APPENDIX A - REFERENCES

Appendix A - References

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APPENDIX B - RESOLUTION

HUGHSON CITY COUNCIL

RESOLUTION NO. 06-221

RESOLUTION OF THE CITY COUNCIL OF THE CITY OF HUGHSON ADOPTING AN URBAN WATER MANAGEMENT PLAN

WHEREAS, the City Council seeks to provide for the public good and the good stewardship of its water resources; and

WHEREAS, the City of Hughson has prepared a Draft Urban Water Management Plan in accordance with State Law; and

WHEREAS, the City of Hughson has solicited comments and input from various stakeholders, which include public agencies and the general public; and,

WHEREAS, the City Council conducted a public hearing on November 13 2006 and continued that hearing to November 27, 2006 in order to provide for greater public input; and

NOW THEREFORE, BE IT RESOLVED that the City Council of Hughson hereby adopts and finalizes the 2005 Urban Water Management Plan.

PASSED AND ADOPTED by the Hughson City Council at a regular meeting thereof held on November 27, 2006, by the following vote:

AYES: Council Members QUALLS, BAWANAN, ADAMS and Mayor Pro Tem MOORE

NOES: None

ABSTENTIONS: None

///////////

///////////

///////////

ABSENT: Mayor CROWDER

THOMAS E. CROWDER, Mayor

ATTEST:

MARY JANE CANTRELL, CMC, City Clerk

APPENDIX C - ADVERTISEMENT

Affidavit of Publication

NOV - 3

STATE OF CALIFORNIA }ss.
County of Stanislaus

RUTH REYES

Here-un-to being first duly sworn, deposes and says that all time hereinafter mentioned he/she was a citizen of the United States over the age of twenty-one (21) years, and doing business in said county, not interested in the matter of the attached publication, and is competent to testify in said matter, that he/she was at and during all said time the principal clerk to the printer and publisher of the

HUGHSON CHRONICLE/DENAIR DISPATCH

a legal newspaper of general circulation published weekly in Hughson in said County of Stanislaus, State of California: that said

HUGHSON CHRONICLE/DENAIR DISPATCH

is and was at all times herein mentioned, a newspaper of general circulation as that term is defined by Section 6000 of the Government Code, and as provided by said section and so adjudicated by Decree No. 41926 by the Superior Court of Stanislaus County, State of California, is published for the dissemination of local and telegraphic news and intelligence of a general character, have a bonafide subscription list of paying subscribers, and is not devoted to the interest, or published for the entertainment or instruction of a particular class, profession, trade, calling, race of denomination: or for the entertainment and instruction of any number of such classes, professions, trades, callings, races or denominations: that at all times said newspaper has been established, in Hughson; in said County and State, at regular intervals for more than one year preceding the first publication of the notice herein mentioned, that said notice was set in type not smaller than nonpareil and was preceded with words printed in blackface type not smaller than nonpareil, describing and expressing in general terms, the purport and character of the notice intended to be given

Notice of Public Hearing concerning Urban Water Management Plan for 2005-2010.

of which named annexed is a printed copy, was published and printed in said

HUGHSON CHRONICLE

at least 1 time, commencing on the 24th day of October 2006 and ending on the the 24th day of October 2006 the day inclusive, and as often during said time as said newspaper was regularly issued, to wit:

October 24, 2006

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.
Dated this 27th day of October 2006.

Ruth Reyes

PRINCIPAL CLERK OF THE PRINTER

...icle

LEGAL# 7803

NOTICE OF PUBLIC HEARING BY THE HUGHSON CITY COUNCIL

NOTICE IS HEREBY GIVEN that a public hearing will be held by the HUGHSON CITY COUNCIL on November 13, 2006, at 7:00 P.M., or as soon thereafter as the normal course of business permits, in the City Council Chambers, 7018 Pine Street, Hughson, California, for the purpose of receiving public comments concerning the proposed Urban Water Management Plan for 2005-1010 preparation cycle as required under the California Urban Water Management Planning Act. Any person desiring to make comments or present information to the Council may make an oral presentation at the public hearing or may submit written comments or information for Council consideration by delivering said written comments to the City Clerk prior to the time of the hearing. A draft of the Plan is available for review on the City's website at www.hughson.org or at City Hall, 7018 Pine Street, Hughson, CA.

Testimony from interested persons will be heard and duly considered prior to taking action. Any material which is submitted (i.e. photographs, maps, petitions, letters, etc.) cannot be returned. If a challenge is made in court to the above request, persons may be limited to raising only those issues they or someone else raised at the Public Hearing described in this notice, or prior to, the Public Hearing.

Date: October 16, 2006
City of Hughson
By: Mary Jane Cantrell, CMC, City Clerk
Published Dates: 10/24/06

APPENDIX D - GROUNDWATER MANAGEMENT PLAN

TURLOCK GROUNDWATER BASIN

Groundwater Management Plan

Prepared for:

Insert Name of Agency
Street Address
City, California ZIP

[Insert date]

Prepared by:

Turlock Groundwater Basin Association

Tables

Figures

Appendices

Acronyms & Abbreviations

AB	Assembly Bill
AF	Acre-Feet
AF/yr	Acre-Feet per Year (1,120 AF/yr = 1 MGD)
BCWD	Ballico-Cortez Water District
BMO	Basin Management Objective
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CWC	California Water Code
DBCP	Dibromochloropropane
DEH	Division of Environmental Health (Merced Co.)
DER	Department of Environmental Resources (Stanislaus Co.)
DHS	Department of Health Services
DMS	Data Management System
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment & Protection
EC	Electrical Conductivity
EDB	Ethylene dibromide
EPA	United States Environmental Protection Agency (also U.S. EPA)
EWD	Eastside Water District
GMP	Groundwater Management Plan
gpm	gallons per minute
GW	groundwater
ID	Irrigation District
M&I	Municipal and Industrial
MCL	Maximum Contaminant Level
MGD	Million gallons per day (1 MGD = 1,120 AF/yr)
MID	Merced Irrigation District
µg/L	micrograms per liter = ppb
µmhos/cm	micromhos per centimeter
mg/L	milligrams per liter = ppm
mmhos/cm	millimhos per centimeter
MGD	Million Gallons per Day
MOU	Memorandum of Understanding
msl	mean sea level
NAWQA	National Water Quality Assessment
PBE	Physical Barrier Effectiveness
PCA	Potential Contaminating Activity
PCE	Perchloroethylene
ppb	parts per billion = µg/L
ppm	parts per million = mg/L
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SCADA	Supervisory Control and Data Acquisition
SOP	Standard Operating Procedure
SW	surface water
SWRCB	State Water Resources Control Board

TCE	Trichloroethylene
TDS	Total Dissolved Solids
TGB	Turlock Groundwater Basin
TGBA	Turlock Groundwater Basin Association
TID	Turlock Irrigation District
USGS	U.S. Geological Survey
UST	Underground storage tanks
VOC	Volatile organic compound
WPA	Wellhead Protection Area
WPP	Wellhead Protection Program
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

This is to either contain a "Preface" or an "Executive Summary" whichever appears most appropriate. It is not necessary to write this section now - will be written as the plan is nearing completion.

1 INTRODUCTION

The following sections provide a brief introduction to groundwater management and related issues pertinent to the Turlock Groundwater Basin including: the agencies situated within the Basin and participating in the groundwater management process; historic groundwater management efforts; and other relevant information.

The DWR website[1] includes information on Bulletin 118 (2003), the publication in which the California Department of Water Resources identifies and describes the various groundwater basins and subbasins within the state. The website and available information from Bulletin 118 (2003) were utilized, along with other documentation, in preparing this report.

It is important to note that the Turlock Groundwater Basin or Turlock Subbasin are referenced in a variety of ways within the report. DWR Bulletin 118 (2003) identifies the area covered under this plan as the Turlock Subbasin of the San Joaquin Valley Groundwater Basin. For the purposes of this document, the name "Turlock Subbasin," "Turlock Groundwater Basin," "Basin," and "Subbasin" are used interchangeably to represent the same geographic area. All other groundwater basins referenced in this document are listed by their proper name.

In addition, although this document is titled the "Turlock Groundwater Basin Groundwater Management Plan," it is also referred to as the "Turlock Groundwater Management Plan," the "Groundwater Management Plan" or merely the "Plan."

1.1 GEOGRAPHIC SETTING

The Turlock Subbasin lies on the eastern side of California's San Joaquin Valley, and encompasses portions of both Stanislaus and Merced counties. The groundwater system is bounded by the Tuolumne River on the north, the Merced River on the south, and the San Joaquin River on the west, as shown in Figure 1. The eastern boundary of the system is the western extent of the outcrop of crystalline basement rock in the foothills of the Sierra Nevada.

1.2 LOCAL AGENCIES

Local agencies eligible to participate in a groundwater management plan situated within the Subbasin are: the Turlock and Merced irrigation districts; the cities of Ceres, Turlock, Modesto and Hughson; the Hilmar and Delhi county water districts; the Keyes, Denair and Ballico community services districts; the Eastside and Ballico-Cortez water districts; as well as Stanislaus and Merced counties. Figure ____ shows the location of the various entities within the Subbasin and their respective political boundaries.

It is understood that each local water agency may adopt the groundwater management plan to manage groundwater resources within their jurisdiction. If a county adopts the groundwater management plan, the plan shall apply to those areas lying outside the other agencies' boundaries.

[1] At http://www.dpla2.water.ca.gov/publications/groundwater/bulletin118/basins/5-22.03_Turlock.pdf

1.3 TURLOCK GROUNDWATER BASIN ASSOCIATION

In 1995 the Turlock Groundwater Basin Association was formed for the purposes of studying and evaluating the condition of the Basin, and developing a groundwater management plan for the preservation, protection and enhancement of the Basin. The Turlock Groundwater Basin Groundwater Management Plan was adopted by the local public agencies between October and December 1997. After which, the 1995 Memorandum of Understanding terminated by its own terms.

Following the dissolution of the Association in 1997, the local public agencies continued to meet on a regular basis in their efforts to cooperatively manage groundwater resources within the Turlock Basin.

In 2001 the Turlock Groundwater Basin Association was reformed to provide a mechanism for the local public agencies to collectively implement the Plan. The following purposes and goals were set forth in the Memorandum of Understanding (MOU):

- "To provide a mechanism to coordinate the implementation of the Plan and other groundwater management activities;
- To create an association of the Parties to enhance the ability to obtain funding to carry out the Plan and related groundwater management projects; and
- Provide information and guidance for the management, preservation, protection and enhancement of the Basin."

In addition, the signatories to the MOU believed that "non-coordinated action by water providers and users within the Basin could result in counterproductive competition for finite resources resulting in adverse impacts to the groundwater and surface water supplies within the Basin," and that the "creation of an Association for water suppliers within the Basin is important to protect the groundwater and surface water resources and will assist in meeting the needs of all users of such resources within the Basin." In addition, it was clear that local management of water resources is desirable in order to maintain local control of these resources.

In forming the Association, the local agencies desired that the Association not be formed as a separate governmental entity, nor have any enforceable regulatory authority over any agency's facilities or any agency's respective surface water or groundwater supplies or rights, nor duplicate any services, duties or authority of any other agency. Instead, the purpose of the Association is to provide a forum in which the local public agencies can work cooperatively; to combine the available talent of the respective agency staffs; and to accomplish the purposes of the MOU. For reference, a copy of the MOU is attached to this report in Appendix A.

1.4 ONGOING GROUNDWATER MANAGEMENT-RELATED ACTIVITIES

1.4.1 Historical Prospective

An initial Turlock Groundwater Basin Groundwater Management Plan was developed and adopted by the local public agencies in 1997. Groundwater supply, demand, quality and other issues pertinent to groundwater management change over time. As a result, it is understood that a groundwater management plan must be updated occasionally to reflect current conditions and requirements. As such, the Turlock Groundwater Basin Association has developed this Plan. It is intended to update and supercede the 1997 Plan. It includes the pertinent information contained within the original plan, with additional or updated data inserted as needed to comply with the current groundwater management requirements.

1.4.2 Previous Efforts

The agencies within the Turlock Groundwater Basin have been meeting to coordinate groundwater management efforts since 1995. It began with the development of the 1997 version of the Turlock Groundwater Basin Groundwater Management Plan. Following the adoption of the Plan, the agencies continued to meet monthly to discuss groundwater management related issues, including:

- Development of a preliminary groundwater level and water quality monitoring program.
- Identification of groundwater management activities being conducted by the local agencies and coordination needed to accomplish the Plan goals.
- Formation of the Turlock Groundwater Basin Association.
- Contracted with a hydrologist in 2003 to conduct a groundwater balance study for the Basin.
- Supported individual groundwater management related efforts by local agencies, as appropriate.

1.4.3 Efforts of Individual Agencies

The local public agencies within the Basin have historically provided a variety of on-going groundwater management related services including:

- **Well Abandonment or Destruction Programs:** There are existing programs in place at the city/county level. Proper well abandonment/destruction of an old well can be made a condition of installing a new well. Education programs have been implemented to advise well owners of the importance of proper well destruction.
- **Well Construction Standards:** The cities and counties have established well construction standards that are consistent with, or in some cases more stringent than the State of California Well Standards (Bulletin 74-81 and it's supplements). These standards regulate the installation and abandonment for any new wells installed within the Basin.
- **Public Education Programs:** Many local public agencies have implemented public education programs related to water quality, wellhead protection, water conservation and other water issues.

- **Land Use Planning:** The cities and counties have land use planning programs in place to evaluate and reduce potential impacts to groundwater resources due to proposed development and other land use changes.
- **Regulation of Mitigation of Contaminated Groundwater:** The regulatory agencies responsible for the water quality have been the key agency responsible for this item, with local public agencies coordinating efforts with the regulatory agencies as needed.
- **Development of Relationships with Local, State and Federal Agencies:** The Turlock Groundwater Basin Association provides a mechanism for interaction and coordination amongst local agencies, as well as communication with state and federal agencies. In addition, the various local agencies maintain individual relationships with the various state and federal agencies associated with groundwater management related issues.
- **Funding:** Individual agencies have applied for and secured grants to study a variety of groundwater management related issues including:
    - In October 2001, the Eastside Water District submitted to the California Department of Water Resources, Division of Planning and Local Assistance, an application for a grant from the “Local Groundwater Assistance Fund (AB303) to finance an “Eastside Water District Groundwater & Multiple Resources Integration Planning Study.” The Grant was approved and the District received the final signed contract on September 23, 2002. The amount of the grant was $200,000. The EWD contribution was approximately $100,000. The study was completed in October 2003. The study examined options for acquisition of additional water supplies as well as alternatives for conveyance of the water to the district.
    - In September 2003, the Denair Community Services District was awarded a grant under the Local Groundwater Management Act of 2000 (AB303) for $200,000.00. Denair CSD proposes to construct two cluster-monitoring or “nesting” test wells. Information from these two test wells, and other existing wells, will be used to support advancement of a hydro geologic model of the producing groundwater system and to monitor the quality and quantity of groundwater produced from the alluvial aquifer sequences underlying Denair CSD.

- **Groundwater Monitoring:** The local agencies conduct a variety of groundwater quality and level monitoring. Urban agencies and others providing drinking water to local residents are required to monitor for a variety of water quality constituents. To a lesser extent, agricultural agencies conduct water quality monitoring. Water level measurements are conducted by agricultural and urban entities. In addition, the following special projects have been implemented:
    - Denair CSD developed its groundwater management program in 2001 with the drilling of a test hole, subsurface interpretations of favorable aquifer sequences, and by creating formal guidelines for residential developers to use to construct Denair CSD-required test and monitoring wells. Due to inadequate funding, Denair CSD's program is currently limited to residential developer's activities. The first well was constructed in 2002.
    - Denair CSD also obtained funding to install two cluster or “nesting” wells for the purpose of water quality monitoring (see “Funding” section above).

- **Groundwater Recharge:** The Eastside Water District, in conjunction with the Turlock Irrigation District, conducted a recharge study, in which a ¼ acre basin was installed and operated for several years. The districts are currently working on a potential expanded study, in which several larger basins could be installed and operated to further evaluate the potential recharge opportunities within the basin.

2 NEED FOR GROUNDWATER MANAGEMENT PLANNING

2.1 DEFINITION OF GROUNDWATER MANAGEMENT

The California Department of Water Resources Bulletin 118 (2003) defines "groundwater management" as "the planned and coordinated management of a groundwater basin with a goal of long-term sustainability of the resource." It goes on to define a "groundwater management plan" as a "comprehensive written document developed for the purpose of groundwater management and adopted by an agency having appropriate legal and statutory authority." A "groundwater management program," as defined by Water Code section 10752(e), is a "coordinated and ongoing activity undertaken for the benefit of a groundwater basin, pursuant to a groundwater management plan" adopted as specified in the Water Code.

2.2 PURPOSE OF THE GROUNDWATER MANAGEMENT PLAN

The Water Code § 10752(d) defines a groundwater management plan as a "document that describes the activities intended to be included in a groundwater management program." The Turlock Groundwater Basin Association developed this Plan for the purposes of documenting:

1) Groundwater basin conditions;
2) The areas managed by the local entities and the legal authorities to do so;
3) Groundwater management goals and objectives;
4) Historic, ongoing and planned future groundwater management activities; and
5) Stakeholder involvement processes.

Additionally, the local public agencies within the Subbasin have embarked on the development of this Plan to comply with the State of California groundwater management planning requirements, ~~to enable the Association and its member agencies to consider applying for State grant funding to implement groundwater management and other related activities.~~and to create a framework for coordination of groundwater management activities to achieve the collective and individual goals spelled later in this plan.

2.3 LEGAL AUTHORITY

The following discussion describes the various areas where legal authority is given to local agencies to develop groundwater management plans and participate in groundwater management related activities.

2.3.1 AB 3030

The Groundwater Management Act (AB 3030) was passed by the State legislature during the 1992 session, and became law on January 1, 1993. The Groundwater Management Act, as codified in California Water Code § 10750 *et seq.*, identifies groundwater as a valuable resource that should be managed to ensure both its safe production and its quality. AB 3030 also encourages local agencies to work cooperatively to manage groundwater resources within their jurisdiction.

The act applies to all groundwater basins identified in the Department of Water Resources (DWR) Bulletin 118 (dated September 1975), except those already subject to groundwater management by a local agency or watermaster pursuant to other law, court order, judgment or decree, unless the local agency or watermaster agrees. Bulletin 118 specifically identifies the Turlock Groundwater Basin making it eligible for groundwater management under AB 3030.

The law provides that any district or other political subdivision of the state which is authorized to provide water service and is exercising that authority, may by ordinance or resolution adopt and implement a groundwater management plan within all or a portion of its service area. The law also indicates that a local public agency that provides flood control, groundwater management, groundwater replenishment, or a local agency, formed pursuant to the Water Code for the principal purpose of providing water service, that has not yet provided that service, may establish an AB 3030 groundwater management plan within its boundaries provided that those areas are not served by another local agency.

The act also authorizes a local public agency to exercise the specified powers of a water replenishment district, subject to the approval of the voters within the agency's service area.

2.3.2 Other Legislation

Additional legislation, in the form of Senate Bill 1938, was enacted in 2002 further refining the Water Code sections related to groundwater management. SB 1938 made a variety of modifications to the groundwater management plan requirements, much of which dealt with public participation in the development and implementation of groundwater management plans, availability of the documents, as well as the ability to obtain certain grant funds in implementing groundwater management activities.

Language added by SB 1938 requires agencies wishing to develop a groundwater management plan to make available to the public a written statement describing the manner in which interested parties may participate in the development of that plan. The bill also requires local agencies, which elect to apply for certain types of state grant funding, to prepare and implement a groundwater management plan that contains specific basin management objectives and components, and to adopt certain monitoring protocols. Table 2-1 below provides a listing of these components, along with the location where that information can be found within this document.

2.4 GROUNDWATER MANAGEMENT PLAN COMPONENTS

The GMP includes the following required and recommended components:

- CWC § 10750 *et seq.* (seven mandatory components). Recent amendments to the CWC § 10750 *et seq.* require GMPs to include several components to be eligible for the award of funds administered by DWR for the construction of groundwater projects or groundwater quality projects. (Note: These amendments to the CWC were included in Senate Bill 1938, effective January 1, 2003.)
- DWR Bulletin 118 (2003) components (seven recommended components).
- CWC § 10750 *et seq.* (12 voluntary components). CWC § 10750 *et seq.* includes 12 specific technical issues that could be addressed in GMPs to manage the basin optimally and protect against adverse conditions.

TABLE 2-1 lists the section(s) in which each component is addressed.

Table 2-1. Location of TGB GMP Components

Description	Section(s)
A. CWC § 10750 *et seq.*, Mandatory Components	
1. Documentation of public involvement statement.	7.4
2. Basin Management Objectives (BMOs).	5.3
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping.	5.5-5.6 & 6.1-6.8
4. Plan to involve other agencies located within groundwater basin.	7.1-7.3
5. Adoption of monitoring protocols by basin stakeholders.	5.5-5.6
6. Map of groundwater basin showing area of agency subject to GMP, other local agency boundaries, and groundwater basin boundary as defined in DWR Bulletin 118.	1.1-1.2 & 5.2
7. For agencies not overlying groundwater basins, prepare GMP using appropriate geologic and hydrogeologic principles.	N/A
B. DWR's Suggested Components	
1. Manage with guidance of advisory committee.	7.2
2. Describe area to be managed under GMP.	5.2
3. Create link between BMOs and goals and actions of GMP.	???
4. Describe GMP monitoring program.	5.6
5. Describe integrated water management planning efforts.	????
6. Report on implementation of GMP.	8.2
7. Evaluate GMP periodically.	
C. CWC § 10750 *et seq.*, Voluntary Components	
1. Control of saline water intrusion.	6.1
2. Identification and management of wellhead protection areas and recharge areas.	6.2
3. Regulation of the migration of contaminated groundwater.	6.3
4. Administration of well abandonment and well destruction program.	6.4
5. Mitigation of conditions of overdraft.	6.5
6. Replenishment of groundwater extracted by water producers.	6.6
7. Monitoring of groundwater levels and storage.	5.5-5.6
8. Facilitating conjunctive use operations.	5.7
9. Identification of well construction policies.	6.7
10. Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	6.8
11. Development of relationships with state and federal regulatory agencies.	7.5
12. Review of land use plans and coordination with land use planning agencies to assess activities that create reasonable risk of groundwater contamination.	3.3 & 6.9

3 WATER RESOURCES SETTING

3.1 LAND AND WATER USE WITHIN THE BASIN

The Turlock Subbasin is comprised of approximately 346,000 acres, including roughly 250,000 acres of irrigated crops, 20,000 acres of urban development, and 72,000 acres of native vegetation. Figure ___ (NOTE: Figure 2.1 of Durbin Study) shows the Turlock Subbasin and the boundaries of five subareas for which land-use acreages have been estimated. Four of the subareas include the areas within the Turlock Irrigation District, Eastside Water District, Ballico-Cortez Water District and Merced Irrigation District. Regions outside the boundaries of a water agency are combined into a fifth subarea. The Turlock Irrigation District subarea represents the district's irrigation boundaries and includes the communities of Ceres, Delhi, Denair, Hickman, Hilmar, Hughson, Keyes, south Modesto and Turlock.

Land uses within the Turlock Irrigation District (TID) include irrigated agriculture (using either groundwater or surface water supplies), on-farm non-irrigated lands (i.e. buildings, farm roads, equipment yards, etc.), other non-irrigated lands (i.e. grazing land, non-irrigated crop land, etc.), city urban lands (urbanized areas within the city's political boundaries), non-city urban lands (urbanized areas outside the political boundaries of a city), and highways and roads (highways, roads, canal and railroad right-of-ways).

Figure _____ (Figure 2.3 of Durbin Study) illustrates the changes in land use within the TID between 1952 and 2002. While the total acreage has remained the same, the proportions of irrigated, urban and other land uses have changed. Most notable is the urbanization characterized by an increase in urban areas, and a corresponding decrease in irrigated agricultural land. In addition, a small number of acres have shifted from the use of canal water to groundwater for irrigation, typically combined with a change from flood irrigation to drip and micro irrigation systems.

Irrigated land within the TID utilizes mainly surface water supplies for irrigation, and is the main source of recharge within the Subbasin. Municipalities currently rely entirely upon groundwater for their water supply. In the future, should urban areas continue to utilize groundwater, as urbanization occurs, the reliance upon groundwater will increase while recharge through agricultural use will decrease, likely resulting in reductions in groundwater supplies within the Subbasin. Similarly, a significant movement from the use of surface water, to groundwater supplies on agricultural lands within the TID could also impact groundwater supply availability.

Figures ____ (Figure 2.4a-c of Durbin Study) depict the changes in land use within the Eastside Water District (EWD), Ballico-Cortez Water District (BCWD), Merced Irrigation District (MID). These areas have not had the urban development found within the TID subarea. However, with the exception of the MID subarea which has remained relatively constant, there have been shifts in land use patterns from non-irrigated lands to irrigated agriculture within these areas. The majority of the agricultural development within the EWD and BCWD occurred between 1952 and 1984.

Irrigated agriculture within the Eastside and Ballico-Cortez water districts is dependent upon groundwater for their water supply. Unless additional land use changes occur within these subareas, the main changes in water needs will likely come from improvements in water use efficiency practices or changing cropping patterns.

Lastly, Figures ______ (Figures 2.4d-g of Durbin Study) illustrates the land use changes for those areas located outside the boundaries of a water agency. Figure ____ (Figure 2.4d of Durbin Study) shows changes in land use within the foothill non-district areas (those areas to the east of EWD and BCWD), including a gradual increase in irrigated agriculture between 1952 and 1985, with a marked increase between 1986 and 2002. As of 2002 there were approximately 68,000 acres of non-irrigated lands in the foothill area. If this trend were to continue, the irrigated lands within this area could potentially triple in size, resulting in a corresponding increase in groundwater usage.

Figures _____ (Figures 2.4e-g of Durbin Study) show the land use in non-district areas adjacent to the rivers. Land use in the non-district areas near the Merced River have changed very little between 1990 and 2002. Within the San Joaquin and Tuolumne river areas, however, the irrigated acres have decreased.

3.2 MAJOR WATER PURVEYORS AND OTHER AGENCIES WITHIN THE BASIN

The following section provides a description of the various types of water agencies within the basin, when they were formed, water supplies utilized, as well as other pertinent information.

3.2.1 Purveyors of Agricultural Water Supplies

The Turlock and Merced irrigation districts described below supply irrigation water to growers within the Turlock Subbasin. The irrigation districts represent areas that are mainly rural in nature, and are comprised of small communities, ranches, farms, private residences, etc. In addition to the water supplied by these local agencies, some growers located with an irrigation district's boundaries have their own private irrigation well which they use in lieu of, or in addition to any water supplied by the local public agency.

Domestic use in these areas may be through a private well supplying an individual residence, or through a small public water system. Both rely entirely on groundwater. The small public water systems are regulated through their respective county's Department of Health Services or equivalent.

In addition to domestic and irrigation uses, water may be pumped for use for other agricultural purposes on dairies and other agricultural facilities located within the areas represented by these agencies.

It is important to note that there are several other agencies that represent areas within the Subbasin that are mainly rural in nature. These agencies are described in Section 3.2.3 below.

3.2.1.1 Turlock Irrigation District

The Turlock Irrigation District (TID) was formed in 1887 under the provisions of the Wright Act (California Water Code § 20500 et seq.). It supplies irrigation water to approximately 150,000 acres, electricity to a 662 square mile service area, and municipal water to the community of La Grange, California. The TID irrigation service area, represented on Figure ___, covers a significant portion of the Turlock Subbasin.

TID's canal system begins at La Grange Dam on the Tuolumne River where water is diverted into TID's Upper Main Canal for conveyance to Turlock Lake, which acts as a canal regulating reservoir. From Turlock Lake, water is released into the Main Canal for distribution to downstream growers for irrigating mainly high value, non-subsidized crops.

TID owns and operates approximately 250 miles of canals and laterals (Figures??), most of which have been concrete-lined. Water that is not utilized for irrigation purposes flows to the river system. Canal spills occur through spill gates or over weirs located at the end of canals, and at several median locations within the canal system. Releases either flow directly to the river or through a drain that then flows to the river.

TID utilizes groundwater pumped from drainage and rented wells to supplement its surface water supplies. In dry years, when less surface water is available, groundwater makes up a larger portion of the overall water supply. Conversely, in wet years, less groundwater is utilized. TID owned drainage wells are used to lower groundwater levels, as well as supplement the surface water supplies. The groundwater pumped for drainage purposes is utilized as much as possible for irrigation supply. Rented wells are private or improvement district wells that are rented by the TID to supplement irrigation supplies. The actual wells rented each year varies depending upon a variety of factors including the anticipated amount of rented pumping needed, condition of the well, quality and quantity of the water pumped, etc. Water pumped from drainage and rented wells either discharge directly into the canal, into a pipeline that flows back to the canal, or into a pipeline from which it is utilized for irrigation purposes.

3.2.1.2 Merced Irrigation District

The Merced Irrigation District (Merced ID) became a legal entity on December 8, 1919. The District covers a service area of 154,394 gross acres, supplying irrigation water to approximately 10,000 acres which are within the Turlock Subbasin. The Merced River provides the principal renewable water supply for the Merced ID Water is diverted from the river into the portion of the Merced ID within the Turlock Subbasin by the North Side Canal from a pool created by Merced Falls Dam east of the town of Snelling.

The Merced ID owns and operates approximately 26 miles of open earthen channels within the Turlock Subbasin. Water which is not used for irrigation passes through one concrete overpour weir and discharges to the Merced River.

The Merced ID operates three (3) small domestic wells within the Turlock Subasin which provide water for recreation area facilities. The Merced ID does not own or operate irrigation water supply wells within the Turlock Subasin, but there are an unknown number of privately owned irrigation water supply wells within the area.

3.2.2 Purveyors of Municipal Water Supplies

The municipal water purveyors, described below, currently rely entirely on groundwater for their supply. Some local agencies, however, are continuing to evaluate the potential for utilizing surface water supplies to supplement groundwater resources.

In addition to drinking water supplies, many of these agencies provide wastewater treatment services to the houses and industries located within the boundaries. Some wastewater is discharged to surface waters, some is utilized for power plant cooling water, while the majority is percolated back into the groundwater system.

3.2.2.1 City of Turlock

Turlock was founded on December 22, 1871 and incorporated as a city in 1908. The City water system has always used groundwater wells to supply water to its citizens. As growth occurred, the City has added new wells as needed, to accommodate the additional supply needs. The City of Turlock currently serves a population of over 60,000 with 24 active groundwater wells and more than 180 miles of water distribution lines. The wells can produce a maximum of 53 million gallons of water per day.

Over the last ten years, potable water use has increased at an average rate of 3.5% per year, with water use in 2004 totaling 8.3 billion gallons. The average static groundwater levels over the last twenty years have declined 14 feet but the current levels still remain 8 feet above the all time low of 75 feet (below ground surface???) encountered during the 1988-1989 drought year.

In the last ten years, four city wells have been closed due to contamination. Nitrate contamination was the cause for two of the well closures and it is a major threat to the city wells. Average nitrate levels have increased over the last twenty years from 12 ppm to 20 ppm.

The City of Turlock has an additional water resource. The Regional Water Quality Control Facility discharges an average 12 MGD to the Harding Drain which flows into the San Joaquin River. Influent flows to the facility are from the City of Turlock, Denair Community Services District, Keyes Community Service District and the City of Ceres. By 2006 the regional facility will provide full tertiary treatment to the wastewater entering the facility. (NOTE: Is this still the correct timeline for tertiary treatment? Please update.)

The treated wastewater is currently used for a variety of reuse functions including landscape and agricultural irrigation as well as disposal into the San Joaquin River. Future plans for the water include use in industrial cooling towers, irrigation of City owned open space as well as being provided to private users.

3.2.2.2 City of Modesto

The City of Modesto was founded in October 1870 and incorporated as a City in 1884. There are approximately 6,600 City of Modesto water service customers located within the Turlock Groundwater Subbasin, including South Modesto, the Community of Hickman and parts of the City of Turlock. The South Modesto Service Area (Service Area), includes the areas of Modesto that are south of the Tuolumne River, and portions of unincorporated County and parts of Ceres that were part of the former Del Este service area.

Currently, the only source of domestic water to the City of Modesto's customers in the Turlock Groundwater Subbasin is groundwater. Groundwater is supplied by 12 wells in the South Modesto service area, two wells in Hickman and four wells in the Turlock area.
The annual groundwater production of the South Modesto Service Area is 4,119 acre-feet per year, while total water demands of the Service Area is 6,793 acre-feet per year. The Service Area's water demands are supplemented with water from groundwater wells from north of the Tuolumne River. Recent population projections indicate that water demands could be up to 8,733 acre-feet per year by the year 2025. Annual water production is approximately 220 acre-feet for Hickman and 541 acre-feet in Turlock. Both Hickman and Turlock water service areas are considered to be built-out.

There are groundwater quality concerns in the South Modesto service area, such as radionuclides and nitrates. Currently, there are 4 wells off-line due to water quality issues. Three of the active wells in the Service Area are currently being blended, while another has recently been put back on-line with wellhead treatment. The Hickman and Turlock water supply wells do not have any significant water quality problems at this time. However, the Turlock wells could be affected in the Arsenic MCL is lowered below 10 ppb.

The City of Modesto is currently investigating alternatives to maintain existing supplies, as well as increase the water supplies to the Service Area, including drilling wells in new developments, developing wellhead treatment opportunities and possibly purchasing treated surface water.

The City of Modesto also provides sewer service to properties in the South Modesto Service Area that are either within the Modesto Municipal Sewer District No. 1 or have sewer service agreements. The remaining properties are assumed to be on septic tanks.

The City of Modesto Wastewater Treatment Facilities are located on two sites, separated by approximately 7 miles. The Sutter Avenue primary plant (headworks, primary clarification, and solids handling) is adjacent to the Tuolumne River. The Jennings Street secondary plant (oxidation ponds, storage, and ranchlands) is adjacent to the San Joaquin River.

All domestic wastewater is initially treated at the primary treatment plant. After primary treatment, effluent from the primary plant is pumped approximately 7 miles to the secondary plant through twin 60-inch outfall pipelines, where it is treated further. While a portion of the secondary treated effluent is disposed of as ranchland irrigation, the majority of the effluent is stored in ponds and is seasonally discharged to the San Joaquin River.

3.2.2.3 City of Ceres

The City of Ceres, incorporated in 1918, supplies drinking water to approximately 35,000 customers from groundwater pumped by the City's wells. The City's wells are capable of pumping a maximum of 17.5 million gallons per day. During 2003, water production was 3.2 billion gallons.

The City collects, treats, and disposes of 1.0 billion gallons of wastewater each year. Currently, disposal takes place in 108 acres of percolation ponds. A pipeline to the City of Turlock Water Quality Control Facility has been constructed. Future plans are to pump 1.0 million gallons per day of treated wastewater to Turlock for disposal, freeing up additional disposal capacity in the City of Ceres percolation ponds.

3.2.2.4 City of Hughson

The City of Hughson was founded in 1907 and incorporated as a City in 1972. Hughson is the smallest city in Stanislaus County, with a population that has grown from 3,259 in 1990, to 5,232 in 2004. The City of Hughson uses groundwater to provide domestic water to approximately 1900 connections within its 1.42 square mile service area.

The current annual production within the Hughson service area is 956 acre-feet/year (or 312 million gallons/year). Recent population projections indicate that water demands could be up to 4,764 acre-feet/year (or 1552 million gallons/year) by the year 2023.

At the direction of the California Department of Health Services, the City is in the process of increasing source capacity by replacing its Well Number 2 and providing storage tank capacity as well. The system currently has no reservoir storage capacity.

The City of Hughson also provides wastewater services to properties within its service area. All domestic wastewater goes through primary and secondary treatment processes, and is disposed of through percolation ponds.

3.2.2.5 Hilmar County Water District

The Hilmar County Water District was founded in 1965 pursuant to the California Government Code. The District serves the unincorporated community of Hilmar in northern Merced County. The District encompasses approximately 225 acres, all of which are fully developed. The Merced County Planning Department is currently conducting a study to update the Specific Urban Development Plan for the Hilmar area. The results of the study, anticipated to be completed in early 2006, could lead to possible expansion of the District's boundaries.
Within its current service area, the District provides domestic water and sewer services to 1,504 connections, and a population of approximately 4,850 people (as of the 2000 census). Current demand for water reaches nearly 1.8 MGD during the summer months with a peak hour flow demand close to 3,000 GPM. Annual production of domestic water from the District's three (3) wells for the year 2004 totaled 1,380 acre-feet (or 452 million gallons). In order to accommodate growth, the District's master plan calls for construction of storage facilities and additional well development.

The District also provides wastewater services to properties within its service area. The District treates sanitary sewage utilizing an Advanced Intergrated Wastewater Pond System. The wastewater facilities are permitted to treat up to 0.55 MGD. The current average daily flow is 0.43 MGD. In 2004, the annual flow of treated effluent to 17 acres of percolation ponds was 480 acre-feet (or 157 million gallons).

3.2.2.6 Delhi County Water District

NEED INFORMATION from Delhi CWD or Merced Co. to fill in this section.

3.2.2.7 Denair Community Services District

The Denair Community Services District (CSD) is a community water system located in the unincorporated town of Denair approximately four miles north-east of Turlock, in central southern Stanislaus County.

The Denair CSD was formed on October 3, 1961 pursuant to California Government Code Section 61000, et. seq., and is under the regulatory jurisdiction of the Department of Health Services Stockton District Office. Denair CSD has 1,250 non-metered active service connections and 10 commercial metered connections at various locations.

The Denair CSD provides domestic water supply to approximately 3,300 people, according to the 2000 census.

All of the water for Denair CSD is supplied from five deep wells. The district has produced water, which continuously meets all State drinking water requirements. The objective of the District is to maintain the highest quality of water to meet all customers' needs in the most efficient and financially sound manner.

Denair CSD does not provide wastewater services to the community of Denair. Wastewater generated from the community is transported to the City of Turlock for treatment and disposal.

3.2.2.8 Keyes Community Services District

The Keyes Community Services District was formed on June 20, 1955 pursuant to California Government Code, Section 61000, et. seq. The District is located in the unincorporated community of Keyes, near the City of Turlock. The boundaries of the District encompass approximately 467 acres, while the LAFCO approved Sphere of Influence (SOI) includes 804 acres .

The District provides sewer, water and street lighting services to the community of Keyes. In addition, the District has a contractual agreement with the City of Turlock for sewer disposal services. According to a ______ LAFCO report, the District serves 1,274 customers with municipal water and 1,317 customers sewer service. With regards to sewer service, the report indicated that the District is operating at capacity and must negotiate with the City of Turlock to purchase additional capacity to serve future development within its sphere of influence.

As of ________, the District utilized 5 groundwater wells and 3 lift stations to provide domestic water to areas within the District boundaries. The report indicated that in order to serve future growth areas, and due to changes in state regulations with regards to groundwater, the District may explore other alternatives such as supplementing the existing water well system with treated water. (Need info. from Keyes or Stanislaus Co. to complete.)

3.2.2.9 Ballico Community Services District

The small, rural community of Ballico is located approximately 8 miles southeast of Turlock, and 2 miles north of the Merced River. The community has approximately 65 residences, a small number of businesses, and an elementary school. It has a community public water system operated by the Ballico Community Services District, but at this time there is no community sewer system available. The community is not large enough at this time for a community sewer system, and it is not able to consolidate with another community due to distance.

The District was formed in the late 1980's for constructing a public water system. The system began operation in July, 1989.

The District currently has one well serving the community. A slight amount of growth in the community has been experienced, however future growth in Ballico depends upon obtaining an additional water supply.

Given the very small size of the community, it is often difficult to find a sufficient number of residents willing to volunteer to serve as members of the Ballico Community Services District Board of Directors. When there are no volunteers to maintain the needed number of board members, the Merced County Board of Supervisors appoints persons from the area at-large to serve.

3.2.3 Other Local Public Agencies Participating in Groundwater Management Activities

This section provides a description of the other local public agencies situated within the Turlock Subbasin that play a role in groundwater management. There are two water districts that represent rural areas within the Subbasin. These agencies do not provide water supplies to their customers, but represent these areas in water related issues.

In addition, the Turlock Subbasin is bisected by two counties. The counties, should they choose to adopt the Plan, will represent the areas within the Subbasin that are not located within the boundaries of another local public agency. Regardless of whether a county adopts the Plan to officially "represent" those areas, the counties are members of the Association, and will continue to participate in groundwater management activities within the Subbasin.

Groundwater makes up the majority of water utilized for domestic and agricultural purposes within the areas represented by the agencies described below. There are some lands, located adjacent to the irrigation districts described in Section 3.2.1 above, which utilize small amounts of surface water supplies provided by an adjacent irrigation district, when possible. The availability of the surface water supplies varies based on hydrologic, operational, institutional and facility-related constraints. In addition, some local agricultural operations have riparian water rights and pump surface water from the rivers adjacent to the Subbasin. The operations able to utilize this supply are only those parcels located directly adjacent to the river.

3.2.3.1 Eastside Water District

The Eastside Water District (District) is comprised of about 54,000 acres in Merced and Stanislaus Counties farming high value, non-subsidized crops that are irrigated by highly efficient methods. Most of the land within District is agricultural and is irrigated with groundwater. The only other source of supply is a very limited amount of surface water from purchases in wet years from the Turlock and Merced irrigation district's canals lying adjacent to District and from riparian water rights along the Tuolumne and Merced Rivers. The groundwater within the vicinity has dropped dramatically since the mid 1950's.

The EWD does not at present supply water. It was formed to address declining groundwater levels. It may at some point supply water. The District does not own or operate any water conveyance or storage facilities.

The District was formed in 1985, after about twenty years of struggle, in recognition that if the overdraft was allowed to continue unabated there could come a time when pumping groundwater for irrigation would no longer be economic, or the quality of water pumped would not be satisfactory for irrigation. The District was formed, by election of landowners within the District, under California Law, as a legal body to address water needs of the area. The District is governed by a five person Board of Directors elected to serve alternating four year terms.

Since the late 1980's the district has conducted a number of studies with the objective identifying ways to stabilize groundwater levels. In 1994, the District completed a Groundwater Management Plan under California Assembly Bill 3030. ~~In years 1995 through 2000~~On a year to year basis since 1995 the District developed and funded an incentive program to encourage irrigators to use available wet year water from the Turlock and Merced irrigation districts. In 1996 EWD began investigation of the potential of recharging the aquifer using constructed recharge basins. After boring test holes at various locations in the EWD, a site adjacent to the TID Highline Canal, just South of Monte Vista Avenue was selected for construction of the Monte Vista Pilot Recharge Basin. Operation of the basin in 1998, 1999 and 2000 proved to be successful.

The District has joined other agencies who pump water from the common Turlock Groundwater Basin in developing and adopting a Basin-wide Groundwater Management Plan with the objective of coordination and joint efforts to stabilize groundwater levels.

3.2.3.2 Ballico-Cortez Water District

The Ballico-Cortez Water District is comprised of about 6,700 acres mainly located in Merced County farming high value, non-subsidized crops. Most of the land within District is agricultural and is irrigated with groundwater. The only other source of supply is a very limited amount of surface water from purchases in wet years from the Turlock and Merced irrigation district's canals lying adjacent to District. The groundwater within the vicinity has dropped dramatically ~~over the past 49 years~~since the mid 1950's.

The Ballico-Cortez Water District does not at present supply water. It was formed to address declining groundwater levels. It may at some point supply water. The District does not own or operate any water conveyance or storage facilities.

The District was formed in the 1960's in recognition that if the overdraft was allowed to continue unabated there could come a time when pumping groundwater for irrigation would no longer be economic, or the quality of water pumped would not be satisfactory for irrigation. The District was formed, by election of landowners within the District, under California Law, as a legal body to address water needs of the area. The District is governed by a five person Board of Directors elected to serve alternating four-year terms.

CHECK WITH BCWD TO ENSURE THIS IS CORRECT

3.2.3.3 Stanislaus County

NEED INFORMATION

3.2.3.4 Merced County

The Merced County Division of Environmental Health was established in 1952. The Division conducted inspections of food establishments, labor camps, substandard housing, water supplies, sewage and solid waste disposal problems. The Division also responded to citizen's complaints relating to nuisances such as flies and odors. Additionally, the Division was instrumental in establishing community sewer and public water systems for many communities in Merced County.

The Division adopted a water well ordinance in 1975. It began issuing well construction permits, destruction permits, and conducting inspections of new water installations and destructions. Similarly, the Division issues permits and conducts inspections of sewage disposal system installations and repairs.

Over the years, the Division has added and expanded environmental health programs to include: land use planning, dairy and animal confinement, underground fuel storage tanks, hazardous materials, childhood lead exposure, medical waste disposal, tattoo and body piercing facility inspections, backflow prevention, and abandoned vehicle abatement. The programs involve ensuring that federal, state, and local standards are being met, and taking enforcement action when necessary to achieve compliance.

The Division recognizes the prime importance of protecting and conserving the groundwater supply, for quantity as well as quality. The Division has been from the outset, and continues to be, an active participant in the local groundwater associations within both the Turlock and Merced subbasins.

3.3 LAND USE PLANNING ACTIVITIES

The various agencies within the Subbasin participate in a variety of land use planning activities which serve to ensure water supply availability, groundwater protection, and other groundwater management related activities. Section 1.4.3 above describes some of these activities, while Appendix C provides a more detailed listing of activities per agency.

3.3.1 Agencies' Sphere of Influence

A Local Agency Formation Commission (LAFCO) ensures the orderly growth of cities, decides on proposed annexations, and whether district or agency boundaries can be expanded or changed. LAFCO defines the limits of a city or service district and the sphere of influence for each city and local public agency in the state.

The sphere of influence of a local public agency's land use planning activities are generally consistent with their political boundaries. Figure ____ shows the political boundaries of the local public agencies. In addition, activities outside of their boundaries, which can impact land and water uses within their boundaries are also of interest.

3.3.2 Planning for Growth

Local agencies within the Subbasin have a variety of planning practices to ensure they are able to meet the needs of their constituents. Local cities conduct their own planning activities, while the local County Planning Department, with the advise of a Municipal Advisory Committee, fulfills this role for the unincorporated areas (i.e. any urban agency that is not a "city"). Planning efforts, as they relate to groundwater management activities, are described in Section 1.4.3 and Appendix C.

3.3.3 Potential Future Annexations

As urban growth continues, municipal agencies will continue to annex lands historically represented by other local public agencies, into their agency. As a result, the sphere of influence of the various agencies is anticipated to change as growth occurs.

As urban growth occurs, there is likely to be a corresponding decrease in agricultural lands within the Subbasin boundaries.

3.3.4 Other Land Use Planning or Regulatory ActivitiesChanges

Land use changes on privately owned properties, are planned by the individual property owner. Growers, for example, determine the water supply use, irrigation method, cropping patterns, and other issues for their lands. Unless a permit is required to install buildings, wells, or other structural improvements, the modifications are not part of a larger land use planning process.

Within this area of the State, the Central Valley Regional Water Quality Control Board is responsible for protecting water quality. Although the majority of regulatory programs are surface water related, the Regional Board is responsible for the protection of both surface water and groundwater resources. An example of programs designed to protect water quality include: permitting of wastewater treatment plants, industries, and other point sources discharges; Agricultural Waiver and urban stormwater runoff programs designed to address non-point source discharges; Basin Plan Amendments implemented to address water quality impairments in surface waters; as well as a new dairy permitting program.

4 WATER RESOURCES IN THE TURLOCK SUBBASIN

Locations of water agencies within the Turlock Subbasin are shown in **Figure __**. Water purveyors within this area utilize both surface water and groundwater supplies. Some rely exclusively on groundwater, while others use a combination of surface water and groundwater to meet their needs. The groundwater and surface water supplies available to the region are summarized below.

4.1 GROUNDWATER SUPPLIES

DWR Bulletin 118 (2003) defines a groundwater basin as an alluvial aquifer or a stacked series of alluvial aquifers with reasonably well defined boundaries in a lateral direction with a definable bottom. In its text, the Bulletin further defines a groundwater basin as an area underlain by permeable materials capable of furnishing a significant supply of groundwater to wells or storing a significant amount of water. The bulletin defines a groundwater subbasin as a subdivision of a groundwater basin created by dividing the basin using geologic and hydrologic conditions or institutional barriers.

The following sections describe the Turlock Subbasin; its geographical location; the geology and hydrogeology of the Subbasin; as well as groundwater facilities, usage, recharge, quality and other groundwater supply related issues.

4.1.1 Turlock Subbasin

A map showing the area of the Turlock Subbasin, as defined in DWR Bulletin 118 (2003) is presented in **Figure __**. It is important to note that groundwater basins and subbasins are three-dimensional and include both the surface extent and all of the subsurface fresh water yielding material. However, available data used by DWR to determine the groundwater basin and subbasin boundaries, only permits two-dimensional delineation of groundwater basins. The current DWR groundwater basin maps, including the maps used to identify the Turlock Subbasin and the adjacent areas depict a surface expression of groundwater basin boundaries and it should not be construed to imply that these boundaries extend downward in a three-dimensional fashion.

As defined in DWR Bulletin 118 (2003) the Turlock Subbasin is a portion of the San Joaquin Valley Groundwater Basin. The San Joaquin Valley is bounded on the west by the Coast Ranges, on the south by the San Emigdio and Tehachapi Mountains, on the east by the Sierra Nevada Foothills and on the north by the Sacramento-San Joaquin Delta and Sacramento Valley. Drainage within the San Joaquin Valley flows in two directions. The northern portion of the valley drains toward the Delta by the San Joaquin River and its tributaries, the Fresno, Merced, Tuolumne, and Stanislaus Rivers. The southern portion of the valley is internally drained by the Kings, Kaweah, Tulare, and Kern Rivers that flow into the Tulare drainage basin including the beds of the former Tulare, Buena Vista, and Kern Lakes.

The Turlock Subbasin lies within the eastern portion of Stanislaus and Merced counties and covers approximately 347,000 acres or 542 square miles. The Subbasin is situated between the Tuolumne and Merced rivers and is bounded on the west by the San Joaquin River and on the east by crystalline basement rock of the Sierra Nevada foothills. The subbasin's northern, western, and southern boundaries are shared with the Modesto, Delta-Mendota, and Merced Groundwater subbasins, respectively.

The following sections provide a description of the geologic and hydrogeologic conditions of the underlying groundwater basin.

4.1.1.1 Hydrogeologic Setting and Water Bearing Deposits

As stated above, DWR Bulletin 118 (2003) defines the groundwater basin boundaries and provides a description of the hydrogeologic setting for the San Joaquin Valley Groundwater Basin and the Turlock Subbasin. The description provided below is primarily taken from DWR Bulletin 118 (2003), and supplemented with addition information as it was available.

The San Joaquin Valley represents the southern portion of California's Central Valley. The valley is a structural trough up to 200 miles long and 70 miles wide, filled with up to 32,000 feet of marine and continental sediments of Cretaceous age (140 million years ago) through Quaternary age (through today). The valley geologic formations were deposited due to the periodic inundation by the Pacific Ocean and by erosion of the surrounding mountains, respectively. Continental deposits originating from the surrounding mountains form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough.

The Turlock groundwater basin represents a subbasin of the San Joaquin Valley Groundwater Basin. The primary hydrogeologic units in the Turlock Subbasin include both consolidated and unconsolidated sedimentary deposits that are as much as 16,000 feet in thickness within the western portion of the subbasin (California Division of Mines and Geology, 1966a). Figures ___ and ___ show the generalized extent, thickness and stratigraphic position for the hydrogeologic units of the Turlock Subbasin.

The consolidated deposits include the following formations, listed in order from the oldest to youngest deposits: the Ione Formation of Eocene age, the Valley Springs Formation of Miocene age, and the Mehrten Formation, which was deposited during the Miocene to Pliocene Epochs. Water within the Valley Springs and Ione Formations is typically saline due to the marine shales contained within these formations. The consolidated deposits lie in the eastern portion of the subbasin and generally yield small quantities of water to wells, except for the Mehrten Formation, which is an important aquifer.

Unconsolidated deposits, including continental deposits, older alluvium, younger alluvium, and flood-basin deposits, overlie the Mehrten Formation. Those units are known as the Turlock Lake, Riverbank and Modesto formations. Both the Turlock Lake and Modesto formations contain lake and floodplain deposits. Where those fine-grained deposits occur within the Turlock Lake Formation, they are referred to in this report as the shallow aquitard. Lacustrine and marsh deposits, which constitute the Corcoran or E-clay aquitard, underlie the western half of the subbasin at depths ranging between about 50 and 200 feet (DWR 1981). The continental deposits and older alluvium are the main water-yielding units in the unconsolidated deposits. The lacustrine and marsh deposits and the flood-subbasin deposits yield little water to wells. The younger alluvium, in most places, probably yields only moderate quantities of water.

4.1.1.2 Geologic Formations

The following paragraphs describe in more detail each of the water bearing formations within the Turlock Subbasin. Information utilized to draft this section of the report were derived from the Water Balance Study conducted by the Turlock Groundwater Basin Association, as well as information contained within DWR Bulletin 118 (2003). As noted above, Figures ___ and ___ show the generalized extent, thickness and stratigraphic position for the hydrogeologic units comprising the groundwater system, including the Corcoran Clay and the shallow aquitard. (NOTE: Figures 1.7-1.8 of the water balance study – Need to renumber figures when inserting them into the revised Plan.)

The Modesto Formation, which is of late Pleistocene age (about 1 million years ago to today), outcrops in the western one-third of the subbasin (Figures 1.7 and 1.8) and is as much as 120 ft 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 1.7), and does not crop out at the land surface (Figure 1.8). The unit is comprised of silt and clay with some sand. The shallow aquitard is encountered 30 to 50 ft 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 Subbasin (Figures 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 200 ft. 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 1.7 and 1.8). 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 aquitard portion of the Turlock Lake Formation (Figures 1.7 and 1.8) ranges in thickness from 10 to 80 feet, and is typically found at depths ranging between 50 to 200 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 Subbasin.

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 Subbasin (Figures 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 800 ft. The formation consists of claystone, tuff siltstone, breccia, sandstone, and conglomerate (Page, 1973); yields small to moderate quantities of water to wells; and is saline at lower elevations within the western and central parts of the Turlock Subbasin.

The Valley Springs Formation, which is of Miocene age (24 million to 5 million years ago), underlies the Mehrten Formation and crops out on the eastern edge of the Turlock Subbasin (Figures 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 500 ft (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 34 million years ago), underlies the Valley Springs Formation and crops out on the eastern edge of the Turlock Subbasin (Figures 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 200 ft (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 Subbasin (Page, 1986).

4.1.1.3 Aquifers

Groundwater within the Turlock Subbasin occurs under unconfined and confined conditions. As described in DWR Bulletin 118 (2003) a portion of the Basin is underlain by the Corcoran clay which separates the groundwater into two zones; an upper, unconfined aquifer and a lower, confined aquifer (see Figure 2 – NOTE: Figure 2 in old Plan – Figure 1.8 of the water balance study – Need to renumber when plan is finalized). There is also a deeply buried confined aquifer containing saline brine extending into the unconsolidated sediments. The presumed origin of the saline brine is the connate water sourced with the Upper Cretaceous marine shales that underlie the Pleistocene and Holocene sediments.

The following sections describe in more detail the various aquifer conditions found within the Turlock Subbasin.

Unconfined Aquifer

An unconfined aquifer is an aquifer in which the groundwater is not under pressure. In the Turlock Subbasin, the unconfined aquifer occurs in unconsolidated sedimentary deposits, mainly within the Modesto and Riverbank formations, situated above and to the east of the Corcoran clay. In the area underlain by the Corcoran clay, the top of the clay is the base of the aquifer. To the east of the clay, the top of the consolidated rocks is the base of the aquifer. Above and to the east of the Corcoran clay, the top of the unconfined aquifer is the water table. The unconfined aquifer has areas, particularly in the western portion of the subbasin, which are locally confined by clay layers that are not continuous over long distances. This area is referred to as the shallow aquitard and is described further below.

With the exception of those areas containing the shallow aquitard, the unconfined aquifer is the water-table aquifer. It is about 150 feet in thickness, and the depth to its top ranges from less than 10 feet in the western part of the subbasin to 50 feet within the central part of the subbasin. Within the western part of the subbasin, the unconfined aquifer is used as an agricultural supply. Wells less than 200 feet in depth draw for the unconfined aquifer.

The general direction of regional groundwater flow in the unconfined aquifer is westward and southward towards the valley trough (see Figure ___). The direction of groundwater flow is controlled by the elevations of the Tuolumne, Merced and San Joaquin rivers. The elevation of the water table is maintained along these rivers at the local elevation of the water surface within the river. Groundwater levels are maintained by exchanges of water between the river and the groundwater system.

Freshwater Confined Aquifer

A confined aquifer is an aquifer in which the groundwater is contained under pressure. The aquifer referred to in this report as the confined aquifer is contained within the unconsolidated deposits of the Turlock Lake and Mehrten formations. The top of the consolidated rocks is the base of the unconsolidated deposits. It is confined by the Corcoran clay member of the Turlock Lake Formation within the western part of the subbasin. The top of the confined aquifer in this area is the bottom of the Corcoran clay. The aquifer is semi-confined within the eastern part of the basin, where the Riverbank Formation directly overlies it. It is unconfined in the eastern part of the subbasin, where the Turlock Lake and Mehrten formations crop out.

The freshwater confined aquifer is about 1,300 feet in thickness, and the depth to its top ranges from 200 feet in the western portion of the subbasin to 100 feet within the eastern portion of the subbasin. The freshwater confined aquifer is used extensively as an agricultural and municipal water supply. Wells greater than about 200 feet draw from the freshwater confined aquifer. However, such wells will also draw from the unconfined aquifer, if the depth to the top of the well perforations is less than 200 feet.

Based on general hydrologic considerations, the direction of groundwater flow in the confined aquifer is probably similar to that in the unconfined aquifer, westward and southward. Under historical conditions, the hydraulic head in the confined aquifer was greater than that of the unconfined aquifer, which caused water to flow upwards through the Corcoran clay from the confined to the unconfined system. Under present conditions, the pumping that has occurred in the unconfined aquifer would tend to maintain an increase in the upward gradient (head differential) between the aquifers. However, because of the lack of information on the conditions in the confined aquifer, an upward gradient across the Corcoran clay cannot be confirmed.

Saline Confined Aquifer

Fresh groundwater in the San Joaquin Valley is underlain by a saline brine groundwater body. The saline confined aquifer occurs within the Valley Springs and Ione formations. The aquifer is confined except where the formations crop out. The saline confined aquifer is about 600 feet in thickness, and the depth to its top ranges from 1,500 feet in the western portion of the Turlock Subbasin to 100 feet within the eastern portion of the subbasin. The deep aquifer is used little as a water supply.

Some gas exploration wells were drilled into the deep marine rocks along the Tuolumne River near Waterford and Ceres. The wells were artesian, flowing wells which produced saline brines without pumping for many years, until they were plugged in the 1970's. The artesian conditions indicate that the deep, saline groundwater is under sufficient hydraulic head (pressure) to push water up to the land surface. This head will cause the saline water to migrate upwards where movement is possible. This upwelling can occur in wells, as well as along cracks, fissures, and faults. Saline brines are migrating upward and mix with the shallow fresh groundwaters to form high total dissolved-solids (TDS) groundwater at a certain depth below the surface. The base of the fresh water is extremely variable and often occurs in the unconsolidated sediments.

The deep, saline groundwater flows, as does all the groundwater in the valley, from the valley's sides towards its trough. Upwelling occurs at the trough where the flows from the opposite sides of the valley meet, and the only direction for the water to go is up. On the surface, the San Joaquin River occupies the valley trough. Water for the river flow is derived in the same way. Groundwater flows from the opposite sides of the valley meet and move upwards providing water to the river.

Shallow Aquifer

The discontinuous shallow aquitard, and an overlying shallow aquifer that occur within the unconfined aquifer result in a high groundwater table in the western portion of the subbasin. The low vertical permeability of the shallow aquitard restricts the downward percolation of infiltrated precipitation and irrigation applications. The shallow aquifer is a water-table aquifer. The depth to groundwater can be less than 6 feet in these areas. The aquifer is about 40 feet in thickness, and the shallow aquitard forms its base. The shallow aquitard is about 15 feet in thickness.

4.1.2 Groundwater Usage

Discharges from the Turlock Basin occurs because of pumping from wells, groundwater seepage to the Tuolumne, Merced and San Joaquin rivers, discharges from subsurface agricultural drains, and water use by riparian vegetation. A recent water budget study conducted by the Turlock Groundwater Basin Association resulted in the following water usage information. (Durbin, 2003)

Groundwater is utilized to supply the water needed by both agricultural and urban users within the Basin. Between 1998 and 2002 it is estimated that an average of 411,000 AF/yr was pumped by agricultural and urban agencies as well as small domestic water systems and private property owners for domestic or agricultural uses. The following sections further describe these uses.

4.1.2.1 Agricultural Groundwater Pumping

The Turlock Irrigation District supplements its surface water supply with groundwater to satisfy crop-water requirements, the extent of which varies from year to year depending on the availability of surface water. The TID pumps groundwater directly into canals from both TID owned drainage wells and rented wells for distribution to users within its irrigation service area. In addition, some individual growers within the District pump groundwater to supplement their surface water allotments, while others use groundwater to meet their entire crop-water requirement.

Like the Turlock Irrigation District, the Merced Irrigation District supplements its surface water supply with groundwater to satisfy crop-water requirements, the extent of which varies from year to year depending on the availability of surface water. The Merced ID pumps groundwater directly into canals, laterals and pipelines exclusively from Merced ID-owned irrigation and drainage wells. All of Merced Irrigation District’s wells are located outside the area of the Turlock Groundwater Basin. Even so, the District incorporates pumped groundwater into its’ total supply and makes deliveries to lands in the area of the Turlock Groundwater Basin on the same basis as it delivers to other lands within its’ District boundaries. Only in severe drought conditions does the Merced ID permit the discharge and wheeling of groundwater from privately owned wells into the Merced ID’s water conveyance system. In some areas of Merced ID, growers meet their crop-water requirements from their own groundwater supplies.

Growers within the Eastside and Ballico-Cortez water districts have limited access to surface water supplies for irrigation purposes, and rely upon the groundwater to supply their crop-water requirements. Within these districts there are individual properties with access to occasional surface water deliveries from either Turlock or Merced irrigation districts. This type of water is not available on a consistent basis, being dependent upon both surface water availability and system capacity constraints. Therefore, due to the unreliability of this type of water, it is appropriate to assume that the growers within the Eastside and Ballico-Cortez water districts must rely on groundwater to supply their crop-water requirements.

There are agricultural areas located outside of the local water agency boundaries which also utilize groundwater to irrigate their crops. There is a fairly large area located on the eastern boundary of the Basin. Starting in 1985, this area, called the "foothill non-district" subarea in Section 3.1, has had significant conversions from non-irrigated to irrigated lands.

In addition to agricultural irrigation water, groundwater is pumped for a variety of agricultural operational needs. A portion of which may ultimately be used irrigation supply purposes. For example, groundwater is pumped to supply dairy operations water supply needs. A portion of the water may find its way into the lagoon, and utilized for irrigation purposes. This water use is considered small, as compared to the overall amount of irrigation water use within the Subbasin.

The total annual application of groundwater for irrigation purposes varies from year to year depending on the availability of surface water. In wet years, less groundwater is needed to supplement irrigation supplies. Drainage pumping to lower groundwater levels also varies depending on the weather conditions. For the period between 1998 and 2002, the average drainage pumping within the basin was about 69,000 AF/yr, while the average agricultural pumping totalled 296,000 AF/yr.

Growers within the Turlock Irrigation District utilize groundwater to supplement canal deliveries or for use on farm for purposes other than irrigation. Between 1998 and 2002, the average pumping from private and improvement district owned wells for various agricultural purposes is estimated to be 20,946 AF/yr. Figure _____ (Fig. 3.2 of Durbin Study) shows the annual estimated pumping from these wells.

TID uses groundwater pumped for drainage purposes, as well as rented wells to supplement its surface water supplies. Rented pumping by TID varies depending on surface water supplies and operational constraints. Figure ____ (Fig. 3.3 of Durbin Study) show the annual rented pumping between 1952 and 2002. From 1998-2002 the average rented pumping totaled __________________.

Some growers within the TID choose not to receive surface water and irrigate with groundwater instead. The average pumping from these types of wells was estimated to average 9,200 AF/yr during the recent 1998-2002 timeframe. It is important to note, however, that this type of pumping increased from an estimated 4,000 AF/yr in 1998 to about 13,000 AF/yr in 2002. Figure ____ (Fig. 3.4 of Durbin Study) provides a graphical illustration of this type of pumping between 1952-2002. The majority of these lands have switched from flood to drip/micro irrigation methods. Should additional lands choose to make a similar switch, and not utilize surface water supplies, the demand upon groundwater will increase.

Growers within Merced Irrigation District also receive a combination of groundwater and surface water supplies. As with the TID, there are some growers within the MID that choose not to receive surface water and irrigate with groundwater instead. The combined pumping from MID and private sources was estimated to be 120 AF/yr between 1998-2002. Figure ____ (Fig. 3.7 of Durbin Study) provides a graphical illustration of the extent of this type of pumping between 1952-2002.

Growers within Eastside and Ballico-Cortez water districts as well as the non-district areas produced a combined estimated 250,000 AF/yr between 1998-2002. With the exception of those properties adjacent to the rivers that have riparian water rights, these areas rely upon groundwater for their entire water supply. Figures _____, ______ and ______ (Figures 3.5, 3.6 & 3.8 of Durbin Study) illustrate the estimated water usage in these areas between 1952 and 2002.

It is estimated that growers within the non-district areas, located along the river margins and east of the Eastside and Ballico-Cortez water districts, pumped an average of 99,000 AF/yr between 1998 and 2002. With the exception of those properties adjacent to the rivers that have riparian water rights, these areas rely upon groundwater for their entire water supply. Figure _____ (Figure 3.8 of Durbin Study) shows the estimated groundwater usage in these areas between 1952-2002. As agricultural development continues to occur in these areas, the dependence upon groundwater will likely increase.

4.1.2.2 Urban Groundwater Pumping

Presently, municipal, industrial and individual domestic water users rely solely on groundwater. While the supply has been adequate, the groundwater quality has deteriorated in some areas to the point where treatment is required to make it suitable for these uses.

The communities of Ceres, Delhi, Denair, Hickman, Hilmar, Hughson, Keyes, south Modesto, and Turlock pump, collectively, from approximately 76 wells. The average pumping from municipal wells was about 42,000 AF/yr between 1998-2002. Figures _____ (Fig. 3.9a-I of the Durbin Study) show the annual pumping for municipal wells from 1952 to 2002.

As urban development continues, the demands upon groundwater supplies will increase unless alternative supplies are considered.

There are an estimated 3,300 residences within the Turlock Basin that are not connected to a municipal water system which pump groundwater for domestic supply. The average pumping from private or small community wells was about 4,000 AF/yr between 1998 and 2002.

4.1.2.3 Other Groundwater Outflows

Groundwater discharges occur along the lower reaches of the Tuolumne and Merced rivers, and along the entire reach of the San Joaquin River. Along the upper reaches of the Tuolumne and Merced rivers, groundwater is recharged by streamflows. However, under current conditions, the net effect is that the groundwater discharge to the rivers exceeds the streamflow recharge to the groundwater system. Between 1998 and 2002, the net groundwater discharge to rivers was approximately 41,000 AF/yr.

High groundwater levels are known to occur in mainly the western and southern portions of the Subbasin. Water levels that encroach into the crop root zone can reduce crop yields. As a result, some local growers have installed subsurface drains to lower the groundwater table on their lands. Between 1998 and 2002, subsurface drains removed approximately 14,000 AF of high groundwater per year.

Lastly, phreatophytes, plants that live along the river system with their roots below or near the water table extract their water requirements directly from the saturated zone. There are approximately 18,500 acres of native phreatophytes along the Tuolumne, Merced and San

Joaquin rivers. The average groundwater consumption of riparian phreatophytes was estimated to be 41,000 AF/yr between 1998 and 2002.

4.1.3 Groundwater Recharge

Groundwater recharge occurring within the Basin is mainly the result of the irrigation of crops and landscape vegetation, precipitation, percolation from the Tuolumne and Merced rivers, leakage from Turlock Lake, underflow from the Sierra Nevada foothills, and upward seepage from deep geologic fractures. A recent water budget study conducted by the Turlock Groundwater Basin Association (Durbin, 2003) resulted in the following calculated estimates of recharge occurring within the Basin from 1998-2002. The total recharge from the various sources within the Basin was calculated to be approximately 508,000 AF/yr.

The majority of recharge is due to irrigation, which occurs when the applied irrigation water and effective precipitation exceed the consumptive use of agricultural crops or landscape vegetation. The excess water infiltrates below the crop root zone and then percolates downward into the groundwater table. It is estimated that irrigation produced groundwater recharge of nearly 428,000 AF/yr. Recharge from croplands was estimated to be 422,000 AF/yr, while recharge from landscaping within urban areas was approximately 6,000 AF/yr.

Groundwater recharge from precipitation on dry, undeveloped land occurs when the effective precipitation exceeds the consumptive use of the annual or perennial vegetation. This process produces an average of 42,000 AF/yr of recharge.

Turlock Lake, a regulating reservoir on the Turlock Irrigation District's canal system, receives water from the Tuolumne River. The reservoir has a surface area of approximately 3,300 acres. Because Turlock Lake is underlain by the moderately permeable sediments of the Mehrten Formation, water leaks from the lake into the underlying and adjacent groundwater system. The average leakage was estimated to be approximately 36,000 AF/yr.

The Basin is also recharged from subsurface inflows that enter the groundwater basin across its eastern boundary and the base of the groundwater system. Recharge from both these sources was calculated to be about 3,000 AF/yr.

As indicated in Section 4.1.2 above, streamflow from the Tuolumne and Merced rivers provide recharge to the Turlock Basin, mainly along the upper reaches of the rivers. However, within the lower reaches of the Tuolumne and Merced rivers, as well as where the San Joaquin River borders the Basin, groundwater typically discharges to the rivers. Within the water budget study (Durbin, 2003), streamflow-groundwater interactions were expressed in terms of the net groundwater discharge to the rivers. The actually groundwater inflow or outflow per location was not calculated. However, between 1998 and 2002, there was a net discharge of approximately 41,000 AF/yr to the river system. Therefore, the discharge to the river system from the Basin significantly exceeded the recharge.

4.1.4 Groundwater Conditions

Groundwater conditions within the Basin vary. Levels in the eastern areas have declined significantly since the 1960's. Levels in the western areas of the Basin are high to the point of requiring pumping in certain areas to keep the groundwater from encroaching into the root zone of agricultural crops.

Figures ______ (Fig. 13a-d of Durbin Study) show a series of contours of groundwater elevations between 1960 and 1998. The figures illustrate the cone of depression that has formed on the eastern side of the basin, largely due to pumping groundwater to irrigate lands east of the Turlock Irrigation District, where surface water supplies are not available.

Additional analysis of the water level readings from several wells, provides an understanding of the changes in water levels of the various areas within the Subbasin over time. Figure ____ (Figure 1.12 of Durbin Study) provides a reference point as to the location of each well within the Subbasin. Figures _____ through _____ (Figures 1.14a-d of Durbin Study) provide hydrographs of the groundwater levels at each of these well sites. Analysis of the well data shows that although there has been a decline in groundwater levels since the 1960's, particularly in the eastern portion of the groundwater basin, there has been a slight recovery in groundwater levels in some areas, and a stabilization of levels in others.

A recent study of the basin's groundwater budget has found that although there has been an increase in pumping over the last three decades, a new state of equilibrium appears to have been established within the basin. The outflows from the groundwater basin are about balanced with the inflows, and the year-to-year groundwater level storage and the corresponding groundwater levels are not changing significantly over time.

It is important to note that while the groundwater basin is currently in a newly found state of equilibrium, it will most likely not be permanent. For example, the delicate balance can be easily disrupted by changes in groundwater pumping due to increased urbanization; further agricultural development in areas dependent upon groundwater for irrigation purposes; changes in irrigation practices resulting in the movement from surface water to groundwater supplies; and changes in cropping patterns.

4.1.5 Groundwater Quality

Groundwater is a component of the water supply, and as such, the quality of local groundwater is an important issue to consider. The following section describes the monitoring conducted, conditions within the basin, as well as various issues and concerns facing the local agencies.

4.1.5.1 Groundwater Quality Monitoring

Water quality monitoring requirements for public water systems are set by Title 22, Chapter 15, of the California Code of Regulations and vary depending upon the type of water system. Large public water systems (greater than 200 service connections) are regulated by the State of California. Wells at large public water systems must be sampled, for general mineral, physical, inorganic, organic, and radiological analyses. Small public water systems (less than 200 service connections) are regulated by local county environmental health agencies. Sampling of small public water systems is dependent upon type of water system: small community, non transient non community, transient non community or state small. Public water systems are required to perform routine bacteriological analyses, usually from water distribution systems. Frequency of bacteriological analyses is defined in Title 22, Chapter 15, California Code of Regulations, and varies depending upon type of water system.

A standardized monitoring system has not been established for private domestic wells, or the agricultural community. Individual domestic well owners, farmers and agricultural agencies do monitor groundwater quality, however, the monitoring frequency and constituents monitored varies throughout the Basin. In most cases, the water quality data for the private domestic and agricultural wells sampled is not publicly available.

4.1.5.2 Water Quality Conditions

There are numerous constituents found in the Basin's groundwater supply. Some constituents occur naturally, while others have been introduced into the groundwater from man-made sources. Many constituents found in groundwater do not, according to current water quality standards, have the potential to impact groundwater usage within the Basin. These constituents are not addressed in this section. The constituents identified in this section either currently impact groundwater usage within the Basin, or have the potential to impact the Basin's future groundwater usage. (Asked the Counties what info. from water supply well sampling is available.)

Salinity

Salinity can be of concern for both irrigation and municipal uses. Salinity levels are expressed as a total salt concentration or total dissolved solids (TDS), or electrical conductivity (EC). Salinity is a measure of the total sum of dissolved inorganic ions and molecules. The most common salts found in water include sodium chloride (NaCl, also referred to as "table salt"), calcium sulfate ($CaSO_4$, better known as "gypsum"), magnesium sulfate ($MgSO_4$ or "Epsom salts"), and sodium bicarbonate ($NaHCO_3$ also known as "baking soda"). Salts dissolve in water and form positive ions (cations) and negative ions (anions). The most common cations are calcium (Ca^{2+}), magnesium (Mg^{2+}), and sodium (Na^{+}) while the most common anions include chloride (Cl^{-}), sulfate (SO_4^{2-}), and bicarbonate (HCO_3^{-}). Potassium (K^{+}), carbonate (CO_3^{2-}), boron (B^{3+}) and nitrate (NO_3^{-}) also exist in water supplies.

TDS is usually expressed in milligrams of salt per liter (mg/L) of water. This represents the total number of milligrams of salt that would remain after 1 liter of water is evaporated to dryness. The higher the TDS, the higher the salinity of the water.

EC is another means of describing salinity levels. Salts dissolved in water conduct electricity, and, therefore, the salt content in the water is directly related to the EC. Units of EC reported by laboratories are usually in millimhos per centimeter (mmhos/cm) or decisiemens per meter (dS/m).

Often conversions between EC and TDS are made, but caution is advised because conversion factors depend both on the salinity level and composition of the water. A typical conversion factor is as follows:

$$TDS(mg/L) = 640 \times EC(dS/m), \text{ when } EC < 5 \text{ dS/m}$$
$$TDS(mg/L) = 800 \times EC(dS/m), \text{ when } EC > 5 \text{ dS/m}$$

In addition, sulfate salts do not conduct electricity in the same way as other types of salts. Therefore, if water contains high levels of sulfate salts, the conversion factors are invalid and must be adjusted upward.

The recommended municipal supply limit for salinity is 500 mg/l (TDS) with 1,000 mg/l being the highest allowable limit for long term use.. Municipal wells with a depth ranging from 184 to 450 feet (within the City of Ceres and Turlock) have produced water between 260 and 810 mg/l TDS. (Do any of the other agencies have data on this. Please send me your info. so I can describe the range of values.)

Agricultural crops vary in the sensitivity to salinity levels. Beans, for example, are one of the most sensitive crops, where EC greater than 0.7 mmhos/cm (or 450 mg/l TDS) can result in reduced crop yields. However, almonds, grapes, apricots, peaches and plums can all thrive on water with an EC of 1.0 mmhos/cm or (640 mg/l TDS). . Technically it is the salts of the element sodium that are largely responsible for most of the crop injury or yield loss. Salinity reduces crop yield primarily by reducing the ability of the plant roots to absorb water. In essence, even though the field appears to have plenty of water, the plants wilt because insufficient water is absorbed by the roots to replace that which was lost from transpiration. Total dissolved solids in groundwater in the eastern two-thirds of the Basin is generally less than 500 mg/l. TDS in groundwater increases westward towards the San Joaquin River and southward towards the Merced River. In these areas, high TDS water is found in wells deeper than 350 feet. Better quality groundwater (less than 1,000 mg/l) in these areas is found at shallower depths.

Within the confined aquifer, groundwater with high TDS concentrations is principally the result of the migration of a deep, saline water body which originates in regionally deposited, marine sedimentary rocks that underlie the San Joaquin Valley. The depth of this saline water body within the Basin boundaries, is very shallow compared to other parts of the Valley.

Groundwater with high concentrations of total dissolved solids is present beneath the entire Basin at depths from about 400 feet in the west to over 800 feet in the east. The shallowest high TDS groundwater occurs in zones five (5) to six (6) miles wide adjacent and parallel to the San Joaquin River and the lower part of the Merced River west of Hilmar, where high TDS groundwater is upwelling.

Under natural pressure, the saline groundwater body is migrating upward. Brines move up through permeable sedimentary rocks and also up through wells, faults and fractures. The chemistry of groundwater in the Basin indicates that mixing is occurring between the shallow, fresh groundwater and the brines, which produces the high TDS groundwater observed. Pumping of deep wells in the western and southern parts of the Basin may be causing these saline brines to upwell and mix with fresh water aquifers more rapidly than under natural conditions.

The Corcoran clay has provided a natural impediment to the migration of high TDS groundwater from the confined aquifer into the unconfined aquifer. High permeability pathways through the clay from the confined to the unconfined aquifer may be created by wells perforated in both the unconfined and confined aquifers.

A variety of salts are represented in measured salinity levels within the Basin, including nitrates. As noted below, there are areas within the Basin where the shallow aquifer has higher nitrate concentrations, and therefore higher salinity levels. Agricultural wells in these areas have been known to produce water ranging from __________ to _________ mg/l TDS.

Nitrates
Nitrate is an important parameter in drinking water, and in some cases may affect crops. Nitrate can be from both natural and man-made sources, and is widespread in groundwater in many parts of the San Joaquin Valley. High concentrations of nitrate in groundwater are mostly a concern for potable water supplies. The maximum contaminant level (MCL) for nitrate in public drinking water supplies is 45 mg/L (as NO^3).

Communities within the Basin, including Ceres, Turlock, Keyes, Delhi, Hilmar, Denair and South Modesto have had wells test high in nitrate concentrations close to or exceeding the current MCL. No specific areas containing higher concentrations of nitrates have been identified by the urban agencies. The presence of nitrates in the confined aquifer, utilized by the urban agencies for supply, seems to be sporadic. To date, the only means of determining the potential water quality for a new well site is to drill a test hole and draw samples.

The City of Modesto has implemented ion exchange wellhead treatment for wells that are high in nitrates. In this process, the contaminated groundwater is pumped into the ion exchange unit, where the nitrate levels are reduced below the MCL. The treated water is then introduced back into the water distribution system. The City of Modesto has installed systems at City Well No. 100 (South Modesto) and at wells in the Community of Grayson.

Nitrate in irrigation water is not a major concern for many crops, since it acts as fertilizer. However, permanent crop production, including grape vineyards, may be adversely affected by excess nitrate concentrations. However, nitrates in groundwater pumped into the canal system for irrigation supply can contribute to aquatic weed growth. Aquatic weeds can clog irrigation systems and impede the flow of irrigation water, impacting irrigation water deliveries.

High nitrate concentrations are typically found in shallower groundwater zones. It has been attributed to various sources, such as agricultural fertilizers, sewer effluent, septic tank disposal, and animal wastes.

Iron and Manganese
Groundwater in several areas within the Basin has elevated iron and manganese levels. Some wells in the cities of Ceres, Turlock and South Modesto, as well as within what was the Del Este system have encountered problems due to manganese. Generally "reducing conditions" (lack of oxygen) may lead to elevated iron and manganese levels in groundwater. Also, shallow groundwater near streams often has high manganese and sometimes high iron concentrations.

No specific areas where iron and/or manganese have been identified by the urban agencies. The presence of these constituents in the confined aquifer, utilized by the urban agencies for supply, seems to be sporadic. To date, the only means of determining the potential water quality for a new well site is to drill a test hole and draw samples.

(NEED INPUT FROM URBAN AGENCIES – Where in the Del Este System? – It might be better to list that, since Del Este doesn't exist any more.)

Boron

Boron in drinking water is not generally considered a health hazard to humans and is not currently a concern for public drinking water suppliers within the Basin. Boron concentrations up to 30 mg/L are not considered harmful in drinking water. However, concentrations above 30 mg/L may interfere with digestion due to boron's preservative effect on foods. It has been recommended that a boron limit of 20 mg/L be applied to drinking water ("Water Quality Criteria," published by the California State Water Resources Control Board, 1976).

Boron is found in most waters used for irrigation in the United States. Although traces of boron are essential for all plant growth, concentrations above the plant tolerance level can cause damage to the plant and reduce crop production. Plant tolerances for crops currently grown within the Basin varies from 0.5 mg/L for the most sensitive crops to approximately 10.0 mg/L for the most tolerant. Current boron concentrations in irrigation water are within plant tolerance levels and are not adversely impacting crop production.

Arsenic

Arsenic is naturally present in rocks and minerals in the earth's crust, and naturally is present in groundwater, at levels often higher than current and contemplated standards, especially in the western states. Arsenic is also found in pesticide formulations. Arsenic has been linked to lung and bladder cancer in humans. As a result, the Environmental Protection Agency (EPA) has promulgated a new, more stringent arsenic rule, lowering the MCL from 50 mg/l to 10 mg/l, effective January 2006. The State of California Department of Health Services (DHS) had considered establishing a lower standard for California, however, at this time it is understood DHS will conform with the US EPA MCL requirements.

Arsenic concentrations in water from public water supply wells in the Basin are typically below the old standard, but some are higher than the new MCL. As a result, urban agencies are considering options available to reduce arsenic levels, including utilizing surface water supplies, or installing costly wellhead treatment technologies. Should the State of California adopt new, more stringent standards, most local urban water supplies will be impacted.

For example, the City of Turlock has two wells that will require treatment in order to meet the new EPA limit. With treatment they do not anticipate any loss of water capacity at these wells. These wells are less than 10% above the new limit.

The City of Modesto's arsenic levels, in the system wells, vary from non-detect to 10 mg/L. If the California DHS lowers the arsenic MCL in the future, several Modesto wells, including a few of the City wells in the Turlock sub-basin, could exceed the MCL, and would be removed from the domestic water system.

Arsenic levels within the City of Hughson system average around 11 µg/l. A treatment assessment study has been conducted by Carollo Engineers (available on the City website at www.Hughson.org) to determine suitable treatment options to meet the new Federal and State MCL limits. Hughson is working towards the development and implementation of a treatment system to achieve this goal.

Radionuclides

Radionuclides are produced as a result of radioactive decay of certain elements. These parameters are primarily from natural sources and can affect drinking water supplies. The drinking water standard for "gross alpha," the general measure of the potential for radioactive substances to be in the water is 15 picocuries per liter. Additional testing is required for specific radioactive species, if radiological constituents above the MCL are detected. The MCL for uranium is 20 picocuries per liter.

Sampling in the Basin for radiological constituents has generally been limited to public water systems. Groundwater with high uranium activities has been detected in the Hilmar, Hughson, South Modesto and ____________(ARE THERE OTHER AREAS WE NEED TO INCLUDE?) areas. The occurrences are indicated to be natural and are based on available data.

The City of Modesto's gross alpha levels vary from non-detect to 35 picocuries per liter, while uranium levels vary from non-detect to 40 picocuries per liter. A number of City of Modesto wells, including a few in South Modesto, have been removed from water production due to gross alpha and/or uranium contamination.
Within the City of Hughson, uranium was found in one of the production wells in 1986. The well was subsequently closed.

The EPA has discussed establishing a standard for radon in drinking water. Depending on how low this standard is set, natural activities of radon could be a concern in the future.

Bacteria

Bacteriological quality in the Basin is generally acceptable in deep groundwater aquifers. Bacteriological quality of groundwater pumped by individual wells can not be generalized and depends on many factors pertaining to the well and surrounding conditions.

Inadequately constructed and improperly located, destroyed or abandoned water wells may contribute to bacteriological contamination of groundwater. Some of the factors that may influence contamination of water wells include: location with respect to sources of contamination; inadequate construction features being present on wells; general deterioration and or inadequate maintenance of wells; improper use of water wells for disposal of wastes.

Bacteriological contamination of groundwater is a health concern since groundwater is used for drinking water. Water wells used to supply drinking water are routinely tested for pathogenic microorganisms. The City of Ceres, for example, tests their wells weekly.

Pesticides

Pesticide contamination is primarily the result of the widespread use of the agricultural nematicide Dibromochloropropane (DBCP) on crop lands for several decades before it was banned in 1977. DBCP in the groundwater is usually associated with vineyards or orchards where the pesticide was used. DBCP is a carcinogen at very low concentrations in water, and is a concern for potable water supplies. It moves freely with the groundwater and persists for long periods. The MCL for DBCP is 0.2 micrograms per Liter (μg/l). DBCP has been found in two wells in the Turlock at extremely low levels, just above the detection limit. DBCP has also been found in public water supply wells in the South Modesto, Keyes and Ceres areas at levels either close to or exceeding the MCL. In the case where the DBCP levels are exceeding the MCL, wellhead treatment is being utilized. (WHAT IS THE DETECTION LIMIT FOR DBCP? IS IT CLOSE TO THE MCL? IF SO, SHOULD I ADD TURLOCK TO THE LIST OF CITIES ABOVE?)

Another pesticide that has been detected in the Basin's groundwater is ethylene dibromide (EDB). EDB (another agricultural nematicide, used primarily on vineyards, that was banned in the early 1980's) has been detected in one public water supply well in the Turlock area.

Trichloroethylene

Trichloroethylene (TCE) is a nonflammable, colorless liquid with a sweet odor and is used as a solvent for dyes, rug cleaners, as well as a degreaser for metal parts. Improper storage and disposal have made TCE a major contaminant of groundwater supplies in California, however the extent of TCE contamination within the Basin is currently unknown. TCE is known to contaminate water wells close to refineries, metal processing plants, chemical manufacturers, military bases, and electroplating operations. The contamination is persistent due to TCE's long half-life in groundwater which typically ranges from 9 months to 3 years.

The California Drinking Water Action Level of 5 ppb (5 parts per billion is equivalent to 5 μg/l) for TCE is based upon what is considered a negligible risk level for cancer. In other words, if one million people drank about 2 liters of water containing TCE at this level every day over a 70 year lifetime, there would theoretically be no more than one additional case of cancer in the million people exposed.

Other Trace Organics

Other trace organic compounds have been detected in the Basin's groundwater including, but are not limited to, carbon tetrachloride, perchloroethylene and hydrocarbon-based products. Improper use, storage and accidents have resulted in unauthorized releases of these substances.

Volatile organic compounds (VOC's) derived primarily from solvents have contaminated the groundwater, in some areas. Some of these can be attributed to industries that handle, store and use solvents. Perchloroethylene (PCE) has been detected at one time or another in some of the Basin's public water supply wells. Industrial wastes and dry cleaners are a recognized source of

PCE in groundwater in some municipal areas, such as the City of Turlock.

Carbon tetrachloride is often attributed to auto repair shops which have historically used it as a solvent or degreaser. One well within the City of Turlock was closed in 1999 due to levels of carbon tetrachloride exceeding the MCL of 0.5 µg/l in public water supply wells. It is not clear if this compound was in the groundwater or was a contaminant of the oil used to lubricate the pump.

Several unauthorized releases from underground storage tanks (UST) have occurred in the Basin. Most of these cases are very localized in nature in terms of groundwater impacts, and public water supply wells are not known to have been affected. The Merced County Division of Environmental Health, and the Stanislaus County Department of Environmental Resources is involved in monitoring and regulating the clean-up of sites involving many VOC and UST spills. The county agencies have a contract with the State Water Resources Control Board to provide mitigation services for the definition and clean-up of releases resulting from underground storage tanks.

4.1.5.3 Areas of Concern

Agricultural and municipal agencies within the Basin are concerned about maintaining adequate supplies of groundwater within the Basin. Groundwater is the primary source of water for the agricultural agencies on the eastern side of the Basin. As a result, they are concerned about the continued decline of groundwater levels on that side of the Basin. The municipalities, which also rely on groundwater for their source of water, are not as concerned about the present quantities of water as they are about the future quantities of water which will be needed as the cities continue to expand.

Agencies within the Basin are also concerned about maintaining the Basin's groundwater quality. The Basin, generally, has good quality groundwater. As a result, the municipalities are not currently required to provide significant water treatment. In most cases, treatment is limited to chlorination.

However, there are some areas of water quality concern. For example, saline brines continue to migrate upward from the saline confined aquifer, resulting in increased salinity levels. In addition, constituents such as PCE, DBCP, EDB, uranium, nitrates, manganese and iron have been found in a few water supply wells within the Basin. In a few cases, these constituents have impacted the municipalities' ability to utilize the wells to supply potable water and resulting in the wells being retired, or requiring some form of treatment. In the future, the municipalities within the Basin may be required to investigate various options, such as well head treatment, to meet ever increasingly stringent minimum water quality requirements. An example of one such substance of concern is arsenic. New EPA and state standards will likely impact most local agencies.

Additionally, it is important to note, that the San Joaquin River is listed as impaired for salt and boron. The Central Valley Regional Water Quality Control Board adopted a Basin Plan Amendment to implement a control plan in the form of a TMDL (Total Maximum Daily Load) to address both salt and boron concentrations in the river. The water quality objectives at

Vernalis are as follows:

Salinity:	0.7 mmhos/cm during the irrigation season 1.0 mmhos/cm during the non-irrigation season
Boron:	0.8 mg/L during the irrigation season1 1.0 mg/L during the non-irrigation season

In addition, the Regional Board plans to adopt salinity standards upstream of Vernalis.

The Basin Plan Amendment recognizes the interaction between groundwater and surface water flows, and therefore that groundwater is a component of the salt loading in the river system. As a result, if implementation measures to control surface water inputs do not result in the required improvements, the Regional Board has committed to developing a groundwater control plan to improve the salinity contributions from groundwater sources.

4.2 SURFACE WATER SUPPLIES

4.2.1 Supplies

The Turlock Irrigation District and the Merced Irrigation District are the only entities within the Basin with access to firm supplies of developed surface water. During wet years, at the discretion of the Turlock and Merced irrigation districts, irrigators outside the districts boundaries, but situated along the districts canals, are offered surface water. In addition, there are some individual property owners, with riparian rights that utilize water from the bordering rivers. The extent of this type of usage is undocumented.

The Turlock Irrigation District's main source of water is through surface water diversions from the Tuolumne River. TID and the Modesto Irrigation District jointly operate the Don Pedro Reservoir on the Tuolumne River to store winter and spring runoff for agricultural and municipal uses. The surface water available to growers within TID is based on the runoff each year coupled with its share of carry-over storage from Don Pedro.

The Merced Irrigation District's main source of surface water is the Merced River. Merced ID operates Lake McClure to store winter and spring runoff for summer irrigation. The surface water available to Merced ID each year is based on the runoff for that year coupled with the Merced ID's direct diversion rights and stored water from Lake McClure.

Within the Basin, surface water supplies an average of fifty-three percent (53%) of the total irrigation water applied to land within the districts, or approximately 470,000 acre-feet per year. Figure ____ shows the annual surface water used for irrigation between 1952-2002. A significant part of applied irrigation water percolates past the root zone to become groundwater recharge. The effect of the deep percolation of applied surface water on groundwater recharge is illustrated on Figure ___ (Inflows and Outflows to Groundwater Basin). Therefore, a majority of water in the Basin groundwater system originated from the Tuolumne River, and to a much lesser extent the Merced River. (NOTE: From old plan – need to update and include additional information from Water Balance Study)

4.2.2 Surface Water Quality

As described earlier, surface water is diverted from the Tuolumne and Merced rivers for irrigation purposes. The quality of the river surface water supplies is exceptionally high. Similar water is diverted on the north side of the Tuolumne River, treated, and delivered to the City of Modesto for drinking water purposes.

No known water quality problems have been identified for these sources.

4.3 OTHER SUPPLIES

Although surface water diversions is the main water supply within the Subbasin, other sources are water are utilized. These sources are described below.

4.3.1 Precipitation

Within the Basin, precipitation alone does not satisfy urban and agricultural water supply requirements. The amount of precipitation in this part of the valley varies widely from year to year. According to DWR Bulletin 118 (2003), the average annual precipitation is estimated to be 11 to 13 inches, increasing eastward, with 15 inches in the Sierra foothills. TID records show a forty (40) year average of ____ inches at its Broadway Yard facility in the city of Turlock.

Since the majority of precipitation falls in the winter, most landscaping, crops and orchards are dependent upon irrigation during the growing season. While the precipitation does not fully satisfy water demands, it does contribute to groundwater recharge. Therefore, the groundwater system contains some portion of water that originated from the direct infiltration of precipitation.

Stormwater ponds and dry wells are facilities designed to help manage urban stormwater runoff generated when precipitation falls on impervious areas or in excess of the land's ability to readily absorb the water. These facilities also provide a means for stormwater to percolate down into the groundwater system. Most communities have stormwater ponds. Dry wells, an older means of disposing of stormwater, are found within the communities of South Modesto, Turlock, and _____________ . (NEED INPUT FROM THE OTHER URBAN AGENCIES…)

4.3.2 Recycled Water

The major municipal water suppliers in the Basin, in the course of disposing treated effluent, are in the practice of reclaiming water for either reuse or percolation. Many agencies utilize percolation ponds to dispose of wastewater, while others utilize the water for irrigation purposes. Table ___ (was Table 6) illustrates the various methods of treated effluent reuse, recharge and disposal within the Basin.

The City of Modesto is currently working on a Recycled Water Feasibility Study for their area of influence.

(NEED TO UPDATE TABLE 6 FROM THE PREVIOUS GW MGMT. PLAN. IF YOU HAVE NOT ALREADY, PLEASE PROVIDE THE NECESSARY DATA.)

4.3.2.1 Reuse

The City of Modesto imports wastewater into the Basin each year, for example, between 2000 and 2004 it imported an average of 4,605 million gallons (14,132 acre-feet), 2,805 million gallons (8,607 acre-feet) of which is utilized for irrigation purposes on 2,526 acres of land adjacent to the San Joaquin River. The remainder is currently stored in ponds and seasonally discharged to the San Joaquin River. The City, however, is considering expanding the reuse of treated water for irrigation in the future.

The City of Turlock Regional Water Quality Control Facility currently reuses a portion of its wastewater effluent to irrigate 135 acres of farmland. The wastewater facility is in the process of upgrading to tertiary treatment, with the new upgrades expected to be on-line by 2006. Up to two MGD of this effluent is anticipated to be used by the new TID Walnut Energy Center that is due to be on-line in early 2006. Plans are being made to also use the tertiary treated effluent for irrigation of parks, medians, landscaping, and additional crop irrigation. Use of recycled water will offset the need for additional groundwater supplies.

The City of Ceres reuses it's treated effluent for landscape irrigation purposes at the wastewater treatment plant. Landscape uses total approximately 221 acre-feet per year, or 300,000 gpd during summer months and 100,000 gpd during winter months.

(DO ANY OF THE OTHER AGENCIES REUSE WATER FOR LANDSCAPE IRRIGATION OR OTHER USES?)

4.3.2.2 Percolation

The cities of Ceres and Hughson, and Hilmar and Delhi county water districts utilize percolation ponds as a means of disposing of treated effluent. Through these facilities a portion of the water is evaporated, while the remaining water percolates into the groundwater system. Approximately _____ acre-feet of treated effluent is delivered to percolation ponds each year. As these communities continue to grow, the amount of water percolated through this processes will increase proportionately.

(CERES – approx. 3,159 acre-feet/year;

HILMAR – approx. 480 acre-feet/year;

HUGHSON – approx. ___________ acre-feet/year?

DELHI – approx. ________ acre-feet/year?)

(NEED UPDATED DATA TO INCLUDE IN TEXT AND TABLE 6 (from old GW Mgmt. plan).

4.4 FACILITIES AND OPERATIONS

Public agencies and individual property owners have facilities they own, operate and maintain to provide water for their needs.

4.4.1 Facilities Owned by Local Public Agencies

Turlock and Merced irrigation districts own and operate a water delivery system canals and laterals that transport surface water to local growers. The majority of the time, water flows by gravity to the irrigated land. The majority of lands within the districts are irrigated using flood irrigation techniques. However, some growers have moved to drip/micro or other more advanced technologies. Water is managed within the canal system to minimize spills to the river and maximize the efficient use of water within District facilities.

The urban agencies within the Subbasin currently rely entirely on groundwater for their supplies. Some agencies utilize chlorination and a variety of storage tank options, while others do not. Wells, storage tanks and distribution lines are designed to meet the needs of each individual community.

Urban agencies utilize the general planning process to evaluate the facilities and resources needed to supply the projected population growth within their community. As communities grow, they continue to consider the best combination of water supply and infrastructure improvements to meet their needs.

4.4.2 Other Public Facilities

There are small community water supply systems that are operated by the community and regulated by the local county environmental health agency. These communities rely entirely upon groundwater for their supplies.

4.4.3 Privately Owned Facilities

All irrigation facilities within the Eastside and Ballico-Cortez water district are privately owned and operated. Growers have installed irrigation supply wells as needed, to irrigate their crops.

Privately owned irrigation supply wells, and domestic wells are installed in locations throughout the Subbasin to provide irrigation and on-farm water, as well as private domestic supplies to rural homes and businesses. These facilities are installed, operated, and maintained and on an as-needed basis, to meet the individual needs of the property owner.

5 GROUNDWATER MANAGEMENT PLAN

5.1 DEFINITION OF THE GROUNDWATER BASIN

The California Water Code § 10752 defines a groundwater basin as "any basin identified in… Bulletin 118… but does not include a basin in which the average well yield, excluding domestic wells that supply water to a single-unit dwelling, is less than 100 gallons per minute." The area within the Turlock Groundwater Subbasin is described in detail in Section 4.1.1 above.

5.2 AGENCIES COVERED UNDER GROUNDWATER MANAGEMENT PLAN, THEIR BOUNDARIES, AND GROUNDWATER MANAGEMENT AREAS

As described in Section 1.2 above, there are a wide variety of agencies located within the Turlock Groundwater Subbasin. The Subbasin has been divided into Groundwater Management Areas or "subareas," defined by the political boundaries of the local public agencies. Each agency represents the lands within their boundaries. In the event that a City, County Water District, Community Services District or other municipal water supply agency lies within an irrigation district or other entity's boundary's, the municipal water supply agency will represent the overlapping areas. Similarly, although both Merced and Stanislaus county's combined cover the entire Subbasin, the county's management areas are defined as those areas not contained within another agency's boundaries.

This document, developed by the Association, is designed to cover the entire Subbasin. However, each agency is required to adopt the Plan for their respective agency. As a result, only those areas within the boundaries of the agencies which adopt the Plan, are covered. Appendix F lists the agencies which have adopted the Plan, as well as a copy of the resolutions pertaining to those actions.

It is important to note that agencies that may choose not to adopt the Plan will be encouraged to continue to participate in the Association, work with the other local agencies in groundwater management related activities, and consider adopting the Plan in the future.

5.3 BASIN MANAGEMENT GOALS AND OBJECTIVES

The agencies within the TGBA agree that the groundwater and surface waters within the Turlock Groundwater Basin are a vitally important resource that provides the foundation for maintaining current and future water needs. Preservation of these resources is essential in order to maintain the economic viability and prosperity of the Basin area. It is the goal of the Agencies that groundwater will continue to be a reliable, safe, efficient and cost effective water supply. The agencies, individually and collectively, are pursuing and will continue to pursue water management strategies to maintain viable local sources of water supply. The goals of the agencies and the TGBA include:

1. Maintain an adequate water level in the groundwater basin.
2. Protect groundwater quality and implement measures, where feasible to reduce the potential movement of existing contaminants.

3. Monitor groundwater extraction to reduce the potential for land subsidence.
4. Promote conjunctive use of groundwater and surface waters.
5. Support and encourage water conservation.
6. Develop and support alternate water supplies. Educate users on the benefits of water recycling.
7. Continue coordination and cooperation between the TGBA members and customers.

5.3.1 Maintain Groundwater Levels

Groundwater conditions within the Basin vary. Levels in the eastern areas have declined significantly since the 1960's. Levels in the western area of the Basin are high to the point of requiring pumping in certain areas to keep the groundwater from encroaching into the root zone of agricultural crops. Based on a recent study, the groundwater basin overall is close to being in balance. However, significant declines in water levels have been noted on the east side of the basin and in several cities as their use of water has increased with increased urbanization.

There are several programs and policies that can be used to help maintain adequate groundwater levels.

- Monitor groundwater for usage, quality and water levels.
- Encourage conjunctive use policies that decrease the use of groundwater when surface water supplies are abundant.
- Develop a water budget within the basin to establish if the basin or areas within the basin are in overdraft.
- Support a comprehensive approach to identify and protect natural recharge areas .
- Support and encourage water conservation programs to reduce ground water usage.
- Evaluate feasibility of groundwater recharge projects.
- Capture storm water run off for recharge or use as an alternate water supply.

5.3.2 Protect Groundwater Quality

While water quality within the basin is generally acceptable, there are many wells that have constituents of concern, at levels impacting the use of the water, primarily for municipal supplies. Contamination is usually found first in public potable water sources since these wells are analyzed on a regular basis. Actions that may be taken to protect groundwater quality, reduce the risk of movement of existing contaminants include the following:

- Continue to support a program to monitor area wells that are not currently required to test for water quality.
- Develop and maintain a database of water quality data for the use of the Association.
- Encourage sound well standards and well abandonment practices to protect groundwater quality.

- Promote land use practices that protect the groundwater recharge areas from contamination.
- Implement measures to stabilize groundwater levels to reduce the movement of contaminants.
- Evaluate the impact of urbanization on groundwater levels and quality.
- Where practicable, use recent hydrogeologic assessments to develop programs and to implement projects that control the migration of poor quality water.
- Where possible, reduce reliance on wells that may induce the upward movement of salts within the Basin.

5.3.3 Land Subsidence

Historically, land surface subsidence within the basin has not been significant. It does not appear that subsidence will be a major problem in the future as long as the ground water levels are maintained at current levels. The Association will investigate any reports of land subsidence that may occur in the future and develop a policy based on the results of the investigation.

5.3.4 Conjunctive Use

The Association will continue to promote policies that allow groundwater banking and alternate surface water uses that benefit the local groundwater basin.

- Agencies within the basin are evaluating the potential for utilizing surface water to supply a portion of the potable water needs within the urban areas. The use of surface water for potable uses will reduce the quantity of groundwater extracted by the domestic water suppliers, thus helping to maintain adequate groundwater levels within these areas.
- The continued use of flood irrigation in agricultural operations is useful in banking water for later use in dry years. It also helps reduce salt buildup in the soil that may be detrimental to crops.
- A study is proceeding to determine if groundwater recharge basins on the east side of the district could be used to help stabilize groundwater levels in the area.

5.3.5 Water Conservation

There are several conservation programs that are available for both agriculture and domestic uses. The Association will promote conservation for all water users in the Basin.

- Current legislation requires water metering for domestic users. Several studies have shown meters reduce water use by 20-25%.
- Promote water rates that require domestic users to pay for the actual amount of water used instead of a flat rate for unlimited use.
- Educate users on the most efficient water use practices for agriculture, commercial, industrial and domestic users that would result in reduced use of groundwater supplies, help maintain groundwater levels, and protect groundwater quality.

5.3.6 Alternate Water Supplies

The Association will support when appropriate, the development of additional water supplies such as the use of recycled water and storm water. Such an approach should be implemented in a manner that is protective of groundwater quality. In addition, changing water quality regulations must be considered when implementing such programs.

Sources of supply could include:

- Wastewater effluent when properly treated can be used for agriculture, landscaping, and industrial cooling uses.
- Excessive landscape runoff captured by storm water systems could be contained and used for additional irrigation.
- Storm water could be captured and used for groundwater recharge or other uses.
- Reuse of non-potable water: Where feasible, groundwater that does not meet potable water regulations may be used for crops.
- Promote the increased use of shallow non-potable wells for irrigation of crops, landscaping and other non-potable uses. These wells typically have been used to reduce high groundwater levels and to supplement irrigation. Other uses of this water could include industrial cooling water, decorative fountains, parks and roadside landscaping.

5.3.7 Cooperation and Coordination

Members of the TGBA will continue coordination among the member agencies and interested parties to mange the water supplies within the Turlock Groundwater Basin. The TGBA will continue to cooperate and develop basin-wide programs and projects to benefit the basin's resources.

The TGBA meetings will continue to be a forum where regional, state and federal agencies can meet to discuss ongoing and future regulatory issues.

5.4 GROUNDWATER MANAGEMENT AREAS' GOALS AND OBJECTIVES

The basin management objectives for the Turlock Subbasin, described above, are supported by groundwater management goals and objectives for each of the subareas. In some cases, the Subbasin and subarea goals and objectives may be one in the same. In other cases, agencies may have additional goals and objectives they wish to pursue, beyond those of the Subbasin. The goals and objectives for each of the subareas is listed in Appendix E.

5.5 CURRENT GROUNDWATER MONITORING ACTIVITIES

5.5.1 Groundwater Level Monitoring

Groundwater level monitoring is conducted by a variety of agencies within the Basin. DWR has a network of wells throughout the valley that are monitored on a semi-annual basis. In addition, local agencies have developed a similar program, monitoring groundwater levels at local supply wells. Local monitoring activities are typically conducted in November and March of each year.

The November measurement is meant to represent the "after irrigation season" measurement, when crops are going dormant, and irrigation is no longer occurring. By that time, the canneries are no longer utilizing significant amounts of water. Conversely, the March measurement is designed to illustrate the groundwater levels before next irrigation season starts, and after much of the rainfall received has percolated into the soil.

5.5.2 Groundwater Quality Monitoring

Local cities and small community water systems conduct water quality monitoring of the wells utilized to supply drinking water. The Department of Health Services (DOHS) regulates the type of monitoring and frequency required to ensure the quality of local drinking water supplies. The information from these monitoring practices is available for review and analysis.

To a lesser extent, agriculture has conducted limited monitoring of agricultural wells. The wells are typically constructed differently, and often draw from different aquifers than the municipal supply wells.

5.5.3 Subsidence Monitoring

There has been no significant subsidence detected within the Subbasin to date. Local agencies have wells and other facilities that would be experiencing problems should subsidence be occurring. Inquires with DWR have shown no documented occurances of subsidence within the Turlock Subbasin (telephone conversation with Al Steele from DWR). Should conditions change, local agencies will consider subsidence monitoring in the future.

5.6 GROUNDWATER MONITORING PLAN

A review of the groundwater quality and level data available should be reviewed and evaluated as a starting point to development of a comprehensive basin-wide groundwater monitoring plan. The plan should be developed to meet the goals and objectives of the Basin's agencies.

(WE MAY NEED TO ADD MORE SPECIFICS HERE – EXPAND ON THE DETAILS OF THE CURRENT MONITORING PROGRAM. PROVIDE A MAP SHOWING THE MONITORING LOCATIONS, PROVIDE DETAILS ON THE MONITORING SITES, DESCRIBE HOW THE DATA IS TO BE USED, ETC… - SB820 WILL IMPACT THE REQUIREMENTS FOR THIS SECTION!!!)

5.7 FACILITATING CONJUNCTIVE USE OPERATIONS

Conjunctive use of groundwater and surface water in a groundwater basin typically occurs when the surface water supply to the Basin varies from year to year and Basin water demand is relatively constant. In some years, the surface water supply is greater than the Basin water demand; in other years, the surface water supply is less than the Basin water demand. In the years of plentiful supply, surface water is utilized to recharge the groundwater aquifer. Recharge can occur either directly by surface recharge or injection well, or by using surface water in lieu of groundwater when it is available. In effect, the groundwater basin is utilized as a storage reservoir and water is placed in the reservoir during wet years and withdrawn from the reservoir during dry years. Turlock and Merced irrigation district have been practicing an informal form of conjunctive use for years as a means of making the best use of available resources. In wet years where more surface water is available, the districts rely more heavily on surface water to supply irrigation customers. In drier years, when less surface water is available, groundwater is used to supplement surface water supplies both by the irrigation districts as well as individual growers with access to wells. Since irrigation is the main source of recharge within the Subbasin, this form of conjunctive use results in surface water flows recharging the groundwater basin in wet years, making groundwater available in drier years when it is needed.

To a lesser extent, conjunctive use is facilitated by the districts through the sale of irrigation water to lands adjacent to their canals, but located outside the irrigation district service area. When surface water is available, and there is sufficient canal capacity to deliver the water, TID and MID sell surface water supplies to growers that would otherwise be required to pump groundwater to irrigate their crops. The extent this program is utilized, as well as the amount of water available various from year to year. Although the overall amount of water delivered in this manner is small compared to total irrigation deliveries within the Subbasin, the amount of water utilized results in an equivalent amount of water remaining in the groundwater system for later use. Additional conjunctive use opportunities may be available. The local agencies will continue to explore these opportunities.

6 GROUNDWATER PROTECTION MEASURES

A high priority of the Turlock Groundwater Basin Association (TGBA) is protection of the groundwater resources. This will be accomplished through a series of actions, described below, that will be implemented by the Association members and facilitated by the Association. (NOTE: THIS AN OLDER VERSION OF CHAPTER 6 THE SUBCOMMITTEE HAS PROVIDED COMMENTS TO MODESTO STAFF, WHO IS IN THE PROCESS OF MAKING REVISIONS. THE REVISED VERSION WAS NOT AVAILABLE TO INSERT INTO THIS DOCUMENT PRIOR TO ITS BEING SENT. – THE STRIKE-OUT VERSION OF CHAPTER 6 (AT THE END OF THE CHAPTER) WAS AN EARLIER VERSION DEVELOPED BASED ON LANGUAGE FROM THE OLD PLAN.)

6.1 IDENTIFICATION AND MANAGEMENT OF WELLHEAD PROTECTION AREA

The purpose of wellhead protection is to protect the groundwater used for public supply, thereby eliminating costly treatment to meet relevant drinking water quality standards. A Wellhead Protection Area (WPA), as defined by the Federal Wellhead Protection Program established by Section 1428 of the Safe Drinking Water Act Amendment of 1986, is “the surface and subsurface area surrounding a water well or wellfield supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield.” The WPA may also be the recharge area that provides the water to a well or wellfield. Unlike surface watersheds that can be easily determined from topography, WPA’s can vary in size and shape depending on subsurface geologic conditions, the direction of groundwater flow, pumping rates, and aquifer characteristics. WPA’s are not directly an agricultural issue. However, in the Turlock Groundwater Basin, because of the relationship between agricultural and municipal water uses, some important considerations in delineating WPA’s are as follows:

- Location of existing public supply wells
- Identification of probable locations of future public supply wells
- Present direction of groundwater flow
- Probable direction of future groundwater flow
- Construction characteristics of public supply wells (i.e.; perforated intervals and annular seals)
- Subsurface geologic conditions (i.e., restricting layers, confining beds, and other features)
- Rate of current groundwater flow
- Pumping from up gradient areas

- Potential sources of contamination
- Forecasted future land use

Potential areas of water quality risk include:

- Areas without improved sewage collection systems
- Areas with leaky sewer pipes and septic systems
- Wells improperly abandoned
- Confined animal feedlots
- Agricultural practices where chemicals are used
- Areas with potential for spills of hazardous materials

Identification of WPA's is a component of the Drinking Water Source Assessment and Protection Program (DWSAP Program) administered by the Department of Health Services. It set a goal for all water systems statewide to complete Drinking Water Source Assessments by December 31, 2002. The cities of Modesto, ____________ have completed their required assessments by performing the three major required components listed below:

- Delineation of capture zones around sources (wells)
- Inventory of Potential Contaminating Activities (PCA's) within protection areas
- Vulnerability analysis to identify the PCA's to which the source is most vulnerable

Delineation of capture zones includes using groundwater gradient and hydraulic conductivity data to calculate the surface area overlying the portion of the aquifer that contributes water to a well within specified time-of-travel periods. Typically, areas are delineated representing 2-, 5-, and 10-year time-of-travel periods. These protection areas need to be managed to protect the drinking water supply from viral, microbial, and direct chemical contamination.

Inventories of PCA's include identifying potential origins of contamination to the drinking water source and protection areas. PCA's may consist of commercial, industrial, agricultural, and residential sites, or infrastructure sources such as utilities and roads. Depending on the type of source, each PCA is assigned a risk ranking, ranging from *very high* for such sources as gas stations, dry cleaners, and landfills, to *low* for such sources as schools, lakes, and non-irrigated cropland.

Vulnerability analysis includes determining the most significant threats to the quality of the water supply by evaluating PCA's in terms of risk rankings, proximity to the well being surveyed, Physical Barrier Effectiveness (PBE), and whether contaminants have previously been detected. PBE takes into account factors that could limit infiltration of contaminants including type of aquifer, aquifer material (for unconfined aquifers), well operation, and well construction. The vulnerability analysis is based on a scoring system that assigns point values for PCA risk rankings, PCA locations within the wellhead protection area, and well area PBE. The PCA's to which drinking water wells are most vulnerable are apparent once vulnerability scoring is complete.

6.1.1 Actions

The Association will facilitate the following actions:

- A component of the DWSAP Program is an assessment of vulnerability of groundwater sources to quality degradation. The Association member agencies providing drinking water should obtain proper clearances for the release of information and prepare vulnerability summaries from the DWSAP Program to be used for guiding management decisions in the basin.
- Contact groundwater basin managers in other areas of the state for technical advice, effective management practices, and "lessons learned" regarding establishing wellhead protection areas.
- Attend groundwater conferences and technical workshops and meetings to learn more about groundwater management practices.

6.2 REGULATION OF THE MIGRATION OF CONTAMINATED GROUNDWATER

The migration and remediation of contaminated groundwater is of primary concern to the cities of Modesto, ________________. Also of concern is the localized contamination of groundwater by industrial point sources such as dry cleaning facilities, food processors and the numerous fuel stations throughout the Basin service area.

While the Association does not have authority or responsibility for remediation of this contamination, it is committed to coordinating with responsible parties and regulatory agencies to keep Association members informed of the status of known groundwater contamination in the basin.

6.2.1 Actions

The Association will take the following actions:

- Coordinate with the USGS to expand the network of monitoring wells to provide for an early warning system for public supply wells.

- If detections occur in these monitoring wells, facilitate meetings between the responsible parties and potentially impacted member agency(ies) to develop strategies to minimize the further spread of contaminants. Specifically, the consideration of altering groundwater extraction patterns or altering production wells in the vicinity of a pollutant plume to change the groundwater gradient.

- Provide a forum to share all information on mapped contaminant plumes and Leaking Underground Storage Tank sites in order to develop groundwater extraction patterns and in site planning of future production or monitoring wells.

- Meet with representatives of the Central Valley Regional Water Quality Control Board (RWQCB) to establish a relationship and identify ways to have open and expedient communications with the RWQCB regarding any new occurrences of contamination, particularly when contamination is believed to have reached the water table.

- Track upcoming regulations on septic systems, agricultural discharges and other regulatory programs that pertain to water quality degradation.

6.3 IDENTIFICATION OF WELL CONSTRUCTION POLICIES

The Stanislaus County Department of Environmental Resources (DER) and Merced County Division of Environmental Health (DEH) administers the well permitting program in the unincorporated areas of the Turlock Groundwater Basin. The standards for construction are consistent with those recommended in State Water Code Section 13801. This section requires counties, cities, and water agencies to adopt the State Model Well Ordinance as a minimum standard for well construction or a more rigorous standard if desired. Each city in the Association has enacted a well ordinance adopting the *California Well Standards, Bulletin 74-81*, and all supplements. This ordinance is utilized in wells constructed within the incorporated area of each city. Each city provides a review of well construction plans and specifications within the incorporated area. The Stanislaus County DER have enacted well ordinances adopting the *California Well Standards, Bulletin 74-81* and all supplements for the unincorporated areas of these counties. The Stanislaus County DER staffs also review applications and construction plans and specifications and issue permits for wells constructed or destroyed in unincorporated areas. The county requires and maintains well logs and water well driller reports for constructed wells.

Standards also exist for contractors involved in well construction. Section 13750 of the California Water Code requires that well drillers possess a C-57 Water Well Contractors License, and Section 13751 requires well drillers to file a well completion log with DWR for every production or monitoring well constructed.

The number of service connections determines whether operating permits for wells used for public drinking water are provided through the Department of Health Services, Stanislaus

County DER or Merced County DEH. The Department of Health Services has jurisdiction over public water system wells with over 200 service connections. Wells that serve public water systems with fewer than 200 service connections fall under the jurisdiction of the county.

6.3.1 Actions

The Association will facilitate the following actions:

- Ensure that all member agencies are provided a copy of the applicable county well construction ordinance and understand the proper well construction procedures.
- Coordinate with member agencies to provide guidance, as appropriate, on well construction to prevent creating conduits through regionally confining beds. Where feasible and appropriate, this could include the use of USGS lithologic data prior to construction of the well to assist in well design.

6.4 ADMINISTRATION OF WELL ABANDONMENT AND DESTRUCTION PROGRAMS

There are many unknown, obsolete or abandoned water supply and natural gas wells within the Turlock Groundwater Basin. These wells provide potential locations for monitoring of groundwater levels, but more frequently serve as a source of contamination and should be abandoned.

One of the primary concerns of local agencies is the groundwater contamination risk posed by unused wells that have not been properly destroyed. Section 21 of DWR Bulletin 74-81 and revisions contained in Part II of Bulletin 74-90 allow classification of unused wells into two types, abandoned and inactive. An abandoned well is defined as one, which has not been used for a period of one year, and whose owner has declared the well will not be used again. If the well has not been used during the past year, but the owner demonstrates his/her intention to use the well again for supplying water, the well is considered inactive. Four criteria must be met in order for a well to maintain the inactive, rather than abandoned, classification. These criteria are:

- The well has no defects
- The well is securely covered
- The well is clearly marked
- The surrounding area is kept clear of brush and debris

Failure to meet these criteria could result in the well being classified as abandoned under current regulations. All abandoned wells, exploration or test holes, and monitoring wells must be destroyed as stated in Section 22 of Bulletin 74-81 and revisions contained in Bulletin 74-90.

An abandonment program should focus on those wells that pose the greatest threat to groundwater; however, numerous factors make the abandonment and destruction of wells difficult. These factors include lack of consistency in records regarding well construction, location and use; cost of well destruction; and the defined classification for abandonment of wells. Well construction within the study area has taken place for nearly a century, with records and standards altered over time. Recent records pertinent to construction and location of new wells are more complete than earlier records, which are often inconsistent. The lack of financial incentive for well owners to declare a well as abandoned also reduces the effectiveness of the well abandonment program.

Stanislaus or Merced county administer the well destruction program in most of the Turlock Basin. The standards for construction are identified in the county codes and are based on State of California standards. However, counties have the authority to establish more stringent standards as deemed necessary to provide the necessary protection for groundwater supplies.

6.4.1 Actions

The Association members, including the counties and cities, will take the following actions for lands within their jurisdictions:

- Ensure that all Association members are provided a copy of the code and understand the proper destruction procedures and support implementation of these procedures.
- Follow up with Association members on reported abandoned and destroyed wells to confirm information collected from DWR and receive information on abandoned and destroyed wells to fill gaps in county records.
- Obtain "wildcat" map from California Division of Oil and Gas to ascertain the extent of historic gas well drilling operations in the area as these wells could function as conduits of contamination if not properly destroyed.
- Seek funding to develop and implement a program to assist well owners in the proper destruction of abandoned wells.

6.5 MITIGATION OF OVERDRAFT CONDITIONS

The Association supports activities to reduce the dependency groundwater to help minimize any potential localized overdrafting. The Association also supports actions by TID to encourage customers to continue to receive surface water deliveries so that growers do not turn to groundwater as a more flexible source of irrigation supply during periods when surface water is abundant.

Do we want to add something here to address the proposed future surface water deliveries to urban communities? The surface water will reduce groundwater impacts as well.

6.5.1 Actions

The Association will facilitate the following actions:

- Support programs that relieve aquifer overdraft through substitution of surface water for groundwater.
- Continue implementation of water conservation programs that will reduce reliance on groundwater pumping.
- Continue and enhance groundwater monitoring and groundwater use to ensure the balanced state of the groundwater basin
- Support programs by TID to improve irrigation service to water users who may otherwise irrigate using groundwater because of the greater operational flexibility achievable through pumping.
- Seek funding for programs and projects that would identify and mitigate potential condition of overdraft in the basin.

6.6 REPLENISHMENT OF GROUNDWATER EXTRACTED BY WATER PRODUCERS

A component of wellhead protection and an important groundwater management strategy is the protection of major recharge and withdrawal zones. This strategy has far-reaching effects in the Turlock Basins because of the significant groundwater recharge occurring as a result of agricultural surface irrigation. Groundwater recharge must be adequate to replenish extracted groundwater, while withdrawal zones need protection from up gradient sources to ensure that the quality of extracted groundwater meets the standards established for the intended use.

A comprehensive approach to the protection and management of the major recharge and withdrawal zones is much more appropriate than the use of individual zoning techniques. Communities, in concert with neighboring towns and in coordination with the region, must develop comprehensive land and water resource management programs that go beyond simple zoning approaches for the protection of agricultural and urban areas.

The Association has evaluated surface geology within and directly adjacent to its boundary for the purpose of delineating areas having potentially high recharge rates. The basin contains numerous discontinuous recharge and withdrawal areas that do not allow for easily defined mapping of recharge zones. Nevertheless, a large portion of the study area has been determined to contribute to recharge. The Association supports land use measures that will preserve potential recharge areas from development that would reduce or eliminate their effectiveness as recharge sites.

6.6.1 Actions

The Association's member agencies will take the following actions:

- Identify areas having high potential for contributing to aquifer recharge and encourage agencies to communicate with land use planning entities to enact measures that will protect these lands from development that would reduce their value as recharge sites or enact an ordinance to ensure the implementation of replacement recharge projects to offset the lost recharge.

- Communicate with DWR and other governmental agencies studying groundwater and river interactions.

6.7 CONSTRUCTION AND OPERATION OF RECHARGE, STORAGE, CONSERVATION, WATER RECYCLING AND EXTRACTION PROJECTS

Various Association members share responsibility for development and operation of recharge, storage, conservation, water recycling and extraction projects. The role of the Association is to promote cooperation and sharing of information between the agencies sponsoring water management projects and other member agencies. To the extent feasible, the Association will also support measures to coordinate development and optimize operation of facilities to improve the basin-wide effectiveness and efficiency of water management.

6.7.1 Actions

The Association will take the following actions:

- Encourage sharing of information on project planning, design and operation among member agencies.

- Promote a coordinated approach toward project development and operation to lower the costs and increase the benefits of water management efforts.

- Seek funding for projects and programs that will contribute to water conservation, recycling, and recharge of the groundwater basin.

6.8 CONTROL OF SALINE WATER INTRUSION

Saline water intrusion from the San Joaquin River or from the west side of the San Joaquin Valley (including intrusion from the marine layers) is not well documented in the Turlock Groundwater Basin. Groundwater elevations prevalent in the basin have historically maintained a positive gradient preventing significant migration of saline water associated with groundwater from the western San Joaquin Valley. Maintaining the positive groundwater gradient will continue to prevent induced flow from the river or from groundwater west of the San Joaquin River.

6.8.1 Actions

The Association coordinates with member agencies and other local and state agencies to take the following actions:

- Continue collecting groundwater quality data along the San Joaquin River, and track the progression, if any, of saline water moving east from the San Joaquin River. This action will include communicating with DWR's District Office on a biennial basis to check for significant changes to TDS concentrations in wells. DWR has a regular program of sampling water quality in selected domestic, agricultural and monitoring wells throughout the basin. These wells will be augmented by additional monitoring wells to develop an early warning system able to detect saline water intrusion from the river.

- The program of monitoring for intrusion of saline water will be supplemented by the Groundwater Monitoring Program described in this plan. The program includes provisions for monitoring groundwater levels and quality.

- Observe TDS concentrations in public supply wells that are routinely sampled under the DHS Title 22 Program.

~~The following sections provide a discussion of some of the measures that could potentially be implemented to protect groundwater quality and quantity. Implementation of groundwater protection measures should be explored pursuant to the goals and objectives of individual agencies, as well as the Basin as a whole. As groundwater management activities are undertaken additional measures, not currently identified, may also be implemented as necessary to protect the local groundwater basin.~~

~~6.1CONTROL OF SALINE WATER INTRUSION~~

~~Permanent degradation of good quality groundwater can occur if poor quality groundwater migrates into aquifer zones containing better quality water. Such degradation can seriously affect the usability of the groundwater especially for potable uses. Variations in soil conditions, soil type, geologic structure, irrigation practices, and irrigation water quality can result in a wide variation in the quality of groundwater, especially in the upper water bearing zones. Because of these influences, groundwater salinity is the lowest in the easterly portion of the Turlock Groundwater Basin and increases westward towards the San Joaquin River and southward towards the Merced River. Increased groundwater pumping can alter historical flow patterns and cause the poor quality groundwater to commingle with and contaminate the better quality groundwater.~~

~~Also, as has been described, there is the natural tendency of deep saline water to up-well; i.e.,~~

~~move vertically upward and mix with the better quality water above it. Increasing the pumping of the fresh water increases the hydraulic gradient between the two zones, which increases the rate of fresh water degradation.~~

~~To maximize the sustainability of the groundwater basin, knowledge of the various water quality zones and the groundwater flow patterns are necessary. With this information, groundwater management techniques can be evaluated to protect zones of high quality water so that the beneficial use of the groundwater supply can continue.~~

~~A program to minimize water quality degradation due to saline water intrusion could include the following elements:~~

~~a. Establish a network of monitoring wells completed to various depths throughout the management area.~~

~~b. Monitor well water quality annually for salinity, nitrates, boron, and other constituents that may be of concern, i.e., certain organic chemicals such as dibromochloropropane (DBCP). Monitoring requirements may change with evidence of salinity change.~~

~~c. Identify areas where the groundwater flow patterns suggest a high probability of water quality degradation.~~

~~d. Identify zones of marginal quality water that can be used in conjunction with surface water to increase the water supply for agricultural purposes and reduce migration of saline water into zones containing potable groundwater.~~

~~e. Identify water management strategies that may be employed to minimize degradation.~~

~~If water quality changes begin to occur, the cause should be investigated and action taken to reverse the trend.~~

~~6.2IDENTIFICATION AND MANAGEMENT OF WELLHEAD PROTECTION AREA~~

~~The Federal Wellhead Protection Program (WPP) established by Section 1428 of the Safe Drinking Water Act Amendments of 1986 is designed to protect groundwater resources of public drinking water from contamination to minimize the need for costly treatment to meet drinking water standards. A wellhead protection area (WPA), as defined by the 1986 Amendments, is "*the surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water or well field.*" Under the act, the states are required to develop an EPA approved WPP. To date, California does not have a formal program but instead relies on public agencies to plan and implement programs under AB 3030. The basic task of wellhead and recharge area protection programs is the identification of zones around public water supply wells and groundwater recharge areas where land use must be controlled to minimize the possibility of contamination of the drinking water supply. Merced County has developed and adopted a comprehensive county-~~

wide wellhead protection program.

Recharge in the Turlock Groundwater Basin occurs primarily from percolation of irrigation water, seepage losses from canals and ditches and from rainfall. Protection of recharge areas is realized by controlling or regulating surface contaminants before their migration into the groundwater, either by percolation or, more directly, via wells that have not been properly constructed or destroyed.

Regulation of waste disposal is administered by the Regional Water Quality Control Board (RWQCB), the Department of Toxic Substances Control (DTSC), or the local county environmental health agencies. Each participating agency should provide assistance to the RWQCB, DTSC, and the local county environmental health agencies by identifying areas that are the most susceptible to groundwater contamination.

To protect recharge areas, each participating agency should review applications for Waste Discharge Permits within and adjoining their boundaries that have the potential to degrade groundwater quality. Such waste disposal systems include disposal of dairy wastes, disposal of industrial wastes, sewage treatment plant effluent disposal, and solid waste disposal. Environmental documents for such facilities and Tentative Waste Discharge Permits issued by the RWQCB should be closely reviewed to ensure the appropriate monitoring and mitigation measures are developed to preclude the possibility of migration of pollutants from the disposal sites. Each participating agency should be on the lookout for existing and proposed land use activities that have the potential to degrade groundwater quality, so that appropriate action can be taken.

The State of California Department of Health Services requires all urban water sources to complete a Drinking Water Source Assessment for each well or surface water supply. The assessment requires the supplier to look at the vulnerability of each source to contamination, inventory the possible contamination sources within the region of influence, provide an assessment map and identify and rank the most likely sources of contamination. This information is used to exclude potentially polluting activities from locating in vulnerable areas and to delineate where new sources can be located.

If monitoring indicates the need, additional wellhead protection programs could be implemented by local agencies. A wellhead protection program for public water supply wells could be developed by each agency, around the following basic elements:

a. Identification and description of all public water supply wells.

b. Delineation of the WPA for each well based on groundwater flow and quality information.

c. Identification of potential sources of contaminants within each WPA.

d. Establishment of land use ordinances to preclude or control future land uses within each WPA that have the potential for groundwater contamination.

e. Development of site specific well construction and abandonment programs to minimize contaminant migration (See also: "Administration of Well Abandonment and Well Destruction Program," and "Well Construction Standards").

f. Development of a contingency plan to implement if a WPA becomes contaminated.

6.3REGULATION OF THE MIGRATION OF CONTAMINATED GROUNDWATER

Contaminants in this section are those that result from improper application, storage or disposal of petroleum products, solvents, pesticides, fertilizers, sewage effluent, and chemicals used by industry, and are distinguished from the salinity degradation that is addressed under "Control of Saline Water Intrusion" (Section 6.1). Each participating agency's role in protecting groundwater from contamination by point sources should include supporting the RWQCB, which holds the primary responsibility for enforcing water quality regulations, and the respective counties who oversee soil and groundwater cleanup activities from leaking underground storage tanks and other point source contamination sites. Each participating agency should also assist in understanding the hydrogeology of the Turlock Groundwater Basin, the vertical and lateral groundwater flow directions, and groundwater quality based on the groundwater monitoring activities carried out by each participating agency. In addition, each participating agency should make the appropriate regulating agency aware of changes in groundwater quality, which may indicate that point source contamination is occurring.

6.4ADMINISTRATION OF A WELL ABANDONMENT AND WELL DESTRUCTION PROGRAM

State regulations require that all unused or inactive wells be properly maintained, as defined by the "Water Well Standards: State of California," DWR Bulletins 74-81 and 74-90. State regulations also require all inactive wells, that are not properly maintained (in accordance with Section 24400 of the California Health and Safety Code), be properly destroyed. Wells that are not properly maintained or destroyed can act as conduits for mixing of groundwater of differing quality or create a safety problem. Non-pumped wells are a much greater threat than pumped wells, since pumping normally quickly removes contaminants that may have migrated during idle periods.

Permits are required from the applicable county and/or city for destruction of wells within their respective jurisdictions. For public water supply wells, additional requirements may be prescribed by the State Department of Health Services (DOHS).

Each participating agency will rely on continued administration of the well abandonment and destruction program by the permitting agencies. Each participating agency's role in well abandonment and destruction should be to provide available groundwater data, assist in identifying locations of operating and abandoned wells, and advise well owners why proper well destruction is important for protection of water quality.

6.5MITIGATION OF CONDITIONS OF OVERDRAFT

The development of agricultural lands, dependent on groundwater supplies for their irrigation needs, resulted in significant declines in groundwater levels in the eastern portion of the Basin. For many years, the amount of pumping in this area exceeded the local recharge, creating a condition of local groundwater overdraft.

Although it appears as though the Basin has reached a new equilibrium or steady state, changes in water use within the Basin have the potential to impact groundwater levels in the future. For example, continued development in the eastern portion of the Basin may result in continued lowering of the groundwater levels in these areas. Eventually groundwater levels may decline to such depths that farming the overlying lands, which rely primarily on groundwater, could no longer be economical. In addition, the wells surrounding the area of overdraft may be adversely affected by the lowering of the water table and/or by water quality changes that can occur due to changes in hydraulic gradients. The depletion also reduces the amount of groundwater available within the Basin for use when surface water supplies are low.

Groundwater conditions within the Basin should continue to be monitored. As urban lands encroach into agricultural areas, agricultural lands dependent upon groundwater develop, and cropping and irrigation practices change, local agencies need to continue to evaluate the potential impacts of these changes on groundwater conditions and develop a plan to mitigate future overdraft conditions.

6.6REPLENISHMENT OF GROUNDWATER EXTRACTED BY WATER PRODUCERS

Most of the recharge of the Turlock Groundwater Basin occurs from irrigation water diverted from the Tuolumne River. As the water is transported and distributed to the field, a certain amount of seepage loss occurs, which percolates through the soil and recharges the groundwater basin. As irrigation water is applied to crops, a portion of the applied water percolates past the root zone and continues downward, also recharging the groundwater basin.

To increase replenishment, additional surface water must be absorbed within the Basin either by increasing surface water irrigation to displace groundwater use, or by direct recharge. Through "Facilitating Conjunctive Use Operations" (Section 5.7) participating agencies should be exploring methods of replenishing the depleted groundwater supplies and optimizing use of available aquifer storage.

6.7IDENTIFICATION OF WELL CONSTRUCTION POLICIES

Improperly constructed wells can establish pathways for pollutants to enter from surface drainage and can cause mixing of water between aquifers of differing quality. Sections 13700 through 13806 of the California Water Code require proper construction of wells. The standards of well construction are specified in DWR Bulletins 74-81 and 74-90.

The counties and cities within the Turlock Groundwater Basin have the responsibility to enforce well construction standards. Well construction permits are required to drill a new well or to modify an existing well. Well Driller's Reports must be filed with the DWR and the respective counties. Stanislaus County has adopted the DWR standards. Merced County, however, has adopted their own standards which are stricter than the established DWR standards.

Because of their responsibility to enforce standards for construction and destruction of wells and

~~for issuance of drinking water permits for small public water systems, the county environmental health agencies maintain records on wells and groundwater quality. The records maintained by the various counties could be supplemented with data on water levels and groundwater quality collected by each participating agency to identify locations susceptible to intermixing of aquifer zones of varying water quality. The information could be used to establish specifications for well construction and destruction to optimize well water quality and minimize mixing of water between zones of varying water quality. Better understanding of the subsurface geology and water quality is needed to define the confining beds between aquifer zones of differing water quality. Site specific hydrogeologic investigations may be necessary to support well designs and should be submitted with the proposed well designs to obtain the well drilling permit.~~

~~Authority over well construction will remain with the respective counties and cities. A method should be developed to exchange pertinent well information to assist in groundwater management activities.~~

~~6.8 CONSTRUCTION AND OPERATION OF GROUNDWATER CONTAMINATION CLEANUP, RECHARGE, STORAGE, CONSERVATION, WATER RECYCLING, AND EXTRACTION PROJECTS~~

~~As part of the groundwater management plan, projects to improve water utilization within the Turlock Groundwater Basin should be identified and evaluated. Potential projects include:~~

- ~~a. Use of reclaimed wastewater for agricultural or landscape irrigation purposes;~~
- ~~b. Expanded surface water distribution systems to increase its use;~~
- ~~c. Construction of recharge facilities in the eastern portion of the Basin; and~~
- ~~d. Construction of additional surface water storage facilities to increase water availability.~~

~~For items b, c and d above, sufficient additional surface water or conserved water must become available to make these projects viable. Construction of additional surface water storage facilities or redistribution of current supplies under an expanded conjunctive use program may be needed to increase water supply. Increased usage of reclaimed water could potentially reduce additional surface water requirements.~~

~~Along with the potential benefits that these projects can provide, there are associated costs. Any project must undergo a thorough evaluation to quantify the water supply benefits and to identify all costs associated with the project. In addition, many legal, contractual, and political issues are sure to arise when evaluating such projects.~~

~~6.9 REVIEW OF LAND USE PLANS AND COORDINATION WITH LAND USE PLANNING AGENCIES TO ASSESS ACTIVITIES THAT CREATE REASONABLE RISK OF GROUNDWATER CONTAMINATION~~

~~In most instances, the local planning agency is also a water supply agency or a county which~~

~~provides the planning for some of the smaller water agencies within the Basin. Each participating agency should review proposed development plans and associated environmental documentation to assess the potential groundwater impacts of proposed land use changes. Each participating agency should review initial studies, proposed negative declarations, draft environmental impact reports, and provide comments as appropriate to insure that potential threats to groundwater can be addressed and avoided. In cases where the proposed land use involves disposal of wastes, storage of hazardous materials, or handling of petroleum products, solvents, or chemicals such as pesticides and fertilizers, each participating agency should coordinate with the appropriate State regulatory agencies to insure that compliance with regulations for containment and disposal of wastes is obtained.~~

~~During periodic land use plan preparation and updates, the cities and counties in the Turlock Groundwater Basin should consult with the appropriate participating agency to avail themselves of the latest information on groundwater conditions that may be affected by proposed activities, so that necessary mitigation measures can be included in the plans.~~

7 STAKEHOLDER INVOLVEMENT

7.1 AGENCY INVOLVEMENT

The Turlock Groundwater Basin Association was formed to facilitate agency involvement in groundwater management activities within the Turlock Subbasin. The majority of agencies have joined the Association, with the others encouraged to participate in Association activities. The MOU utilized to form the Association provides a process for additional entities to join. (A copy of the MOU is attached in Appendix A.) Any local public agency, whose service area includes land located within the Subbasin, which uses groundwater, or is authorized to provide groundwater, groundwater quality management, or groundwater replenishment within its service area, and whose service area includes all or a portion of the Turlock Subbasin, may apply for membership. Application is subject to approval by the Association membership, and the joining entity must pay any back contributions, if any, and as determined by the Association's governing body.

7.2 ADVISORY COMMITTEE

The Association representatives currently serve in an advisory role for groundwater management activities within the Subbasin. Additional committees, including an Advisory Committee, will be formed as necessary. The MOU includes language specifying that the Association Board may establish any committees it deems as necessary or desirable.

7.3 COORDINATION WITH OTHER AGENCIES

The Association provides a mechanism for local public agencies to coordinate groundwater management activities. Meetings are typically held on a monthly basis to work through groundwater management issues. In addition to action items included on the agenda, time is allotted at each meeting for participants to provide updates on groundwater and related issues not specifically identified.

Additional coordination efforts includes development of ongoing and future relationships with State and Federal agencies. These activities are described in Section 7.5 below.

7.4 PUBLIC INVOLVEMENT PROCESS

Prior to developing this plan, local agencies held public hearings, noticed pursuant to Section 6066 of the Government Code. As noticed, the intent of these meetings was to let the public know an update of the Plan is being developed and provide an opportunity for the public to provide input on what issues should be considered in that process. All comments received in this process were reported back to the Association and considered in developing the Plan.

All Association meetings are open to the public and held pursuant to the Brown Act. Agendas are posted and available for public review. When requested, agendas are sent to interested parties, as well as each of the local public agencies within the Subbasin. The Association worked through the Plan update in this public forum, providing additional opportunity to provide input into the process.

A second public hearing, noticed pursuant to Section 6066 of the Government Code is required for a local public agency to adopt a groundwater management plan. This provided additional opportunity for the public to provide input as to whether or not the agency should consider adopting the updated Plan.

In addition to the opportunities available to the public to provide input into the development and adoption of the Plan, there is an on-going opportunity for the public to participate in the groundwater management activities of the Association. A public comment period is included at each Association meeting, providing a time for any interested parties to raise issues and concerns they may have. Due to specific Brown Act requirements, items discussed during the public comment period may not be acted upon at that time. However, those issues identified through this forum may be brought back to the Association Board of Directors for consideration at a future meeting.

7.5 DEVELOPING RELATIONSHIPS WITH STATE AND FEDERAL AGENCIES

Local public agencies that make up the Turlock Groundwater Basin Association have relationships with various State and Federal agencies. These individual relationships will continue to be fostered, and utilized as necessary, to implement subarea and Subbasin groundwater management activities.

The Association will develop an Annual Report, documenting its activities, which will be submitted to the State of California's Department of Water Resources (DWR). This process will assist in fostering an ongoing relationship with DWR. Additional relationships will be developed with other State and Federal agencies, as necessary.

8 PLAN IMPLEMENTATION

8.1 RECOMMENDATIONS

8.2 GROUNDWATER MANAGEMENT PLAN IMPLEMENTATION REPORT

Periodic reports will be produced, as necessary, to comply with groundwater management requirements. Reports will be designed to summarize groundwater basin conditions, and describe groundwater management activities. These reports may be prepared by the Association, or by an individual agency. Reports generated by individual agencies, will be coordinated through the Association.

The periodic reports should include the following types of information:

- A summary of monitoring results, including historical trends,
- A summary of management actions implemented,
- A summary, supported by monitoring results, of whether management actions are meeting the management goals and objectives,
- A summary of proposed management actions, and
- A summary of any Plan component changes, including addition or modification of management measures.

8.3 FINANCIAL PLANNING FOR RECOMMENDED ACTIONS/PROJECT IMPLEMENTATION

8.4 PERIODIC REVIEW OF THE GROUNDWATER MANAGEMENT PLAN

As indicted in Section 8.2, one of the issues to be evaluated when preparing the periodic reports, is whether or not there are any changes needed to the Plan. As such, when the Association develops periodic summary reports, it will also consider whether or not an update of the Plan is warranted. In any event, to maintain consistency and encourage coordination amongst local water agencies, it is the intent of the Association to continue to pursue updates of the Plan as a basin-wide activity.

9 REFERENCES

INCLUDE THE PERTINENT INFORMATION FOR THE FOLLOWING REFERENCES:

DWR Bulletin 118(s)

Durbin Study – Water Budget Study 2003

Previous Groundwater Management Plan

LAFCO reports

General Plans

Appendix A

MEMORANDUM OF UNDERSTANDING ESTABLISHING THE TURLOCK GROUNDWATER BASIN ASSOCIATION

MEMORANDUM OF UNDERSTANDING
ESTABLISHING THE TURLOCK GROUNDWATER BASIN ASSOCIATION

1. PARTIES:

The parties to the Memorandum of Understanding ("MOU") are: City of Ceres, a California Public Agency; Keyes Community Services District, a California Public Services District; Denair Community Services District, a California Public Services District; City of Turlock, a California public agency; Hilmar County Water District, a California Public Services District; Delhi County Water District, a California Public Services District; City of Hughson, a California public agency; City of Modesto, a California public agency; Merced Irrigation District, a California Irrigation District; Ballico Community Services District, a California Public Services District; County of Merced, a Political Subdivision of the State of California; County of Stanislaus, a Political Subdivision of the State of California; Eastside Water District, a California Water District; Ballico-Cortez Water District, a California Water District; and Turlock Irrigation District, a California Irrigation District.

2. RECITALS:

This MOU is entered into with regard to the following facts and circumstances, among others:

2.1 Groundwater and surface water resources within the Turlock Groundwater Basin are vitally important resources, in that they provide the foundation to maintain current and fulfill future agricultural, domestic, municipal and industrial needs, as well as other needs, and to maintain the economic viability and prosperity of the Basin area.

2.2 The Stanislaus/Merced County area is one of the world's foremost agricultural areas; and the agricultural industry has played a major role in the development of the economy of Stanislaus/Merced County area. In an era of increasing competition for the area's finite water resources, it is important to understand and plan for the utilization of all the area's water resources in order to preserve all elements of the local economy vital to the area's well-being.

2.3 The Parties entered into a Memorandum of Understanding on or around July 14, 1995, for the purposes of studying and evaluating the condition of the Basin, and developing a groundwater management plan for the preservation, protection and enhancement of the Basin. The Turlock Groundwater Basin Groundwater Management Plan was adopted by the Parties on or about October 1997. The 1995 Memorandum of Understanding terminated by its own terms on December 31, 1997.

2.4 The Parties desire to form an association, which will be known as the Turlock Groundwater Basin Association, to provide a mechanism for the Parties to collectively implement the Plan and the purposes and goals of this Memorandum of Understanding.

2.5 Purposes and Goals: The purposes and goals for the formation of the Association are:

2.5.1 To provide a mechanism to coordinate the implementation of the Plan and other groundwater management activities;

2.5.2 To create an association of the Parties to enhance the ability to obtain funding to carry out the Plan and related groundwater management projects; and

2.5.3 Provide information and guidance for the management, preservation, protection and enhancement of the Basin.

2.6 The Parties believe that non-coordinated action by water providers and users within the Basin could result in counter productive competition for finite resources resulting in adverse impacts to the groundwater and surface water supplies within the Basin.

2.7 The Parties believe that creation of an Association for water suppliers within the Basin is important to protect the groundwater and surface water resources and will assist in meeting the needs of all users of such resources within the Basin.

2.8 Because of the enactment of Water Code Sections 10750 et seq., it is clear to the Parties that local management of water resources is desirable in order that local control be maintained over such resources.

2.9 The Parties hereto desire to enter into this MOU in order to form an association to promote the stated goals and provide coordinated implementation of the Plan to make the best use of available water resources to meet the needs of their respective constituents and service territories.

2.10 In forming the Association, it is the Parties' desire that the Association not be formed as a separate governmental entity, nor have any enforceable regulatory authority over any Party's facilities or any Party's respective surface water or groundwater supplies or rights, nor duplicate any services, duties or authority of any other agency.

3. <u>AGREEMENT:</u>

The Parties agree as follows:

4. DEFINITIONS:

The following terms, whether in the singular or the plural, and when used herein with initial capitalization, shall have the meanings specified in this Section 4:

4.1 **Basin:** The Turlock Groundwater Basin, which is geographically defined as that area in the State of California bounded on the west by the San Joaquin River; on the north by the Tuolumne River, on the east by the base of the Sierra Nevada foothills; and on the south by the Merced River, and includes the area of land overlying that basin and all tributaries therein.

4.2 **Board:** That body, consisting of one representative from each of the Parties, which governs the Association, as established pursuant to Section 5.2 of this MOU.

4.3 **Chairperson:** The presiding officer of the Association as elected by the Board.

4.4 **Governing Bodies:** The legislative bodies of the governmental Parties to this MOU.

4.5 **MOU:** This Memorandum of Understanding Establishing the Turlock Groundwater Basin Association.

4.6 **Parties:** Each of those entities named in Section 1 of this MOU, or those Parties added pursuant to Section 5.4 of this MOU.

4.7 **Plan:** The Turlock Groundwater Basin Groundwater Management Plan, adopted on or about October 1997.

5. THE ASSOCIATION:

5.1 **Powers and Purposes:** The Parties to this MOU hereby form the Turlock Groundwater Basin Association.

5.1.1 The purpose of the Association is to provide a forum in which the Parties can work cooperatively; to combine the available talent of the Parties' respective staffs; and to accomplish the purposes described in Section 2 of this MOU.

5.1.2 This Association shall have no enforceable regulatory authority over any person or entity, including Parties or Parties' facilities or rights.

5.2 **Board:** The Association shall be governed by a Board whose membership, duties and responsibilities are set forth herein.

5.2.1 Each Party shall designate one person to serve as a member of the Board, and one or more alternates. Each member of the board, and each alternate, shall serve at the pleasure of the Party appointing such member. A Party's alternate may serve in the place of that Party's member in the absence of such member and, in such case, the alternate shall have the powers of the member.

5.2.2 The Board, at its first meeting, shall elect a chairperson and vice-chairperson from its members. Such officers shall serve at the pleasure of the Board and in such capacities until the first meeting of the Board in 2002 at which time the Board shall elect new officers. Thereafter, the Board shall elect a chairperson and vice-chairperson from its members at the first meeting of each even numbered calendar year. The Chairperson shall be responsible for presiding over meetings of the Board, and shall notify committee members of meetings of the Board. The Board shall establish a date, time and place for its regular meetings, and may hold special meetings when required for the proper transaction of business. All meetings of the Board shall be held in accordance with the provisions of the Brown Act, California Government Code §54950 et seq. The Board shall prescribe such procedures for the conduct of its business as it deems appropriate.

5.2.3 A quorum shall consist of a majority of the Voting Members of the Board, except that less than a quorum may adjourn meetings of the Board. Alternatively, the Chairperson may adjourn a meeting of the Board to a specified time, date and place if there is less than a quorum of members present for a meeting.

5.2.4 The Board shall have the following duties and responsibilities:

a. Develop and implement the activities, including work schedule, designated to achieve the objectives of the Association as set forth in Section 2 of this MOU.
b. Monitor work activities of the Association.
c. Establish such committees as may be necessary or desirable to carry out the purposes of the Association, and to exercise general supervision over such committees.

5.2.6 Except for actions for which a different approval standard is set forth in this MOU, all actions of the Board shall be approved by a majority of the members present.

5.3 **Staff; Employees:** The Association may have employees upon a decision by the Board, and/or may obtain staff and support services through the Parties.

5.4 **New Parties:** New Parties may join the Association, provided that they meet the requirements set forth in this Section 5.4.

5.4.1 Any local public agency, whose service area includes land located within the Basin, which uses groundwater, or is authorized to provide groundwater, groundwater quality management, or groundwater replenishment within its service area, and whose service includes all or a portion of the Basin, may apply for membership in the Association.

5.4.2 Application for membership shall be subject to approval by the Governing Bodies of the Parties; approval shall require the affirmative vote of the Governing bodies of two-thirds (2/3) of the Parties.

5.4.3 Any new Party to this Agreement shall, as a condition of admission to the Association, be required to first pay its proportionate share of back contributions, if any, as determined by the Board.

6. COMMITTEES:

The Board may establish any committees it determines are necessary or desirable.

7. ASSOCIATION COSTS:

7.1 Costs incurred by any Party in connection with any functions of the Association, or any committee established by the Board, and expenses of a Party's personnel including, without limitations, the regular and alternate members appointed by a party to any committee while performing such functions, shall not be reimbursed by the Association except upon approval of the Board.

8. FUNDING AND VOTING PERCENTAGES:

8.1 It is anticipated that the Parties will fund their own staff work. However, outside funding may be available or the Parties, or any subgroup of the Parties, may make additional funding contributions, if necessary, upon agreement of those Parties participating in the funding.

8.2 **Voting Rights:** Each Party's representative on the Board shall be entitled to one vote.

8.3 **Modification by Party:** Funding percentages and/or voting percentages as indicated in Section 8.1 and 8.2 respectively, may be changed only upon the approval of the Governing Bodies of two-thirds (2/3) of the Parties.

9. RELATIONSHIP OF THE PARTICIPANTS:

9.1 **Each Party's Action is Independent of the Other:** The obligation of each Party to make payments under the terms and provisions of this MOU is an individual and several obligation and not a joint obligation with those of the other Parties. Each Party shall be individually responsible for its own covenants, obligations and liabilities under this MOU. No Party shall be under the control of or shall be deemed to control any other Party or the Parties collectively. No Party shall be precluded from independently pursuing any of the activities contemplated in this MOU. No Party shall be the agent of or have the right or power to bind any other Party without such Party's express written consent, except as expressly provided in this MOU.

9.2 **No Creation of a Joint Powers Agency:** The Parties agree that by this MOU they do not intend to provide for the creation of an agency or entity which is separate from the Parties pursuant to Chapter 5 (commencing with §6500) of Division 7 of Title 1 of the Government Code, relating to the joint exercise of powers.

10. TERMS OF THIS MOU: The term of this MOU shall commence on November 15, 2001 and shall continue until terminated by Board action.

Upon termination of this MOU, the Board shall determine the assets and liabilities of the Association; make every effort to satisfy all obligations within sixty (60) days of the termination of the MOU; and distribute the remaining fund balance equitably to each Party in proportion to each Party's funding contribution to the Association.

11. GENERAL PROVISIONS GOVERNING MOU:

11.1 **Invalidity of Any Term Not to Invalidate the Entire Memorandum:** In the event that any of the terms, covenants or conditions of this MOU or the application of any such term, covenant or condition shall be held invalid as to any Party, person or circumstance by any court of competent jurisdiction, all other terms, covenants or conditions of this MOU and their application shall not be affected thereby, but shall remain in full force and effect unless any such court holds that those provisions are not separable from all other provisions of this MOU.

11.2 **Construction of Terms:** This MOU is for the sole benefit of the Parties and shall not be construed as granting rights to any person other than the Parties or imposing obligations on a Party to any person other than another Party.

11.3 **Good Faith:** Each Party should use its best efforts and work wholeheartedly and in good faith for the expeditious completion of the objectives of this MOU and the satisfactory performance of the terms and provisions contained herein.

11.4 **Withdrawal or Termination of Membership:** Except in the event of the termination of this MOU pursuant to Section 10, a party who withdraws or terminates its membership in the Association shall not be entitled to a refund of its funding contributions. Any Party may terminate membership and withdraw from this Association upon thirty (30) days written notice of termination to the Association. If a Party withdraws from the Association when the Party is in arrears as to its funding contributions to the Association, that Party's entitlement to use any work product of the Association as provided for herein shall be determined by the Board.

11.5 **Amendment:** An amendment to this MOU must be approved by the affirmative vote of the Governing Bodies of two-thirds (2/3) of the Parties.

11.6 **Counterpart Execution:** This MOU may be executed in counterparts each of which shall be deemed an original but all of which together shall constitute one and the same instrument.

11.7 **Governance:** This MOU is made under and shall be governed by the laws of the State of California.

11.8 **Reasonable Delivery of Documents:** Each Party agrees upon request by the Chairperson or by the Board, to make, execute and deliver any and all documents reasonably required to implement this MOU.

IN WITNESS WHEREOF, the Parties have caused this MOU to be executed, each signatory hereto represents that he has been appropriately authorized to enter into this MOU on behalf of the Party for whom he/she signs.

EACH PARTICIPANT HAS A SEPARATE SIGNATURE PAGE

MOU Signatories include:

- Merced Irrigation District
- Turlock Irrigation District
- Ballico-Cortez Water District
- Eastside Water District
- City of Ceres
- City of Hughson
- City of Modesto
- City of Turlock
- Denair Community Services District
- Hilmar County Water District
- Merced County
- Stanislaus County

Appendix B

DEFINITIONS

AB 3030 - Assembly Bill 3030, the Groundwater Management Act (codified in California Water Code sections 10750 *et seq.*) was passed by the State legislature during the 1992 session, and became law on January 1, 1993.

Abandonment - See "Well Abandonment"

Association - Refers to the "Turlock Groundwater Basin Association"

Aquifer - A geologic formation that stores, transmits and yields significant quantities of water to wells and springs.

Basin - See "Turlock Groundwater Basin"

Conjunctive Use - A term used to describe operation of a groundwater basin in coordination with a surface water reservoir system. The purpose is to artificially recharge the basin during years of above-average precipitation so that the water can be withdrawn during years of below-average precipitation, when surface supplies are below normal.

Groundwater - Subsurface water occurring in the zone of saturation.

High Groundwater - Groundwater levels higher than 6 feet below ground level which can adversely impact crops. High groundwater can be caused by "perched" water, overall high groundwater conditions, or other factors.

Inactive Wells - An unused well that the owner demonstrates his intention to use the well again. The California Water Well Standards (Bulletins 74-81 & 74-90) includes specific guidelines for things the owner must do to show evidence of his intention to continued to use the well

Local county environmental health agencies - Merced County Division of Environmental Health and the Stanislaus County Department of Environmental Resources

Overdraft - The condition of a groundwater basin where the amount of water withdrawn from an aquifer or groundwater basin exceeds the amount of water replenishing the basin (net recharge) over a period of time.

Participating Agency - Any local agency within the Turlock Groundwater Basin which adopts this AB 3030 groundwater management plan.

Public Water System - See Appendix D, entitled: "PUBLIC WATER SYSTEM DEFINITIONS"

Recharge - Flow to groundwater storage from precipitation, infiltration from streams, and other sources of water.

Reducing Conditions - A lack of oxygen in the groundwater.

Safe Yield - The maximum quantity of water that can be continuously withdrawn from a groundwater basin without adverse effect.

Saline - Consisting of or containing salts, the most common of which are potassium, sodium, or magnesium in combination with chloride, nitrate, or carbonate.

SCADA - Supervisory Control and Data Acquisition - a type of remote monitoring and control system.

Subbasin For the purposes of this document, the name "Turlock Subbasin," "Turlock Groundwater Basin," "Basin," and "Subbasin" are used interchangeably to represent the same geographic area.

TDS - "Total dissolved-solids," the quantity of minerals (salts) in solution in water, usually expressed in milligrams per liter (mg/L) or parts per million (ppm).

Turlock Groundwater Basin - A groundwater system located on the eastern side of the San Joaquin Valley bounded by the Tuolumne River on the north, the Merced River on the south, the San Joaquin River on the west, and the Sierra Nevada foothills (specifically the western extent of the low-permeability Valley Springs rock formation) on the east.

Unused Wells - Wells that are not being used are considered "unused." Wells that are not used for a period of one year are considered "abandoned," unless the owner demonstrates his intention to use the well again. (see "Inactive Wells")

Well Abandonment - According to the California State Well Standards *a well is considered "abandoned"... if it has not been used for one year, unless the owner demonstrates intention to use the well again...* All "abandoned" wells must be properly destroyed. (see "Well Destruction")

Well Destruction - All "abandoned" wells (see Well Abandonment") and exploration or test holes must be properly destroyed. The objective of well destruction is to restore subsurface conditions as nearly as possible to the conditions that existed before the well was constructed, taking into consideration any changes which may have occurred since the time of construction. Each of the counties and some of the cities within the Basin have established well standards which specify well destruction requirements.

WPA - Wellhead Protection Area defined by the Safe Drinking Water Act Amendments of 1986 as *"the surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water or well field."*

WPP - Federal Wellhead Protection Program established by Section 1428 of the Safe Drinking Water Act Amendments of 1986. They are designed to protect groundwater resources of public drinking water from contamination to minimize the need for costly treatment to meet drinking water standards.

Appendix C

DESCRIPTION OF THE VARIOUS GROUNDWATER MANAGEMENT ACTIVITIES IMPLEMENTED BY THE LOCAL PUBLIC AGENCIES

MERCED COUNTY

Section	Efforts of Individual Agencies and Groundwater Management Plan Components	Merced County Division of Environmental Health (MCDEH)
1.7.2	Well Abandonment or Destruction Programs	Ongoing program to find abandoned wells and have them properly destroyed (also in conjunction with applications for permits for new wells).
1.7.2	Well Construction Standards	Enforce the Merced County Well Ordinance which contains well construction standards
1.7.2	Public Education Programs	No ongoing programs
1.7.2	Land Use Planning	Review of proposed land use projects for well and septic system suitability, and water availability.
1.7.2	Regulation of Mitigation of Contaminated Groundwater	Local Oversight Program (LOP) for leaking underground storage tanks and pipelines.
1.7.2	Development of Relationships with Local, State, and Federal Agencies	Working relationships
1.7.2	Funding	Funding/revenues obtained through well and septic permit fees
1.7.2	Groundwater Monitoring	Water quality data collected with each new domestic well permit and some minor monitoring of certain areas
C.1.	Control of saline water intrusion.	No
C.2.	Identification and management of wellhead protection areas and recharge areas.	WHP is done through many of our programs: Well & Septic, Small Water Systems, Dairies, etc.
C.3.	Regulation of the migration of contaminated groundwater.	Local Oversight Program (LOP) for leaking underground storage tanks and pipelines.
C.4.	Administration of well abandonment and well destruction program.	Ongoing program to find abandoned wells and have them properly destroyed (also in conjunction with applications for permits for new wells).
C.5.	Mitigation of conditions of overdraft.	No
C.6.	Replenishment of groundwater extracted by water producers.	No
C.7.	Monitoring of groundwater levels and storage.	No
C.8.	Facilitating conjunctive use operations.	No
C.9.	Identification of well construction policies.	Enforce the Merced County Well Ordinance which contains well construction standards
C.10.	Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	If not LOP, the California Regional Water Quality Control Board (CRWQCB) would have jurisdiction over cleanup sites
C.11.	Development of relationships with state and federal regulatory agencies.	Working relationships
C.12.	Review of land use plans and coordination with land use planning agencies.	Review of proposed land use projects for well and septic system suitability, and water availability.

MERCED IRRIGATION DISTRICT

Section	Efforts of Individual Agencies and Groundwater Management Plan Components	Merced Irrigation District
1.7.2	**Well Abandonment or Destruction Programs** (For both private and agency owned wells.)	No Program. Merced I.D. complies with the Merced County requirements when a well is abandoned.
1.7.2	**Public Education Programs** (Water conservation, water quality, etc…)	
1.7.2	**Land Use Planning** (What land use planning is conducted by your agency and on what frequency? Changes in population? Annexations? Water needs? Etc.)	Developed a Water Management Plan in compliance with AB 3616, the Agricultural Water Suppliers Efficient Water Management Practices Act of 1990. Participates in the Merced Area Groundwater Pool Interests and the Turlock Groundwater Basin Association under authority of AB303, the Groundwater Management Act of 1993.
1.7.2	Regulation of Mitigation of Contaminated Groundwater	No Program
1.7.2	Development of Relationships with Local, State, and Federal Agencies	
1.7.2	**Funding** (Grants received to address groundwater related issues???)	
C.1.	Control of saline water intrusion.	
C.2.	Identification and management of wellhead protection areas and recharge areas.	
C.5.	Mitigation of conditions of overdraft.	
C.6.	Replenishment of groundwater extracted by water producers.	
C.7.	**Monitoring of groundwater levels and storage.** (Also groundwater quality monitoring.)	
C.8.	Facilitating conjunctive use operations.	
C.9.	**Identification of well construction policies** (and standards. For what types of wells within your area?)	No Program
C.10.	Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	
C.11.	Development of relationships with state and federal regulatory agencies.	

STANISLAUS COUNTY ENVIRONMENTAL RESOURCES DEPARTMENT (DER)

Section	Efforts of Individual Agencies and Groundwater Management Plan Components	STANISLAUS COUNTY ENVIRONMENTAL RESOURCES DEPARTMENT (DER) Environmental Health Division (EH) Hazardous Materials Division (HAZMAT)
1.7.2	**Well Abandonment or Destruction Programs** (For both private and agency owned wells.)	EH enforces State Model Well Ordinance in unincorporated Stanislaus County, Ordinance requires well destruction under permit and inspection.
1.7.2	**Water Well Construction Standards**	EH enforces State Model Well Ordinance in unincorporated Stanislaus County. Ordinance requires well construction under permit and inspection of EH; and compliance with Water Wells Standards State of CA.
1.7.2	**Public Education Programs** (Water conservation, water quality, etc…)	EH presents various public programs relating to water issues, upon request. Stanislaus County has a Water Conservation Ordinance that applies to the unincorporated County area. Informational mailings are provided upon request or when complaints are received.
1.7.2	**Land Use Planning** (What land use planning is conducted by your agency and on what frequency? Changes in population? Annexations? Water needs? Etc.)	DER reviews proposals for and comments on land use and water projects relating to rezoning, new sub divisions, EIR/EIS. EH issues permits for new construction and repairs to individual onsite waster water disposal facilities in the unincorporated Stanislaus County areas.
1.7.2	Regulation of Mitigation of Contaminated Groundwater	HAZMAT regulates and mitigates contaminated groundwater through the Local Oversight Program (LOP) and the Non-Pilot Site Investigation Program.
1.7.2	Development of Relationships with Local, State, and Federal Agencies	DER participates in efforts of Groundwater Basin-wide associations/authorities/committees within Stanislaus County that conduct groundwater management and planning. DER partners with local State and Federal Agencies in performance of mandates.
1.7.2	**Funding** (Grants received to address groundwater related issues???)	DER has applied and received Environmental Trust Fund Grants, and regulatory oversight program grants, State and Federal Grants relating to water.
C.1.	Control of saline water intrusion.	None
C.2.	Identification and management of wellhead protection areas and recharge areas.	EH Regulates the installation and repair of sewage disposal facilities in unincorporated County area, to ensure adequate separation between water wells and sewage disposal facilitates. EH issues permits and performs inspections of well installations, destructions and repairs in the County unincorporated areas.

C.5.	Mitigation of conditions of overdraft.	DER reviews proposals for and comments on land use and water projects relating to rezoning, new sub divisions, EIR/EIS.
C.6.	Replenishment of groundwater extracted by water producers.	Stanislaus County has approved a past resolution of support for studies that were conducted by the East Side Water District (11/06/01).
C.7.	**Monitoring of groundwater levels and storage.** (Also groundwater quality monitoring.)	EH enforces regulations relating to monitoring of small public water systems (including groundwater quality monitoring). The HAZMAT Division's Local Oversight Program collects groundwater quality data on known contaminated sites in Stanislaus County. This data is site specific and is not tabulated or calculated to apply to an entire basin quality plan. This program does not address the issue of quantity of water in storage.
C.8.	Facilitating conjunctive use operations.	None
C.9.	**Identification of well construction policies** (and standards. For what types of wells within your area?)	EH enforces CA Model Well Ordinance and CA Water Well Standards in the unincorporated Stanislaus County areas. Where State Water Well Standards are insufficient, policies have been adopted relating to water well construction and abandonment requirements relating to set backs between water wells and various sources of contamination.
C.10.	Construction and operation by local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling, and extraction projects.	The HAZMAT Division's Local Oversight Program regulates the operation and construction of groundwater contamination cleanup projects. HAZMAT does not regulate the construction or operation of recharge, storage, conservation, or recycling projects not related to groundwater remediation.
C.11.	Development of relationships with state and federal regulatory agencies.	All Divisions in the DER work closely with representatives of CAL EPA, and other various state and federal agencies (including the CA RWQCB, CA DHS, CA DWR, U.S. EPA) in the course of regular job duties.
C.12.	Public Water Systems	Under contract with the CA Department of Health Services, DER conducts a small public water systems inspection and oversight program. Inventories of public water systems, water quality monitoring records, water sources, water system owners are maintained in an electronic format and in file hard copies.

Appendix D

TABLE OF STANDARD CONVERSIONS

Appendix E

SUBAREA GOALS AND OBJECTIVES FOR AGENCIES WITHIN THE TURLOCK GROUNDWATER BASIN

MERCED COUNTY - DIVISION OF ENVIRONMENTAL HEALTH

Goals and Objectives

The Merced County Division of Environmental Health endeavors to protect the quantity and quality of groundwater in Merced County.

Activities Conducted to Support these Objectives

1. **Wellhead Protection Program**
    a. Issues well permits for the construction of all new wells in Merced County; Samples all new domestic wells for Coliform bacteria, nitrates, DBCP/EDB, and general mineral/inorganics;
    b. Collects water samples at customer request upon payment of fees;
    c. Enforces the Merced County Well Ordinance to insure proper well location, setback distances, and proper well construction for all wells in Merced County;
    d. Maintains a program to identify all possible sources of contamination that may threaten groundwater;
    e. Operates the small public water system program for all water systems with fewer than 200 service connections;
    f. Oversees the cleanup of leaking underground fuel storage tank sites;
    g. Operates the dairy/poultry animal confinement program; also operates the sludge management program, and the food processing waste program;
    h. Conducts water quality monitoring in areas where there is known contamination and water quality degradation;
    i. Responds to well emergencies such as floods, droughts, and other conditions which threaten the quality or quantity of drinking water;

2. **Abandoned Well Destruction Program**
    a. Issues well destruction permits for all inactive, inoperative, and abandoned wells in Merced County;
    b. Conducts a program to find, identify, and destroy old wells needing to be properly destroyed;

3. **Other Activities**
    a. Participates in, and supports, local efforts to protect the groundwater basins in Merced County, and adjacent counties where basins straddle county lines;
    b. Serves as a resource for the general public (individuals and groups) to provide accurate information and some limited technical assistance in dealing with questions regarding water supply, wells, and related groundwater issues;

CITY OF HUGHSON

Goals and Objectives

Provide sufficient water supplies and facilities to serve the City in the most efficient and financially sound manner, while maintaining the highest standards required to enhance the quality of like for existing and future residents.

Activities Conducted to Support these Objectives

CITY OF TURLOCK

Goals and Objectives

The objective of the City's groundwater program is to maintain the highest quality of water to meet all customers' needs while protecting health and property and providing a sufficient quantity of groundwater well into the future.

Activities Conducted to Support these Objectives

- Closely monitor each potable water well to insure it meets or exceeds the water quality limits established by the EPA and State of California.
- Frequently test each well for nitrate and TDS data to determine if there is a trend that will result in a reduction of water quality.
- If a contaminant reaches 90% of the MCL for that compound at any well, initiate well head treatment, blending or other methods to insure the water leaving any well site does not exceed this limit.
- Check well water levels monthly to determine the status of underground water storage within the City. If the annual average static water levels are less than 40 feet MSL for any three consecutive years, increase the mandated water conservation measures, i.e. go to Stage 2 from Stage 1.
- Maintain a strong City presence within the Turlock Groundwater Basin Association to encourage the replenishment and wise use of the basin's water resources.
- Within the next 10 years, find uses for all of the tertiary treated water produced by the Regional Water Quality Control Facility. This will reduce the need for groundwater extraction in the basin.
- By 2010, install water meters at all of the user connections in the water system and bill for actual water used.
- Find alternate water sources such as surface water to supplement local groundwater.
- Reduce extraction amounts at any well site where there is a trend of increasing TDS and/or nitrate.

CITY OF CERES

GOALS AND OBJECTIVES

Insure that no constituents exceed the MCL for public drinking water.
Insure a safe, sustainable supply of drinking water is available for the beneficial use of the City's customers.

ACTIVITIES CONDUCTED TO SUPPORT THESE OBJECTIVES

Monitor groundwater levels monthly.
Monitor groundwater quality as required by the DHS.

Manage the groundwater resource to prevent contamination from above ground sources.

EASTSIDE WATER DISTRICT

Goals and Objectives

The primary goal of the Eastside Water District (EWD) is that groundwater will continue to be a reliable, safe, efficient and cost effective water supply.

Groundwater is a vitally important resource to all irrigators within the EWD. In the decades between the 1950's and 1990's water levels dropped dramatically, in significant part, as a result of pumping within the EWD. In recent years groundwater levels appeared to have stabilized. Studies in 2003 confirmed that the aquifer has reached equilibrium. The EWD Board of Directors recognize that in future years land uses and groundwater uses may change with the results that groundwater levels may again decline and groundwater quality may be adversely impacted.

The EWD recognizes that the Turlock Groundwater Basin is a shared resource and that it is important for all users in the basin to continue to manage groundwater for the benefit of all.

Activities Conducted to Support these Objectives

Water Levels: Continue to participate in the Turlock Groundwater Basin Association water level monitoring program.

Water Quality: Be alert to existing and changing agricultural and industrial activities within the EWD, which may adversely affect groundwater quality.

Conservation: Continue to encourage irrigators to conserve groundwater by use of highly efficient irrigation methods and use of surface water purchased as available the Turlock and Merced Irrigation Districts.

Studies and Investigations: Continue singularly and in cooperation with other agencies to study methods of avoiding and/or mitigating overdraft conditions.

Public Outreach: Continue a program of public education, water conservation and awareness of basin groundwater issues.

CITY OF MODESTO

Goals and Objectives

Until 1995, the City of Modesto relied solely on groundwater for its service area. Groundwater degradation and more stringent drinking water quality standards resulted in the abandonment of a number of wells within the City's service area. Currently, the City is augmenting its groundwater supplies in its contingency service area north of the Tuolumne River with surface water received from Modesto Irrigation District. In addition, the City is also considering augmenting its water supply for its water service customers south of the Tuolumne River by participating in the development of a future regional surface water treatment facility with the Turlock Irrigation District.

In the meantime, however, groundwater quality issues, including elevated levels of uranium and arsenic, continue to threaten the City's groundwater supply. To protect its groundwater and maintain groundwater as a viable drinking water source, the City has formulated the following BMO's for its management area:

Activities Conducted to Support these Objectives

Groundwater Quality Protection

The City proposes to protect groundwater quality by developing and implementing specific actions to identify potential sources of contamination and to develop a management plan to control and curtail movement of contamination into and within the basin. The specific actions may include the following:

- Develop a database and populate it with water quality data. Using the database information, develop tools to map contaminated areas, as well as historic movement of the contaminants.

- Formulate and implement a geologic assessment to better understand the basin's aquifer characteristics and water movement and to evaluate and understand the sources of contaminants. Detect potential changes in water quality that could affect the long-term quality and quantity of the drinking water supply.

- Develop a well field management plan that will manage groundwater pumping to reduce or eliminate contaminate movement into and within the Basin. Develop well design criteria, including proper spacing and screening of wells to manage groundwater pumping and the movement of contaminants.

Groundwater Levels

Groundwater levels, historically, were declining in this management area. Since 1995,the importation of treated surface water to augment the groundwater supply has allowed the groundwater levels to recover north of the Tuolumne River. A proposed surface water supply may provide an opportunity for the recovery of the groundwater levels in the Turlock Sub-basin. However, future population growth in and around the management area will increase groundwater consumption. To maintain groundwater levels in the management area, the City of Modesto formulated the following management objectives:

- Work with other entities in the subbasin to identify and protect potential groundwater recharge areas.

- Evaluate the feasibility of groundwater recharge and conjunctive use projects including the development of artificial recharge areas, conjunctive use projects, and storage tanks with transmission mains for added reliability to the system.

- Work with TID to evaluate the feasibility of developing a cooperative in-lieu recharge and/or water exchange programs including the following:

    - The use of surface water to augment the groundwater supply in the Turlock Sub-Basin.

- Develop an exchange program to mix the groundwater of marginal quality (for drinking water) with surface water and deliver it for agricultural use, golf courses, parks, and other open space areas in exchange for a surface water supply for the City of Modesto.

Water Conservation and System Improvement

The City of Modesto, under its Urban Water Management Planning function, will continue to evaluate water conservation and metering opportunities to reduce water demands in the service area. The City also plans to undertake a conveyance system interconnection improvement project to connect isolated delivery systems to its delivery network. These actions will add flexibility to the system and enable the City to reduce pumping from the areas of poor water quality and reduce movement of contaminants in the basin.

DENAIR COMMUNITY SERVICES DISTRICT

Goals and Objectives

The Denair Community Services District (DCSD) is a community water system located in the unincorporated town of Denair approximately four miles north-east of Turlock, in central southern Stanislaus County.

The District was formed on October 3, 1961 pursuant to California Government Code Section 61000, et. seq. The District is under the regulatory jurisdiction of the Department of Health Services Stockton District Office. The District has 1,250 non-metered active service connections and 10 commercial metered connections at various locations.

The DCSD has an approximate population of 3300 people, according to the 2000 census.

All of the water for Denair CSD is supplied from five deep wells. The District has produced water, which continuously meets all State drinking water requirements. The objective of the District is to maintain the highest quality of water to meet all customers' needs in the most efficient and financially sound manner.

Activities Conducted to Support these Objectives

Funding:

In September 2003, the Denair Community Services District was awarded a grant under the Local Groundwater Management Act of 2000 (AB303) for $200,000.00.

DCSD proposes to construct two cluster-monitoring (test) wells. Information from these two test wells, and other existing wells, will be used to support advancement of a hydro geologic model of the producing groundwater system and to monitor the quality and quantity of groundwater produced from the alluvial aquifer sequences underlying DCSD.

The title of "Cluster-monitoring well" was changed by DWR. They now call these wells "Nesting Wells."

Groundwater Monitoring:

DCSD developed its groundwater management program in 2001 with the drilling of a test hole, subsurface interpretations of favorable aquifer sequences, and by creating formal guidelines for residential developers to use to construct DCSD-required test and monitoring wells. Due to inadequate funding, DCSD's program is currently limited to residential developer's activities.

Proponents of residential development in 2002 recently constructed a nesting monitoring well. This well was the first one constructed to meet the guidelines established by the DCSD as part of its groundwater management program.

The DCSD provides proponents of residential development with guidelines for nesting monitoring well construction. DCSD then approves or disapproves of the test well results before a production well is planned and constructed. These test wells are required by DCSD. Funding is also needed for DCSD to advance the characterization and test well program in areas where residential development is not currently underway.

DELHI COUNTY WATER DISTRICT

Goals and Objectives

Activities Conducted to Support these Objectives

KEYES COMMUNITY SERVICES DISTRICT

Goals and Objectives

Activities Conducted to Support these Objectives

HILMAR COUNTY WATER DISTRICT

Goals and Objectives

The objective of the Hilmar County Water District is “to provide safe, affordable and reliable drinking water, wastewater, and storm drainage service”.

Activities Conducted to Support these Objectives

The Hilmar County Water District was established in 1965 under Division 12 of the Water Code of the State of California for the purpose of providing potable water to the residents of the Hilmar community. The District also provides wastewater collection and treatment for the community.

Closely monitor each potable water well to insure compliance with all water quality standards as established by the EPA and the State of California.

The District's customer base is fully metered and conservation pricing is in place to encourage wise use of our water resource.

Continued participation in the Turlock Groundwater Basin Association.

BALLICO COMMUNITY SERVICES DISTRICT

Goals and Objectives

Activities Conducted to Support these Objectives

BALLICO-CORTEZ WATER DISTRICT

Goals and Objectives

The primary goal of the Ballico Cortez Water District (BCWD) is that groundwater will continue to be a reliable, safe, efficient and effective water supply.

Groundwater is a vitally important resource to all irrigators within the BCWD. In the decades between the 1950's and 1990's water levels dropped as a result of basin wide pumping. In recent years groundwater levels appeared to have stabilized. Studies in 2003 confirmed that the aquifer has reached equilibrium. The Board of Directors recognize that in future years land uses and groundwater uses may change with the results that groundwater levels may again decline and groundwater quality may be adversely impacted

The BCWD recognizes that the Turlock Groundwater Basin is a shared resource and that it is important for all users in the basin to continue to manage groundwater for the benefit of all.

Activities conducted to support these objectives

Water levels: Continue to participate in the Turlock Groundwater Basin Association water level monitoring program.

Water Quality: Be alert to existing and changing agricultural and industrial activities within the BCWD. Which may adversely affect groundwater quality.

Conservation: Continue to encourage irrigators to conserve groundwater by use of highly efficient irrigation methods and use of surface water purchased as available from Turlock Irrigation District.

Studies and Investigations: Continue singularly and in cooperation with other agencies to study methods of avoiding and/or mitigating overdraft conditions.

Public Out reach: Continue a program of public education, water conservation and awareness of basin groundwater issues.

TURLOCK IRRIGATION DISTRICT

Goals and Objectives

The Turlock Irrigation District (TID) utilizes groundwater and surface water conjunctively. As such, it relies upon groundwater as a source of water in drier years, when surface water supplies are less abundant.

The Turlock Irrigation District (TID) endeavors to protect the quantity and quality of groundwater in Turlock Irrigation District, such that:

- Groundwater will continue to be a reliable, safe, efficient and cost effective water supply.
- Groundwater provides a high quality water supply to irrigation customers.

The TID recognizes that the Turlock Groundwater Basin is a shared resource and that it is important for all users in the basin to continue to manage groundwater for the benefit of all.

Activities Conducted to Support these Objectives

Water Levels: Continue to participate in the Turlock Groundwater Basin Association water level monitoring program. Continue to monitor shallow groundwater levels located at section corners. Continue to provide drainage, as appropriate, so long as it is in accordance with the District's rules and procedures, as well as the changing water quality regulatory requirements.

Water Quality: Be alert to existing and changing activities within the Turlock Groundwater Basin which may adversely affect groundwater quality. Continue to monitor changes to regulatory requirements, and provide comments, as necessary, in these processes. Adjust practices, as necessary, to comply with regulatory requirements.

Conservation: Continue to encourage the use of surface water supplies for irrigation purposes within the District. Support urban agencies use of surface water supplies, where available, from the TID, in addition to or in lieu of groundwater, for urban uses. Continue to participate in the Ag Water Management Council, and maintain the District's Ag Water Management Plan.

Studies and Investigations: Continue to study, both individually and collectively with other agencies, methods for protecting and preserving the quantity and quality of groundwater supplies within the Basin including: avoiding and/or mitigating overdraft conditions; groundwater quality and means of addressing water quality issues; future water supply needs and availability; water supply for urban uses; and river interactions and the affects upon the groundwater basin.

Public Outreach: Continue to provide public education on water related issues including, but not limited to, water conservation and awareness of basin groundwater issues. Continue participation in the Turlock Groundwater Basin Association.

MERCED IRRIGATION DISTRICT

Goals and Objectives

Activities Conducted to Support these Objectives

STANISLAUS COUNTY

Goals and Objectives

Activities Conducted to Support these Objectives

Appendix F

LIST OF AGENCIES THAT HAVE ADOPTED THE
TURLOCK GROUNDWATER BASIN GROUNDWATER MANAGEMENT PLAN
AND COPIES OF THE ACTIONS TAKEN TO ADOPTED THE PLAN

APPENDIX E - TURLOCK GROUNDWATER BASIN WATER BUDGET

TURLOCK GROUNDWATER BASIN
WATER BUDGET
1952-2002

December 2003

Prepared for
Turlock Groundwater Basin Association

Prepared by
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CONSULTING HYDROLOGISTS

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1.0 INTRODUCTION

1.1 Purpose of the Study

The Turlock Groundwater Basin Association was established to coordinate the common interests of local public agencies in the utilization and protection of groundwater within the Turlock basin. The members include the City of Ceres, City of Hughson, City of Modesto, City of Turlock, Denair Community Services District, Hilmar County Water District, Ballico-Cortez Water District, Eastside Water District, Merced Irrigation District, Turlock Irrigation District, Stanislaus County, and Merced County. A particular common interest of the Association is the groundwater budget for the Turlock basin. This report describes the groundwater budget for the Turlock basin for 1952-2002, which was prepared for the Association. The Delhi County Water District participated in the study, but it is not a member of the Association.

The groundwater budget represents a quantification of the water inflows to, and outflows from the groundwater basin. The inflows represent the replenishment of groundwater. The principal inflow is the deep percolation water from agricultural irrigation. The outflows represent the depletion of groundwater. The principal outflow is groundwater pumping for agricultural and municipal uses. The difference between the inflows and outflows determines the groundwater-level trends within the basin. If the total inflows exceed the total outflows, groundwater levels rise and the volume of groundwater stored increases within the basin. Likewise, if the total outflows exceed the total inflows, groundwater levels decline and the volume of groundwater stored decreases within the basin.

The Turlock groundwater basin comprises an area of about 350,000 acres or 540 square miles. The basin is bounded on the north by the Tuolumne River, on the west by the San Joaquin River, on the south by the Merced River, and on the east by the rocks of the Sierra Nevada foothills (Figure 1.1). These boundaries for the most part isolate the Turlock basin from the groundwater conditions outside its boundaries, and the groundwater conditions outside the Turlock basin for the most part have little impact within the basin. Correspondingly, the groundwater conditions within the Turlock basin for the most part have little impact on the groundwater conditions outside the basin. However, where significant groundwater pumping occurs near the Tuolumne or Merced rivers, that pumping can cause identifiable groundwater impacts on the opposite side of the river.

1.2 Cultural Setting

The Turlock basin contains both large urban and large agricultural areas (Figure 1.1). The urban areas cover about 20,000 acres or 6 percent of the basin. The agricultural areas with irrigated crops cover about 250,000 acres or 72 percent of the basin. The remaining percentage includes areas of non-irrigated crops and native vegetation. The urban and irrigated agricultural areas are located primarily within the western and central parts of the Turlock basin. The native areas are located mostly within the eastern part of the basin.

Nine communities are located within the basin (Figure 1.2). These include the cities of Ceres, Hughson, and Turlock, part of the city of Modesto, and the communities of Delhi, Denair, Hickman, Hilmar, and Keyes. Groundwater is the water-supply source for these communities. The current groundwater pumping for these communities is about 42,000 acre-feet per year (acre-ft/yr). Figure 1.3 shows the annual pumping for 1952-2002.

Four agricultural water agencies are located within the Turlock basin (Figure 1.2). These are the Ballico-Cortez Water District, Eastside Water District, Turlock Irrigation District, and part of the Merced Irrigation District, which currently and collectively includes about 193,000 acres of irrigated land. Groundwater is the sole water-supply source within the Ballico-Cortez and Eastside water districts, except for small areas intermittently irrigated from surface-water sources. Surface water is the principal water-supply source within the Merced and Turlock irrigation districts, but supplemental groundwater is pumped. The Turlock Irrigation District diverts from the Tuolumne River, while the Merced Irrigation District diverts from the Merced River. The annual diversion from the Tuolumne River is about 540,000 acre-ft/yr. The annual diversion from the Merced River to irrigate lands within the Turlock basin is about 20,000 acre-ft/yr. The total groundwater pumping within the four districts is about 300,000 acre-ft/yr. Figure 1.4 shows the combined annual diversions from the Tuolumne and Merced rivers for 1952-2002, and Figure 1.5 shows the combined agricultural irrigation groundwater pumping within the four districts for 1952-2002.

1.3 Geologic Setting

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 ft in thickness within the western part of the Turlock basin (California Division of Mines and Geology, 1966a). The Turlock groundwater basin occurs within marine deposits of Eocene age (55 to 34 million years ago) and continental deposits of Miocene age (beginning 24 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 1.6).

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 1.7 and 1.8 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 1.7 and 1.8) and is as much as 120 ft 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 1.7), and does not crop out at the land surface (Figure 1.8). The unit is comprised of silt and clay with some sand. The shallow aquitard is encountered 30 to 50 ft 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 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 200 ft. 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 (Figures1.7 and 1.8). 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 1.7 and 1.8) 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 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 800 ft. 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 (24 million to 5 million years ago), underlies the Mehrten Formation and crops out on the eastern edge of the Turlock groundwater basin (Figures 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 500 ft (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 34 million years ago), underlies the Valley Springs Formation and crops out on the eastern edge of the Turlock groundwater basin (Figures 1.7 and 1.8). The thickness of the unit increases westward, but the thickness generally is less than 200 ft (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).

1.4 Hydrologic Setting

1.4.1 Description of Aquifers

The groundwater system consists of three aquifers. In order of downward occurrence, these are the unconfined aquifer, freshwater confined aquifer, and the saline confined aquifer (Figure 1.8).

The unconfined aquifer occurs within the Modesto and Riverbank formations (Figure 1.8). However, this aquifer is confined locally by a discontinuous shallow aquitard that occurs within the western part of the Turlock groundwater basin. Otherwise, the unconfined aquifer is a water-table aquifer. This aquifer is about 150 ft in thickness, and the depth to its top ranges from less than 10 ft in the western part of the Turlock basin to 50 ft within the central part of the basin. Within the western part of the groundwater basin, the unconfined aquifer is underlain by the Corcoran Clay, which is about 90 ft in thickness. The unconfined aquifer is used extensively as an agricultural and municipal water supply. Wells less than about 200 ft in depth draw from the unconfined aquifer.

The freshwater confined aquifer occurs within the Turlock Lake and Mehrten formations. It is confined by the Corcoran Clay member of the Turlock Lake Formation (Figure 1.8) within the western part of the Turlock groundwater basin. It is semi-confined within the eastern part of the basin, where the Riverbank Formation directly overlies it. It is unconfined in the eastern part of the basin, where the Turlock Lake and Mehrten formations crop out. The freshwater confined aquifer is about 1,300 ft in thickness, and the depth to its top ranges from 200 ft in the western part of the Turlock basin to 100 ft within the eastern part of the basin. The freshwater confined aquifer is used extensively as an agricultural and municipal water supply. Wells greater than about 200 ft in depth draw from the freshwater confined aquifer. However, such wells will draw also from the unconfined aquifer, if the depth to the top of the well perforations is less than 200 ft.

The saline confined aquifer occurs within the Valley Springs and Ione formations (Figure 1.8). The aquifer is confined except where the formations crop out. The saline confined aquifer is about 600 ft in thickness, and the depth to its top ranges from 1,500 ft in the western part of the Turlock groundwater basin to 100 ft within the eastern part of the basin. The deep aquifer is used little as a water supply.

The discontinuous shallow aquitard, and an overlying shallow aquifer, that occurs within the unconfined aquifer causes a high groundwater table in the western part of the groundwater basin. The low vertical permeability of the shallow aquitard restricts the downward percolation of infiltrated precipitation and irrigation applications. The shallow aquifer is a water-table aquifer, and the depth to the groundwater table is generally less than 6 ft. The aquifer is about 40 ft in thickness, and the shallow aquitard forms its base. The shallow aquitard is about 15 ft in thickness.

1.4.2 Groundwater Levels

The Turlock Irrigation District and the California Department of Water Resources have collected groundwater-level data for the Turlock basin since about 1950. The District collected data from wells that monitor shallow groundwater levels within the unconfined aquifer. The Department collected data from wells that monitor intermediate-depth groundwater levels within the unconfined and freshwater confined aquifers. Groundwater-level data are not available for the saline confined aquifer.

Section corner well locations are displayed on Figure 1.9. Figures 1.10a-e show contours of the measured depth to groundwater in section corner wells at July 1960, 1970, 1980, 1990 and 2000. However, contours are not shown where the depth to groundwater is greater than 15 ft. Because the section corner wells are only about 15 feet in depth, a depth cannot be measured if the depth to groundwater is greater than 15 ft. Figures 1.11a-d respectively show temporal groundwater elevation in section corner Well 221, Well 310, Well 351, and Well 401. The locations for these wells are shown on Figure 1.9.

The depth to groundwater within the section corner wells ranges geographically from less than 4 ft to more than 15 ft (Figures 1.10a-e). The depth to groundwater within the wells at any particular time depends on a number of factors. Those include prior irrigation, precipitation, drainage pumping, and irrigation pumping. Irrigation applications and precipitation cause higher groundwater levels. Drainage pumping by the Turlock Irrigation District helps to lower groundwater levels. Private irrigation pumping also causes lower groundwater levels. The interactions between these factors cause the geographic pattern of groundwater levels to vary seasonally and inter-annually. However, groundwater levels within the section corner wells do not display a long-term trend of either increasing or decreasing.

Intermediate-depth monitoring well locations are displayed on Figure 1.12. The wells represent typical irrigation wells used by the California Department of Water Resources for monitoring wells. Figures 1.13a-d show the measured groundwater elevations in intermediate-depth monitoring wells for December 1960, November 1977, November 1986, and November 1998. These particular years were selected due to the availability of monitoring data that provide a good geographic coverage. Figures 1.14a-d respectively show temporal groundwater levels for wells 04S08E22R001M, 04S11E08A001M, 05S11E25A001M, and 06S10E16M001M. The locations for these wells are shown on Figure 1.12.

While groundwater levels within the shallow aquifer do not have a temporal trend, groundwater levels within the intermediate-depth monitoring wells do have a trend toward lower groundwater elevations. Within most of the Turlock Irrigation District the trend is small, and groundwater levels have declined less than 10 ft since 1960. However, within the central part of the Turlock basin, groundwater levels have declined as much as 90 ft since 1960 (Figures 1.13a and 1.13d). These declines occurred mostly during 1970-1990, and the current rate of decline is small (Figures 1.14b and 1.14c).

1.5 Water-Budget Equation

The water-budget equation for a groundwater basin represents an application of the law from physics of mass conservation. The mass conservation law states that for an incompressible fluid the volumetric inflow to a defined region minus the volumetric outflow from that region equals the rate of change in the fluid volume stored within the region. This law is expressed for a groundwater basin by the equation

$$\begin{bmatrix} \textit{Groundwater} \\ \textit{Inflow} \end{bmatrix} - \begin{bmatrix} \textit{Groundwater} \\ \textit{Outflow} \end{bmatrix} = \begin{bmatrix} \textit{Groundwater} \\ \textit{Storage} \\ \textit{Change} \end{bmatrix}$$

The water budget for a groundwater basin must always balance according to this equation.

For the Turlock groundwater basin, the water budget equation in more detail has the form

$$Q_{ri} + Q_{rni} + Q_{rr} + Q_{rt} + Q_{rf} - Q_{op} - Q_{or} - Q_{oad} - Q_{ov} = \Delta S$$

where

Q_{ri} is groundwater recharge from irrigated areas (acre-ft/yr),
Q_{rni} is recharge from non-irrigated areas (acre-ft/yr),
Q_{rr} is recharge from the Tuolumne, Merced, and San Joaquin rivers (acre-ft/yr),
Q_{rt} is recharge from Turlock Lake (acre-ft/yr),
Q_{rf} is recharge from the Sierra Nevada foothills (acre-ft/yr),
Q_{op} is groundwater discharge from pumping (acre-ft.yr),
Q_{or} is discharge to the Tuolumne, Merced, and San Joaquin rivers (acre-ft/yr),
Q_{oad} is discharge to agricultural drains (acre-ft.yr),
Q_{ov} is groundwater use by riparian vegetation (acre-ft/yr), and
ΔS is the rate of change in groundwater storage (acre-ft/yr).

The compilation of the water budget for the Turlock basin involved quantifying each of the terms in this equation. Data were available to evaluate eight of the ten terms comprising the water-budget equation. Data were not available to independently quantify either the groundwater recharge from the Tuolumne, Merced, and San Joaquin rivers or the groundwater discharge to the rivers.

The water-budget terms other than the net groundwater discharge to the rivers were quantified from compiled data. Data representing the period 1952-2002 were compiled from the City of Ceres, City of Hughson, City of Modesto, City of Turlock, Denair Community Services District, Delhi County Water District, Hilmar County Water District, Ballico-Cortez Water District, Eastside Water District, Merced Irrigation District, Turlock Irrigation District, Stanislaus County, and Merced County, California Department of Water Resources, U. S. Geological Survey, and other organizations. Data were compiled on the hydrogeology of the groundwater basin, the location and construction of wells, groundwater pumping from wells, land use, canal deliveries for irrigation, crop acreages, crop consumptive use, streamflow, groundwater levels, and other subjects. Those data were analyzed to develop estimates of recharge from irrigated areas, non-irrigated areas, rivers, Turlock Lake, and the Sierra Nevada foothills. Additionally, those data were analyzed to develop estimates of discharge from pumping, seepage to rivers, seepage to agricultural drains, and groundwater use by riparian vegetation. Finally, those data were analyzed to develop estimates of changes in groundwater storage.

The net groundwater discharge to the Tuolumne, Merced, and San Joaquin rivers was derived from the quantification of the other terms within the water budget equation. The net groundwater discharge is give by the relation

$$Q_{nor} = Q_{or} - Q_{rr}$$

where Q_{nor} is the net groundwater discharge to the Tuolumne, Merced, and San Joaquin rivers (acre-ft/yr). If this equation is substituted into the water-budget equation, the relation for the net groundwater discharge to the rivers is

$$Q_{nor} = Q_{ri} + Q_{rmi} + Q_{rt} + Q_{rf} - Q_{op} - Q_{oad} - Q_{ov} - \Delta S$$

The compilation of the water budget for the Turlock groundwater basin involved using the available data to quantify all right-hand terms in this equation in order to quantify the net groundwater discharge to the rivers.

2.0 LAND USE WITHIN THE TURLOCK GROUNDWATER BASIN

The Turlock groundwater basin is comprised of approximately 346,000 acres, including 250,000 acres of irrigated crops, 20,000 acres of urban development, and 72,000 acres of native vegetation. Figure 2.1 shows the Turlock groundwater basin and the boundaries of five subareas for which land-use acreages have been estimated. The Turlock Irrigation District, Eastside Water District, Ballico-Cortez Water District, and Merced Irrigation District comprise four of the subareas. Regions outside the boundaries of these districts comprise the other subarea. The subarea representing the Turlock Irrigation District includes the communities of Ceres, Delhi, Denair, Hickman, Hilmar, Hughson, Keyes, south Modesto, and Turlock.

Figures 2.2a-i show the urbanized and landscaped acreages for the nine urban communities within the Turlock Irrigation District for 1952-2002. The irrigated acreages represent areas of residential, community, and commercial landscaping. The non-irrigated acreages represent, in part, areas with an impervious surface, such as streets, buildings, parking lots, and similar covers. The non-irrigated acreages represent also areas with a pervious surface, such as vacant lots, construction sites, and similar covers.

The land uses within the Turlock Irrigation District include irrigated agricultural land, on-farm non-irrigated land, other non-irrigated land, city urban land, non-city urban land, and highways and roads. The land-use category of irrigated agricultural land is the acreage actually irrigated. The category of on-farm non-irrigated land is the on-farm area occupied by farm roads, buildings, equipment yards, and similar non-irrigated uses. The category of other non-irrigated land includes grazing land, non-irrigated cropland, and similar non-irrigated land uses. The category of city urban land is the urbanized area within a city political boundary. The category of non-city urbanized land comprises urbanized areas outside a city political boundary. The category of highways and roads is the area occupied by highways, roads, and canal and railroad right-of-ways.

Land use within the Turlock Irrigation District is shown on Figure 2.3 for 1952-2002. Figure 2.3 indicates that the total acreage within the District has remained unchanged, but the partitioning of the total acreage among irrigated, urban, and other land uses has changed over time. Most notably is the fact that the urban acreage has increased over time, while the irrigated agricultural acreage correspondingly has decreased over time. These opposite trends are a result of the urbanization of agricultural land.

The land uses within the Eastside Water District, Ballico-Cortez Water District, Merced Irrigation District, and non-district areas include irrigated agricultural land, on-farm non-irrigated land, other non-irrigated land, highways and roads, and non-city urban land. While city urban land occurs within the Turlock Irrigation District, that land-use category does not occur within these other areas. As defined before, irrigated agricultural land is the acreage actually irrigated, exclusive of on-farm non-irrigated areas. On-farm non-irrigated land is the on-farm area occupied by roads, buildings, equipment yards, and similar non-irrigated uses. Other non-irrigated land includes grazing land, non-irrigated cropland, and similar non-irrigated land uses. Non-city urbanized land comprises urbanized areas outside a city political boundary. Based on these categories, the land use within the Eastside Water District, Ballico-Cortez Water District, Merced Irrigation District, and non-district areas is shown on Figures 2.4a-g for 1952-2002.

3.0 OUTFLOWS FROM THE TURLOCK GROUNDWATER BASIN

Discharge from the Turlock groundwater basin occurs because of pumping for wells, groundwater seepage to the Tuolumne, Merced, and San Joaquin rivers, discharges from subsurface agricultural drains, and water use by riparian vegetation. The total discharge for these outflows was about 506,000 acre-ft/yr during the recent five-year period 1998-2002. The discharge for each component is described below.

3.1 Groundwater Pumping

The average groundwater pumping within the Turlock groundwater basin was about 411,000 acre-ft/yr during the recent five-year period 1998-2002, including drainage, agricultural, municipal, and private domestic pumping. The average drainage pumping was about 69,000 acre-ft/yr, while the average agricultural pumping was 296,000 acre-ft/yr. The average municipal pumping was about 42,000 acre-ft/yr. This included pumping for the communities of Ceres, Delhi, Denair, Hickman, Hilmar, Hughson, Keyes, south Modesto, and Turlock. The average private domestic pumping was about 4,000 acre-ft/yr.

To lower the high groundwater table within the western part of the Turlock groundwater basin the Turlock Irrigation District pumps from about 170 drainage wells. The average pumping from the District drainage wells was 69,000 acre-ft/yr during the recent five-year period 1998-2002. Figure 3.1 shows the annual pumping from these wells for 1952-2002.

Growers within the Turlock Irrigation District pump from about 895 wells to supplement canal deliveries. The average pumping from supplemental-source private and improvement district wells within the Turlock Irrigation District was 20,946 acre ft/yr during the recent five-year period 1998-2002. Wells of this type fall into two distinct categories. The first category is comprised of supplemental-source private and improvement district irrigation wells not rented by the Turlock Irrigation District. These are wells owned and operated for private usage. Figure 3.2 shows the annual pumping from non-rented supplemental-source wells for 1952-2002. Water from wells that are not rented irrigates crops near the non-rented well. The second category is comprised of supplemental-source private and improvement district irrigation wells that are rented by the District. These are wells owned privately, but operated publicly to supplement the Tuolumne River diversions. Figure 3.3 shows the annual pumping from rented wells. Water pumped from wells that are rented becomes part of the district-wide water supply as provided by the District.

Some growers within the Turlock Irrigation District choose not to receive annual deliveries and irrigate instead from groundwater. The average pumping from primary-source irrigation wells within the District was about 9,200 acre-ft/yr during the recent five-year period 1998-2002. However, the primary-source pumping has increased from about 4,000 acre-ft/yr in 1998 to about 13,000 acre-ft/yr in 2002. Figure 3.4 shows the annual estimated pumping from these wells.

Growers within the Eastside Water District, Ballico-Cortez Water District, and non-district area pump from about 180 wells. The average pumping from primary-source private irrigation wells within the Eastside Water District, Ballico-Cortez Water District, and non-district areas was about 250,000 acre-ft/yr during the recent five-year period 1998-2002. Figures 3.5 and 3.6 show the annual pumping from these wells, which represents the sole irrigation supply.

Growers within the Merced Irrigation District pump groundwater to supplement canal deliveries. Additionally, some growers within the District choose not to receive annual deliveries and irrigate instead from groundwater. The combined average annual pumping from the supplemental-source and primary-source private irrigation wells was 120 acre-ft/yr during the recent five-year period 1998-2002. Figure 3.7 shows the combined annual pumpage from the supplemental-source and primary-source private irrigation wells within this District for 1952-2002.

The communities of Ceres, Delhi, Denair, Hickman, Hilmar, Hughson, Keyes, south Modesto, and Turlock pump, collectively pump groundwater from approximately 76 wells. The average pumping from municipal wells was about 42,000 acre-ft/yr during the recent five-year period 1998-2002. Figures 3.9a-i show the annual pumping for municipal wells for 1952-2002.

About 3,300 residences within the Turlock groundwater basin use groundwater for domestic usage. The average pumping from private domestic wells was about 4,000 acre-ft/yr during the recent five-year period 1998-2002. Figure 3.10 shows the annual pumping from these wells.

3.2 Groundwater Discharge to Tuolumne, Merced, and San Joaquin Rivers

Groundwater discharges occur along the lower reaches of the Tuolumne and Merced rivers, and along the entire reach of the San Joaquin River. Along the upper reaches of the Tuolumne and Merced rivers, streamflow recharges the groundwater basin. However, the net effect is that the groundwater discharge to the rivers generally exceeds the streamflow recharge to the groundwater basin. Correspondingly, the net groundwater discharge to the rivers is positive. During the recent five-year period 1998-2002, the net discharge was 41,000 acre-ft/yr.

3.3 Groundwater Discharge from Subsurface Agricultural Drains

Some growers within the Turlock groundwater basin have installed subsurface drains to lower the groundwater table. If the depth to the groundwater table is within the root zone of a crop, the crop can be damaged. To prevent such damage, growers have installed perforated subsurface pipes that drain away excess groundwater. About 6,700 acres within the Turlock groundwater basin are underlain with subsurface drains. The average groundwater discharge to the drains was about 14,000 acre-ft/yr over the recent five-year period 1998-2002. Annual total discharges from all drains are shown on Figure 3.11 for 1977-2002.

3.4 Groundwater Consumed by Riparian Phreatophytes

Phreatophytes are plants that can live with their roots below or near the water table and extract their moisture requirements directly from the saturated zone or overlying capillary fringe (Freeze and Cherry, 1979). About 18,500 acres of native phreatophytes occur along the Tuolumne, Merced and San Joaquin rivers. The average groundwater consumption of the riparian phreatophytes is about 41,000 acre-ft/yr over the recent five-year period 1998-2002. The annual groundwater usage of the riparian vegetation is shown on Figure 3.12.

4.0 INFLOWS TO THE TURLOCK GROUNDWATER BASIN

Recharge to the Turlock groundwater basin results from the irrigation of crops and landscape vegetation, precipitation, percolation from the Tuolumne and Merced rivers, leakage from Turlock Lake, an underflow from the Sierra Nevada foothills, and upward seepage from deep geologic fractures. The total recharge from these sources was about 508,000 acre-ft/yr during the recent five-year period 1998-2002. The recharge for each component of the total is described below.

4.1 Groundwater Recharge from Irrigated Land

Groundwater recharge from irrigation results when the applied irrigation water and effective precipitation exceed the consumptive water use of agricultural crops or landscape vegetation. The excess water infiltrates below the root zone and then percolates downward to the groundwater table. Within the central and western parts of the Turlock groundwater basin, the percolation to the water table recharges the unconfined aquifer, because in those parts of the basin the unconfined aquifer is the water-table aquifer. Within the eastern part of the groundwater basin, the percolation recharges both the freshwater and saline confined aquifers, because in that part of the basin those aquifers respectively eastward are the water-table aquifer. Within the western part of the Turlock groundwater basin, the Corcoran Clay separates the freshwater confined aquifer from the overlying unconfined aquifer. The freshwater confined aquifer is recharged in that part of the basin by westward groundwater flow from the eastern part of the basin and locally downward groundwater flow through the Corcoran Clay. However, in the far western part of the freshwater confined aquifer, groundwater tends to move upward through the Corcoran Clay.

Within the Turlock groundwater basin, irrigation produced groundwater recharge of 427,800 acre-ft/yr over the recent five-year period 1998-2002. The recharge from croplands was 422,000 acre-ft/yr. The recharge from landscaping within urban areas was 5,900 acre-ft/yr. Figures 4.1-4.8 show the annual recharge from irrigated land for 1952-2002, which is the recharge that occurs from the combine effects of precipitation and irrigation applications. Also shown on Figures 4.1-4.8 is the recharge that would have occurred from precipitation, based on the assumption that the recharge fraction due to precipitation is the precipitation as a percentage of the total irrigation plus precipitation.

4.2 Groundwater Recharge from Non-irrigated Land

Groundwater recharge from precipitation on dry undeveloped land results when the effective precipitation exceeds the consumptive water use of the annual or perennial vegetation. Within the Turlock groundwater basin, this phenomenon produced groundwater recharge of 42,000 acre-ft/yr over the recent five-year period 1998-2002. Figure 4.9 shows the annual groundwater recharge for 1952-2002.

4.3 Recharge from Tuolumne and Merced Rivers

Streamflow within the Tuolumne and Merced rivers recharges the Turlock groundwater basin. The recharge occurs along the upper reaches of the rivers. Within the lower reaches of the Tuolumne and Merced rivers, groundwater discharges to the rivers. Additionally, groundwater discharges to the San Joaquin River along its entire reach. Within the groundwater budget for the Turlock groundwater basin, the streamflow-groundwater interactions are expressed in terms of the net groundwater discharge to the rivers.

4.4 Recharge from Turlock Lake

Turlock Lake (Figure 1.1), which has a surface area of about 3,300 acres, is an off-channel reservoir used to regulate releases into the Turlock Irrigation District canal network. Because Turlock Lake is underlain by the moderately permeable sediments of the Mehrten Formation, water leaks from the lake into the underlying and adjacent groundwater system. The average leakage is about 36,000 acre-ft/yr over the recent five-year period 1998-2002.

4.5 Recharge from Foothills and Deep Geologic Formations

The Turlock groundwater basin is recharged from subsurface inflows that enter the groundwater basin across its eastern boundary and the base of the groundwater system. The recharge from both sources is about 3,000 acre-ft/yr.

The fractured rocks that constitute Sierra Nevada foothills contain groundwater. The regional direction of groundwater flow is westward. At the eastern boundary of the Turlock groundwater basin, that westward groundwater flow produces subsurface flow into the Turlock groundwater basin. The slope of the groundwater table within the Turlock groundwater basin near its eastern boundary suggests that the subsurface flow is about 1,000 acre-ft/yr.

The marine formations that underlie the Turlock groundwater basin leak water upwards into the Ione formation. Groundwater samples from oil and gas wells indicate the leakage is saline, with dissolved solids as much as 50,000 milligrams per liter (mg/L). The excessive groundwater salinity within the deeper and more westerly parts of the Turlock groundwater basin suggests the upward leakage is about 2,000 acre-ft/yr.

5.0 CHANGE IN GROUNDWATER STORAGE

The change in groundwater storage over the recent five-year period 1998-2002 was 2,000 acre-ft/yr based on measured groundwater levels. This storage change balances the difference between the recharge and discharge for the Turlock groundwater basin, as required by the water-balance equation. The total recharge was 508,000 acre-ft/yr during the recent five-year period 1998-2002, and the total discharge was 506,000 acre-ft/yr. The recharge exceeds the discharge by 2,000 acre-ft/yr.

Groundwater level changes were estimated from the available groundwater-level data. The data included measurements by the Turlock Irrigation District within the section corner wells and measurements by the California Department of Water Resources in intermediate-depth monitoring wells. Based on these data, groundwater-level changes were estimated not only for the five-year period 1998-2002, but also for each consecutive five-year period for 1952-1997. Figures 5.1a-j show resulting contours of groundwater-level change respectively for each of the five-year periods, where the contours indicate the average annual change during a five-year period. The groundwater-storage and basin-wide average groundwater-level changes, for each consecutive five-year period for 1952-2002, are shown in Table 5.1.

Groundwater storage has been depleted within the Turlock groundwater basin. However, storage depletions did not begin until about 1963. As indicated in Table 5.1 and Figures 5.1a-b, groundwater-levels were essentially unchanged during 1952-1962. Correspondingly, groundwater storage was unchanged. However, as indicated on Figures 5.1c-h and Table 5.1, groundwater levels declined during 1963-1992. The cumulative basin-wide average groundwater-level decline was about 45 ft. Correspondingly, the cumulative storage depletion was about 1.6 million acre-ft. Nevertheless, groundwater levels again have been essentially unchanged during 1993-2002.

Groundwater-level changes within the Turlock groundwater basin have occurred mostly within the Eastside Water District, as shown on Figures 5.1c-j. While the basin-wide average groundwater-level decline was about 45 ft during 1963-1992, the maximum decline within the Eastside Water District was about 100 ft.

6.0 SUMMARY WATER BUDGET FOR TURLOCK GROUNDWATER BASIN

The water budget for the Turlock groundwater basin is listed in Table 6.1 for the five-year periods during 1953-2002. For each five-year period, the component inflows to and outflows from the groundwater basin are listed. Additionally, the changes in groundwater storage are listed. The groundwater inflows include recharge from irrigated areas, recharge from non-irrigated areas, seepage from Turlock Lake, underflow from the Sierra Nevada foothills, and upward seepage from deep geologic formations. The groundwater outflows include pumping from wells, groundwater discharge to rivers, groundwater discharge from subsurface agricultural drains, and groundwater consumption by riparian vegetation.

Table 6.1 indicates the groundwater storage within the Turlock groundwater basin was depleted during 1963-1992. The cumulative storage depletion was about 1.6 million acre-ft, which represents an average depletion of about 53,000 acre-ft/yr. However, depletions have mostly ceased. In fact, the storage within the Turlock groundwater basin has increased somewhat. The cumulative increased storage during 1993-2002 was 74,000 acre-ft, which represents an average accretion of about 7,000 acre-ft/yr. Nevertheless, groundwater storage remains substantially depleted with respect to groundwater conditions in 1962.

The slight recovery of the Turlock groundwater basin suggests that an equilibrium state, or steady state, condition has been established. The outflows from the groundwater basin are about balanced by the inflows to the basin. Correspondingly, the year-to-year groundwater storage and groundwater levels are not changing over time. This equilibrium state has been established even though groundwater pumping has increased over the last three decades. While the groundwater pumping during 1953-1957 was 404,000 acre-ft/yr, the groundwater pumping during 1998-2002 was 507,000 acre-ft/yr, which represents a 25 percent increase in pumping. The increased pumping was accompanied by a decrease in the groundwater discharges to the Tuolumne, Merced, and San Joaquin rivers. As indicated in Table 6.1, the average annual net discharge to the rivers was about 85,000 acre-ft/yr during 1953-62, but about 41,000 acre-ft/yr during 1993-2002. The increased pumping was accompanied also by the depletion of groundwater storage. As can be derived from Table 6.1, the average storage-depletion rate during 1953-2002 was about 30,000 acre-ft/yr, which occurred primarily in the eastern part of the Turlock groundwater basin.

While the groundwater basin currently is in an equilibrium state, that state most likely will not be permanent. The current equilibrium will be disrupted by any change in groundwater recharge or discharge. The most immediate disruption will be caused by increased urbanization of irrigated agricultural land within the Turlock groundwater basin. The effects of urbanization are to increase pumping and to decrease recharge, both of which will produce renewed groundwater-storage depletions. Groundwater pumping can be increased as urbanization converts agricultural land irrigated mostly with surface water to developed land supplied from groundwater. Groundwater recharge can be decreased as urbanization reduces the irrigated area and the corresponding recharge from irrigation and precipitation on irrigated areas. Without urbanization, crops cover nearly 100 percent of the land area. With urbanization, landscape vegetation covers only a small percentage of the original crop area.

Changes in crop acreages and irrigation practices also can disrupt the equilibrium of the groundwater basin. If the acreage of crops irrigated with groundwater were to increase, groundwater pumping necessarily would increase. If the acreage of crops irrigated with surface water were to change to more advanced irrigation practices groundwater recharge could decrease. This occurs because advanced irrigation technologies typically result in increased irrigation efficiency, and reduced recharge. If crops, which historically were irrigated with surface water move to groundwater, along with these advanced irrigation technologies, the impact to groundwater would be two-fold. Not only would there be reduced recharge, but there would also be additional extractions from the groundwater basin. Conversely, changes to advanced irrigation technologies for existing crops irrigated with groundwater will typically have essentially no water-budget impact. This occurs because increased irrigation efficiency through advanced irrigation technologies decreases equally both pumping and the irrigation recharge resulting from the application of the pumped water.

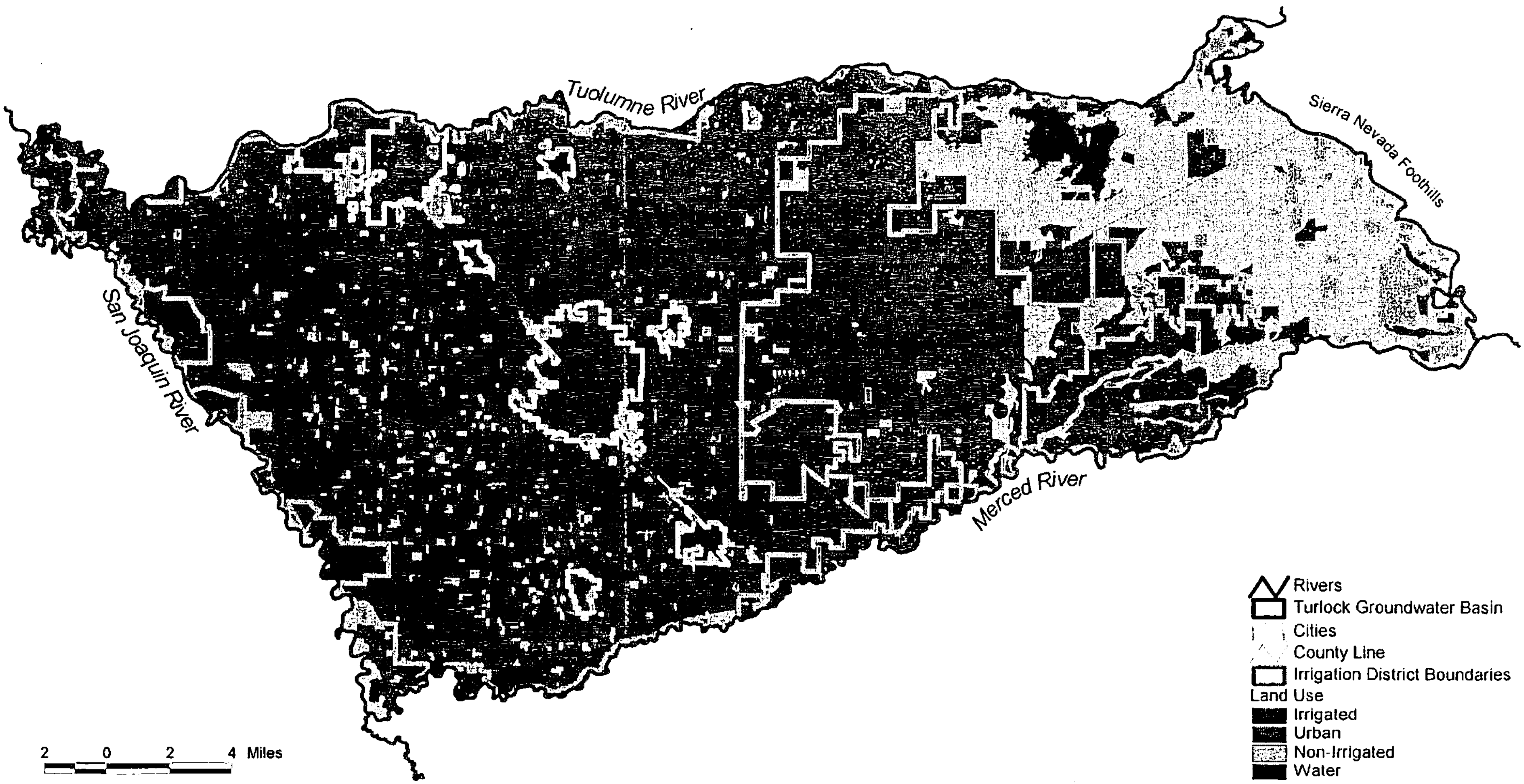

Figure 1.1 Land Use within the Turlock Groundwater Basin for 2000

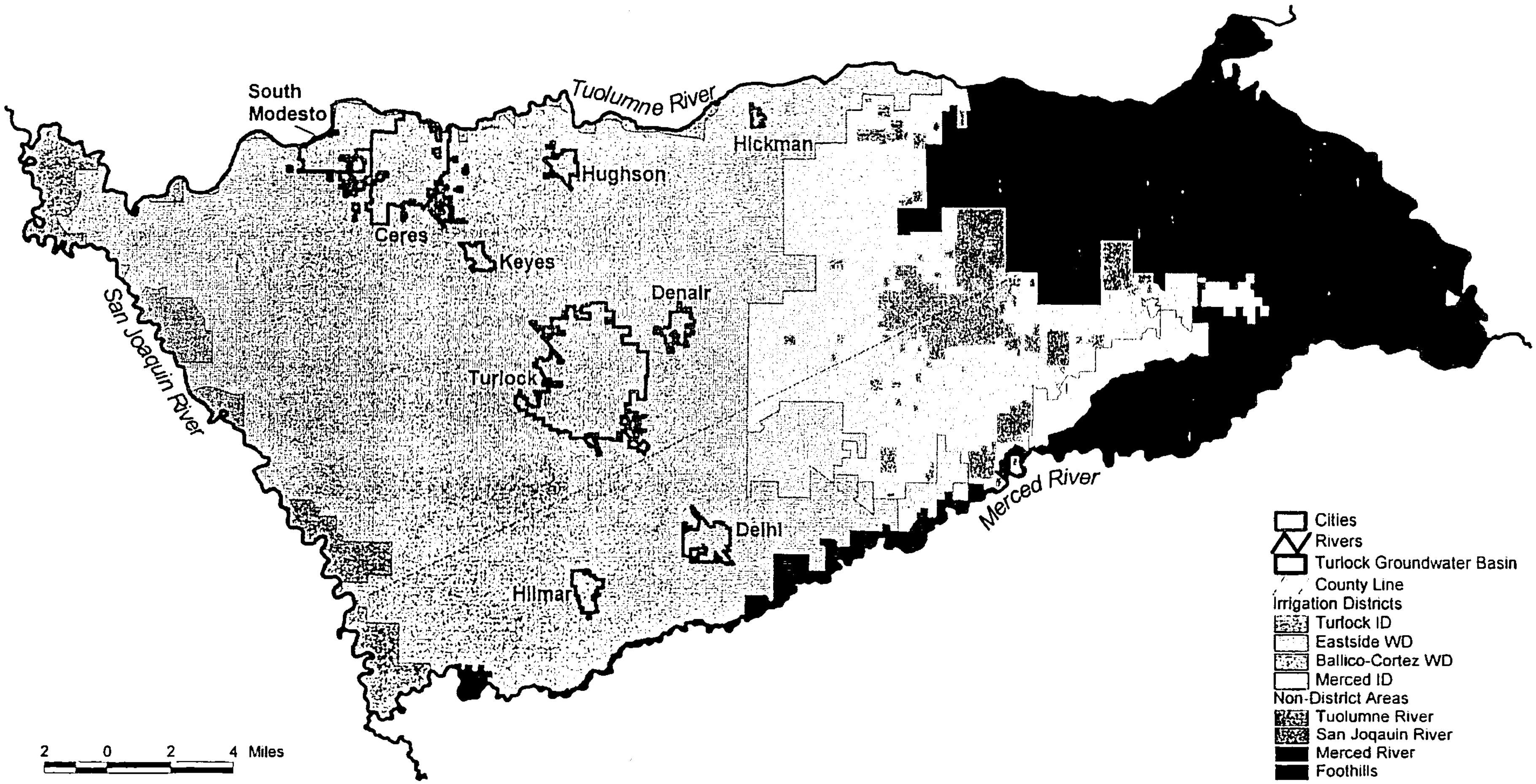

Figure 1.2 Urban Areas, Irrigation Districts, and Non-District Areas within Turlock Groundwater Basin

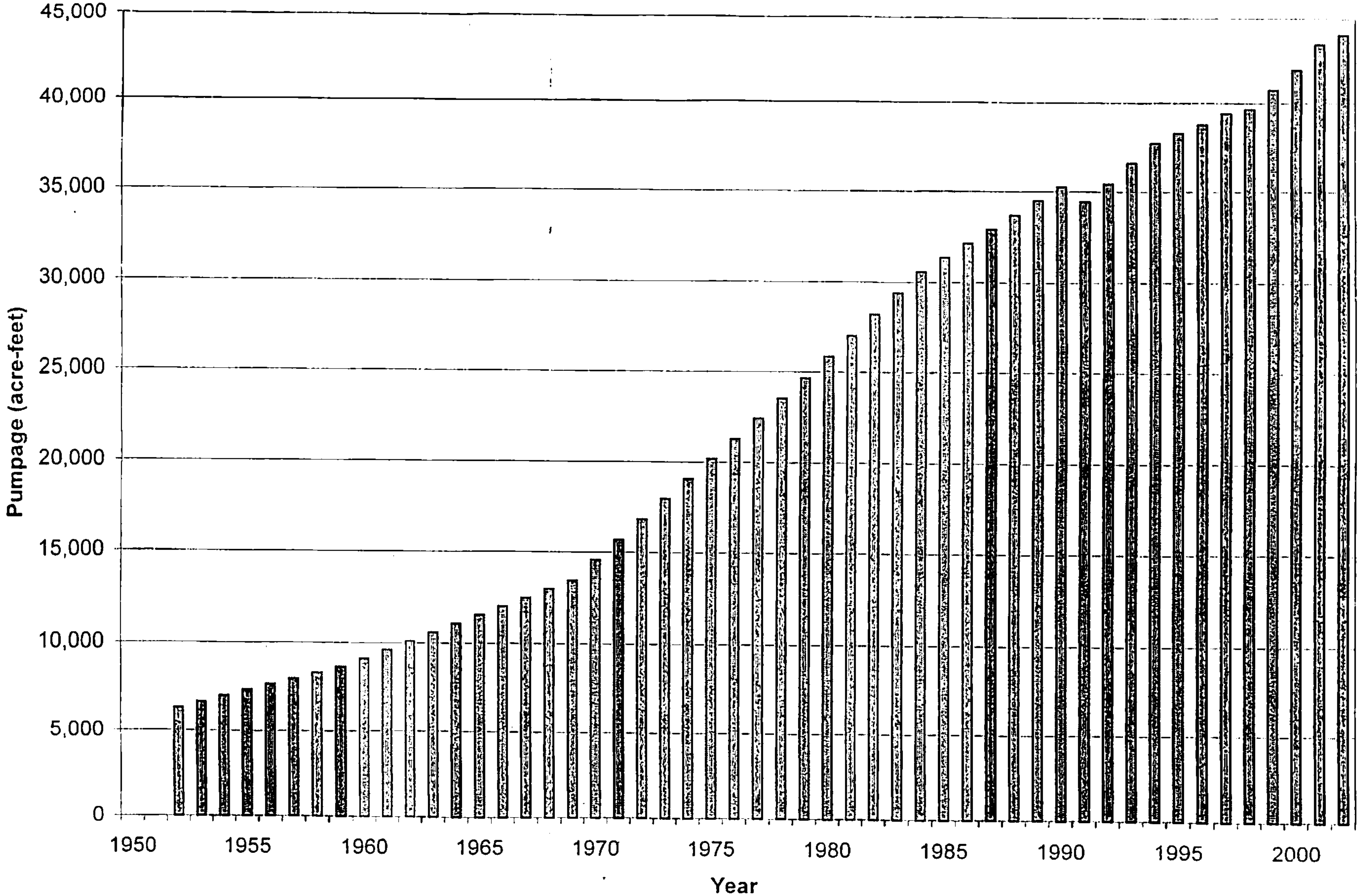

Figure 1.3 Municipal Groundwater Pumping within the Turlock Groundwater Basin, 1952-2002

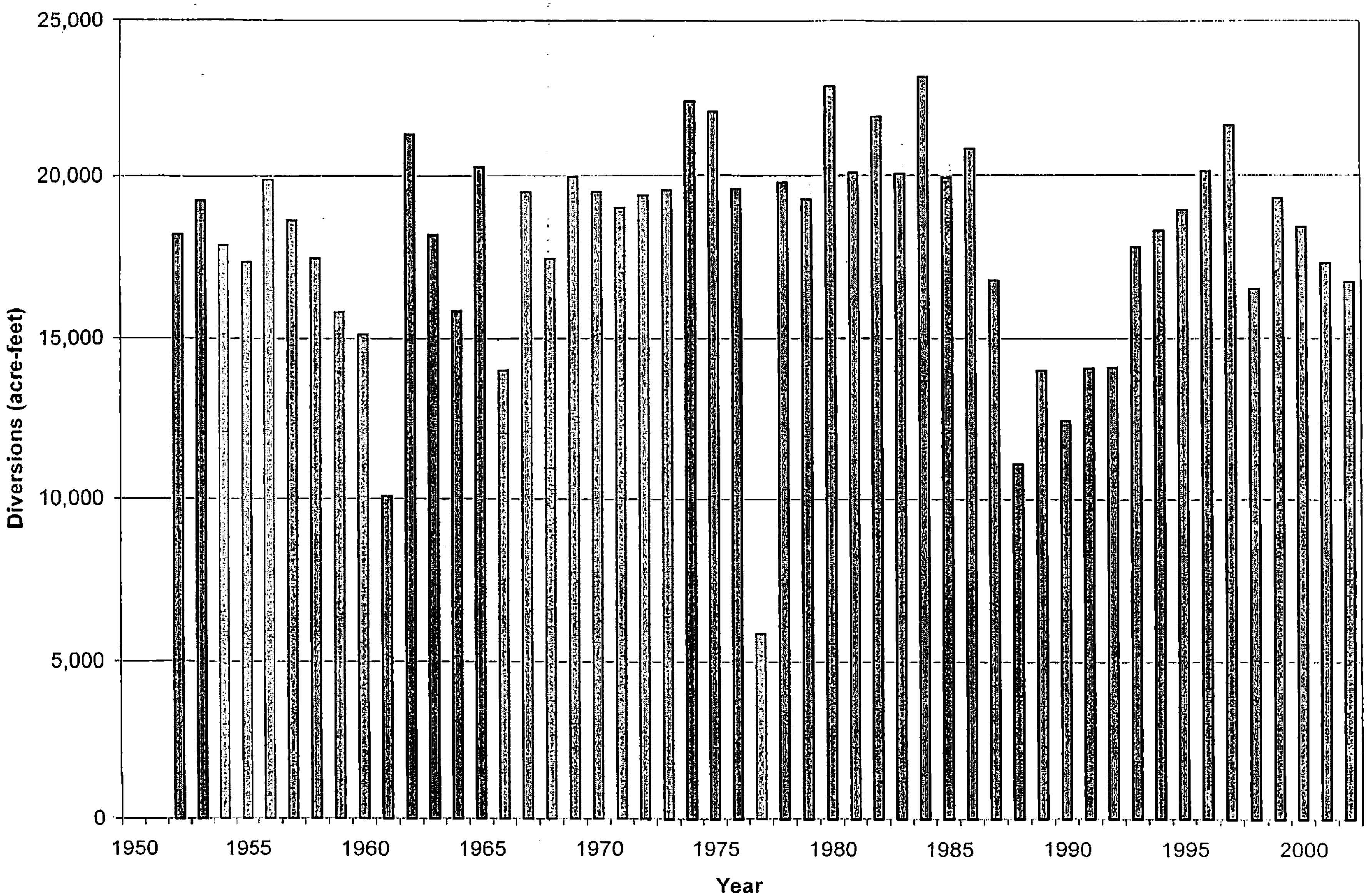

Figure 1.4 Combined Agricultural Diversions from Tuolumne and Merced Rivers, 1952-2002

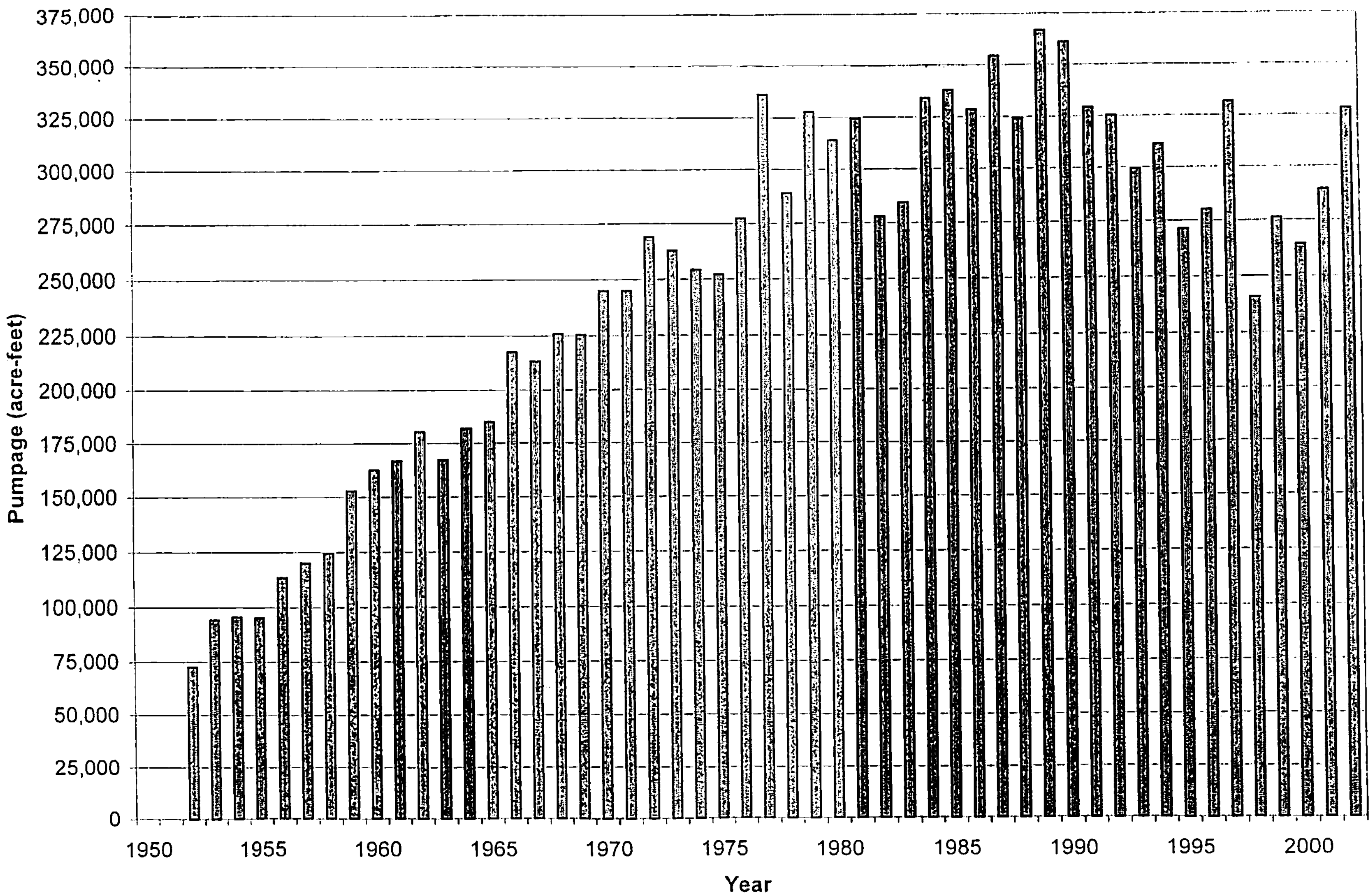

Figure 1.5 Agricultural Groundwater Pumping from Water Districts within the Turlock Groundwater Basin, 1952-2002

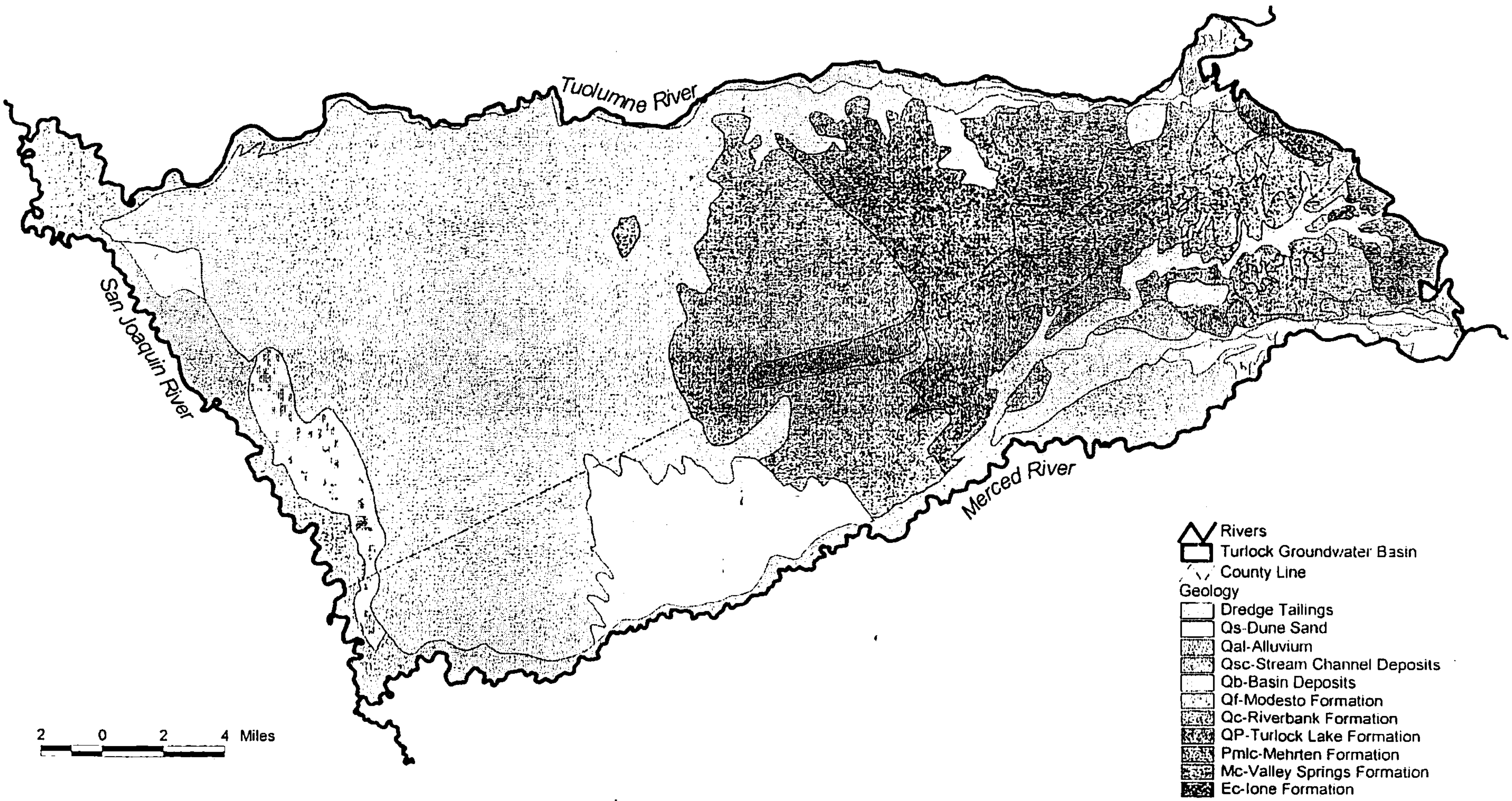

Figure 1.6 Geology of the Turlock Groundwater Basin

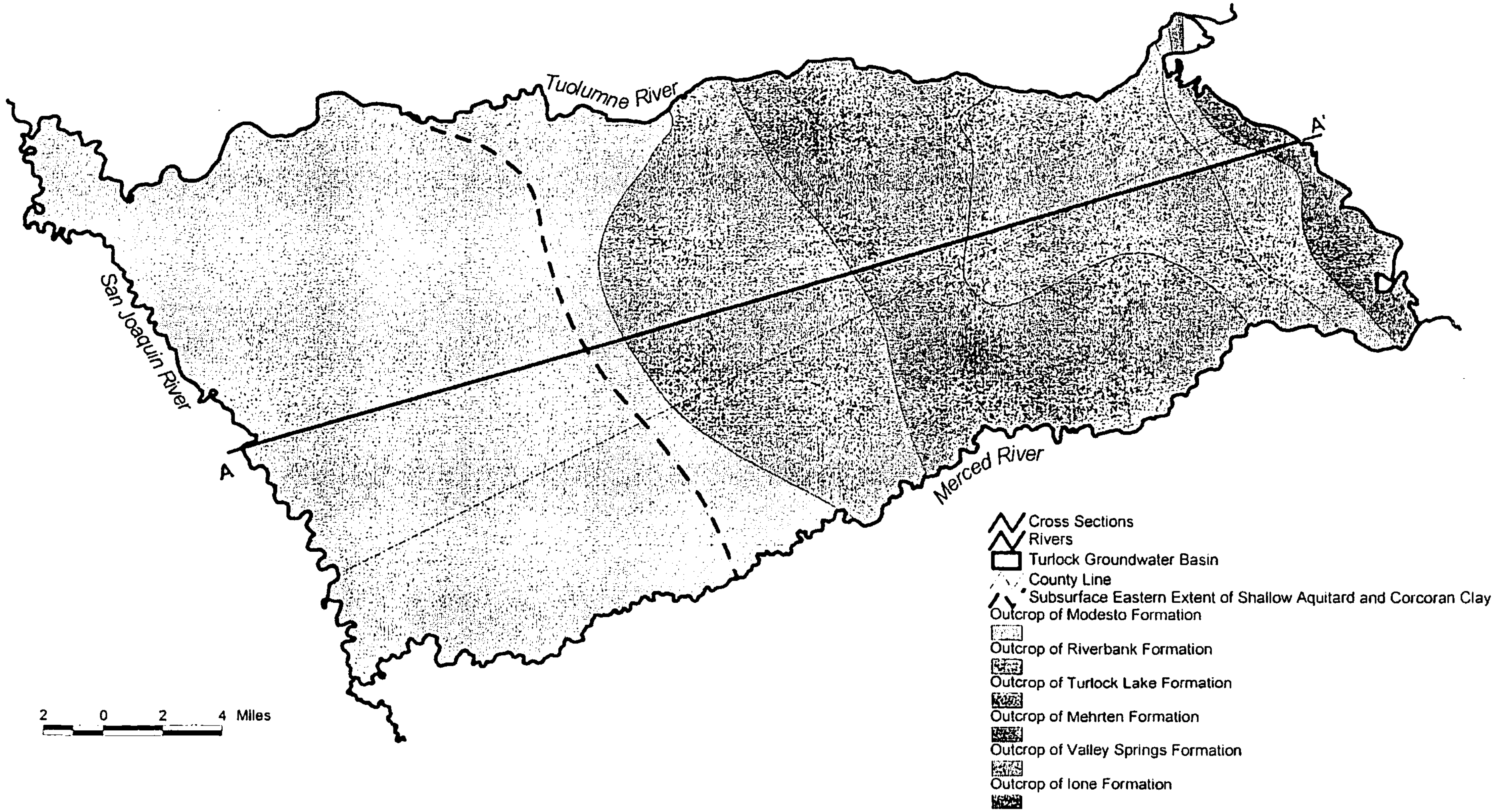

Figure 1.7 Hydrogeologic Units Represented within the Groundwater Model

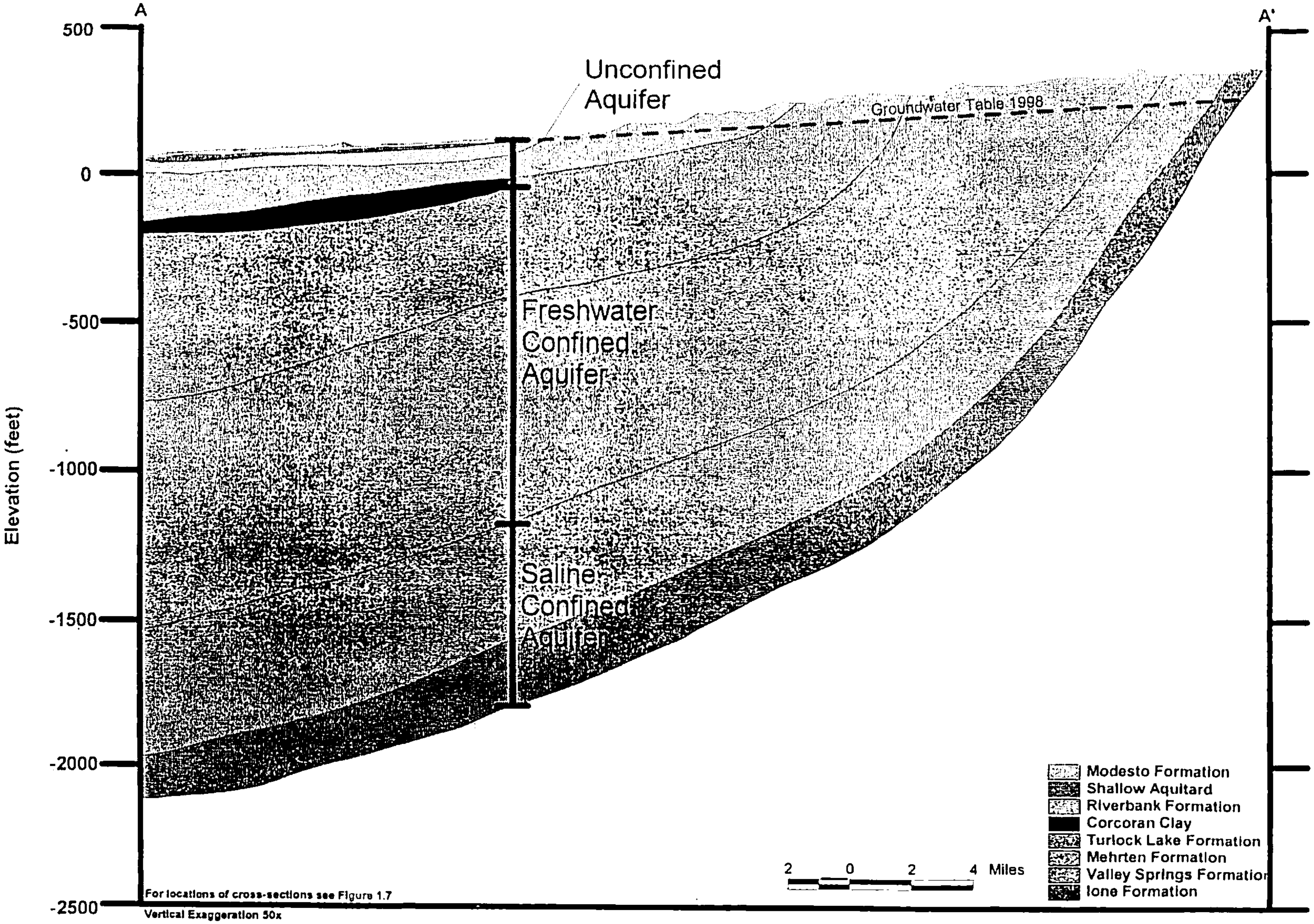

Figure 1.8 East-West Cross-Section Showing Hydrogeologic Units within the Groundwater Basin

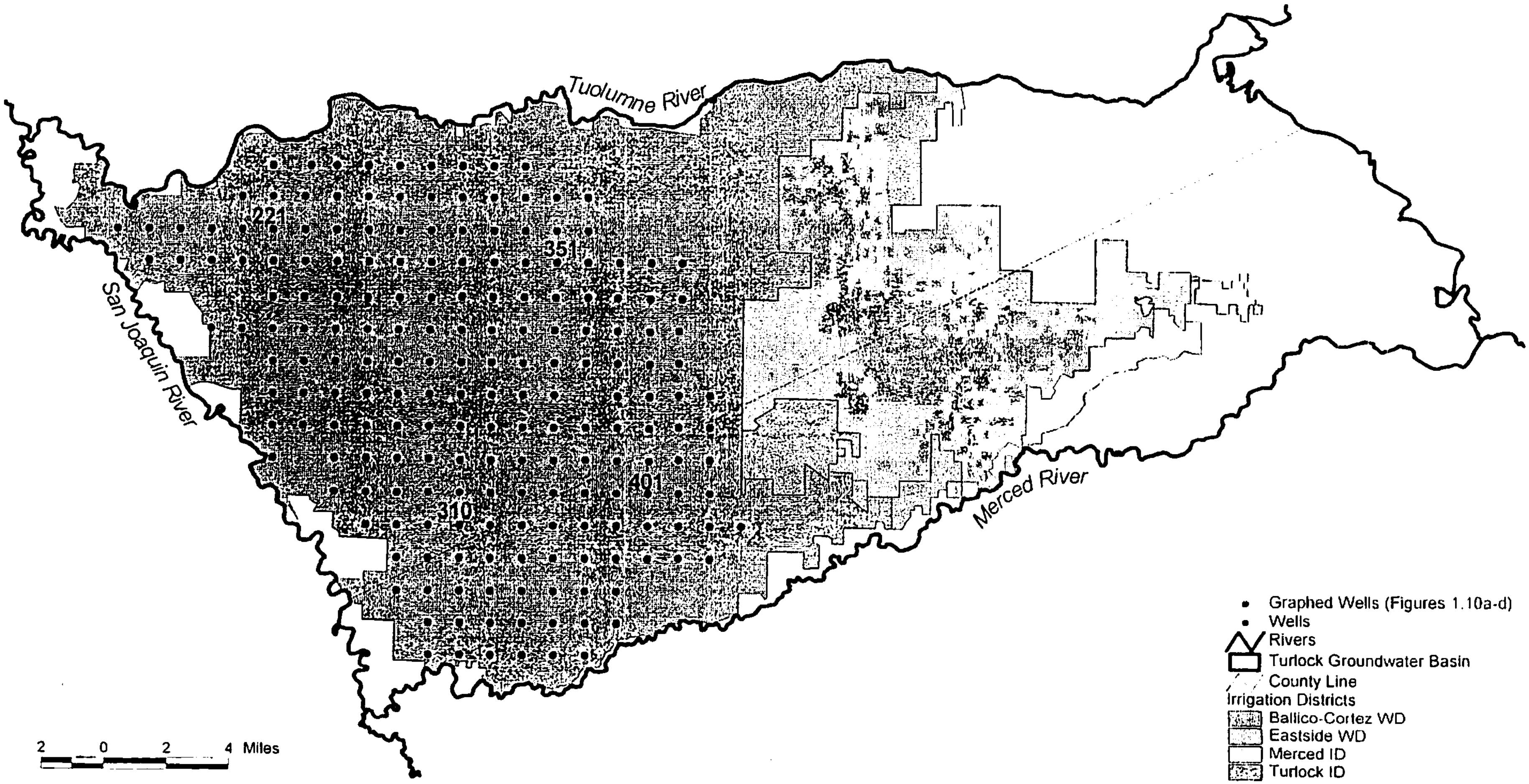

Figure 1.9 Locations of Section-Corner Wells

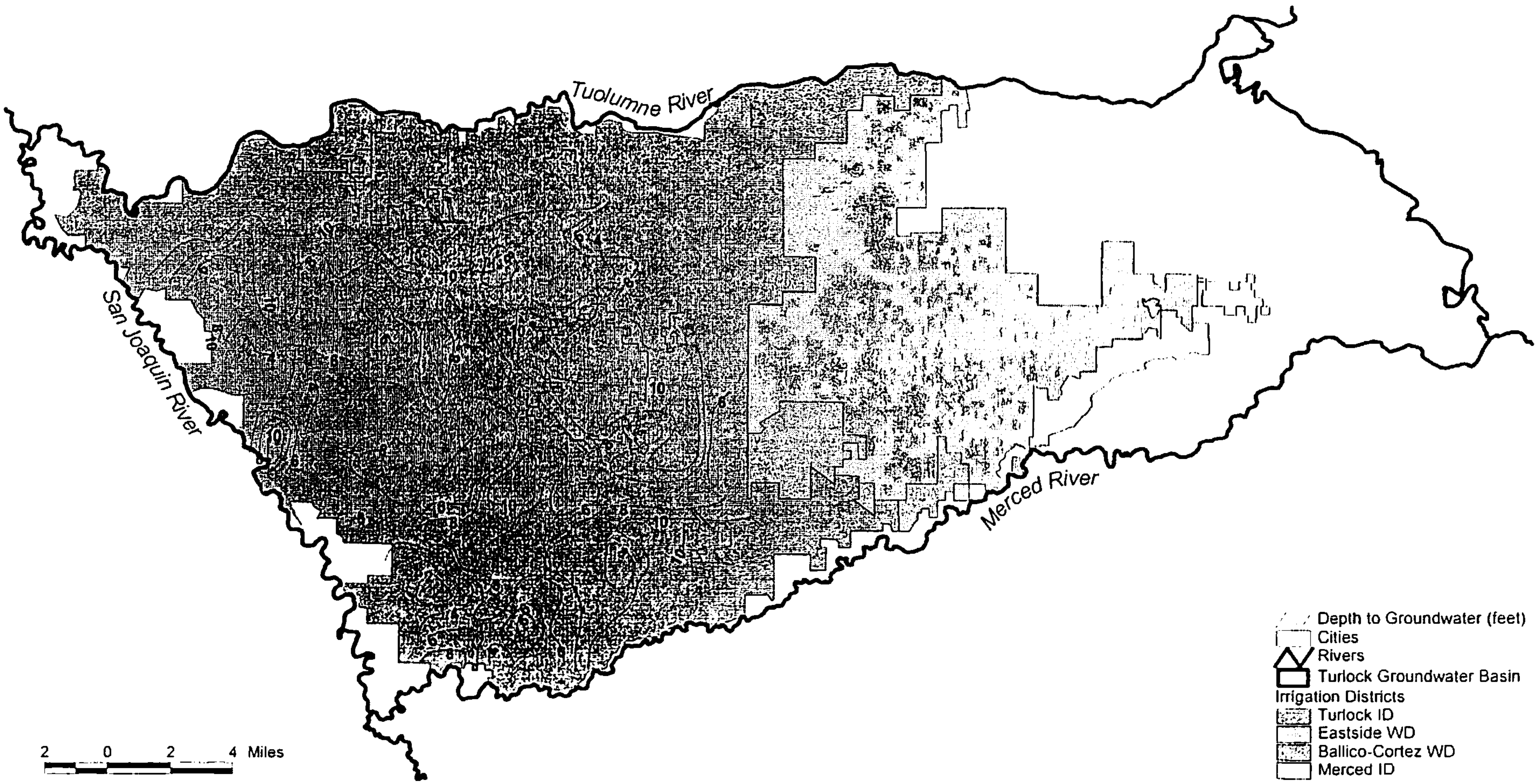

Figure 1.10a Measured Depth to Groundwater in Section-Corner Wells, July 1960

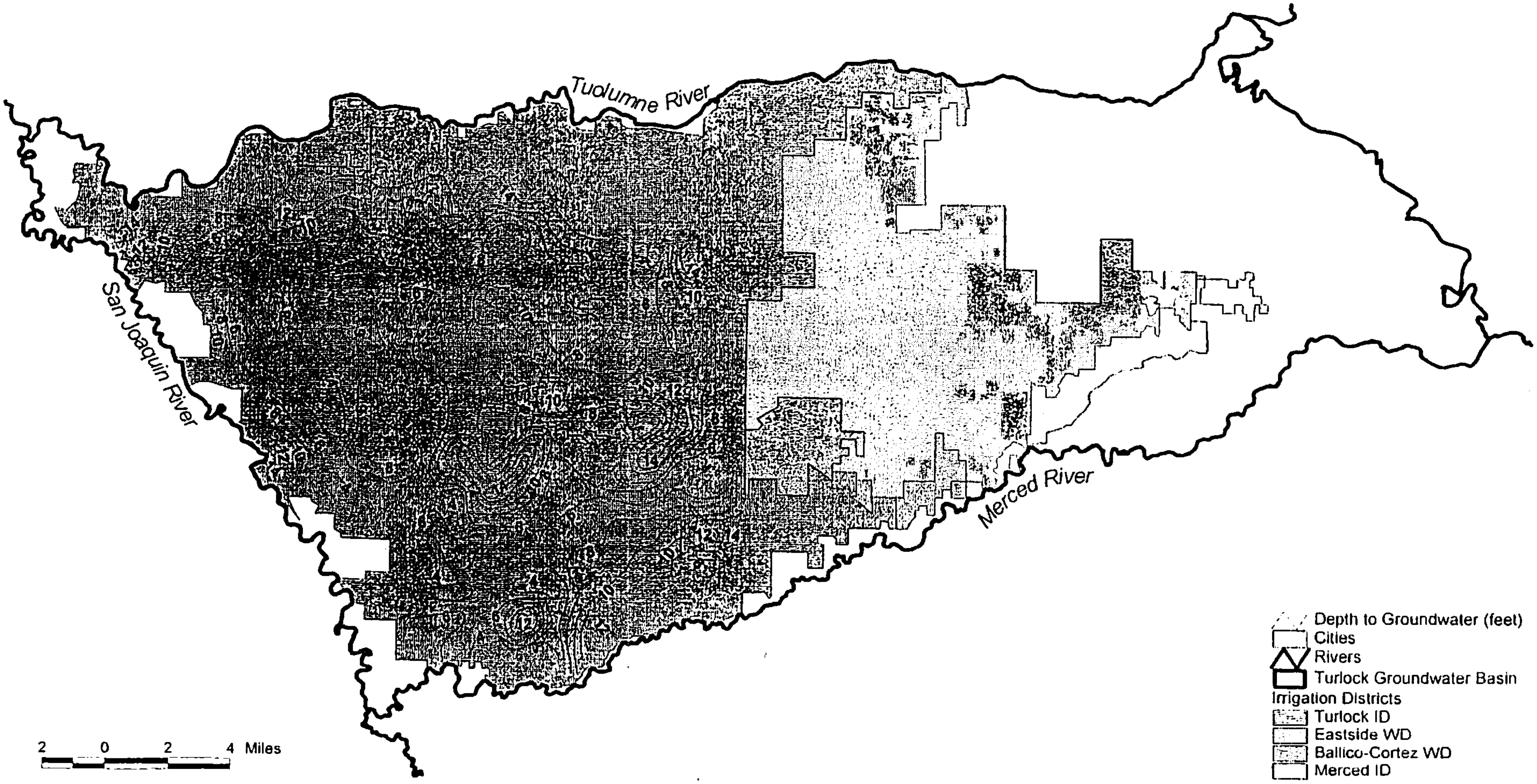

Figure 1.10b Measured Depth to Groundwater in Section-Corner Wells, July 1970

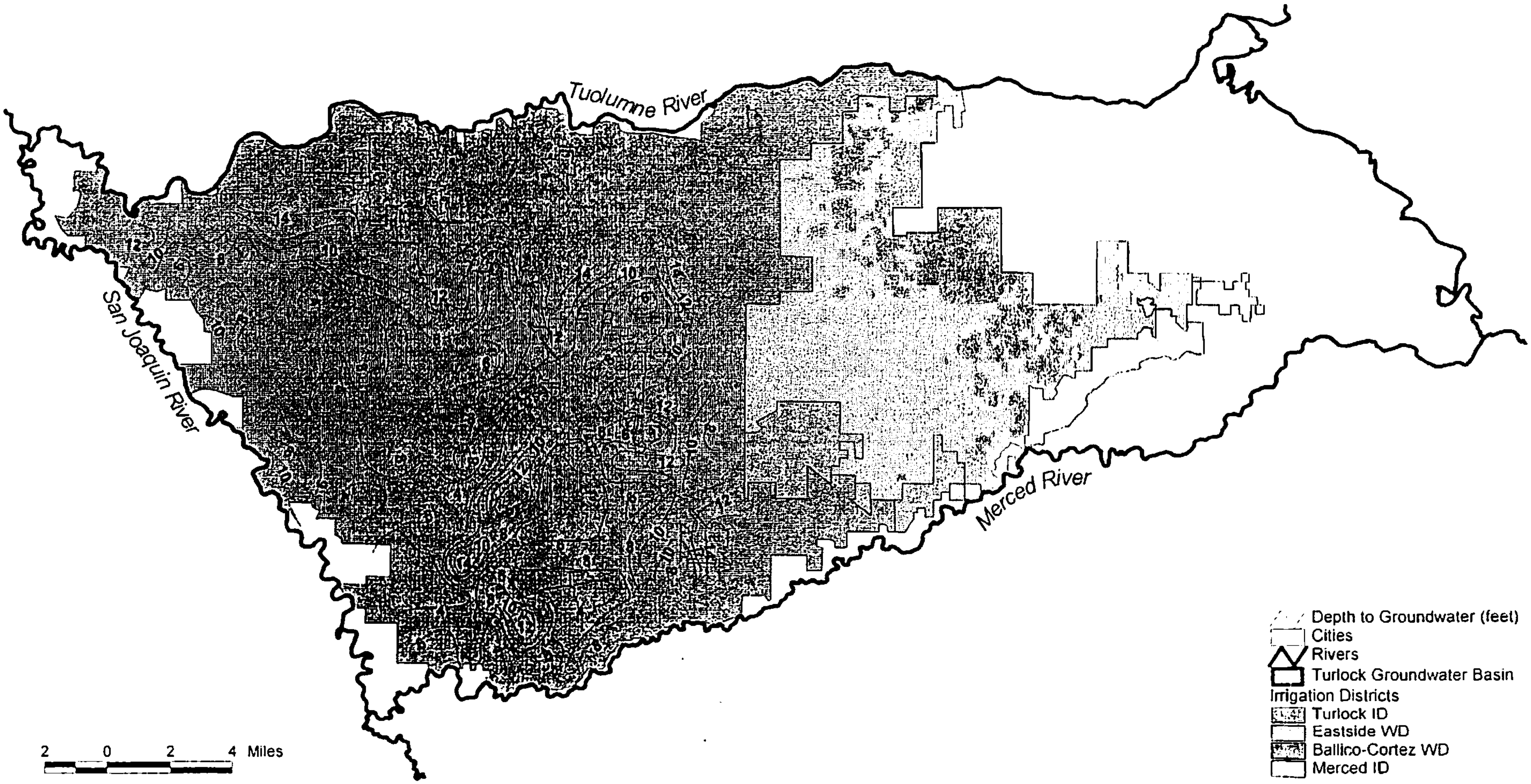

Figure 1.10c Measured Depth to Groundwater in Section-Corner Wells, July 1980

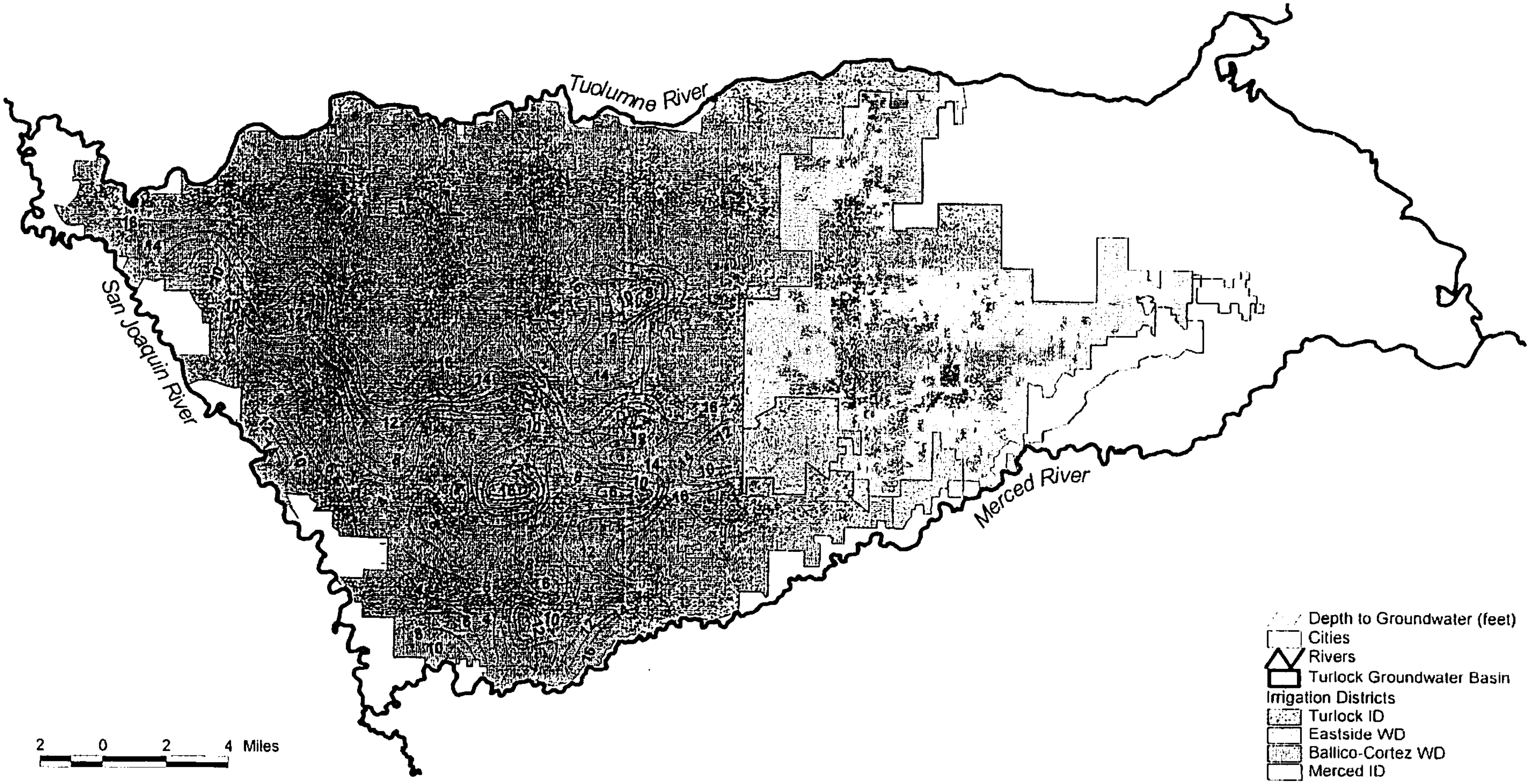

Figure 1.10d Measured Depth to Groundwater in Section-Corner Wells, July 1990

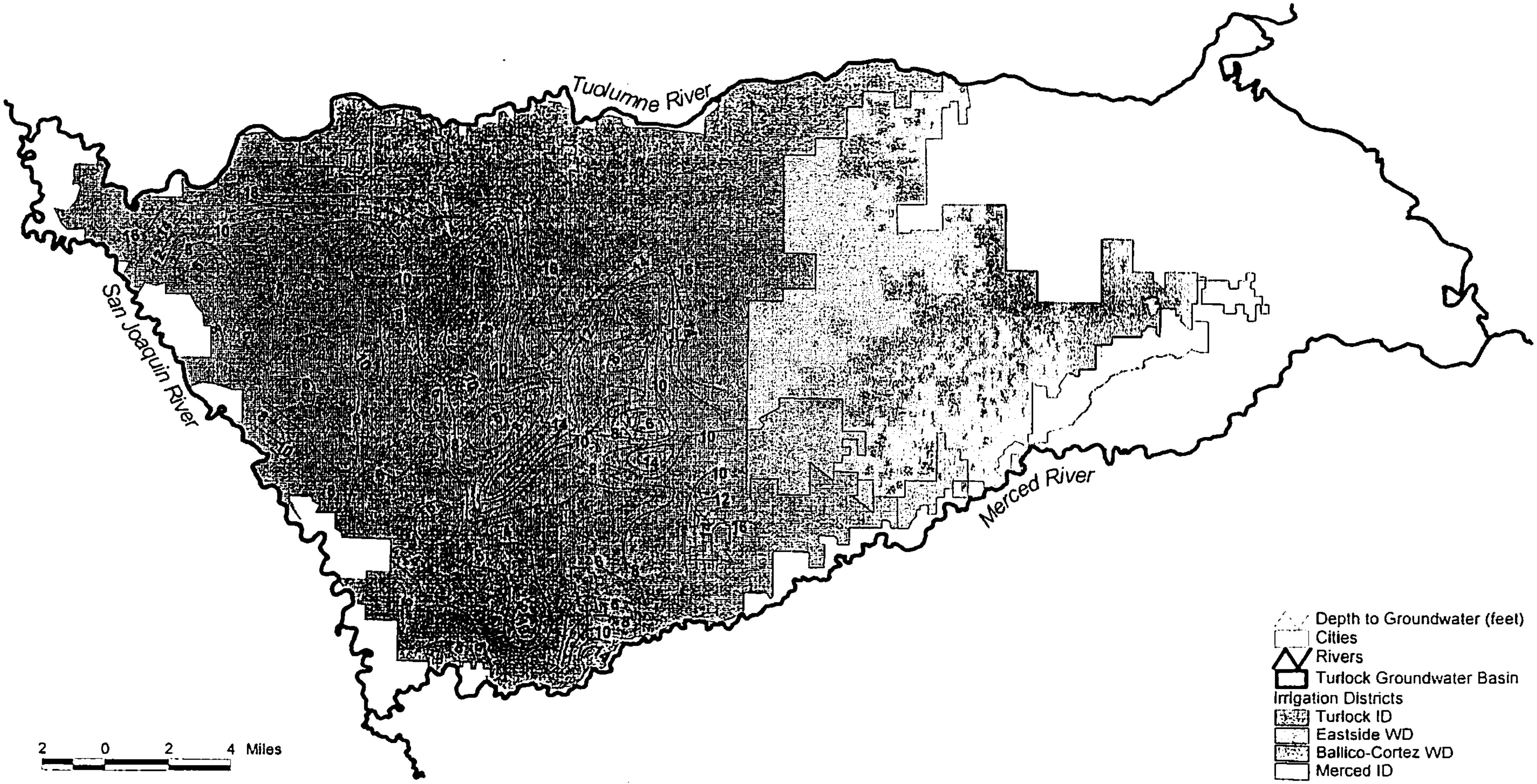

Figure 1.10e Measured Depth to Groundwater in Section-Corner Wells, July 2000

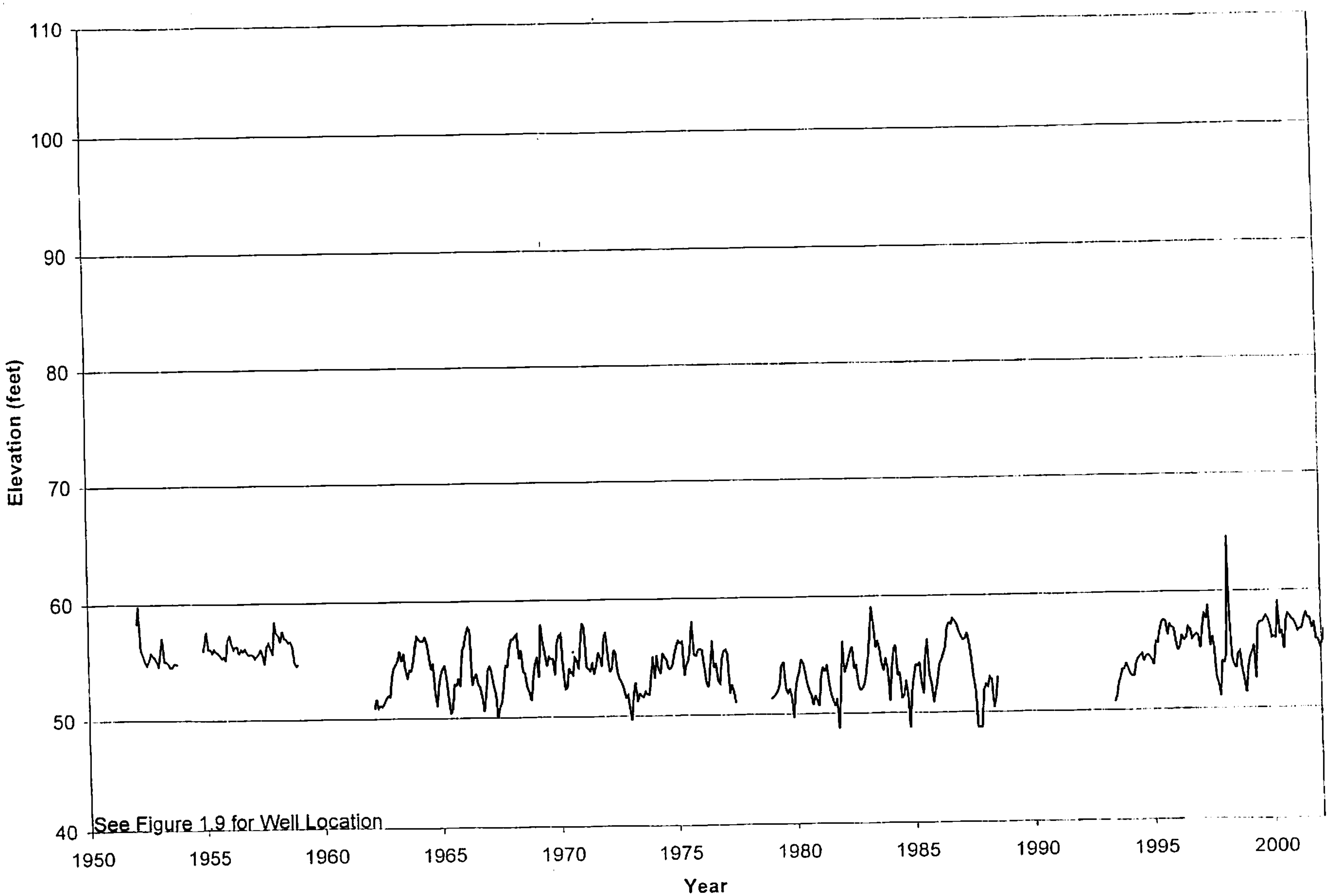

Figure 1.11a Measured Temporal Groundwater Levels in Section-Corner Well 221

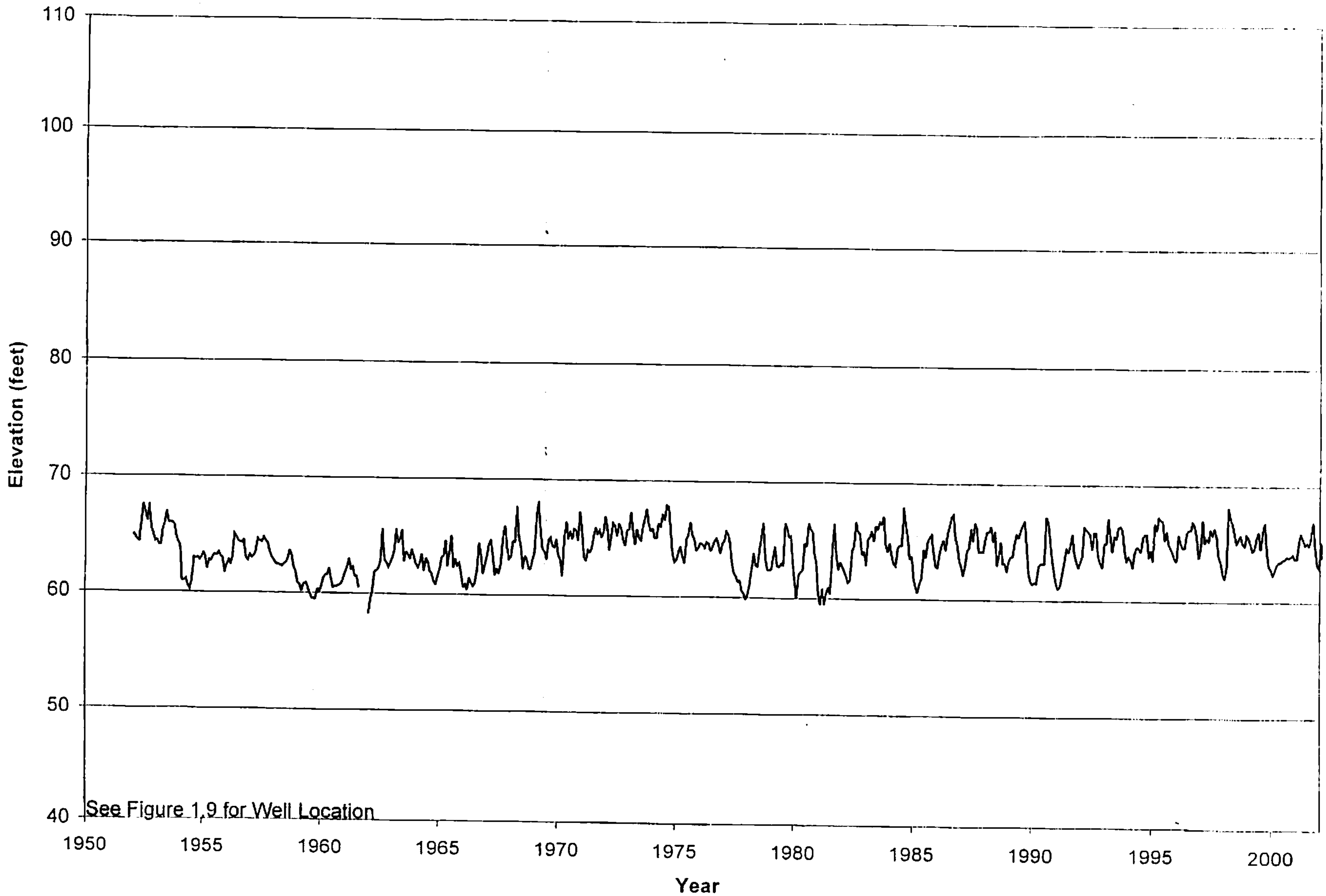

Figure 1.11b Measured Temporal Groundwater Levels in Section-Corner Well 310

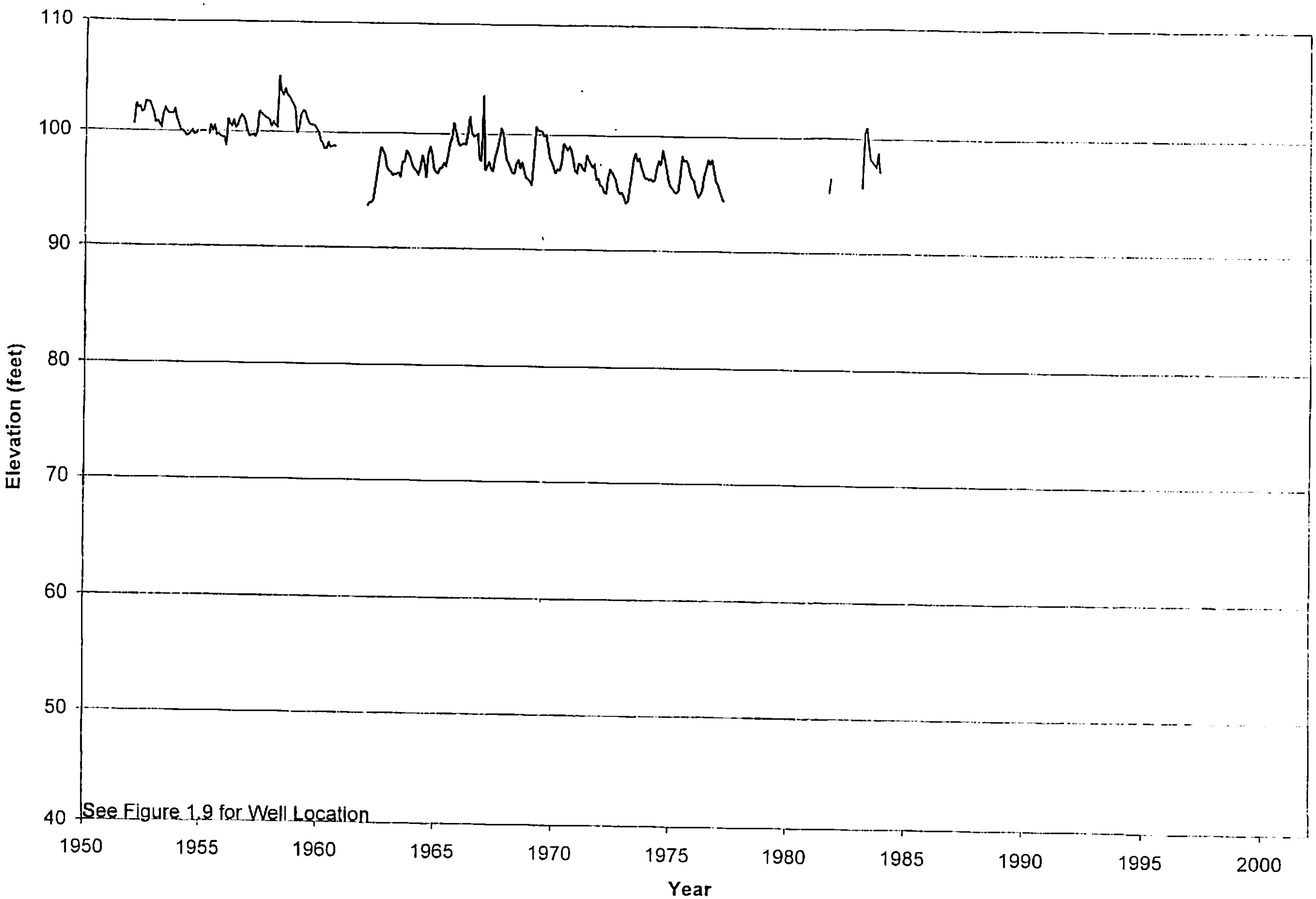

Figure 1.11c Measured Temporal Groundwater Levels in Section-Corner Well 351

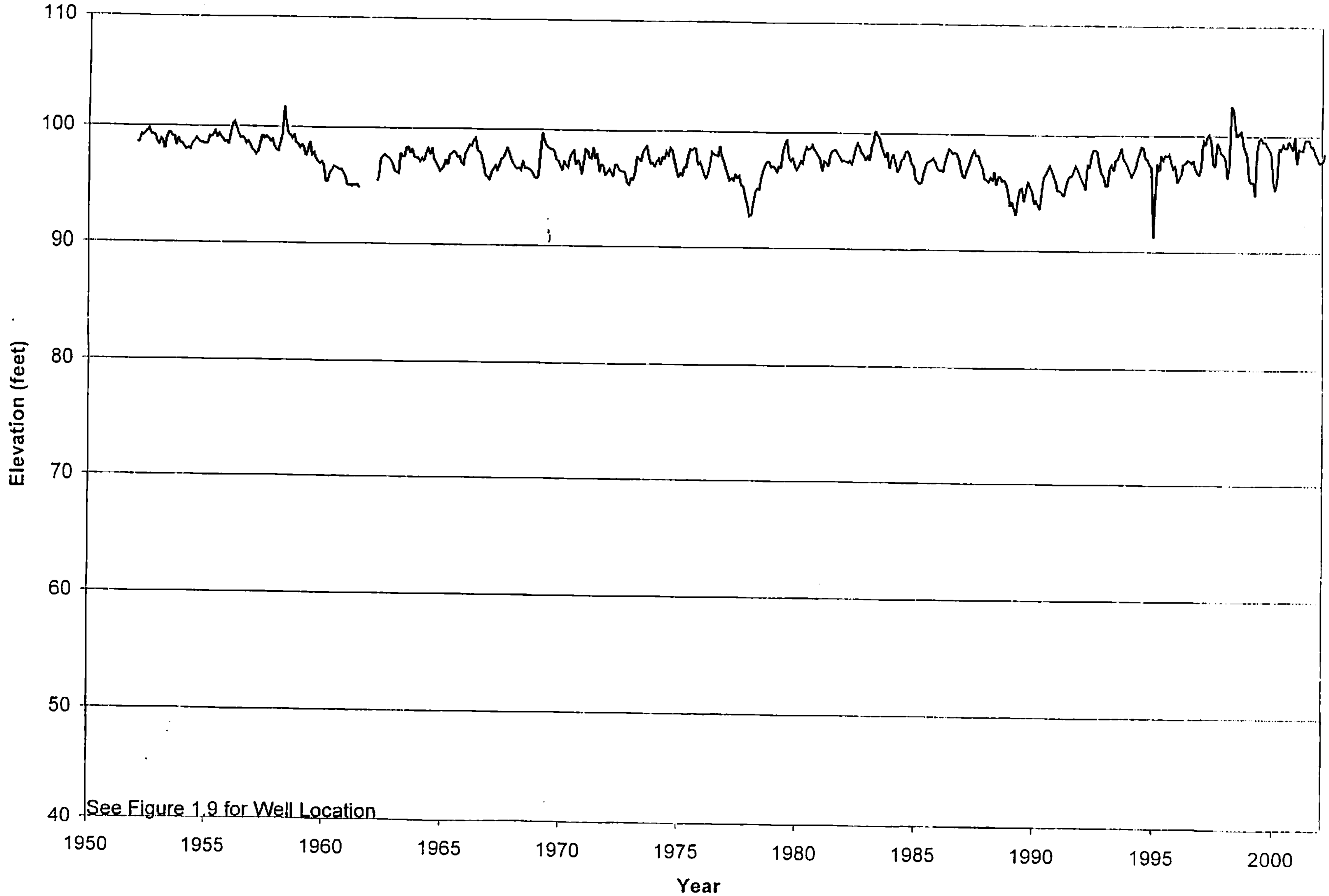

Figure 1.11d Measured Temporal Groundwater Levels in Section-Corner Well 401

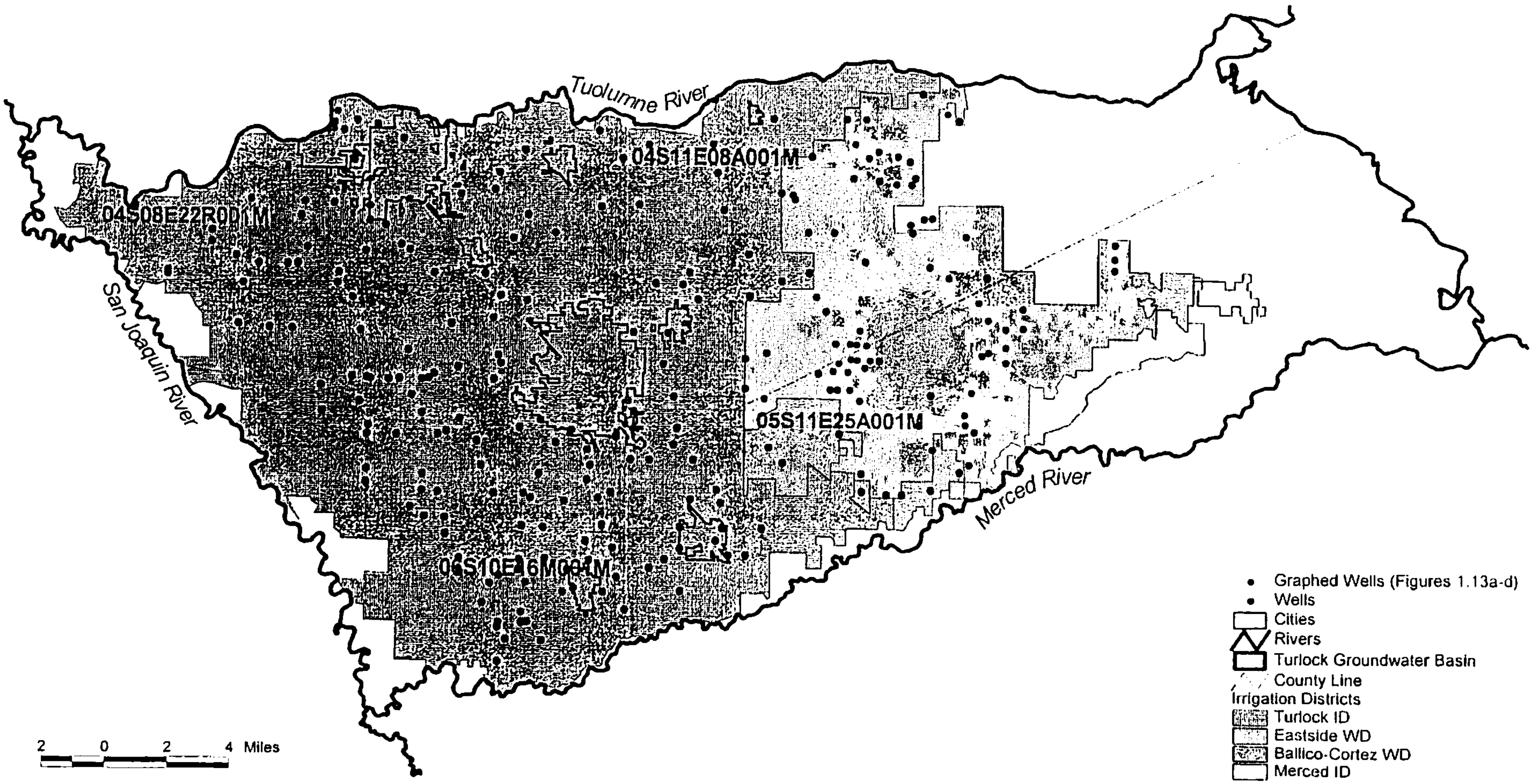

Figure 1.12 Locations of Intermediate-Depth Monitoring Wells

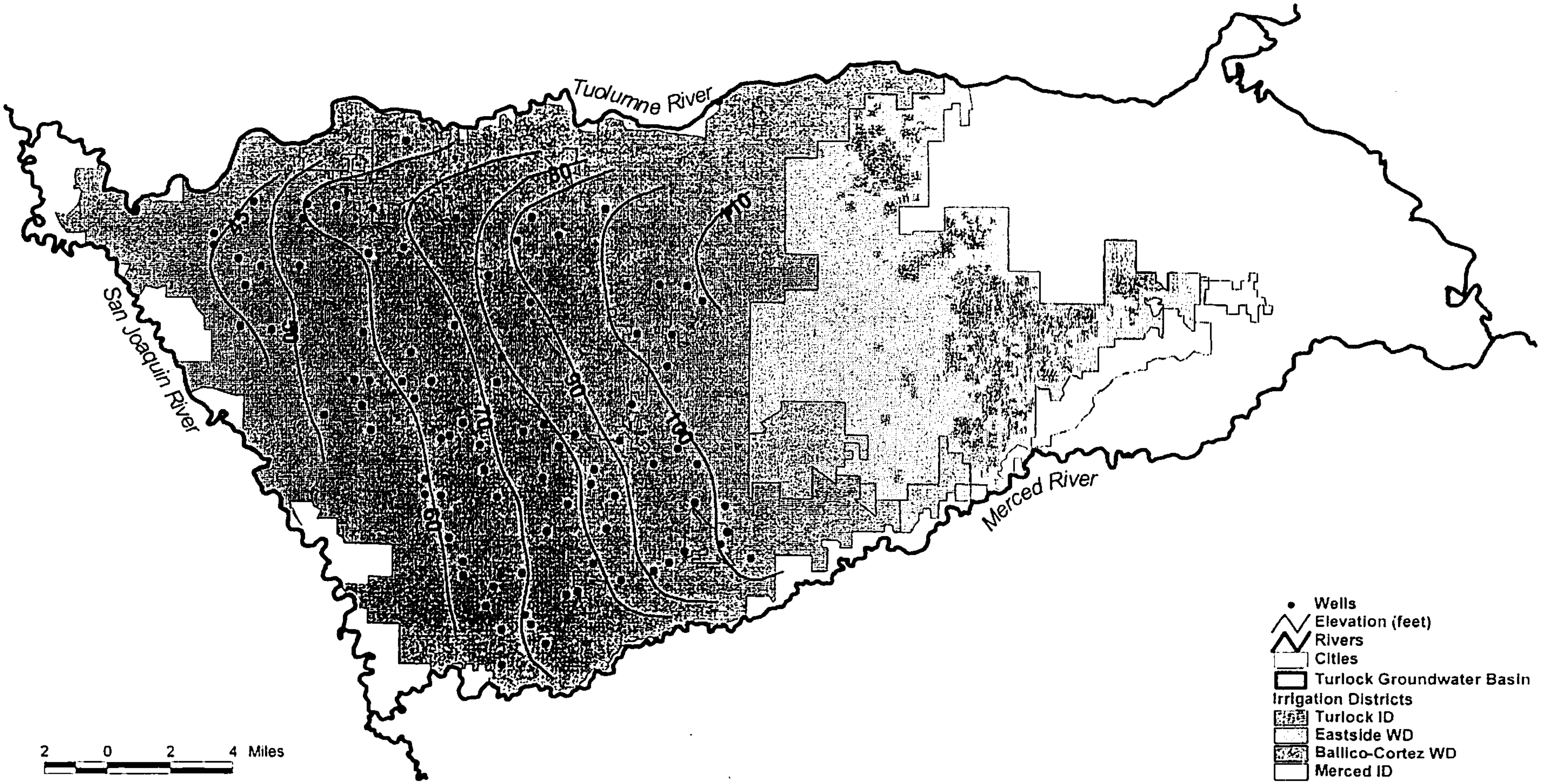

Figure 1.13a Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, December 1960

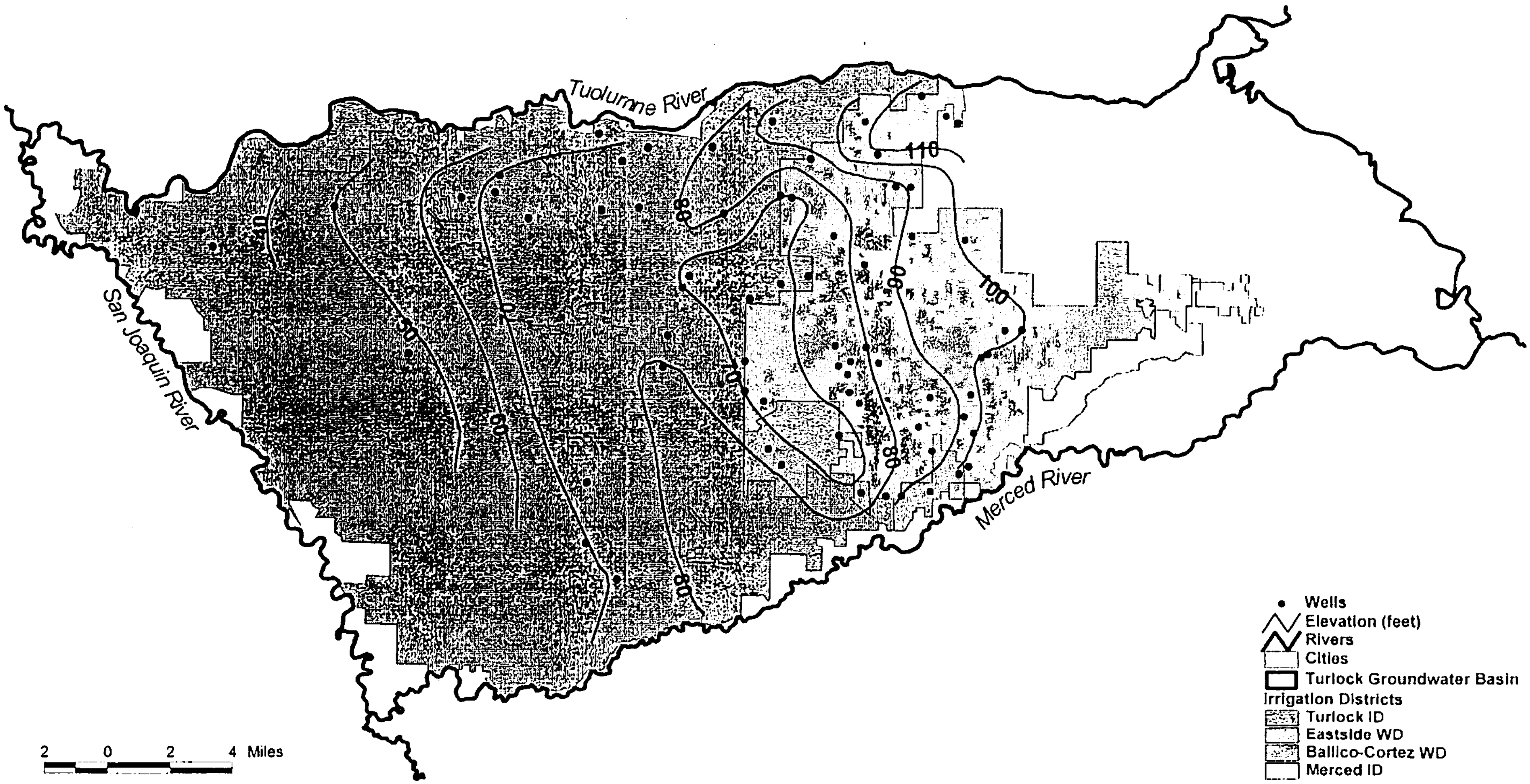

Figure 1.13b Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, November 1977

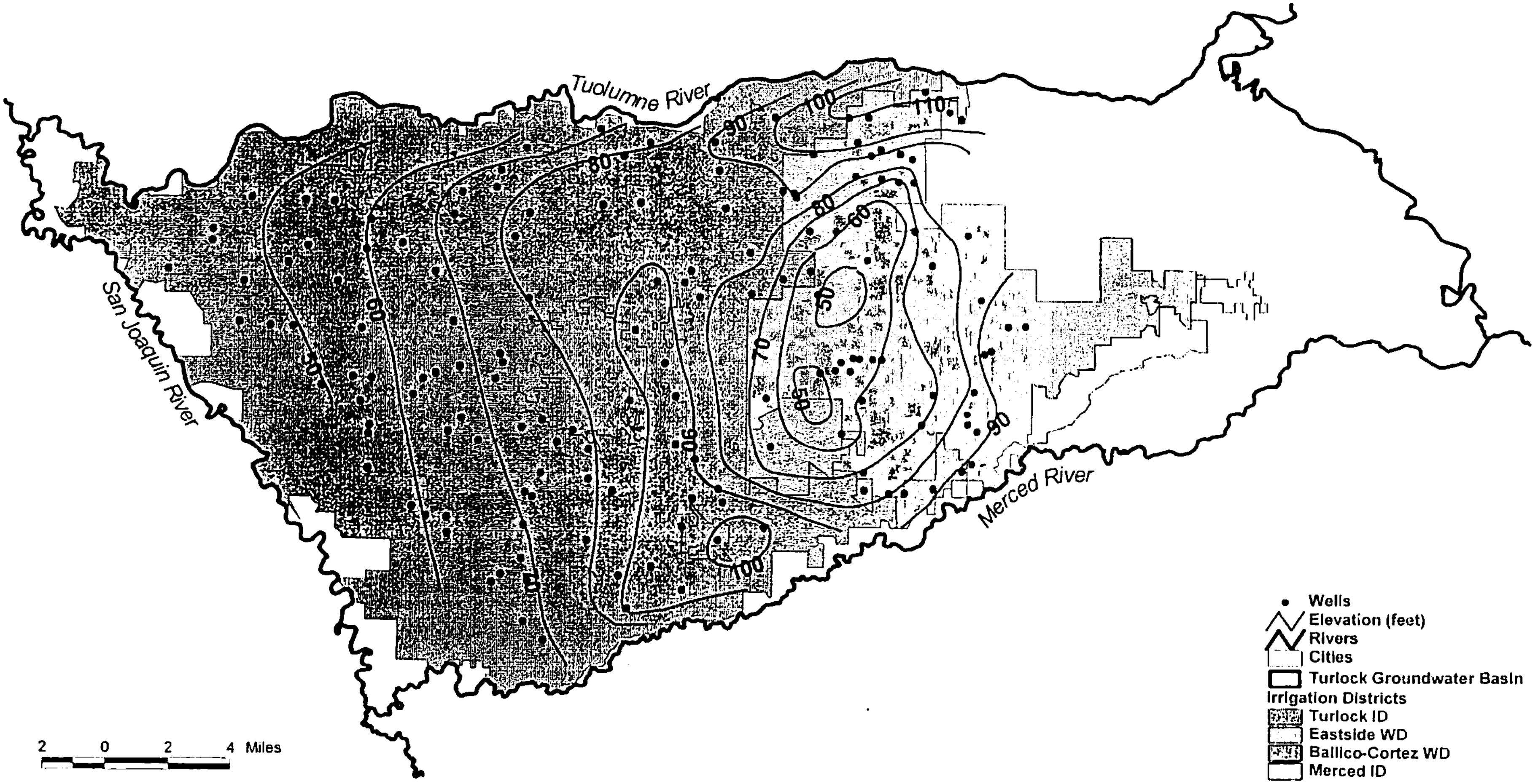

Figure 1.13c Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, November 1986

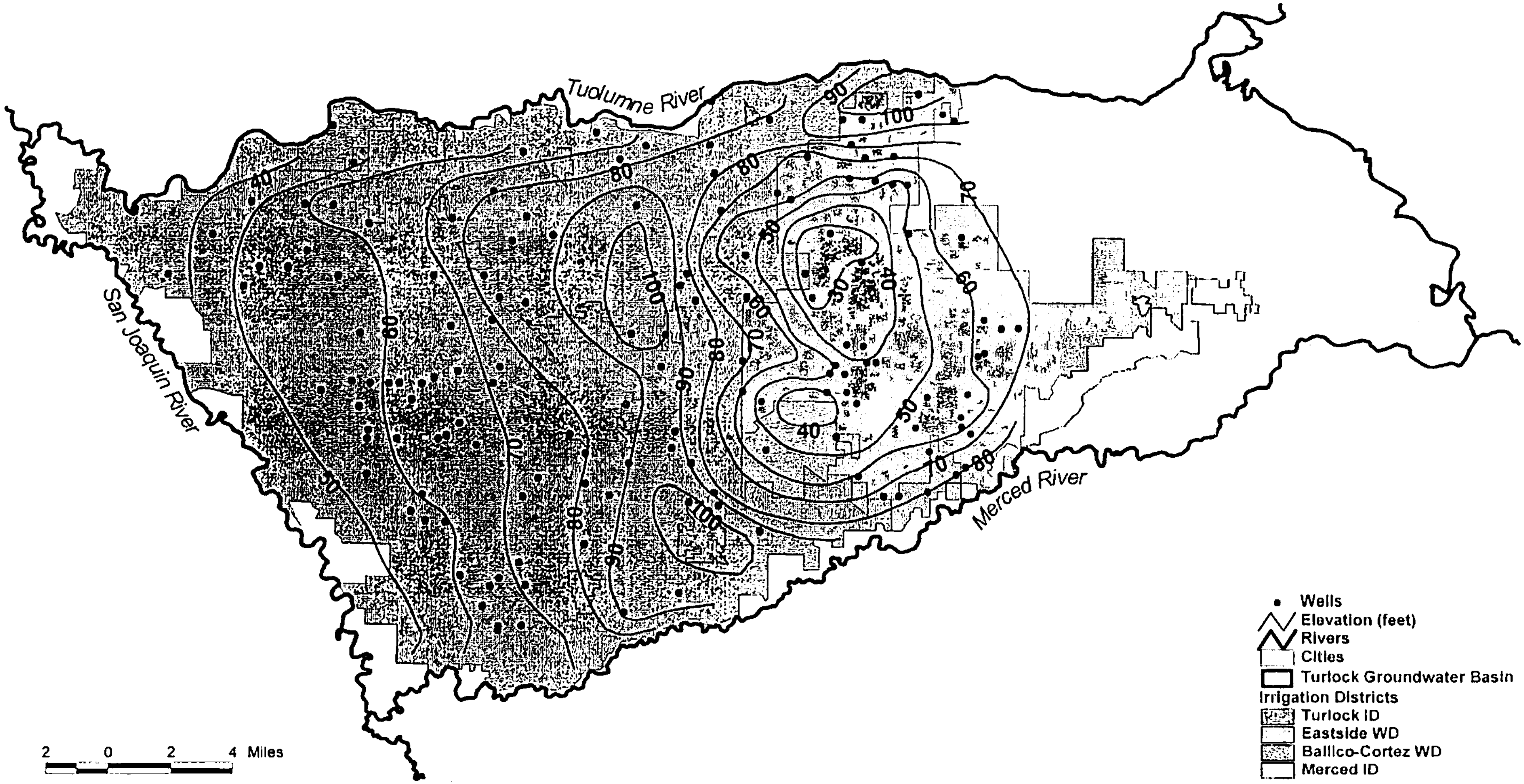

Figure 1.13d Measured Groundwater Elevations in Intermediate Depth Monitoring Wells, November 1998

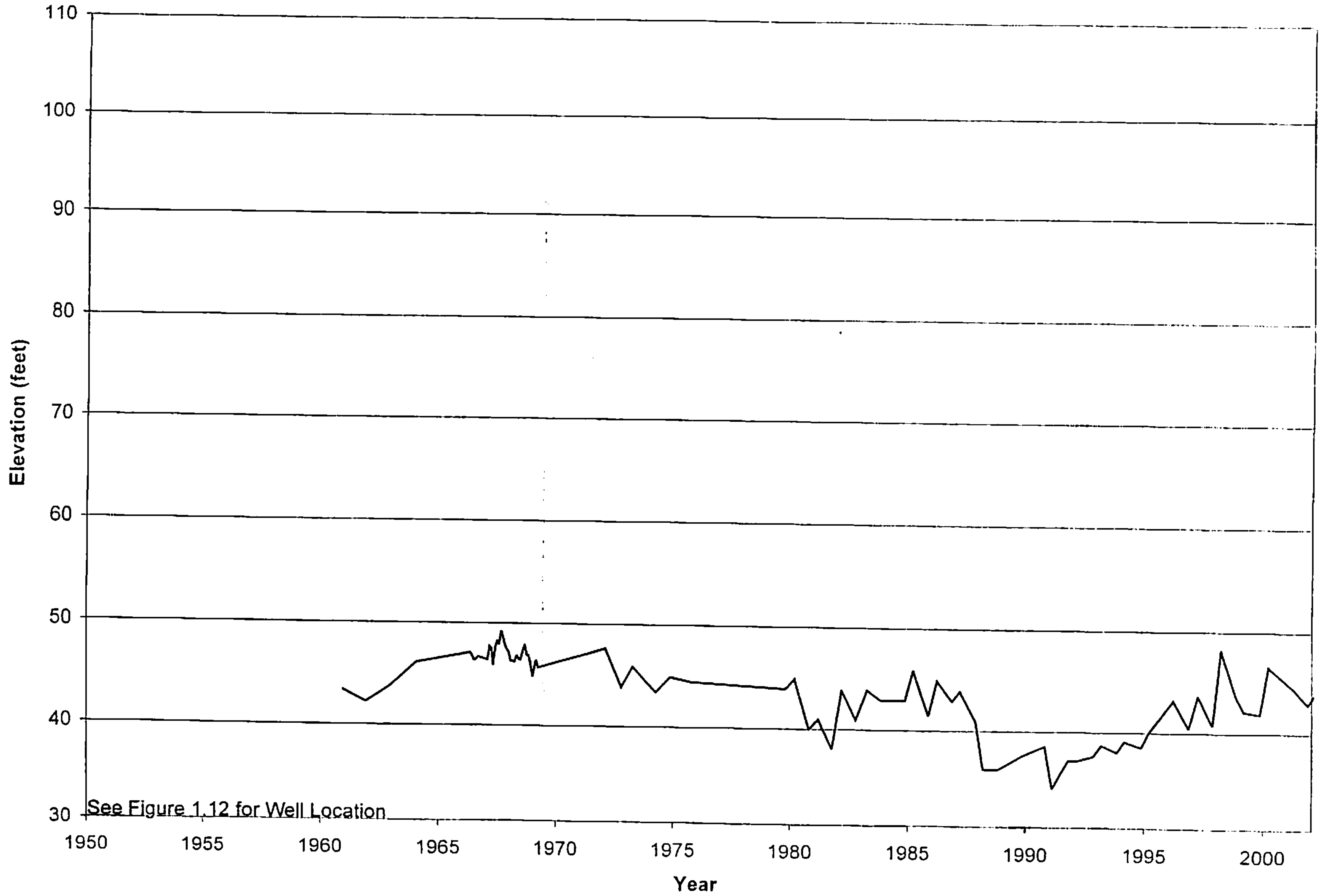

Figure 1.14a Measured Temporal Groundwater Levels in Monitoring Well 04S08E22R001M

Figure 1.14b Measured Temporal Groundwater Levels in Monitoring Well 04S11E08A001M

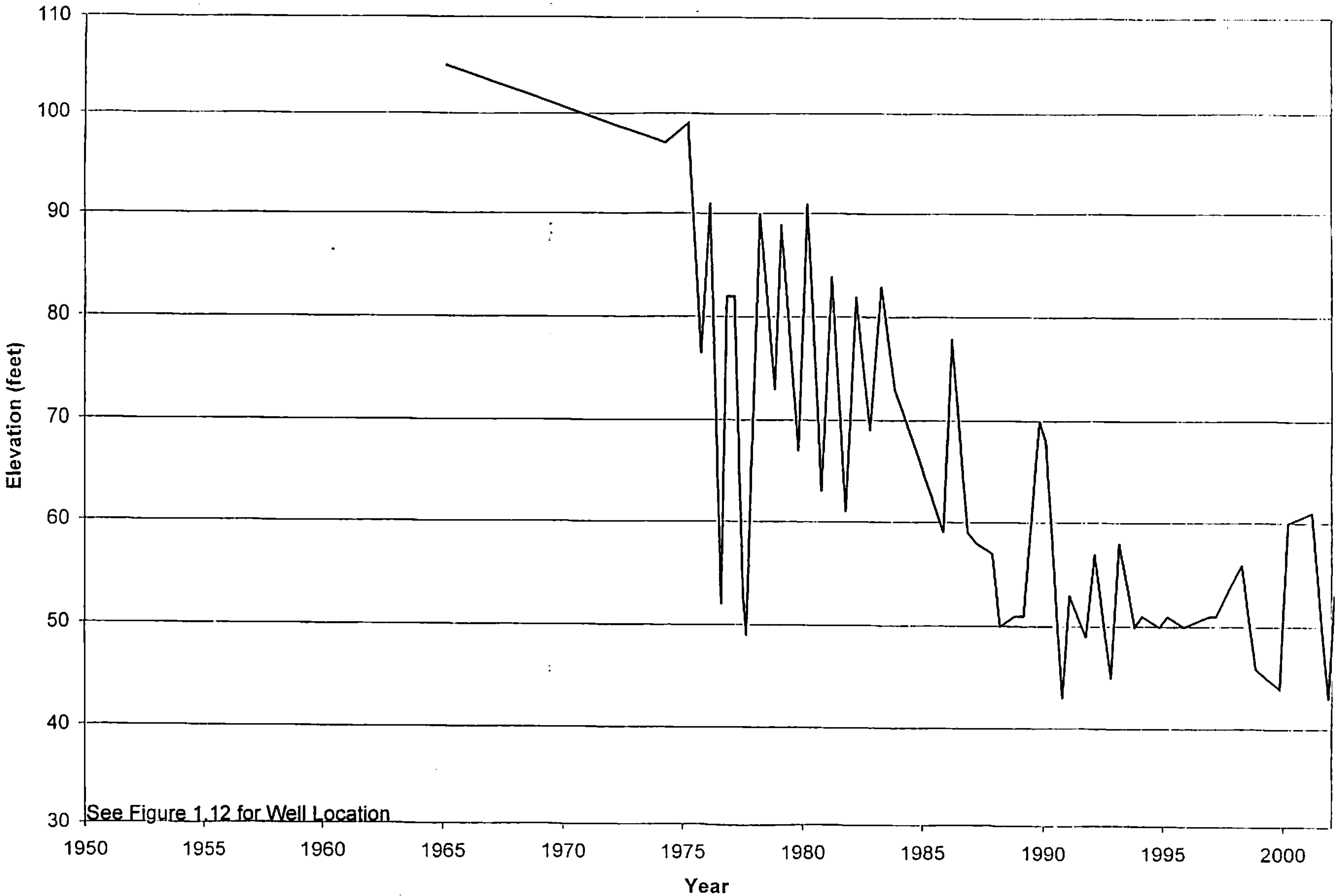

Figure 1.14c Measured Temporal Groundwater Levels in Monitoring Well 05S11E25A001M

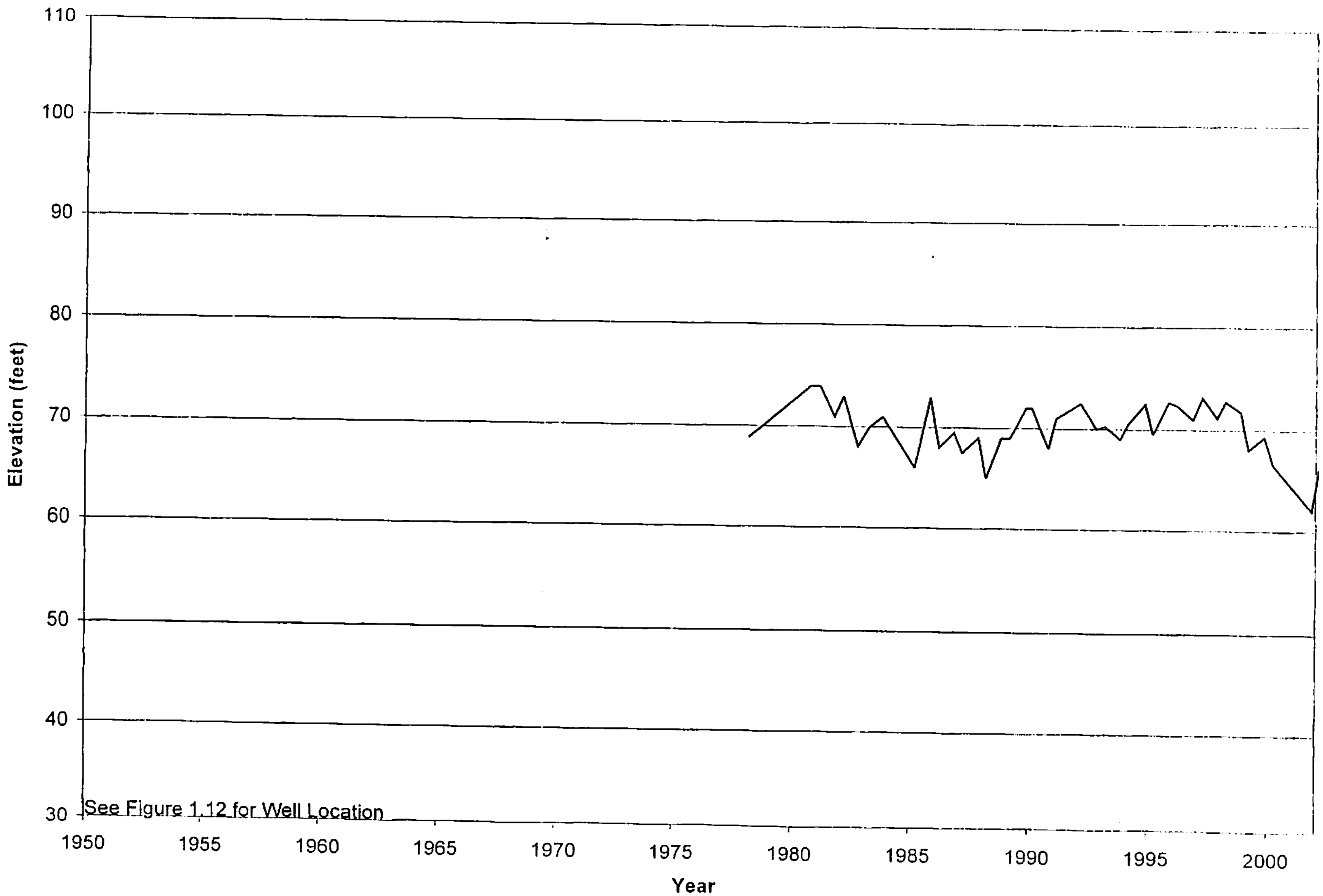

Figure 1.14d Measured Temporal Groundwater Levels in Monitoring Well 06S10E16M001M

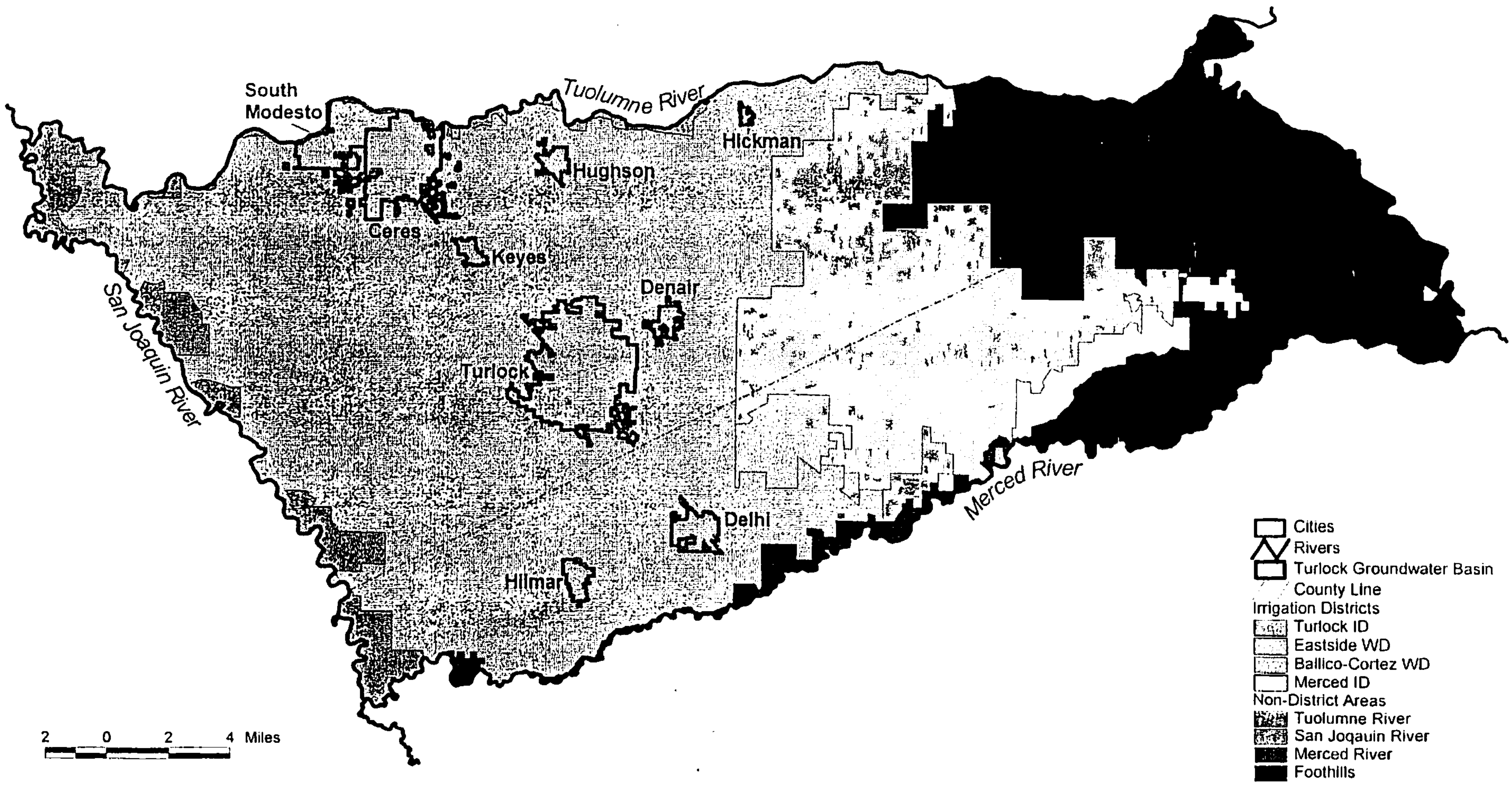

Figure 2.1 Urban Areas, Irrigation Districts, and Non-District Areas within Turlock Groundwater Basin

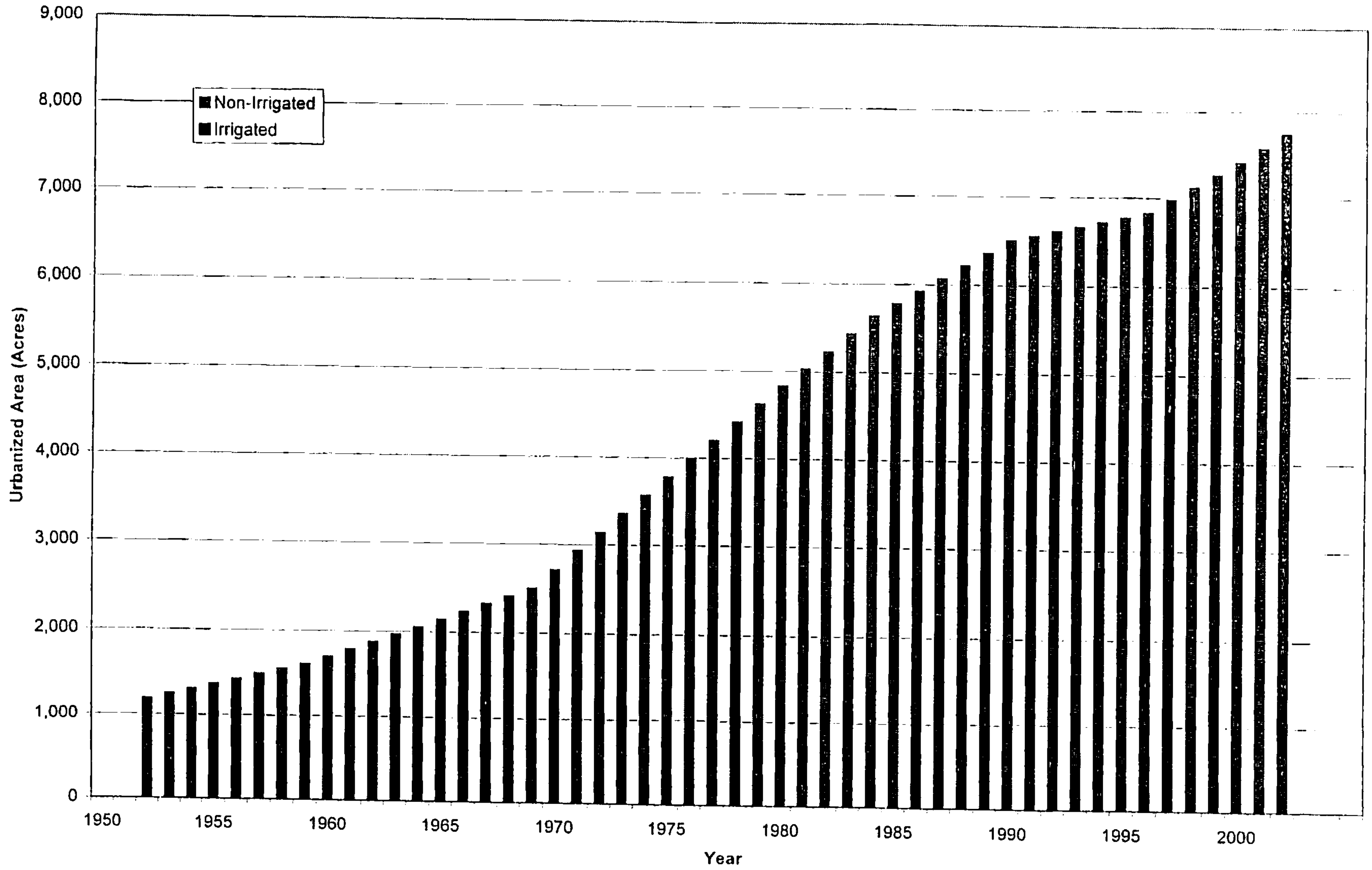

Figure 2.2a Urbanized and Landscaped Area within the Turlock Groundwater Basin, 1952-2002, for Turlock

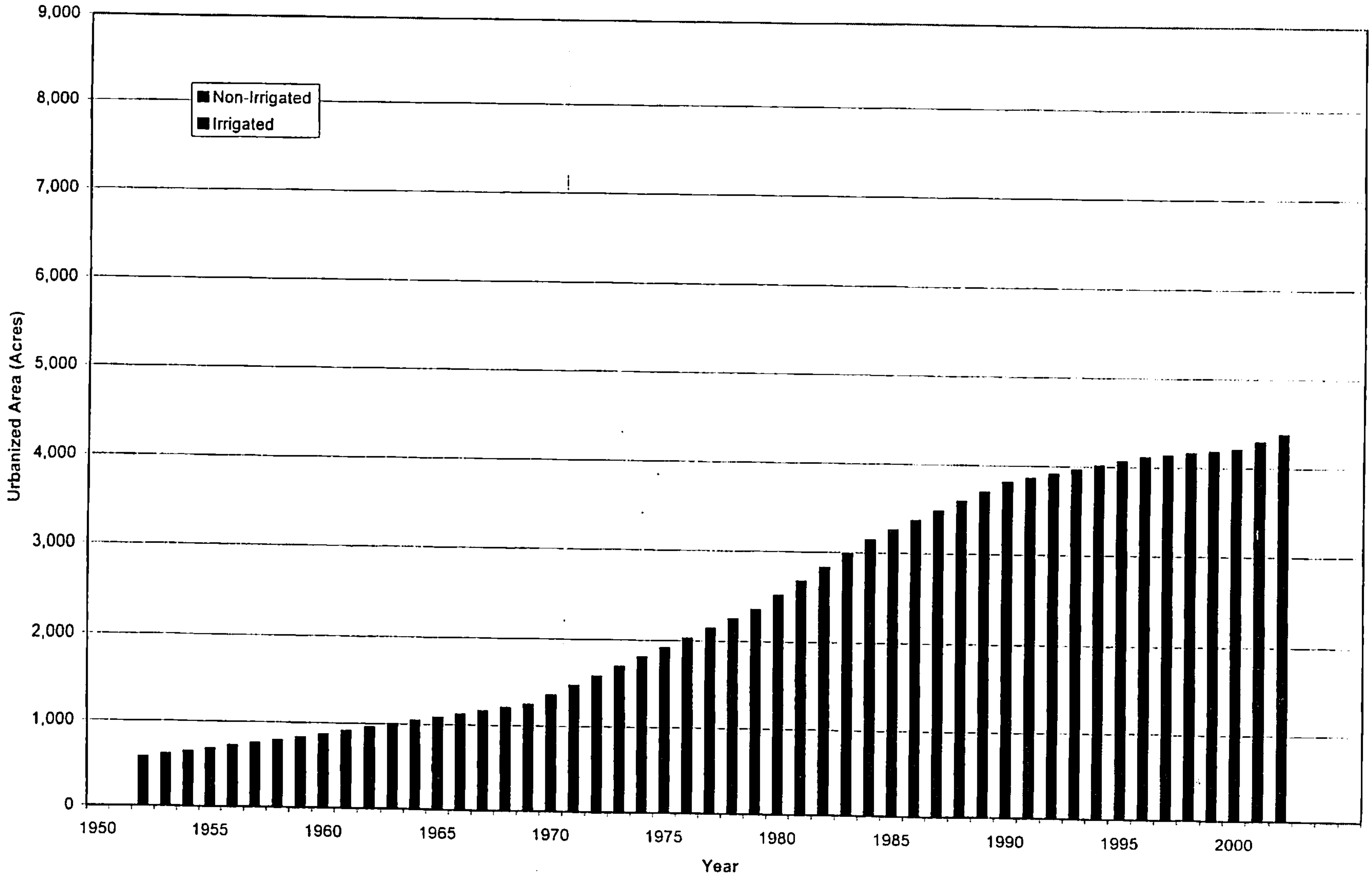

Figure 2.2b Urbanized and Landscaped Area within the Turlock Groundwater Basin, 1952-2002, for Ceres

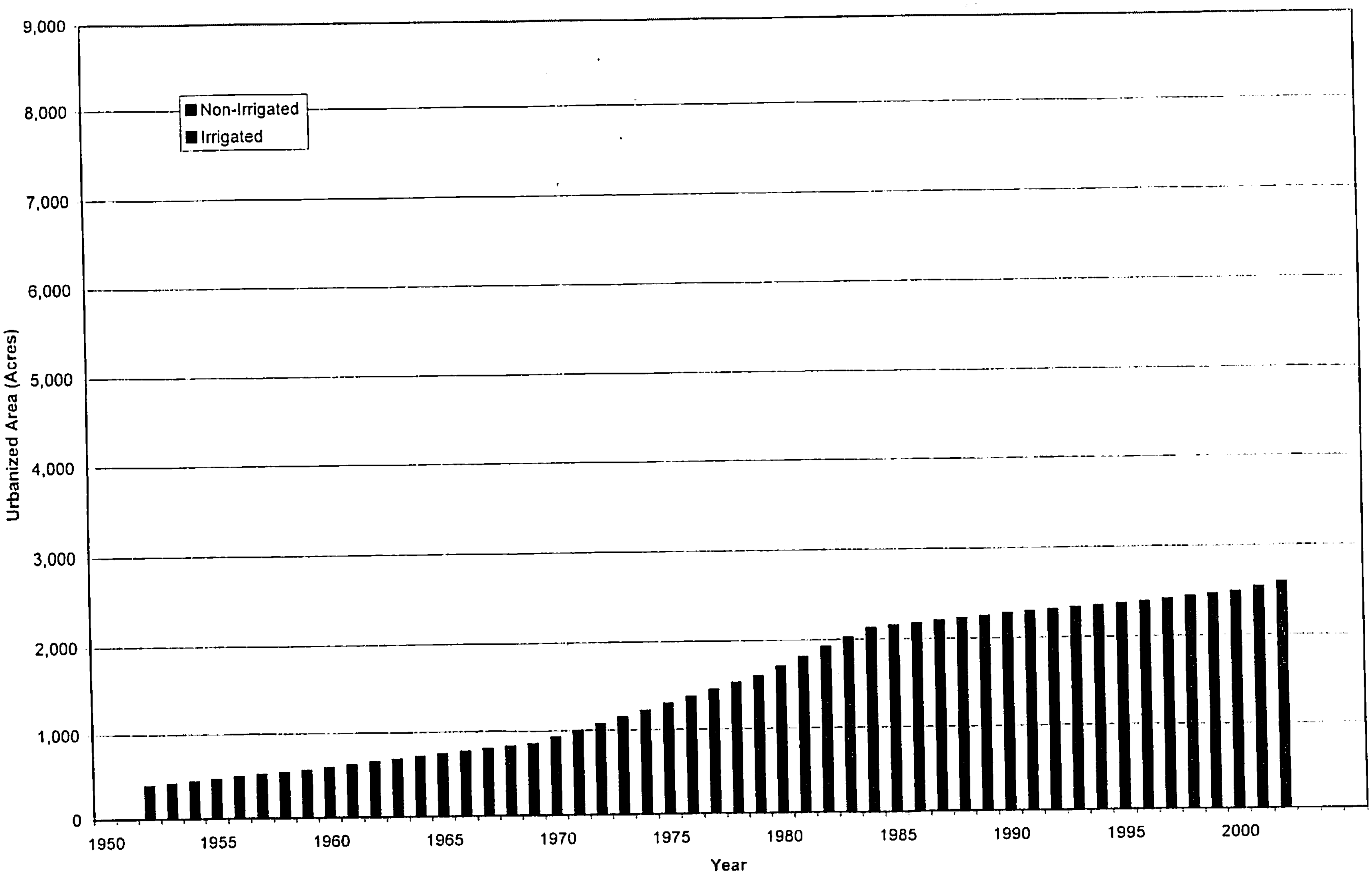

Figure 2.2c Urbanized and Landscaped Area within the Turlock Groundwater Basin, 1952-2002, for South Modesto

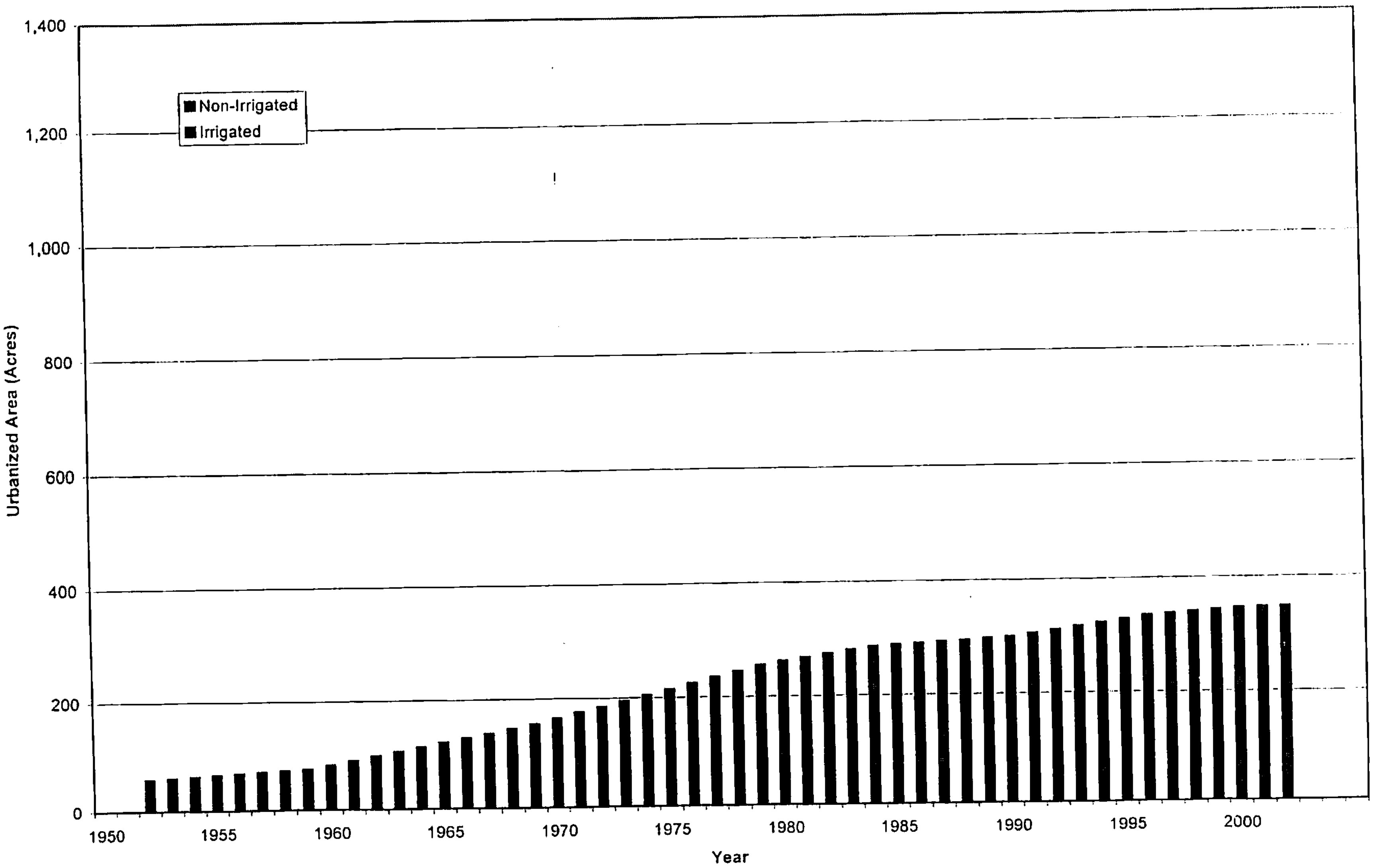

Figure 2.2d Urbanized and Landscaped Area within the Turlock Groundwater Basin, 1952-2002, for Keyes

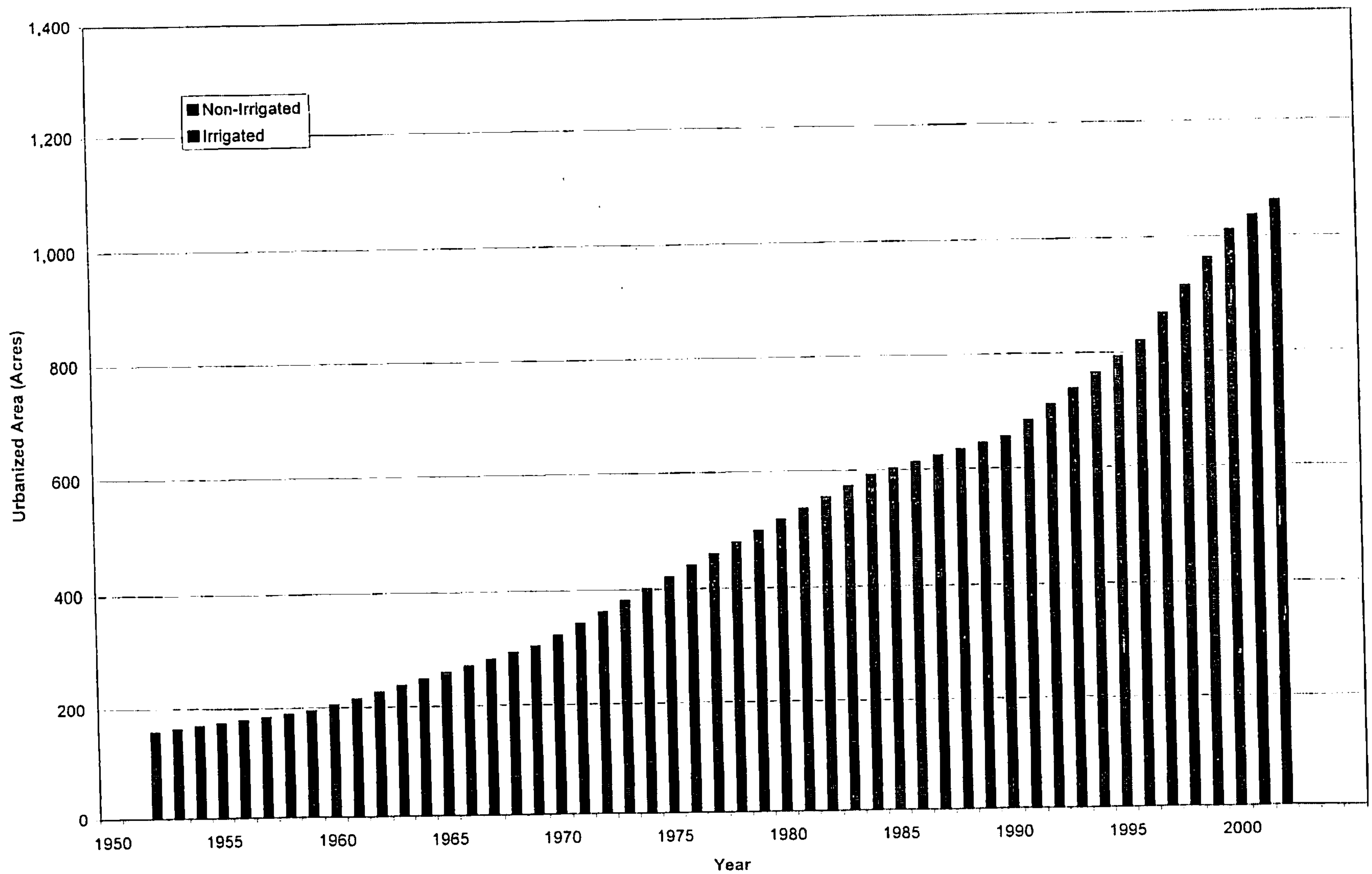

Figure 2.2e Urbanized and Landscaped Area within the Turlock Groundwater Basin, 1952-2002, for Delhi

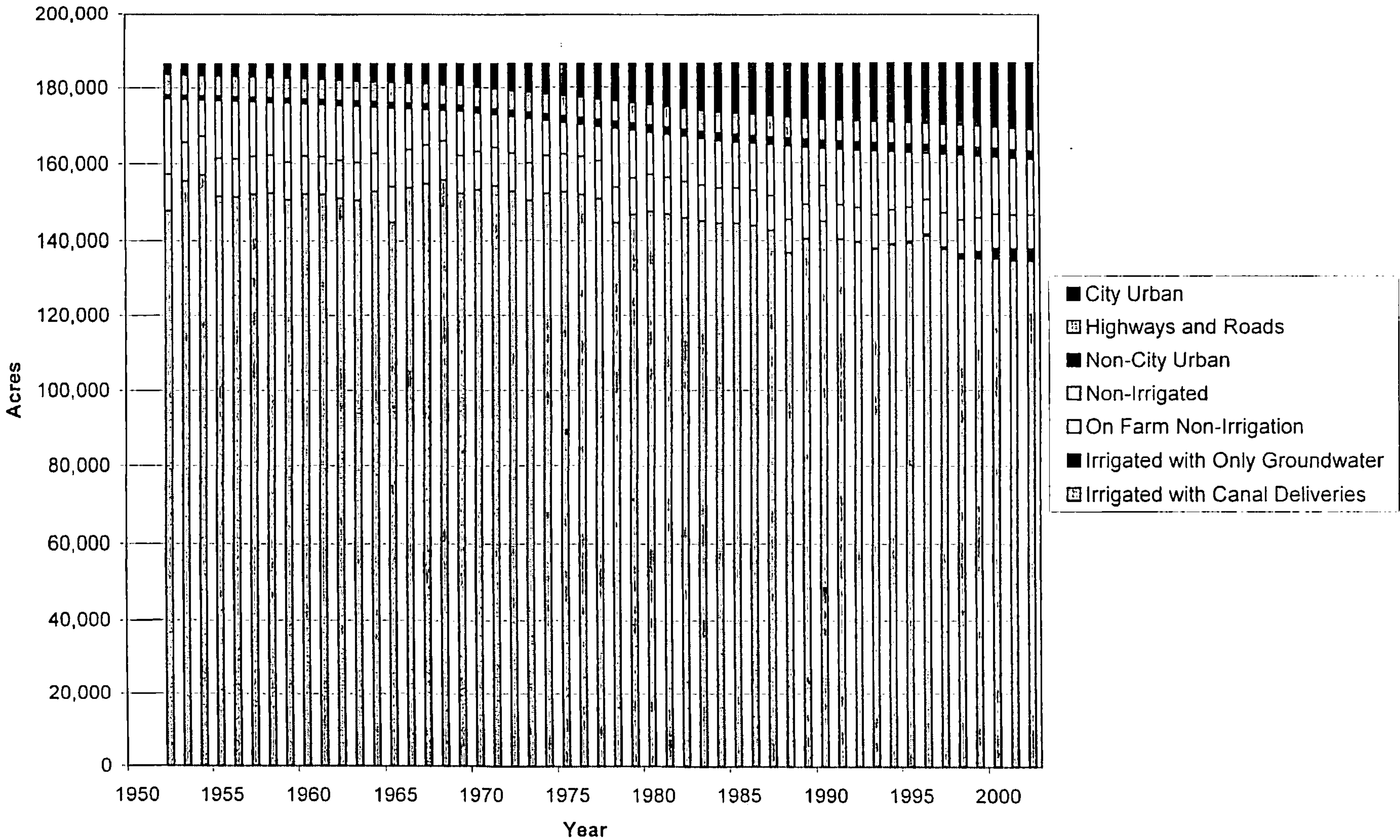

Figure 2.3 Land Use within the Turlock Groundwater Basin, 1952-2002, for Turlock Irrigation District

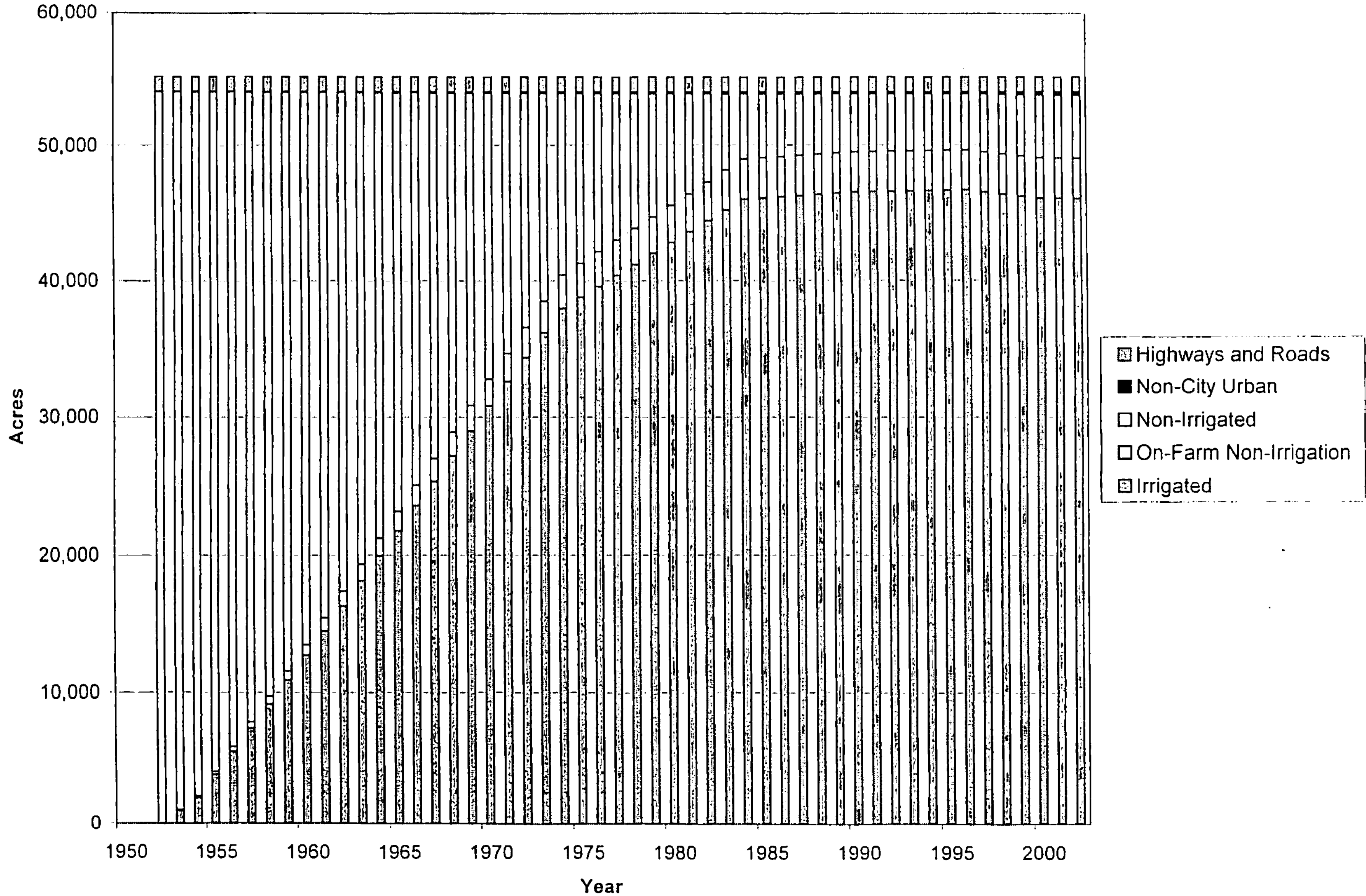

Figure 2.4a Land Use within the Turlock Groundwater Basin, 1952-2002, for Eastside Water District

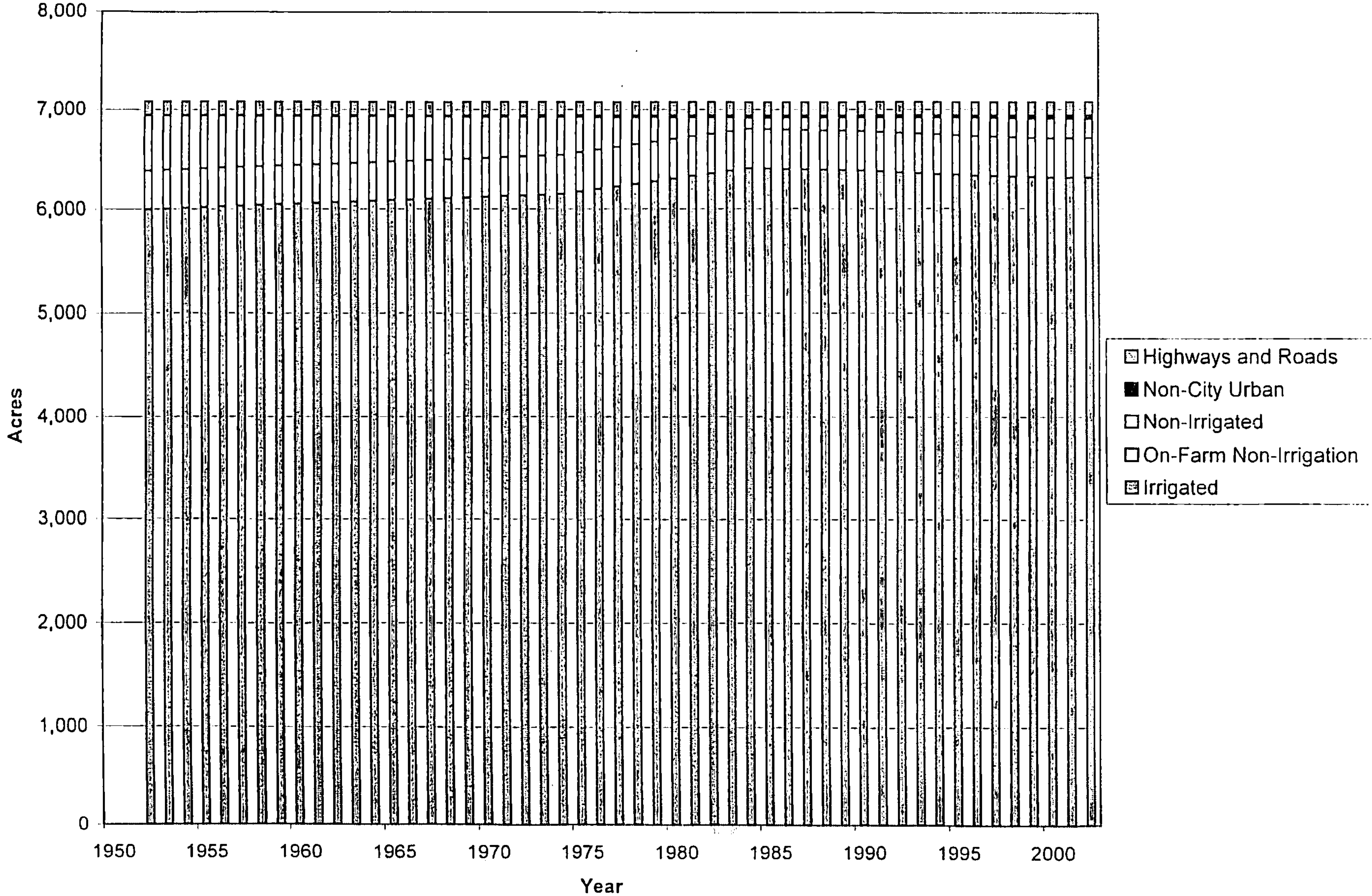

Figure 2.4b Land Use within the Turlock Groundwater Basin, 1952-2002, for Ballico-Cortez Water District

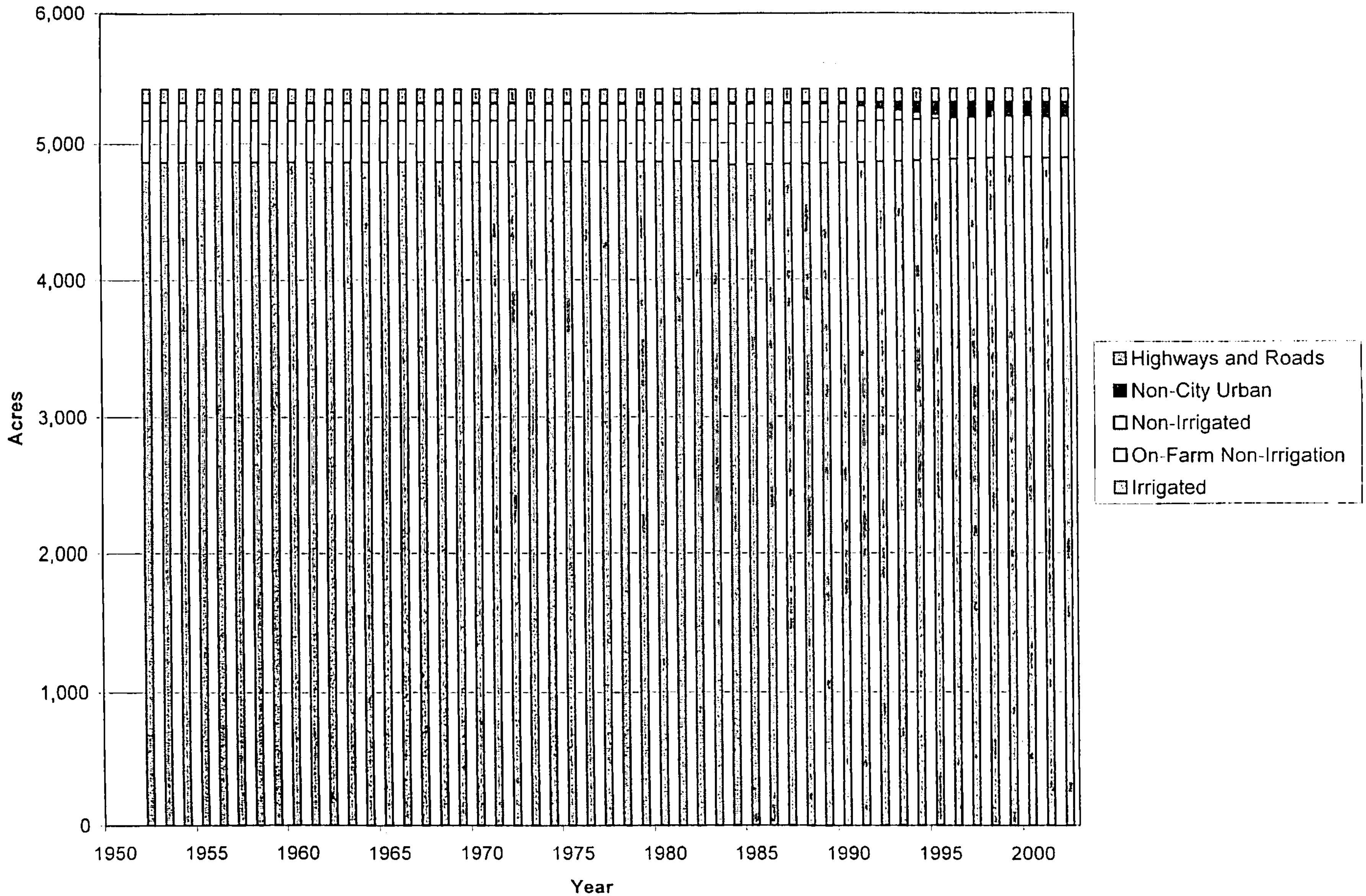

Figure 2.4c Land Use within the Turlock Groundwater Basin, 1952-2002, for Merced Irrigation District

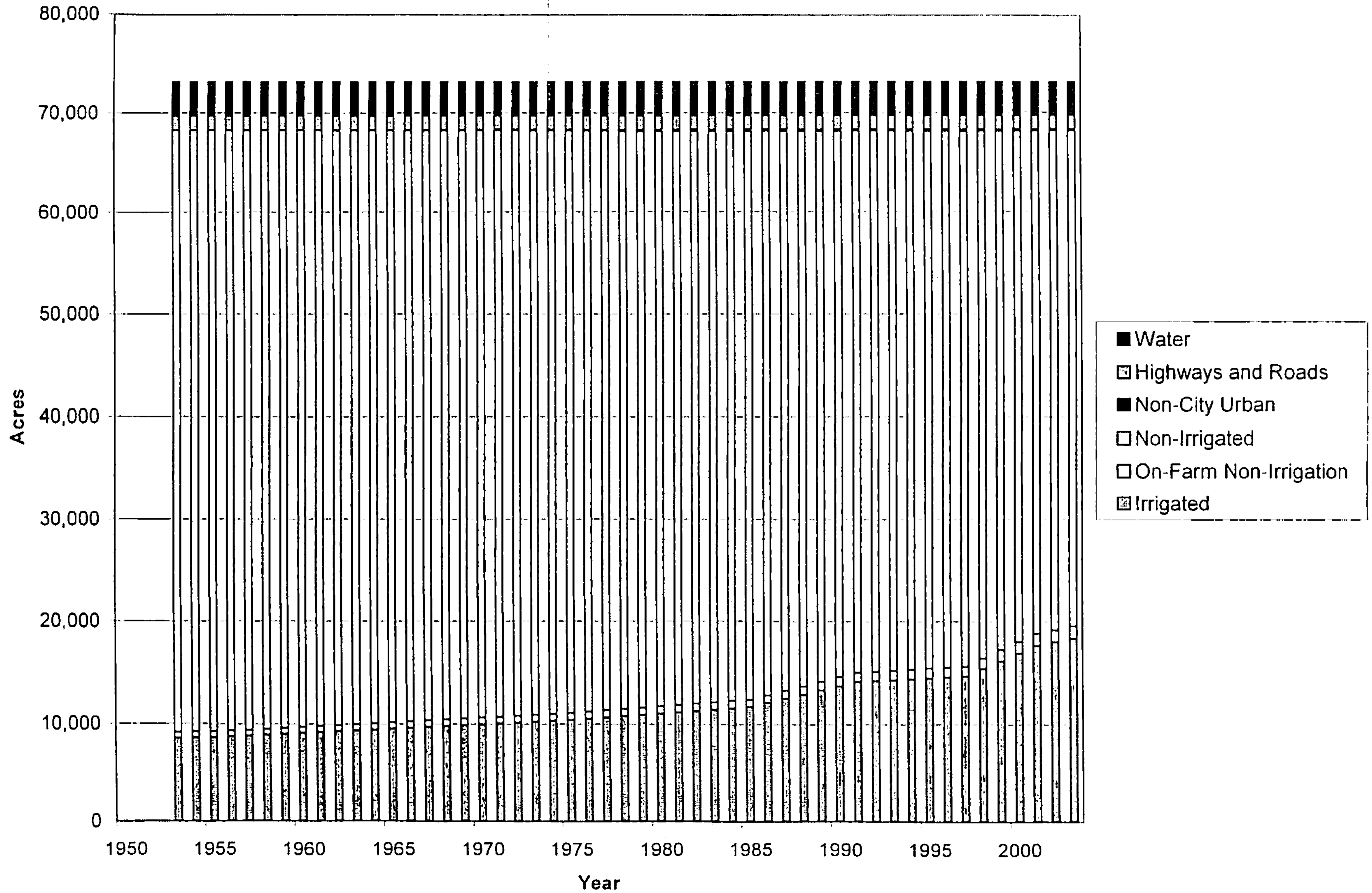

Figure 2.4d Land Use within the Turlock Groundwater Basin, 1952-2002, for Foothills Non-District Area

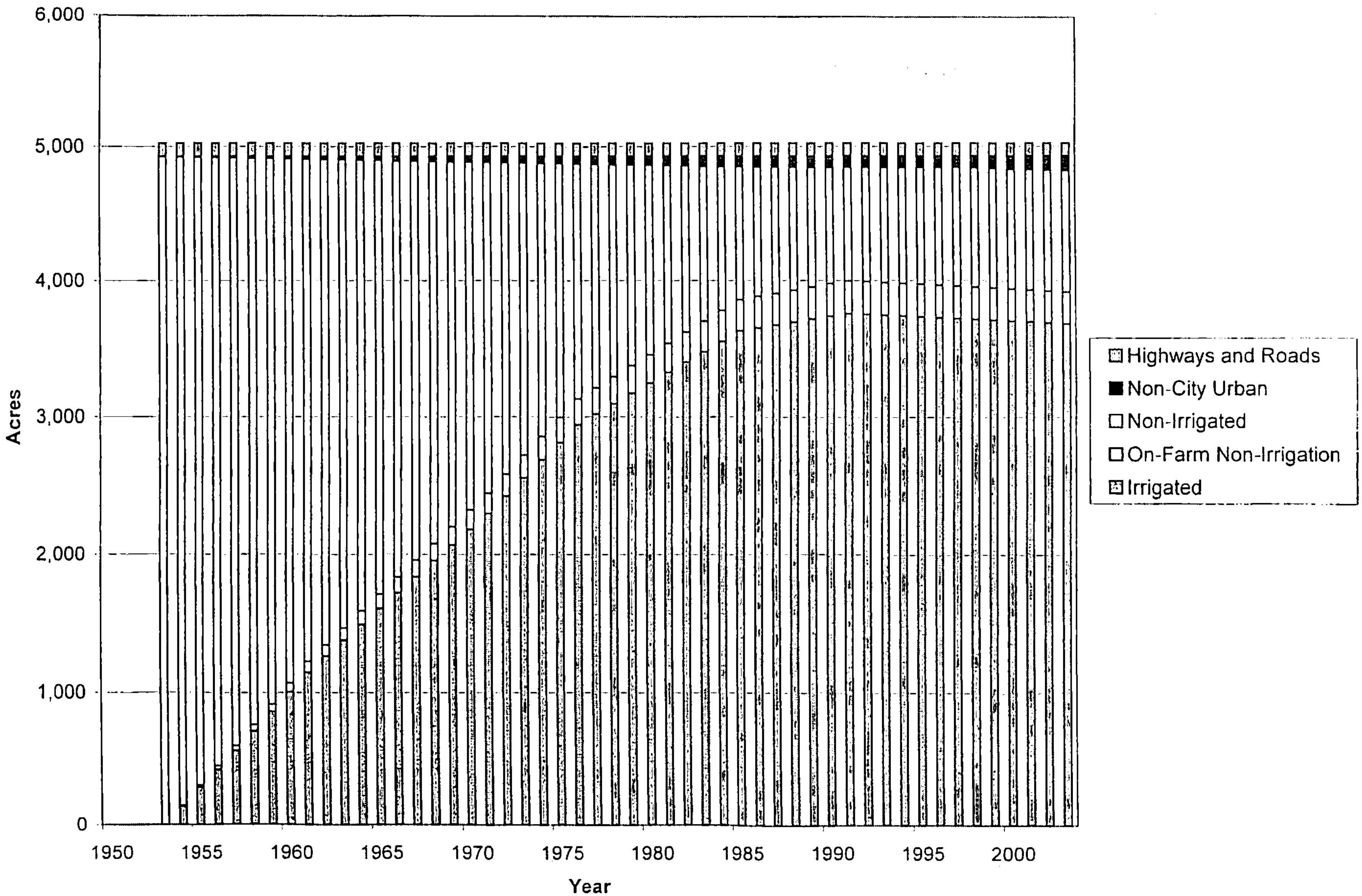

Figure 2.4e Land Use within the Turlock Groundwater Basin, 1952-2002, for Merced River Non-District Area

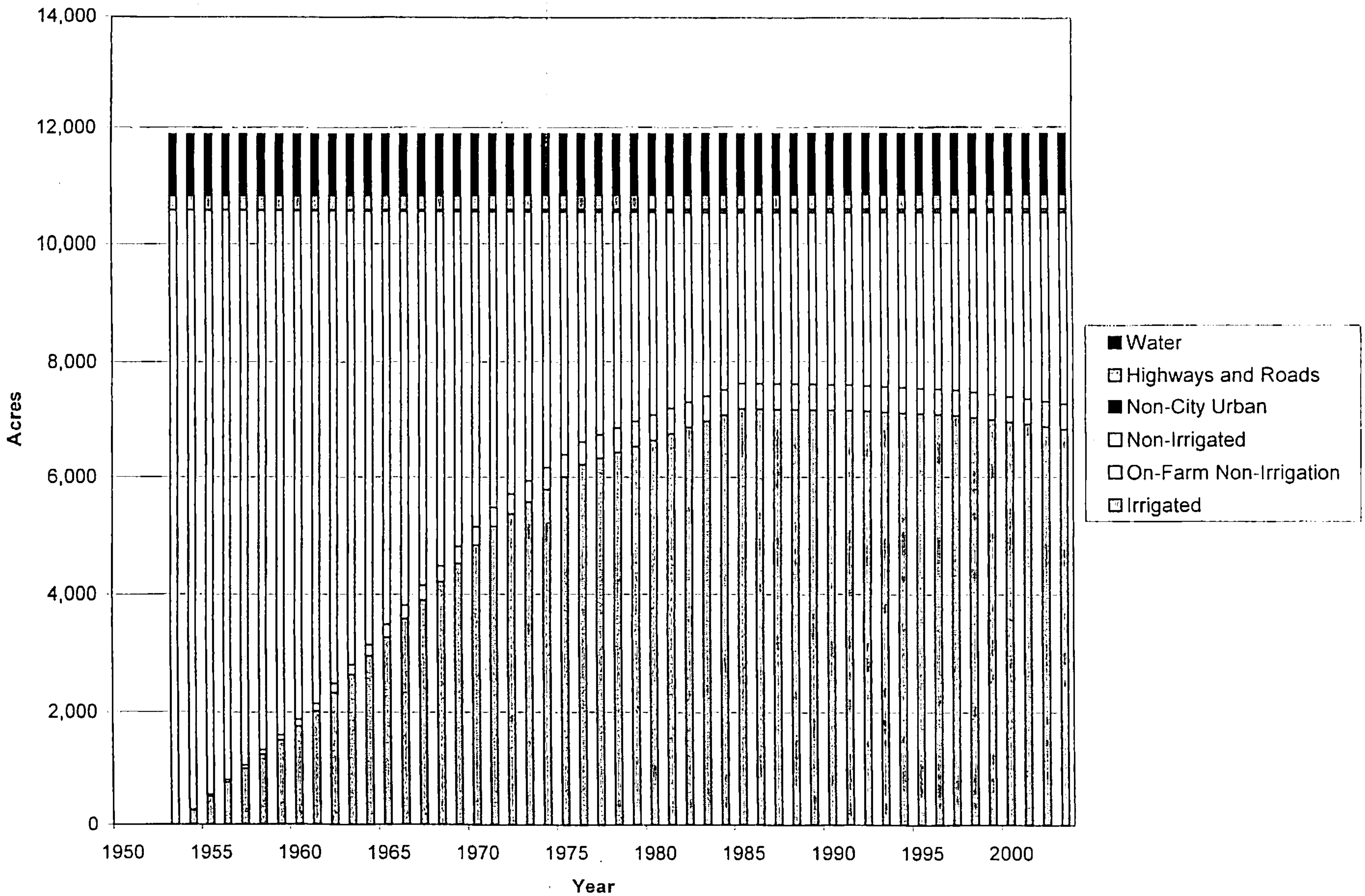

Figure 2.4f Land use within the Turlock Groundwater Basin, 1952-2002, for San Joaquin River Non-District Area

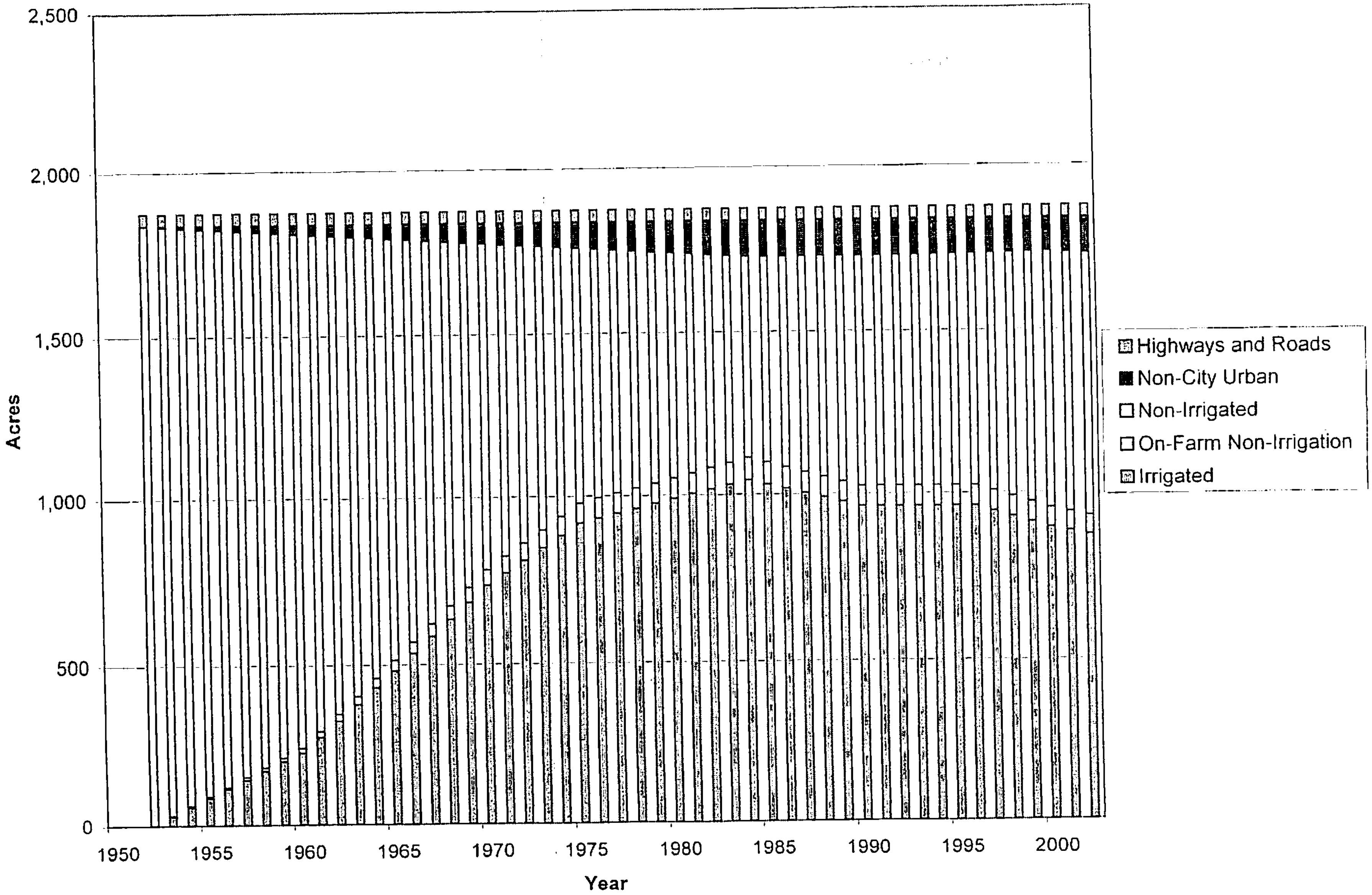

Figure 2.4g Land Use within the Turlock Groundwater Basin, 1952-2002, for Tuolumne River Non-District Area

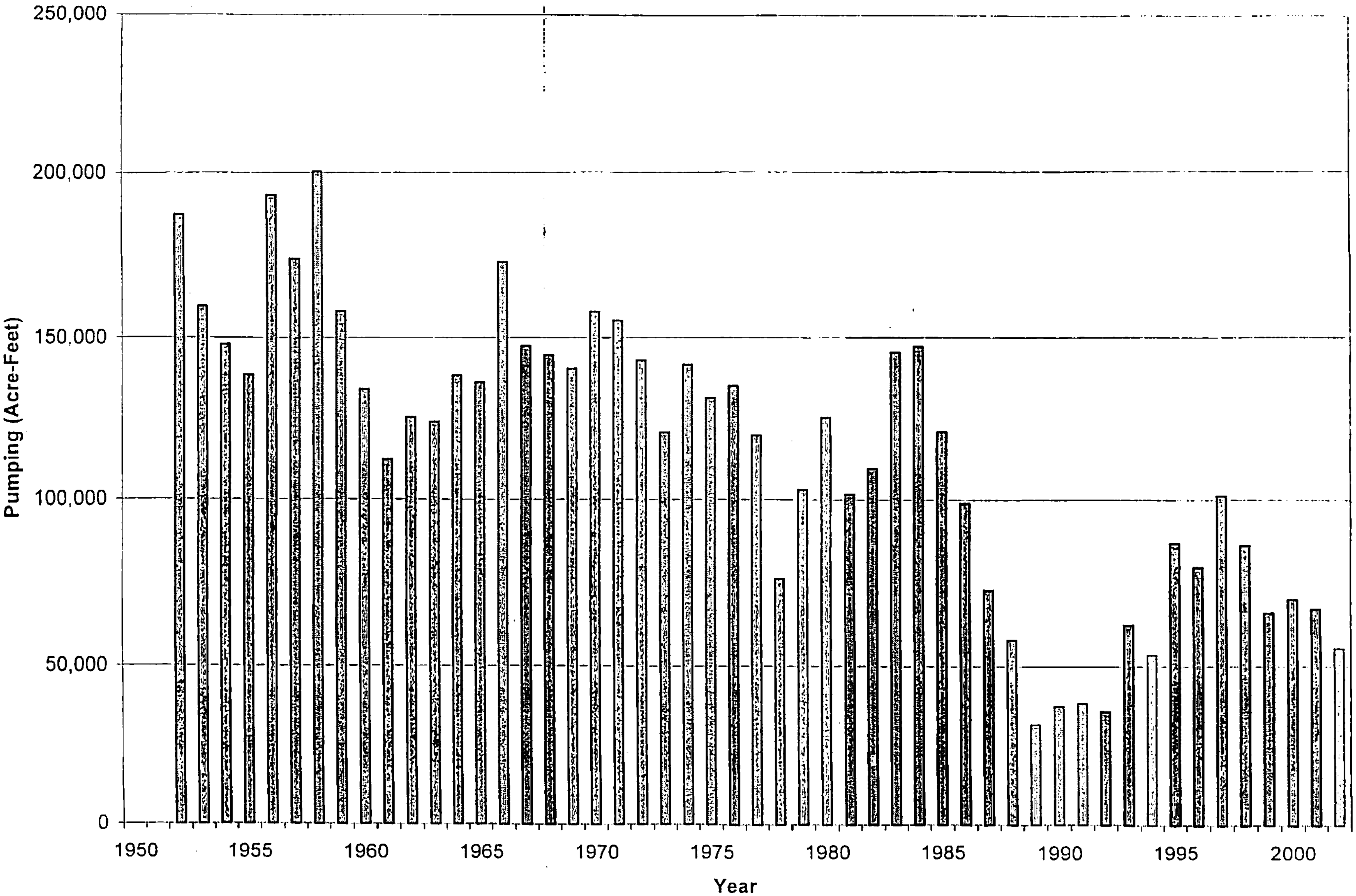

Figure 3.1 Annual Pumpage from Turlock Irrigation District Drainage Wells, 1952-2002

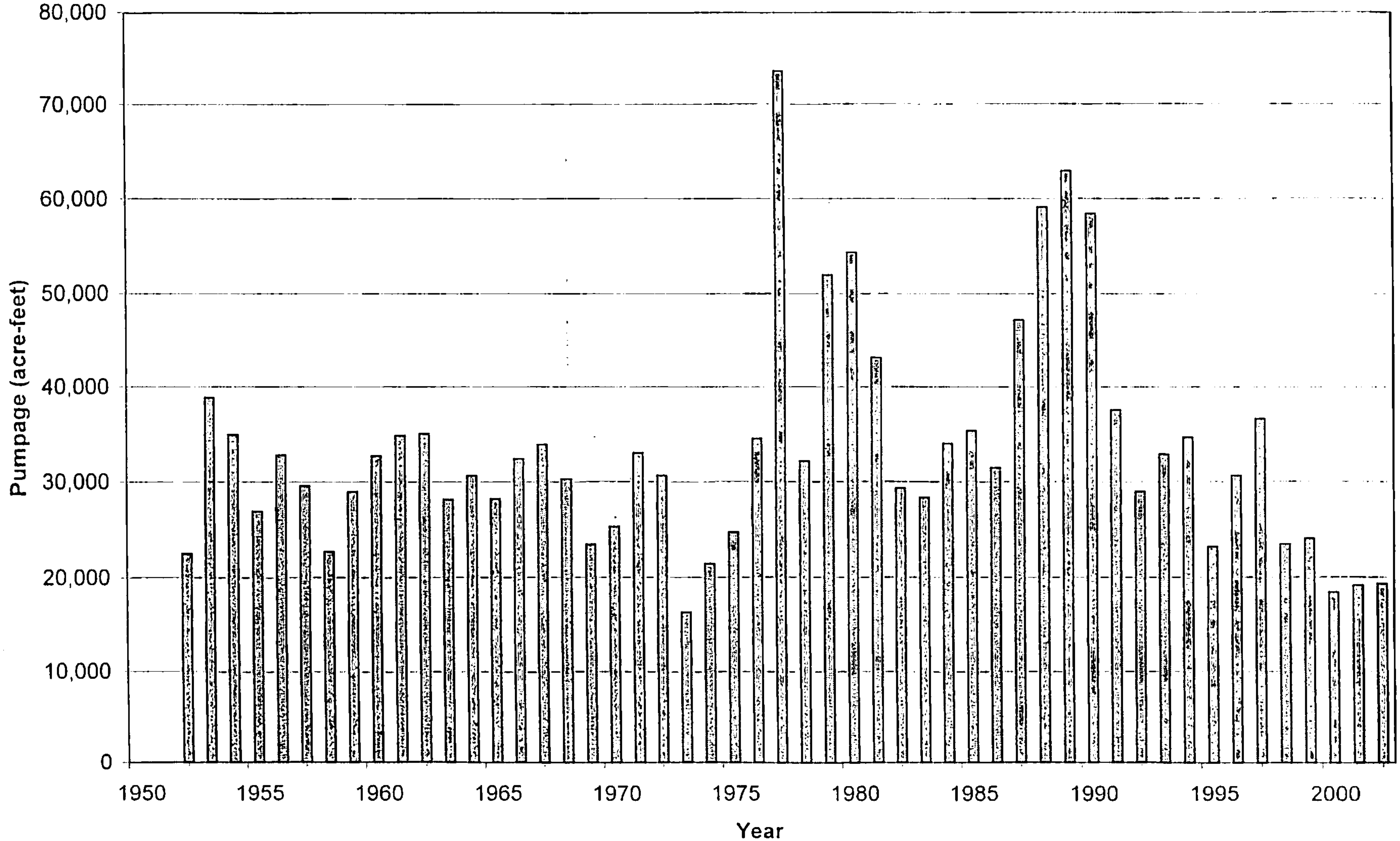

Figure 3.2 Annual Pumpage from Supplemental-Source Private and Improvement District Irrigation Wells Within Turlock Irrigation District, 1952-2002

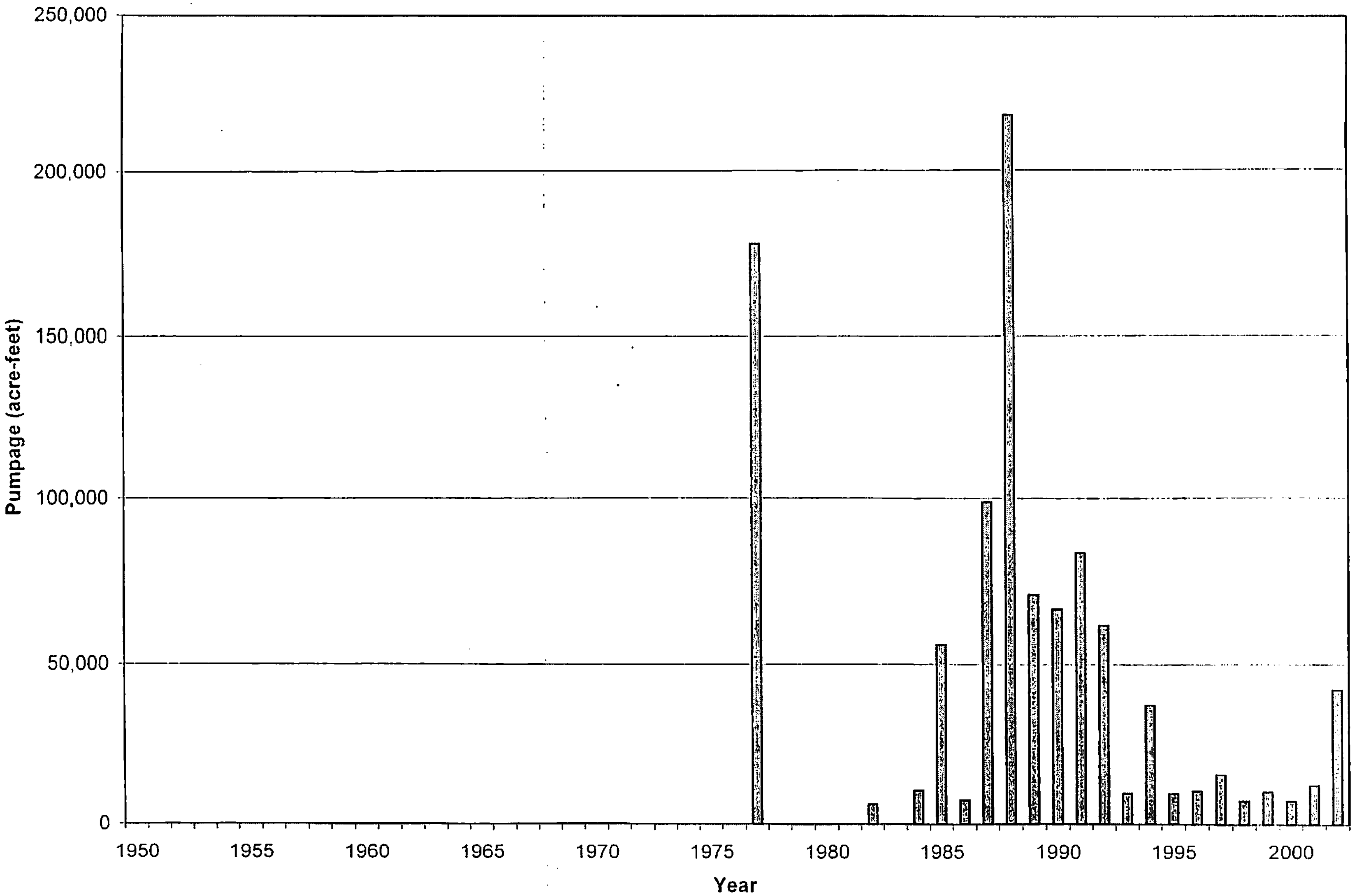

Figure 3.3 Annual Pumpage from Supplemental-Source Private and Improvement District Irrigation Wells Rented Within Turlock Irrigation District, 1977-2002

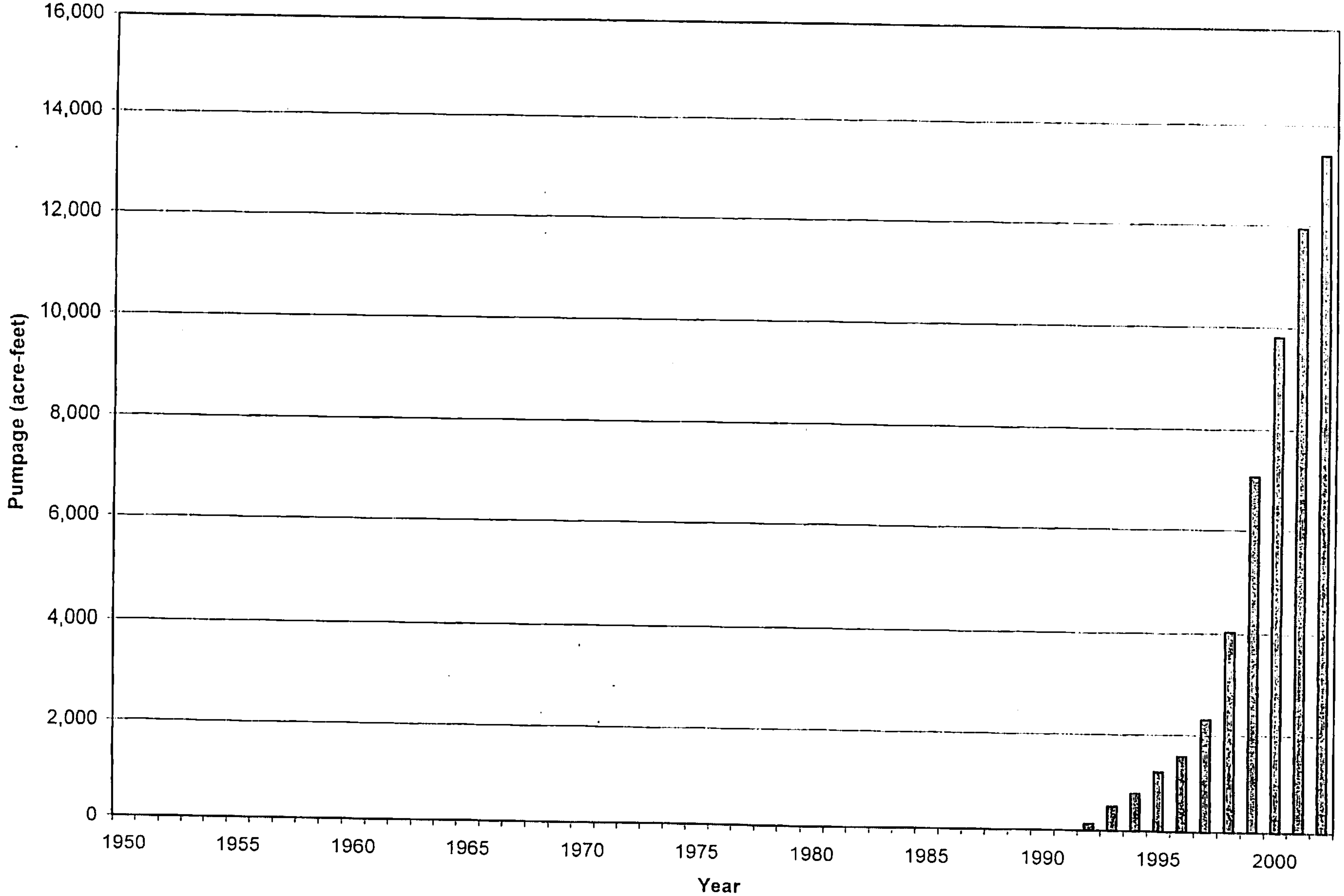

Figure 3.4 Annual Pumpage from Primary-Source Private Irrigation Wells within Turlock Irrigation District, 1952-2002

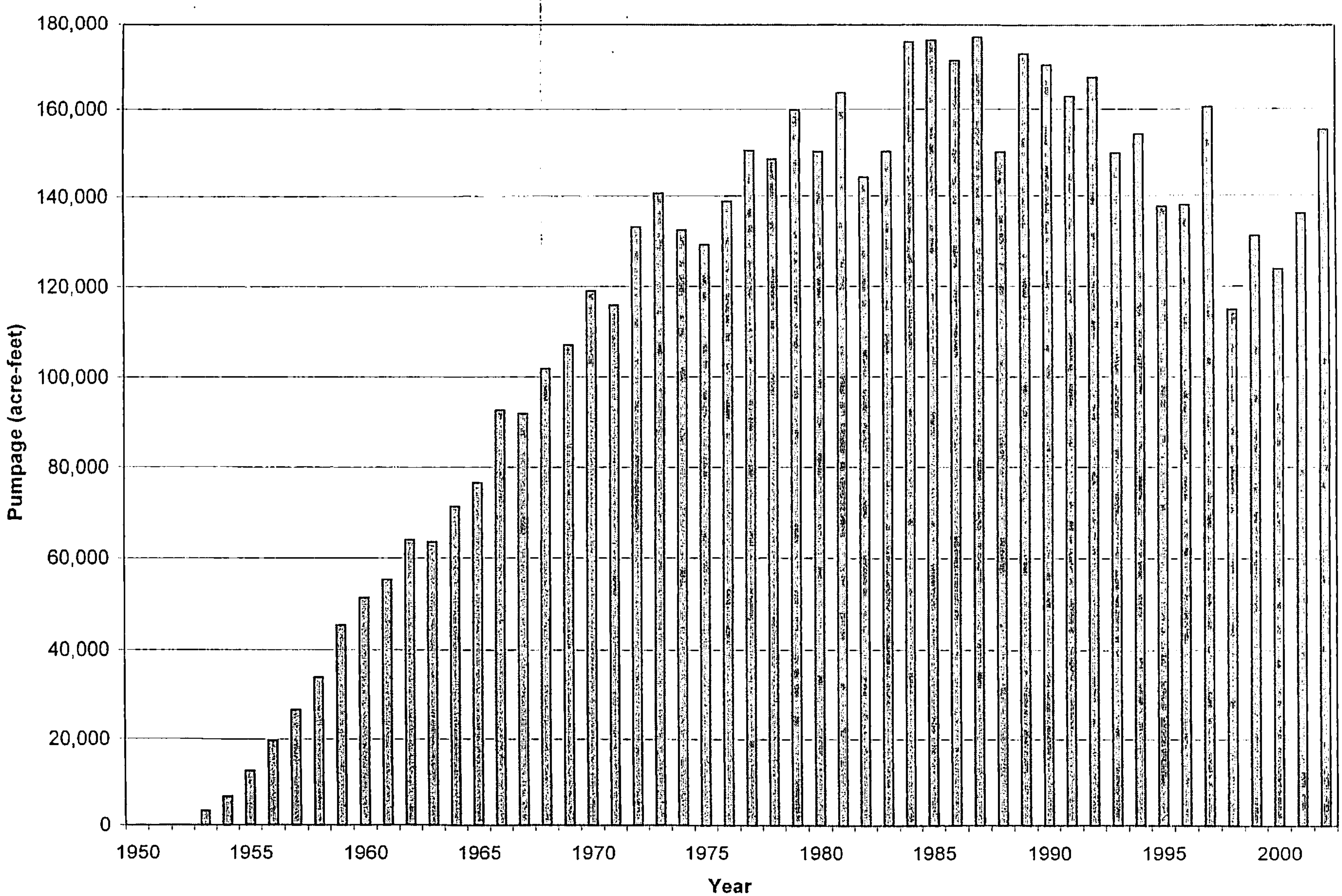

Figure 3.5 Annual Pumpage from Private Irrigation Wells within Eastside Water District, 1952-2002

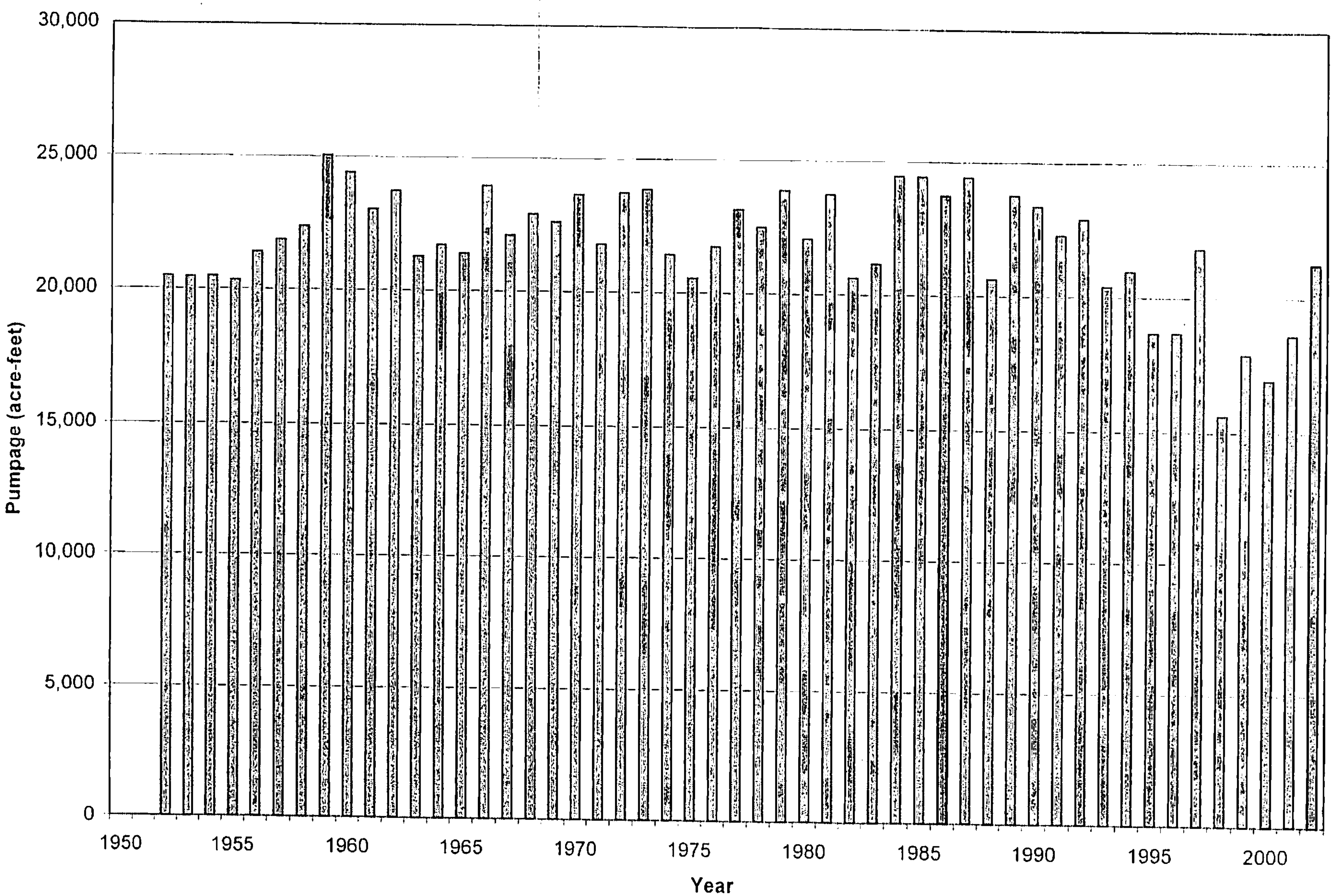

Figure 3.6 Annual Pumpage from Private Irrigation Wells within Ballico-Cortez Water District, 1952-2002

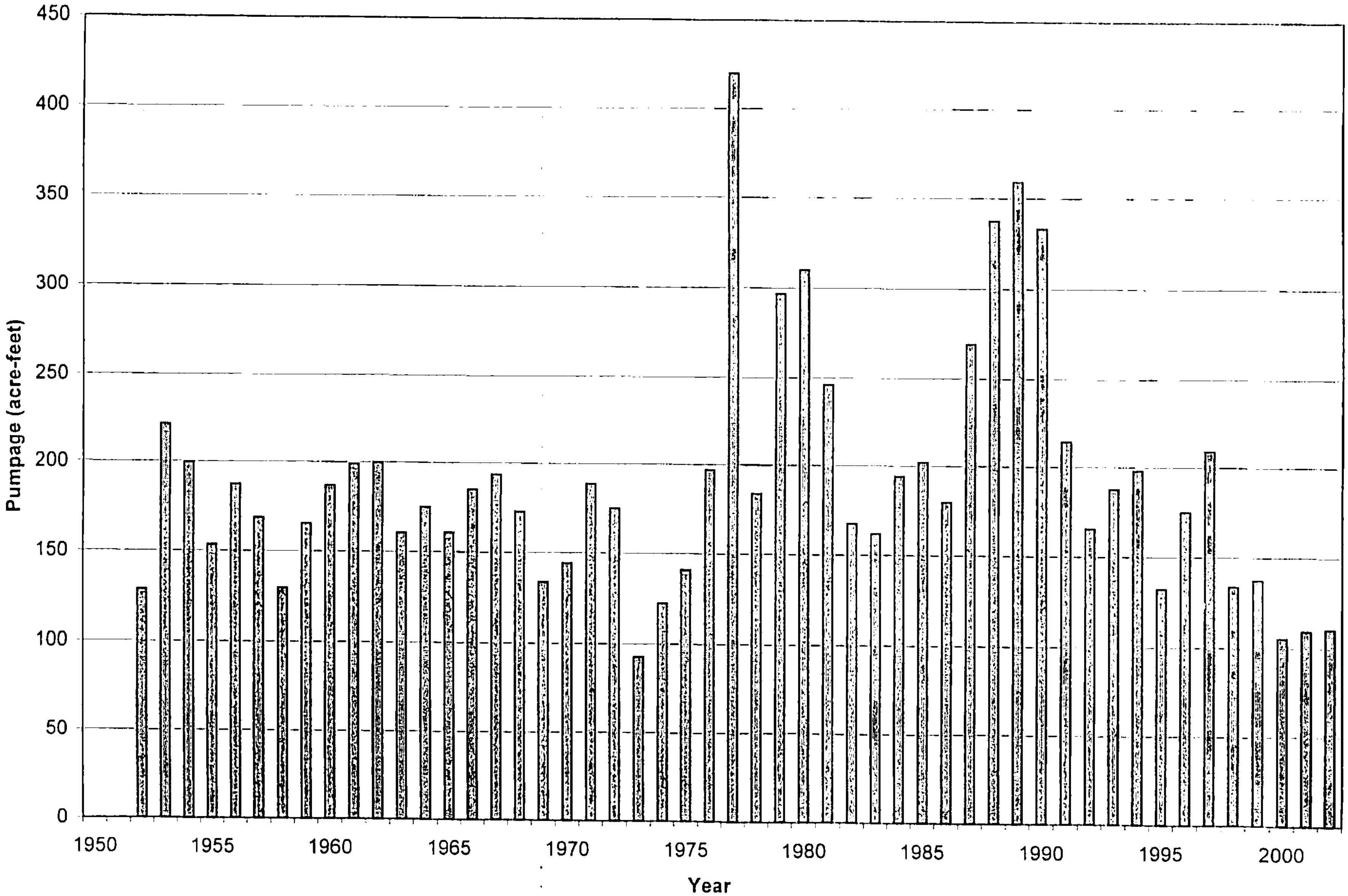

Figure 3.7 Annual Pumpage from Private Irrigation Wells within Merced Irrigation District, 1952-2002

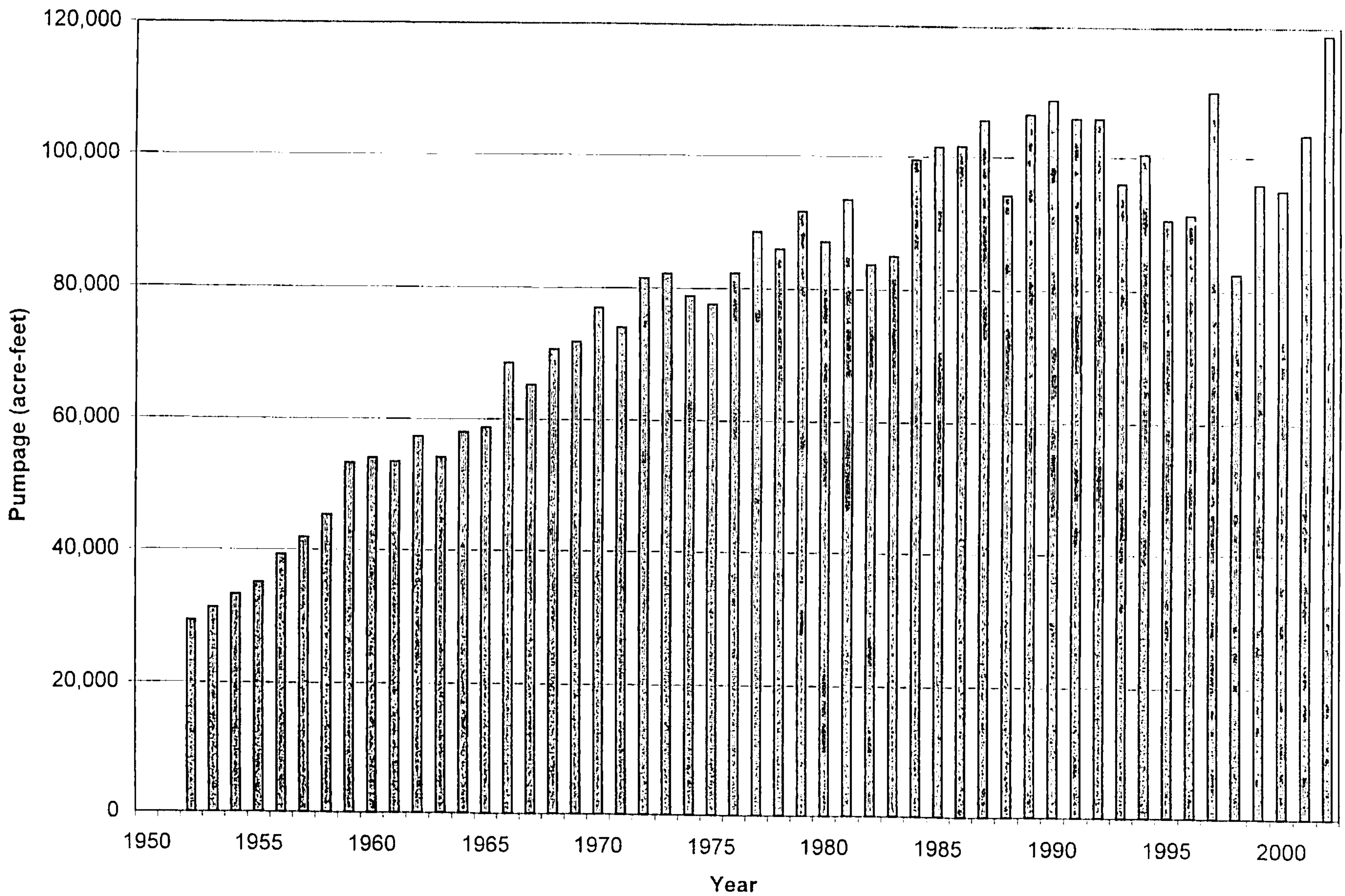

Figure 3.8 Annual Pumpage from Private Irrigation Wells within Non-District Areas, 1952-2002

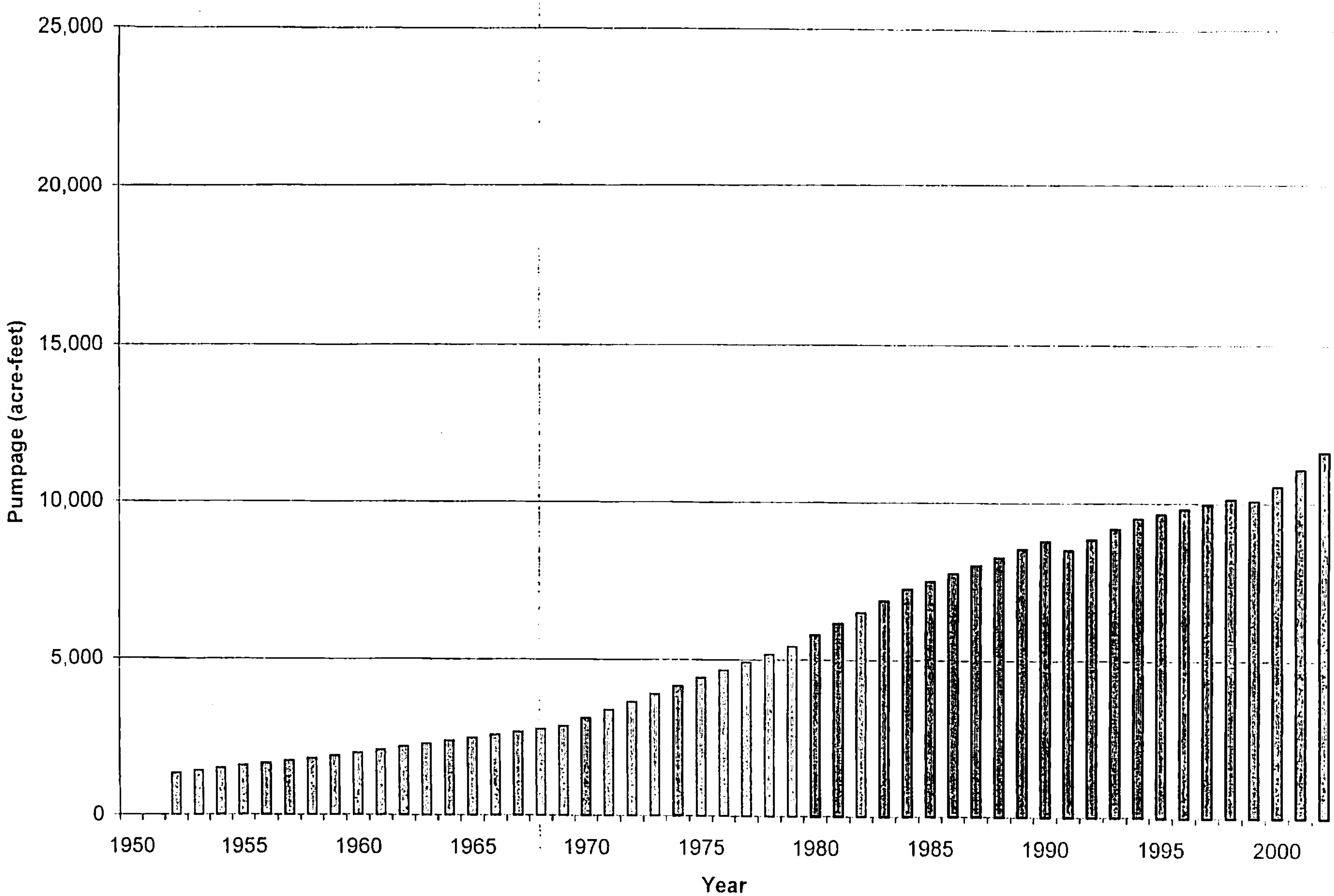

Figure 3.9a Annual Pumpage from Municipal Wells for Ceres, 1952-2002

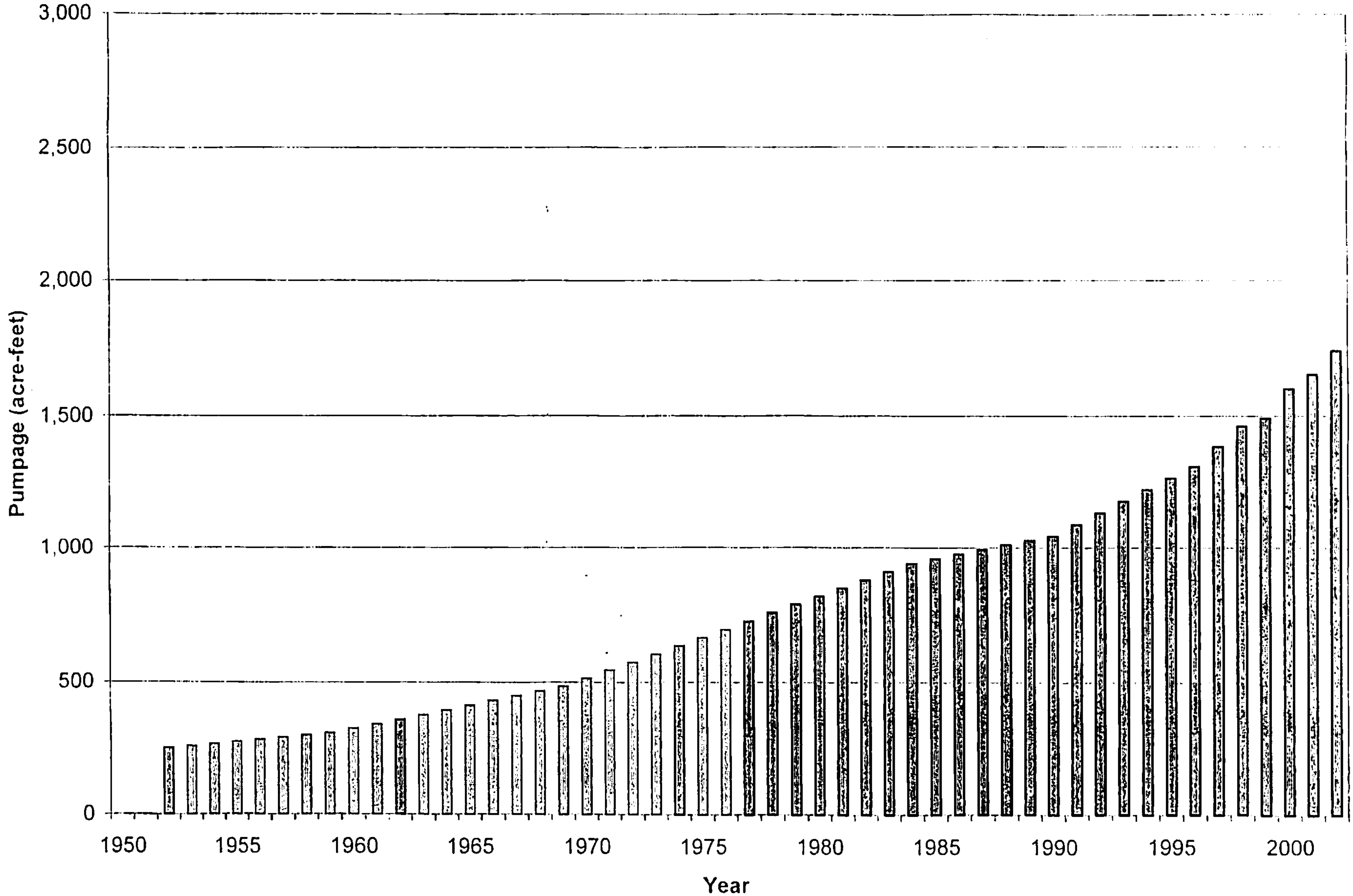

Figure 3.9b Annual Pumpage from Municipal Wells for Delhi, 1952-2002

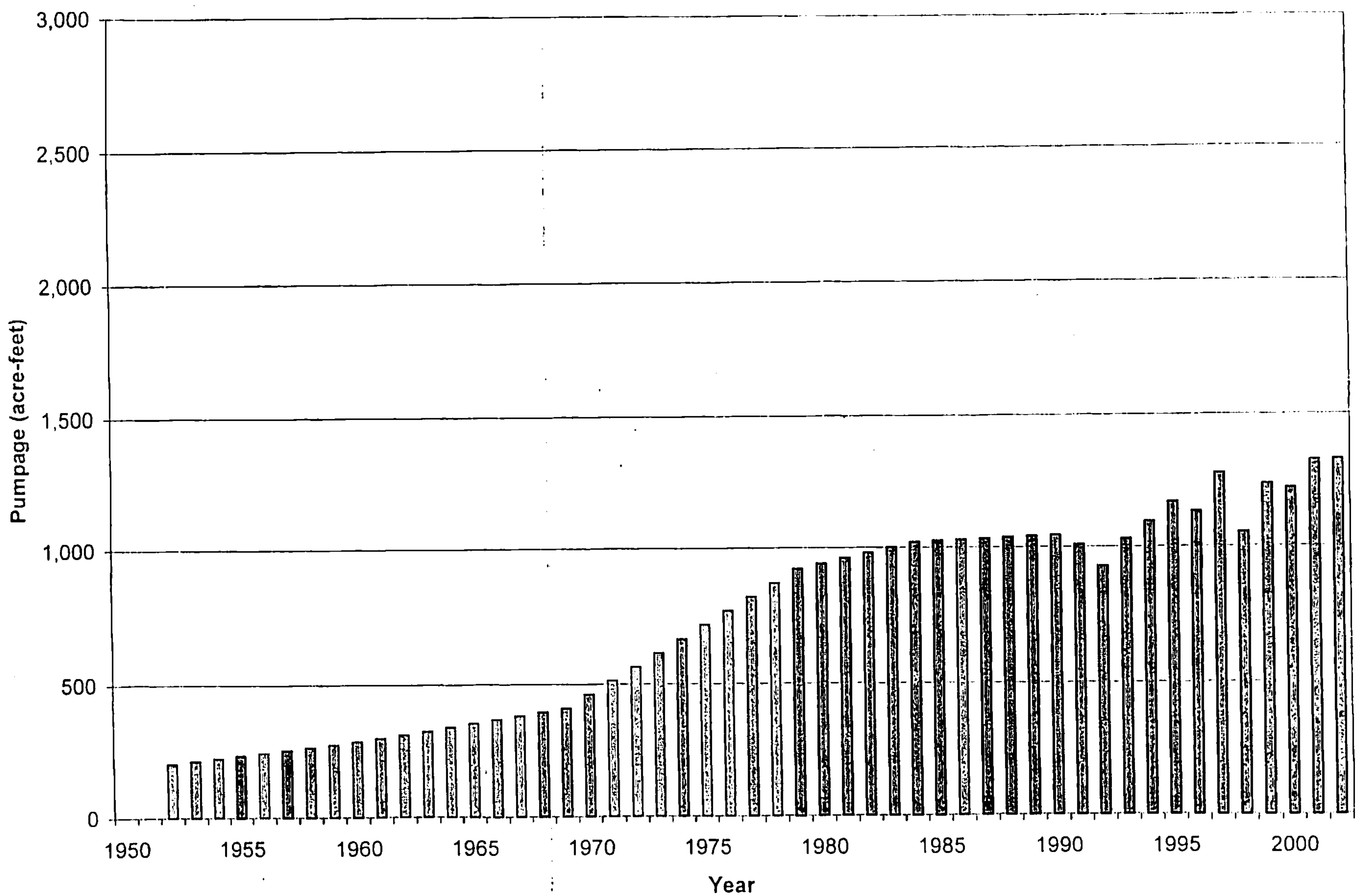

Figure 3.9c Annual Pumpage from Municipal Wells for Denair, 1952-2002

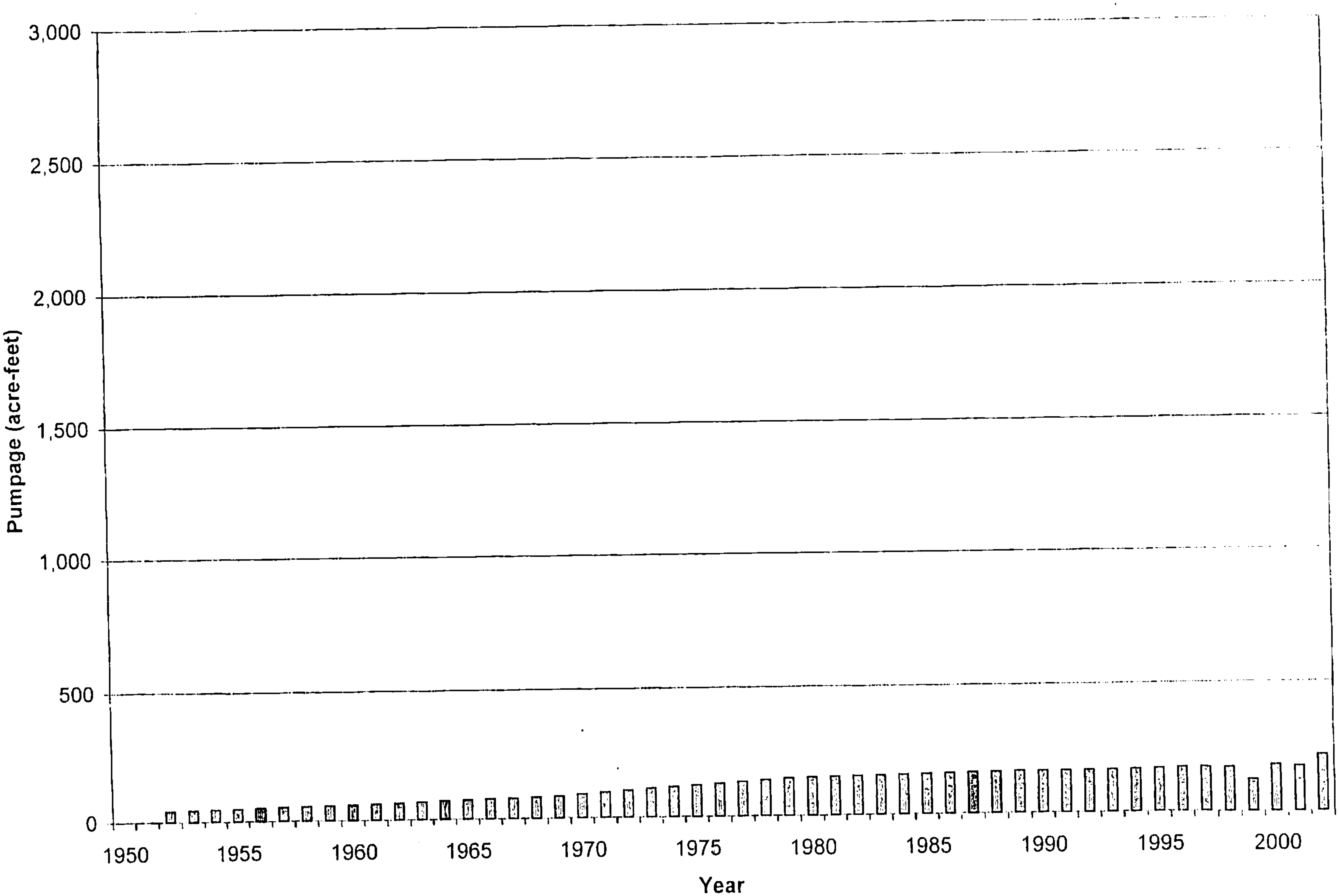

Figure 3.9d Annual Pumpage from Municipal Wells for Hickman, 1952-2002

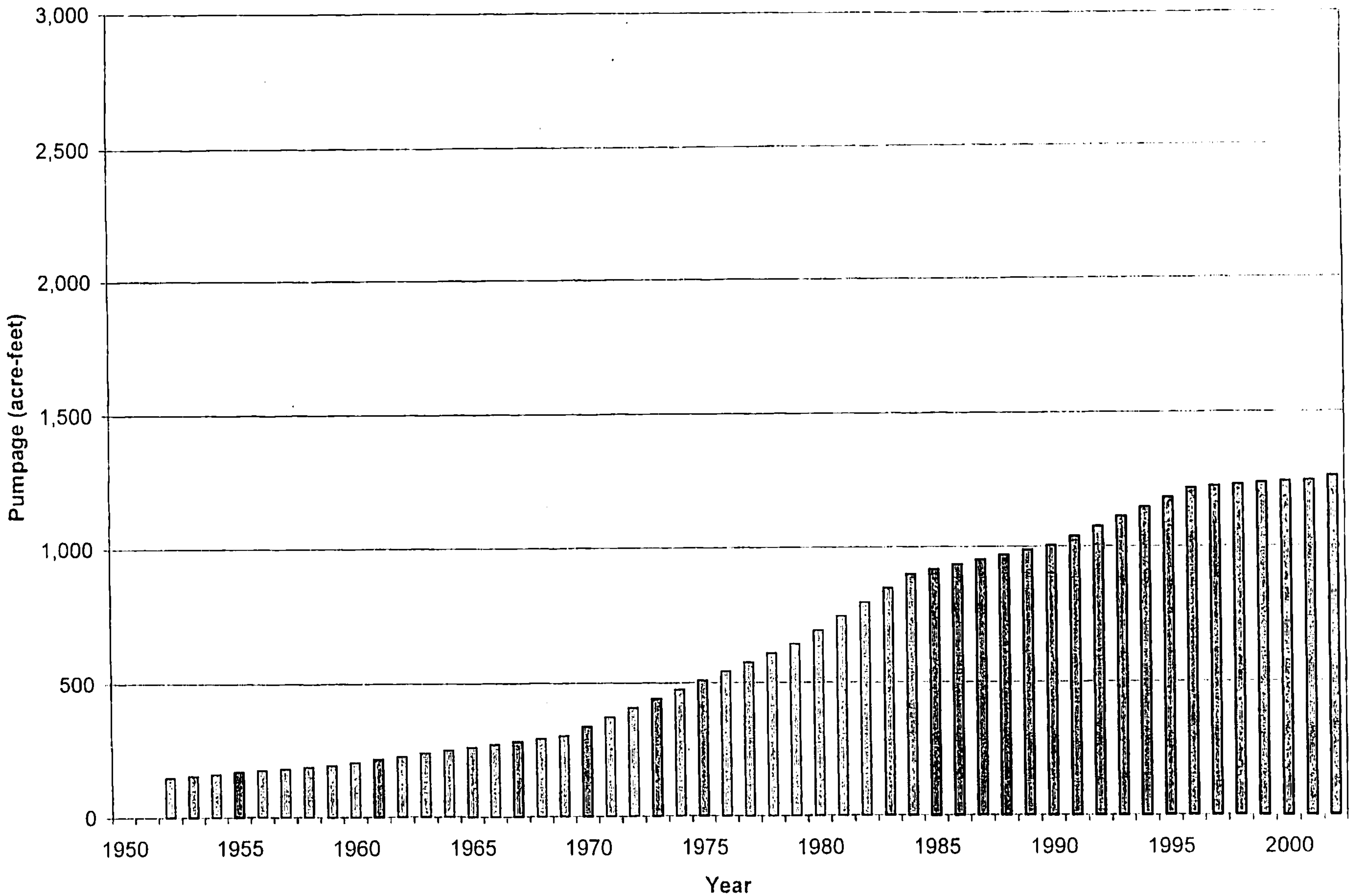

Figure 3.9e Annual Pumpage from Municipal Wells for Hilmar, 1952-2002

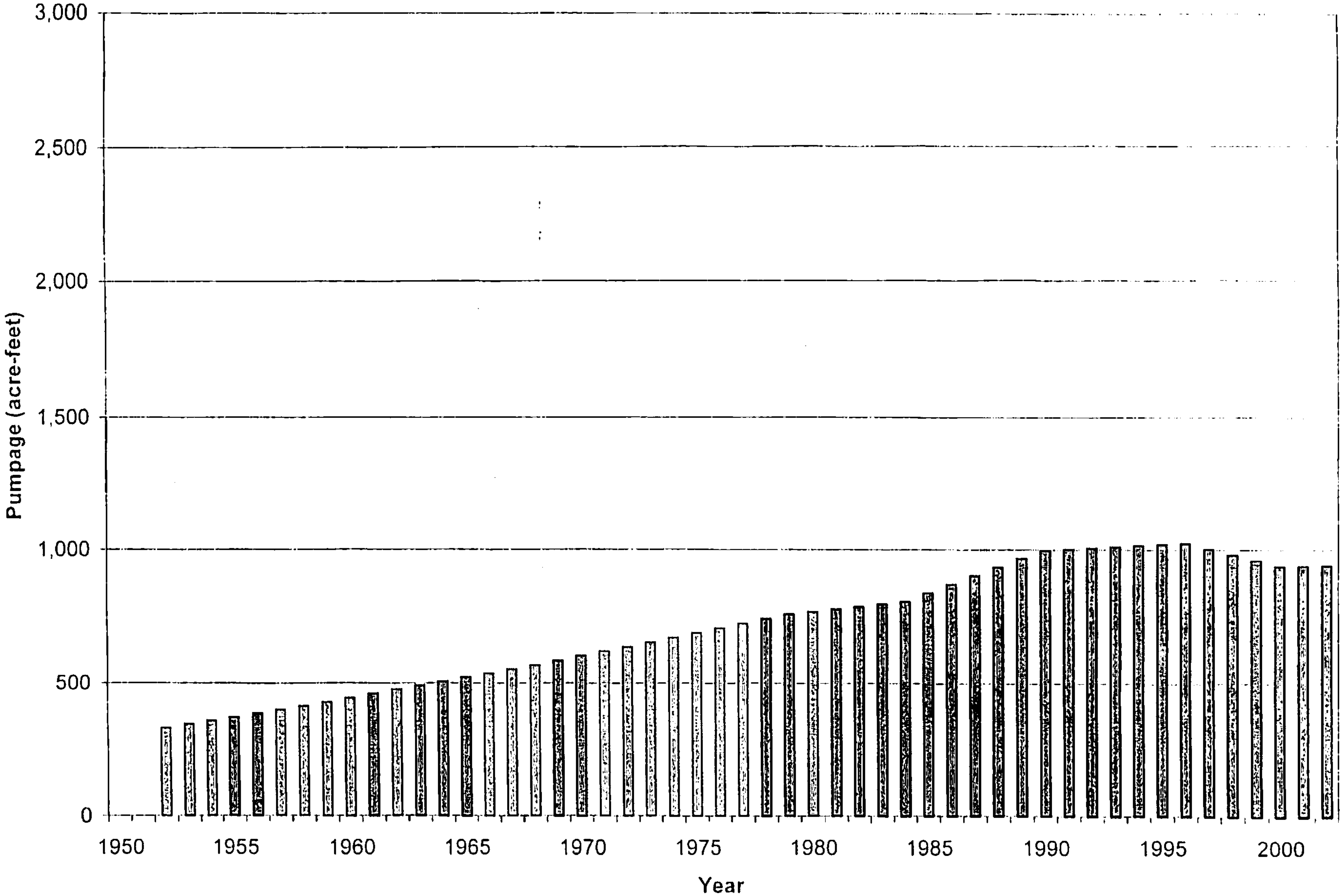

Figure 3.9f Annual Pumpage from Municipal Wells for Hughson, 1952-2002

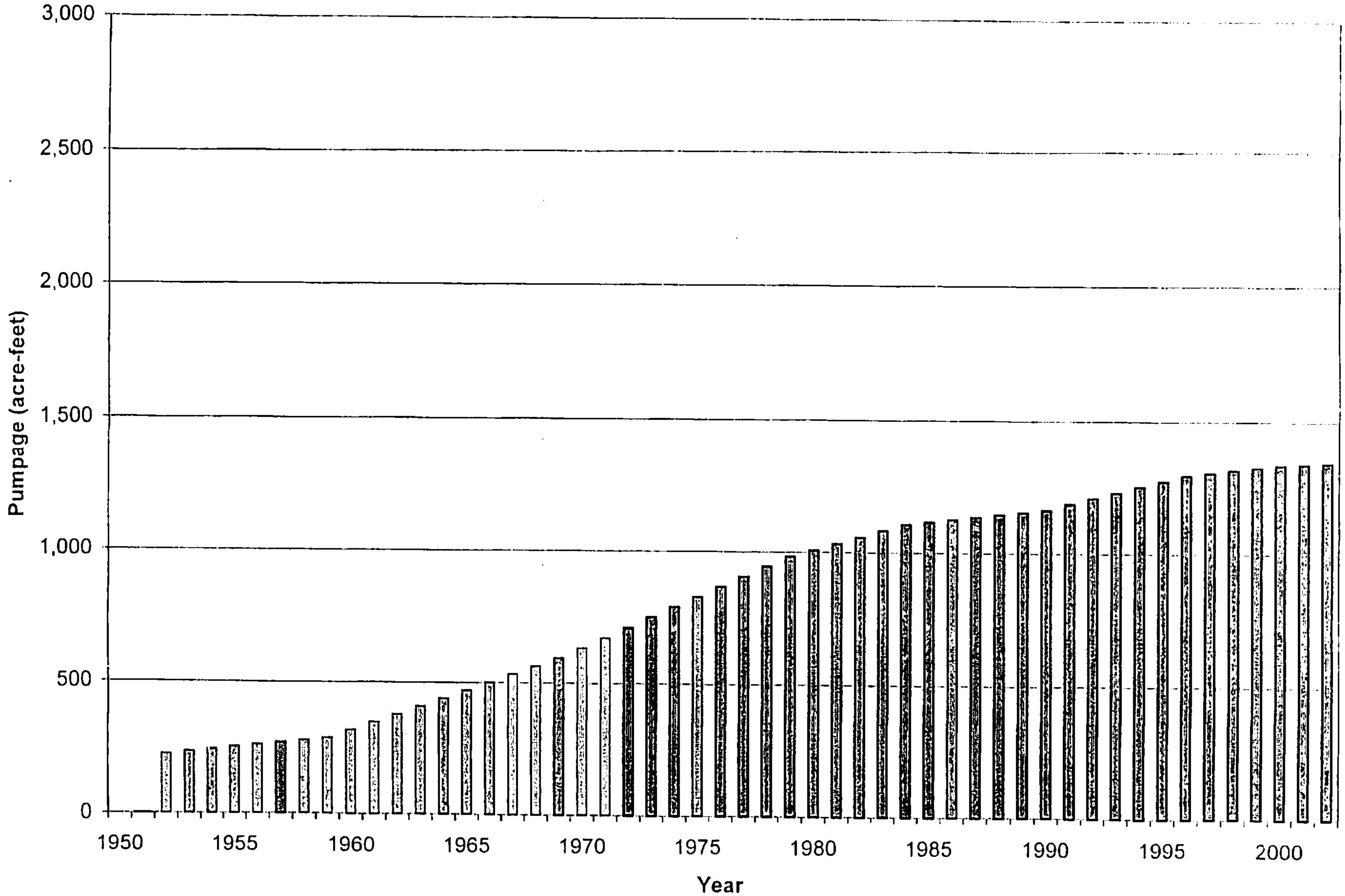

Figure 3.9g Annual Pumpage from Municipal Wells for Keyes, 1952-2002

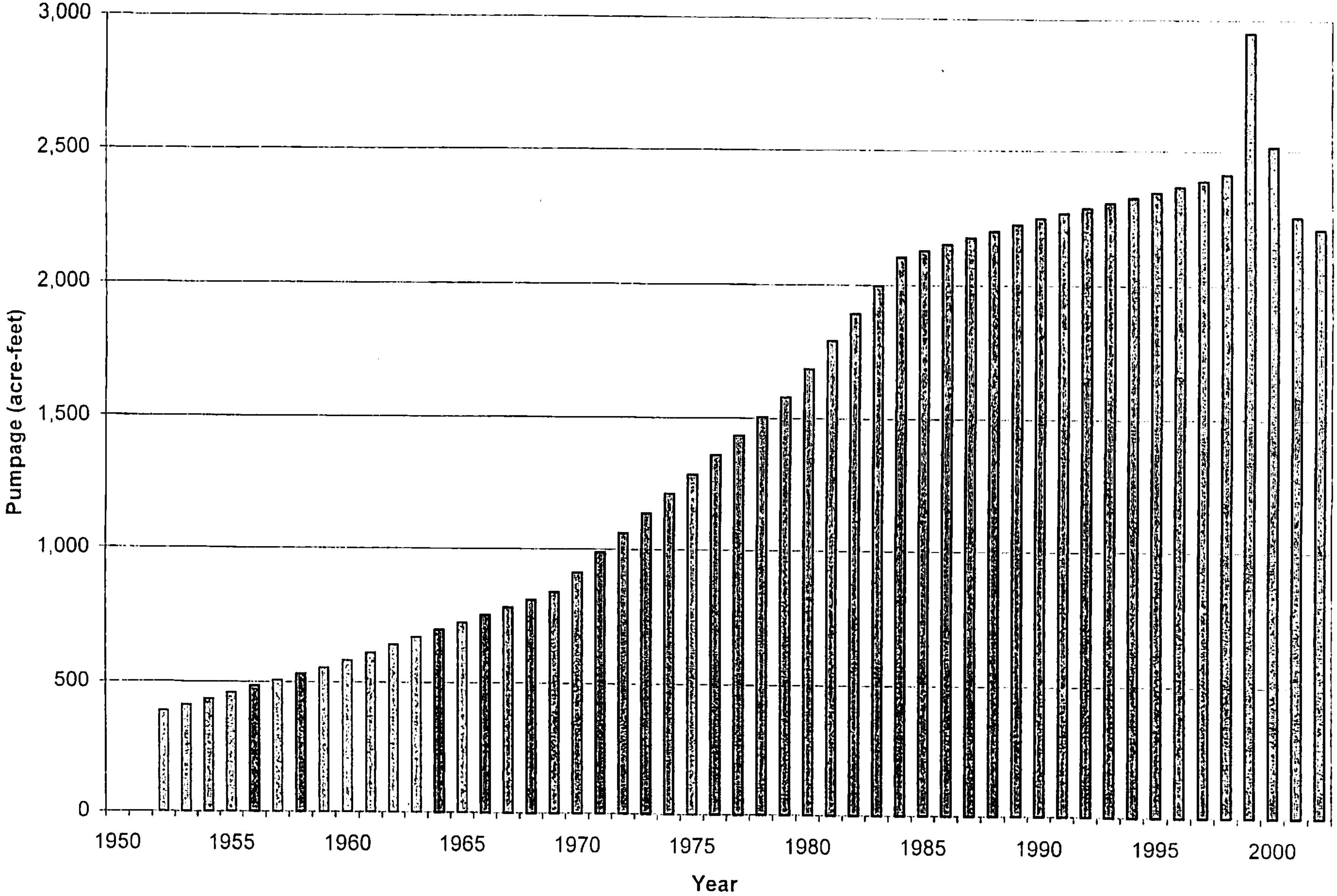

Figure 3.9h Annual Pumpage from Municipal Wells for South Modesto, 1952-2002

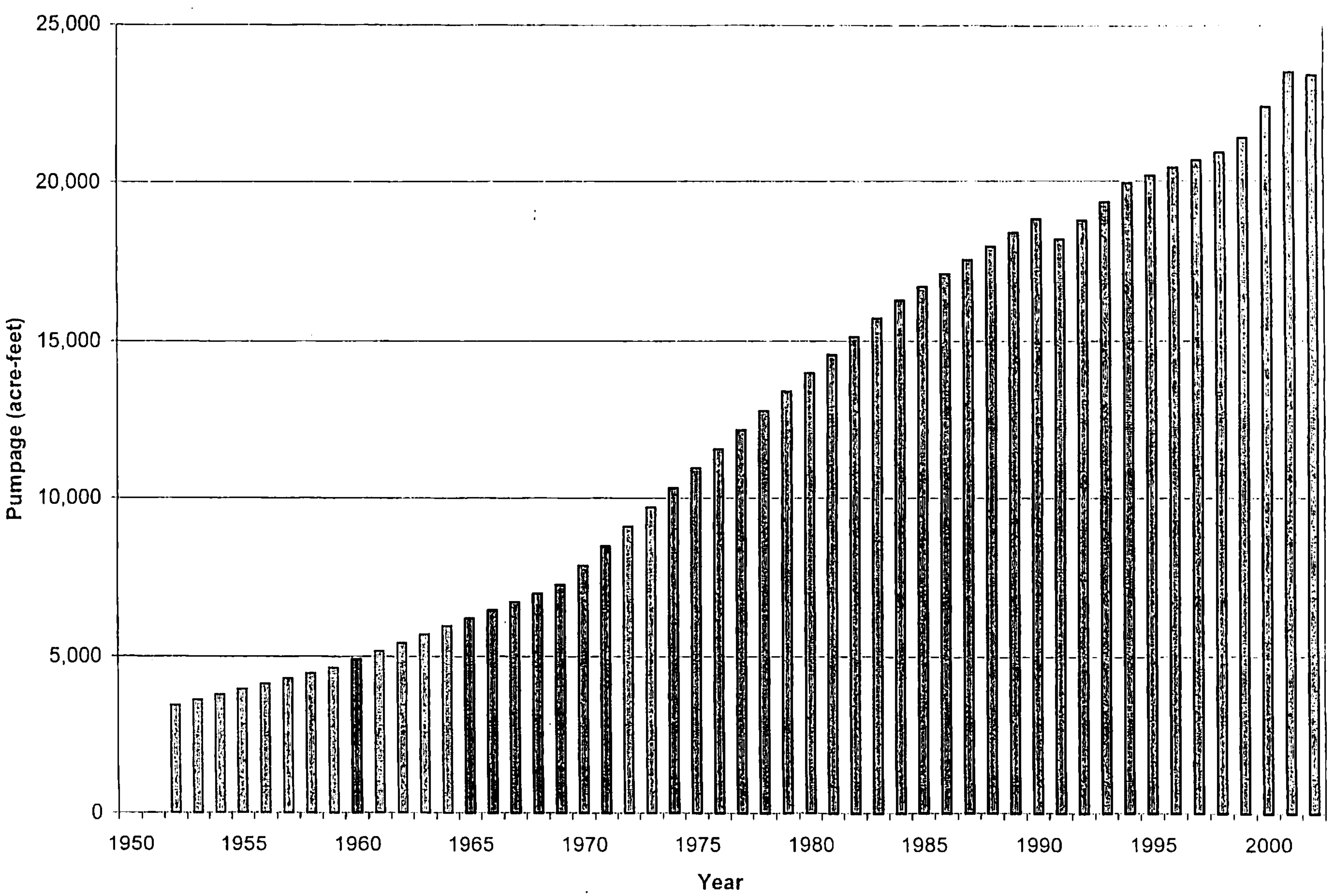

Figure 3.9i Annual Pumpage from Municipal Wells for Turlock, 1952-2002

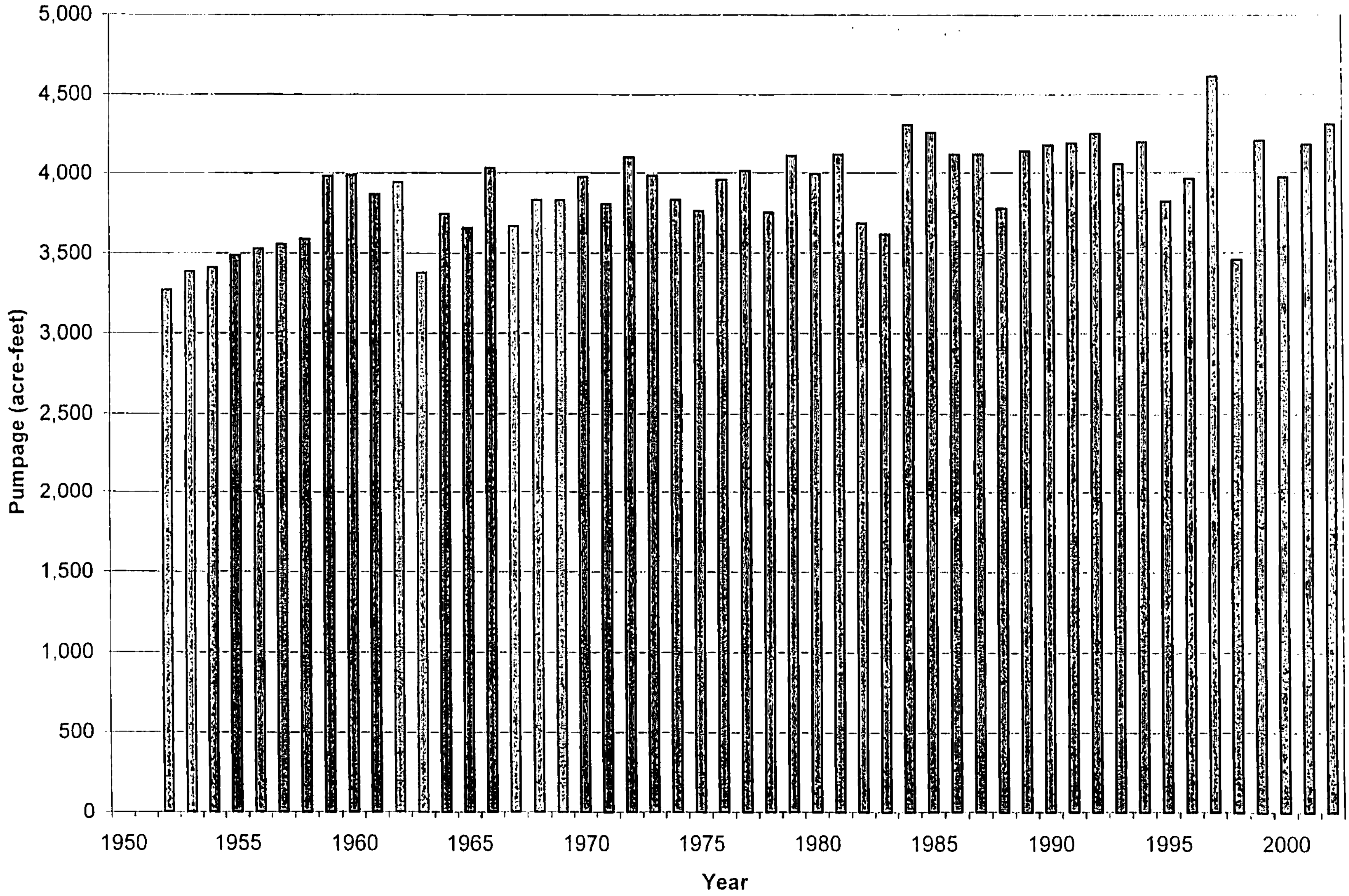

Figure 3.10 Annual Pumpage from Private Domestic Wells, 1952-2002

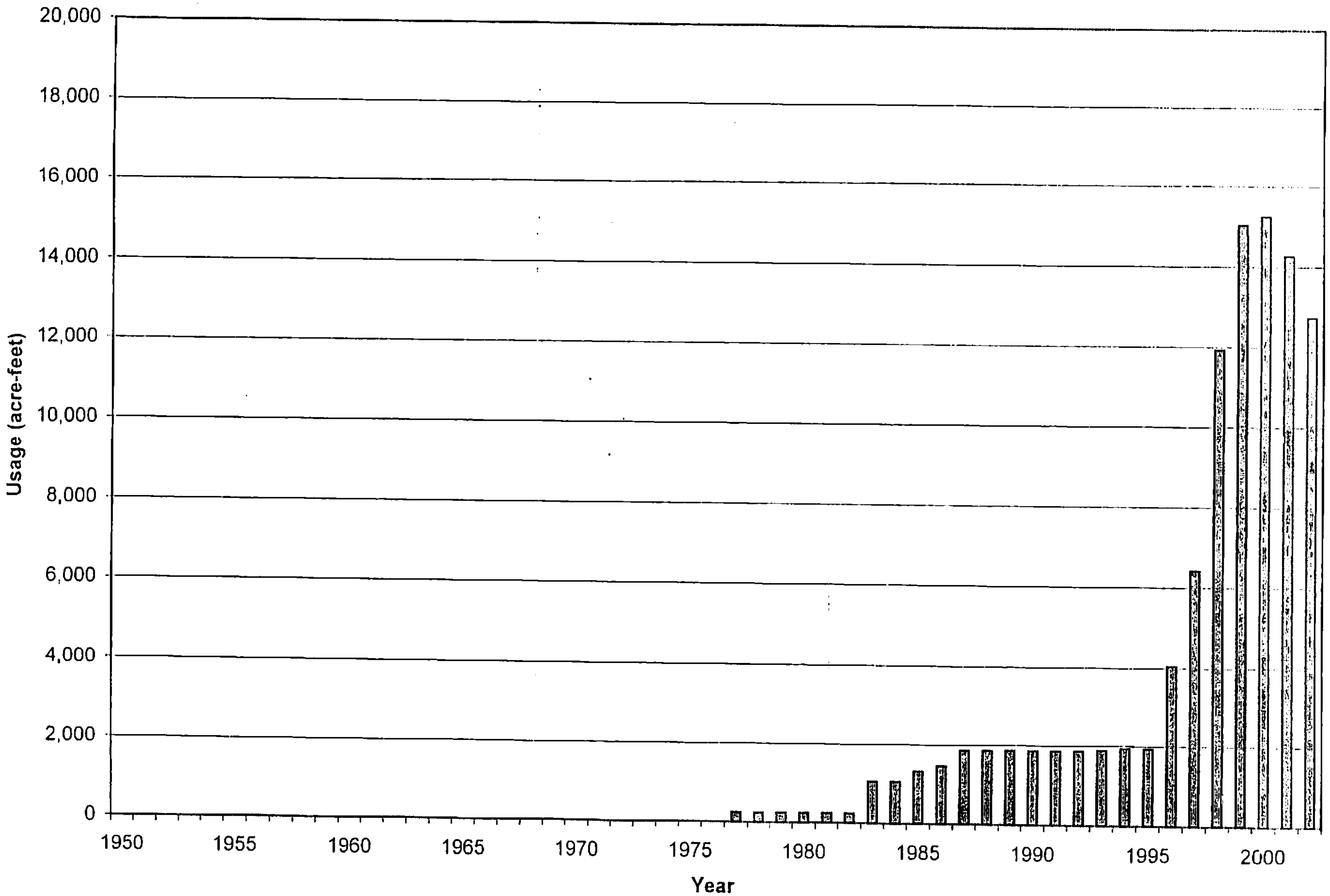

Figure 3.11 Annual Discharge from Subsurface Agricultural Drains, 1952-2002

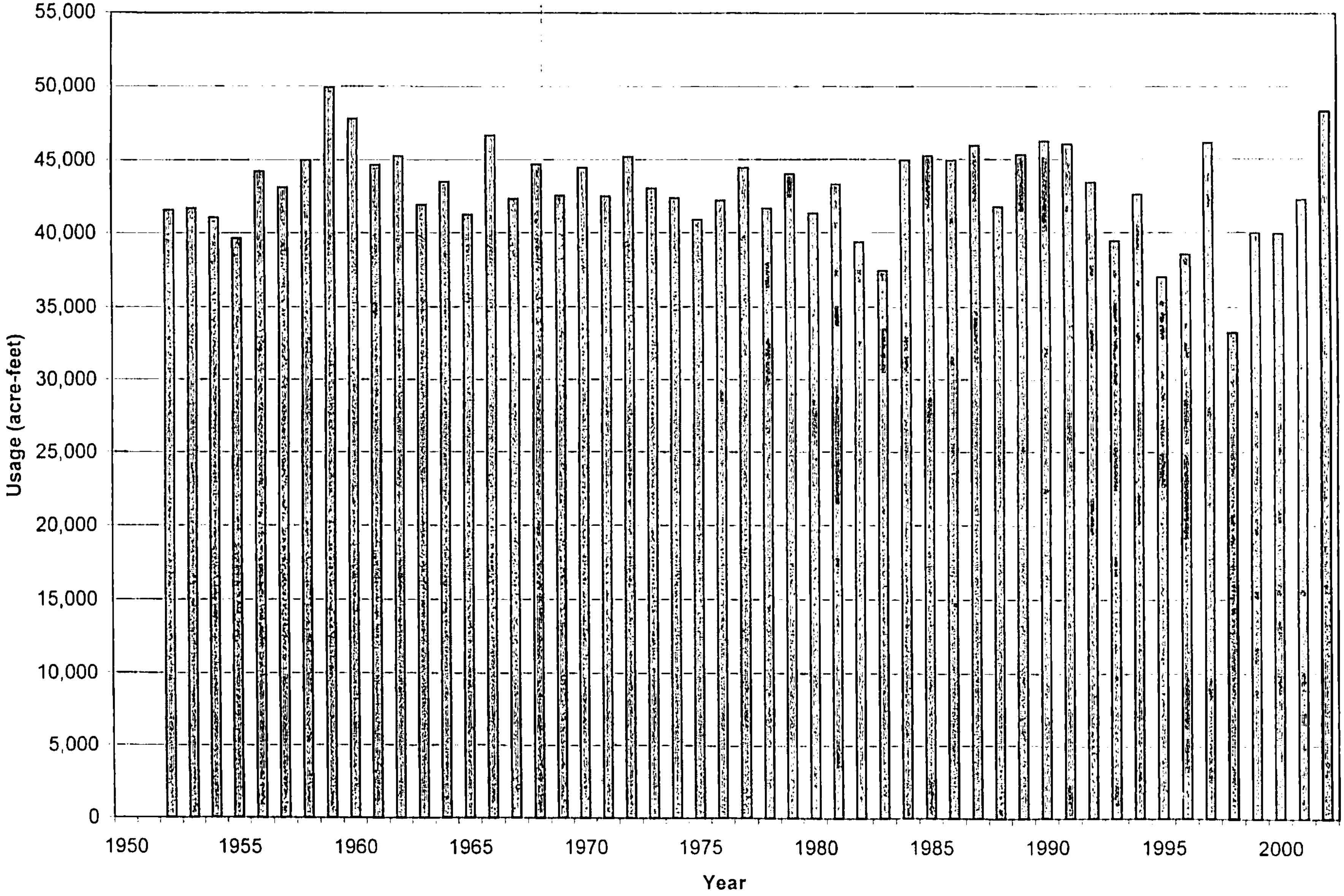

Figure 3.12 Annual Groundwater Usage by Riparian Vegetation, 1952-2002

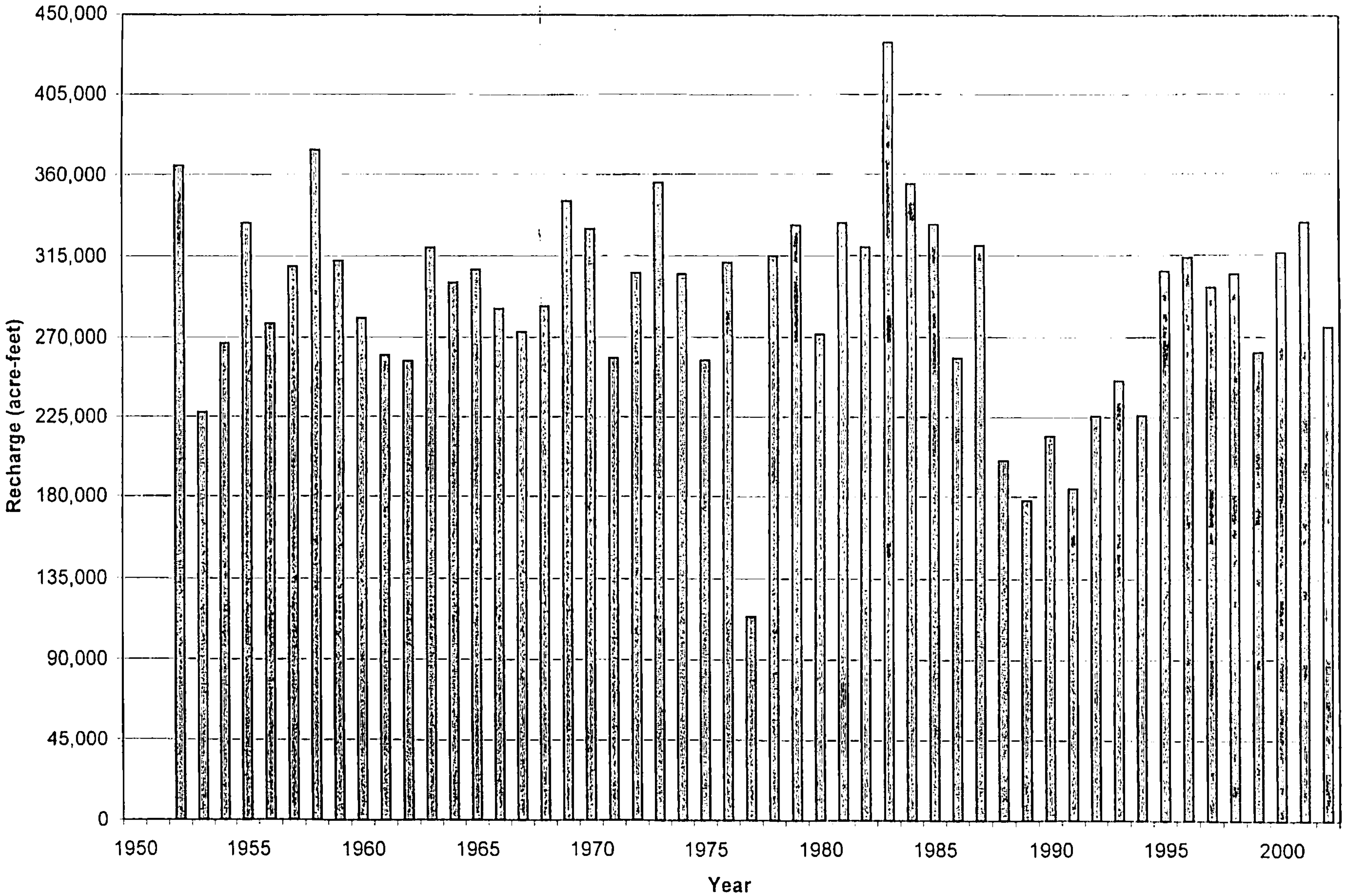

Figure 4.1 Annual Recharge from Turlock Irrigation District Canal-Delivery Lands, 1952-2002

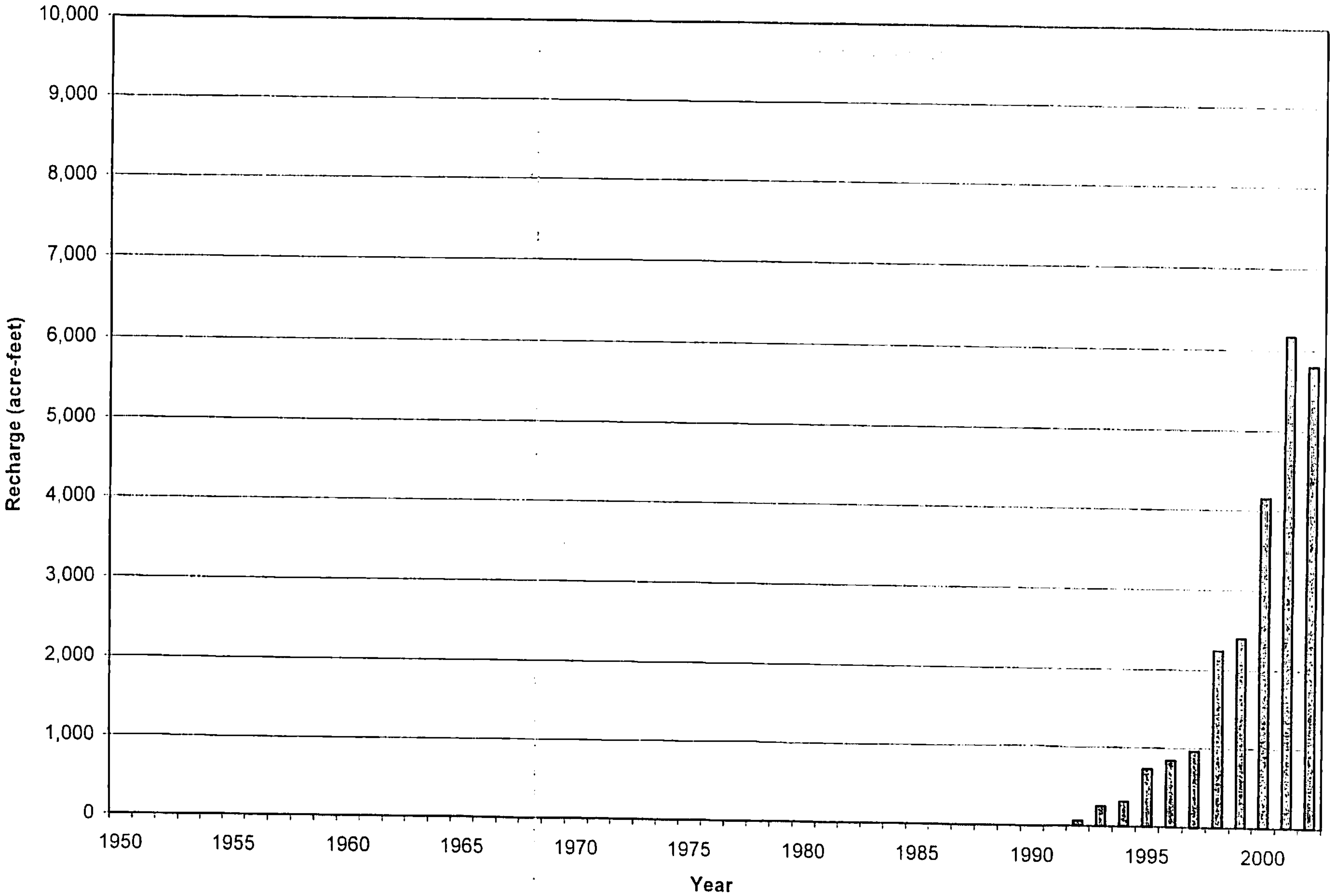

Figure 4.2 Annual Recharge from Turlock Irrigation District Groundwater-Only Lands, 1952-2002

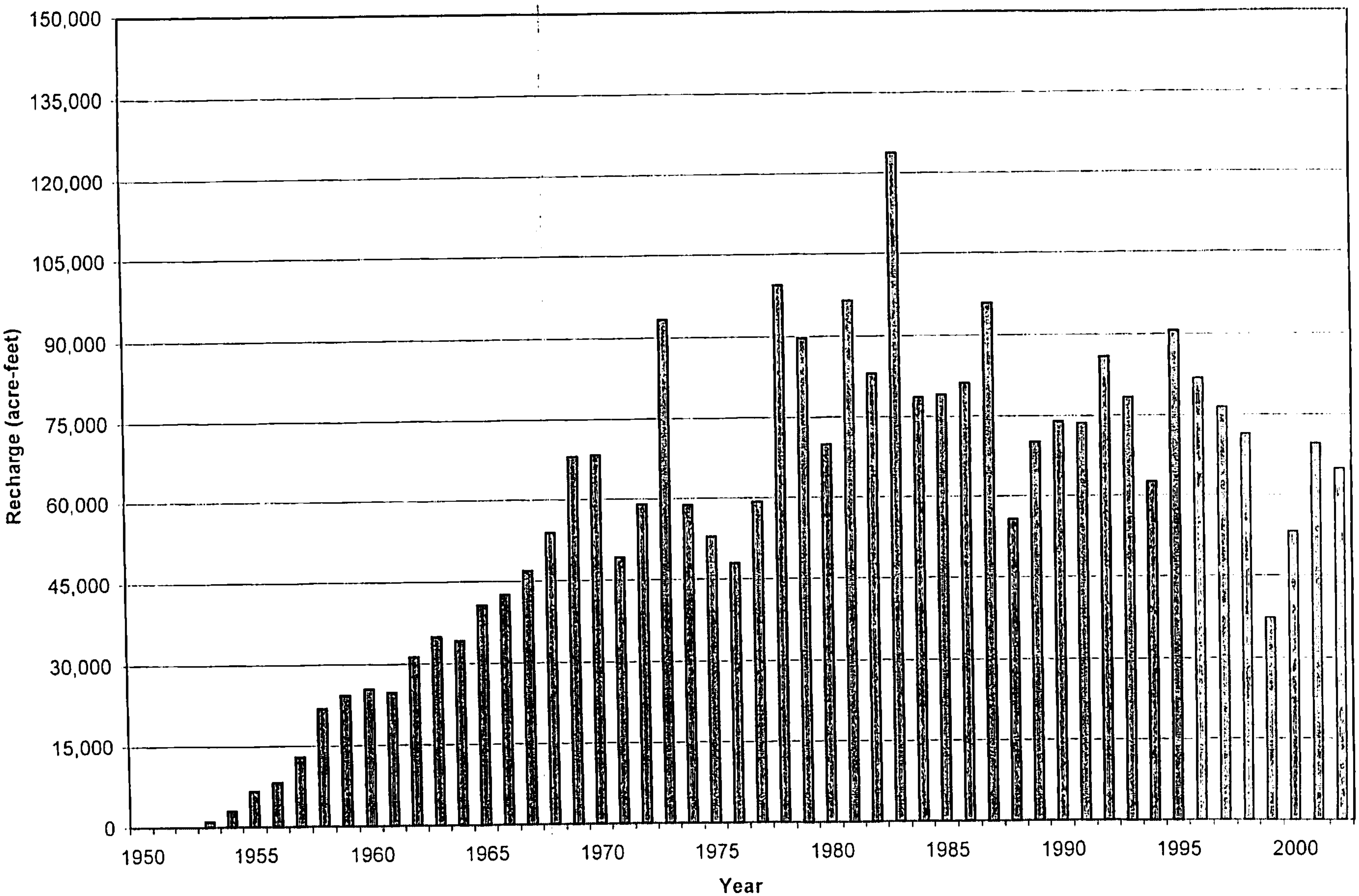

Figure 4.3 Annual Recharge from Eastside Water District, 1952-2002

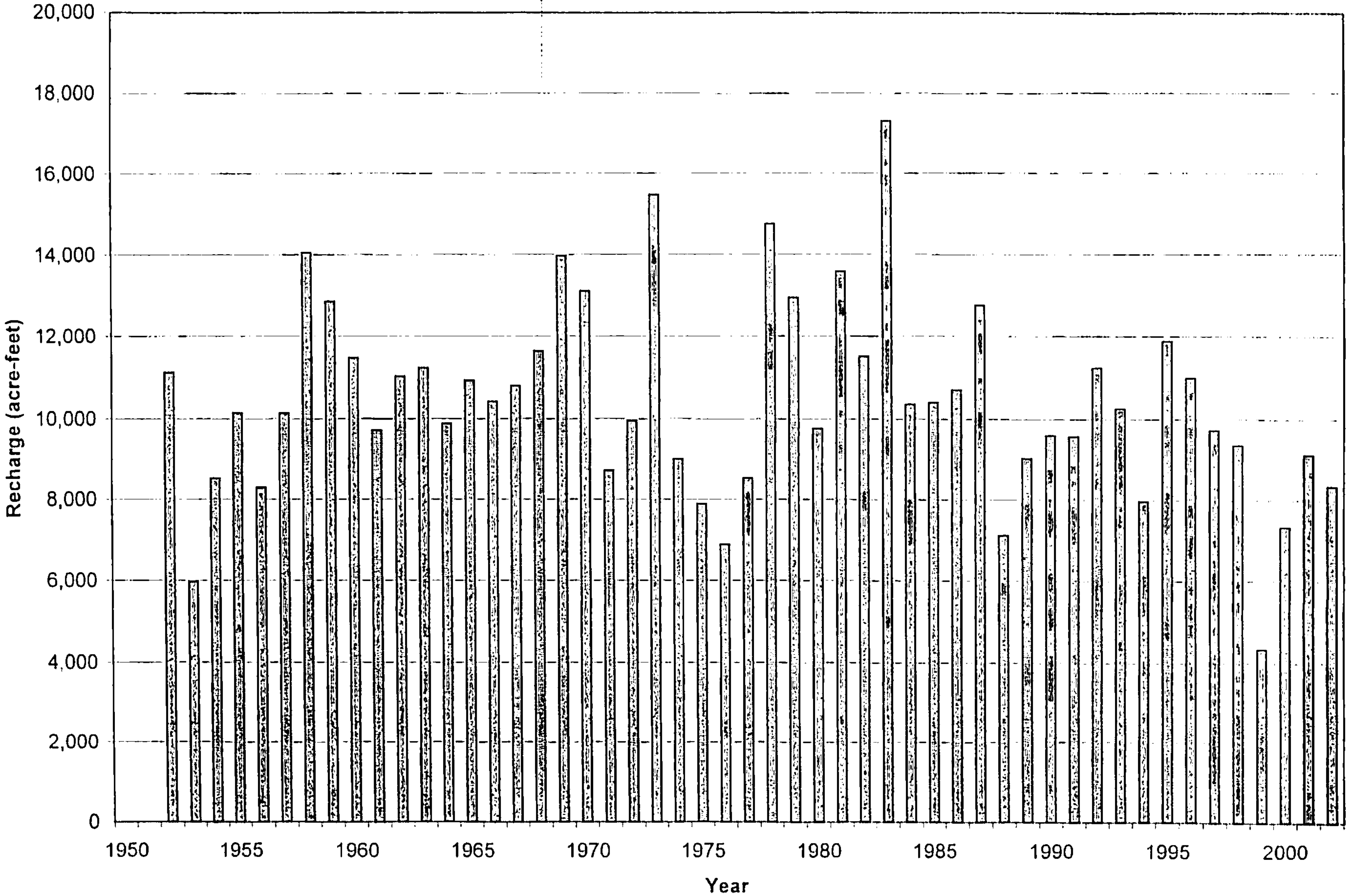

Figure 4.4 Annual Recharge from Ballico-Cortez Water District, 1952-2002

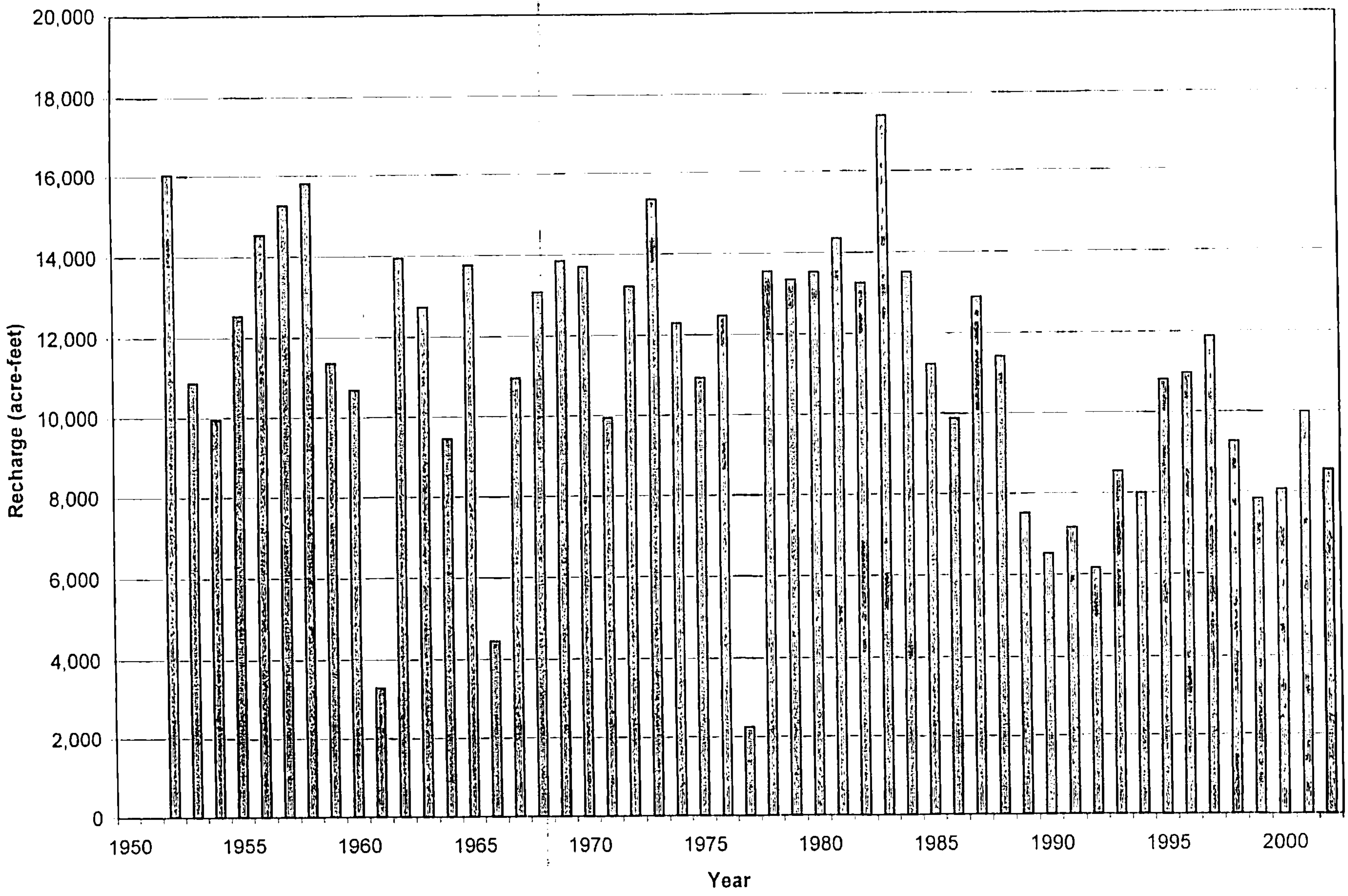

Figure 4.5 Annual Recharge from Merced Irrigation District, 1952-2002

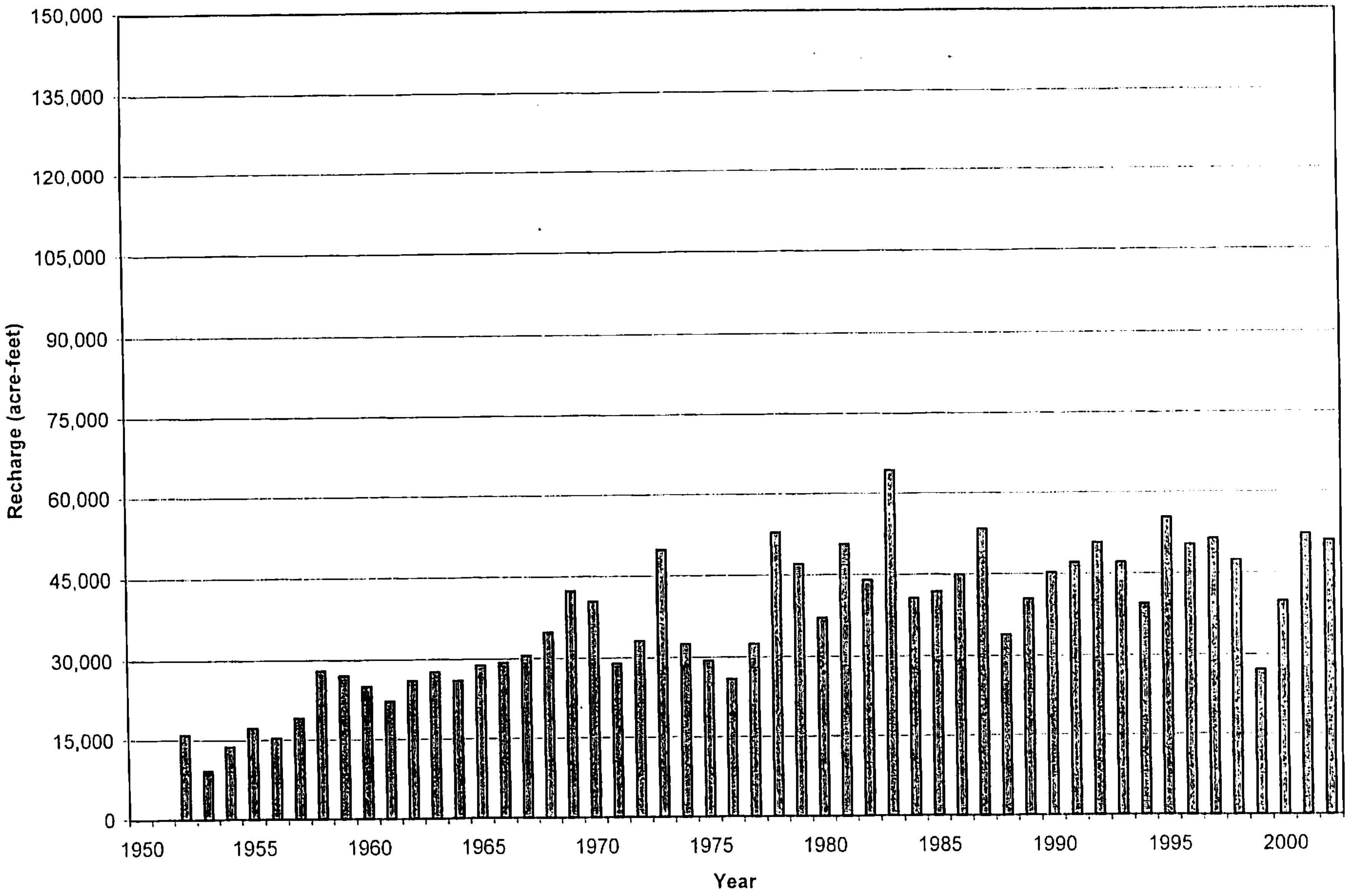

Figure 4.6 Annual Recharge from Non-District Areas, 1952-2002

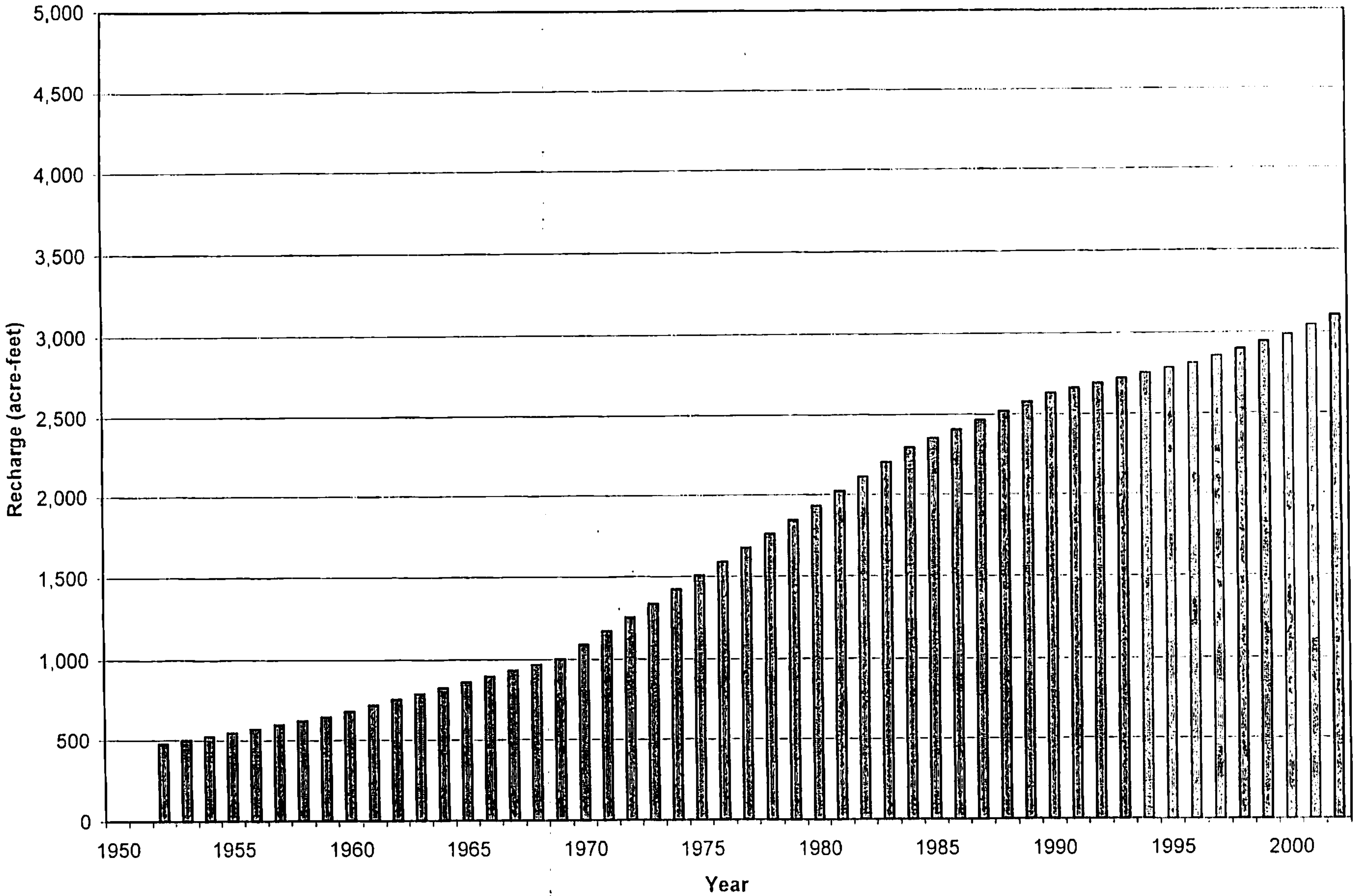

Figure 4.7 Annual Recharge from City Areas, 1952-2002

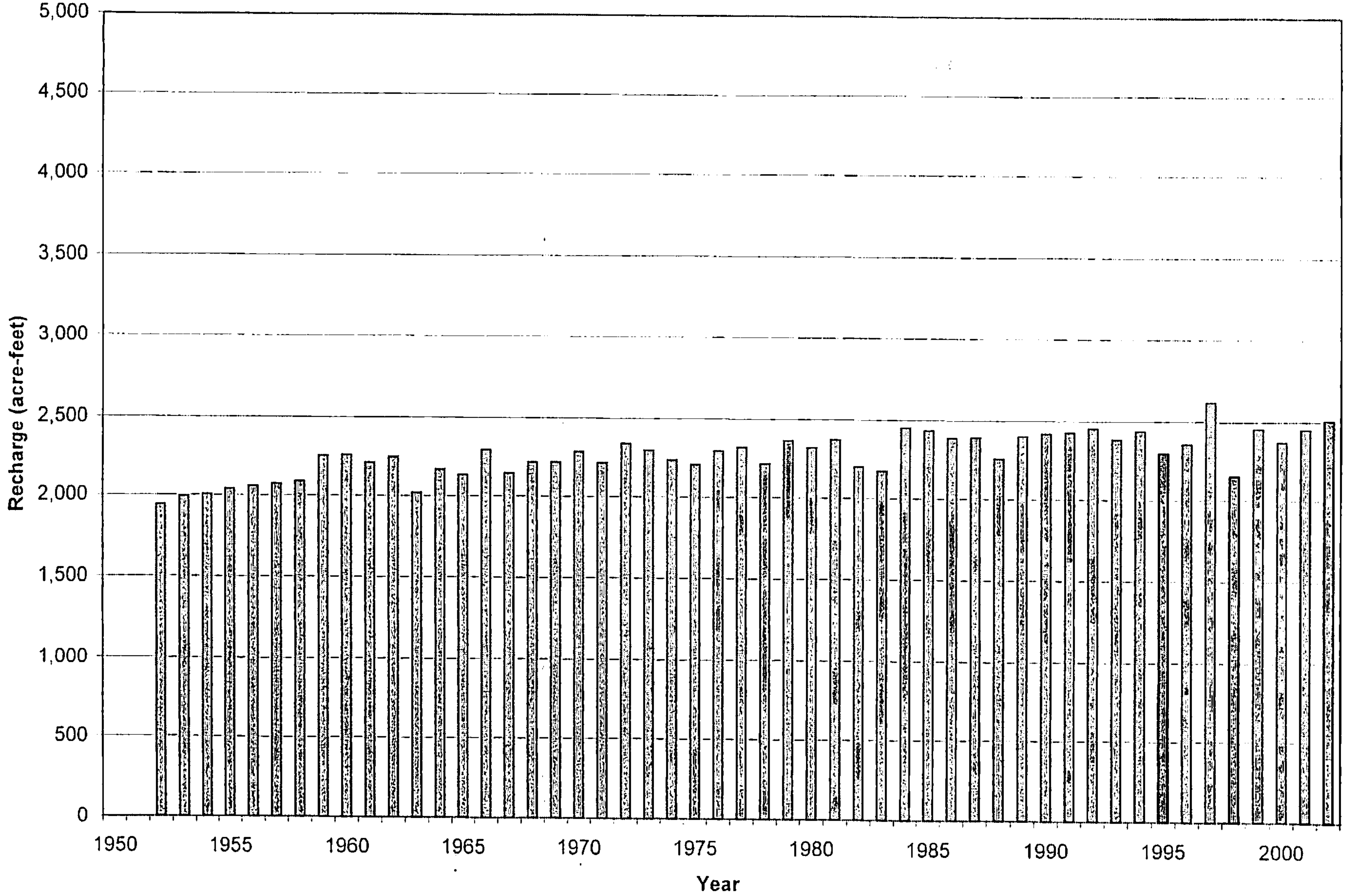

Figure 4.8 Annual Recharge from Rural Residences, 1952-2002

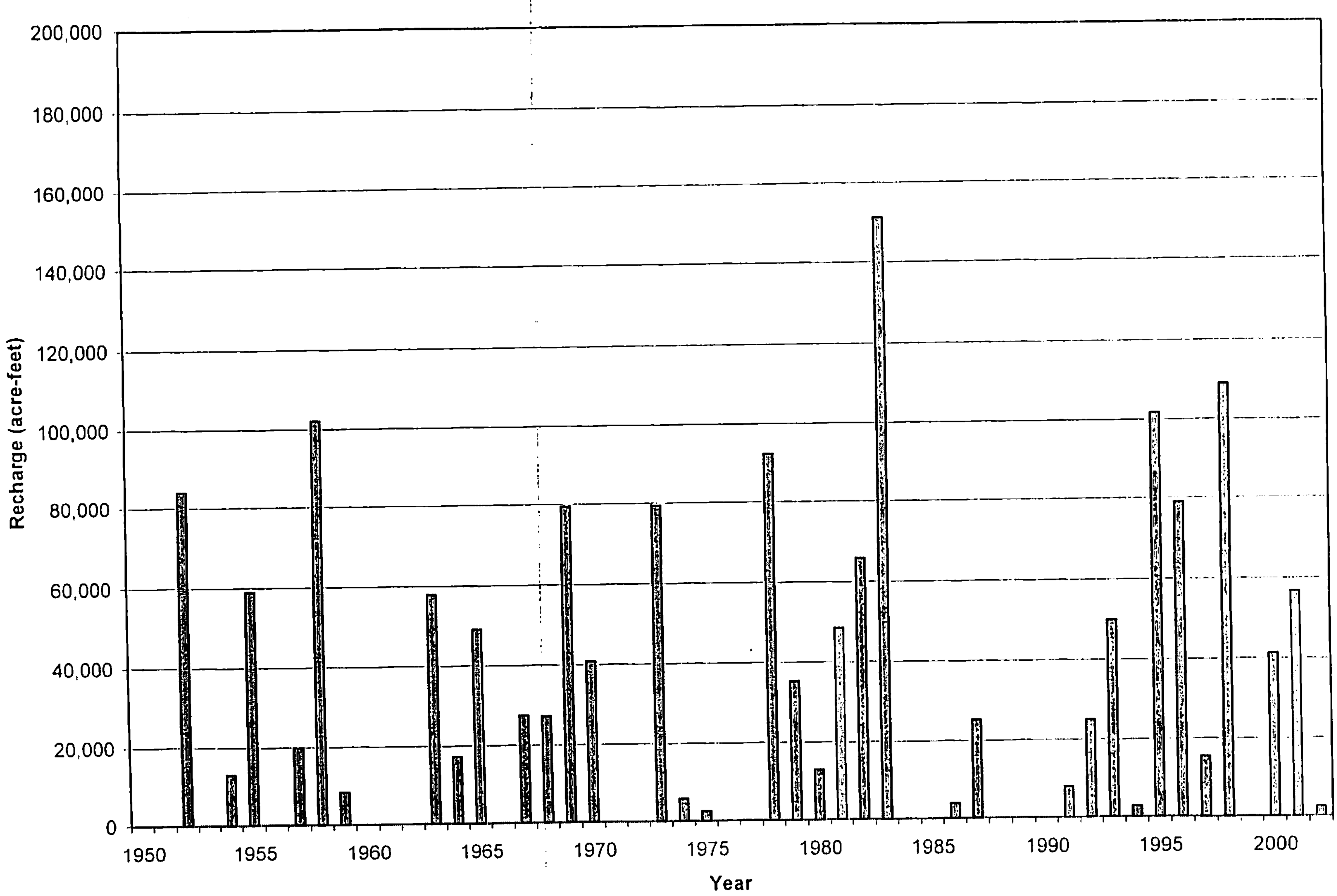

Figure 4.9 Annual Recharge from Non-Irrigated Areas, 1952-2002

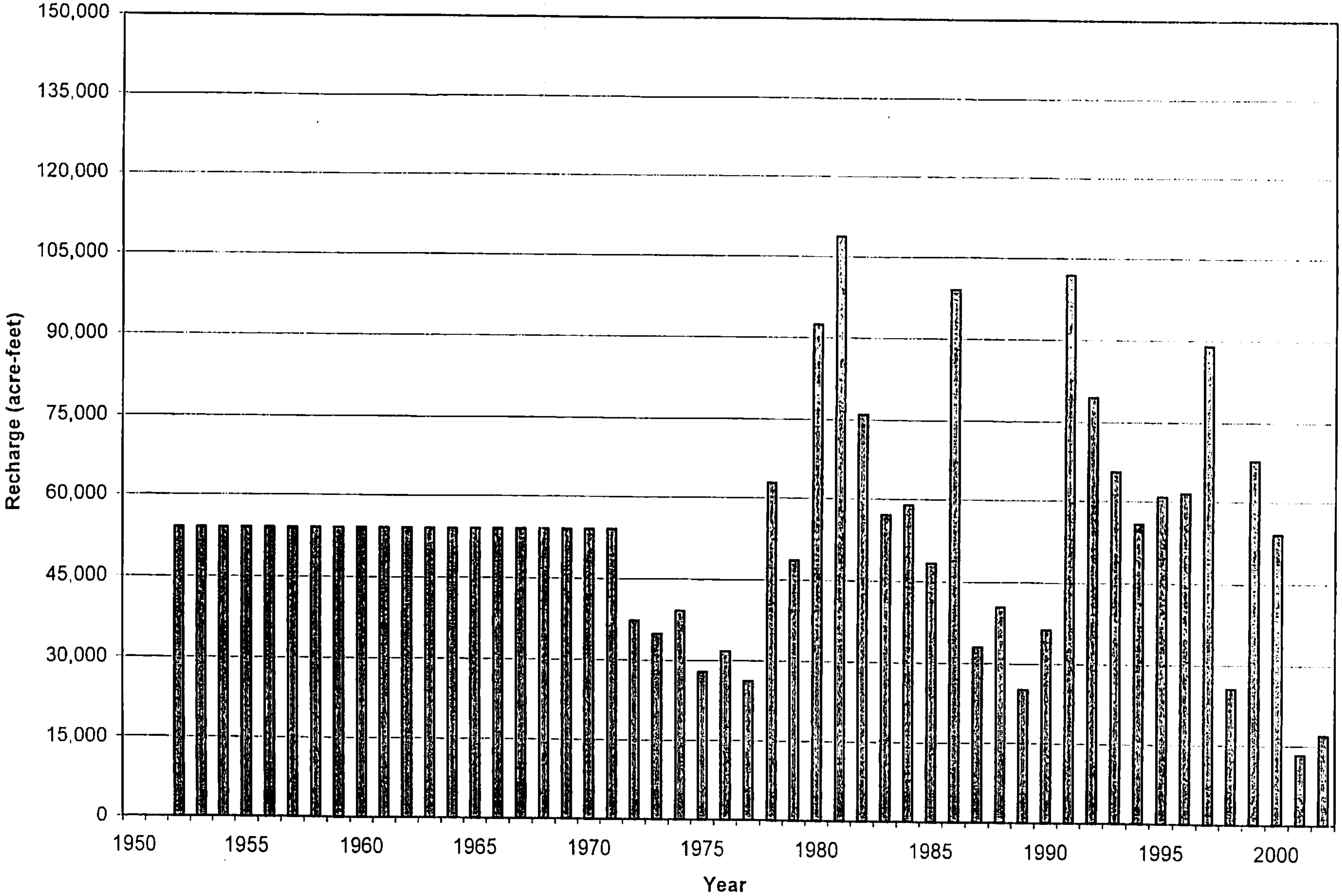

Figure 4.10 Annual Recharge from Turlock Lake, 1952-2002

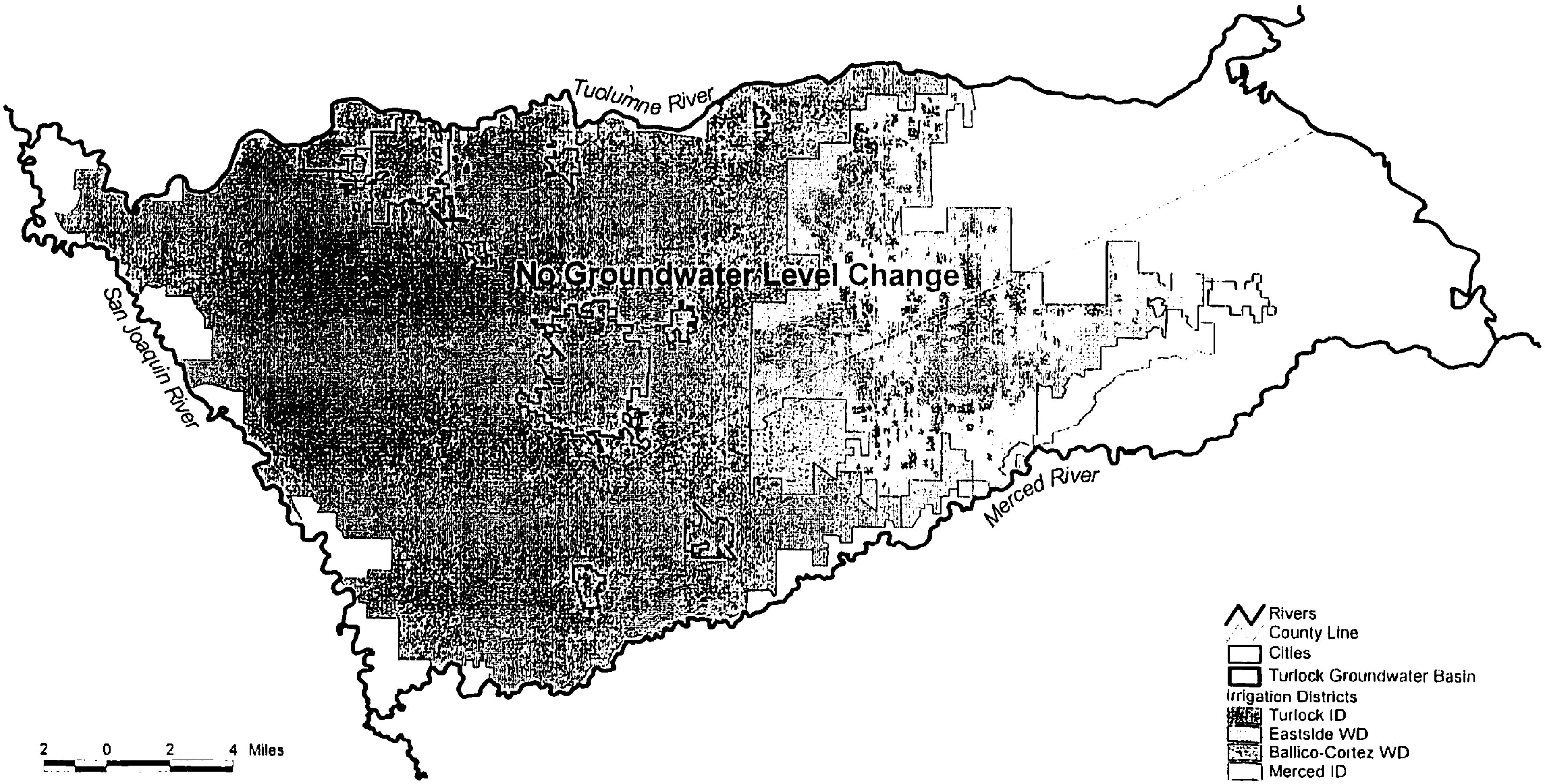

Figure 5.1a Annual Groundwater Level Changes within Turlock Groundwater Basin, 1953-1957

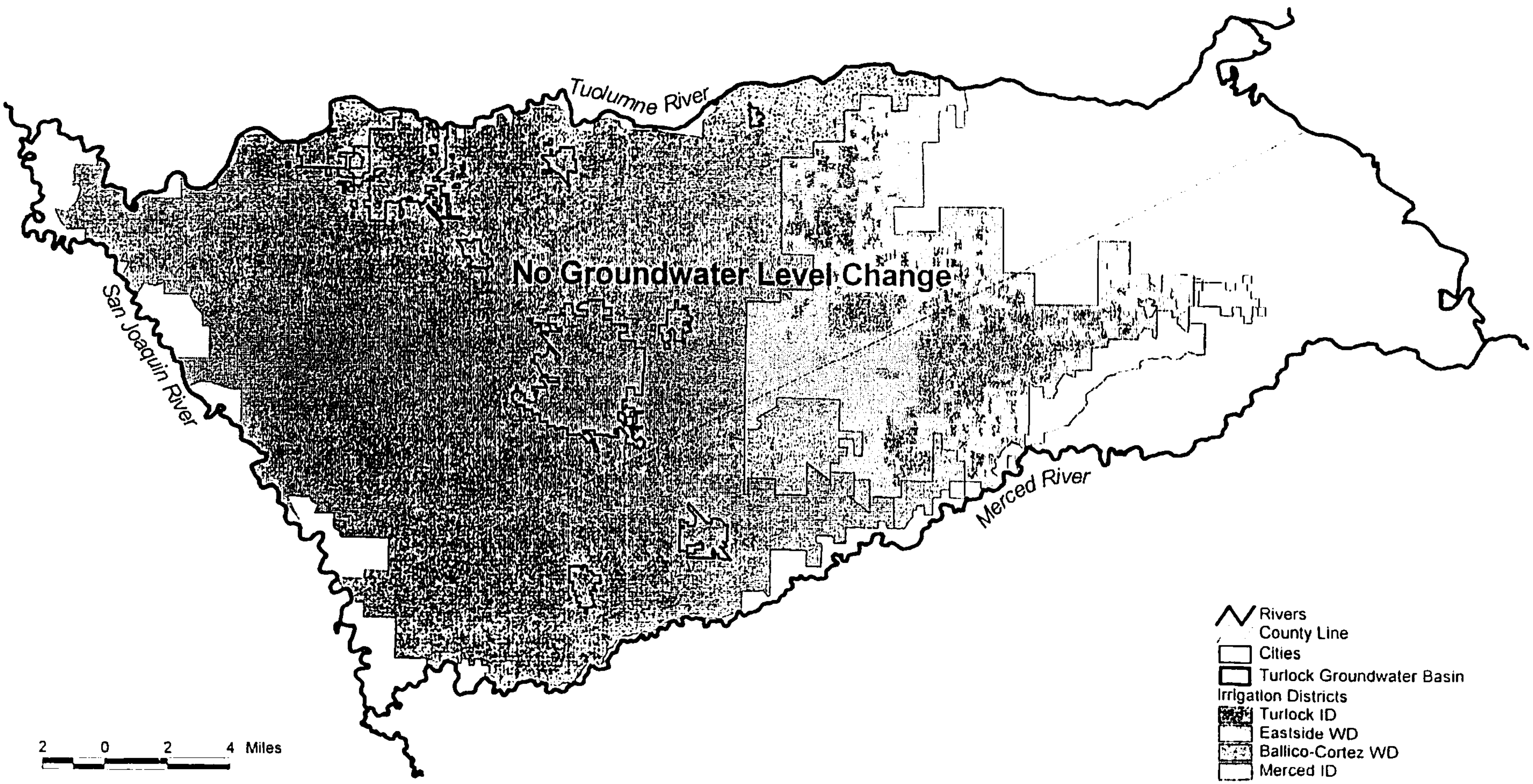

Figure 5.1b Annual Groundwater Level Changes within Turlock Groundwater Basin, 1958-1962

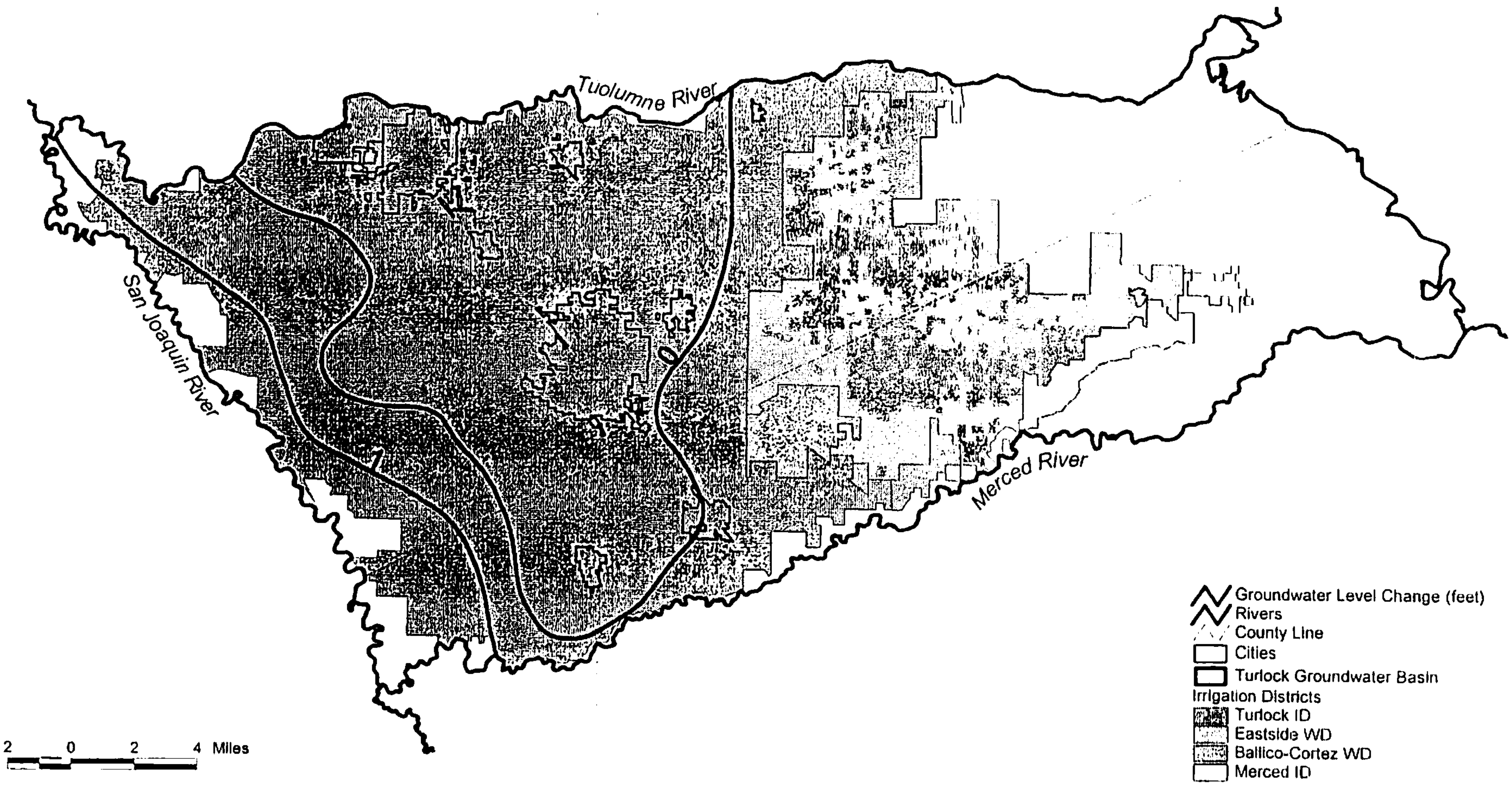

Figure 5.1c Annual Groundwater Level Changes within Turlock Groundwater Basin, 1963-1967

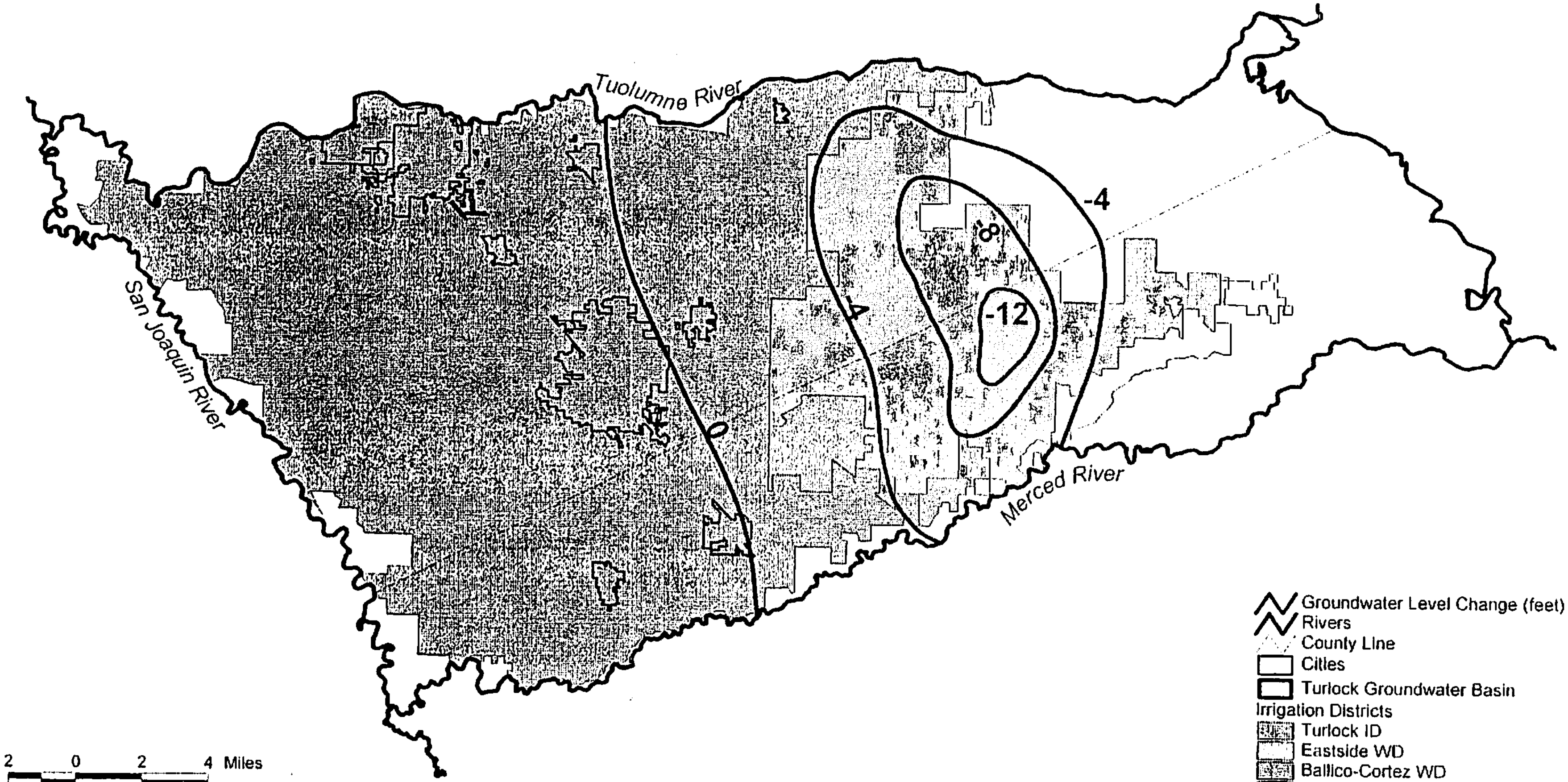

Figure 5.1d Annual Groundwater Level Changes within Turlock Groundwater Basin, 1968-1972

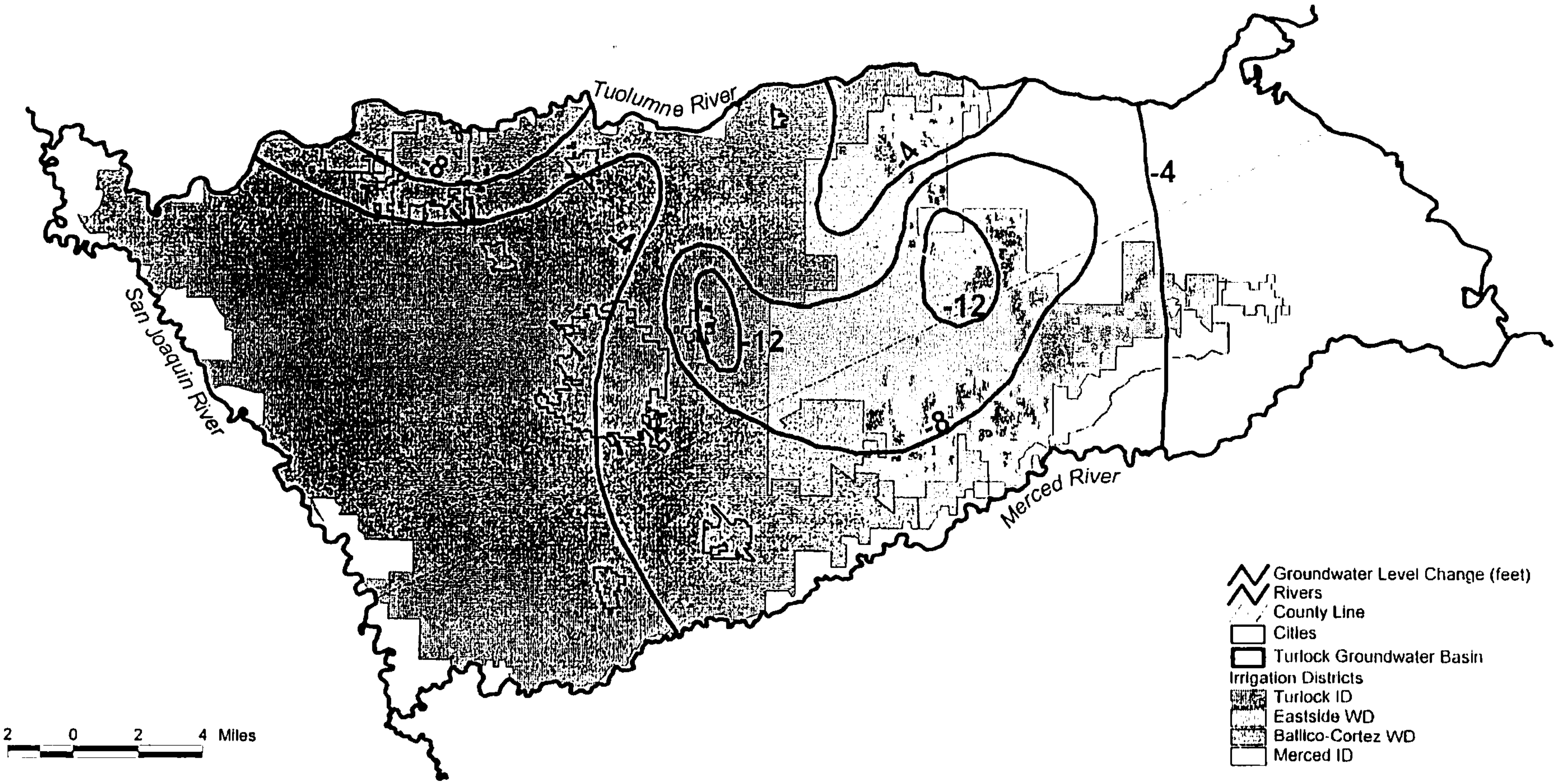

Figure 5.1e Annual Groundwater Level Changes within Turlock Groundwater Basin, 1973-1977

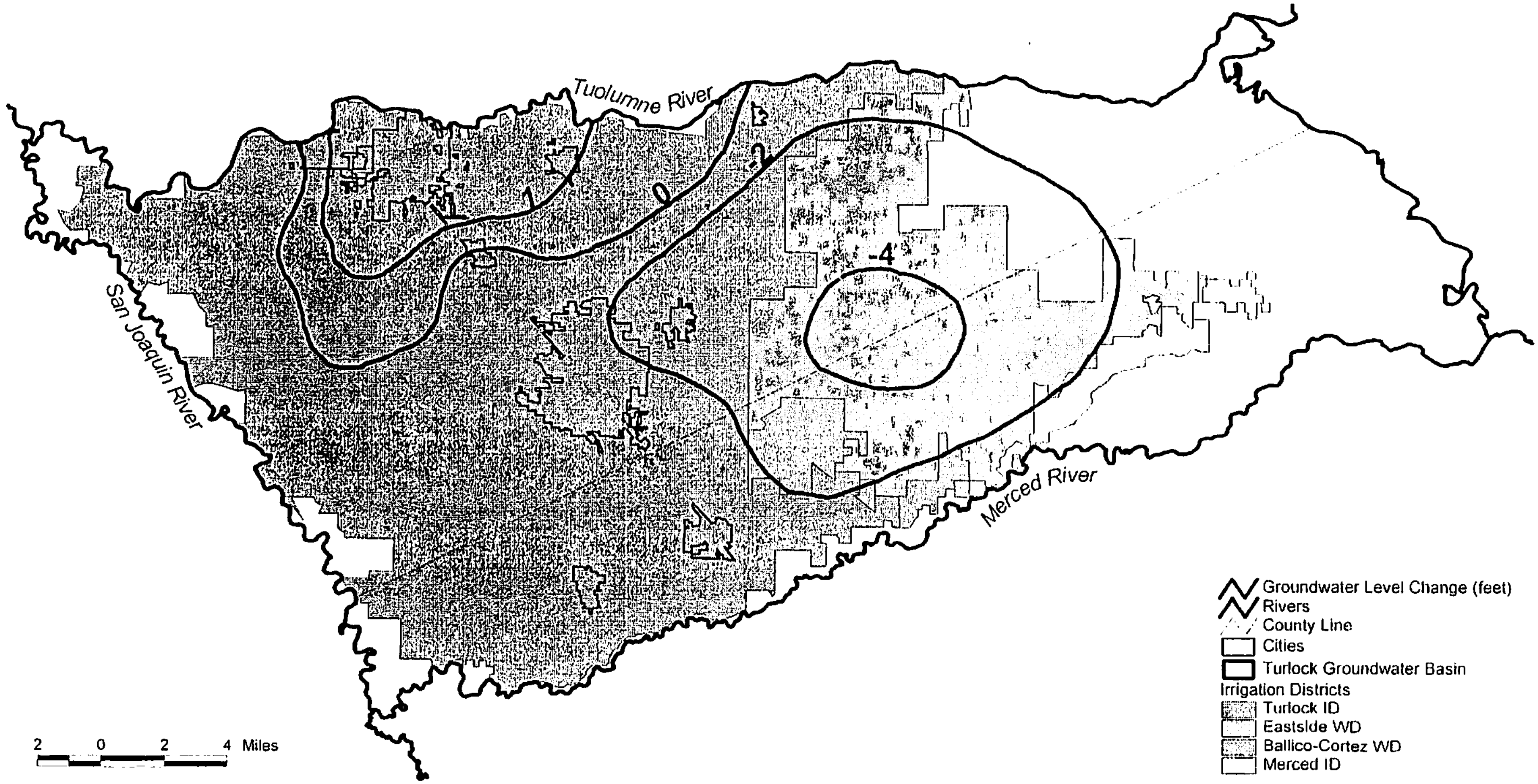

Figure 5.1f Annual Groundwater Level Changes within Turlock Groundwater Basin, 1978-1982

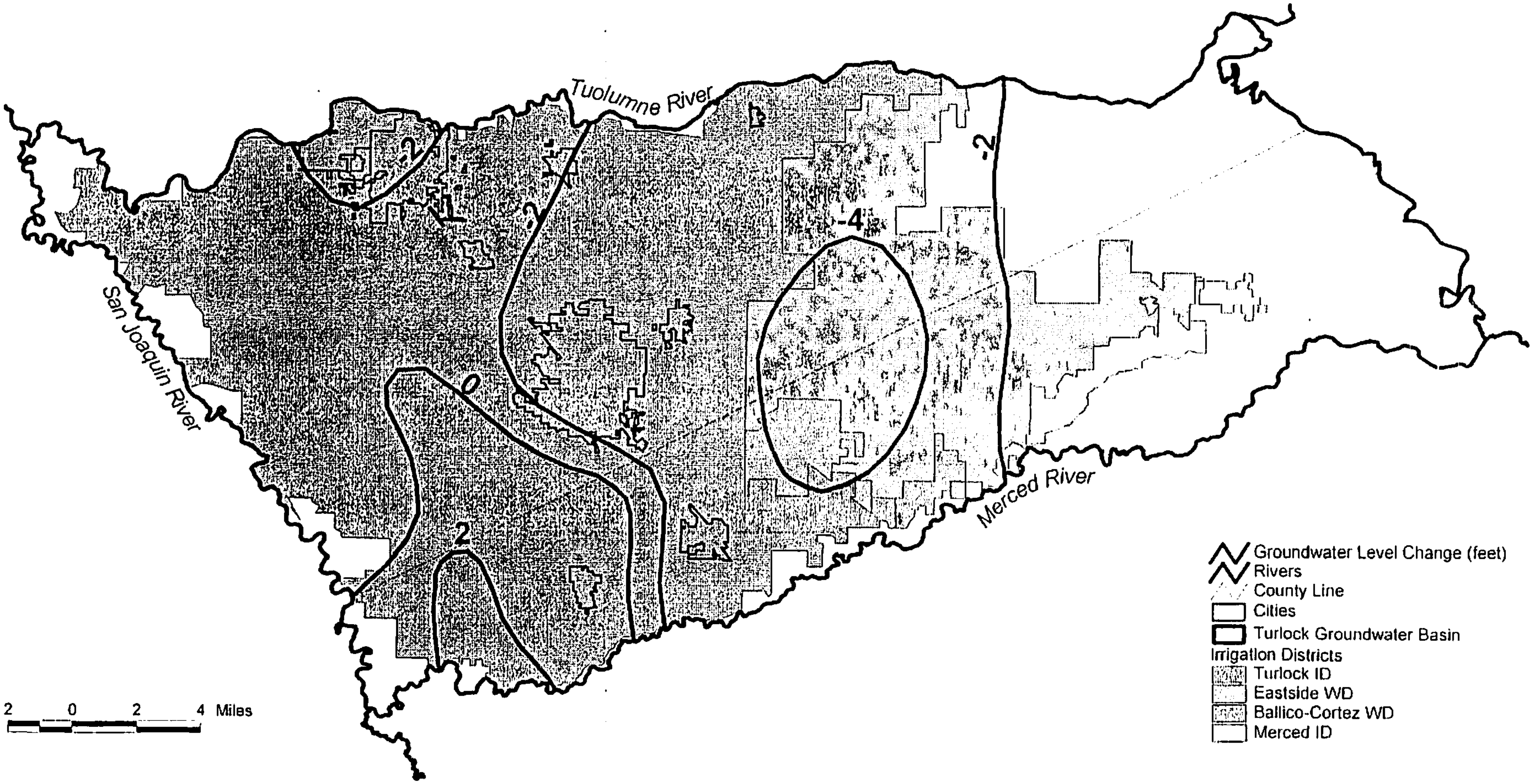

Figure 5.1g Annual Groundwater Level Changes within Turlock Groundwater Basin, 1983-1987

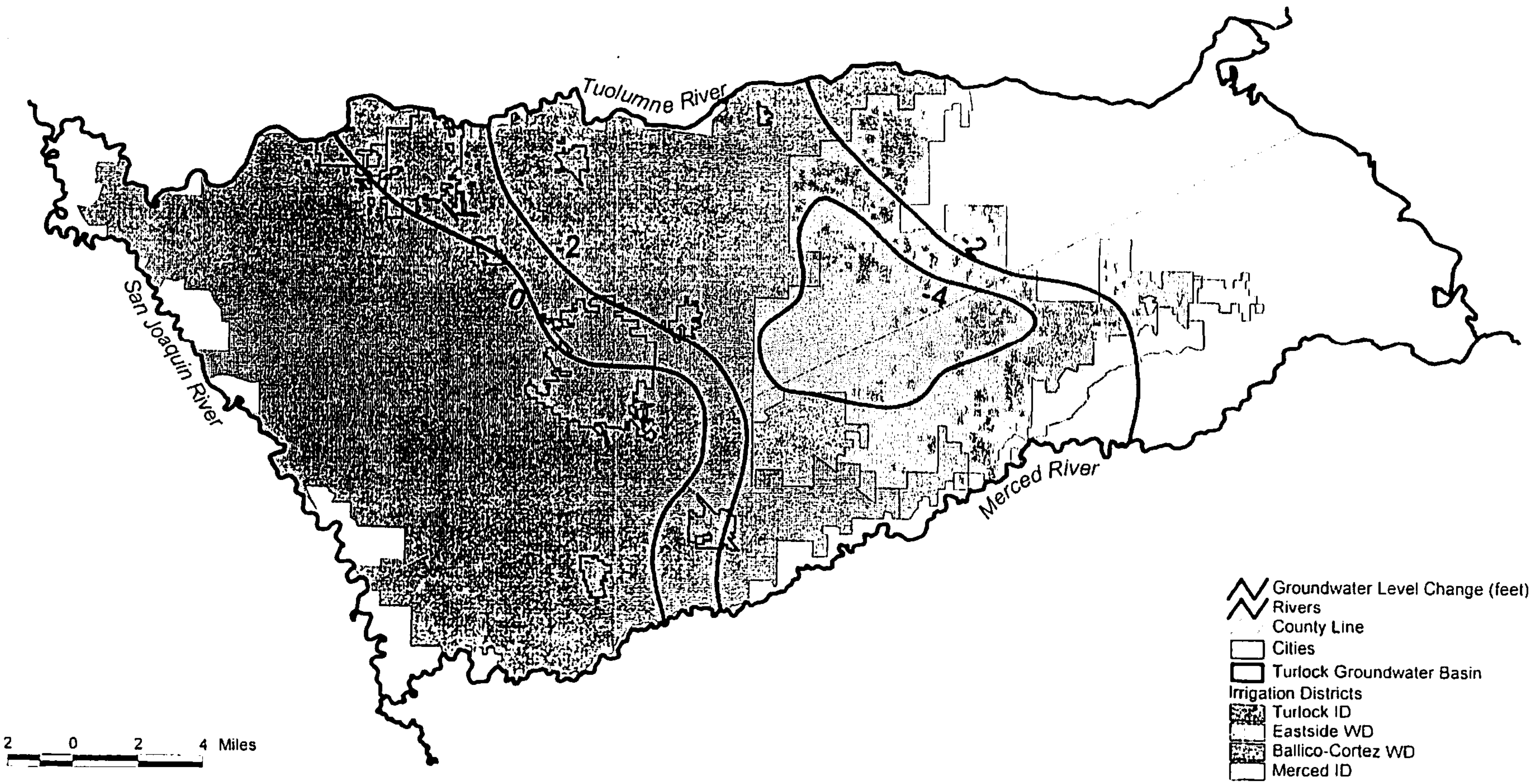

Figure 5.1h Annual Groundwater Level Changes within Turlock Groundwater Basin, 1988-1992

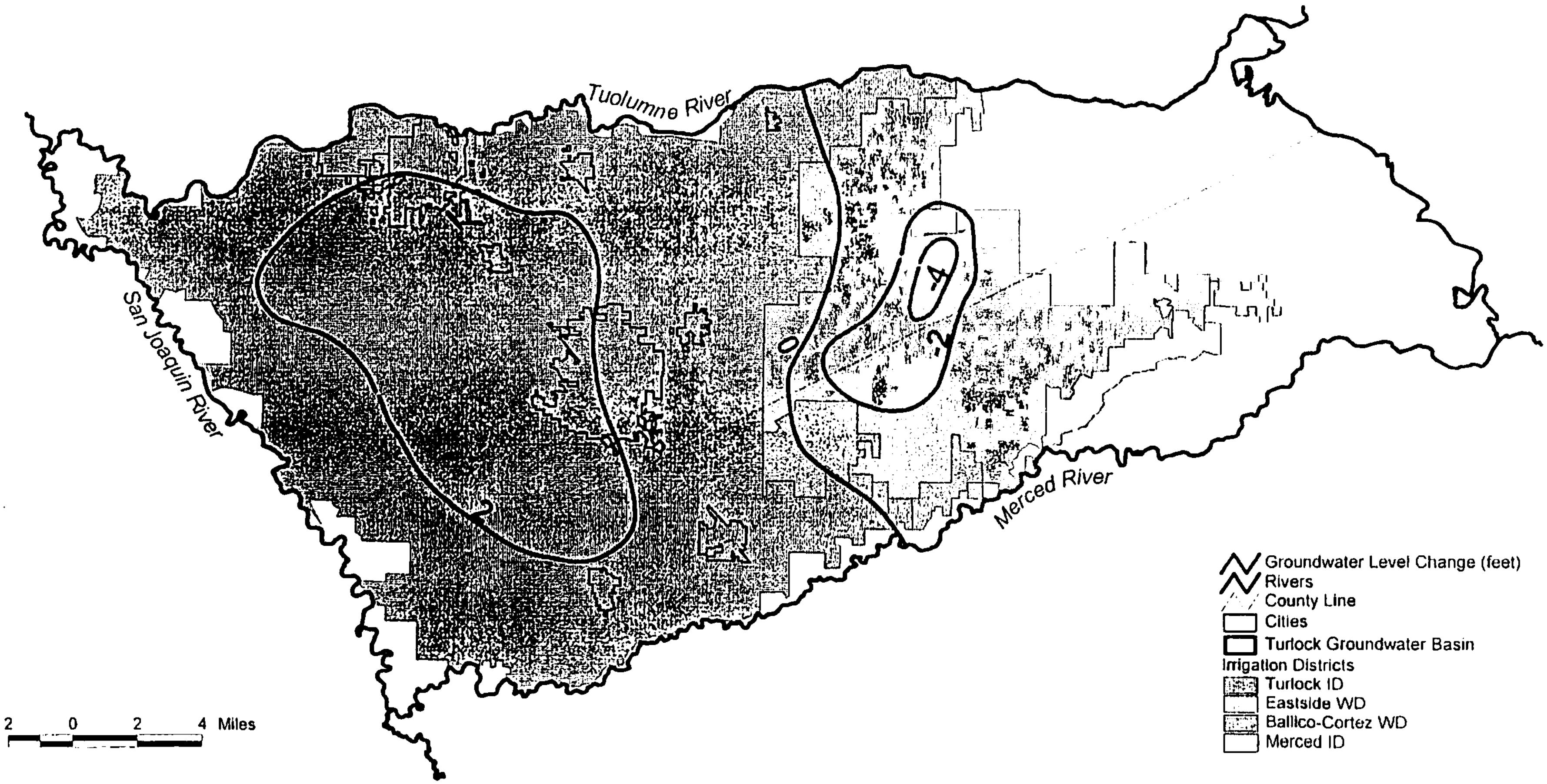

Figure 5.1i Annual Groundwater Level Changes within Turlock Groundwater Basin, 1993-1997

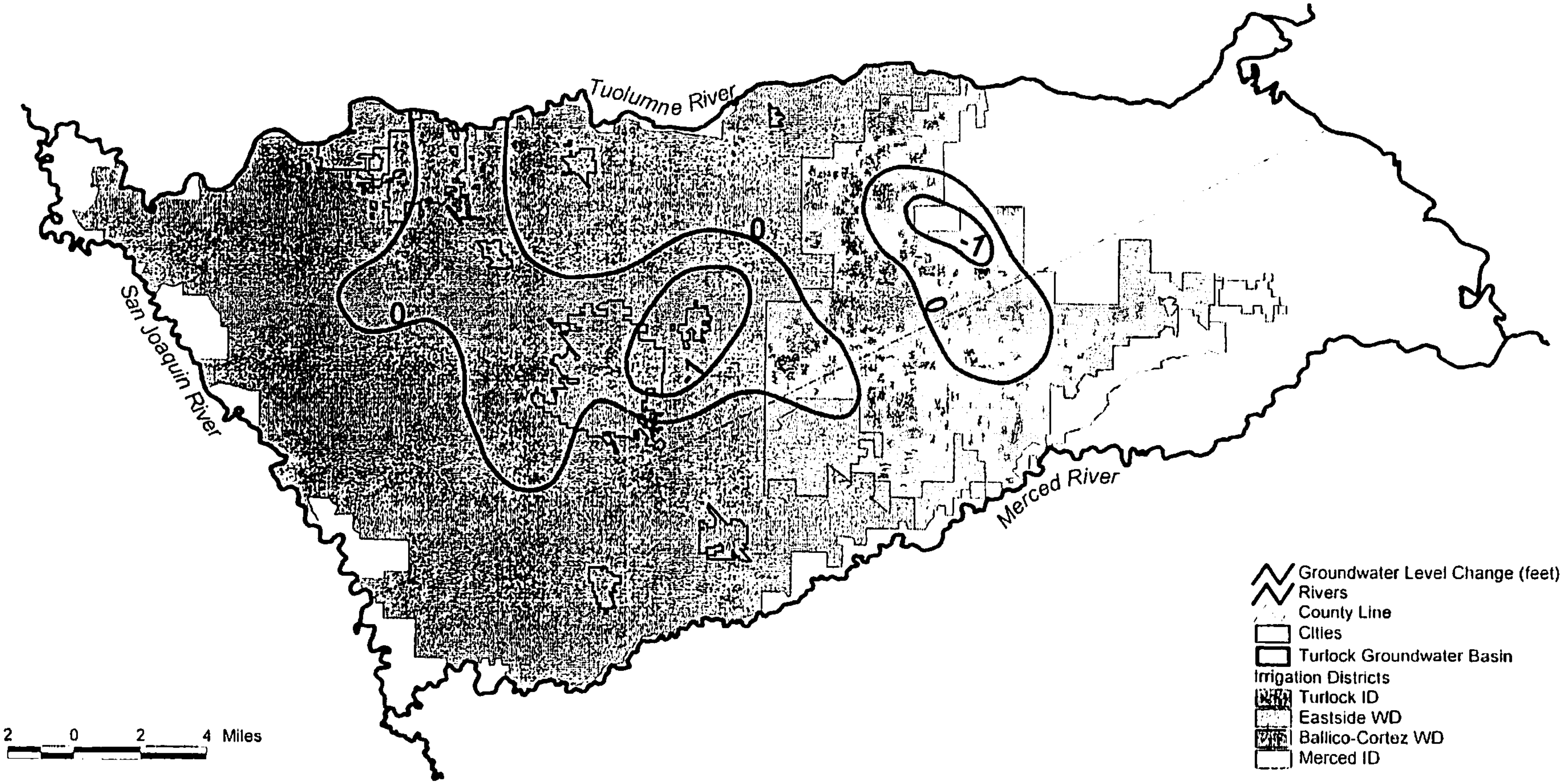

Figure 5.1j Annual Groundwater Level Changes within Turlock Groundwater Basin, 1998-2002

Table 5.1 Change in Groundwater Levels and Storage for Turlock Groundwater Basin, 1953-2002

Period	Average Annual Groundwater-Level Change (Feet/Year)	Average Groundwater-Storage Change (Acre-Feet/Year)
1953-1957	0.00	0
1958-1962	0.00	0
1963-1967	0.37	12,950
1968-1972	-1.98	-69,300
1973-1977	-4.67	-163,450
1978-1982	-0.99	-34,650
1983-1987	-0.59	-20,650
1988-1992	-1.19	-41,650
1993-1997	0.37	12,950
1998-2002	0.05	1,820

Table 6.1a Water Budget for Turlock Groundwater Basin 1953-1977
(Acre-Feet per year)

Water-Budget Component	Period				
	1953-1957	1958-1962	1963-1967	1968-1972	1973-1977
Groundwater Discharge					
Groundwater Pumping					
Turlock irrigation District Drainage Wells	162,735	146,095	143,830	148,366	129,786
Turlock Irrigation District Rented Wells	0	0	0	0	35,547
Turlock Irrigation District Supplemental Wells	32,650	30,900	30,708	28,594	34,169
Turlock Irrigation District Primary-Source Wells	0	0	0	0	0
Eastside Water District	13,859	50,116	79,272	115,486	138,331
Ballico-Cortez Water District	20,913	23,729	22,085	22,939	22,143
Merced Irrigation District	186	176	175	163	195
Non-District Areas	36,258	52,745	61,035	75,060	81,961
Ceres	1,588	2,022	2,509	3,187	4,428
Delhi	277	330	416	519	671
Denair	236	291	358	471	718
Hickman	50	61	75	93	124
Hilmar	167	206	261	344	510
Hughson	374	446	523	603	690
Keyes	254	325	473	635	828
South Modesto	461	586	728	924	1,285
Turlock	3,980	4,944	6,219	7,940	10,946
Rural Residences	3,476	3,876	3,698	3,910	3,910
Groundwater Net Discharge to Rivers	84,501	89,641	68,971	122,918	96,313
Groundwater Discharge from Subsurface Drains	0	0	0	0	243
Groundwater Consumption by Phreatophytes	41,971	46,555	43,152	43,882	42,591
TOTAL	403,939	453,043	464,487	576,034	605,388
Groundwater Recharge					
Groundwater Recharge from Irrigated Areas					
Turlock Irrigation District Canal-Delivery Lands	283,210	296,915	297,483	305,486	268,774
Turlock Irrigation District Groundwater-Only Lands	0	0	0	0	0
Eastside Water District	6,365	25,492	39,863	59,684	62,497
Ballico-Cortez Water District	8,622	11,833	10,668	11,480	9,561
Merced Irrigation District	12,637	11,024	10,283	12,770	10,670
Non-District Areas	14,993	25,650	28,522	35,963	34,027
Ceres	123	156	194	246	342
Delhi	21	26	32	40	52
Denair	22	27	33	43	65
Hickman	5	6	7	9	12
Hilmar	12	15	19	25	37
Hughson	24	29	34	39	45
Keyes	20	25	37	49	64
South Modesto	42	54	67	85	118
Turlock	282	350	440	562	774
Rural Residences	2,035	2,210	2,153	2,253	2,269
Groundwater Recharge from Non-Irrigated Areas	18,400	22,107	30,477	29,635	17,621
Groundwater Recharge from Turlock Lake	54,126	54,126	54,126	50,764	32,010
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	403,939	453,043	477,437	512,134	441,938
Change in Groundwater Storage	0	0	12,950	-63,900	-163,450

Table 6.1b 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	5,829	7,489	8,598	9,640	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	162,348	70,302	-121,310	59,095	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