity of Reclaimed Water (Ac-Ft/Yr)	
		Stage	Cumulative
Irrigated Ranch Pasture (Kirkland, Smoky, and Fagundes Properties)	Existing	1,622	1,622
Chardonnay Golf Course/Vineyards	1995	647	2,269
Kennedy Golf Course/Park; Napa Community College; Napa Valley Memorial Gardens; Bedford Industrial Park	2000±	828	3,097
Napa State Hospital; Potential Development Acreage; Various Industrial Park Landscaping	2012	1,365	4,462
Additional Irrigated Ranch Pasture (Airport and new Kirkland Ranch)	2012	1,481	5,943

Wastewater treatment will be such that Title 22 unrestricted use will be allowed. The sum of the ranch pasture requirements represents a minimum reclamation quantity for the wastewater plant (total of 3,103 Ac-Ft); the additional 2,840 Ac-Ft represents a replacement for fresh water now being used or which would need to be used in the future for irrigation of these properties.

In addition, landscape irrigation at the California Veterans Home could be supplied by reclaimed water from the Yountville wastewater plant.

New Supplemental Water Supplies

Supplemental water supplies that have been previously considered include new local reservoir storage and new imported water. A review of the mean annual runoff isohyetal map developed by the U.S. Geological Survey shows the most productive watersheds to be in the northwestern corner of the County (Kimball and Bell Canyon Reservoirs are located in this area) and along a narrow ridge on the western County line north of Yountville. Watersheds to the east and south show relatively low mean annual runoffs. A recent study for St. Helena (1989) suggested three potential reservoir sites - Spring Valley, Bale Slough, and York Creek. The latter two reservoirs are small; the former, supplied primarily from Napa River diversions, had a maximum capacity of 10,000 Ac-Ft. However, vineyard development in the area probably precludes any further consideration of this site. It would appear that any significant new surface water supply within the County would have to tap Napa River flows since they originate in the productive northwest corner. (Enlargement of Kimball and Bell Canyon Reservoirs would also be productive according to the mean annual runoff map, as per prior discussion of yield from the reservoirs but would be very costly).

New imported supplies, in addition to firming up the existing North Bay Aqueduct supply, as previously discussed, could include extension of the Central Valley Project's Tehama-Colusa Canal into Solano County to the Vacaville area, and use of the North Bay Aqueduct for conveyance. In reference to the aqueduct, expansion of terminal storage in the Jameson Canyon area would improve the flexibility of the aqueduct and perhaps its yield.

WATER MANAGEMENT PLAN

Where supply deficiencies are indicated in Table 6-1 and Figure 6-1, water management measures, such as discussed above, can be implemented to match needs. In some cases, there is a current urgency to achieve a balance, while in others, the gradual water need build up out to the year 2020 will allow a more planned, staged approach. The current drought period, which began after the wet year of 1986, clearly has stressed several of the County's municipalities since they are almost exclusively dependent on surface water supplies, both local and imported. It is these multi-year, rain-deficient periods that must be used in planning water management strategy. That the current drought period is not a real extreme situation can be seen by looking at the 1928-34 period, which is several years longer, and is in fact the critical period for the much larger water projects of the state and the federal government in the Central Valley. What is apparent is that if the drought continues, the County's imported supply will most likely face a temporary contract entitlement cutback. A ten percent cutback for municipal and industrial users (60 percent for agriculture) was envisioned in the spring of 1989 when a late-season rainfall made those cutbacks unnecessary. Such a cutback should be anticipated if the drought continues into 1991.

Where immediate action is required to balance water need and supply, the following water management measures would be available:

- Mandatory rationing of municipality-supplied customers.
- Re-activation or construction of new wells to tap groundwater.
- In-County water transfers.

- Purchase of additional water from water-surplus entities such as the Yuba County Water Agency and Placer County Water Agency, whose water can be wheeled via the North Bay Aqueduct.

Where the need/balance is a longer-range problem, all of the previously discussed measures would be available for consideration.

Based upon the water need/supply balance (surplus or deficit) for 1990 and 2020, (as shown in Table 6-1, and the incremental supply available from alternative water management measures, as summarized in Table 6-2, it is recommended that the Napa County Water Management Plan consist of the following elements:

- **Public Information Element.** As monitor of the County's groundwater supplies; as holder of a key water contract (North Bay Aqueduct); and based on involvement in the potential reserved water from Lake Berryessa, the District should develop, maintain, and distribute information to County water users regarding:

  - the source of the County's water supplies including groundwater, river diversion, local reservoir storage, imported water, and wastewater reclamation. The recent presentation by County Board and engineering staff at the Napa County Water Forum and resultant newspaper coverage is a good example of this type of activity.

  - current hydrologic conditions in the County and for the State Water Project (North Bay Aqueduct) and how County water users will be impacted. Conditions would include rainfall to date versus normal and recent years; general groundwater levels; storage level in the five municipal reservoirs; Napa River flow; and anticipated North Bay Aqueduct delivery rates. Consideration should be given to establishing a water deficiency (drought) index that would trigger certain actions to restrain water use and to enhance supplies through transfers or short-term supplemental supplies. The focus would be on critical drought periods, such as the current four-year period. Early public information and written guidelines and criteria would enhance voluntary adjustments to any water/need supply imbalance and minimize economic hardships.

  - status of State's efforts to meet its water contract entitlement buildup (key projects under way and their implementation schedule; legislative activities; etc.)

TABLE 6-2
INCREMENTAL SUPPLY FROM WATER MANAGEMENT MEASURES

Water Management Measure	Incremental Supply (Ac-Ft/Yr) 1990	2020
Drought-Period Water Use Cutback (25%)		
Calistoga	248	379
St. Helena	484	672
Yountville	112	156
City of Napa	3,456	4,549
American Canyon	398	579
Rural (Total)	947	1,245
Agricultural (Total)	8,888	11,656
Total	14,533	19,236
Groundwater as Municipal Supply		
Calistoga	---	---
St. Helena	---	---
Yountville	---	---
City of Napa	---	---
American Canyon	Not Available	
Total	9,776	2,048
Maximizing River Diversions		
Napa River above Oak Knoll Avenue	---	
Other Streams	---	
Total	5,000	
Maximizing Municipal Reservoir Yield		
Milliken (20-ft dam height increase)	600	
Rector	Minimal	
Lake Hennessey (15-ft dam height increase)	1,500	
Bell Canyon (20-ft dam height increase)	700	
Kimball (40-ft dam height increase)	500	
Total	3,300	
Lake Berryessa Supply	Indeterminate	
Firming Up North Bay Aqueduct Supply (45%)		
Calistoga	0	225
Yountville	0	225
City of Napa	0	8,415
American Canyon	0	2,340
Total	0	11,205

TABLE 6-2
INCREMENTAL SUPPLY FROM WATER MANAGEMENT MEASURES
(CONTINUED)

Water Management Measure	Incremental Supply (Ac-Ft/Yr) 1990	2020
In-County Water Transfers		
American Canyon NBA Entitlement	610	546
North Napa Valley Groundwater	9,776	2,048
Total	10,386	2,594
Additional Wastewater Reclamation		
Napa Sanitation District	4,321	
Calistoga	200	
St. Helena	500	
Yountville	100	
Total	5,121	
New Supplemental Water Supplies		
Local Storage Reservoirs		
Napa River, Off-stream	10,000	
Others	1,000	
Imported		
Central Valley Project	10,000	
Total	21,000	

- status of municipal, industrial, and agricultural water conservation efforts.

- status of wastewater reclamation efforts.

- **Water Need Element.** At five-year intervals (1995, 2000, etc.), the District should update the County-wide water needs analysis to track the baseline water use and establish revised alternative demand need projections, if necessary. A key future issue will be beneficial use, water conservation, and reuse. For example, turf irrigation and vineyard frost and heat protection may not represent the optimum beneficial use of stored (reservoir), imported, or groundwater, respectively. Alternative water, such as reclaimed wastewater, can be used for turf irrigation, while, for example, wind machines could be used for vineyard frost and heat protection, replacing the use of sprinklers for this purpose. The District should encourage compliance by municipalities with the conservation commitments contained in their State - mandated urban water management plans, and should foster introduction of incentives and ordinances to increase water conservation, especially with respect to turf and landscape layout. The District should also encourage agriculture to use advanced water-saving vineyard development methods including the use of drip irrigation and soil moisture tracking.

- **Water Supply Element.** With the completion of the current Water Resource Study for the Napa County Region, the District has added two key water supply evaluations-determination of the safe yield of the North Napa Valley Groundwater Basin, and yield-frequency relationships for the five municipal water supply reservoirs-Milliken, Hennessey, Rector, Bell Canyon, and Kimball. The study also reviewed available information on the safe yields of three other County groundwater basins: Milliken-Sarco-Tulucay, Lake Berryessa (Pope and Capell Valleys), and Carneros; the flow variation of the Napa River at Oak Knoll Avenue; the reliability of the North Bay Aqueduct supply; and the reclamation plans of the Napa Sanitation District.

  Based on the Water Resource Study, the following guidelines are offered to the District in resolving near-term and short-term imbalances between County water needs and supplies:

  - Water conservation can have a very significant impact on getting through drought periods. An automatic drought action triggering mechanism would provide early warning of the need for temporary measures and would minimize economic impacts.

- There appears to be adequate groundwater reserve in the North Napa Valley Groundwater Basin to allow municipalities to use wells as a supplemental drought-period supply. Such a short-term use may, however, not be economically justified, and once in-place would tend to be used more continuously. Sharing of such facilities with agricultural users might enhance the economics of such an arrangement.

- Reservoir storage, especially as supplied from the Napa River, is the key to river diversion capability for vineyard irrigation and frost protection. The total current storage capacity is not well documented.

- There are some opportunities for near-term transfers among the North Bay Aqueduct contractors from surpluses indicated for American Canyon and Yountville.

- Near-term multi-year arrangements for water to supplement the North Bay Aqueduct entitlement from the State are vital. Arrangements should be made through the State with such sources as Yuba and Placer County Water Agencies, using unused aqueduct capacity, as available.

- A review of the watershed inflow - storage relationship for the 50 percent frequency yield shows that there are opportunities to enhance the supply at Kimball, Milliken, and Bell Reservoirs. The efficiency of such yield enhancement at Rector and Hennessey is poor. A major constraint on dam enlargement is the cost.

As far as future activities with regard to water supply, it is recommended that the District consider the following:

- encourage or sponsor additional investigation of the smaller groundwater basins to refine safe yield estimates.

- track exploration for new wells by municipalities and wineries with regard to depth, production, and water quality.

- inventory County storage facilities beyond the five major municipal reservoirs, with special focus on facilities that derive water from the Napa River. Such an inventory may best be accomplished through a follow-up on the Questionnaire for the Napa County Wine Industry that was conducted during the current study. Information on alternate sources, such as groundwater, for filling such storage facilities should be requested, as well as the timing of filling and emptying. Review offstream storage potential if unused Napa River flows are available.

- for County development use permits, insure that drainage is retained on site to encourage groundwater recharge, and that the adequacy of water supply is fully demonstrated.

- negotiate with Solano County for allocation of the water rights reservation from Lake Berryessa considering the water needs and supplies of the Lake Berryessa Subarea.

- serve as the lead agency in firming up the North Bay Aqueduct supply. Incorporate St. Helena into the contract entitlement.

- encourage the implementation of Napa Sanitation/American Canyon Water District's reclamation plans at the joint Soscol Wastewater Plant.

- investigate the advantages of conversion of the District into a County Water Agency if water supply consumes an increasing share of District's activities. Such a conversion is currently under way by the Monterey County Flood Control and Water Conservation District which becomes effective January 1, 1991. Monterey's recent activities have focused more and more on County-wide management of groundwater and seeking supplemental water supplies.

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3. **Redding, J. R. 1991. Water Availability Analysis Policy. *Public Works Department Report on Water Availability Analysis* [Memorandum] and *Water Availability Analysis* [Staff Report]. Napa, CA: Napa County Department of Conservation, Development, and Planning. February 27, 1991.**

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