

Big Valley

**GROUNDWATER
MANAGEMENT PLAN**

BIG VALLEY GROUNDWATER MANAGEMENT PLAN

Adopted by Board of Directors, Lake County Flood Control
and Water Conservation District: May 18, 1999

Big Valley Groundwater Management Zone Commission

Ray Mostin

Dick Keithly

Richard Smith

Gus Schnabl

Al Moorhead

Gary Barber

Staff

Robert L. A Lossius
Deputy Director Public Works – Water Resources

Thomas R. Smythe
Water Resources Engineer

Emily White
Linda Keyes
Executive Secretary

TABLE OF CONTENTS

<u>Description</u>	<u>Page</u>
Introduction	1
Purpose	3
Summary of Groundwater Law	3
Groundwater Law As It Applies to Groundwater Management	6
The Big Valley Area	8
Area Location and Description	8
Land Use	11
Groundwater Geology and Hydrology	11
Kelseyville Basin	21
Adobe Creek - Manning Creek Basin	26
Western Upland	28
Central Upland and Upper Big Valley	28
Volcanic Ash Aquifer	30
Cole Creek Upland	32
Volcanic Ridge	32
Mount Konocti	33
Mayacmas Mountains	33
Groundwater Quality	34
Relation of Water Quality to Geology in Big Valley	36
Basin Water Budget	39
Anticipated Future Water Needs	41
Components of the Groundwater Management Plan	42
Control of Saline Water Intrusion	43
Wellhead Protection and Recharge Area Protection	43
Regulation of Migration of Contaminated Groundwater	44
Administration of Well Abandonment and Well Destruction Program	45
Migration of Conditions of Overdraft	45
Replenishment of Groundwater Extracted by Water Producers	46
Monitoring of Groundwater Levels and Storage	47
Facilitating Conjunctive Use Operations	47
Well Construction Policies	49
Construction and Operation of Groundwater Projects	49
Develop Relationships with State and Federal Agencies	49
Review and Coordination of Land Use Issues	50
Plan Implementation and Financing	50
Flood Control Zone 5 Budget	50
Plan Implementation	53
Funding Alternatives	54
Conclusion	56

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Location Map	2
2	Basin Features	9
3	Geologic-Hydrologic Map	10
4	Current Land Use	12
5	Average Spring Groundwater Level	14
6	Average Fall Groundwater Level	15
7	Average Annual Groundwater Level Changes	16
8	Sample Well Hydrograph Locations	17
9	Sample Well Hydrographs	18
10	Wells Measured	48
11	Revenue and Expense Projections, Flood Control Zone 5	52

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
1	Irrigation Water Suitability	35
2	Boron Content of Well Water	40
3	1985 Water Budget – Big Valley Watershed	42
4	Anticipated Water Needs – Big Valley Watershed	42

INTRODUCTION

The Groundwater Management Act (AB3030), signed into law in 1992, authorizes a local agency that provides water service to adopt and implement a Groundwater Management Plan, in accordance with specified procedures.

A Groundwater Management Plan is defined by the State of California Department of Water Resources Bulletin 118-80 as "planned use of the groundwater basin yield, storage space, transmission capability, and water in storage."

As the local agency, the Lake County Flood Control and Water Conservation District (District) has adopted this Plan to manage the groundwater resources in the Big Valley Groundwater Basin. The Big Valley Groundwater Basin is designated as Kelseyville Valley, Basin No. 5-15, in Bulletin No. 118-80. Big Valley is located on the southwest side of Clear Lake and covers 39.5 square miles, see Figure 1. The Big Valley watershed covers 124 square miles. Approximately 20,000 acre-feet of groundwater is annually pumped from the aquifer for agricultural, domestic and municipal use.

Groundwater management includes:

- (1) Protection of natural recharge and use of intentional recharge;
- (2) Planned variation in amount and location of pumping over time;
- (3) Use of groundwater storage conjunctively with surface water from local and imported sources;
and
- (4) Protection and planned maintenance of groundwater quality.

On June 9, 1998, the District Board of Directors, following a public hearing, adopted a Resolution of Intention to Adopt a Groundwater Management Plan for Big Valley pursuant to Water Code Section 10753, et. seq.

The Plan is being prepared with the input of the Big Valley Groundwater Management Zone Commission. The Commission consists of seven citizens appointed by the District Board of Directors. The Commission consists of four representatives of agricultural water users, two representatives of public water supply users, and one at large representative. The Commission participated in Plan preparation and will participate in Plan implementation.

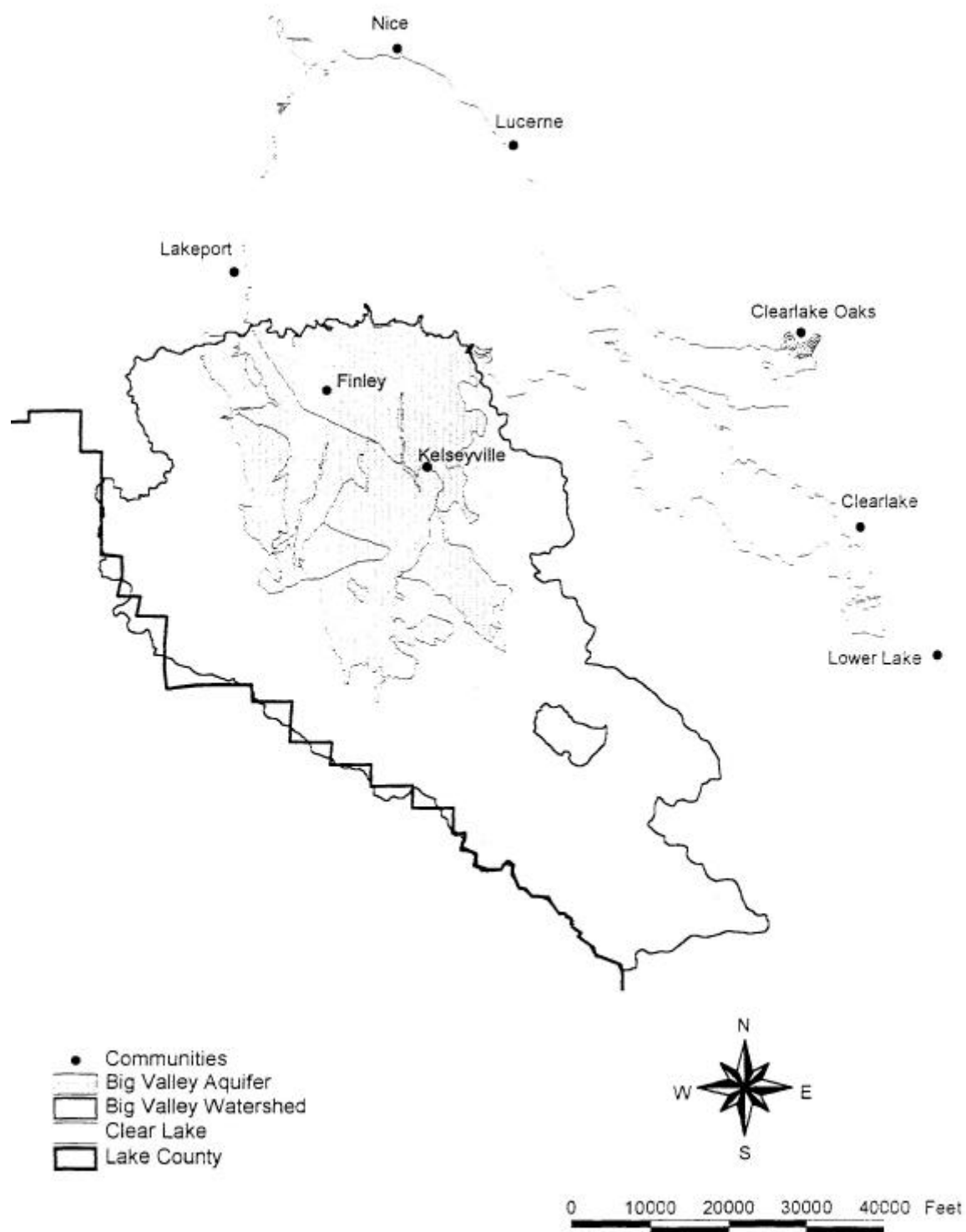


Figure 1: Location Map

PURPOSE

The purpose of this Groundwater Management Plan is to formalize the components of a management plan to monitor, analyze, and implement effective management practices to utilize and protect our valuable groundwater resources.

SUMMARY OF GROUNDWATER LAW

California water law is a complex body of legislative acts and court decisions that has evolved over the past one hundred and forty eight years since the State's entry into the Union in 1850. Of necessity, we have limited our coverage of the law in this report to those legal issues that have a bearing on groundwater management.

Water law recognizes five types of surface and groundwater rights, which can be defined as follows:

- *Riparian Rights.* The riparian right is based on ownership of land contiguous to a surface or underground stream, a lake, or a pond, and exists without regard to use or priority of use. The riparian owner is vested with a right to the use of so much of the water as may be required for beneficial purposes on his riparian lands. Riparian lands must be within the watershed of the water to which it is riparian and, with certain exceptions, contiguous to or abut the body of water. The length of frontage on the body of water is an immaterial factor; however, the riparian right extends only to the smallest tract under one title in the chain of title leading to the present owner.
- *Overlying Rights.* The right of the owner of lands overlying percolating groundwater is the right to use such water for reasonable beneficial purposes on the overlying land, a right analogous to the riparian right. As between overlying owners, such rights are correlative and each owner is entitled to an equitable apportionment if the supply is insufficient to meet the needs of all. Overlying rights are not subject to loss merely by non-use.
- *Appropriative Rights.* The appropriative right exists without regard to contiguity of land to the water and is based on the taking of water for a beneficial use, the first user acquiring a prior right to continue the use over subsequent appropriators. Such rights are applicable to definite bodies of surface water and to all groundwater. They depend on use and may be lost by non-use. The rights of riparian and overlying landowners are paramount and appropriative rights extend only to the taking of water that is surplus to their needs.

- *Pueblo Rights*. "Pueblo Rights" developed under Mexican law. Communities associated with the early missions acquired the legal status of municipalities, or pueblos, and the laws governing pueblos included the right to utilize adjacent water sources to meet the needs of the inhabitants. The California courts in the nineteenth century recognized and protected these rights, which included the right to use the waters of sources that ran through the pueblo, both surface and underground, from their origin to the sea. These pueblo rights, although highly limited, are still considered to be superior to all other claims.
- *Prescriptive Rights*. A prescriptive right is acquired by adverse taking of water for a statutory period of time that allows it to ripen into a right to continue such adverse use. Such rights can be acquired as against riparian and overlying owners. They also can be acquired as against most appropriators; however, there is considerable doubt that a right to water which is subject to statutory appropriation can be obtained in any other manner than through compliance with the procedure prescribed by law. An adverse taking of water occurs when an appropriator has no clear right to the water so taken. If no one objects to the taking, or enjoins, or attempts to enjoin, the taker from doing so for a period of five years, the adverse taking can become a prescriptive right.

According to these definitions, all water rights convey the "right to use" water. In addition, both riparian and overlying rights are based on ownership of land, and in accordance with English Common Law these rights are considered "real property" vested in the owners of the land. But, does this mean that a landowner actually owns the water riparian to or underneath his property? Unfortunately, both the courts and the State Legislature have muddled the waters with regard to this question.

In 1896, in *Gould v. Eaton* (44 P. 319, 111 C.639, 52 Am. St. R. 201), the court ruled that "Percolating waters belong absolutely to the owner of the soil". In 1903 in *Katz v. Walkinshaw* 74 P.766, 141 C. 116, 64 L.R.A. 236, 99 A. St.R 35.) The California Supreme Court took a different position, stating that "Since the common-law rule that an owner of land was the absolute owner of the percolating waters beneath the surface of his land could not be equitably applied to the state of California by reason of its peculiar physical condition, such rule was not adopted as part of the English common law" in California. However, in *Katz v. Walkinshaw* the Court modified the Common Law Doctrine by developing a set of rules for groundwater - known as the "Correlative Rights Doctrine" in which owners of land overlying a groundwater basin *who used the water on the overlying land* were recognized as holding the paramount right. These owners were to share the water among themselves on a correlative basis, similar to the sharing of surface waters by riparian owners, *with any water surplus to the needs of these overlying owners remaining available for appropriation by others.*

As amended in 1911, the opening declaration of Section 1410 of the California Civil Code stated that "all water or the use of water within the state is the property of the people of the state." In a 1921 case involving "percolating water" - or groundwater, the California Supreme Court objected to this declaration and ruled that "The original title to percolating water was in the owner of the land in which it is found, under the elementary rule that the title and ownership of land extends to the center of the earth and includes everything in the cone having the superficial boundaries of the land for the base and the center of the earth for its vertex. The transfer of the land by the government to the individual passed this title and gave the land owner the right to all the water therein." The Court further concluded that "The opening declaration of Section 1410, as amended in 1911, that all water or use of water within the state is the property of the people of the state, it taken literally would include all water in the state privately owned, and that pertaining to the lands of the United States, as well as that owned by the state, but the declaration was without effect as to any water other than that pertaining to or contained in the lands of the state, since the state cannot, in view of article I, section 14, of the constitution, take private property for public use in such a manner." (*San Bernardino v. Riverside*, 186 Cal., 9-10, June 1921)

In spite of the fact that it was clouded in ambiguity, Section 1410 of the Civil Code was restated as Section 102 of the Water Code in 1943. Section 102, entitled "State ownership of water; right to use", states that "All water within the State is the property of the people of the state, but the right to the use of water may be acquired by appropriation in the manner provided by law." This seemingly simple but still ambiguous statement of policy implies that actual ownership of the water is vested in the people at large, or in other words, as "public" property. And the issue is further clouded by the claim in Section 102 that the right to use may be acquired by appropriation without any reference whatsoever to landowners' riparian or overlying rights *that are actually superior to the rights of appropriators!*

In 1928, the California Constitution was amended to prohibit the waste of water and to extend a reasonable use standard to water rights. Although groundwater was not specifically mentioned in the Amendment, it was later interpreted as applying to all water without regard to its source. Thus, the 1928 Amendment, which became known as the "Reasonable Beneficial Use Doctrine", actually reinforced the correlative rights principle by limiting overlying owners to only that amount of groundwater reasonably necessary for overlying use, and appropriators to only the amount of surplus water that could be put to reasonable non-overlying use. Taken together, the "Correlative Rights Doctrine" and the "Reasonable Beneficial Use Doctrine" are the cornerstone of California groundwater law.

Within the explicit meaning of the term, an appropriator is a person who extracts groundwater from his well for use away from his parcel of land, in which case he is an exporter; whether the water is used by his neighbor, or is shipped out of the county but used within the groundwater basin, or is shipped out of the

basin. In this case, as an appropriator, he is limited to the taking of surplus water and the reasonable beneficial use doctrine applies. But this exporting of surplus water from his land does not infringe on his paramount right as an overlying landowner to also take water for use on his overlying land. *And it is this fundamental difference between the primary rights of overlying landowners and the subordinate rights of appropriators that must prevail in the development of a reasonable plan for groundwater management within the county.*

In summary, with water marketing and water transfers being touted as the wave of the future, it is clearly evident that groundwater management is needed in Lake County, and that defense of the primary rights of overlying landowners against the subordinate rights of appropriators must be held paramount in any groundwater management plan. While the rights of appropriators must also be respected, the appropriative right must be strictly limited to the taking of water that is surplus, with appropriator bearing the burden of proof that the water he intends to take is indeed surplus to the needs of other landowners on their overlying lands.

As long as the underlying basin has surplus water we have no problem. Everyone should be able to help themselves for their reasonable beneficial use on their overlying land, provided that in doing so, they do not infringe on the equal and correlative rights of their neighbors. In the Big Valley Basin, studies have shown that there is no surplus water to the needs of the overlying uses in dry years and, in some cases, overdraft has occurred.

To insure that these needs are preserved for the overlying land owners, a comprehensive management plan must be put in place as soon as possible.

GROUNDWATER LAW AS IT APPLIES TO THE GROUNDWATER MANAGEMENT

The purpose of the following discussion is to focus attention on key elements of groundwater law as they apply to the development and implementation of a reasonable, and lawful, groundwater management plan.

Groundwater and rights to its use are considered real property, and resolving legal questions regarding groundwater falls almost entirely within the jurisdiction of the courts. Hence statutory law is scant, although the developing water market is now causing a rash of legislation involving or affecting groundwater rights. Any of this legislation (be it local, state, or federal) that serves to diminish a person's lawful right to the use of groundwater, under common law principles that historically have been recognized by the California courts will eventually be challenged in the courts.

In creating a context for considering groundwater management policies for Lake County, of particular importance is the central principle of groundwater law, namely: that California law places the burden of proof upon the claimant of any water right. That is, the claim to right must be proved by the claimant in order that the claim be considered legitimate. Of equal importance is the fact the those rights which are claimed do not become legal rights until they have been acknowledged by the court.

For example, a person who extracts groundwater for non-overlying use may do so under claim of an appropriative right. At that point, there is no right, merely a claim of right. If prior rightholders, whose rights may be adversely affected by this non-overlying use, do not challenge it in court, the non-overlying user may continue to pump without restraint.

Normally, there is a five-year statutory time period during which such an adverse taking "ripens" into a prescriptive right. If prior rightholders legally challenge this non-overlying use anytime during the statutory "ripening" period, the non-overlying user can be enjoined from taking this groundwater until such time as he proves the existence of groundwater surplus to the needs of the prior rightholders. However, if the prior rightholders fail to challenge his non-overlying use during this statutory period, he then has claim to a prescriptive right based on his historic reasonable and beneficial use. In other words, after the passage of this statutory time period, in order to perfect a prescriptive right the non-overlying user has only to prove his historic reasonable and beneficial use of the water, but not the existence of a surplus supply. And once a prescriptive right has been perfected it has a higher legal priority than any overlying right since the prescription is against all of the prior rightholders! Thus, by allowing the non-overlying use to go unchallenged, the prior rightholders have forsaken their paramount rights in favor of the non-overlying user.

When a landowner legally claims his vested overlying right to groundwater, in most instances the proof is self-evident, since, if he applies the groundwater upon his land overlying the source from which the water is taken, he is by definition simply exercising his overlying right. However, whenever the user takes water for use upon land other than directly overlying its source, such as, for example, on a non-contiguous parcel, the situation is considerably different. To make such a use of groundwater under the claim of overlying right, the user must prove that the two parcels overlie a common groundwater supply. Without this proof, the groundwater user cannot claim that this off-parcel use is an exercise of his vested overlying right, it being instead an appropriation subject to the laws governing appropriation.

When considering appropriation, it is essential that one very important point be understood. California law holds that it is incumbent upon the would-be appropriator to prove his taking of water will not injure prior rightholders since, by definition, appropriation is limited to that water which is surplus to the

overlying needs of the other owners of land overlying the groundwater supply in question. Therefore, without providing proof that such a surplus exists, the would-be appropriator has no legal right to appropriate the water.

In this matter of appropriation and the burden of proof, it is often erroneously claimed that an appropriator has the legal right to appropriate freely unless prior right- holders can prove that they have been injured by this appropriation. It is important that prior rightholders and policy-makers understand the law correctly to maintain the water rights for overlying uses.

Appropriation of groundwater for private uses is straightforward. When the groundwater basin is in surplus, that surplus can be appropriated for non-overlying use. But, without a surplus, appropriation of groundwater cannot occur. However, appropriation of groundwater for "public use" must be treated with great care, if not avoided altogether, for what initially may have been a legal and legitimate appropriation of surplus groundwater for "public use", in the event of basin overdraft could immediately become a prescriptive right without the normal statutory "ripening" period being required. Simply put, we should always assume that groundwater applied to "public use" has been permanently acquired. Short of prohibiting any appropriation of private groundwater for public use, which is not feasible, the only protection against this potential loss of paramount private rights by public use prescription appears to be through the process of individual landowners obtaining legal Declarations of their Overlying Rights.

THE BIG VALLEY AREA (Source: Soil Mechanics and Foundation Engineers Inc., Big Valley Ground-Water Recharge Investigation, March 1967)

Area Location and Description

The area known as Big Valley is located in the west-central portion of Lake County in the northern Coast Ranges of California. The location, form, and principal topographic and cultural features of the Valley are shown in Figure 2. The Valley is triangular in outline, with southwest and southeast sides being bounded by the Mayacmas Mountains and by Mt. Konocti, respectively, and with the north side opening to Clear Lake. The Valley area comprises extensive lowland flood plains and terrace-like uplands. For convenience of reference, the names indicated on the Geologic - Hydrologic Map, Figure 3, have been assigned to the corresponding outlined areas. Names such as "Kelseyville Basin" and Central Upland" are used throughout this report to indicated specific areas within the Valley.

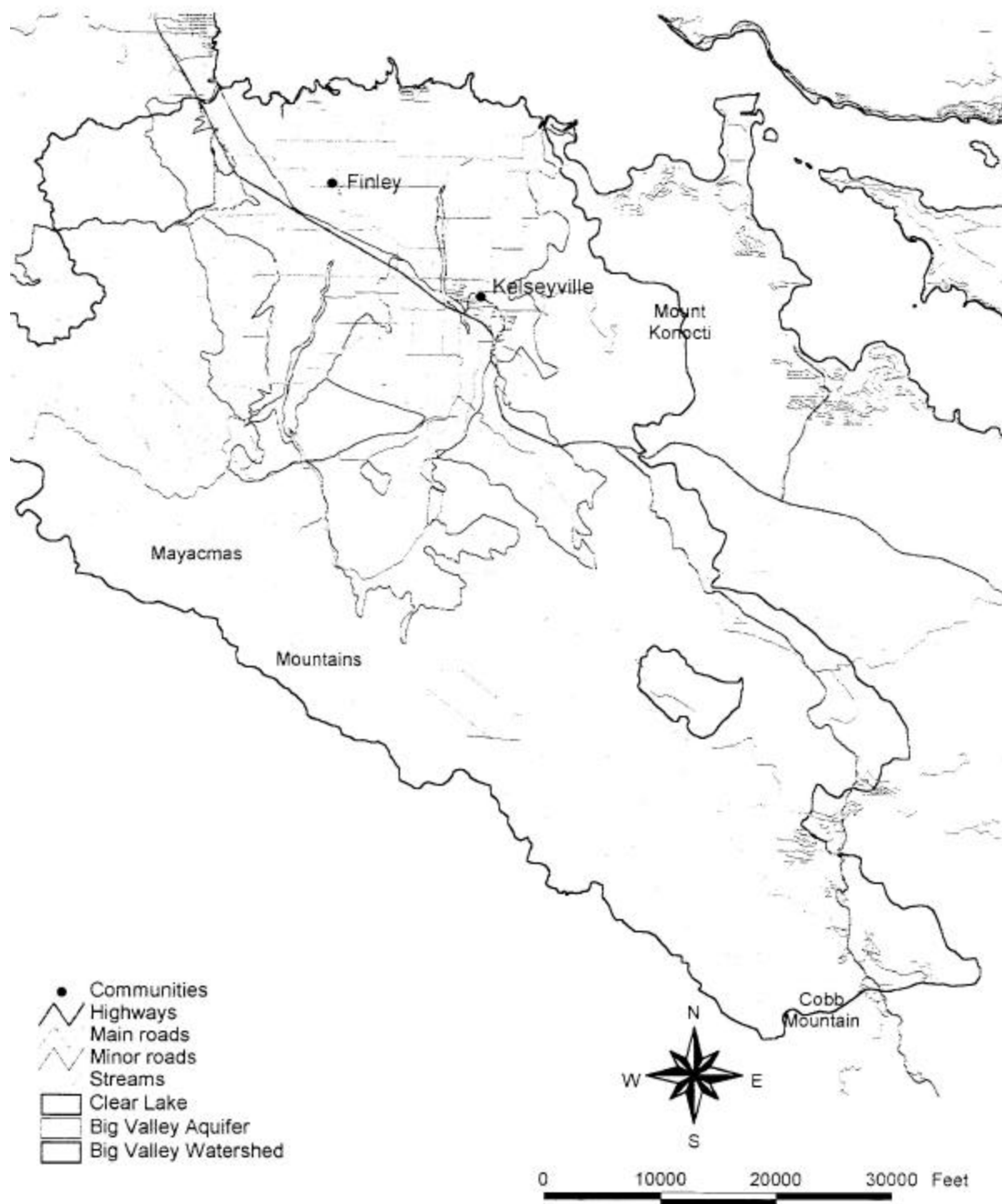


Figure 2: Basin Features

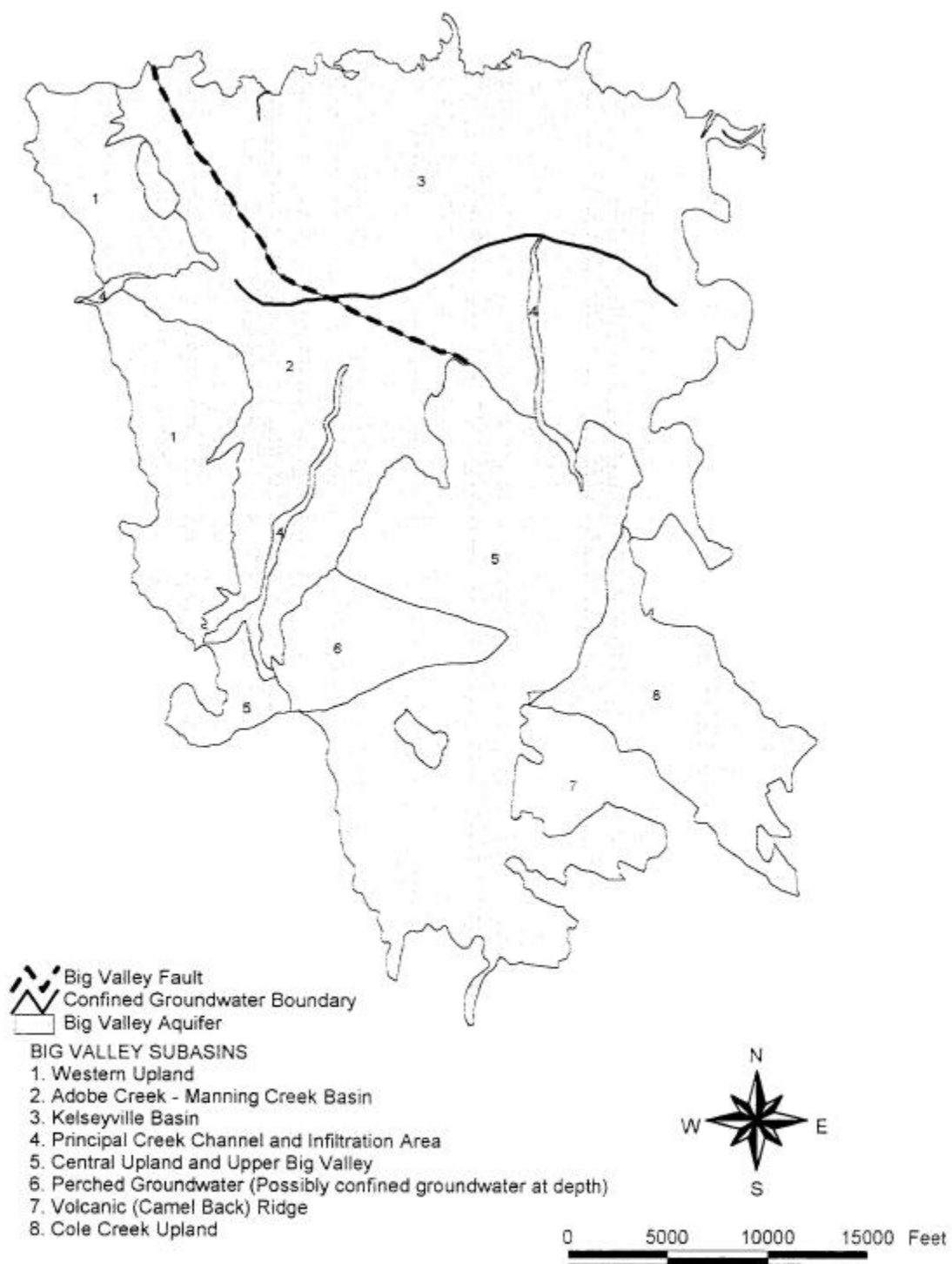


Figure 3: Geologic - Hydrologic Map

Big Valley has a total area of 39.5 square miles, or 25,300 acres. Its maximum width and length are each about 7 miles. Elevations of the lowland portions of the Valley range from 1330 feet, adjacent to Clear Lake, to 1440 feet below Adobe Creek Dam. The upland areas are 1440 to about 1600 feet in elevation, with local hilly areas rising to 1800 feet elevation. The surrounding mountains rise to elevations of 2500 to about 4000 feet.

Land Use

Land use in Big Valley is predominantly agricultural. Most of the lowland area is cultivated, and the greater part of this land is irrigated. Some of the upland areas are being developed into grapes with irrigation, but much of the land in these areas is still undeveloped. Pear orchards predominate in the lowland in northern Big Valley, where groundwater for irrigation is readily obtainable. Walnuts and grapes are grown both in the lowlands and in the drier upland areas. Considerable land also is used for raising feed crops, and irrigated alfalfa fields are located at various places in the lowlands and also on the terrace benches adjacent to Kelsey Creek above Kelseyville.

Most of the undeveloped land in Big Valley is covered with dense California chaparral type brush, though areas of open grassland with scattered brush and trees exist near the head of the Valley.

Two small towns, Kelseyville and Finley, are located in Big Valley. Local industries include several fruit packing and processing establishments, wineries, and walnut drying plants.

The Kelseyville Area Plan prepared by the Lake County Community Development Department, Planning Division, and adopted on August 15, 1995, identifies the land uses in most of the Big Valley Basin, see Figure 4.

Groundwater Geology and Hydrology

Groundwater occurs in Big Valley in several distinct systems. The elements which define these systems include the surface water and/or groundwater supply for each system, geologic conditions including distribution of materials of varying permeability, presence of boundaries to groundwater flow or storage, and the topographic setting. In order to facilitate description and discussion of groundwater conditions, a number of "geologic-hydrologic subunits" have been designated within the Valley. The subunits were defined on the basis of their geologic character, as related to groundwater storage, transmission, and recharge, and by behavior of groundwater within them as indicated by well water level readings and by initial water interception

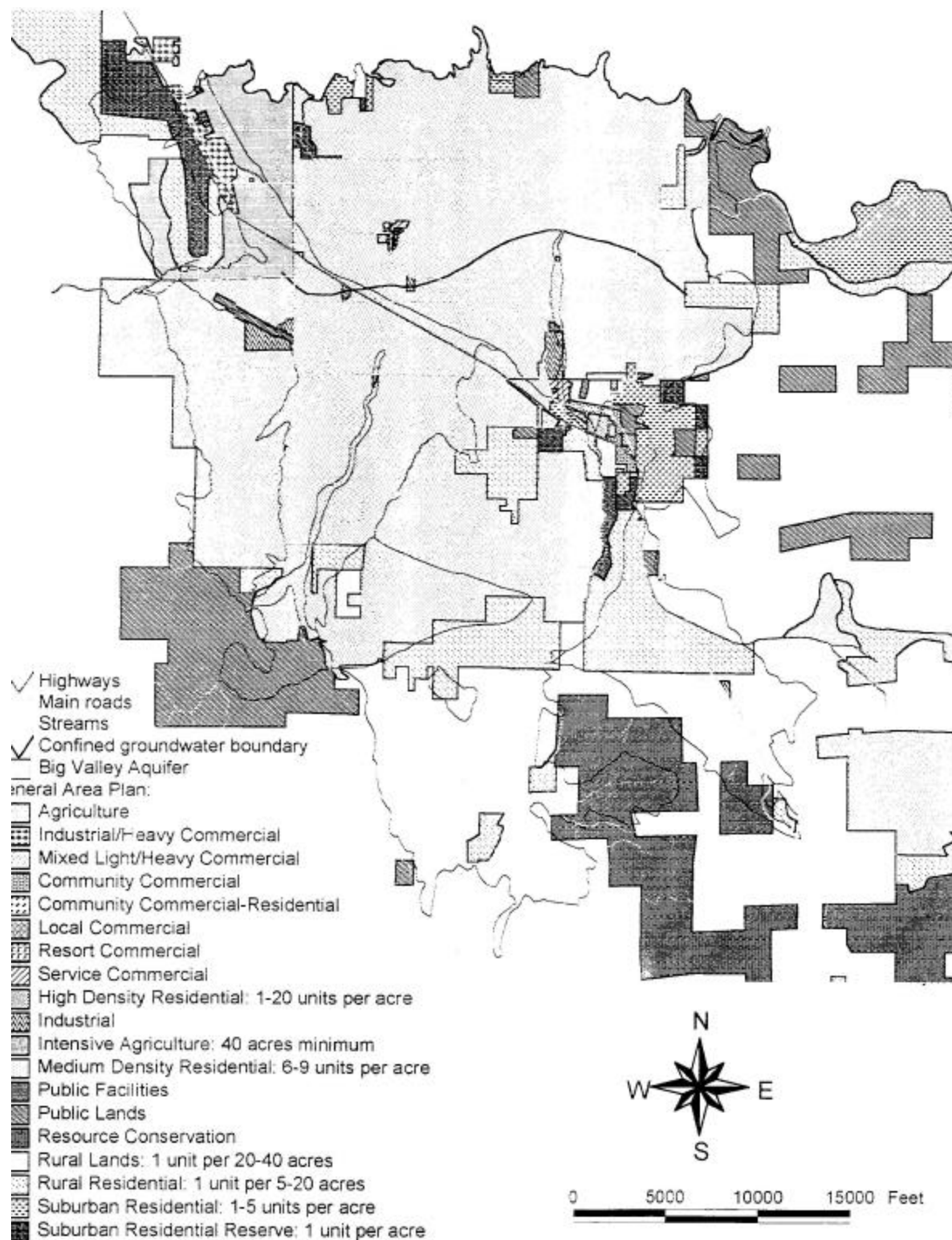


Figure 4: Current Land Use

data recorded by well drillers. The subunits form the constituent parts, which make up the Big Valley hydrologic unit.

Elements of the geologic-hydrologic regimen in Big Valley are illustrated on Figure 3, "Geologic-Hydrologic Map"; Figure 5 and 6 show the average spring and fall groundwater levels in the northern portion of the Big Valley aquifer. Figure 7 shows the average groundwater level change from spring to fall. Figures 8 and 9 show the locations of several representative wells and their hydrographs within the groundwater basin.

The four general modes of groundwater occurrence in the geologic-hydrologic subunits of the Big Valley area are as follows:

- The principal occurrence of groundwater is in the alluvium and lake sediment-filled basins underlying Adobe and Manning Creeks and lower Big Valley (lower Kelsey Creek). Much of the groundwater in these basins is unconfined, but confined areas or zones exist locally where extensive horizons of relatively impermeable clay are present near the surface. Recharge is mainly by infiltration from the channels of Adobe Creek and the reach of Kelsey Creek below Kelseyville. Additional recharge takes place by underflow of groundwater from adjacent, higher level subunits and, to a limited extent, from irrigation.
- Groundwater occurs in relatively permeable zones in the older, high level alluvial deposits of the Central, Western, and Cole Creek uplands. The groundwater in occurrences of this type is in aquifers of limited areal extent, which are perched on relatively impermeable older lake sediments. Limited recharge occurs by infiltration from the surface and from the channels of ephemeral upland streams.
- Confined groundwater occurs in a thin bed of "volcanic ash" (lithic tuff) present within the older lake deposits underlying the upland areas (and the upper portion of the Adobe Creek-Manning Creek basin). The "ash" consists of angular fragments of volcanic rock, of coarse sand to pea gravel size, and it is quite permeable. Recharge to this aquifer is believed to occur by infiltration in areas where the "ash" crops out in stream courses and by leakage into the aquifer from saturated confining strata.
- Varying, though generally limited, amounts of groundwater occur in permeable fracture zones in the volcanic rocks and Franciscan formation bedrock surrounding Big Valley.

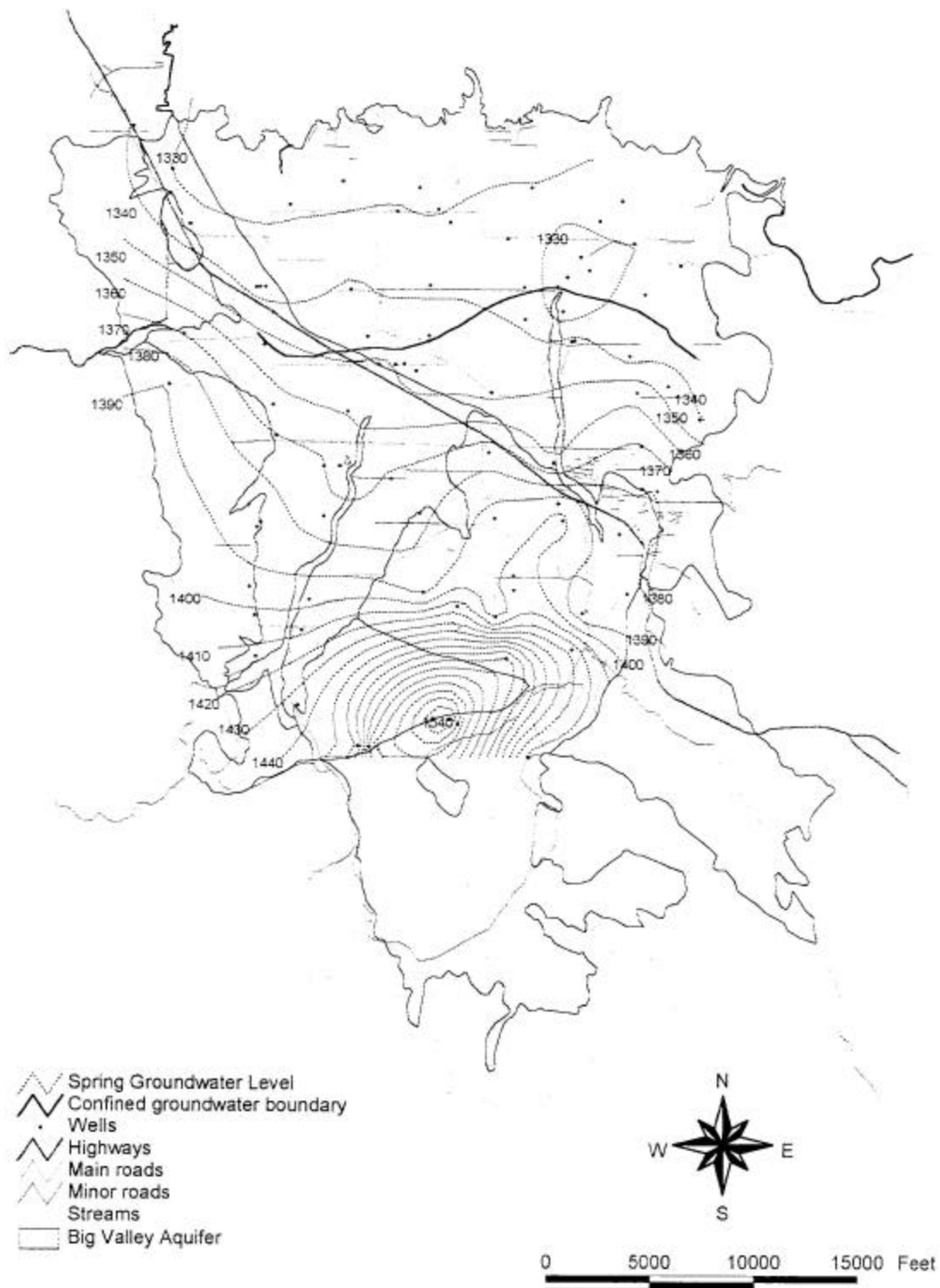


Figure 5: Average Spring Groundwater Level

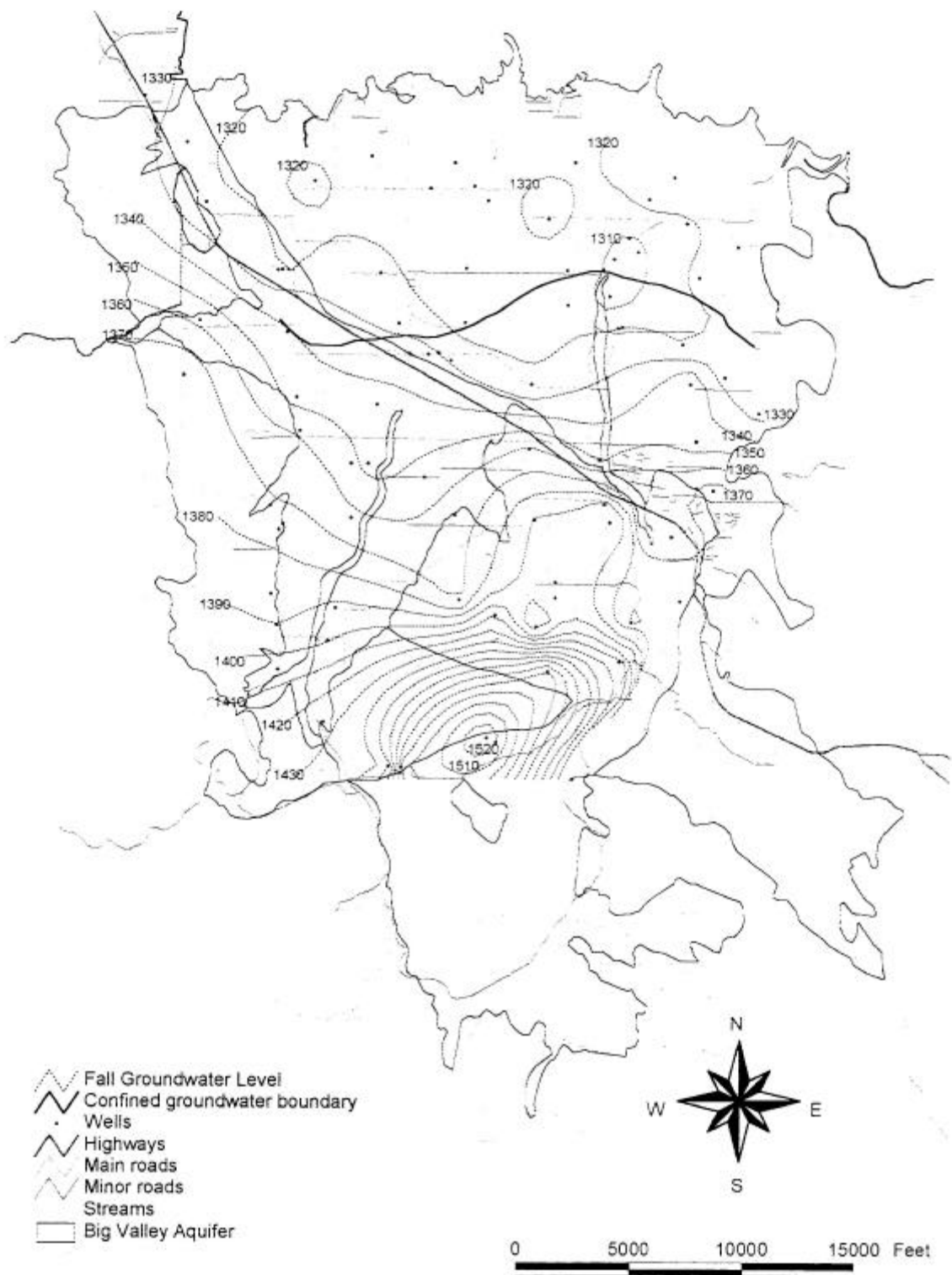


Figure 6: Average Fall Groundwater Level

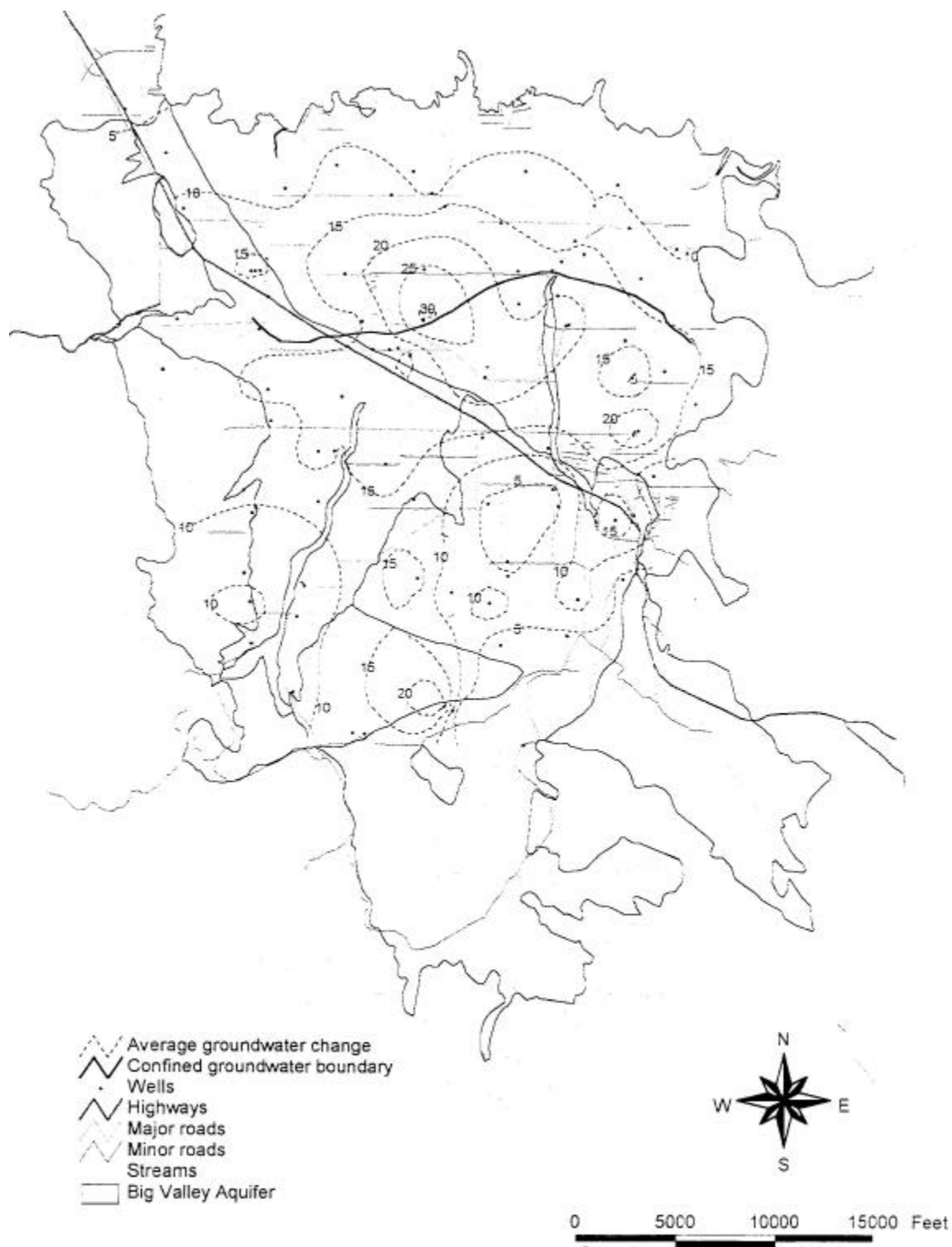


Figure 7: Average Annual Groundwater Level Changes

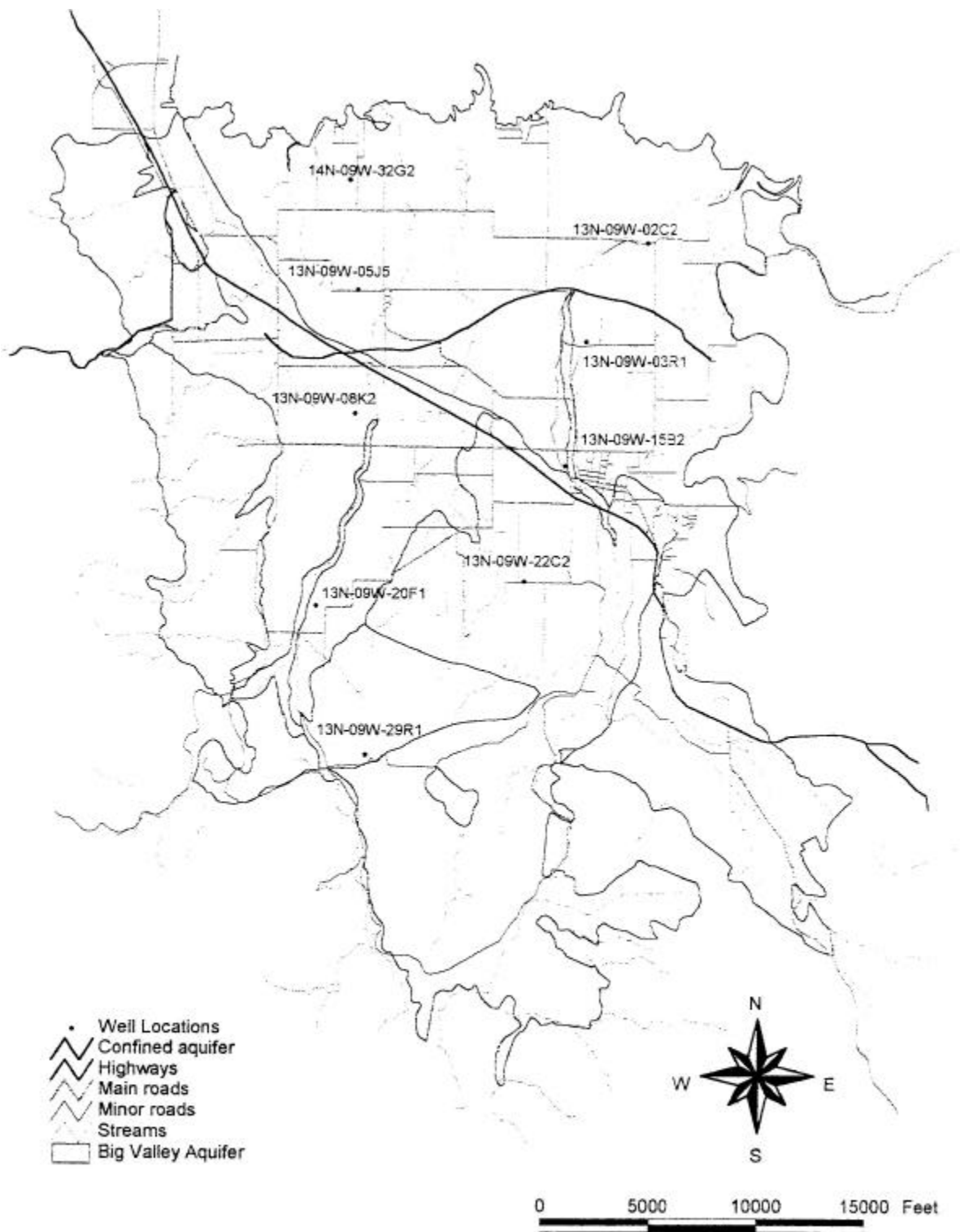


Figure 8: Sample Well Hydrograph Locations

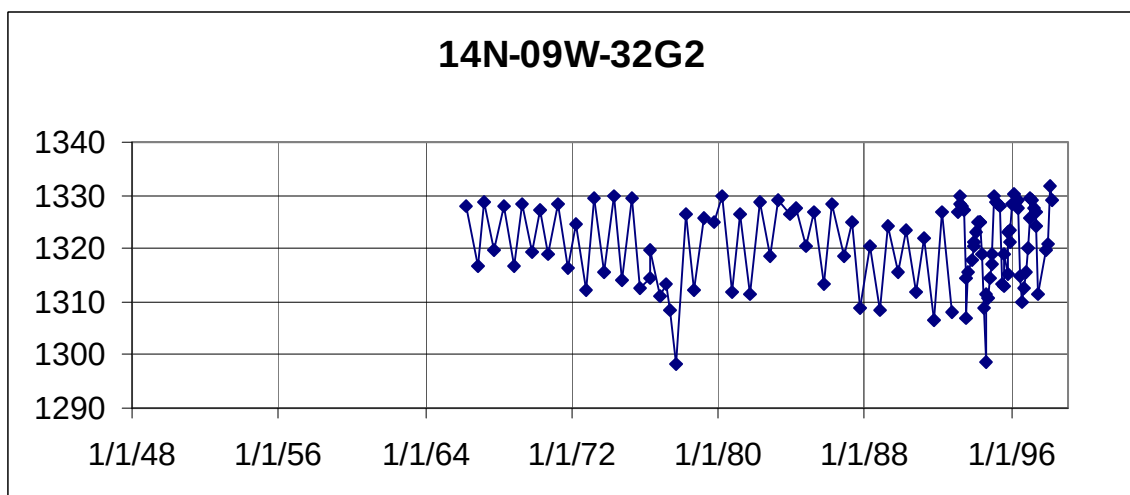
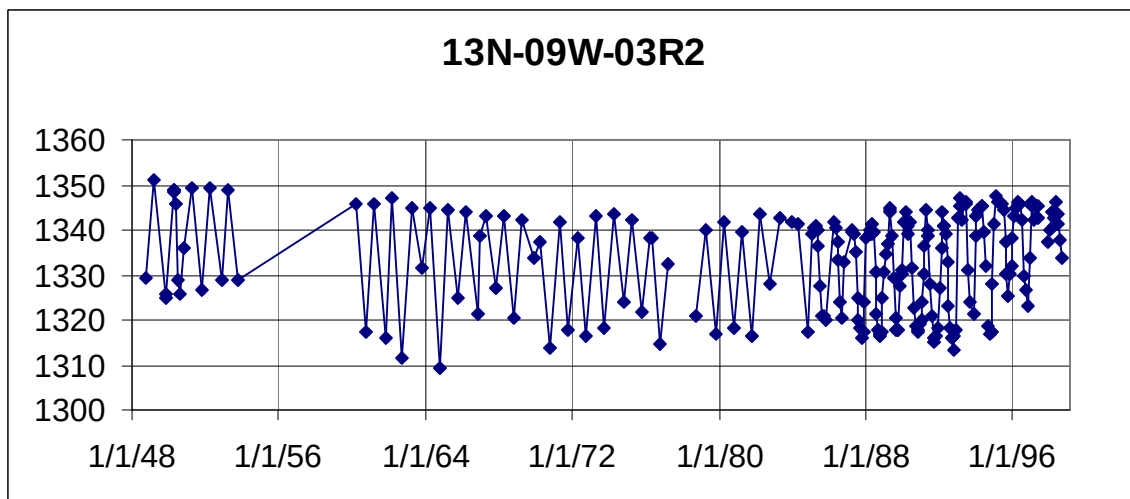
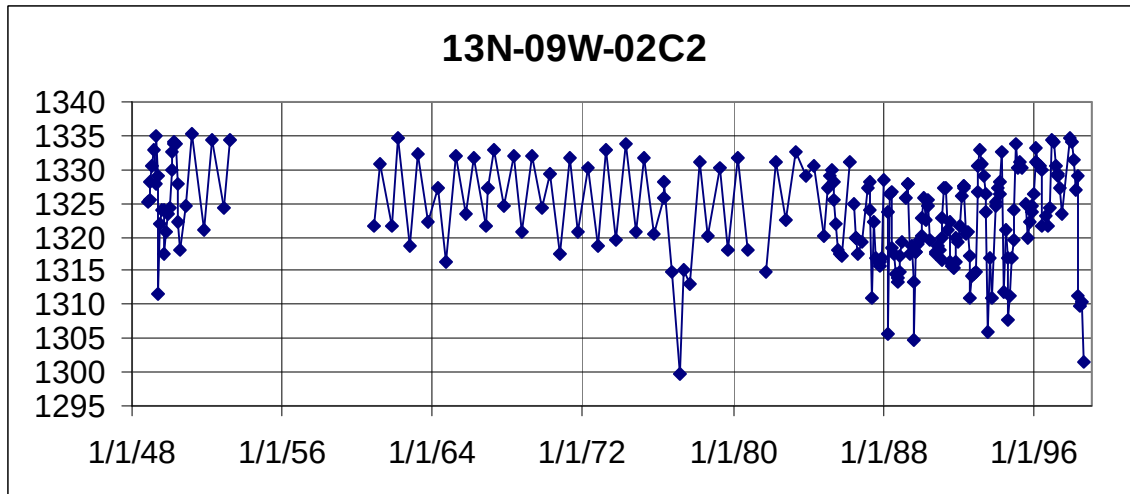


Figure 9: Sample Well Hydrographs

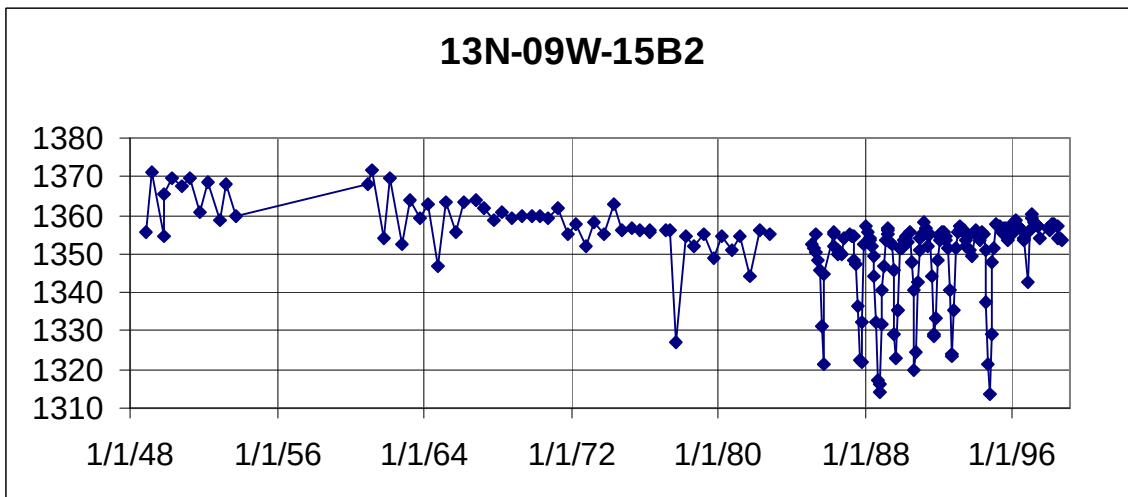
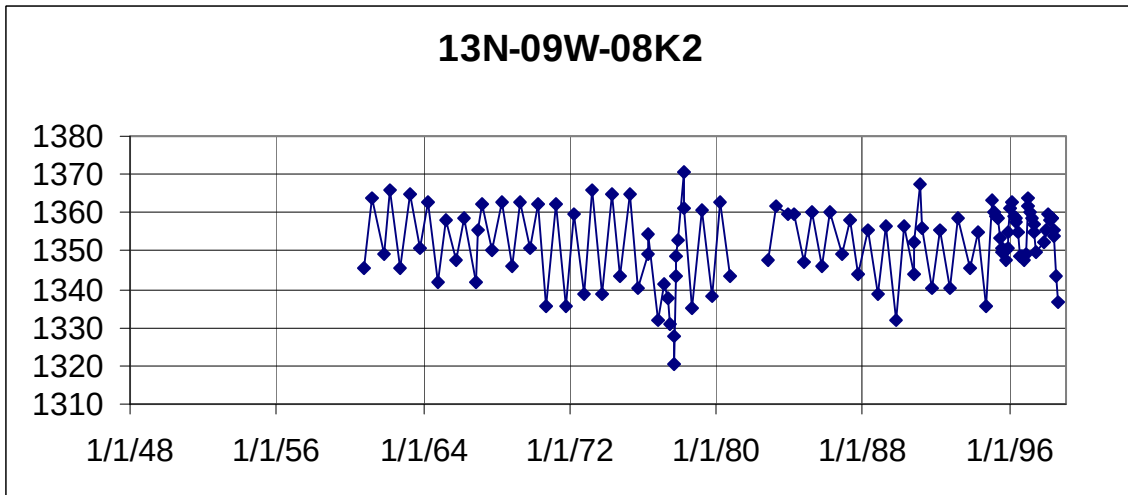
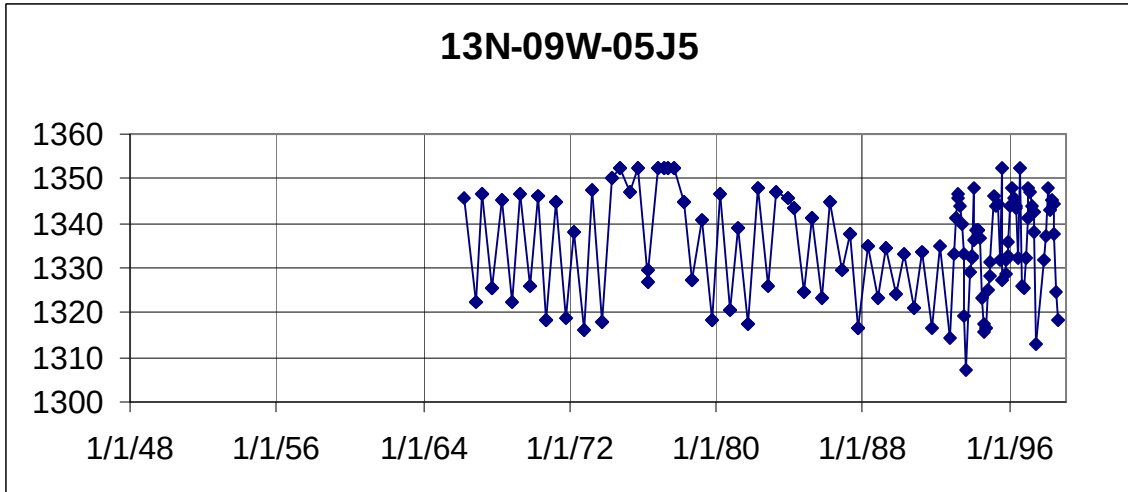


Figure 9: Sample Well Hydrographs

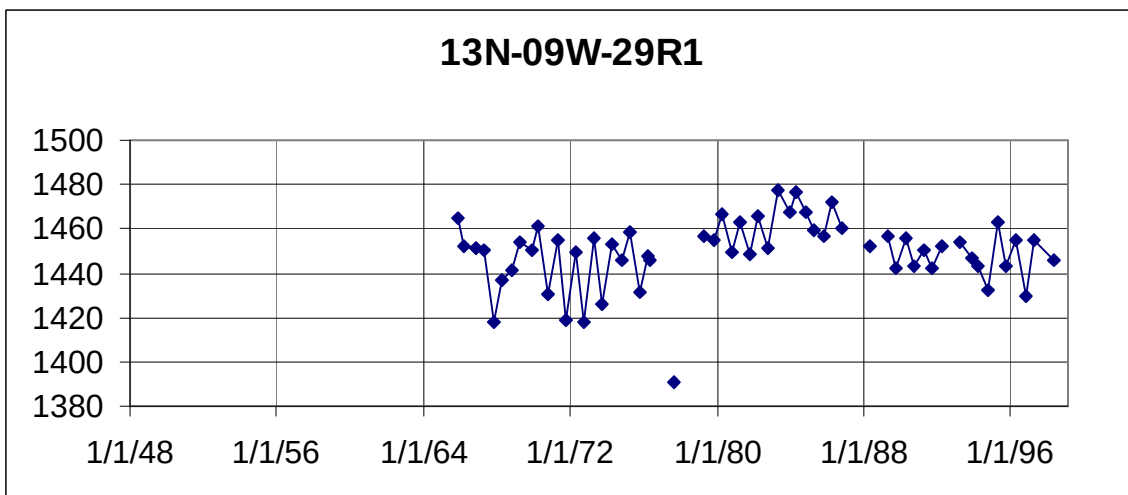
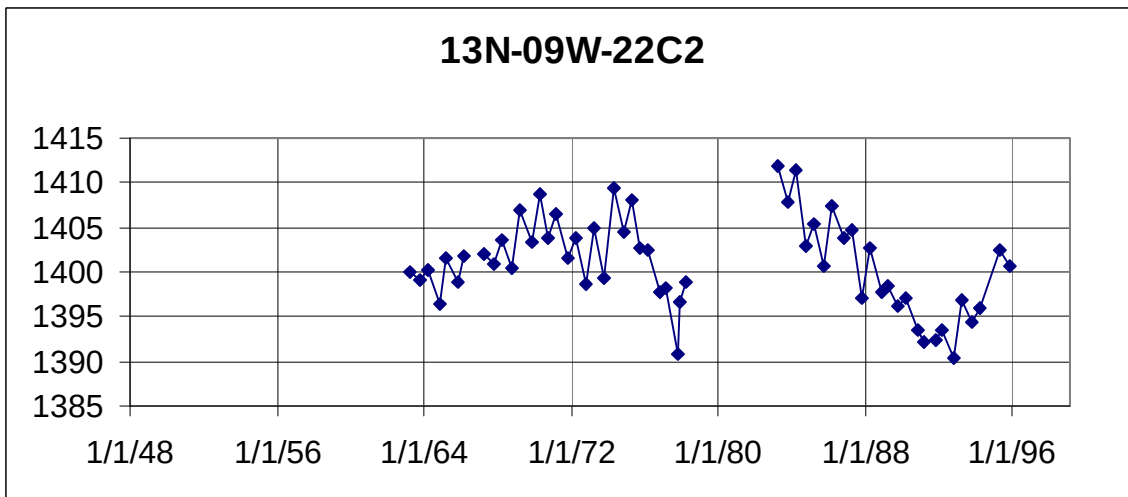
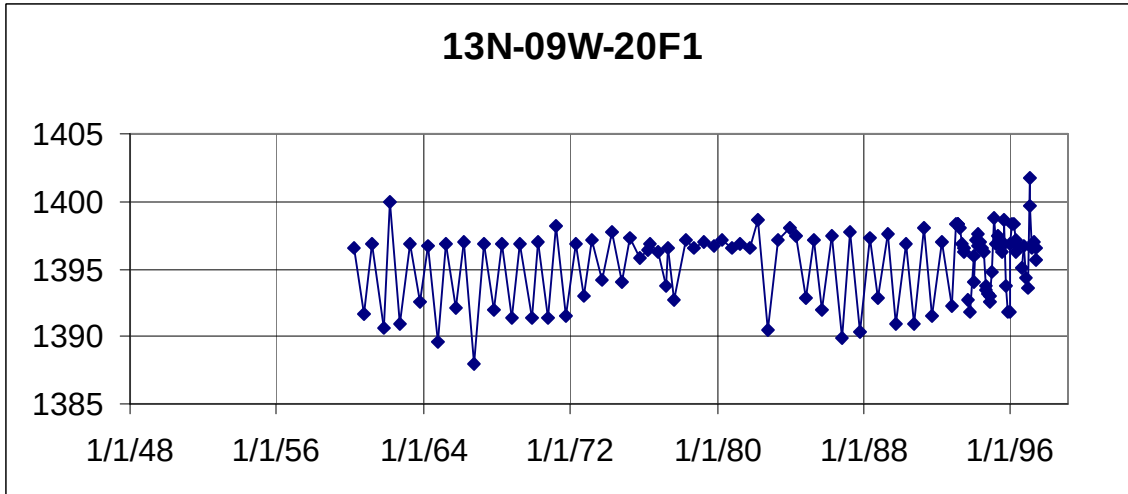


Figure 9: Sample Well Hydrographs

Most of the groundwater pumped in Big Valley is extracted from the Kelseyville and Adobe Creek-Manning Creek basins. Wells in the Western and Central Upland subunits draw from the "volcanic ash" aquifer and also, to a limited extent, from the upper aquifers in these areas. No data are available relating to wells in the Cole Creek Upland. The volcanic ridge subunit yields water to at least one developed spring (in the NE 1/4 of Section 2, R9W, T12N) and to two wells. No groundwater is known to be extracted directly from the Big Valley side of Mt. Konocti or from the Mayacmas Mountains immediately above Big Valley.

Groundwater and pertinent geologic conditions in the geologic-hydrologic subunits of Big Valley are discussed in the sections of this chapter following.

Kelseyville Basin:

The Kelseyville Basin is a lake and alluvial sediment-filled structural basin about 10 square miles in area. It is the principal groundwater storage and production subunit in Big Valley.

The basin is bounded by the buried lower west slope of Mt. Konocti on the east, and by the escarpment of the Big Valley fault on the south and west. This escapement is exposed at the surface along the north end of the Central Upland, but is buried beneath 90 to 120 feet of valley fill of the Adobe-Manning Creek basin, at the interface between the subunits. The sedimentary fill in the basins is continuous, so groundwater contained within two basins is in complete hydraulic continuity. To the north, the basin merges with the sediments underlying northwestern Clear Lake.

Geology: Sediments contained within the Kelseyville Basin range in character from lake silt and clay to stream sand and gravel. The fine-grained materials tend to occur in relatively continuous layers, extending over sizable areas. A near surface layer of clayey material is present over most of the basin, except for the floodplain of Kelsey Creek for a distance of about two miles north of Kelseyville. A persistent layer or series of layers of "blue clay" is present at a depth of about 70 feet through much of the basin. The layer is missing at this depth in the area east of Kelsey Creek, but a similar layer exists at about 130 feet depth there. It is possible that this is the same layer offset by displacement along a (postulated) branch of the Big Valley fault. Generally coarse grained material laid down as channel, flood-plain, and delta deposits by the ancestral Kelsey and Adobe creeks predominates in the south-central portion of Kelseyville Basin at depths of 20 to 70 feet.

The sand and gravel of this area inter-lens with and gradually give way to finer grained sediments to the north, toward the lake. Other, less continuous zones of coarse material are present elsewhere in the basin, notably between depths of 50 and 200 feet in the area east of Kelsey Creek.

The near surface clayey layer acts as a confining membrane of "capping" for groundwater in the basin north of where the water table intersects the bottom of this layer. Buried layers of fine-grained material may also confine water in deeper aquifers so that several levels of pressure water may exist within the basin. Apparently, however, the pressure in deeper zones is not high enough to raise water above the elevation of the overlying water table.

Recharge: Water is recharged to the Kelseyville basin aquifers by infiltration from the channel of Kelsey Creek between the vicinity of Kelseyville and the middle of Section 3, two miles to the north, and by underflow from the Adobe Creek-Manning Creek Basin. A limited amount of underflow probably enters the basin from the Central Upland and also from Mt. Konocti. Some water may be recharged by infiltration of rain, irrigation, and creek water in areas other than the Kelsey Creek flood plain, but such recharge is greatly inhibited by the clayey subsoil and near surface clay layer.

Kelsey Creek: The reach of the Kelsey Creek channel where most infiltration occurs extends from a point 2,500 feet south of the Highway 29 bridge to the corner of Finley East Road (center of Section 3), a total distance of 13,000 feet. Downstream (north) of this reach, the channel is underlain by a sandy "clay pan" which serves both to inhibit downward percolation of surface water and to confine underlying groundwater. In the percolation area, the channel varies from about 200 to 500 feet width. The creek's east bank is stabilized to a greater or lesser extent by slope and bank protection features. Gravel mining operations were historically carried out in the channel and in the flood-plain terrace along the creek's west bank in the 9,000 feet distance between the Kelseyville Main Street Bridge and the center of Section 3. Mining deepened the channel by about 10 feet in the mid-1960's. Gravel mining in the recharge area has been prohibited since 1980. The channel has only recently begun to aggrade. Well 13N-09W-15B2 in Figure 9 shows the effect of the mining on a well 500 feet north of the Main Street Bridge. This channel deepening, together with the bank stabilization and channel straightening, has greatly changed the character of stream discharge near Kelseyville. Formerly, the channel was only a few feet below the general level of the plain, and the stream flowed in any, or all, of several courses, which shifted back and forth over an area of up to 1,500 feet width. This condition frequently led to flooding of the area around and within Kelseyville, but it also provided a much larger area for the first stages of infiltration from the creek to the aquifers of Kelseyville Basin.

The subsurface character of the channel, as it existed in October 1966, was investigated by excavation, logging, and limited sampling of seventeen backhoe test pits. This investigation showed that the channel contained 6 to more than 14 feet of gravel overlying a layer of sandy to clayey alluvium. The gravel grades to silty sand along the channel margins and in local areas within the main channel. Most of the gravel sections exposed in pit walls contain subhorizontal "open work" zones, although the gravel is fairly sandy in

bulk composition. These zones, and the presence of layers of finer grained material, give the channel fill a significantly higher permeability in the horizontal than the vertical direction. Consequently, infiltrated creek water tends to percolate laterally into the floodplain gravels adjacent to the channel. Percolation to the deeper aquifers within the basin then takes place from the flood-plain gravels. Because of the lateral percolation aspect of the process of groundwater recharge from channel surface level could seriously impair the effectiveness of basin recharge by Kelsey Creek by restricting or partially sealing off the hydraulic connection between the channel and the adjacent near surface aquifer gravels.

Measurements made by DWR in 1948, 1949, and 1950 indicated losses in the flow of Kelsey Creek between Kelseyville and Soda Bay Road of 2400 to 3600 acre-feet per month (during months of continuous, mostly heavy flow). This loss represents the amount of water infiltrated into the creek channel and banks. Assuming an average rate of infiltration of 3000 acre-feet per month, and assuming that the channel area in the zone of infiltration was about the same as present, seventy acres, this figure indicates a percolation rate of roughly 1.5 acre-feet per day per wetted acre of channel. A rough check measurement of flow loss in Kelsey Creek above and below the reach of maximum infiltration, made in November 1966, indicate a percolation rate of 1.7 acre-feet per acre per day. Such amounts are comparable to the lower range of spreading basin recharge rates in other basins in California. The relatively low rate observed for Kelsey Creek probably results from the presence of finer grained material under the channel gravel and the consequent necessity for lateral diffusion of infiltrated water as part of the recharge process.

Relation to Adobe Creek-Manning Creek Basin: The "interface" between Adobe Creek-Manning Creek Basin and Kelseyville Basin is roughly 1200 feet wide, if the area northwest of Manning Creek is neglected. The interface extends 70 to 100 feet below the water table to the bottom of the younger fill in the Adobe Creek-Manning Creek Basin. Underflow from this basin occurs mainly from relatively more permeable zones at depths of 25 to 45 feet and 70 to 90 feet. No data are available which would permit determination of the actual quantity of underflow.

Groundwater Movement: The general direction of movement of groundwater in Kelseyville Basin is northward toward Clear Lake, as shown by the slope and form of water table and piezometric surface. Under natural, high water-level conditions, flow of groundwater in the unconfined zone is radial away from the upper (south) end of the channel infiltration area, down a hydraulic gradient ranging between 20:1 and 40:1. In the confined zone, movement is in response to a pressure gradient caused by the difference in elevation between the water table at the upper, south edge of the confining layer, and the surface of Clear Lake. In the spring, the head difference is 20 to 30 feet. Movement of the confined water is to be submerged springs under Clear Lake, where the water enters the lake by effluent flow.

At present, the configuration and elevation of the water table and pressure surface are considerably altered by midsummer, mainly by extensive pumping withdrawal. Groundwater movement in the unconfined zone is still to the north. In the confined zone, however, an east-west aligned shallow trough of reduced pressure is created, with the maximum lowering of piezometric head being in the area north and northwest of Finley. When this condition develops, movement of groundwater becomes radial toward the axis or centers of reduced pressure. Normal flow northward to the lake is re-established only after pumping ceases and the trough is eradicated by the gradual restoration of pressure in the area.

The movement of groundwater just described occurs principally in the upper 70 feet of the basin, above the persistent "blue clay" horizon. It is probable that natural circulation of groundwater in deeper aquifers is limited and that movement may be largely in response to pressure gradients caused by withdrawals through deeper wells. There is, however, no positive evidence to support this view.

Changes in Groundwater Storage: Changes in the volume of groundwater stored in the Kelseyville Basin are indicated by fluctuations in the level of the (unconfined) water table. Variations in the piezometric surface in the (confined) pressure area only indicate changes in pressure and are not a direct measure of changes in the volume of stored water.

The volume of the ground within the zone of unconfined water-level fluctuation within the Basin, multiplied by the specific yield of material comprising that ground, represents the minimum change in the amount of stored groundwater. In the Kelseyville Basin, the volume of ground within the zone of water level fluctuation is approximately 34,000 acre-feet. The specific yield of this ground is estimated, from well logs, to average 22 percent. The change in volume of stored groundwater between times of high and low water levels is therefore a minimum of 7500 acre-feet. This amount, however, represents only the difference in quantity of water stored at one time and is not a measure of the amount of water that passes through the basin during a season. This could be calculated only by determination of the quantity of surface and subsurface inflow to the basin compared with the volume of outflow and of total extraction, plus the volume change in storage. Data, which would permit determination of this amount, are not available. Elements of information which are lacking are 1) amounts of water recharged to Kelsey and Adobe Creek-Manning Creek Basins, and 2) amounts of water extracted from these basins under current conditions.

Operation of the Kelseyville Basin Groundwater System: The hydraulic system within the basin operates in response to the following variable conditions:

- Level of unconfined groundwater and piezometric surface (pressure head) of confined groundwater.

- Head difference between water at the interfaces between Kelseyville Basin and upstream sources of underflow, notably the Adobe Creek-Manning Creek Basin.
- Availability of water in the recharge area of the channel of Kelsey Creek.
- Head difference between confined water at the lower (north) margin of the basin and the level of Clear Lake.

Groundwater levels are dependent on the extent to which the basin has been recharged by percolation and underflow or drawn down by well pumping and outflow. The two extremes of these conditions are represented by the time of maximum basin groundwater filling in the spring, and basin drawdown in mid-autumn.

Spring High Groundwater: The water table is at its maximum possible elevation, being essentially up to the elevation of the bottom of the channel of Kelsey Creek. The piezometric surface in the pressure zone has recovered to the maximum elevation permitted by the pressure differential between the water table level at the upper edge of the capping layer, and the level of Clear Lake. Dynamic equilibrium exists between inflow and outflow with underflow and percolation into the basin equaling subsurface outflow to the Lake. Since the water table is at creek channel level, only as much percolation can occur as is required to maintain a balance as outflow to the lake tends to lower the water table. The remainder of the creek flow is discharged to the lake as surface flow. The amount of underflow from the Adobe Creek-Manning Creek Basin that can enter Kelseyville Basin is similarly restricted. Consequently, the upstream basin stays filled to capacity and the flow of Adobe Creek continues on to Clear Lake also.

Mid-autumn Low Groundwater: The water table and piezometric surface in the basin are lowered by amounts ranging from 5 feet around the basin margins to about 25 feet in the area around the northwest of Finley. Water is extracted through wells throughout the basin, and enough wells are pumped at any given time to maintain a broad trough of depression, with deeper local cones of depression, in this area. The small summer flow of Kelsey Creek percolates into the channel, generally in the 4000-foot reach south of the Main Street bridge. Underflow from the Adobe Creek-Manning Creek Basin is at the maximum permitted by the hydraulic gradient between it and the Kelseyville Basin. Outflow from subsurface springs to Clear Lake is probably greatly reduced though it does not cease entirely.

This condition is maintained until the general reduction in pumping occurs at the end of the harvest. Thereafter, there is some recovery of the pressure head in the pressure zone. Recovery probably continues gradually in response to the pressure differential caused by underflow from Adobe Creek-Manning Creek Basin until runoff from the winter rains begins to percolate into the basin.

Adobe Creek – Manning Creek Basin

Geology: Adobe Creek-Manning Creek Basin, in common with its downstream continuation, the Kelseyville Basin, is a lake and alluvial sediment filled structural trough. The basin comprises three areas; 1) the main trough underlying the channel and flood plain of Adobe Creek, 2) a subsidiary trough underlying the channel and flood plain of Manning creek, oriented normal to the main trough, and 3) a "shelf" between the Western Upland the Big Valley fault, north of Manning Creek. The main trough is 80 to 120 feet deep and contains three distinctive horizons; a gravel layer 10 to 20 feet thick at the bottom, a 20 to 40 foot thick clay layer in the middle, at depths of 60 to 100 feet, and an uppermost horizon of mixed alluvial silt and sand with streaks and channels of gravel. These sediments extend into and merge with the fill in Kelseyville basin.

Some wells in the basin draw water from the "Volcanic ash" aquifer confined in the underlying "Older lake and flood-plain deposits". This aquifer appears to be hydraulically independent of the aquifers in the overlying basin fill.

Recharge: Water is recharged to the Adobe Creek-Manning Creek Basin by percolation from the channels of three major and a number of minor creeks and by underflow from the Western and Central Upland areas. The most favorable areas for percolation are the channels of Highland and Adobe Creeks from below the dam on each creek to the confluence of the two channels, and the channel of Adobe Creek north to a point 1,300 north of the Merritt Road crossing, a distance of 2.3 miles (12,000 feet) and also a half mile reach in the channel of Manning Creek where the creek flows from the mountains into Big Valley.

The subsurface character of the channel of Adobe Creek was investigated by excavation, logging, and partial sampling of nine backhoe test pits. The investigation showed that the channel is quite similar in character to the channel of Kelsey Creek around Kelseyville, with an upper horizon of 10 or more feet of sandy gravel having zones of "open work" gravel, underlain by silt and fine grained sand. The fine grained bottom layer was not encountered in some pits, and so may be discontinuous. Alternatively, it may exist at greater depth than could be reached with the backhoe. At the north end of the wide channel reach, the creek bed changes from a gravel and sand to a sandy clay or clayey sand "clay pan". Test pits in this area showed that the gravel extends under the clayey capping but that the capping increases in thickness downstream.

Groundwater Movement: Flow of groundwater in the Adobe Creek-Manning Creek Basin is to the north in the Adobe Creek trough and to the east in the Manning Creek trough. The water table in each area is nearly parallel to the ground surface and slopes down a hydraulic gradient of 15:1 to 20:1. The groundwater flows into and continues flowing within the Kelseyville Basin. This flow pattern continues

throughout the year, with the water table merely being lowered, but not changed in slope direction, during the summer and autumn.

Changes in Groundwater Storage: A majority of the Adobe Creek-Manning Creek Basin is in the free (unconfined) groundwater zone. Only the "shelf" area, north of the Manning Creek trough, is in the confined, pressure area. Changes in water level within the basin, therefore, indicate changes in quantity of "stored" water (or, in the case of this basin, water in transitory storage). The variation in elevation of the water table between spring and fall ranges from 5 to 30 feet, with 10 feet being the average for the larger portion of the basin. The difference in volume of water present in the basin between spring high and mid-autumn low water levels is calculated, using an estimated specific yield of 15 percent for material in the zone of fluctuation, to be approximately 6700 acre-feet.

Operation of the Adobe Creek-Manning Creek Groundwater System: The hydraulic groundwater system within this basin operates in response to the following conditions:

- Groundwater levels.
- Level of unconfined groundwater and of the piezometric surface in Kelseyville Basin, at the interface between the two basins.
- Availability of water in the creek channel recharge areas.
- Amount of underflow from adjacent areas.

Groundwater levels are dependent, as in the case of Kelseyville Basin, on the extent to which the basin has been recharged by percolation and underflow, or drawn down by well pumping and outflow.

The hydraulic operation of the basin can most easily be described starting from a condition of a lowered water table. Normally, flow in Highland and upper Adobe Creeks, as released from the reservoirs on these creeks, is quite small when groundwater levels are low. The entire flow of each creek percolates into the channel gravels in the reach around and above the confluence of the two creeks. This water joins with the basin groundwater body and flows northward, down the hydraulic gradient.

When extraction by pumping drops off and losses to evapo-transpiration are reduced after mid-autumn, the water table rises somewhat, but the recharge-flow system just described continues. However, when Adobe Creek begins to flow more or less continuously, the water table rises to the level of the bottom of the channel, whereupon the basin is essentially filled to capacity. Thereafter, the level of the groundwater in the basin is maintained by underflow from adjacent areas and by very limited percolation in the uppermost reach of the main creek channel. About midway down the length of the basin, the water table intersects and then rises slightly above the level of the channel bottom. Below this zone of intersection, groundwater seeps

into the channel and escapes as surface flow, rather than being recharged from surface flow. This was demonstrated by the comparative creek flow measurements made by the California State Department of Water Resources in 1948, 1949 and 1950. In 1993, District staff performed creek flow measurements that confirmed this relationship still exists. After the first few weeks of flow, the quantity of flow measured near the downstream end of the basin exceeded the quantity measured at Bell Hill Road, near the upstream end, although no significant tributaries discharge into the creek along this reach. The observed excess must have been derived from effluent groundwater discharge into the creek.

Western Upland:

The "Western Upland" is a sloping, partially dissected, one-half to one-mile wide topographic bench along the western margin of Big Valley. The upland is underlain by older terrace deposits, resting on older floodplain and lake deposits. The "Volcanic ash" layer is confined within the fine grained flood-plain and lake deposits but is not known to crop out at the surface. Projection of intercepts of the "ash" layer indicates that it and its enclosing strata dip toward the east and north with an inclination of about 1 to 2 degrees. Wells in the Western Upland extract groundwater from the "volcanic ash" and, near Manning Creek, from a gravel lens in the terrace deposits. Logs of wells situated in the area adjacent to Manning Creek report encountering roughly 20 to 40 feet of water-bearing gravel at depths of 5 to 40 feet. This gravel is probably a buried alluvial fan or flood-plain deposit laid down at an earlier time by the ancestral Manning Creek. Wells further south, away from this creek, encounter only fine-grained materials. The gravels constitute the only known aquifer, other than the "Volcanic ash", in the deposits underlying the Western Upland. The gravel may be in hydraulic communication with the saturated alluvial fill under the channel of Manning Creek, since fluctuations of the water level in Section 7 correspond to fluctuations of the water table in the Manning Creek Basin. Recharge of the gravel, therefore, probably occurs by lateral flow from the basin groundwater body. The only available data indicates a specific capacity of only 1.25 gpm per foot of drawdown for a well drawing from this aquifer.

The characteristics and groundwater system of the "Volcanic ash" aquifer are discussed in Section 5 of this chapter.

Central Upland and Upper Big Valley:

The Central Upland-Upper Big Valley area is geologically similar to the Western Upland but is separated from it topographically by the Adobe Creek flood plain, and structurally by the Adobe Creek Fault system. The Big Valley Fault forms the northern boundary of the area, separating it from the Kelseyville Basin. The east and southeast margin of the Central Upland abuts against Mt. Konocti and the Volcanic Ridge, or grades to the higher Cole Creek Upland. The area is characterized at its northern end by broad,

gently sloping surfaces that give way to hills and ravines to the south. The Central Upland is underlain by "Older terrace deposits" and by the semi-consolidated siltstone-claystone, and fine-grained sandstone of the "Older floodplain and lake deposits". The continuity of geologic structure (and groundwater regimen) is interrupted by the Wight Way Fault and by another fault, which extend across the central portion of the area and bound a block of relatively younger sediment that is faulted down into the "Older floodplain and lake deposits" unit.

The northern portion of the Central Upland is underlain by materials of the upper member of the "Older floodplain and lake deposits" unit. Well logs indicate 10 to 40 feet of "soil" and "brown clay" directly beneath the surface, and then sand or sand and gravel on down to depths of 63 to 104 feet. The sand and gravel zone is partially saturated and yields some water to wells. The "Volcanic ash" layer is enclosed in the fine grained material of the lower member of the "Older floodplain and lake deposits" at depths of 100 to 130 feet beneath the base of the sand and gravel horizon at about 80 to more than 240 feet below the ground surface.

The down-faulted block across Sections 27, 28, and 29 is underlain by "Upland terrace deposits" at least to depths of 110 to 144 feet. The lower portion of this unit consists of as much as 90 feet of sand or sand and gravel, which is partially water saturated. Wells penetrating this section bottom in "blue clay" or "blue hard pan" which is probably the "Older flood-plain and lake deposits" unit.

South of the Wight Way Fault, in the area here referred to as Upper Big Valley, materials of the "Older flood-plain and lake deposits" unit are exposed at the surface. Logs of wells in this area report clayey materials down to shale or volcanic rock. Wells for which pumping test data are available have very low yields unless they draw from the underlying volcanic rock.

The upper sand and gravel horizon under the northern portion of the Central Upland is recharged by slow downward percolation of infiltrated rain, irrigation, and runoff water. Seasonal fluctuations in the level of the groundwater body in this aquifer probably result from drawdown by pumping during the irrigation season, followed by recovery and some recharge during the wet season.

The sand and gravel at the base of the Upland terrace deposits in the fault block in Sections 27, 28, and 29 must also be recharged to some extent by downward percolation of rainwater. However, the channels of several drainage courses are incised into this unit so it probably receives much of its recharged water by percolation from these channels during times of runoff. The aquifer may be in partial hydraulic communication with the groundwater body of the upper Adobe Creek basin, but having a higher water table, would tend to discharge to rather than be recharged by this groundwater. The "Volcanic ash" aquifer is

discussed in Section 5 of this chapter.

"Volcanic Ash" Aquifer

The "Volcanic ash" aquifer is a thin bed of lithic tuff, confined within the older semi-consolidated sediments, which underlies the northern portion of the Central Upland and most of the Western Upland and the Adobe Creek-Manning Creek Basin. The "ash" layer contains groundwater under artesian pressure and yields water to wells located at various places throughout much of the upland areas. Available evidence indicates that the aquifer is offset by the Adobe Creek fault system, and so occurs as two hydraulically independent units.

In discussing its character as an aquifer, the "Volcanic ash" is considered to have an average thickness of 2 feet. The underlying "mixed" clay or silt and ash layer is 3 feet in thickness in the Central Upland area and 2 feet in thickness in the area west of the Adobe Creek fault system.

Geology: In the Central Upland area, the ash layer lies at depths of 130 to more than 230 feet beneath the ground surface, except along the area's east margin, under Kelsey Creek. There, the layer is warped (or possibly faulted) up to crop out at two places in the bed of Kelsey Creek, and is encountered by wells at depths of 78 and 107 feet in Section 23.

The ash layer is tilted down to the northeast in the area west of the Adobe Creek fault. Its depth increases from a projected outcrop under the Adobe Creek basin fill in the vicinity of the Bell Hill Road crossing, to a maximum of 230 feet, where it is intercepted by a well in Section 15. The layer probably continues to the north to greater depths in this area, but no positive evidence of this is presently available.

Groundwater contained within the "Volcanic ash" aquifer is under pressure, with pressure heads of 100 to 150 feet being reported from initial water intercept data by well drillers, and from measured water levels in wells which are perforated only where they intersect the "ash". The piezometric head reported from a well located near the north end of the Central Upland is only slightly permeable, fine grained sediments. Probably much of the water derived from such "leakage" into the confined aquifer is transmitted through fractures rather than by intergranular flow.

Groundwater Movement: Flow within the aquifer is from areas of higher pressure, such as up-dip outcrop infiltration areas, to areas of lower pressure zones of outflow into lower level free groundwater bodies. Diversions to or interruptions of intra-aquifer flow could result from constrictions, or offsets, caused by thinning, warping, or faulting of the volcanic ash layer. The only known offset is along the northwest side

of the Central Upland, where the Adobe Creek fault drops the aquifer down some 180 feet on the Adobe Creek side. Since the "ash" layer is only a few feet thick, even relatively minor fault displacement would completely offset the aquifer and break hydraulic continuity across the fault. The apparent continuity of piezometric head within the aquifer suggests, however, that it is not displaced within the areas on either side of the Adobe Creek fault.

When water is withdrawn from a confined aquifer through a well, the naturally existing pressure and flow conditions in the aquifer are disturbed. Before pumping, water in an aquifer within which a regional pressure gradient exists has a tendency to flow in the direction of decreasing pressure. Also, in any small area, there is approximate static (pressure) equilibrium, or steady state seepage conditions, resulting from a pressure differential between the water in the aquifer and the pore or fracture water in the confining sediments. As soon as water is pumped from the well, however, a local pressure gradient is created with a low-pressure zone being formed around the well. Water in the aquifer then moves radially toward the zone of reduced pressure. Additionally, the local pressure gradient causes some water to be forced from the pore space in the saturated confining, fine grained sediments and to move into the aquifer. In some aquifers, the aquifer material is compressed because of the reduction in supporting pore-water pressure, and additional water is forced out; but tests indicate that the "volcanic ash" is only slightly compressed when subjected to confining pressures approximating those in Big Valley, so compression of the aquifer consequent on reduction of water pressure is probably of very small magnitude. On the other hand, the relatively good yield (considering the thinness of the aquifer) of many of the wells drawing from the volcanic ash, contrasted with the probably limited direct recharge of the aquifer, suggests that quite appreciable amounts of water may enter it by flow from the saturated confining sediments in response to local pressure differentials. It is theoretically possible to determine what fraction of the water produced by a well is derived from "leakage" into the aquifer, by obtaining data from a careful pumping-drawdown test with measurement of decline of piezometric head in a nearby observation well, and application of mathematical analysis to the data. Such an operation, however, is beyond the scope of this investigation.

Yield to Wells: Pumping tests of wells drawing from the "volcanic ash" aquifer report yields of 35 to 1000 gallons per minute, with drawdowns of 1 to 30 feet. Indicated specific capacities of wells range from 11 to 140 gallons per foot of drawdown.

Groundwater Storage and Availability: Calculations of the volume of water actually contained within the "ash" and "mixed ash" layer, using the porosity of the ash determined in the laboratory, and an assumed lesser porosity for the mixed material, indicate that approximately 21,000 acre-feet of water is stored in the aquifer under the Central Upland, and a minimum of 10,500 acre feet is stored under the Western Upland and Adobe Creek-Manning Creek Basins. This is the approximate amount of water contained within the

intergranular pore space in the aquifers, rather than the amount available for pumping by wells. That amount could be determined only by working out the "formation constants" ("S", the "storage coefficient", indicating the amount of water in storage released from a column of aquifer with unit cross section with unit decline of head; and "T", the "transmissivity, defined by the hydraulic conductivity multiplied by the aquifer thickness and the "leakance factor", the quantity of water that flows across a unit area of the boundary between the main aquifer and its semiconfining bed, if the difference between the head in the aquifer and that of the "leakage" water is unity). from mathematical analysis of drawdown and observation well test data.

Cole Creek Upland

No direct information relating either to subsurface conditions or to groundwater conditions in the Cole Creek Upland is presently available. The following discussion, consequently, is based on inference and geologic projection.

The lower, main portion of the Cole Creek Upland is underlain by the "Older floodplain and lake deposits" unit. Excellent exposures of the upper member of this unit may be seen in the road cuts for Highway 29 southeast of Kelseyville. It is possible that the "Volcanic ash" layer may extend under the area within the lower member of the "Older flood-plain and lake deposits", but no evidence for this is available.

Groundwater occurrence in this subunit is probably similar to that in the northern Central Upland, with a saturated zone in the more permeable horizons of the "Older floodplain and lake deposits". Water would be recharged to this zone by downward percolation of infiltrated rainwater, by percolation from the channel of Cole Creek and probably, by underflow from the bordering volcanic hills. Some shallow groundwater also is contained in the alluvial fill under Cole Creek in Sections 25 and 36. Water could leave the subunit by limited underflow to the Central Upland or by effluent flow through the rock of the lower slope of Mt. Konocti back into Cole Creek in Section 23.

Volcanic Ridge

The Volcanic Ridge (Camelback Ridge) is an elongate composite volcano, composed of fine to coarse grained pyroclastic deposits with intercalated thin lava flows and masses of intrusive lava. The surface of the higher part of the ridge is covered by a well-preserved flow of obsidian breccia. Most of these materials are highly permeable, either through intergranular permeability or through jointing and fracturing in the flow and intrusive lava rock.

Groundwater is contained in some zones in the ridge where barriers of reduced permeability impede

outflow. Recharge is entirely through infiltration of rainfall. This is quite effective because a very high percentage of the water that falls on the ridge surface infiltrates immediately, or after a short time and brief surface flow. Percolation occurs so rapidly that surface drainage courses are poorly developed or nonexistent over much of the ridge's area. Where no internal barriers to groundwater flow are present, much of the percolating water is rapidly discharged from temporary springs along the lower margin of the ridge. An internally eroded cavernous opening along Kelsey Creek probably was formed by episodes of rapid outflow following periods of heavy percolation. A spring consisting of a zone of seepage several hundred feet long along the base of the ridge in the northeast 1/4 of Section 2 (T12N, R9W), reportedly flows year round. This spring contributes a small, but appreciable fraction of the flow of Kelsey Creek during the summer months. The ridge may also contribute water to the Cole Creek Upland subunit by underflow.

Two wells are known to tap groundwater from the volcanic rocks. One of these wells, at least, reportedly yields water very high in iron.

Mount Konocti

Mount Konocti, like the Volcanic Ridge, is a composite volcano, made up of alternating layers, or series of layers, of pyroclastic and flow rock. Rain water infiltrates into the surface of the mountain and percolates downward through zones of higher permeability. Much of this water escapes through springs in the vicinity of Soda Bay, outside the Big Valley area. Water from these springs contains considerable boron, which is probably derived from mixing of infiltrated rainwater and mineral bearing thermal water within the volcanic pile. It is probable that underflow of similarly contaminated high-boron water from Mt. Konocti to the aquifers of the Kelseyville Basin causes the local high-boron content of groundwater from some wells near the mountain.

Mayacmas Mountains

The Mayacmas Mountains are underlain by metasedimentary rocks and, locally, by intrusive masses of serpentine and ultrabasic rock. None of these rocks possesses significant primary permeability, but they are all fractured to a greater or lesser extent, and so have some degree of secondary permeability.

Water enters the rocks through infiltration of rainwater and percolation from the upper reaches of creeks. The water is stored in or passes through fracture zones, and finally seeps out as effluent flow to the lower reaches of creeks within the mountains, or as underflow to the adjacent basins. Mineralized water, some of which may have risen from a source at depth, emerges from springs where the Wight Way Fault extends into the mountains.

GROUNDWATER QUALITY

The chemical character or "quality" of groundwater is dependent, generally, on the quality of water which recharges the groundwater system, on the character of materials within which the groundwater travels or is stored and on particular natural conditions or human activities which give rise to a contribution of chemical or bacterial constituents to the water.

Water in the groundwater systems of Big Valley is principally supplied by runoff from the watersheds of Kelsey, Adobe, Highland, and Manning Creeks. This water originates in largely uninhabited mountainous terrain comprised of metamorphic and igneous rocks. The water is of good quality for irrigation, food processing, and domestic uses.

Some additional water is supplied to the groundwater by direct infiltration of rain and of irrigation water in Big Valley. This water is also of good quality except in cases where the water is pumped from Clear Lake or from wells producing water of inferior quality. Irrigation water, however, may be modified in quality by contact with chemical or natural fertilizer materials.

Finally, water enters the Big Valley groundwater system by subsurface flow from the surrounding highlands and also, apparently, from buried springs rising beneath the basin-filling sediments. Much of this water is also of good quality, but some, notably that originating as underflow from Mt. Konocti and as rising spring water, has a relatively high mineral content.

Much data on the chemical composition of both ground and surface water in the Big Valley area has been obtained during investigations by the California State Department of Water Resources and by the California Agriculture Extension Service. DWR Bulletin No. 14, "Lake County Investigation" presents complete mineral analyses of numerous samples of groundwater from Big Valley and also of samples of water from other areas around Clear Lake. This body of data is particularly useful in that it permits comparison of the general compositions of ground and surface waters in differing areas and geologic regimens.

The typical groundwater of Big Valley, from the Kelseyville and Adobe Creek-Manning Creek basins, possesses a distinctive composition which differs somewhat from the composition of groundwater and surface water from other areas around Clear Lake, and from the water of Clear Lake itself. The principal mineral constituents of Big Valley groundwater are magnesium, calcium, and bicarbonate. Sodium is always

present, but in amounts subordinate to calcium. Chloride and sulfate are also present but are greatly subordinate to bicarbonate. The distinctive characteristic of Big Valley water is the magnesium to calcium ratio. In most groundwater, calcium is present in appreciably greater concentration than magnesium; but in Big Valley, the absolute concentration of magnesium is equal to or greater than that of calcium. In terms of chemical equivalents, the magnesium to calcium ratio ranges from 1.5:1 to 3:1.

The amount of total dissolved solids (TDS) in most Big Valley groundwater ranges from 350 ppm to 1200 ppm, averaging 400 to 500 ppm.

The presence of boron in water from some wells in Big Valley in concentrations high enough to be potentially injurious to crops has long been a matter of concern. The water analysis data in DWR Bulletin 14 show that there is generally a moderate (0.10-0.67 ppm) amount of boron present in groundwater throughout Big Valley. Additionally, water from a number of individual wells contained concentrations of 0.67-2.50 ppm boron, and one well yielded water containing 7.28 ppm boron.

Standards relating boron concentration to suitability of water for irrigation purposes, as set forth in the United States Department of Agriculture Technical Bulletin No. 962, are presented in Table 1. The effect of boron is cumulative, with the greatest effect occurring to perennial plants. The three primary crops in Big Valley are all considered "sensitive" crops. Pears are the most sensitive, followed by grapes and walnuts.

However, it should be noted that the effect on a crop of irrigation water containing boron is dependent on a number of factors besides the boron concentration in the water. The more important factors include the sensitivity of the plant to boron, the character of the soil, the amount of irrigation, and the weather or conditions of evapo-transpiration. The effect of a given concentration of boron will be less, ordinarily, if the soil is free draining, and if evapo-transpiration is not high. Heavy application of irrigation will tend to leach boron and prevent a buildup of its concentration in free draining soil, but will tend to cause it to accumulate in a poorly draining soil.

TABLE 1: IRRIGATION WATER SUITABILITY

Irrigation Water Class		Boron Concentration, parts per million		
Rating	Grade	Sensitive crops	Semitolerant crops	Tolerant crops
1	Excellent	less than 0.33	less than 0.67	less than 1.00
2	Good	0.33 to 0.67	0.67 to 1.33	1.00 to 2.00
3	Permissible	0.67 to 1.00	1.33 to 2.00	2.00 to 3.00
4	Doubtful	1.00 to 1.25	2.00 to 2.50	3.00 to 3.75
5	Unsuitable	greater than 1.25	greater than 2.50	greater than 3.75

Most wells in Big Valley yield water containing less than 0.30 ppm boron. Areas may be identified, however, where several wells produce water with 0.60 ppm or more boron content. Comparative analyses made in the spring and fall indicate that the wells usually but not invariably produce water containing a higher boron concentration in the fall, when water levels are lower and the wells draw from deeper in the aquifer. Also, analyses were made by the Agricultural Extension Service of water drawn from two depths in a well (13N-09W-12D2) near Mt. Konocti. The boron content of water from 210 feet depth was 0.32 ppm while it was 1.03 ppm in water from 247 feet depth.

Damage to plants resulting from irrigation with high-boron water has been reported from only a few local areas in Big Valley. This seems to bear out the indication from water analyses that high boron concentrations occur only in a few specific areas and that there is no general stratum or horizon of high-boron water.

Relation of Water Quality to Geology in Big Valley

Geologic conditions in Big Valley and in the watershed areas of the streams that flow into it largely determine the chemical quality of groundwater in the Valley's aquifers. Four principal determining conditions may be recognized: 1) The nature of rock, soil, and springs in the watershed of the streams which flow into Big Valley. This determines the character of surface and underflow water entering Big Valley. 2) Distribution of aquifer materials, capping layers, and other elements comprising the framework of the groundwater system in Big Valley. This determines the paths followed by surface water in gaining, or being denied, access to the groundwater system, and to some extent, the course of migration of water within the system. 3) The nature of materials comprising and adjacent to aquifers. This is important in determining what constituents may be added to (or removed from) groundwater; and 4) Special geologic or other conditions which give rise to contributions of mineral or other constituents to the groundwater. The occurrence of subsurface high-boron springs in the Valley can be considered to be in this category.

The conditions enumerated above are discussed in turn:

- *Geologic Conditions in Watershed Areas:* The watersheds of Kelsey, Adobe, Highland, and Manning Creeks are mountainous areas underlain by metamorphic and igneous rocks. Some volcanic and sedimentary rocks are also present in the lower watershed area of Kelsey Creek. The predominant bedrock material in these areas is the Franciscan Formation consisting mainly of greywacke sandstone, chert, and shale. All these rock types are composed of quartz, clay, carbonates, and silicate minerals. Decomposition and solution of these rocks probably yields most of the calcium, sodium, and bicarbonate observed in the water of Kelsey and Adobe Creeks. However, large quantities of serpentine and

serpentinized peridotite also occur in these mountains, particularly in the watershed of Kelsey Creek. Minerals of the serpentine group are hydrous magnesium silicates, often also containing iron and aluminum, and solution of the serpentine and its weathering products gives rise to a magnesium-rich water. The serpentine, then, is the source of the relatively high magnesium concentrations and the unusual magnesium to calcium ratio present in both the water of Kelsey and Adobe Creeks and also in the groundwater of Big Valley.

The sedimentary rocks in the watershed of Kelsey Creek are not known to contribute significant constituents to water other than the common mineral constituents, which are also derived from the Franciscan Formation rocks. Locally, the volcanic rocks yield water containing unusually high concentrations of iron.

- *Geologic Factors Governing Recharge and Movement of Groundwater:* A feature of the Big Valley groundwater system is that it is mainly recharged by percolation from creek channels and by underflow from higher groundwater. The presence of near surface clay layers over most of the agriculturally developed portions of the Valley greatly inhibits direct downward infiltration of irrigation or wastewater, or of rainfall. Contamination of the groundwater by fertilizer or sewage is therefore greatly restricted, and probably occurs on only a small scale in local areas.

The continuous flow of groundwater in the aquifers of Big Valley tends to dilute and disperse any unusual constituents that are introduced into the groundwater, either from downward percolation, from underflow, or from subsurface spring discharge.

- *Materials in the Groundwater Systems of Big Valley:* The aquifers of the Big Valley groundwater system are generally made up of relatively non-reactive, chemically stable materials, so water passing through or stored within them is not greatly affected chemically. However, comparison of analyses of water from Kelsey and Adobe Creeks with analyses of groundwater from wells shows increases in the content of mineral constituents in the groundwater, which indicates that some material is taken into solution by the circulating groundwater. The composition of water is more strongly affected where iron-rich materials in or adjacent to aquifers is oxidized and partially dissolved, giving a locally high iron content to the groundwater and where buried organic matter is incorporated in the aquifer system. Among the products of the decomposition of organic material are the gases carbon dioxide, methane, and ammonia, and appreciable quantities of these gases may be dissolved in groundwater which circulates through areas of gas formation or accumulation. No specific data on the presence of these gases are available, since carbon dioxide (CO₂) is reported with bicarbonate (HCO₃) in water analyses, and methane is not reported. Ammonia is not reported, but one of its oxidation products is nitrate. Some of the nitrate shown

in analyses may therefore be derived from decomposition of organic material in the aquifers. Dissolved carbon dioxide probably causes the slightly acidic character of some groundwater. Methane is discharged from springs emerging from near shore areas in Clear Lake.

The volcanic ash aquifer is composed of relatively non-reactive fragments and particles of volcanic rock. The high iron content of water from Well 13N-09W-27B1, which draws from this aquifer near its outcrop, is probably derived from iron-cemented zones in sandstone adjacent to the ash layer.

High iron content is reported from Well 13N-09W-27K1, which draws from the rocks of the volcanic ridge, near Kelsey Creek. The source of this iron is not known, but is doubtless within the volcanic material.

- *Special Geologic Conditions:* The presence of a moderate concentration of boron throughout the groundwater of Big Valley and of local higher concentrations of this element is due, ultimately, to the existence of the Clear Lake volcanic field. Boron is one of the notable constituents of thermal water associated with remnant volcanic activity in this area. The question is, how the boron is introduced into and distributed within the groundwater in Big Valley.

Locations of wells that are known to have produced water containing 0.60 ppm or greater concentration of boron are indicated on Plates II and V of this report. The plot shows a group of high-boron wells in the area adjacent to Mt. Konocti and other groups of wells and individual wells at various places in the Valley.

Some of these appear to be randomly located, but several are situated along or near the buried trace of the Big Valley fault. Data on boron content of waters from these wells are presented in Table 2.

The location of isolated high-boron wells in relation to alignments of water seems usually to come from deeper aquifers, and the head in these aquifers is not known to be significantly higher than the head in overlying aquifers, relative to the depth of each; and 2) The boron content of most of the "high-boron" well waters is still low enough (commonly less than 2 ppm) that dilution factors of as little as two to four times would reduce this content to the general level of groundwater in Big Valley.

Contamination of shallow groundwater by percolation of high-boron irrigation water is not likely to occur in Big Valley because there is relatively little percolation of surface water to the groundwater except from the creek channels, especially in the areas where most high-boron water producing wells are located and, again, because typical "high-boron" groundwater in Big Valley still contains relatively little boron.

BASIN WATER BUDGET

The Lake County 1987 Resource Management Plan Update analyzed the water budget for the Big Valley watershed. As a majority of the watershed's water use occurs in the Big Valley Groundwater Basin, the Groundwater Basin water budget is reflected by the watershed budget.

Table 3 presents the annual water budget for the Big Valley watershed. As shown, the average annual runoff in the watershed is approximately 127,500 acre-feet. Total water demand in the basin is approximately 26,100 acre-feet per year, of which 22,420 acre-feet is required for agricultural production. An average net surplus of 101,400 acre-feet is available in the watershed. During the months of June through September, there is a net demand on the groundwater resources of the watershed when insufficient runoff is available. The total net demand on the watershed groundwater aquifers is approximately 17,000 acre-feet.

Based on the estimated aquifer storage capacity of the Big Valley Basin of 50,000 acre-feet, except for a few isolated wells, the 1985 water demand of the area did not exceed available water supplies for a drought event of a 100-year recurrence. However, widespread shortages and dry wells will occur because the groundwater resources are not evenly distributed throughout the Basin. The water supply will not meet the water demand in certain areas of the Basin. There is an immediate need, therefore, to limit further expansion of groundwater use in the Big Valley Groundwater Basin.

TABLE 2
BORON CONTENT OF WELL WATER

Well No.	Date of Analysis	Boron Content (in ppm)	Notes
14N-09W-31N1	8/8/52	0.92	
14N-09W-21P1	8/13/49	0.64	Well 70 ft. deep; perforated 0-68 ft.
14N-09-31Q1	6/5/45	0.72	Well 107 ft. deep
13N-09W-01N1	9/18/47	2.48	
13N-09W-02F1 (D3605*)	1960	1.5	
13N-09W-04D1	8/8/52	0.14	
(D3121*)	1960	1.3	
13N-09W-04M1 (W-636*)	1962 1965	12.9 6.9	Well completed 1961, 57 ft. deep; perforated 37-57 ft.
13N-09W-06C1	9/3/58 6/12/62	0.6 0.48	Well cased to 91 ft; perforated bottom 15 ft., and alternating 4 ft. intervals above.
13N-09W-06H1,2		Reported	"high"
13N-09W-08N1	6/27/49	1.80	
13N-09W-08N2	8/8/52	1.30	
13N-09W-10H4	6/13/62	2.7	Well 548 ft. deep. Reported hard water, about 1.0 ppm boron in Fall, temp. above 70°, no boron in Spring, temp. cold.
13N-09W-11Q2 (W464*)	1962	0.76	
13N-09W-12D2 (D3272*)	1960	0.32 at 210 ft.	
		1.03 at 247 ft.	
13N-09W-12M1	3/24/48 8/8/52	0.92 0.08	Other analyses 1958-1962, .55 to .71 ppm boron
13N-09W-14F1	11/17/48 8/8/52	7.28 0.08	
13N-09W-14N1 (W96*)	1962	2.3	
13N-09W-16D1	1957-1962	.53-.69	

(*) Number used for analysis by Lake County Farm Advisor's Office.

NOTE: Data from California State D.W.R. and U.C. Agriculture Extension Service Farm Advisor's office.

Increases in groundwater drafting may result in some further ground subsidence. During the 1976-1977 and 1987-1992 drought periods when groundwater levels were drawn down significantly, groundwater subsidence was observed. In several locations along Finley East Road, ground subsidence of 12 to 16 inches was observed. While these amounts are significantly less than observed in Scotts Valley, there is a potential for disruption of surface drainage patterns and long-term groundwater storage.

Anticipated Future Water Needs

Table 4 presents the anticipated growth in water demand in the Big Valley watershed between the years 1990 and 2020. As shown, domestic and non-commercial agricultural water demand continually increases, while commercial agricultural demand remains relatively constant over this period. By the year 2020, total water demand will equal approximately 37,850 acre-feet per year.

With projected increases in water demand, in the year 2020 water supplies in the valley will be exceeded by drought events that occur with a 20-year interval. A minimum of 19,600 acre-feet of runoff must occur in order to meet the estimated demand on groundwater under drought conditions. A similar situation of water demand exceeding the available water supply may occur after two or more successive dryer than normal water years.

Before this demand level is reached, the Big Valley Basin will be faced with significant ground subsidence and associated problems. The likelihood of major impacts on the long-term crops such as grapes, pears and walnuts will be significant.

As additional development occurs within the watershed, the water demand will increase. Increased water use is occurring due to geothermal development, commercial and residential development, increases agricultural acreage, and increases in irrigated agriculture. This water demand is not expected to cause any significant decrease in the availability of water supplies to downstream users under normal or average runoff conditions. During normal years, there will continue to be large surpluses of water in the Big Valley watershed. During the dry summer months, withdraw of water can reduce storage and can take away water that would otherwise enter the recharge zones. This amount of water is low; however, at this point all available water is significant.

Continued development in the watershed will further restrict available water supplies, increasing the chances of groundwater overdraft during dry periods.

TABLE 3
1985 WATER BUDGET - BIG VALLEY WATERSHED

Month	Average Total Runoff, acre-feet	Commercial Agricultural Demand	Noncommercial Agricultural Demand	Domestic Demand	Net Available Flow
October	1,700	0	0	65	1,635
November	8,000	0	0	56	7,944
December	20,000	0	0	56	19,944
January	32,300	0	0	56	32,244
February	28,200	0	0	56	28,144
March	19,700	520	60	56	19,064
April	11,400	2,240	270	71	8,819
May	3,600	2,560	300	98	642
June	1,400	4,490	540	113	-3,743
July	500	6,530	780	127	-6,937
August	350	4,920	590	118	5,278
September	350	1,160	140	98	-1,048
Total	127,500	22,420	2,680	970	
Annual Average Surplus/Deficit:		101,430			

TABLE 4
ANTICIPATED WATER NEEDS – BIG VALLEY WATERSHED

Year	Average Annual Runoff	Domestic Demand	Commercial Agricultural Demand	Noncommercial Agricultural Demand	Average Annual Water Surplus
1995	127,500	1,526	22,824	6,375	96,775
2000	127,500	1,791	22,969	7,484	95,256
2005	127,500	2,078	22,667	8,679	94,076
2010	127,500	2,353	22,628	9,831	92,688
2015	127,500	2,629	22,885	10,983	91,003
2020	127,500	2,905	22,813	12,135	89,647

COMPONENTS OF A GROUNDWATER MANAGEMENT PLAN

The California Water Code identified twelve activities that may be undertaken under a Groundwater Management Plan. These activities and their applicability to the Big Valley aquifer are discussed below.

Control of Saline Water Intrusion

Saline groundwater intrusion in the classic sense does not occur in Big Valley. However, the intrusion of geothermal waters containing iron and boron has been inferred in studies as early as 1958. Elevated levels of iron and boron have been noted at greater depths and adjacent to inferred faults that underlie the aquifer. Boron and iron levels also tend to be higher in the fall when groundwater levels are lower. The “hot” well during the 1976-77 drought along Merritt Road also shows the infusion of geothermal water during periods of low groundwater levels

Maintenance of higher groundwater levels would be beneficial to maintaining higher groundwater quality within the aquifer.

Wellhead Protection and Recharge Area Protection

The Lake County Department of Health Services, Division of Environmental Health (Environmental Health) administers several regulatory programs under the authority of State statutes and regulations, and Chapter 9 of the Lake County Ordinance which are designed to protect public health. Several of these programs result in the protection of groundwater resources. This includes permitting programs for regulated underground storage tanks, hazardous waste generators, hazardous materials handlers, on-site septic systems, solid waste facilities, and new water well construction throughout the county.

In October 1996, Environmental Health received a Local Groundwater Protection Grant from U.S. EPA, Region IX. The project lasted from January 1, 1997, through March 30, 1998. The main objectives of the project were to 1) Develop a county-wide contaminant source inventory enhanced with Geographic Information System (GIS) and Global Positioning System (GPS) technology: 2) Identify and abate potential sources of groundwater contamination by performing inspections of suspected hazardous material facilities not currently on the permit inventory and septic systems in selected areas throughout the County: 3) Increase public awareness of groundwater protection issues by distributing educational material.

These efforts resulted in centralizing the data collected in several environmental health regulatory programs into an expandable, versatile, electronic mapping system capable of performing complex analysis and queries. This system enhances the County's ability to link groundwater quality problems to probable sources of contamination and allows environmental health staff to prioritize inspections to areas of greatest contamination risk. Secondly, the project resulted in adding one environmental health specialist to existing staff for one year to conduct inspections and respond to outstanding complaints involving

threats to groundwater. These inspection activities allowed the Division to identify unpermitted hazardous materials facilities and gather information on the performance of selected septic systems throughout Lake County while distributing groundwater protection educational material to businesses and the community. During the course of the project, several potential sources of contamination were identified and eliminated. These efforts will continue in the course of implementing the affected local regulatory programs.

- Environmental Health's efforts to further wellhead and recharge protection are supported by this Plan.
- Changes in their regulations may be made as deemed necessary.

Impacts of in-channel gravel mining on groundwater supplies in the 1960's and 1970's led to the County adopting the Creek Management Plan (CMP) in 1981. The CMP showed that the channel degradation caused by gravel mining has led to a reduction in groundwater storage in Big Valley. Channel degradation of over 10 feet has been documented in Kelsey Creek north of the Main Street Bridge in Kelseyville and over six feet in Adobe Creek near the end of Hummel Lane. Heavy equipment operations during gravel mining operations also compact the creek bottom, reducing the potential groundwater recharge rates. The CMP recommended no further extraction of gravel in Adobe Creek below the Highland Creek and Adobe Creek Reservoirs and no extraction from Kelsey Creek downstream of Camelback Ridge. Extraction for the purposes of flood control and/or erosion control would be allowed on a case by case basis. The Lake County Board of Supervisors adopted these recommendations in 1981. In 1992, the CMP was updated and replaced with the Lake County Aggregate Resource Management Plan (ARMP). The ARMP requires no gravel extraction in Kelsey Creek until it has aggraded to pre-mining levels or to levels no lower than necessary to provide 100-year flood flow capacity in the vicinity of Kelseyville. Gravel extraction in Adobe Creek below the two reservoirs is still prohibited. Extraction for the purposes of flood control and/or erosion control is still allowed on a case by case basis. Since the construction of the Kelsey Creek Detention Structure in 1987, Kelsey Creek has aggraded up to 3 feet upstream to the Merritt Road crossing. The creek downstream of the Structure has degraded in some spots. Allowing the stream to aggrade and reducing disruptive gravel mining activities enhances groundwater storage and protects the recharge areas and the groundwater supply.

The Lake County Community Development Department, Planning Division, administers implementation and enforcement of the ARMP. The District assists by providing the technical information necessary to ensure the goals of the ARMP are met.

- Community Development's implementation of the ARMP is supported by the Plan.
- Future revisions of the ARMP should be reviewed for consistency with the Plan.

Regulation of the Migration of Contaminated Groundwater

Contaminated groundwater has not been documented in the aquifer. Some preliminary studies

using data collected by the Department of Water Resources by District staff in 1993 showed some increases in nitrate levels in individual wells. An insufficient number of wells were analyzed to identify any contamination trends or sources of contamination. Additional wells must be analyzed to determine if the groundwater is being contaminated.

Administration of Well Abandonment and Well Destruction Program

On April 25, 1989, Lake County adopted County Ordinance #1823 that sets minimum standards for the construction of new water wells. This ordinance adopted California Department of Water Resources Bulletin #74-81. This subjects all new wells to minimum construction. In addition, all existing wells that are no longer used are required to be destroyed in a specified manner that adequately protects the source aquifer. The Environmental Health administers the program by issuing permits and conducting site inspections for all new well construction, modifications and destruction. The program is supported in part by fees set by County Ordinance #2205. In an effort to encourage the proper abandonment of wells, there are no fees charged for a well destruction permit.

- Environmental Health's regulation of proper well destruction is supported by this Plan.
- Changes in their regulations may be made as deemed necessary.

Mitigation of Overdraft

There are identified locations within the Big Valley Basin where overdraft conditions have occurred during drought years. The factors to be considered in reducing overdraft include the following:

- Determining and maintaining a safe yield of groundwater for use within the Basin in order to supplement available lake water supplies, without producing overdraft.
- Identifying and monitoring the relationship between Basin groundwater extraction and impacts on groundwater supplies within and adjacent to the Basin.
- Developing data and information that identify impacts on groundwater in adjacent areas that might be affected by groundwater use.
- Establish mitigation measures to offset identified adverse impacts of groundwater extraction.
- Establish quantitative limitations on groundwater extractions for particular areas and establishing criteria for well spacing and operations to limit adverse impacts of groundwater extraction on Basin wells, if needed.

Implementation of the activities identified above will require studies to determine the safe yield of the groundwater basin, groundwater basin storage capabilities and appropriate mitigation measures. These

studies will have substantial costs associated with them. The present political climate does not support some of the monitoring and quantitative limitations on groundwater extraction. Data should be collected and a safe yield determined for the groundwater basin.

Replenishment of Groundwater Extracted by Water Producers

To preserve the groundwater quality from geothermal water intrusion, reduce overdraft conditions and prevent additional subsidence, groundwater use must be reduced and/or natural levels of groundwater recharge must be protected, enhanced and/or supplemented.

The recharge areas for the Central Upland aquifer (volcanic ash) located north of Wight Way should be protected.

The primary recharge areas for the Kelseyville Basin and the Adobe Creek - Manning Creek Basin are the creek beds of Kelsey, Adobe and Manning Creeks. The creek beds must be protected to maintain and managed to optimize their recharge capabilities.

Mining which causes channel degradation and compaction of the creek bed should be discouraged.

- Development that increases creek flow velocities in excess of stable channel velocities should be discouraged.
- The bed of Kelsey Creek should be allowed to aggrade in the historic mining area to levels approaching the 1960 elevation, however, a 100-year flood flow channel capacity in the vicinity of Kelseyville should be maintained.
- Consideration should be given constructing additional grade control structures in Kelsey and Adobe Creeks.

The Kelsey Creek Detention Structure constructed in 1987 with DWR funds has been shown to supplement the groundwater supplies in the eastern half of the Kelseyville Basin. The Structure was constructed to mitigate the channel lowering which occurred in the 1960's. By increasing the depth of water in the creek bed upstream of the Structure, the groundwater recharge rate is increased during periods of when the Structure is closed. The Structure was constructed two feet above the channel flow line to encourage gravel deposition upstream. Four grade control structures were constructed upstream of the Structure to further encourage gravel deposition. District operates the Structure to maximize groundwater recharge, allow creek bedload movement, not aggravate flooding, minimizing operating costs, and to maintain passage for the Clear Lake Hitch. This Plan supports this operation.

- Consideration should be given to conjunctive use projects.
- Additional recharge projects, including in-stream and off-stream facilities should be considered.

Monitoring of Groundwater Levels and Storage

Semi-annually, the District and DWR currently monitor 68 wells in Big Valley in the Spring (April) and the Fall (October). Monthly, the District also monitors sixteen (16) representative wells in the Kelseyville and Adobe-Manning Creek Basins. Figure 10 shows the location of the wells currently monitored.

- These monitoring programs should continue.
- Consideration should be given to expanding the monitoring program to include wells that provide a more accurate assessment of groundwater levels, including wells that provide an increased area of coverage.

Facilitating Conjunctive Use Operations

Conjunctive use is defined as the operation of a groundwater basin in combination with a surface water storage and conveyance system. Conjunctive use operations should be facilitated.

- In 1995, the Natural Resources Conservation Service performed a preliminary study indicating modifying the primary spillway of the Highland Springs Reservoir for use as a conjunctive use facility the project was feasible. A more detailed evaluation, including a reservoir yield study and evaluation of the modifications on flood storage capacity need to be completed.

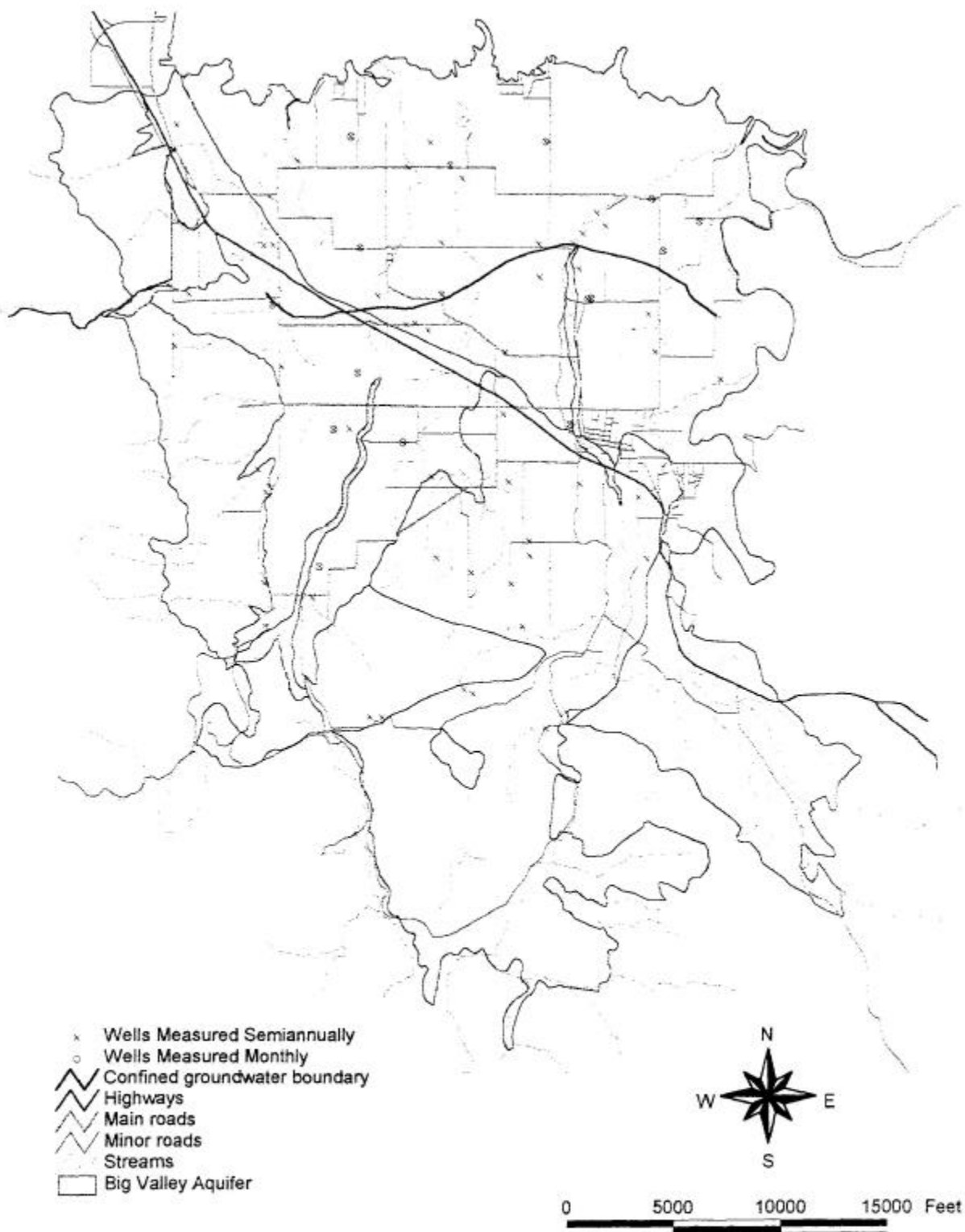


Figure 10: Wells Measured

- If modification of the Highland Springs Reservoir is successful, similar modifications of the Adobe Creek Reservoir should be considered.
- No other public reservoirs exist, or are proposed, within Big Valley watershed. Working with private reservoir owners to develop conjunctive use projects may be considered.

Identification of Well Construction Policies

On April 25, 1989, Lake County adopted County Ordinance #1823 that sets minimum standards for the construction of new water wells. This ordinance adopted California Department of Water Resources Bulletin #74-81. This subjects all new domestic wells, industrial wells, agricultural wells and monitoring wells to minimum construction requirements including, minimum setback requirements to contamination sources, flood plain considerations, and the requirement of a sanitary seal. Environmental Health administers the program by issuing permits and conducting site inspections for all new well construction and modifications. The program is supported in part by fees set by County Ordinance #2205.

- Environmental Health's regulation of proper well construction is supported by this Plan.
- Changes in their regulations may be made as deemed necessary.

Construction and Operation of Groundwater Projects

The Water Code identifies numerous types of projects that fall under the purview of a groundwater plan, such as groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects. New projects identified above will be constructed and operated by the District in conformance with this Plan.

Develop Relationships with State and Federal Agencies

The District has established relationships with the numerous state and federal regulatory and resource agencies. These relationships include the California Department of Water Resources, the California State Water Resources Control Board, the Central Valley Regional Water Quality Control Board, the U.S. Army Corps of Engineers, and the U.S. Environmental Protection Agency. These relationships will be continued and expanded facilitate implementation of the Plan.

Review and Coordination of Land Use Issues

In order to ensure land use decisions are consistent with this Plan,

- District staff will provide comment to the planning agencies to implement the goals and policies of this Plan.
- Major projects will be brought to the attention of the Big Valley Groundwater Management Zone Commission for consideration.
- The District will review and respond as a responsible agency for issues directly related to water use that affects the Big Valley Groundwater Basin.

PLAN IMPLEMENTATION AND FINANCING

Implementation of the Groundwater Management Plan will require dedication of time and financing from the District and the residents and property owners within the Big Valley Groundwater Basin. The amount of time and financing required is dependent on the level of implementation of the Plan.

The District's existing general funding source has insufficient revenue to fully implement groundwater management in Big Valley and the other seven identified groundwater basins in the County.

Flood Control Zone 5 Budget

Flood Control Zone 5 has boundaries that are very similar to the boundaries of the Big Valley Groundwater Basin, and included the major groundwater use areas in the Basin. Flood Control Zone 5 (Zone 5) was created in 1964 "...to study the construction of a project on Kelsey Creek which will furnish water for irrigation and municipal water to the entire Big Valley Area." The project, known as Pomo Dam, was proposed to serve as a conjunctive use facility and to recharge the Big Valley aquifer. The Dam was intended to supplement natural recharge, increasing available groundwater supplies and reducing aquifer overdraft during droughts. Pomo Dam was not constructed. The goals of Zone 5 are similar to the goals of groundwater management, therefore, funds received from tax revenues may be used as seed money for groundwater management activities. Zone 5's current tax revenue is approximately \$3,400 per year, with increases limited by Proposition 13.

In 1987, the Kelsey Creek Detention Structure (Structure) was constructed with funds provided by DWR. In addition to the construction costs, DWR provides annual funds, currently \$11,660 per year, for the operation, maintenance and replacement (OM&R) of the Structure. The OM&R funds are indexed to the U.S. Bureau of Reclamation water construction cost index and has been increasing each year. This revenue

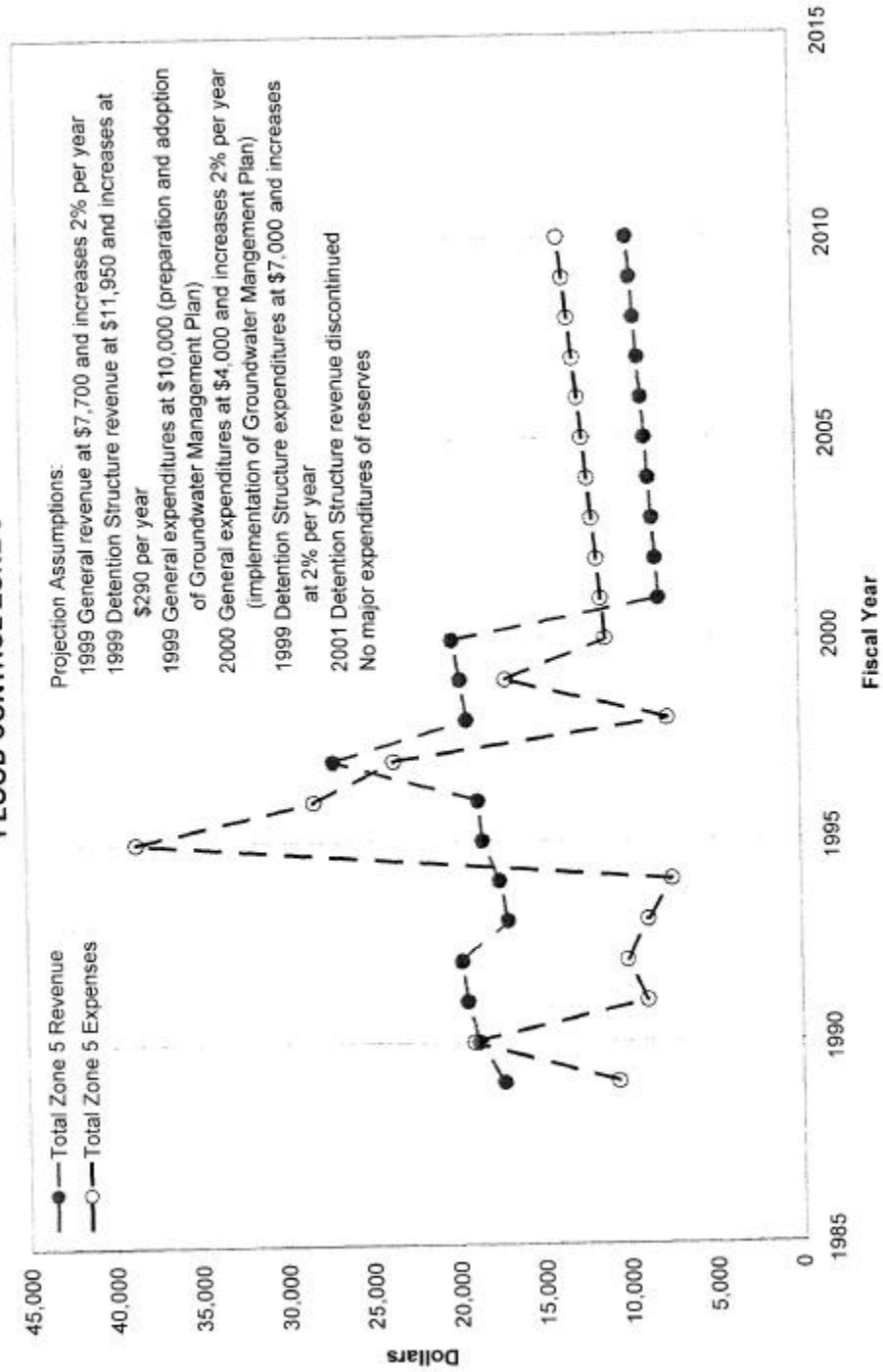
is also added to the Zone 5 budget. DWR's obligation is tied to the development of the DWR Bottle Rock Geothermal Power Plant. An agreement with Lake County requires DWR to pay the OM&R costs as long as DWR operates and/or owns the power plant. The power plant ceased operation in 1990, however, it is still owned by DWR, therefore, OM&R funds are still provided. DWR is currently investigating selling the power plant and/or changing the conditions of the power plant license. This will reduce and/or eliminate the required mitigation costs, including the Structure OM&R costs. The District is tracking this process and has expressed a need to continue the funding of OM&R of the Structure. There is a realistic possibility the annual OM&R funds provided by DWR will be reduced or eliminated in the next ten years.

Since 1964, Zone 5 has accumulated a reserve of \$76,367. The reserves are developed from unspent Zone 5 revenue, including tax and interest revenues, being placed in reserve for future use. All the DWR OM&R revenues have been expended on the Structure and related projects (drop structures). Zone 5 reserves may only be spent for the purposes of Zone 5, such as groundwater management. A portion of the reserves should be set aside for future replacement and major repairs of the Structure. As of 1999, a designated reserve had not been designated for the Structure. The remainder of the reserves could be spent on groundwater management activities. Costs of developing this Plan were paid from these reserves. Approximately \$3,800 on interest is currently earned on the reserves. The interest earned on tax revenue reserves may also be spent on groundwater management activities. Decreases in reserves will result in less interest earned on the reserve.

The amount of funding available from Zone 5 for groundwater management activities is limited, however, it is sufficient to perform many of the basic functions of groundwater management as recommended by the Plan. We estimate the activities identified below can be accomplished for approximately \$4,000.

When the DWR OM&R costs are reduced and/or eliminated, additional funding should be pursued for continued OM&R of the Structure. Based on the historical expenditures and present operational plans for the Structure, we estimate annual expenditures of \$4,000 for groundwater management and \$7,000 for OM&R of the Structure (1999 dollars). Should the DWR OM&R revenue be eliminated, expenditures will exceed annual revenues. Figure 11 shows annual revenues and expenditures from 1988 and projected to 2010. It shows the impacts of loss of the DWR OM&R revenue in 2001. Additional budget tables and graphs are included in Appendix A of the Plan.

FIGURE 11
REVENUE AND EXPENSE PROJECTIONS
FLOOD CONTROL ZONE 5



Plan Implementation

This section discusses implementation of the Plan and funding sources for each of the components of the Plan:

- Control of Saline Water/Geothermal Water Intrusion: No specific action was recommended, therefore, there are no costs associated with the component. Should action be required in the future, supplemental funding will probably be required.
- Wellhead Protection and Recharge Area Protection: These activities are currently administered by Environmental Health and Community Development under their current funding and authorities. The activities are supported by the Plan. Should additional activities be identified, supplemental funding will probably be required.
- Regulation of the Migration of Contaminated Groundwater: No specific action was recommended, therefore, there are no costs associated with the component. Should action be required in the future, supplemental funding will probably be required.
- Administration of Well Abandonment and Well Destruction Program: No specific action was recommended, therefore, there are no costs associated with the component. Should action be required in the future, supplemental funding will probably be required.
- Mitigation of Overdraft: Groundwater studies are necessary to determine the safe yield of the aquifer, aquifer storage capabilities and appropriate mitigation measures. Much of the data collection can be accomplished with existing funds, however, the groundwater studies will require substantial expenditures. Supplemental funding for the studies should be pursued.
- Replenishment of Groundwater Extracted by Water Producers: Protection of the recharge areas is currently regulated through Chapters 17, 21 and 24 of the County Code, Subdivision Regulation, Zoning, and Surface Mining and Reclamation, respectively. District staff will continue to work through these existing regulations to protect the groundwater recharge areas. No additional funding will be required to perform these functions.

The Kelsey Creek Detention Structure will continue to be operated to enhance groundwater recharge in the Kelseyville Basin. No additional funding is required at this time, however, should DWR reduce or eliminate the OM&R funding for the Structure, additional funding may be required.

Development and construction of conjunctive use facilities and additional recharge projects will require new funding sources.

- Monitoring of Groundwater Levels and Storage: District and DWR monitoring programs are currently funded. Extensive expansion of the monitoring program may require supplemental funding.
- Facilitating Conjunctive Use Operations: Preliminary studies evaluating the feasibility of modifying

Highland Springs Reservoir are currently funded by Flood Control Zone 1. Design, construction and OM&R of the modifications will require additional funding.

- Well Construction Policies: These activities are currently administered by Environmental Health under their current funding and authorities. Should additional activities be identified, supplemental funding will probably be required.
- Construction and Operation of Groundwater Projects: New water projects will require additional funding for design, construction and OM&R. Existing funding may be used for preliminary studies, however, these funds are limited.
- Develop Relationships with State and Federal Agencies: The District currently maintains these relationships, therefore, no additional funding is required.
- Review and Coordination of Land Use Issues: District staff will continue to work through these existing regulations to protect the interests of the Big Valley Groundwater Basin. No additional funding will be required to perform these functions.

Funding Alternatives

Additional financing will be necessary to fully implement all the identified components of this Plan. In recognition of the need to assess the impact of the additional financing, an appropriate revenue plan for implementation of the Plan, including preparation of studies, and design, construction and operation/maintenance of groundwater projects is warranted. This report is intended to serve, in part, as a basis for further evaluation and creation of a new revenue plan for groundwater management in Big Valley.

There are several basic revenue alternatives available to groundwater management related activities. All these funding alternatives are subject to the voter approval requirements of Proposition 218. These alternatives include establishment a countywide benefit assessment or special tax for all county property owners, or to create a new user charge or fee for allocation to the users/beneficiaries of the groundwater management program. The latter option is the most likely revenue source for groundwater management. These mechanisms are discussed below.

- Benefit Assessments: A benefit assessment is a funding method that utilizes a special assessment based on benefit received to recover specific costs equitably among properties. Special assessments are based on the special benefits that the public improvements confer upon the assessed lands. Since most public works projects result in an improvement in the use or occupation of lands, a special benefit could be assessed against each of the individual properties based on the level of benefit received. Many municipal entities, nationally and throughout the State, have used benefit assessments for water management activities. This method appears to be used throughout California primarily by Districts where legislation empowered the Districts to levy assessments or taxes upon property to pay specific

costs and expenses.

- **Special Taxes:** A special tax is a funding method utilized to recover specific costs from individual properties. Special taxes are imposed for specific purposes upon a two-thirds vote of the electorate. Since most public works projects result in an improvement in the use of lands, a special tax could be levied against each of the individual properties receiving benefit within the County.
- **Water User Fees:** Water user fees are currently used in many counties throughout the country to fund water management related activities. It is through this general authority that many flood control and water conservation, irrigation and water replenishment districts fund their activities.

There are three primary methods that could be utilized to accommodate the billing of water user fees: utilization of the County Auditor/Controller's Office; utilization of an existing utility billing system or creating a new utility billing system. Each option requires the utilization of County tax roll data for the size and type of land use of each applicable parcel. However, creating a new billing system requires additional data correlation based on parcel address/APN number, as well as additional billing administration and mailing costs.

- **County Tax Rolls:** The County Auditor/Controller's Office provides for the billing of property taxes to all property owners in the County. This system is used as a billing mechanism for taxes and user charges by other municipalities, particularly when the municipality does not have a mechanism to bill charges to the appropriate beneficiaries. The County tax rolls can be used to bill benefit assessments, special taxes and non-tax (user charges) items.

The advantages of recovering costs through the tax billings are: the percentage of collection is usually very high; as a semi-annual bill, the County should receive minimal customer service calls; the data files are in place; it readily provides for the billing of all property including undeveloped land; and, bills will be sent to property owners without special handling. The disadvantages of this mechanism are: billing costs are relatively high ; initial billing errors (estimated at approximately 1% to 2%) may be time consuming and expensive to reconcile; and the County requires a setup fee and annual property tax administrative fee that must be negotiated. To pursue this methodology, the County must adopt the appropriate legal authority and submit the charge per parcel to the County Auditor's Office by the first of August of each year.

- **Utilize an Existing Utility Billing System:** The advantages of using an existing billing system mechanism are: database and billing corrections are all completed by one agency; and cash flow from revenue receipts is continuous. The disadvantages of this methodology are: existing billing schedule would have to be utilized; costs may be incurred for utilizing another agencies billing system; initial number of

customers calls/complaints is expected to exceed the calls from the tax mechanism; a special utility bill would be required to bill owners of undeveloped land.

- Create a New Billing System: The advantages of using a new billing system mechanism are: it provides a flexible implementation schedule; data base adjustments and billing corrections are all completed by one agency; and, cash flow from revenue receipts is continuous. The disadvantages of this methodology are: the billing system must be created; utility accounts billed directly to rental property tenants may require reconciliation to accommodate a special bill to property owners; initial number of customers calls/complaints is expected to exceed the calls from the tax mechanism; and, a special utility bill is required to bill owners of undeveloped land.

Conclusion

Many of the components of the Big Valley Groundwater Management Plan can be implemented under the existing funding authorities of the District, Zone 5, Community Development and Environmental Health. Supplemental funding may be required to develop aquifer storage models, safe yield estimates, potential mitigation measures and new groundwater recharge projects. If recommended at a future date, expansion of existing programs may require supplemental funding.

APPENDIX A

FLOOD CONTROL ZONE 5 BUDGET INFORMATION

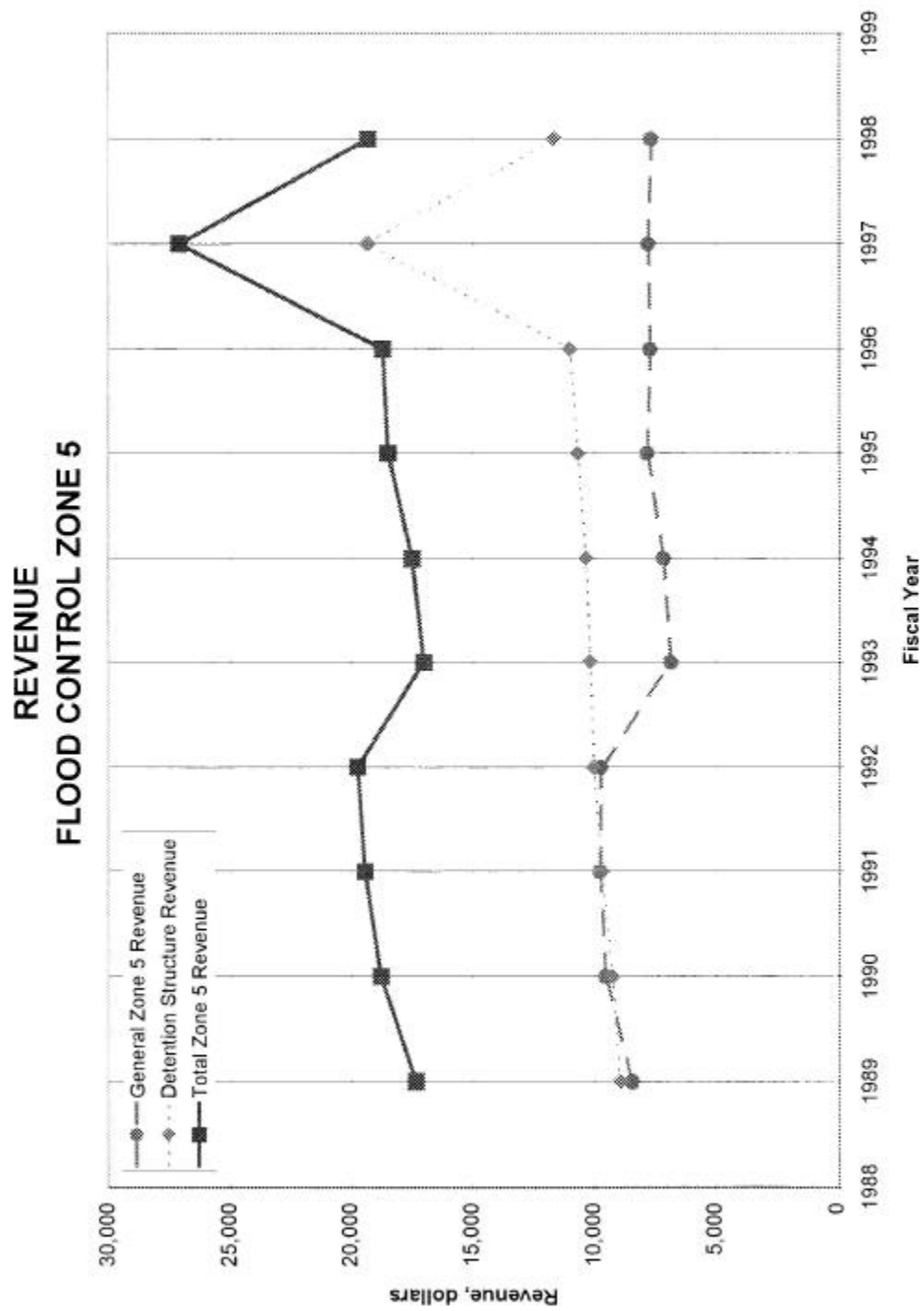
**FLOOD CONTROL ZONE 5
PROJECTIONS OF REVENUE & EXPENDITURES
FY 1988-1989 TO FY 2009-2010**

Fiscal Year	Year	General Reserve 06/30/88	Fund Bal 06/30/88	Revenue		Total Revenue	Expenditures		Total Expenses
				General	Detention Structure		General	Detention Structure	
1987-88	1988	0	64,022		8,923	17,348	0	10,693	10,693
1988-89	1989			8,425		18,789	0	19,075	19,075
1989-90	1990			9,537	9,252	19,446	0	8,946	8,946
1990-91	1991			9,757	9,689	19,743	0	10,085	10,085
1991-92	1992			9,725	10,018	17,030	0	8,877	8,877
1992-93	1993			6,848	10,182	17,506	0	7,455	7,455
1993-94	1994			7,159	10,347	18,488	13,114	25,507	38,621
1994-95	1995			7,813	10,675	18,701	12,771	15,473	28,244
1995-96	1996			7,698	11,003	27,092	2,408	21,176	23,584
1996-97	1997			7,777	19,315	19,315	3,597	4,008	7,605
1997-98	1998			7,655	11,660	19,650	10,000	7,000	17,000
1998-99	1999			7,700	11,950	20,094	4,000	7,140	11,140
1999-2000	2000			7,854	12,240	8,011	4,080	7,283	11,363
2000-01	2001			8,011	0	8,171	4,162	7,428	11,590
2001-02	2002			8,171	0	8,335	4,245	7,577	11,822
2002-03	2003			8,335	0	8,501	4,330	7,729	12,058
2003-04	2004			8,501	0	8,671	4,416	7,883	12,299
2004-05	2005			8,671	0	8,845	4,505	8,041	12,545
2005-06	2006			8,845	0	9,022	4,595	8,202	12,796
2006-07	2007			9,022	0	9,202	4,687	8,366	13,052
2007-08	2008			9,202	0	9,386	4,780	8,533	13,313
2008-09	2009			9,386	0	9,574	4,876	8,704	13,580
2009-10	2010			9,574	0				
TOTALS			0	185,667	135,254	320,921	90,565	225,180	315,744

Projection Assumptions:

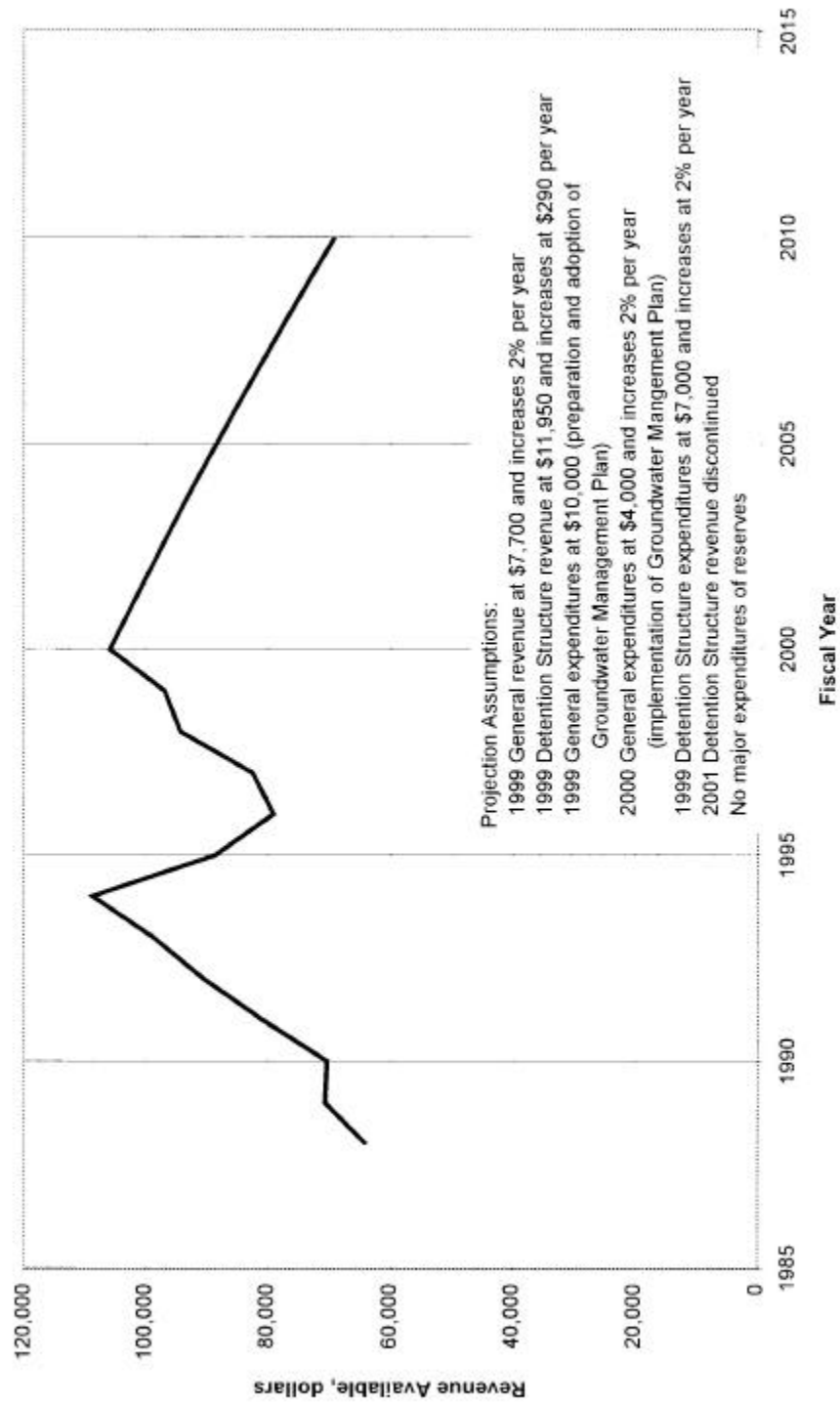
- 1999 General revenue at \$7,700 and increases 2% per year
- 1999 Detention Structure revenue at \$11,950 and increases at \$290 per year
- 1999 General expenditures at \$10,000 (preparation and adoption of Groundwater Management Plan)
- 2000 General expenditures at \$4,000 and increases 2% per year (implementation of Groundwater Management Plan)
- 1999 Detention Structure expenditures at \$7,000 and increases at 2% per year
- 2001 Detention Structure revenue discontinued
- No major expenditures of reserves

e:\08\g-wzone\zone5fb.xls

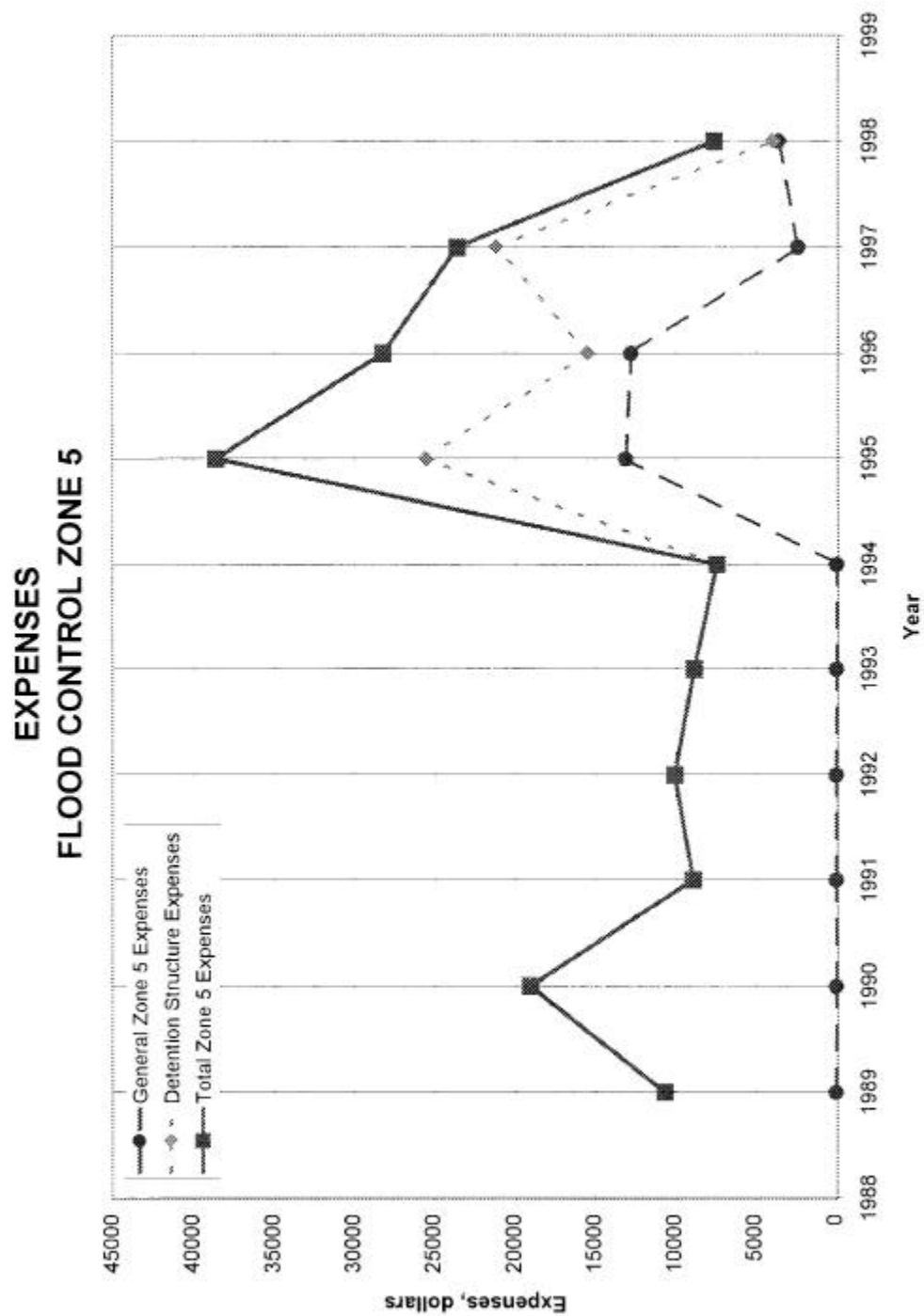


e:\08\g-wzone\zone5fb.xls

REVENUE AVAILABLE FLOOD CONTROL ZONE 5



e:\08g-wzone\zone5fb.xls



e:\08\g-w\zone\zone5fb.xls

BIBLIOGRAPHY

Lake County Planning Department, Resource Management Division, Lake County Aggregate Resource Management Plan, Adopted November 19, 1992

Moore and Taber Northern California Consulting Engineers and Geologists, Creek Management Plans, Fourteen Stream Segments, Lake County, California, Prepared for County of Lake Planning Department, April 1981

Ott Water Engineers Inc., Lake County 1987 Resource Management Plan Update, Report for Lake County Flood Control and Water Conservation District, January 1987

Soil Mechanics and Foundation Engineers Inc., Big Valley Ground-Water Recharge Investigation, Report for Lake County Flood Control and Water Conservation District, March 1967

Tehema County Water Task Force, Report of Groundwater Subcommittee to Tehema County Water Task Force, December 1, 1993