APPENDIX H

WEST CERES SPECIFIC PLAN WATER SUPPLY ASSESSMENT

WATER SUPPLY ASSESSMENT
CITY OF CERES
WEST CERES SPECIFIC PLAN

FEBRUARY 11, 2010

Prepared by

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and
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1.0 Introduction

California Water Code Section 10910 (also known as SB610) requires the preparation of a Water Supply Assessment (WSA) for any project a city or county determines is subject to the California Environmental Quality Act. The West Ceres Specific Plan (the Project) is such an undertaking. Correspondingly, the following is a WSA that addresses water supply sufficiency for the West Ceres Specific Plan.

The West Ceres Specific Plan represents a portion of the overall development of the City of Ceres according to the City of Ceres General Plan. The Project is a mixed development located within the western part of Ceres (Figures 1.1 through 1.3). The Project, which covers approximately 860 acres, is a residential and industrial/commercial development. Residential areas include neighborhood and community parks as well as landscaped walkways, parkways, and paseos. The current land use primarily is for irrigated agricultural production, but also includes a significant amount of industrial/commercial use. The current water source is almost entirely surface water supplied by Turlock Irrigation District. The water demand for the Project will be about 1,800 acre-feet per annum (afa). The Project will be supplied with groundwater pumped by the Ceres Municipal Utilities Department (CMUD), a branch of the City of Ceres government. The Project will involve the construction of several additional wells, which are to be operated and maintained by CMUD. Typical capacity of wells in this area is about 700 gallons per minute (gpm) or 1,129 afa.

The WSA was developed by examining the ability of the CMUD water supply to support not only the Project, but also all projected growth through build-out of the City of Ceres. The population supplied by CMUD is expected to increase from 38,813 in 2005 to 79,000 at build-out according to the City of Ceres Water System Hydraulic Model Update (WSHMU).

Water demand can be calculated based on the population and per capita use or on land-use unit demand. Based on the WSHMU land-use unit demand projection, the water demand on CMUD is projected to increase from 8,180 afa in 2005 to 20,290 afa at build-out. Based on the WSHMU per capita demand projection, the water demand on CMUD is projected to increase from 10,140 afa in 2005 to 21,415 afa at build-out. The WSHMU reports historical use rates that vary from 233 gallons/person/day (gpd) to 252 gpd, depending on the year. The five-year historical average of 242 gpd was used to calculate

annual demand at build-out. The actual pumped volume in 2005 was 10,141 acre-feet. However, the difference in projected demand at build-out is only 5.5 percent, so either method could be safely used. Though the Project demand is based on land use factors, this report uses the per capita demand projection because both historical and projected population data are available while land use factors are not, and the per capita demand method yields a more conservative estimate.

Within and immediately surrounding Ceres are areas supplied with water by entities other than CMUD. Islands of unincorporated areas within Ceres and areas immediately adjacent to Ceres are supplied with water from wells owned by the City of Modesto. The City of Modesto operates five wells in the Ceres area with a combined annual capacity of about 2,700 acre-feet. However, actual use from these wells is estimated to be closer to 1,250 afa. Demand from these wells is not anticipated to change in the future, and the supply from these wells is also presumed to remain steady. Some areas within and near Ceres also receive garden-head deliveries from the Turlock Irrigation District. Garden-head deliveries represent water diverted from a nearby irrigation canal and used for residential gardens and landscaping. These deliveries average 1,950 afa. Water for inside use for these residences is supplied by CMUD. No change is anticipated in garden-head deliveries in the projected time period.

2.0 Demand Analysis

The projected water demand within Ceres as calculated for this report, including demand for the West Ceres Specific Plan, is described below, along with the basis for the projection.

Historically, demand within the City of Ceres has generally increased, yet it also shows some dependency on climate and weather. In 2001, CMUD pumped 9,451 acre-feet; in 2002, 10,067 acre-feet; in 2003, 9,802 acre-feet; in 2004, 10,142 acre-feet; in 2005, 10,140 acre-feet; in 2006, 10,125 acre-feet; in 2007, 10,824 acre-feet; and in 2008, 10,585 acre-feet. Historical average per capita annual use from CMUD wells for the years 2001-2008 (excluding 2005 and 2007-2008 due to incomplete precipitation data) is 229 gpd. Population data from the US Census Bureau for subsequent years are estimates only and so were not used in this calculation.

The potable water demand for the Project at its build-out will be about 1,803 afa, which includes about 1,061 afa for residential and neighborhood landscape irrigation, about 643 afa for industrial/institutional use, and about 99 afa for commercial use. Non-potable groundwater from irrigation wells will be used to supply parks and agriculture within the Project but will be served by reclaimed water as soon as it becomes available. Table 2.1 summarizes the annual water use for each land-use category within the Project. Development of areas such as the Project is included in the City of Ceres General Plan and is consequently incorporated in the projected increases in demand reported in the Water System Hydraulic Model Update. Should the Project immediately build out, the 2010 demand would amount to the 10,585 acre-feet from 2008, the 1,800 acre-feet for the Project, and 200 acre-feet for additional development unrelated to the Project, which represents a total of 12,585 acre-feet or 11.23 millions of gallons per day (mgd). As the Project will likely take several years to fully build out, the 1,800 acre-feet (1.6 mgd) of demand will be incremental and can be included in the demand increases projected for the City as a whole.

The Ceres WSHMU also used varying growth rates among water-use sectors to calculate projected demand and assumed demand would be unchanged by drought conditions. Climatic conditions were not, however, considered except as reflected in averaging historical use in the WSHMU. Even with water conservation measures in place, demand increases during periods of reduced rainfall. As precipitation stops earlier

in a year and begins later in a year, the landscape irrigation season increases in duration. This report applies an average per capita water use for normal years and an alternate average per capita water use for dry years to calculate normal year versus drought year demand. Average precipitation at the Western Regional Climate Center station in Turlock was calculated for the period 1972-2008 and determined to be 12.41 inches/year. Precipitation data for the years 2005 and 2007-2008 were missing several months of data and so were not used when calculating average annual precipitation. Reduced precipitation conditions were assumed to occur during any year in which precipitation was less than 66 percent of average. Normal conditions were assumed to occur during any year in which precipitation was between 66 percent and 133 percent of average.

The historical demand has been higher in dry years than during normal years as shown on Table 2.2. During the historical period 1980-2008, normal conditions occurred during 1980-1981, 1986-1988, 1990-1994, 1997, 2000-2002, 2004, and 2006. Per capita demand for each of those years was averaged together and determined to be 230 gpd. During the historical period 1980-2008, low-precipitation conditions occurred during 1984-1985, 1989, 1999, and 2003. Per capita demand for each of those years was averaged together and determined to be 240 gpd, an increase of 4 percent. As shown in Figure 2.1, per capita demand, while fluctuating according to climate, shows no significant trend upward or downward over time. In the interest of being conservative, this report uses per capita rates of 242 gpd for normal year calculations and 249 gpd for dry year calculations.

Applying the 4 percent increase to the projected normal-year water use yields the projected annual demand during periods of low precipitation. The projected annual demand assuming low precipitation is, therefore, 13,088 afa in 2010, assuming immediate completion of the Project and other unrelated growth in Ceres, and 22,326 afa at build-out. Projected annual demand, considering both normal and low precipitation years, is included in Table 2.3.

The City of Ceres is installing water meters at every residence in 2010. City staff expects a fifteen to twenty percent reduction in per capita use once the meters are installed and metered rates become effective January 1, 2011. The projected per capita use in this report is, therefore, conservative.

3.0 Supply Analysis

The CMUD water supply is currently obtained entirely from groundwater pumping from the underlying Turlock groundwater basin. The Turlock groundwater basin has not been adjudicated, is not currently in overdraft, and is not otherwise regulated with respect to groundwater use. Ceres, as a municipality overlying the groundwater basin, has the right to pump groundwater for reasonable use. To the extent that groundwater is available, Ceres can pump groundwater for residential, commercial, and public uses. As described below in the Groundwater Analysis section, groundwater is available to satisfy the water-supply demands within Ceres, including demand for the Project, provided water quality concerns are met with treatment. Global climate change has been extremely gradual over the last 100 years, and any impending effects of this change are not likely to affect basin-wide storage and capacity in the next 20 years.

The City of Ceres owns, operates, and maintains a public water-supply system as CMUD. The system currently utilizes fourteen CMUD-owned wells, which cumulatively have a capacity of 10,487 gpm, or approximately 16,914 afa assuming the largest well (with a capacity of 1,528 gpm) is out of service. One additional well (Well 19R) has been constructed but not yet placed on line; that well has capacity of 1,150 gpm or 1,855 afa. The 2008 water-supply demand from CMUD wells was 10,585 afa. The anticipated 2010 demand, with the Project and some additional unrelated development within the City of Ceres, will be about 12,585 afa. The Project will involve the construction of several additional wells, which are to be operated and maintained by CMUD. The wells are expected to have a pumping capacity of about 700 gpm or 1,129 afa.

The UWMP assumed that groundwater supply would be affected by drought conditions. Historically, municipal groundwater supply has not, however, been affected since the drought of 1976-1977. The 1976-1977 drought had wide-ranging effects on many users within the groundwater basin because Don Pedro Reservoir was not operated in such a way as to supply farmers within the basin with sufficient surface water during such a severe drought. Consequently, Turlock Irrigation District pumped large amounts of groundwater leading to a drop in groundwater levels of approximately 35 feet in the central portion of the basin. Areas near the rivers bounding the basin experienced groundwater level declines, but nowhere near the magnitude of those in the central portion of the basin. The hydraulic connectivity of the groundwater basin to the rivers bounding it meant the basin could be recharged quickly from the rivers, reducing

groundwater level declines. Since Don Pedro is now operated so as to maintain a surface-water supply even during severe drought, groundwater level declines such as those seen in 1976-1977 will not likely recur. During the drought of 1987-1992, water levels did not decline sufficiently for any reduction in supply to occur. Consequently, even 5-year droughts do not lead to any reduction in groundwater supply (Durbin, 2008).

The droughts of 1976-1977 and 1987-1992 were the result of low snowfall in the foothills and mountains bounding the eastern edge of the basin. The runoff from this snowfall provides surface-water for many users within the basin, and reductions in snowfall-runoff led to drought conditions for those users. The City of Ceres, and other entities dependent entirely on groundwater, experienced no such reduction in supply. Demand in all areas is dependent on local precipitation, not snowfall. Consequently, areas dependent on groundwater will not experience the same drought periods as areas dependent on surface-water (Durbin, 2008).

The annual supply available from CMUD wells is adequate for projected future development, including the Project, through 2018. When Well 19R is included in the calculations, water supply is adequate through 2023. When two proposed wells for the Project are included in supply calculations, the annual supply remains sufficient through 2028. However, CMUD has indicated there have been instances when peak instantaneous demand was greater than well capacity. This occurred in 2003, a dry year, when peak demand approached 16,000 gpm (Steve Wilson, written communication, August 2005). With nine operational wells and a total well pumping capacity of 12,000 gpm, demand exceeded well-pumping supply. In that instance CMUD had to rely on the one reservoir it operated at that time, which stores up to 1.5 million gallons, or 4.6 acre-feet, to meet the increased demand. With a pumping capacity of 4,000 gpm from the reservoir, the total District pumping capacity was 16,000 gpm, thereby meeting demand. This emergency use of storage was required because CMUD's source capacity was inadequate to meet maximum day demand. Storage should only be used to meet peak hour and fire flow demands. CMUD has also constructed another reservoir which has a pumping capacity of approximately 6,000 gpm (Steve Wilson, oral communication, January 2006). Current well pumping capacity is about 12,015 gpm. Assuming the largest well is out of service, the other thirteen wells currently in operation have a combined pumping capacity of 10,487 gpm. Another well has been drilled (Well 19R) but not yet brought on line which has a pumping capacity of 1,150 gpm. When that well is added into the system, the total combined pumping capacity for Ceres will be 13,165 gpm, 11,637 gpm with the largest well out of service. When pumping capacities from the two

reservoirs are added, available total peak-demand pumping capacity is about 23,165 gpm with all wells on line or about 21,637 gpm with the largest well out of service.

4.0 Groundwater Analysis

The Turlock groundwater basin is located within Stanislaus and Merced Counties, California (Figure 1.1), and covers about 540 square miles. The basin is bordered by the Tuolumne River on the north, the San Joaquin River on the west, the Merced River on the south, and the Sierra Nevada foothills on the east. The communities of Ceres, Modesto (the portion south of the Tuolumne River), Delhi, Denair, Hickman, Hilmar, Hughson, Keyes, and Turlock are located within the Turlock groundwater basin. Turlock Irrigation District, Merced Irrigation District, Ballico-Cortez Water District, and Eastside Water District also are located within the basin.

4.1 Geology of the Turlock Groundwater Basin

The Turlock groundwater basin represents a subbasin of the San Joaquin Valley groundwater basin, a northward trending trough filled with marine and continental sediments of Cretaceous age (140 million years ago) through Quaternary age (through today) that are as much as 16,000 feet in thickness within the western part of the Turlock basin (California Division of Mines and Geology, 1966). The Turlock groundwater basin occurs within marine deposits of Eocene age (55 to 30 million years ago) and continental deposits of Miocene age (beginning 30 million year ago) to Holocene age (through today). The continental sediments were deposited as westward-dipping units principally by the Tuolumne and Merced rivers, and their ancestral equivalents (Figure 4.1).

The base unit of the groundwater system is the Ione Formation. The Valley Springs and Mehrten formations overlie the Ione Formation. Three units that represent separate alluvial-fan episodes in turn overlie the Mehrten Formation. Those units are the Turlock Lake, Riverbank, and Modesto formations. Both the Modesto and Turlock Lake formations contain lake and flood-plain deposits. Where those fine-grained deposits occur within the Turlock Lake Formation, they are referred to as the Corcoran Clay. Where those deposits occur in the Modesto Formation, they are referred to as the shallow aquitard. Figures 4.2 and 4.3a-b show the generalized extent, thickness, and stratigraphic position for the hydrogeologic units comprising the groundwater system, including the Corcoran Clay and shallow aquitard.

The Modesto Formation, which is of late Pleistocene age (about 1 million years ago to today), outcrops in the western one-third of the study area (Figures 4.2 and 4.3a-b)

and is as much as 120 feet in thickness. The formation consists of gravel, sand, and silts with rapid coarseness changes, which yields moderate to large quantities of water to wells. The shallow aquitard member of the Modesto Formation occurs only within the western part of that formation (Figure 4.2), and does not crop out at the land surface (Figure 4.3a). The unit is comprised of silt and clay with some sand. The shallow aquitard is encountered 30 to 50 feet below the land surface, and is as much as 15 feet in thickness.

The Riverbank Formation, which is of middle Pleistocene age (about 1.5 million to 1 million years ago), underlies the extent of the Modesto Formation and crops out in the central portion of the Turlock groundwater basin (Figures 4.2 and 4.3a-b). The thickness of the unit increases westward, but the thickness generally is less than 200 feet. The formation consists primarily of sand with scattered gravel and silt lenses, and yields moderate to large quantities of water to wells. The unit tends to coarsen upward (Marchand and Allwardt, 1981).

The Turlock Lake Formation, which is of early Pleistocene and late Pliocene age (2.5 million to 1.5 million years ago), underlies the Riverbank Formation and crops out in the eastern part of the Turlock groundwater basin (Figures 4.2 and 4.3a-b). The thickness of the unit increases westward, but the thickness generally is less than 600 feet. The formation consists of mostly fine sand and silt (Marchand and Allwardt, 1981), and yields moderate to large quantities of water to wells. The Corcoran Clay member of the Turlock Lake Formation (Figures 4.2 and 4.3a-b) ranges in thickness from 10 to 80 feet. The Corcoran Clay lies in the upper part of the Turlock Lake Formation. The unit does not crop out, and occurs only within the western portion of the Turlock groundwater basin.

The Mehrten Formation, which is of Miocene to late Pliocene age (5 million to 2.5 million years ago), underlies the Turlock Lake Formation and crops out on the eastern edge of the Turlock groundwater basin (Figures 4.2 and 4.3a-b). The thickness of the unit increases westward, but the thickness generally is less than 800 feet. The formation consists of claystone, siltstone, sandstone, and conglomerate, yields small to moderate quantities of water to wells, and is saline within the western and central parts of the Turlock groundwater basin.

The Valley Springs Formation, which is of Miocene age (30 million to 5 million years ago), underlies the Mehrten Formation and crops out on the eastern edge of the

Turlock groundwater basin (Figures 4.2 and 4.3a-b). The thickness of the unit increases westward, but the thickness generally is less than 500 feet (Page and Balding, 1973). The formation consists of siltstone and claystone deposited mostly by rivers with occasional ash deposits and yields small quantities of water to wells due to the fine ash and clay matrix (Page, 1986).

The Ione Formation, which is of late Eocene age (40 million to 30 million years ago), underlies the Valley Springs Formation and crops out on the eastern edge of the Turlock groundwater basin (Figures 4.2 and 4.3a-b). The thickness of the unit increases westward, but the thickness generally is less than 200 feet (Page and Balding, 1973). The formation consists of clay, sand, sandstone, and conglomerate, yields only small quantities of water to wells, and is saline throughout much of the Turlock groundwater basin (Page, 1986).

4.2 Groundwater Budgets for the Turlock Groundwater Basin

4.2.1 Historical Budget

Groundwater budgets for the Turlock groundwater basin are listed in Table 4.1 (Timothy J. Durbin, Inc., 2008) for successive 5-year periods during 1978-2002. Data compilation ended in 2002, therefore no compiled data were available for the years 2003-2005. Though the report was published in 2008, the scope of work only included studying the years 1952-2005 and making predictions for 2006 and 2025. The water budget for each 5-year period is an accounting of the inflows, outflows, and storage changes for the groundwater basin. The inflows to the groundwater basin include (1) recharge from landscape irrigation and precipitation in urban areas, (2) recharge from crop irrigation and precipitation in agricultural areas, (3) recharge from Turlock Lake and the Merced, Tuolumne, and San Joaquin rivers, and (4) groundwater underflows from the Sierra Nevada foothills and deep geologic formations. The outflows from the groundwater basin include (1) pumping for municipal supply, (2) pumping for agricultural supply and drainage, and (3) groundwater discharges to the Merced, Tuolumne, and San Joaquin rivers. Increases in pumping within the basin actually induce increased recharge from the rivers bounding the basin. For the period 1993-2002, the average groundwater inflow is about 529,000 afa, and the average outflow is about 522,000 afa. Accordingly, the groundwater outflow was about balanced by the inflow. As changes to basin-wide groundwater storage are minor in comparison to the overall

water budget, changes to the groundwater budget are expected to be quite small for 2003-2005.

4.2.2 Projected Future Budgets

The projected groundwater budget for 2025 for the Turlock groundwater basin is listed in Table 4.2. This is the water budget representing the cumulative development of all communities within the Turlock groundwater basin. For comparison, Table 4.2 also lists the water budget for 2006.

The groundwater budgets for both 2006 and 2025 represent steady-state conditions. While the cumulative urban development of all communities within the basin will cause continual changes in the groundwater budget, due to increased urban pumping and decreased irrigated agricultural acreage, the groundwater basin will tend always to be in a near steady-state. Correspondingly, the steady-state budget for 2006 and 2025 are close approximations of the actual budget for the assumed conditions. These budgets were obtained by projecting future groundwater inflows and outflows based on historical growth patterns. Agricultural drainage pumping and subsurface drainage were combined and assumed to remain unchanged in the future. Likewise, groundwater consumption by phreatophytes (flora which draws it water directly from groundwater) was assumed to remain unchanged in 2025. Agricultural pumping for irrigation in the Ballico-Cortez Water District, Merced Irrigation District, and Eastside Water District remained the same and was combined with agricultural pumping within the Turlock Irrigation District. Agricultural pumping and surface water delivery within the Turlock Irrigation District (TID) were scaled back proportionally as irrigated acreage decreased.

Agricultural discharge from the basin is projected to decrease from 298,000 afa to 289,000 afa, as shown in Table 4.2. Urban pumping was increased in proportion to the increase in urban acreage of the communities within TID, changing from 46,000 afa in 2005 to 62,000 afa in 2025. Similarly, in proportion to their growth in size, recharge from urban areas was increased from 5,000 afa in 2005 to 7,000 afa in 2025, and recharge from agriculture within the irrigation districts was reduced from 422,000 afa in 2005 to 410,000 afa in 2025, incorporating the loss of farmed acres in TID. Again, recharge within the Merced Irrigation District, Eastside Water District, and Ballico-Cortez Water District remained unchanged. As groundwater pumping increases and recharge to the basin decreases, groundwater discharge to the rivers decreases, maintaining a steady-state condition.

4.3 Trends in Groundwater Levels

4.3.1 Historical Levels

Historical groundwater levels documented in the report "Turlock Groundwater Basin Water Budget" (Timothy J. Durbin, Inc., 2003) show a slight decline. Within most of the Turlock Irrigation District that downward trend is quite small, with groundwater levels declining less than 10 feet since 1960. However, within the central portion of the basin, groundwater levels have declined as much as 90 feet since 1960, mostly between 1970 and 1990. However, the current rate of decline is very small and is approaching balance, because the cone of depression caused by the pumping in the central portion of the basin has reached the rivers, inducing recharge into the basin.

This current trend in groundwater levels suggests the Turlock groundwater basin is in a quasi-equilibrium state. While groundwater levels fluctuate seasonally and inter-annually, groundwater levels display no long-term change. Groundwater elevations in intermediate-depth monitoring wells in the vicinity of Ceres were approximately 60 feet in December of 1960, 55 feet in November of 1977 reflecting the 1976-1977 drought, 60 feet in November of 1986 reflecting quick recovery after a prolonged drought, and 60 feet in November of 1998 as shown in Figures 4.5a-d. This means the average discharge from the groundwater basin is roughly in balance with the average recharge to the basin. The groundwater discharges include pumping and groundwater discharge to the Tuolumne, Merced, and San Joaquin rivers. The groundwater recharges include the deep percolation of rainfall and irrigation water, seepage from rivers and Turlock Lake, underflow from the Sierra Nevada foothills, and upward flow from the formations that underlie the Mehrten Formation. The average total discharge during the period of 1978 to 2002 was about 553,000 afa, and the average total recharge was about 537,000 afa, showing a net decrease in storage. However, the average total discharge during the period of 1993 to 2002 was approximately 522,000 afa, and the average total recharge was about 529,000 afa. This suggests the basin is reaching equilibrium.

The locations of intermediate-depth monitoring wells used to measure groundwater levels are shown on Figure 4.4. The measured groundwater levels within the Turlock Lake Formation from 1960 to 1998 are shown on Figures 4.5a-d. The groundwater-elevation contours indicate groundwater elevations range from more than 100 feet above sea level at the central portion of the basin to less than 40 feet at the

western boundary. As a general hydrologic principle, groundwater flows perpendicular to groundwater-elevation contours, and it flows from areas of higher elevation toward areas of lower elevation. Based on those principles, the groundwater-elevation contours on Figures 4.5a-d indicate the general direction of groundwater flow is southwesterly toward the Merced and San Joaquin rivers and northwesterly toward the Tuolumne and San Joaquin rivers. However, in the central portion of the basin there exists a depression in the aquifer caused by increased agricultural pumping.

Figures 4.6a-d show the groundwater levels measured over time in selected monitoring wells. The locations of the selected wells are displayed on Figure 4.4. These hydrographs indicate the groundwater levels within the Turlock groundwater basin fluctuate seasonally and inter-annually. Furthermore, the water levels in some wells display a slight long-term trend of decreasing groundwater levels. However, when considering the entire Turlock groundwater basin, groundwater elevations remain steady since about 1988 though lower than historic highs. Unless all pumping is stopped in the central portion of the basin, groundwater elevations will never recover to historic highs.

As new groundwater pumping is imposed on the groundwater basin, the steady-state condition will be disturbed. However, within a few years or decades, a new steady-state condition will be established. The new steady-state condition will be characterized by lower groundwater levels and increased net recharge to the groundwater basin. In the same way, new pumping tends to be balanced by new recharge. When considering the cumulative development of all communities within the Turlock groundwater basin, the net discharge and corresponding recharge will decrease from 509,000 afa to 499,000 afa (Table 4.2). This represents just a 2-percent change in the groundwater budgets, which means the change in the budget is very small compared with the overall water budget for the Turlock groundwater basin.

4.3.2 Future Levels

As shown on Table 4.2, with all communities in the Turlock groundwater basin growing at their current rates, changes to the groundwater budget are quite minor, only about 2 percent of the discharge/recharge relationship basin-wide. Consequently, changes in groundwater levels will be negligible. Groundwater-level changes likely will be on the order of a few feet or less, and will have no significant impact on the groundwater users within the Turlock groundwater basin. Properly designed domestic wells are engineered to function despite variations in groundwater levels of several feet.

Municipal and district wells have even more tolerance for groundwater variation than domestic wells do because they are deeper and have longer screened intervals. As the Project represents only a minute amount of the total water budget within the basin, the development of the Project will have no significant impact on groundwater levels within the basin.

5.0 Water Supply Sufficiency

Water supply is sufficient for all projected development of Ceres through 2018 with existing on-line wells and through 2023 with Well 19R on-line. With three Project wells, supply will be adequate through 2033 assuming average precipitation. Much of the anticipated demand will be met by other additional wells. There is sufficient groundwater in the basin, provided water quality is maintained through treatment, to maintain supply during future drought conditions. The sufficiency of a groundwater supply is judged by whether groundwater can be pumped for an extended period without adverse impacts on other groundwater users. The groundwater analysis described in Section 4 indicates the groundwater supply is sufficient for future development of Ceres, including the Project. The projected pumping by Ceres will not impact other groundwater users. However, additional sources of water (such as the Project's proposed wells) must be obtained in order to maintain adequate supply for future projected demand beyond 2023. These operational considerations will be addressed in the City's Water Master Plan, which is currently being prepared.

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Williamson, A. K., Prudic, D. E., and Swain, L. A., 1985, Ground-water flow in the Central Valley, California: U.S. Geological Survey Open File Report 85-345, 203 p.

7.0 Qualifications

Timothy Durbin

Timothy J. Durbin, Inc., Fair Oaks, California, Principal. Directs projects relating to groundwater and surface-water hydrology. Areas of expertise include design of multidisciplinary investigations, design of large-scale programs for the collection and interpretation of hydrologic data, and application of mathematical modeling to the analysis of problems in groundwater and surface-water hydrology. Has continuously worked in the study of the Turlock groundwater basin for the past 20 years.

Education	Master of Science in Civil Engineering, 1971 Stanford University, Stanford, California
	Bachelor of Science in Civil Engineering, 1967 Stanford University, Stanford, California
Licenses	Civil Engineer California Civil Engineer Oregon

Figure 1.1 Geographic Location of Turlock Groundwater Basin

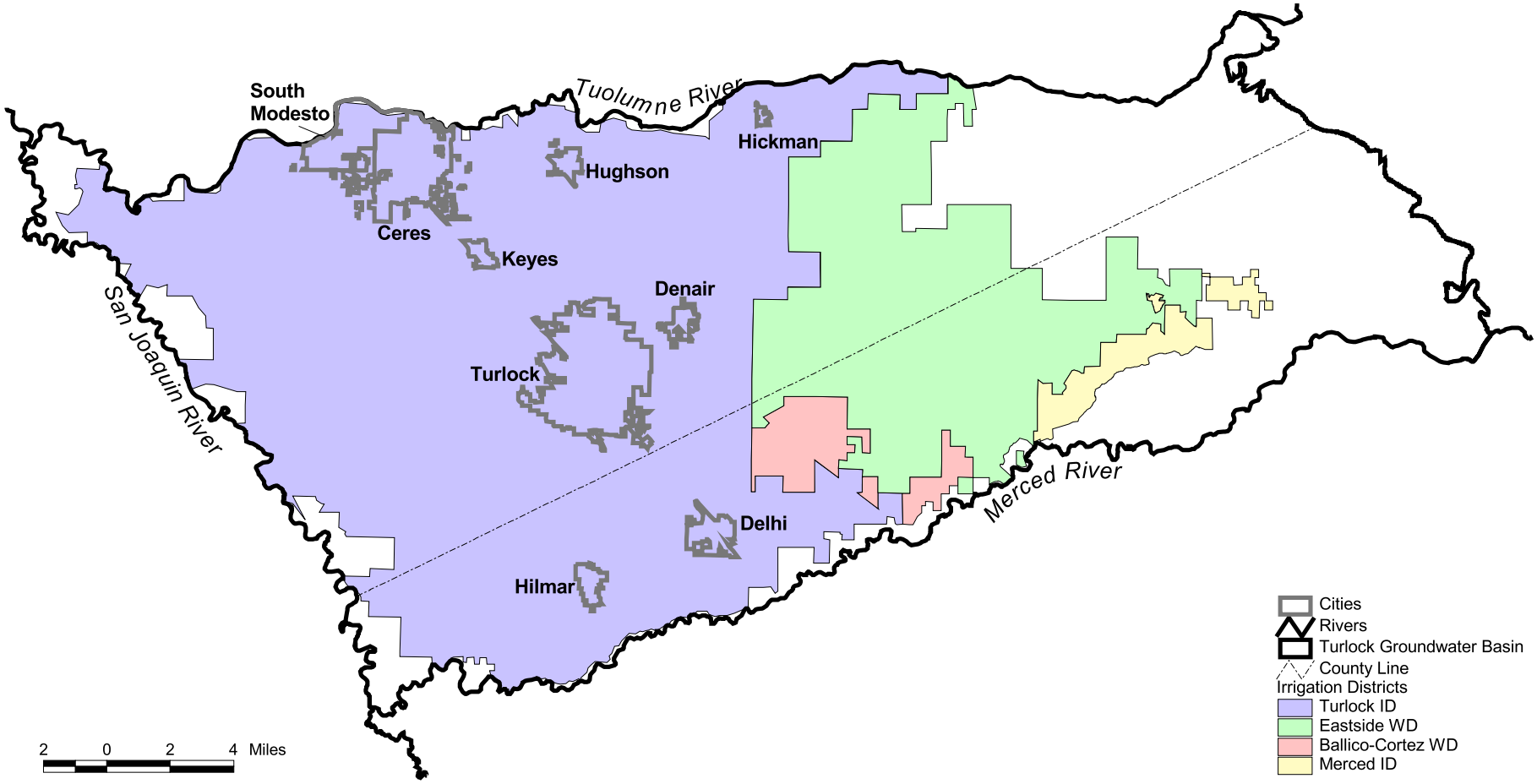
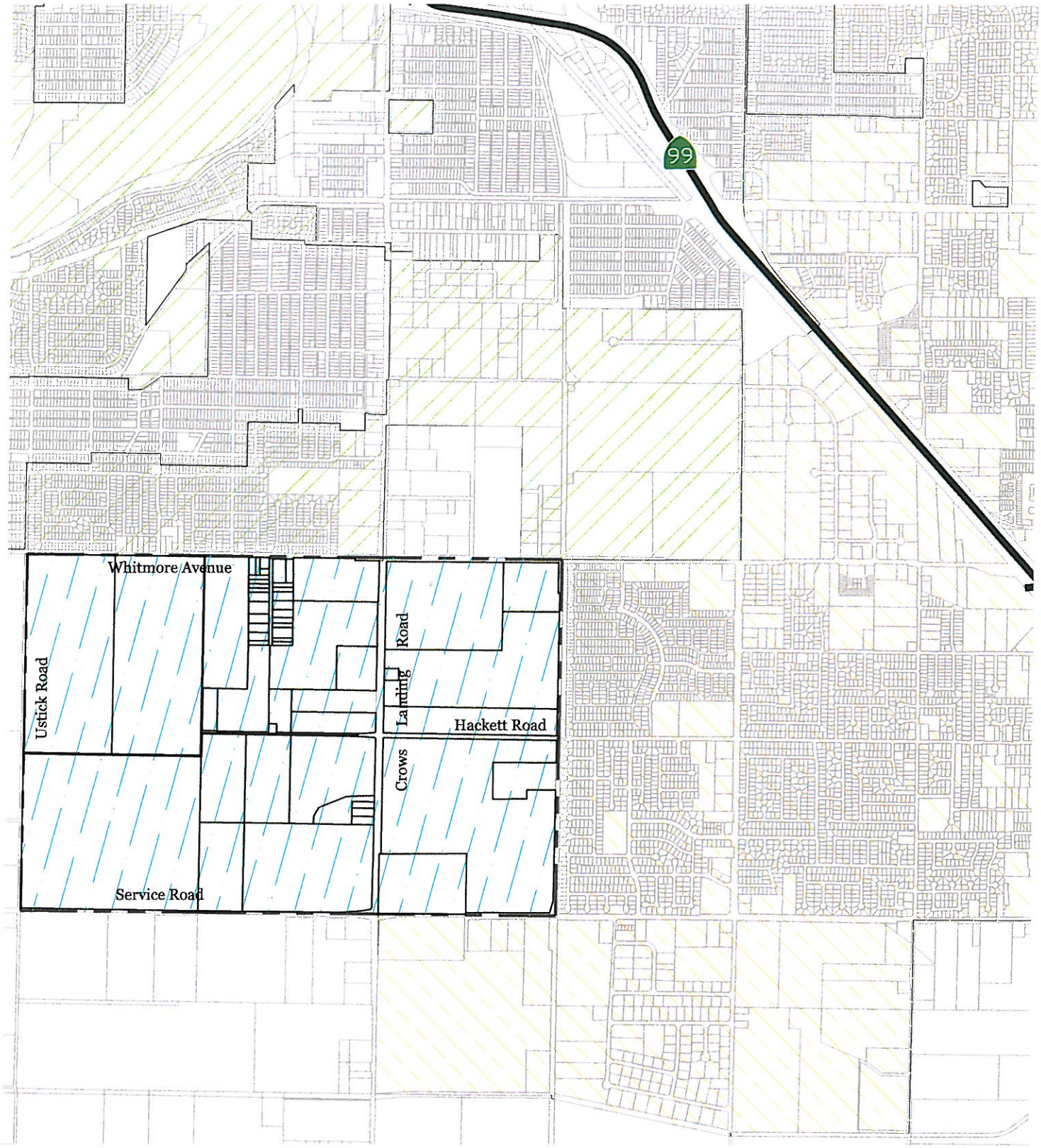


Figure 1.2 Urban Areas, and Irrigation Districts within Turlock Groundwater Basin



Legend

City of Modesto

City of Ceres

Project Boundary

NORTH

SCALE: 1" = 2,000'

Figure 1.3 Project Location Map

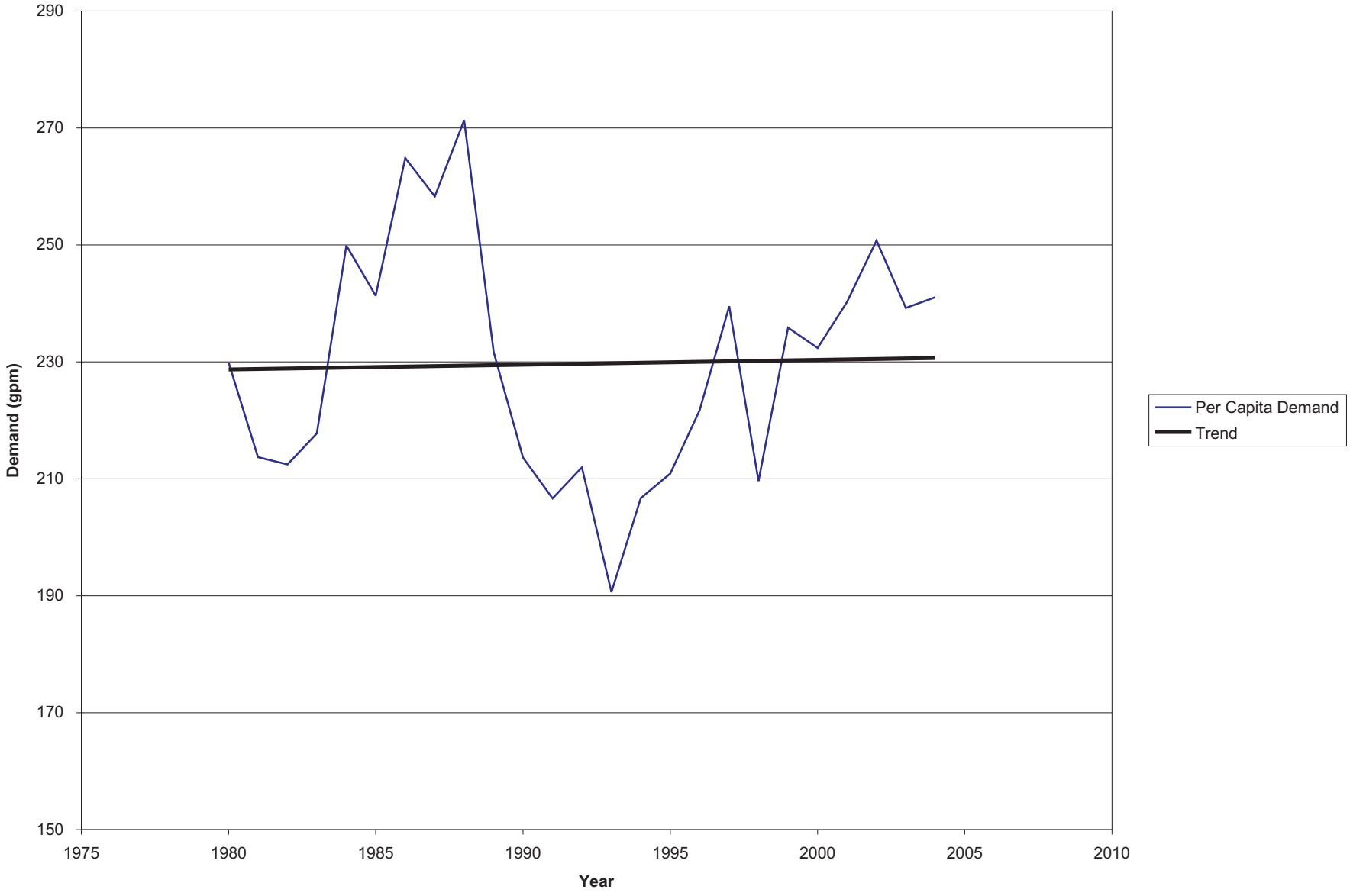


Figure 2.1 Change in Per Capita Demand in the City of Ceres Over Time

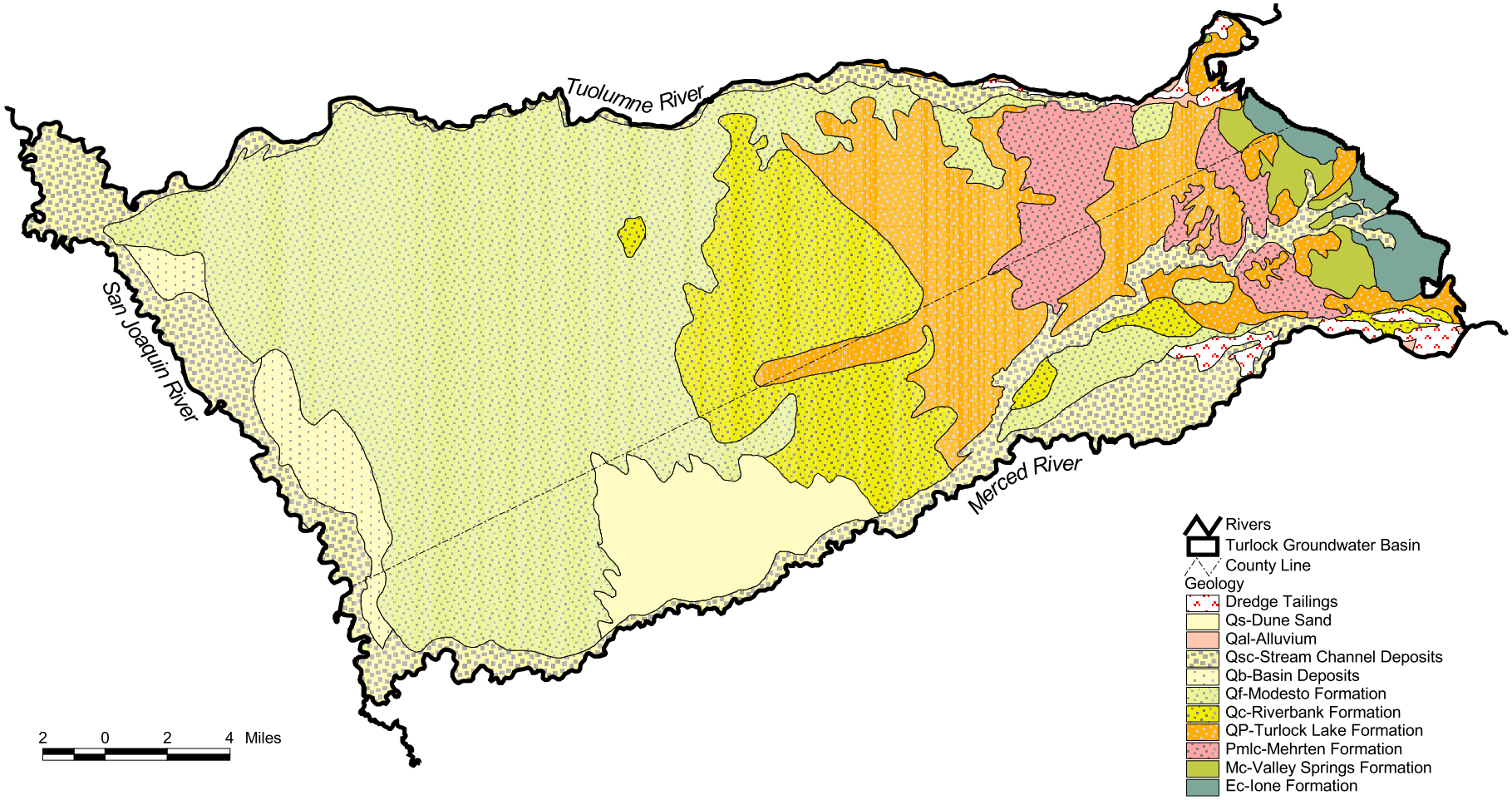


Figure 4.1 Geology of the Turlock Groundwater Basin

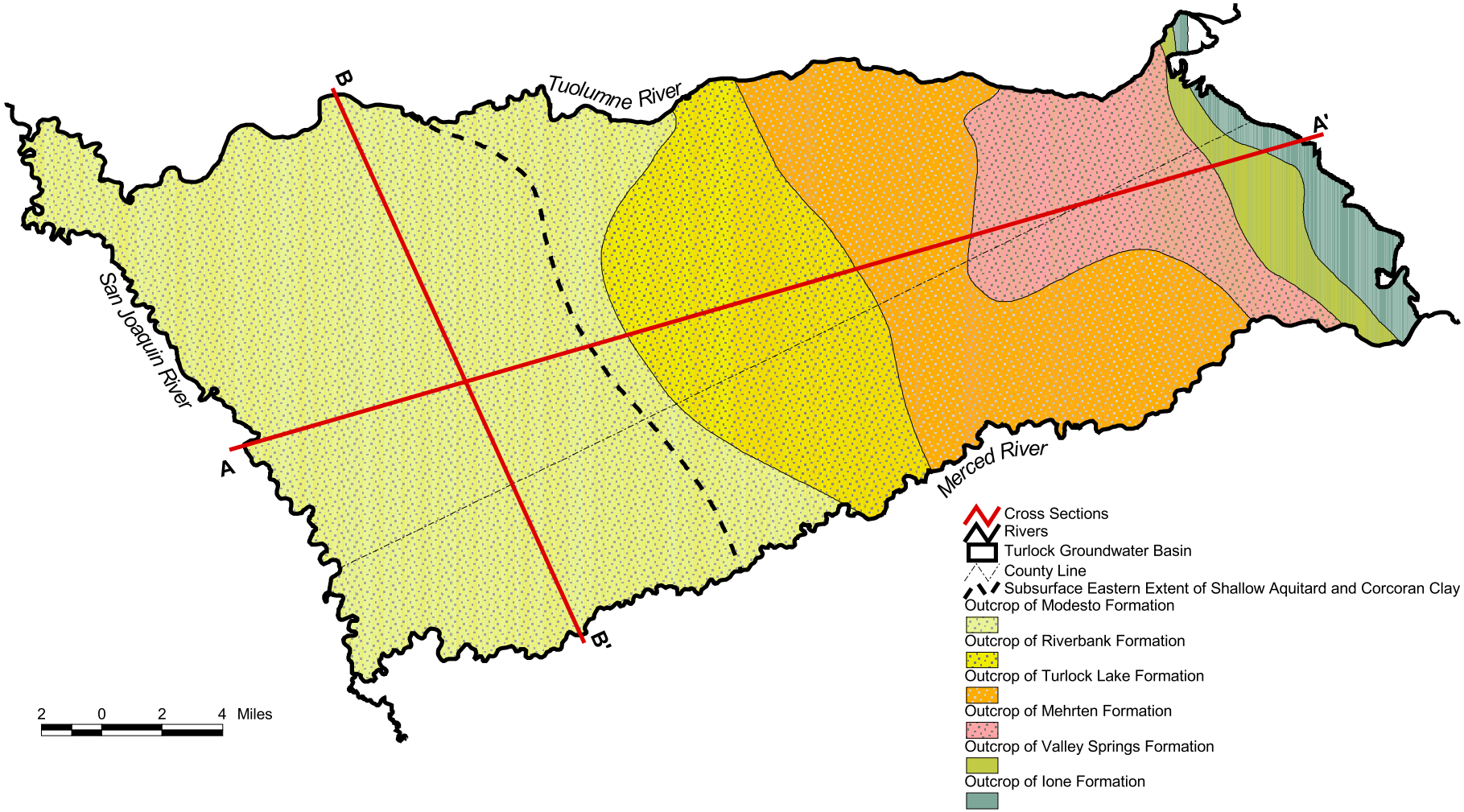


Figure 4.2 Hydrogeologic Units Represented within the Groundwater Model

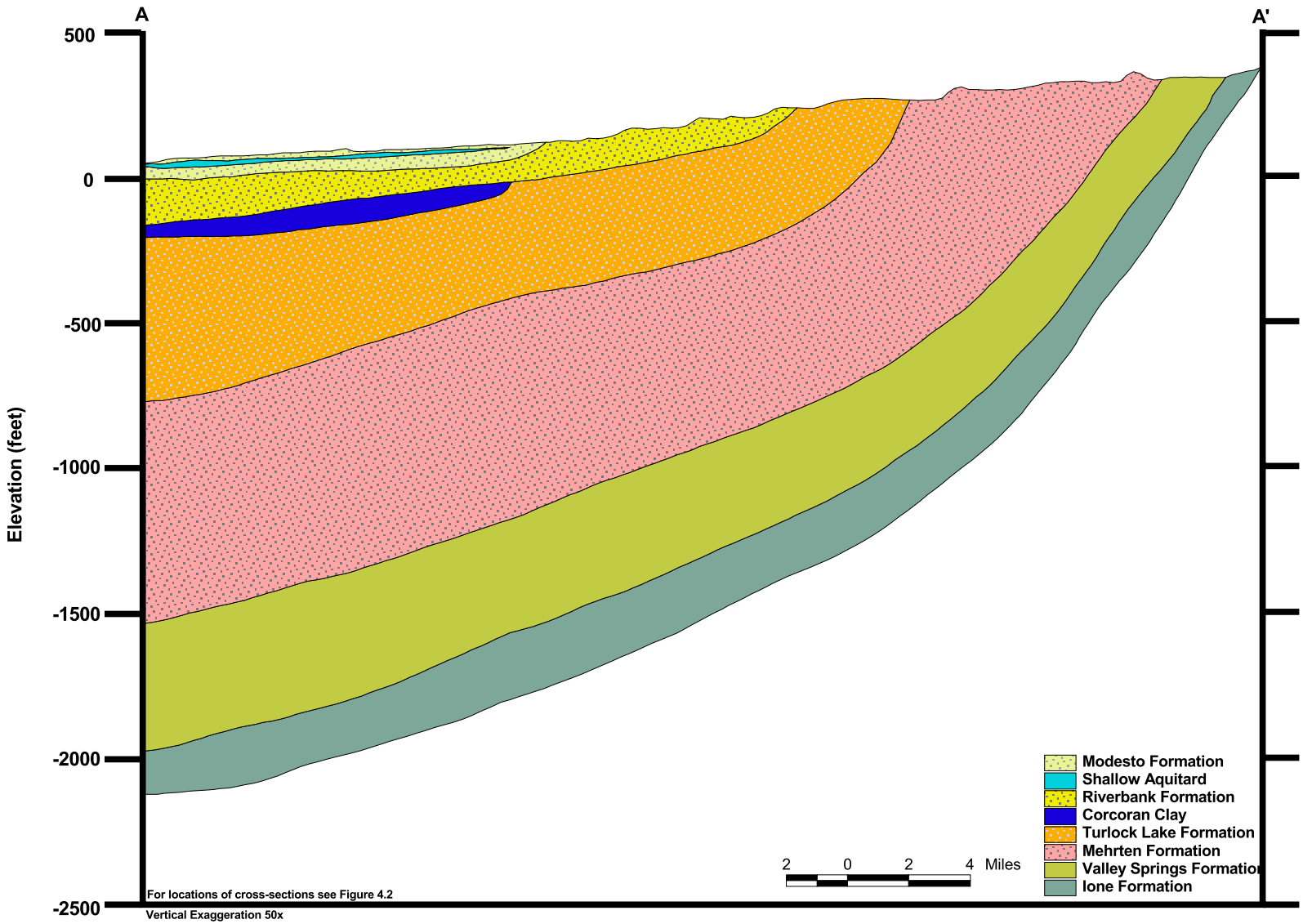


Figure 4.3a East-West Cross-Section Showing Hydrogeologic Units within the Groundwater Basin

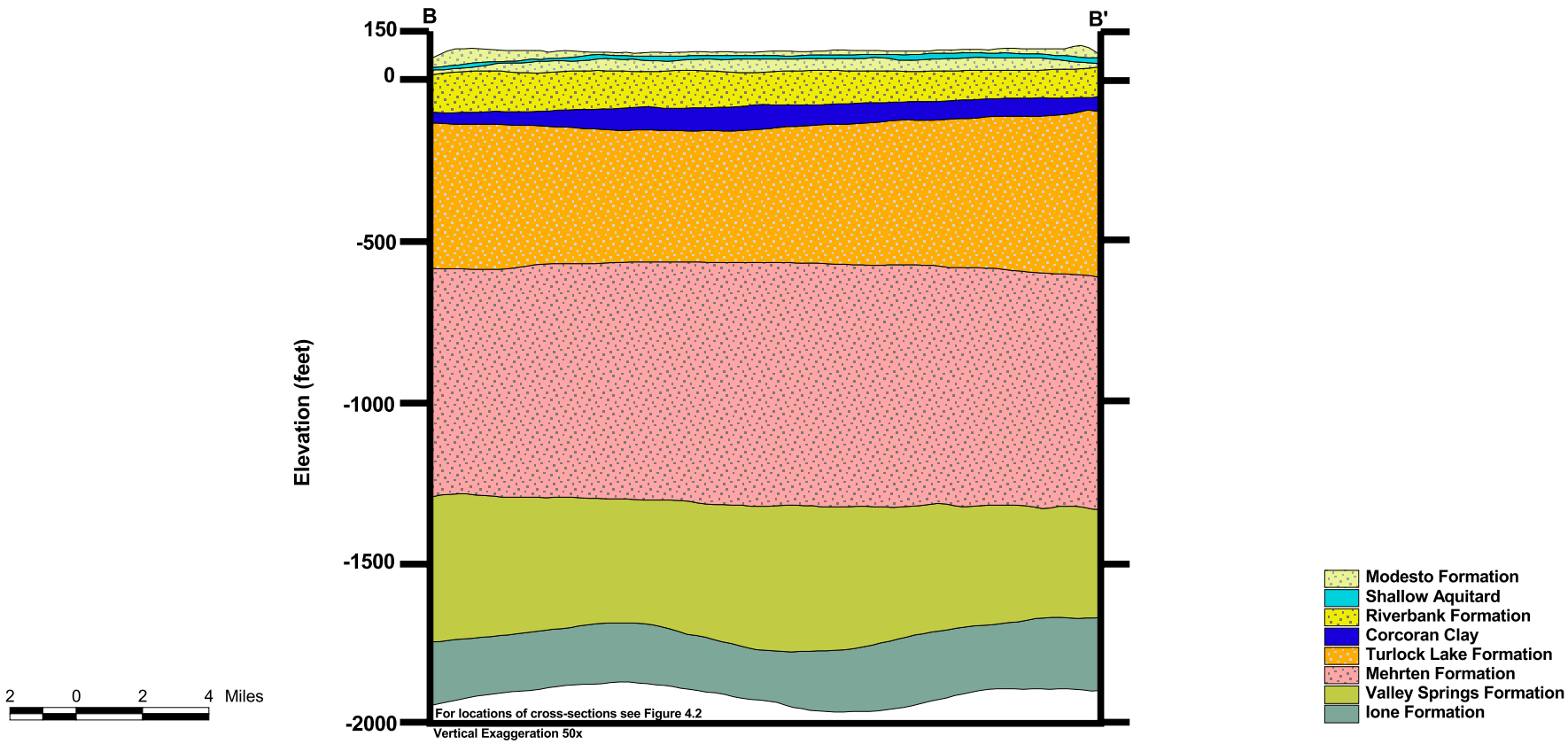


Figure 4.3b North-South Cross-Section Showing Hydrogeologic Units within the Groundwater Basin

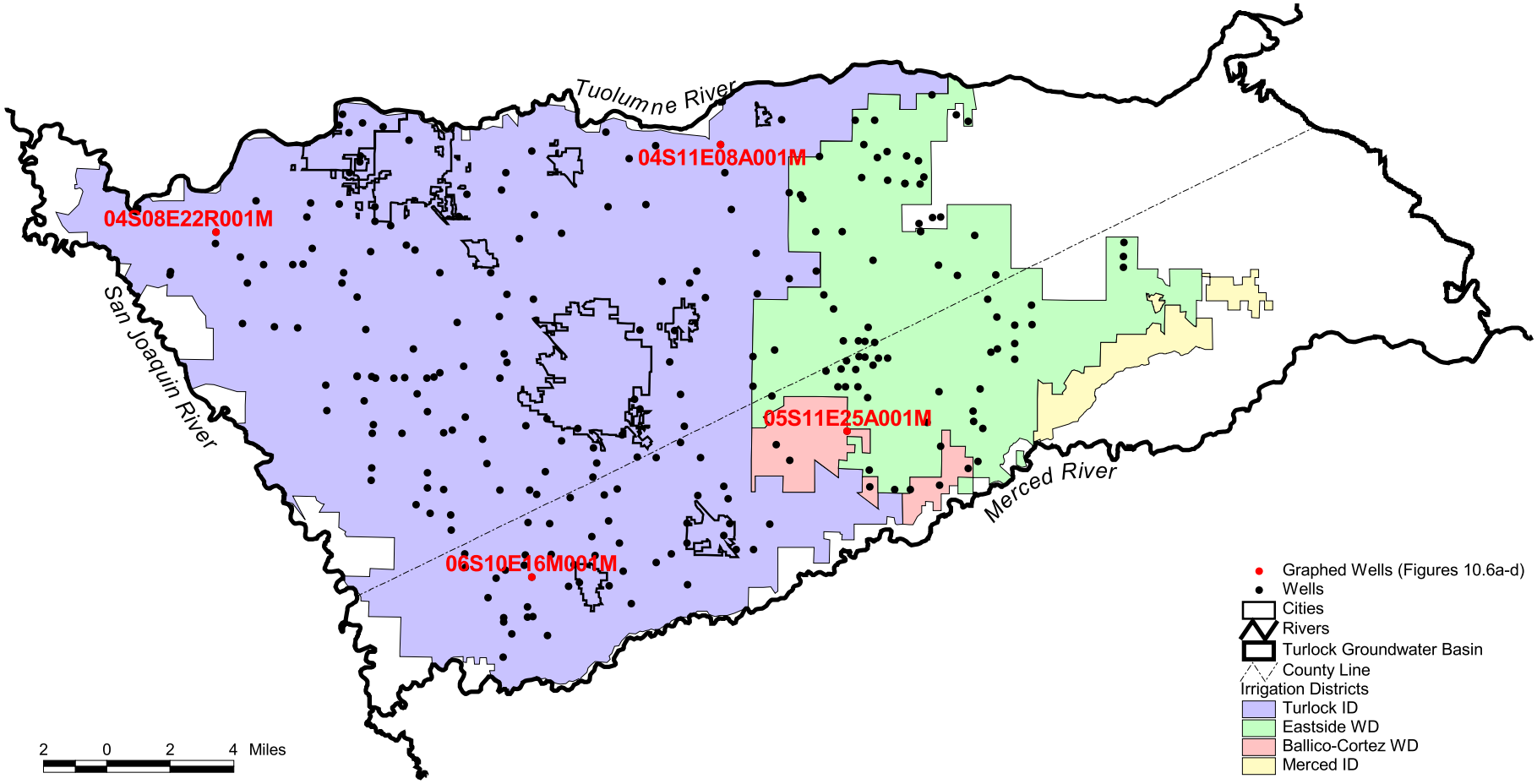


Figure 4.4 Locations of Intermediate-Depth Monitoring Wells

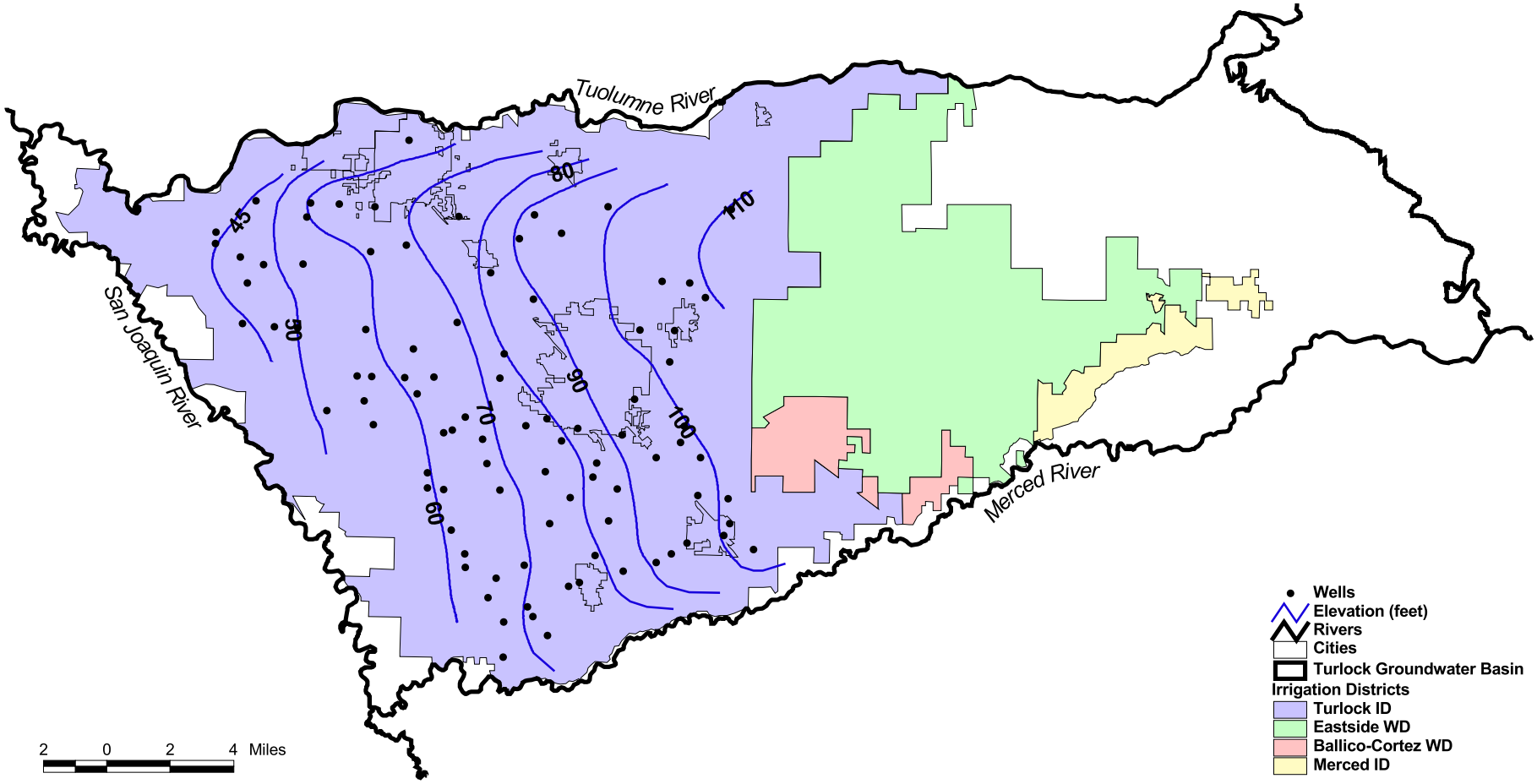


Figure 4.5a Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, December 1960

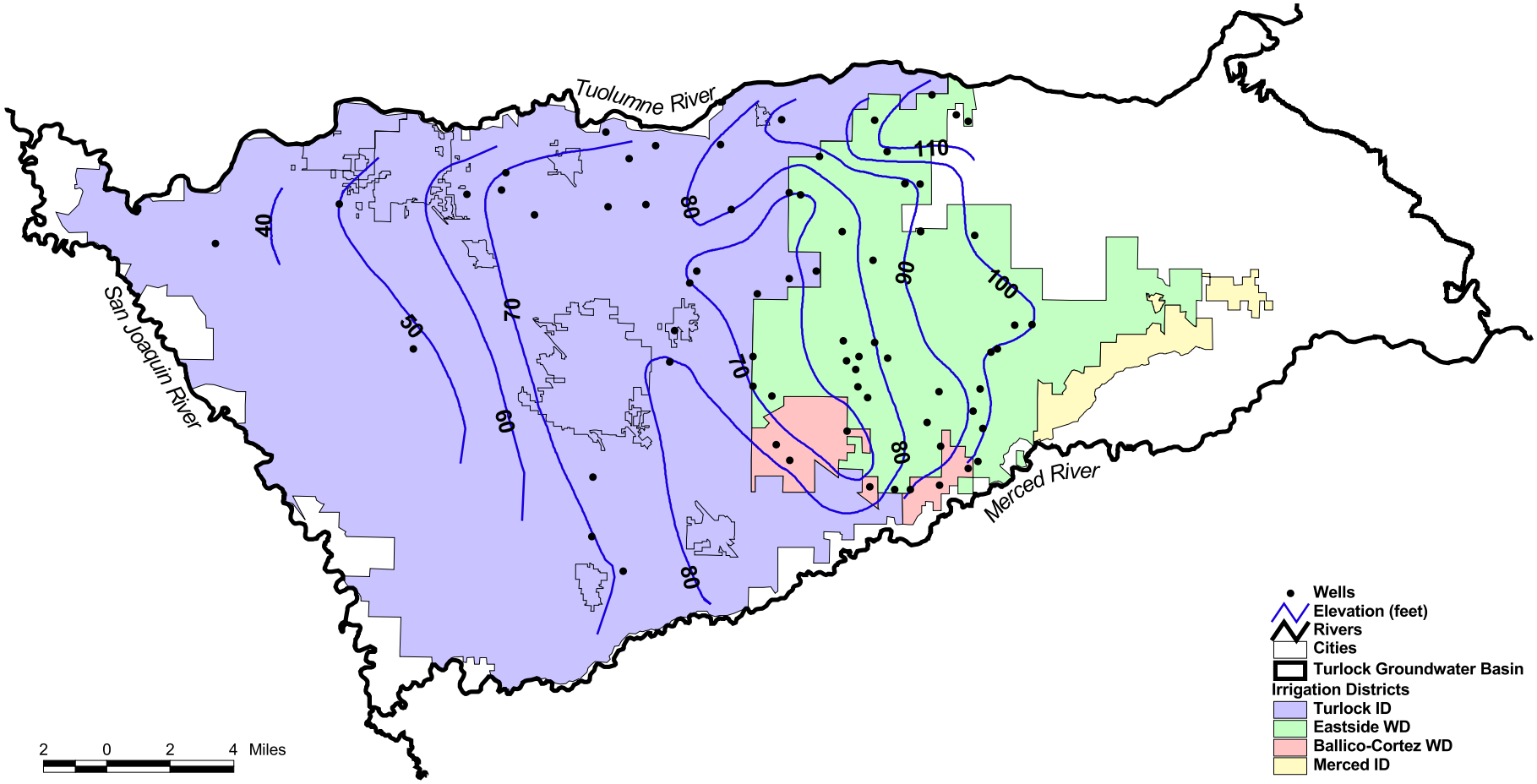


Figure 4.5b Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, November 1977

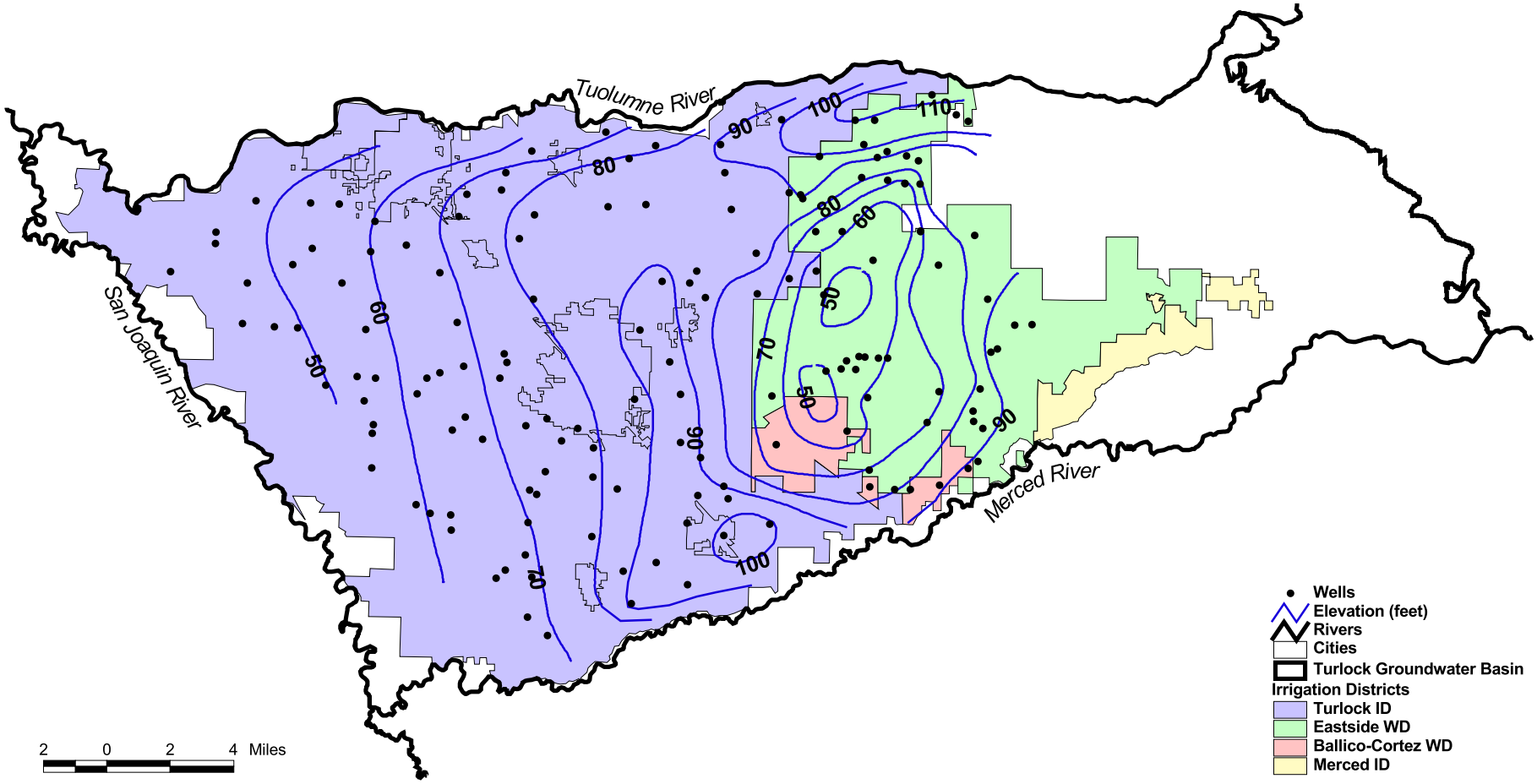


Figure 4.5c Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, November 1986

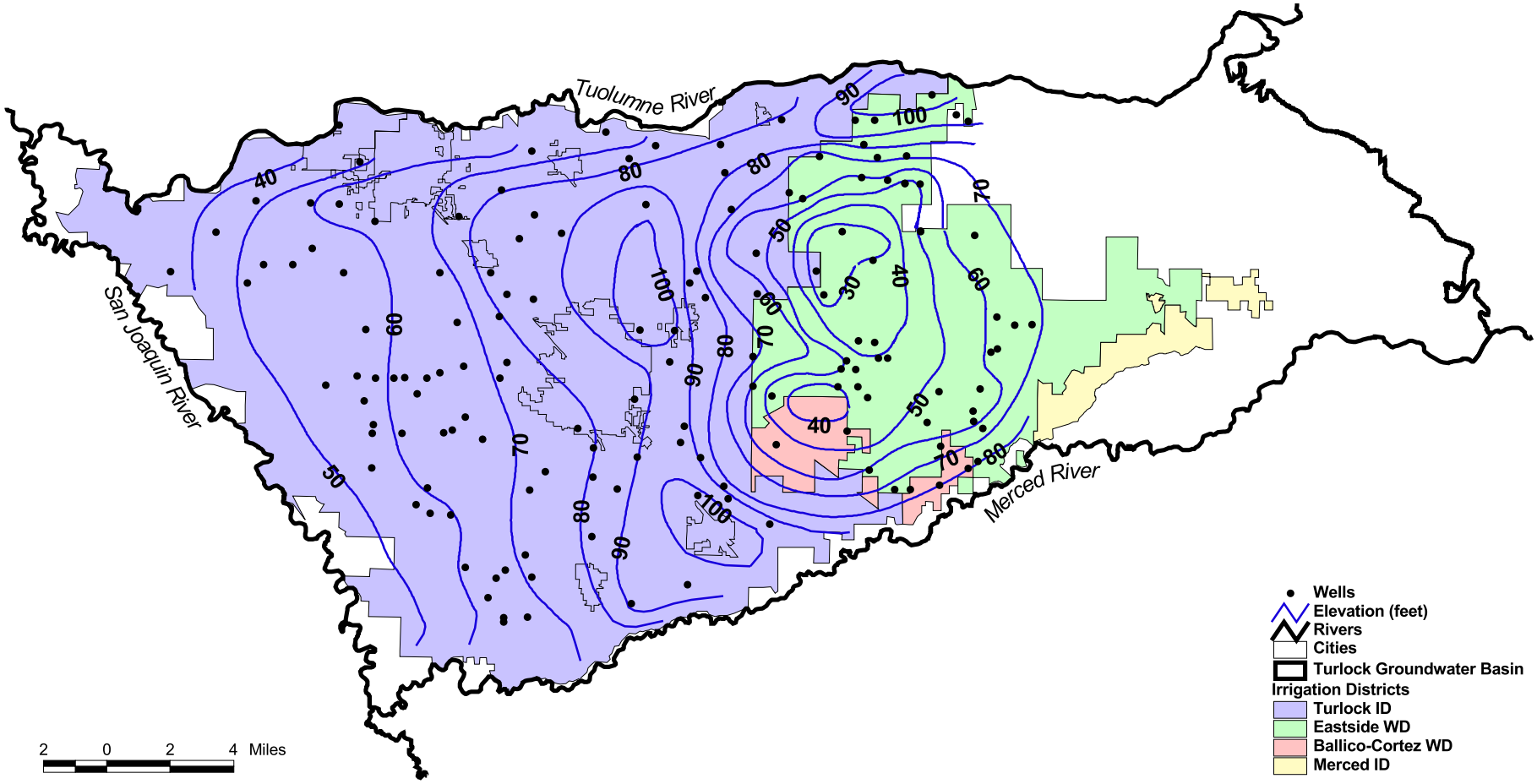


Figure 4.5d Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, November 1998

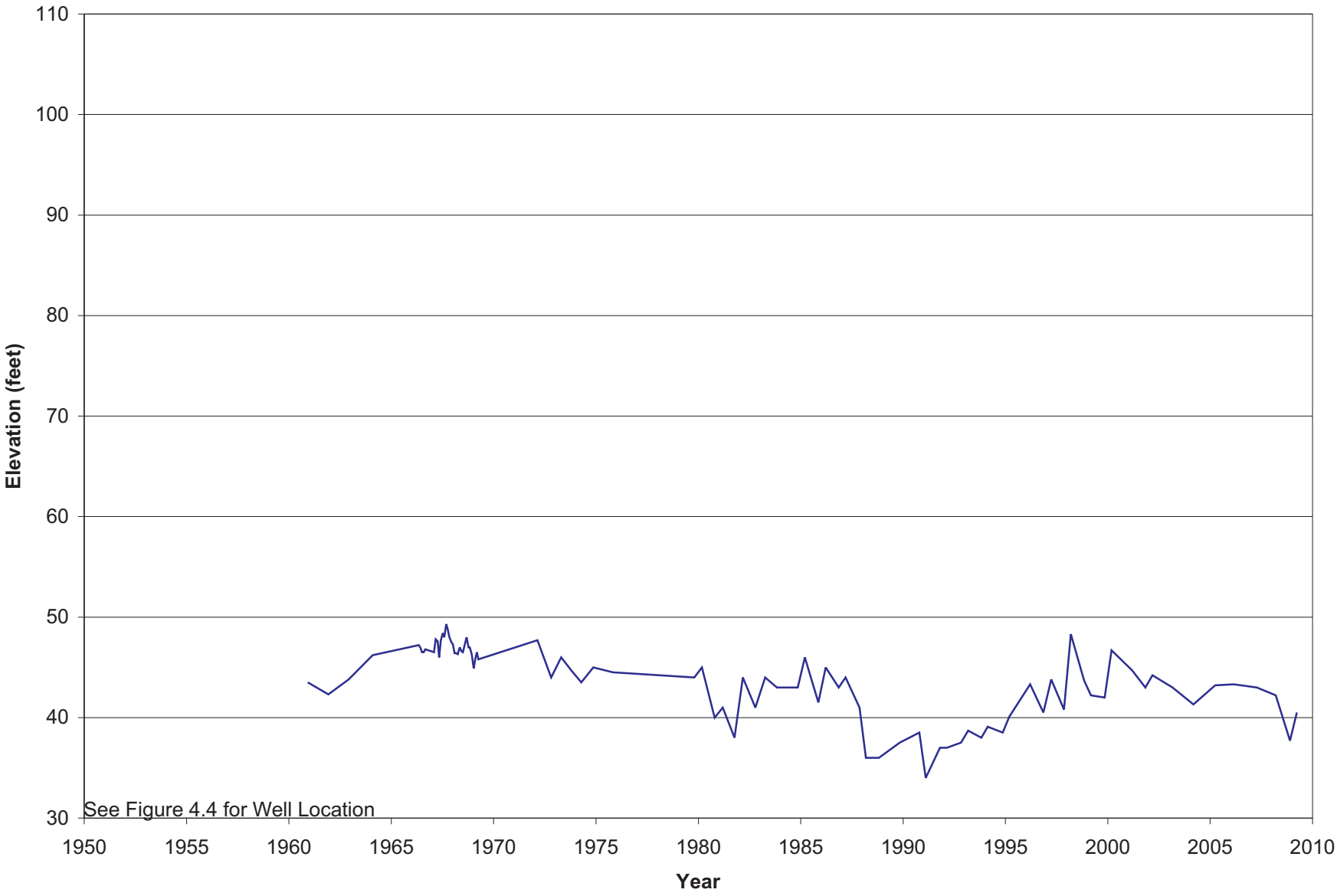


Figure 4.6a Measured Temporal Groundwater Levels in Monitoring Well 04S08E22R001M

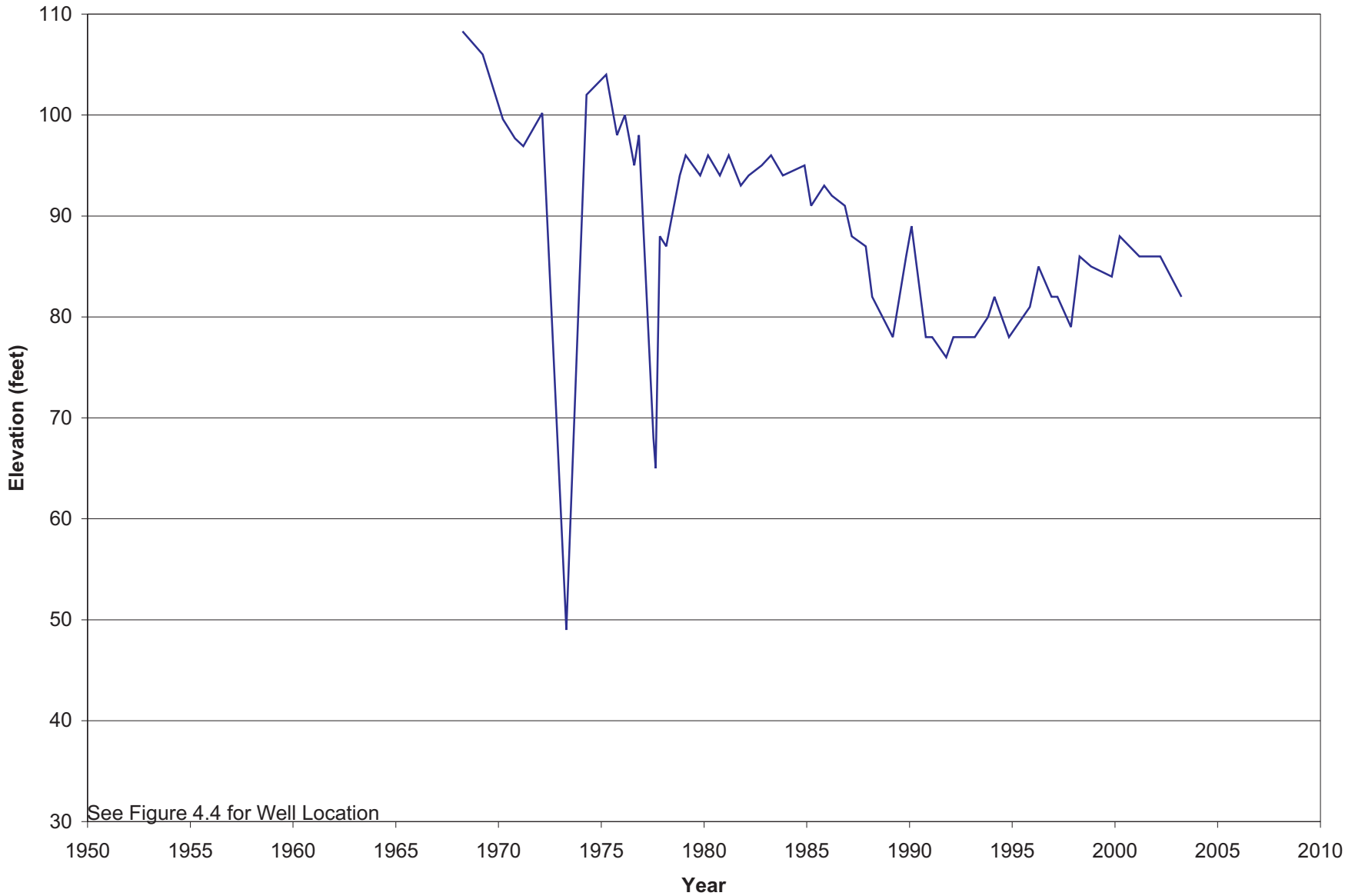


Figure 4.6b Measured Temporal Groundwater Levels in Monitoring Well 04S11E08A001M

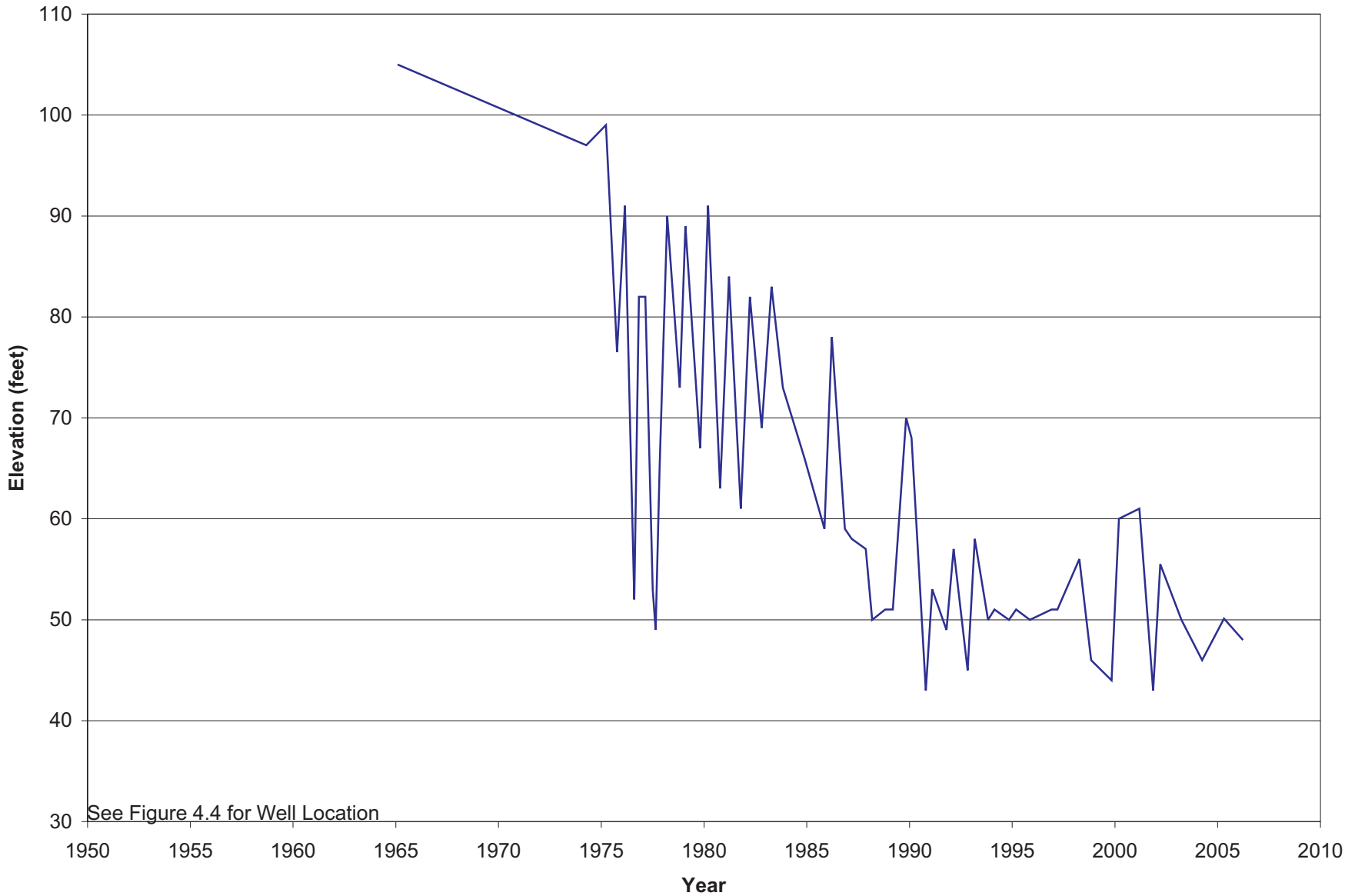


Figure 4.6c Measured Temporal Groundwater Levels in Monitoring Well 05S11E25A001M

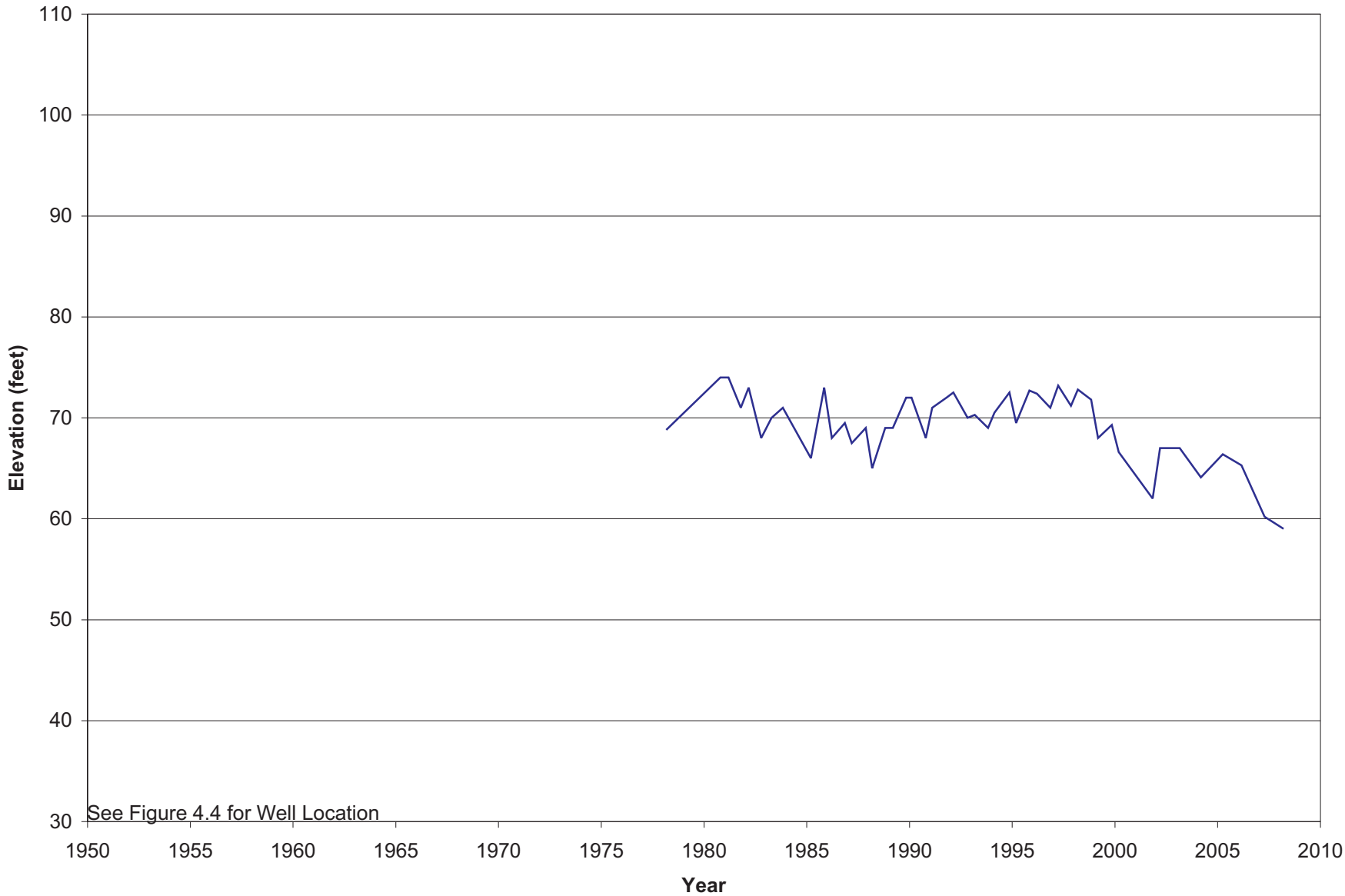


Figure 4.6d Measured Temporal Groundwater Levels in Monitoring Well 06S10E16M001M

Table 2.1 Land-Use Acreages and Pumping within West Ceres Specific Plan (Acres and Acre-Feet per Year)

Area	Land Use (Demand)	Acreage	Pumping		
			Average Day	Maximum Day	Peak Hour
West Ceres Specific Plan	Residential (3.4 ac ft/ac yr)	312.0	1,061	1,909	2,917
	Industrial / Institutional (1.7 ac ft/ac yr)	378.3	643	1,158	1,769
	Commercial (1.0 ac ft/ac yr)	99.3	99	179	273
	Parks /Agriculture (0.0 ac ft/ac yr)	70.1	0.0	0.0	0.0
	Total	**859.7**	**1,803**	**3,246**	**4,959**

Notes:

1. Demands are calculated based on unit demands outlined in the March 21, 2007 City of Ceres Water System Hydraulic Model Update.
2. Maximum day and peak hour peaking factors are 1.8 and 2.75 respectively
3. ac ft/ac yr = acre feet annually per acre.
4. System losses are assumed to be included within Land Use Unit Demands presented in City of Ceres Water System Hydrulaic Model Update. Unit Demands are based on water system yearly produciton rate.

Table 2.2 Ceres Historical Production (Acre-Feet per Year)

Year	Population	Production (gallons)	Per Capita Daily Use	Precip Type
1980	13,000	1,090,782,200	230	Normal
1981	14,250	1,111,506,500	214	Normal
1982	14,900	1,155,547,500	212	Wet
1983	16,250	1,291,522,400	218	Wet
1984	16,550	1,509,610,900	250	Dry
1985	17,250	1,519,350,100	241	Dry
1986	17,750	1,715,958,700	265	Normal
1987	18,550	1,748,941,100	258	Normal
1988	19,300	1,911,393,700	271	Normal
1989	22,950	1,940,567,600	232	Dry
1990	25,850	2,015,488,000	214	Normal
1991	27,600	2,081,718,400	207	Normal
1992	28,700	2,220,405,110	212	Normal
1993	29,800	2,073,287,958	191	Normal
1994	30,400	2,293,572,845	207	Normal
1995	31,400	2,417,485,600	211	Wet
1996	32,100	2,597,703,000	222	Wet
1997	32,800	2,867,598,300	240	Normal
1998	33,450	2,559,322,800	210	Wet
1999	33,850	2,913,872,100	236	Dry
2000	34,650	2,939,090,800	232	Normal
2001	34,609	3,079,631,800	240	Normal
2002	35,841	3,280,204,500	251	Normal
2003	36,576	3,193,878,700	239	Dry
2004	37,559	3,304,608,200	241	Normal
2005	38,813	3,304,216,800	233	Dry*
2006	40,943	3,231,000,000	216	Normal
2007	41,997	3,515,000,000	229	Dry*
2008	42,713	3,475,000,000	223	Dry*

*Precipitation data incomplete

Table 2.3 Ceres Projected Annual Supply Reliability and Demand Comparison with Currently In-Service Wells

(Acre-Feet per Year)

	Average Water Year	Single Dry Water Year	Multiple Dry Water Years		
			Year 1	Year 2	Year 3
2008 Groundwater Supply Total[1]	16,914	16,914	16,914	16,914	16,914
2008 Demand Totals	10,585	11,008	11,008	11,008	11,008
Difference	**6,329**	**5,906**	**5,906**	**5,906**	**5,906**
2013 Groundwater Supply Total[2]	18,769	18,769	18,769	18,769	18,769
2013 Demand Totals	13,101	13,625	13,625	13,625	13,625
Difference	**5,669**	**5,144**	**5,144**	**5,144**	**5,144**
2018 Groundwater Supply Total[2]	22,156	22,156	18,769	18,769	18,769
2018 Demand Totals	14,822	15,415	15,415	15,415	15,415
Difference	**7,334**	**6,741**	**3,354**	**3,354**	**3,354**
2023 Groundwater Supply Total[2]	22,156	22,156	18,769	18,769	18,769
2023 Demand Totals	16,770	17,441	17,441	17,441	17,441
Difference	**5,386**	**4,715**	**1,328**	**1,328**	**1,328**
2028 Groundwater Supply Total[2]	22,156	22,156	18,769	18,769	18,769
2028 Demand Totals	18,974	19,733	19,733	19,733	19,733
Difference	**3,183**	**2,424**	**-964**	**-964**	**-964**
2033 Groundwater Supply Total[2]	22,156	22,156	18,769	18,769	18,769
2033 Demand Totals	21,467	22,326	22,326	22,326	22,326
Difference	**689**	**-169**	**-3,557**	**-3,557**	**-3,557**

[1]Groundwater Supply represents current on-line well capacity as of December, 2009, assuming largest production well is out of service.

[2]Groundwater Supply represents current on-line well capacity as of December, 2009, assuming largest production well is out of service and additional well (19R) which has been drilled but not yet brought on line.

Table 4.1 Water Budget for Turlock Groundwater Basin 1978-2002
(Acre-Feet per Year)

Water-Budget Component	Period				
	1978-1982	1983-1987	1988-1992	1993-1997	1998-2002
Groundwater Discharge					
Groundwater Pumping					
Turlock irrigation District Drainage Wells	103,154	117,146	40,700	76,821	69,148
Turlock Irrigation District Rented Wells	1,288	34,720	100,075	16,586	16,065
Turlock Irrigation District Supplemental Wells	42,231	35,333	49,447	31,658	20,946
Turlock Irrigation District Primary-Source Wells	0	0	30	1,293	9,257
Eastside Water District	153,271	170,082	164,761	148,008	132,249
Ballico-Cortez Water District	22,569	23,652	22,593	20,120	18,087
Merced Irrigation District	241	202	282	181	120
Non-District Areas	88,447	98,732	104,420	97,788	99,216
Ceres	5,821	7,479	8,591	9,628	10,689
Delhi	824	958	1,061	1,269	1,589
Denair	935	1,023	1,013	1,140	1,233
Hickman	150	160	166	172	175
Hilmar	701	914	1,016	1,177	1,242
Hughson	768	844	982	1,016	953
Keyes	1,006	1,112	1,171	1,270	1,329
South Modesto	1,691	2,112	2,246	2,349	2,470
Turlock	13,981	16,694	18,433	20,121	22,316
Rural Residences	3,932	4,084	4,108	4,131	4,026
Groundwater Net Discharge to Rivers	162,355	70,312	-121,304	59,107	40,707
Groundwater Discharge from Subsurface Drains	243	1,358	1,872	3,254	13,857
Groundwater Consumption by Phreatophytes	41,965	43,714	44,566	40,757	40,757
TOTAL	645,573	630,631	446,228	537,844	506,432
Groundwater Recharge					
Groundwater Recharge from Irrigated Areas					
Turlock Irrigation District Canal-Delivery Lands	314,455	340,306	200,625	277,998	298,434
Turlock Irrigation District Groundwater-Only Lands	0	0	13	623	4,158
Eastside Water District	87,776	91,829	71,941	78,060	59,323
Ballico-Cortez Water District	12,519	12,320	9,312	10,182	7,702
Merced Irrigation District	13,616	13,001	7,765	10,052	8,746
Non-District Areas	46,391	49,070	43,504	48,769	43,552
Ceres	450	579	673	724	757
Delhi	64	74	82	98	123
Denair	85	93	95	96	101
Hickman	14	15	16	16	17
Hilmar	51	66	74	85	90
Hughson	50	55	64	66	62
Keyes	78	86	91	98	103
South Modesto	156	194	207	216	228
Turlock	989	1,181	1,320	1,390	1,519
Rural Residences	2,292	2,368	2,393	2,417	2,390
Groundwater Recharge from Non-Irrigated Areas	51,234	36,394	6,666	50,262	42,357
Groundwater Recharge from Turlock Lake	77,793	59,348	56,739	66,641	35,590
Groundwater Recharge from Foothills	1,000	1,000	1,000	1,000	1,000
Groundwater Recharge from Deep Formations	2,000	2,000	2,000	2,000	2,000
TOTAL	611,013	609,981	404,578	550,794	508,252
Change in Groundwater Storage	-34,560	-20,650	-41,650	12,950	1,820

Table 4.2 Water Budget for Turlock Groundwater Basin, 2006 and 2025 (Acre-Feet per Year)

Water-Budget Component	Period	
	2006	2025
Groundwater Discharge		
Groundwater Pumping and Drainage		
Agricultural Drainage	83,000	83,000
Agricultural Pumping	298,000	289,000
Urban Pumping	46,000	62,000
Groundwater Net Discharge to Rivers	41,000	24,000
Groundwater Consumption by Phreatophytes	41,000	41,000
TOTAL	509,000	499,000
Groundwater Recharge		
Groundwater Recharge from Irrigated Areas		
Agricultural Recharge	422,000	410,000
Urban Recharge	5,000	7,000
Groundwater Recharge from Non-Irrigated Areas	43,000	43,000
Groundwater Recharge from Turlock Lake	36,000	36,000
Groundwater Recharge from Foothills	1,000	1,000
Groundwater Recharge from Deep Formations	2,000	2,000
TOTAL	509,000	499,000
Change in Groundwater Storage	0	0