HISTORICAL AND CURRENT WATER USE IN THE MIDDLE RIO GRANDE REGION

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HISTORICAL AND CURRENT WATER USE
IN THE MIDDLE RIO GRANDE REGION

EXECUTIVE SUMMARY

The Historical and Current Water Use in the Middle Rio Grande Region project was carried out under a Professional Services Agreement between John Shomaker & Associates, Inc. (JSAI) and the Middle Rio Grande Council of Governments (MRGCOG), working in cooperation with the Middle Rio Grande Water Assembly. This project is part of the Middle Rio Grande regional water planning process and is supported by funding from the Interstate Stream Commission (ISC). The project follows the ISC's Regional Water Planning Handbook (1994) and requirements of MRGCOG and the Middle Rio Grande Water Assembly Water Demand Working Group.

The Middle Rio Grande Region, as the term is used herein, encompasses the portion of the Rio Grande valley from Cochiti Dam south to the southern boundary of Valencia County. Almost all of three counties, Sandoval County, Bernalillo County, and Valencia County, as well as a small portion of Torrance County, are located within the region. Eleven tribal jurisdictions and twelve municipalities (including Albuquerque, the largest city in New Mexico) are located within the region. The Middle Rio Grande Region is subdivided into three subregions according to major watershed boundaries: the Rio Puerco, Rio Jemez, and Middle Rio Grande Valley (MRGV) (Fig. 1A in report).

The study includes a compilation of water-use data from many sources. These sources include publications and publicly-available data from the New Mexico Office of the State Engineer (NMOSE), the U. S. Bureau of Reclamation, the Middle Rio Grande Conservancy District (MRGCD), as well as publicly-available data from the U.S. Geological Survey, the City of Albuquerque, and numerous other public water suppliers. The historic and current water-use data found in these sources were divided into specific water-use categories, as defined by the NMOSE and the Interstate Stream Commission (ISC).

Water-use data are presented in the form of *withdrawal*, water pumped from ground water or diverted from surface water, and *consumption*, *consumptive use*, or *depletion*, which is water that is removed from the surface- and ground-water systems via evaporation, transpiration, or other processes. All water quantities are expressed in acre-feet, the volume of water necessary to cover an acre to the depth of one foot. There are 325,851 gallons in an acre-foot of water.

In 1995, within the study area, riparian vegetation accounted for 29 percent of consumptive use; irrigated agriculture, 28 percent; public water supply, 25 percent; open-water evaporation, 16 percent; and all other consumption categories fill out the remaining 2 percent of water consumption (Fig. A). Total consumption in 1995 was about 340,000 acre-feet.

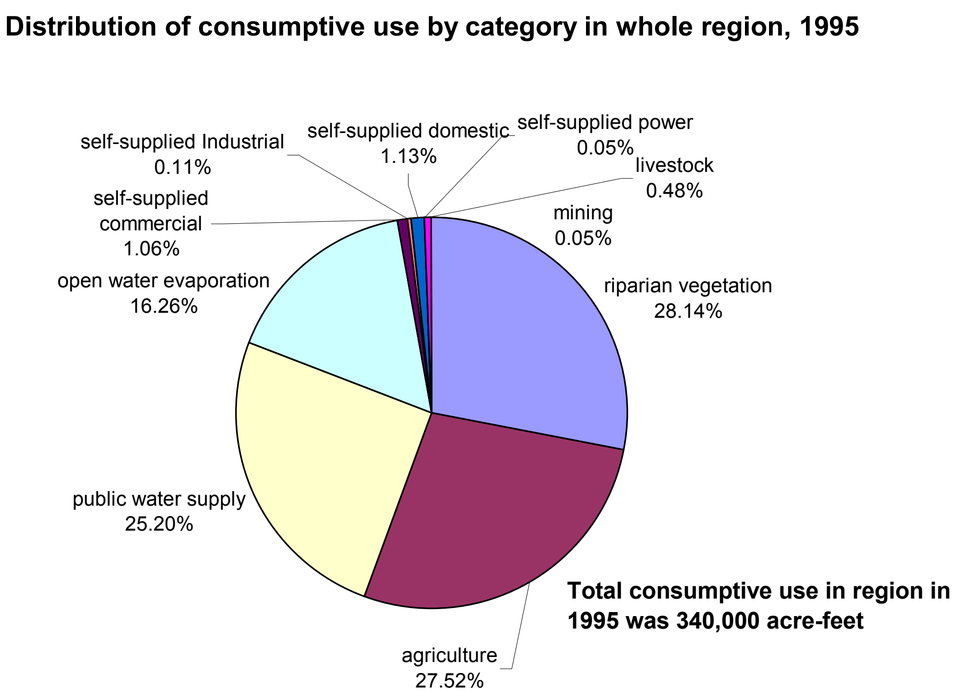
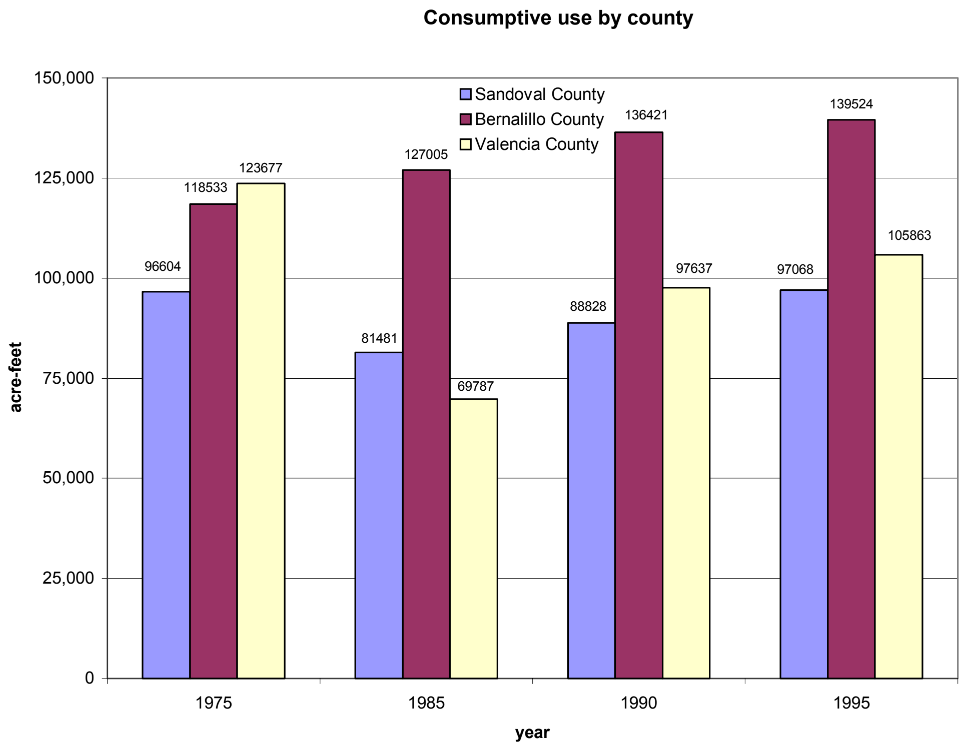


Figure A. (Fig. 52 in the text) Percentages of consumptive use by category in study region.

The amount of water withdrawn each year in Sandoval, Bernalillo, and Valencia counties combined is about 600,000 acre-feet. Roughly half of those withdrawals are for irrigated agriculture, and one quarter is withdrawn for public water-supply systems in the region. Sixteen percent of withdrawals are by riparian vegetation, and 9 percent represent open-water evaporation.

Water is supplied to the different categories from either ground- or surface-water sources. Irrigated agriculture derives its water mostly from the Rio Grande. Water diverted to, but not consumed by, irrigated agriculture either returns directly to the surface-water system or seeps into the shallow ground-water system. Open-water evaporation is obviously withdrawn and consumed from surface-water sources. All public water-supply and self-supplied commercial, industrial, domestic, mining, and power categories derive their water primarily from ground-water sources, except for a very small amount of surface water used for commercial fish hatcheries and public water supply. In general, return flow from self-supplied and municipal systems processed by municipal wastewater treatment facilities is returned to the Rio Grande. Some water evaporates and is lost during the treatment process, and some is reused for landscaping and crop irrigation. Some water is sent to septic systems and returns to the ground-water system. Finally, riparian vegetation (which includes indigenous vegetation like cottonwoods and exotic species such as salt cedar) extracts its water from both surface- and shallow ground-water sources. Overall, roughly equal amounts of water are consumed or depleted from surface- and ground-water sources.

Valencia County leads the Middle Rio Grande region with consumptive use of water, a result of its extensive agricultural development (Fig. B). Bernalillo County is second, with consumption driven by water demand for the City of Albuquerque, New Mexico's largest metropolitan area. Though Sandoval County water use today is less than in either of the other counties, significant population and industrial growth is occurring.



Sources: 1975--no data for self-supplied commercial, self-supplied domestic, and mining
1985--open water evaporation 1975 data; no data for self-supplied domestic
1990--open water evaporation 1993 data
1995--open water evaporation 1993 data; riparian consumptive 1994 data

Figure B. Consumptive use of water by county.

JSAI intends this work to form a basis for projecting water demand in the future, and to highlight the current status of water-demand data availability and quality. Many sources provide very good water-use data, and data collection and processing methods have improved over time. There is still room for improvement, however, and an increase in the quality of water-demand data and the development of a centralized data repository would greatly assist the water planning process in the Middle Rio Grande region. During the process of this project the study team did find inconsistencies in data, but the team would be surprised if improved data quality were to significantly change the currently reported amounts.

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ABBREVIATIONS

ac-ft	acre-feet
ac-ft/ac	acre-feet per acre
AFB	Air Force Base
avg.	average
BIA	Bureau of Indian Affairs
BOR	Bureau of Reclamation
Co.	company
COA	City of Albuquerque
COE	Corps of Engineers
EPA	Environmental Protection Agency
ET	evapotranspiration
Fig.	Figure
ft	feet
GIS	Geographic Information System
gpcd	gallons per capita per day
ISC	Interstate Stream Commission
JSAI	John Shomaker & Associates, Inc.
MDWCA	mutual domestic water consumers' association
MHC	mobile home community
MRG	Middle Rio Grande
MRGCD	Middle Rio Grande Conservancy District
MRGCOG	Middle Rio Grande Council of Governments
MRGV	Middle Rio Grande Valley
MRGWA	Middle Rio Grande Water Assessment
NA	not applicable
ND	no data, missing data
NMOSE	New Mexico Office of the State Engineer
NMSA	New Mexico Statutes Annotated
NMSAS	New Mexico State Agricultural Statistics
NRCS	Natural Resources Conservation Service
pop.	population
PNM	Public Service Company of New Mexico
SCS	Soil Conservation Service
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WATERS	Water Administration Technical Engineering Resource System
WTP	wastewater treatment plant

HISTORICAL AND CURRENT WATER USE
IN THE MIDDLE RIO GRANDE REGION

1. INTRODUCTION

The Middle Rio Grande Region, located in central New Mexico, is perhaps the most complex of the state's water planning regions. Under the Rio Grande Compact, the term *Middle Rio Grande* refers to the reach from Otowi gage to Elephant Butte Dam. However, the regional planning area for which this study was completed consists of the river reach from Cochiti to the Valencia-Socorro county line. The Interstate Stream Commission (ISC) has defined the Middle Rio Grande Region (also referred to as the *study area* or *planning region*) to include three subregions: the Rio Puerco, the Rio Jemez, and the Middle Rio Grande Valley. The boundaries follow a combination of county lines and watershed units (Fig. 1A). Other agencies have studied water use in the Middle Rio Grande area, including the United States Bureau of Reclamation (BOR) (Fig. 1B) and the Middle Rio Grande Conservancy District (MRGCD) (Fig. 1C).

The region includes two declared administrative ground-water basins (the Middle Rio Grande area of the Rio Grande Basin and the Sandia Basin), three principal rivers (the Rio Grande, Rio Puerco, and Rio Jemez), almost all of three counties (Sandoval, Bernalillo, and Valencia) and a small part of a fourth (Torrance), all or portions of eleven tribal jurisdictions (Jicarilla Apache, Jemez, Zia, Santo Domingo, Cochiti, San Felipe, Santa Ana, Sandia, Isleta, Canoncito Band of Navajos (To'Hajiileehee), and Laguna), twelve municipalities including New Mexico's largest metropolis (Cuba, Jemez Springs, San Ysidro, Bernalillo, Rio Rancho, Corrales, Tijeras, Belen, Los Lunas, Bosque Farms, Los Ranchos de Albuquerque, and Albuquerque), and several unincorporated communities. Superimposed on this patchwork of local jurisdictions are the areas of authority of local, state, and federal agencies with distinct and separate missions relating to water. Finally, there are interstate and international allocations of the river, which by law take precedence over the needs of many other stakeholders.

Figure 1A. Middle Rio Grande regional water planning area and subregions.

Figure 1B Bureau of Reclamation study area, including subregion.

Figure 1C Middle Rio Grande Conservancy District boundaries.

The Historical and Current Water Use in the Middle Rio Grande Region regional water planning project was carried out under a Professional Services Agreement between John Shomaker & Associates, Inc. (JSAI) and the Middle Rio Grande Council of Governments (MRGCOG), working in cooperation with the Middle Rio Grande Water Assembly. This regional water-planning project in the Middle Rio Grande is being supported by an award of funds from the Interstate Stream Commission (ISC). The project follows the ISC's Regional Water Planning Handbook (1994) and requirements of MRGCOG and the Middle Rio Grande Water Assembly Water Demand Working Group. Compilation of the portions of this report, including the **Brief History of the Middle Rio Grande Region** and **Looking to the Future** sections, and extensive data collection including developing a water-use survey and interviewing water users, were performed by Susan Gorman of PioneerWest. Data collection, database compilation, analysis, and preparation of the report were performed by JSAI.

The purpose of the historical and current water use study for the Middle Rio Grande Region is to furnish a definitive accounting of historical and current water use by all major water use categories within the study area. The results of the study are intended to illuminate trends in water demand through time, and to provide a basis for forecasts into the future. Data for this accounting are drawn from existing studies, reports, and records from various sources.

Missing data and data inconsistencies are identified in the text and in Appendix 1. The historic and current water-use data found in these sources are divided into specific water use categories, as defined by the New Mexico Office of the State Engineer (NMOSE) and the Interstate Stream Commission (ISC). The data have been disaggregated by county (Sandoval, Bernalillo, and Valencia) and by subregion (the Rio Puerco, the Rio Jemez, and Middle Rio Grande Valley) as defined by the MRGCOG.

2. CONSUMPTION AND WITHDRAWAL

Because of the abundance of oftentimes confusing terminology related to water, it is essential to differentiate among the terms that describe water use. C*onsumption, consumptive use,* and *depletion* refer to water that is lost to the region through evaporation and plant transpiration through use by people, animals, and commercial and industrial activities. Water that is consumed is no longer contained in the ground-water or surface-water supplies of the region, and leaves the region as vapor. Transpiration by riparian vegetation and evaporation from and open water are consumptive uses. One hundred percent of water that these categories "passively withdraw" is consumed. The NMOSE and the Interstate Stream Commission (ISC) consider the terms *consumptive use* and *depletion* to be synonyms, and this report uses these terms interchangeably. *Depletion* has an entirely different meaning as defined in the Middle Rio Grande Water Budget of the Action Committee of the Middle Rio Grande Water Assembly (Middle Rio Grande Water Assembly Action Committee, 1999), and it is important to note that it is not the intended meaning of depletion as used in the present report.

Diversion or *water withdrawal* is a movement from the source, of either ground water or surface water, to the location of use. Some of this water may not be consumed, and returns to the system. This water is called *return flow*. This study provides both withdrawal and consumptive use data when available.

Acre-feet are the quantitative units used to describe amounts of water diverted and consumed. An acre-foot is the quantity of water required to cover one acre (43,560 square feet) of land with one foot of water. There are 325,851 gallons in an acre-foot of water. A comprehensive list of technical terms used in this report can be found in section 9, **Glossary**.

3. BRIEF HISTORY OF WATER USE IN THE MIDDLE RIO GRANDE REGION

The first people settled in the Rio Grande region about 11,000 years ago (Southwest Exhibit, Maxwell Museum, University of New Mexico). Over the millennia, these people changed from hunters and gatherers to farmers, builders, and artists. By 1000 BC, the population had increased, and society had become organized. People learned to grow corn (maize), beans, squash, and cotton in the Rio Grande flood plain. Moisture conservation systems, such as contour terraces, rock grid gardens, check dams, and gravel mulch gardens were developed to overcome the deficiencies in water available in the semiarid environment. The people also used a variety of floodwater farming techniques, constructing dams of logs, brush, mud, and rock to divert and retain water (Anschuetz, 1998). But farming in a river valley can be a difficult endeavor. Floods were frequent and devastating; salinization of soils probably caused decreasing yields and new fields needed to be cleared of dense vegetation (Maxwell Museum, Anschuetz, 1998).

The arrival of Coronado in 1540 AD, and subsequently a European approach to agriculture and water use, caused a major shift in the existing pattern of water use. In the 1600s, Spanish settlers began to establish farms and ranches along the Rio Grande, Rio Puerco and Rio Jemez. Agriculture was converted from floodwater farming to field irrigation by artificial diversions of water through acequias, ditches designed to transport water from a river and distribute it to the farm fields. Native American methods of food production changed during this time, as hunting was replaced by livestock raising, and gathering declined as people began to spend more time tending irrigated fields (Clark, 1987; Horgan, 1954; Scurlock, 1998; Wozniak, 1998).

For 200 years, settlement in the Middle Rio Grande region proceeded through the land grant process to create a region of small, self-sufficient Puebloan and Spanish agricultural communities shaped by their irrigation systems. In 1600 AD there were about 22 acequias irrigating over 25,000 acres and by 1700 AD, there were 61 acequias irrigating 73,500 acres. The completion of the Atchison, Topeka, and Santa Fe Railroad brought an increase in population, and by 1880 there were 80 acequias irrigating over 123,000 acres (Scurlock, 1998). This level of river manipulation began to cause environmental problems such as sediment build-up, waterlogging due to a rising water table, and accumulation of salts in the Rio Grande Valley.

These conditions caused irrigated acreage to decrease steadily to only 40,000 acres by 1925 (Burkholder, 1928; Summers, 1997). During the last half of the 1920s, plans were made for construction of the Middle Rio Grande Conservancy District (MRGCD) works, including a storage reservoir, four diversion dams, canals, ditches, and drains. Work on these projects began in 1930 and was completed in 1935 (Summers, 1997).

The construction of the MRGCD works was followed by additional construction of the channel-shaping jetty jacks: the Jemez Canyon Dam (1953), Galisteo and Abiquiu Dams (1970), and Cochiti Dam (1975). These changes restored agricultural lands, facilitated the growth of the cottonwood and willow bosque, controlled flooding, and enabled urbanization that resulted in the pattern of water use for agriculture, riparian vegetation, residential, commercial, industrial, and recreational uses that are the main focus of this study.

In the years immediately following the construction of the MRGCD works, irrigated acreage increased. In 1941, the U. S. army created Albuquerque Army Air Field, a bomber base, which became Kirtland Air Force Base in 1942. That same year, the army purchased Oxnard Field and established Sandia Base. In 1946, J. Phillip Oppenheimer moved a group of scientists from Los Alamos National Laboratory to Sandia Base, and by 1970, Sandia National Laboratories was the largest employer in the region. At some point between 1954 and 1975, cultivation began to lose ground to urbanization as the population in the Middle Valley increased. By 1950, the City of Albuquerque (COA) had a population of 97,000 and a postwar boom was beginning. The City began to redesign its water and wastewater infrastructure and began drilling deep wells to supply water to residents. Since that time, other community water and wastewater systems have been established to serve the expanding urban population in the region. (Summers, 1997).

4. DATA COLLECTION METHODS

The database of water use was compiled from published and publicly available unpublished data. In an effort to ensure presentation of accurate data, many of the principal investigators of the studies used as sources were contacted by telephone or personal visits. Included in Appendix 1 is an evaluation of the data and data sources. This metadata discussion is simply data about the data. The format of Appendix 1 is an extended annotated bibliography, which discusses data sources, data quality, and other data issues.

A large portion of this database was gathered from NMOSE Technical Reports 41, 44, 46, 47, 49 and 50, which inventory water use in New Mexico by county and by river basin (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997; Wilson and Lucero, 1998). These inventories describe water withdrawals and consumptive uses by county for major categories. For the present study, the water-use categories and their descriptions are based on the NMOSE inventory, *Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 1995* (Wilson and Lucero, 1997). The categories include public water supply, self-supplied domestic, irrigated agriculture, self-supplied livestock, self-supplied commercial, self-supplied industrial, self-supplied mining, and self-supplied power. Open-water evaporation and riparian use are also discussed in the present report. Open-water evaporation includes reservoir and channel evaporation, and riparian use is the consumptive evapotranspiration by vegetation along rivers. It is important to note that the format of the NMOSE reports has evolved through time, methodologies have changed, and categories have been merged, eliminated, or added. The changes of categories and other specific data quality issues are discussed in Appendix 1.

The Bureau of Reclamation (BOR) has also published a significant amount of information on water use in the Middle Rio Grande region, specifically, the Middle Rio Grande Water Assessment (MRGWA) (Hansen and Gorbach, 1997). This is a multi-volume document including several supplements: a regional surface-water budget (Gould, 1995), estimates of riparian and agricultural consumptive use requirements (Kinkel, 1995a and 1995b), and estimates of open-water evaporation (Gould, 1995).

The study team supplemented water-use data from published reports, which individually provide water use information only for selected years, selected regions, or in a certain format, such as withdrawals or depletion, with unpublished but publicly available ground-water meter records from the NMOSE. The District I Office in Albuquerque provided meter files for 1993, 1994, 1996, 1997, and 1998. The meter file for 1999 is currently being updated. Meter records for years prior to 1993 either were not compiled by the NMOSE or were not available. Although the meter-record database is incomplete and may be inaccurate, it provides a significant amount of data for the years between the NMOSE Technical Reports. Further discussion regarding the NMOSE meter files is found in Appendix 1.

Another major source of information was the U.S. Geological Survey (USGS), which provided water-withdrawal data related to the Albuquerque Basin ground-water flow model (Kernodle et al., 1995). The USGS compiled pumping information from the NMOSE and other sources. The USGS was able to abstract the meter records of most of the major water users in the basin. Often the numbers from the USGS matched numbers found by our investigation of the meter files, and numbers reported in the NMOSE inventories.

The study team also obtained surface-water diversion data for irrigated agriculture served by the Middle Rio Grande Conservancy District (MRGCD), which encompasses the main Rio Grande corridor (Fig. 1C). These data are discussed in depth in Section 5.3, **Irrigated Agriculture**.

Current and historic water-use information was collected directly from municipalities and institutions within the MRG planning region that serve more than 1,000 people. These public water suppliers and institutions were surveyed for information about populations served, quantities of water delivered, percentages of water diverted from ground- and surface-water sources, etc. Sixteen responses were received, of the 29 systems surveyed. All public water suppliers were contacted directly and a contact database was formed. The 13 public water suppliers and institutions that did not provide data include smaller public water-supply systems, tribal jurisdictions, and a hospital. The survey, responses, and public water system contact database are included in Appendix 2.

The COA Public Works Department provided additional data regarding historic and present water use. COA provided ground-water production data for its municipal wells from the 1930s to present. COA also provided data on the quantities of water sold to various use categories based on billing records, quantities provided to certain large users such as golf courses and large institutions, and quantities returned through the wastewater treatment system.

This study is as comprehensive as possible. It was clear from the outset of the data-gathering process that data gaps and inconsistencies exist. Water withdrawals are not measured for all uses, and uses that are supposed to be measured often have not been. For example, irrigated agriculture withdrawals are generally not measured outside of the Middle Rio Grande Conservancy District, and water use by self-supplied domestic wells supplying single families is not measured. Furthermore, data from the 11 tribal jurisdictions within the planning area are generally not available. Water use for some of the tribes is included in the data for agriculture, use by riparian vegetation, and open-water evaporation. Water use for two golf courses owned by the Santa Ana and Isleta Pueblos was estimated from the water use of COA's 27-hole courses. Appendix 1 discusses in detail the data and the quality of the data.

5. WATER USE BY CATEGORY

In order to maintain consistency and comply with the requirements of the New Mexico Interstate Stream Commission (ISC), the accounting of water use by major category largely follows the category definitions currently used by the NMOSE. Some complications arise due to the periodic redefinition by the NMOSE of some of the major categories. For instance, in 1990 some specific use categories were changed or merged into different categories. When possible, categories in the earlier reports were modified to have the same constituents as the reports for 1990 and 1995. The changes in categories over time are discussed further in Appendix 1. Open-water evaporation includes river channel and canal evaporation data from the Bureau of Reclamation; it does not include reservoir evaporation data from the NMOSE except when noted. Estimates of riparian consumption were obtained from the Bureau of Reclamation. The NMOSE inventories do not provide estimates of riparian consumption.

For each category, brief definitions are quoted (sometimes with minor modifications) from Wilson and Lucero (1997) in italics, followed by some clarification of the category. For most categories, the **Methods** section describes the data-gathering process and some of the specific sources. Appendix 1 elaborates on the sources and the data quality. Next, selected results are presented in tabular and graphic formats in the **Results** section. Summary data sets for each category are in Appendix 3, and PC-formatted floppy disks containing raw data can be obtained from MRGCOG upon request. Where appropriate, a brief analysis follows the results. The **Public Water Supply** and **Irrigated Agriculture** categories contain additional in-depth discussion. Though we have summarized how the original data were collected, readers are referred to the original publications for detailed descriptions of the methods used to compile and calculate the original data.

5.1 Public Water Supply

Includes community water systems which rely upon surface and/or ground water diversions other than wells permitted by the NMOSE under Section 72-12-1 NMSA, 1978, and which consist of common collection, treatment, storage and distribution facilities operated for the delivery of water to multiple service connections.

Public water-supply providers consist of municipal supply systems, mutual domestic water associations, water cooperatives, mobile home parks, and community wells for subdivisions. The Federal Safe Drinking Water Act of 1986 states that public water-supply systems are those that "have at least 15 service connections or regularly serve an average of at least 25 individuals daily at least 60 days out of the year" (Wilson, 1992). Records from the Environmental Protection Agency (EPA) list approximately 122 public water systems serving populations ranging from 20 to 445,000 within the regional water planning area. Additionally, the EPA categorizes approximately 212 water systems as "non-transient" and "transient." Non-transient systems are those that serve the same people but not year-round, such as schools with their own water systems. Transient systems do not consistently serve the same people and include rest stops, campgrounds, gas stations, restaurants, and other commercial enterprises.

The NMOSE designation of public water suppliers excludes transient and non-transient systems that are of commercial or industrial nature, and instead focuses on systems that supply residents year-round. Water use by transient and non-transient systems are listed under separate categories such as commercial and industrial. Appendix 4 provides a listing of public water systems in the study region as defined by the EPA.

Wells permitted under Section 72-12-1 NMSA are those that supply one household or a small cluster of residences, or certain commercial users, and are limited to diversion of 3.0 acre-feet per year. Supplies from these wells are included in the discussion of **Self-Supplied Domestic** water use, Section 5.2.

5.1.1 Methods

Data regarding public water suppliers in this report are based on several sources. The initial source for data was the NMOSE water-use by category inventories for 1975, 1980, 1985, 1990, and 1995 (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997). Information in the NMOSE inventories is based on meter records, questionnaires, and other information provided to the NMOSE by the specific water user.

The designation of public water supply has differed over time. For example, rural, urban, and military were separate categories until 1990. In the 1990 inventory, these categories were replaced by public water-supply and self-supplied domestic categories. Military was included in public water supply; rural and urban public water suppliers were moved into the public water-supply category; and self-supplied urban and rural users were placed in the newly-created self-supplied domestic category. Further discussion of the evolution of the definitions of categories and the NMOSE process is in Appendix 1.

Another source of information for this study was an informal survey sent to public water suppliers and some institutional users within the regional water planning area. This survey requested data regarding historic and current water use, distribution of use, and information regarding wastewater treatment and water pricing. A copy of the survey form is in Appendix 2. A total of 29 survey forms were mailed, and 16 water-supply systems and two institutions responded. Data were requested of all non-responding systems by telephone and fax. Additional information was also collected from systems that responded via telephone and electronic mail correspondence, and interviews. Results from the surveys and contact information are in Appendix 2. Section 5.1.2.5, **Distribution of Public Water Supply**, and Section 5.1.2.7, **Public Water-supply Return Flow and Consumptive Use,** discuss more of the survey results.

The total number of public water suppliers within each county is not precisely known. The EPA lists 122 public water suppliers that are required to meet water-quality standards. The numbers of water suppliers specifically reported in the NMOSE inventories and listed in the NMOSE meter files for the study area are shown in Table 1. Public water suppliers that provided information for one NMOSE inventory sometimes did not provide information for subsequent inventories. It is likely that some public water providers combined, sold, closed down, or changed their names through time. No data were available for public water supply use by the 11 tribal jurisdictions in the Middle Rio Grande Region. Requests for data were made of the Bureau of Indian Affairs (BIA), and surveys were sent to Santo Domingo Pueblo, Jemez Pueblo, San Felipe Pueblo, and Isleta Pueblo. Although data were not provided, the BIA declared an interest in the regional water planning process. Furthermore, the BIA indicated that much of the information regarding water use by tribal jurisdictions, especially historical data, is very incomplete. However, extensive efforts to measure water use have recently been implemented and are currently being expanded in fulfillment of the tribes' own water planning initiatives.

Table 1. Summary of NMOSE data related to public water suppliers in the study area

NMOSE data source	number of public water suppliers by county			remarks
	Sandoval	Bernalillo	Valencia	
1975 Inventory (Sorensen, 1977)	NA	NA	NA	The 1975 inventory did not provide data regarding specific public water suppliers.
1980 Inventory (Sorensen, 1982)	13	18	3	These do not include institutions, which were listed in this category in 1980.
1985 Inventory (Wilson, 1986)	13	7	3	
1990 Inventory (Wilson, 1992)	11	16	6	
1995 Inventory (Wilson and Lucero, 1997)	19	28	10	
NMOSE District I Meter Files (1993-1998)	28	49	17	Many of these public water suppliers did not always have withdrawal quantities listed in the files.

NMOSE New Mexico Office of the State Engineer

Table 1 above shows the increase in the number of public water suppliers from 1975 to 1999. This trend reflects both the improvement in water-use inventories and the increase in population in the study area. However, even the meter files represent only 77 percent of the number of public water suppliers listed by the EPA. Although 94 public water suppliers are listed in the meter files, in no one year was data for all 94 provided. However, the available data presented in this report do represent the largest public water suppliers in each county and subregion. The NMOSE meter files are discussed below and in the metadata discussion included in Appendix 1.

Meter readings are required to be reported to the NMOSE for many water uses, including public water supply. Exceptions to this requirement are water suppliers whose water rights pre-date declaration of the Rio Grande Underground Water Basin in 1956 and Native American tribes. The District I Office of the State Engineer in Albuquerque provided meter files for 1993, 1994, 1996, 1997, and 1998. Although the meter files are incomplete, records for public water suppliers were generally satisfactory. The reason for this may be that public water suppliers are often actively involved in water rights issues, and it is in their interest to keep their files in good standing with the NMOSE.

The USGS assembled pumping records for use in their ground-water flow modeling (Kernodle et al., 1995). These records also provided extensive data regarding public water supply use in the regional water planning area. Other sources of data include published reports, conference proceedings, and articles. All sources are referenced and described in Appendix 1.

5.1.2 Results

The following graphs (Figs. 2 through 13) show annual water withdrawals by public water suppliers in acre-feet. Most of the water used by public water suppliers in the regional water planning area is pumped from ground water. According to the EPA, the only exceptions are Jemez Springs Mutual Domestic Water Consumers' Association (MDWCA) and Ponderosa MDWCA in the Rio Jemez subregion, and La Jara in the Rio Puerco subregion. La Jara is listed as using surface water, but no quantities of its surface water use were found. Jemez Springs MDWCA and Ponderosa MDWCA withdraw water from springs. The present report follows the convention of the NMOSE to consider spring flow as surface water, even though it is clear that the source of the springs is ground water. It is important to note that the COA and possibly other public water suppliers within the planning region intend to use surface water in the near future.

Public water-supply data are shown by county and by subregion where appropriate. Averages of annual withdrawals are used when multiple values within a similar range were available. The graphs are built from data tables included in Appendix 3. All sources for the data presented in the graphs are listed in Appendix 3 and described in Appendix 1.

The delivery of water to sub-categories by public water suppliers is discussed in Section 5.1.2.5, **Distribution of Public Water Supply by Sub-Category**. Return flows and consumptive use by public water suppliers are discussed in Section 5.1.2.7, **Public Water-supply Return Flow and Consumptive Use**.

5.1.2.1 Sandoval County

Although ground water is overwhelmingly the source of public water supply, a few public water suppliers in Sandoval County also use surface water. Table 2 shows surface-water withdrawals and consumption for Jemez Springs MDWCA and Ponderosa MDWCA, both of which withdraw water from springs. Consumption is calculated from a consumptive-use factor from the NMOSE Technical Reports (Wilson, 1992; Wilson and Lucero, 1997), such that consumption is equal to a percentage of withdrawal. Figure 2 shows surface-water withdrawals for Sandoval County. Figure 3 shows ground-water withdrawals by Bernalillo and Rio Rancho. Figure 4 shows total water withdrawals for Sandoval County, including surface- and ground-water. This total includes Bernalillo, Rio Rancho, and numerous smaller public water suppliers such as La Jara, Regina MDWCA, Cuba Water Systems, mobile home parks, and subdivisions.

The City of Rio Rancho provided production data from 1978 to present and distribution and wastewater data for 1999. Prior to October of 1998, the Rio Rancho water system was run by a private water company, Rio Rancho Utility. Water distribution and wastewater data prior to 1998 were from Rio Rancho Utility records provided by the City of Rio Rancho. The accuracy of the records from Rio Rancho Utility is unknown. Though Intel Corporation is not within the Rio Rancho town boundaries, it did purchase all of its water from Rio Rancho until 1995. The decline in water withdrawals after 1995 is because Intel Corporation partially switched from the Rio Rancho water system to its own wells (Fig. 3). Intel still purchases approximately 1,120 acre-feet per year from Rio Rancho, and discharges its wastewater through the Albuquerque wastewater system via New Mexico Utilities, Inc. Intel reuses a portion of its water for irrigation (City of Rio Rancho survey, 2000). Complete data tables including surface-water withdrawals and consumption for the NMOSE inventory years are in Appendix 3.

Table 2. Surface water use for public supply, Sandoval County

	withdrawal (acre-feet)			consumption (acre-feet)			consumptive use factor		
year	1985	1990	1995	1985	1990	1995	1985	1990	1995
Jemez Springs MDWCA	49	64	93	-	31	45	-	0.48	0.48
Ponderosa MDWCA	-	25	33	-	12	16	-	0.50	0.50
total	**49**	**89**	**126**	**-**	**43**	**61**			

Source: (Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997)

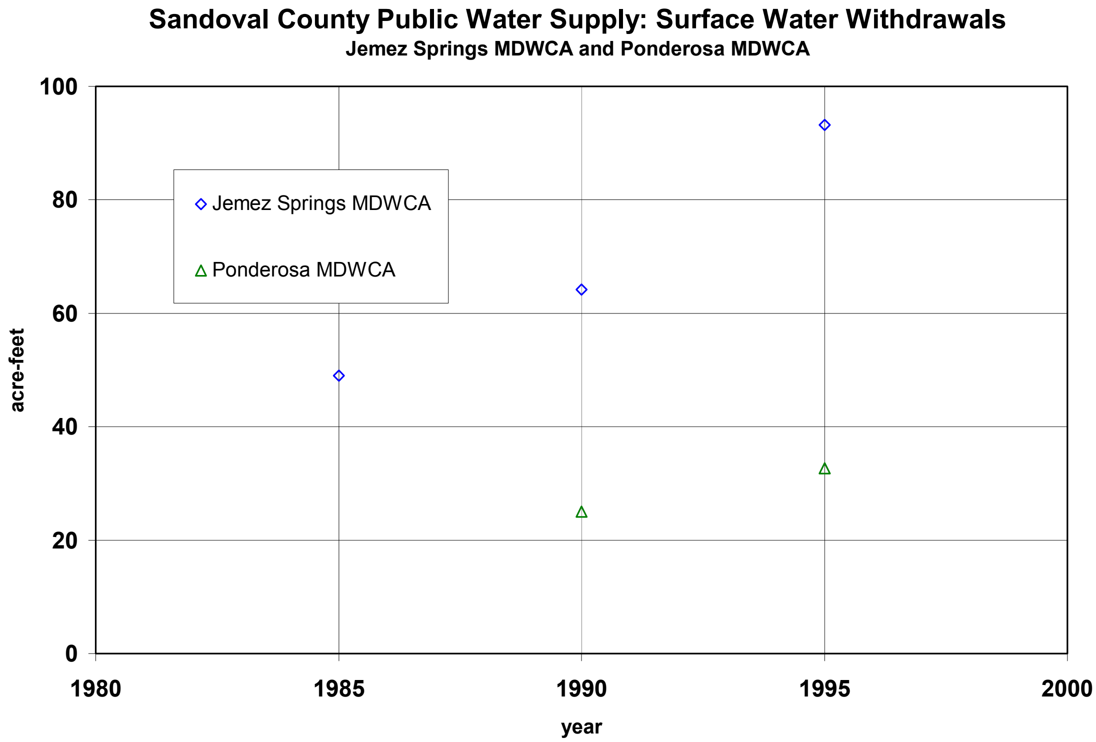

Figure 2. Surface-water withdrawals for public water supply in Sandoval County.

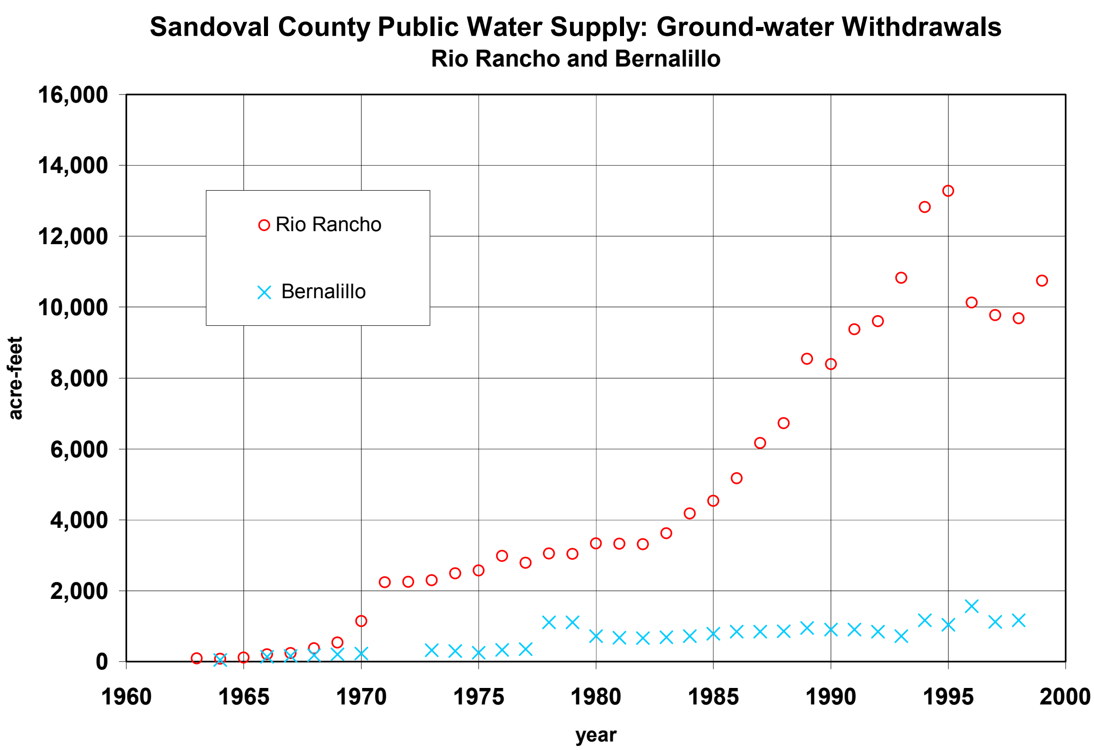

Figure 3. Ground-water withdrawals for public supply in Sandoval County: Rio Rancho and Bernalillo.

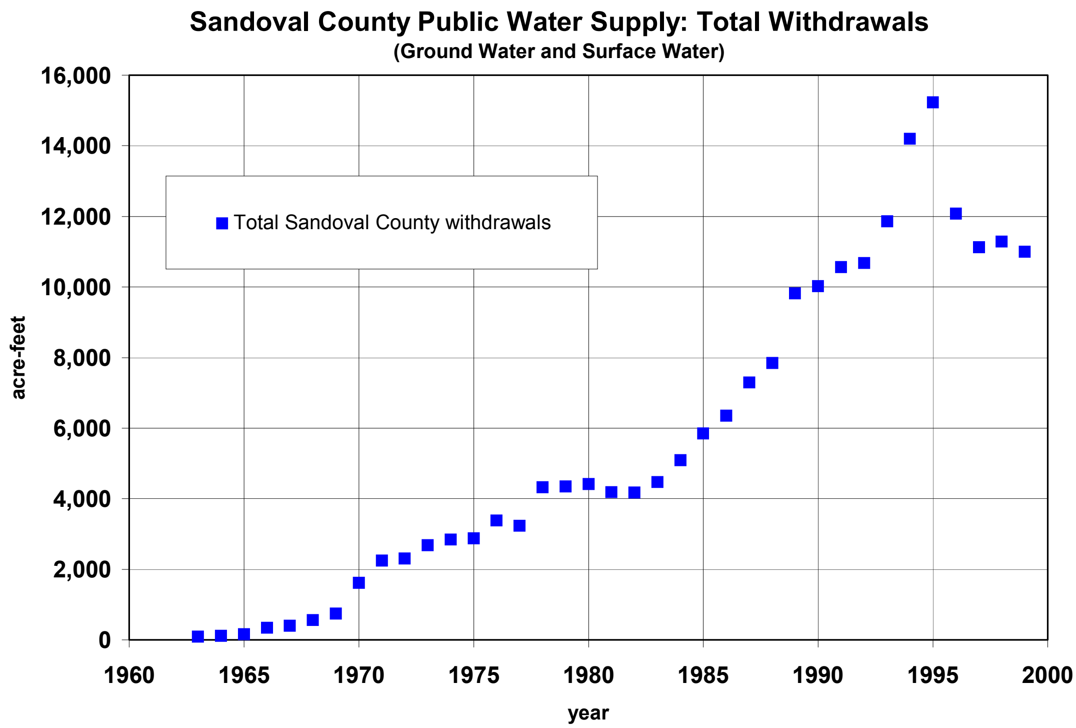

Figure 4. Total water withdrawals for public supply in Sandoval County. The withdrawals decline after 1995 because Intel Corporation began production on its own wells.

5.1.2.2 Bernalillo County

Bernalillo County has the highest public water-supply use in the regional water planning area due to the population, and number of businesses, institutions, industries and other uses served by the COA . Figure 5 shows total water withdrawals for the COA and return flow to the Rio Grande from the COA wastewater treatment plant (WTP). The COA WTP processes and discharges the return flows of several jurisdictions and self-supplied domestic users in addition to its own return flow. Return flow and consumptive use are discussed in detail in Section 5.1.2.7, **Public Water-supply Return Flow and Consumptive Use**. Figure 6 shows water withdrawals for New Mexico Utilities, Inc., Kirtland Air Force Base (AFB), and Sandia Peak Utility Company. New Mexico Utilities, Inc. supplies water to Paradise Hills; the Sandia Heights and Primrose Communities are served by the Sandia Peak Utility Company. Although

Kirtland AFB does purchase some water from the COA system, the water withdrawals portrayed are from Kirtland's own wells. Figure 7 shows total water withdrawals for public supply for Bernalillo County. The totals represented in this graph are not just Albuquerque, Kirtland AFB, New Mexico Utilities, Inc., and Sandia Peak Utility Company use, but also withdrawals from numerous smaller systems such as mobile home parks, subdivisions, and water cooperatives. In 1980 and 1985, total withdrawals include self-supplied domestic water use that could not be separated from public water supply use.

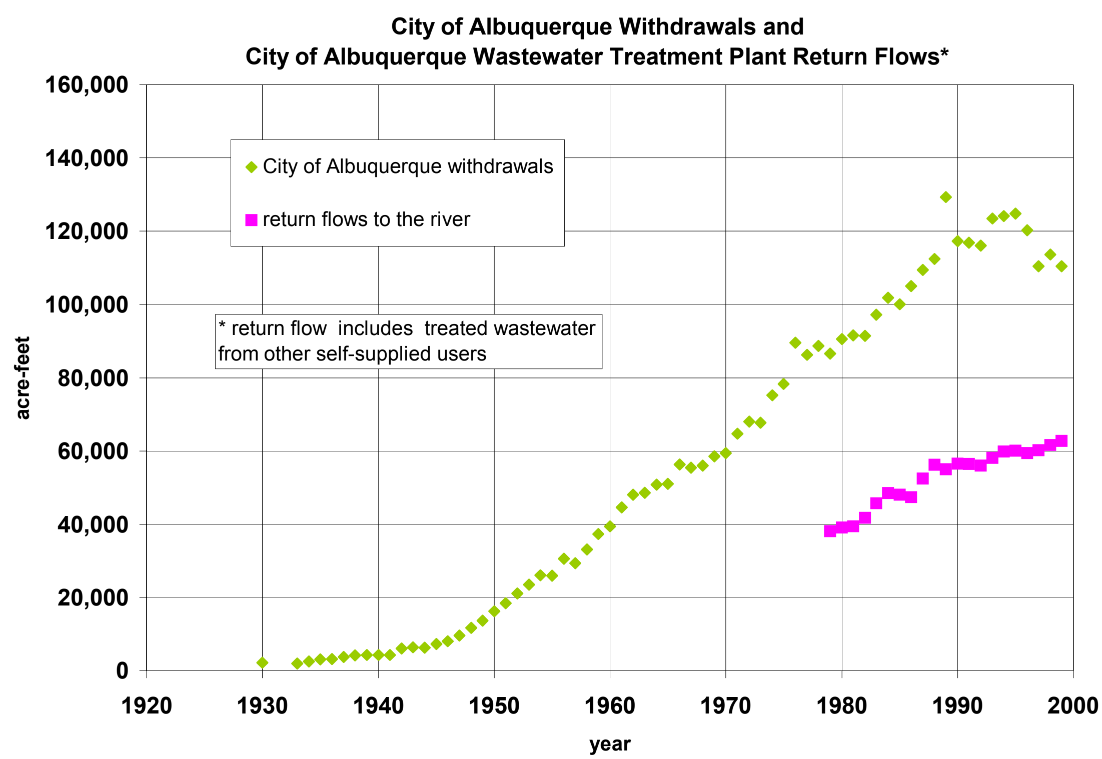

Figure 5. City of Albuquerque ground-water withdrawals and return flows.

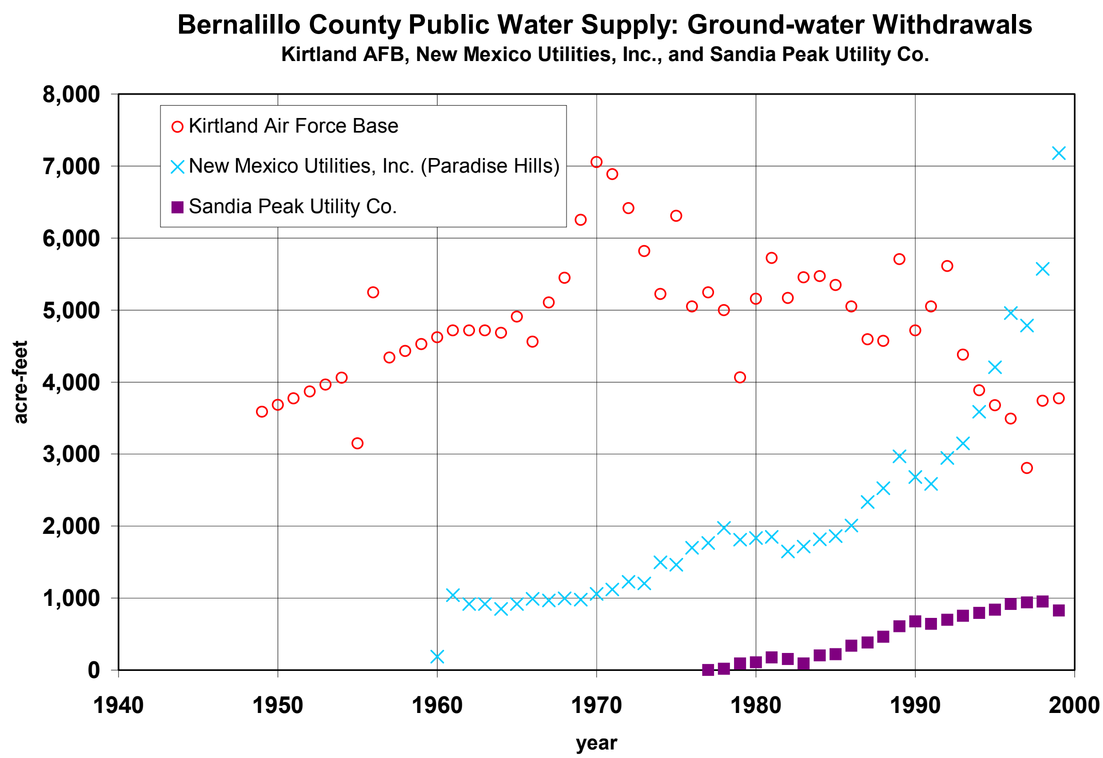

Figure 6. Ground-water withdrawals for Kirtland AFB, New Mexico Utilities, Inc., and Sandia Peak Utility Co.

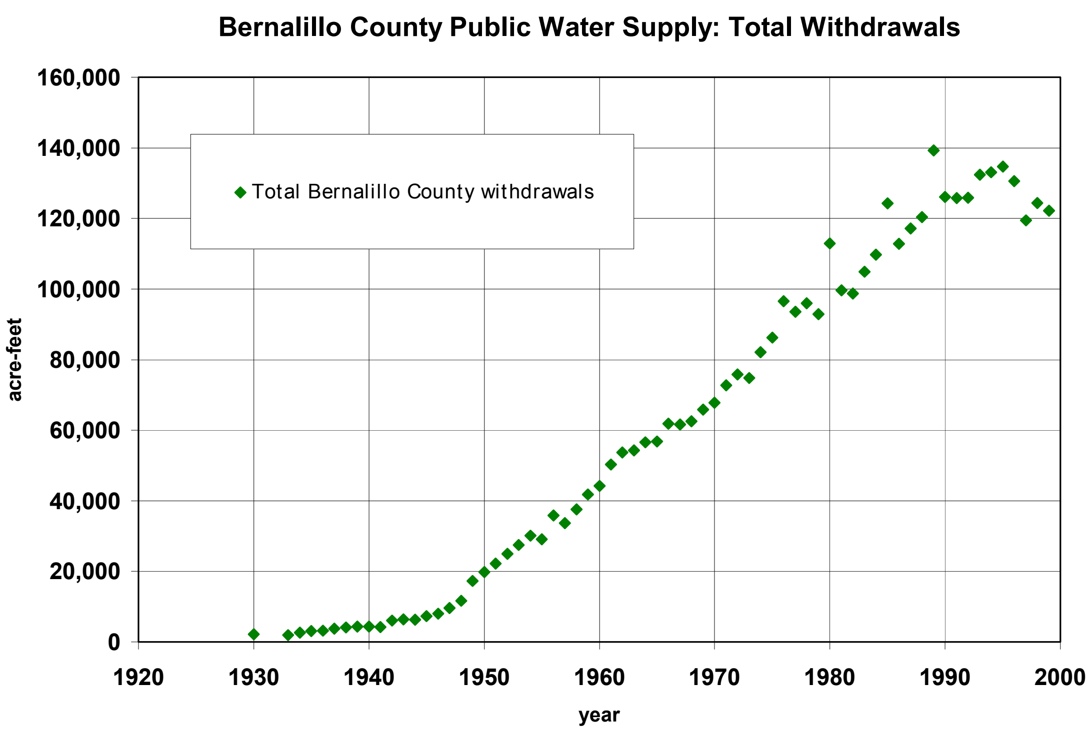

Figure 7. Total water withdrawals for public supply in Bernalillo County.

5.1.2.3 Valencia County

Figures 8 and 9 show ground-water withdrawals by public water suppliers in Valencia County. Figure 8 shows water withdrawals for the Belen water system, Rio Grande Utilities, the Los Lunas water system, National Utility Company, and the Village of Bosque Farms. Rio Grande Utilities provides water to Rio Communities, and National Utility Company provides water to Meadowlake. Belen's high withdrawal volumes in 1996 and 1997 are from data provided by the USGS as part of the ground-water flow modeling of the Albuquerque Basin (Kernodle et al., 1995). Officials at the Public Works Department of Belen could not be reached to confirm these values. Figure 9 shows total ground-water withdrawals for Valencia County including the withdrawals of the providers shown in Figure 8 and smaller public water suppliers in Valencia County.

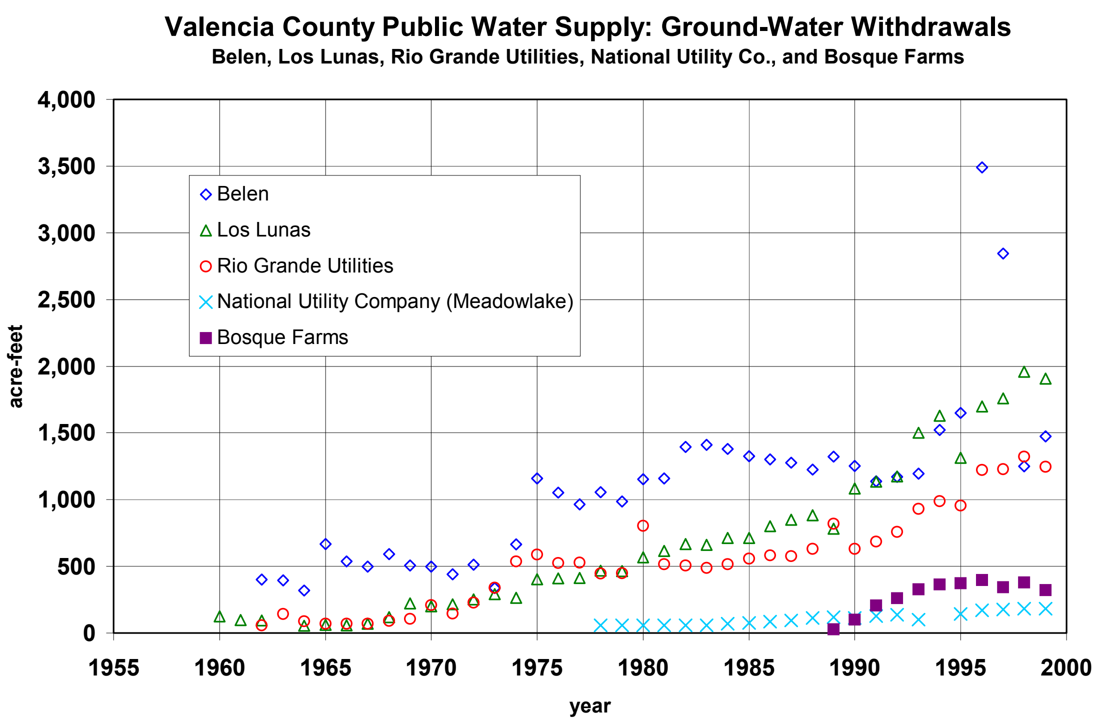

Figure 8. Ground-water withdrawals of the primary public water suppliers in Valencia County.

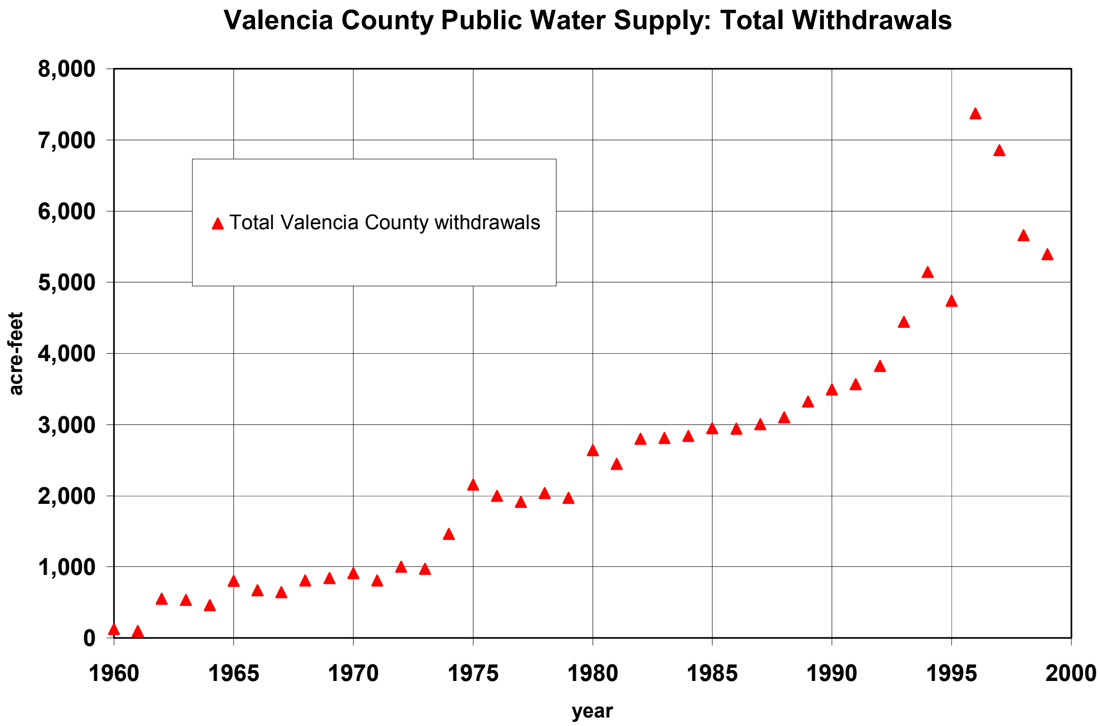

Figure 9. Total water withdrawals for public supply in Valencia County.

5.1.2.4 Totals

The following graphs show total withdrawals by public water suppliers in the regional water planning area. Figure 10 shows the total withdrawals by county. Figure 11 shows the total withdrawals by subregion, and Table 3 is a summary of water use by the Middle Rio Grande Valley (MRGV), Rio Puerco, and Rio Jemez subregions. Figure 12 shows the total public water-supply withdrawals for the regional water planning area, which includes Sandoval, Bernalillo, and Valencia Counties. Figure 13 shows the COA withdrawals, and the sum of all other public water-supply withdrawals in the regional water planning area. Table 4 summarizes water demand by major water users within the planning area. As stated before, values in 1980 and 1985 include self-supplied domestic water use that could not be separated from public water supply. As described, several sources provided water-demand data. In some cases, the water withdrawal values from the different sources did not match exactly and averages were used. This was done only if the data were generally in the same range and followed the same general trend. The original data and the averages are in Appendix 1.

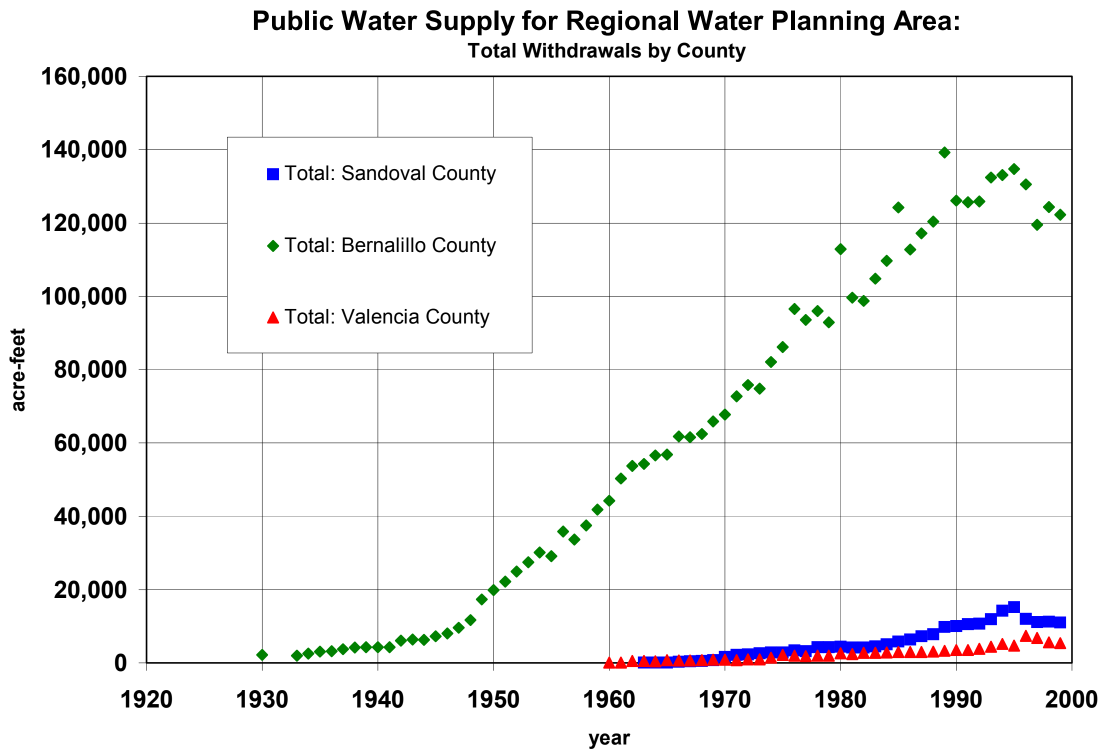

Figure 10. Public water-supply withdrawals by county, Middle Rio Grande regional water planning area.

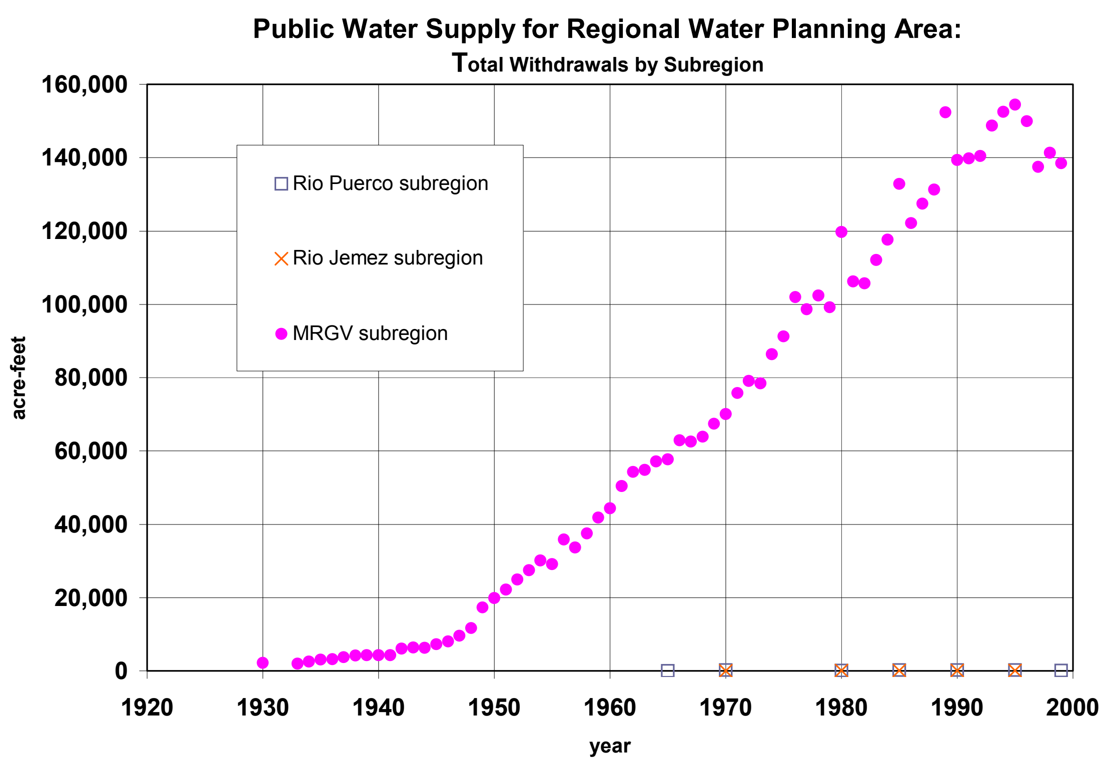

Figure 11. Public water-supply withdrawals by subregion, Middle Rio Grande Region.

Table 3. Summary of public water supply by subregion

subregions	1965 (ac-ft)	1970 (ac-ft)	1980 (ac-ft)	1985 (ac-ft)	1990 (ac-ft)	1995 (ac-ft)	1999 (ac-ft)
Middle Rio Grande Valley Subregion total	55,753	70,099	119,765	132,870	139,348	154,328	138,467
Cuba	39	194	105	155	221	202	151
La Jara			21[a]	33			
Regina					20	29	
Rio Puerco Subregion total	39	194	126	188	241	231	151
Jemez Springs		28	49[a]	49[b]	64[b]	93[b]	
Ponderosa			15	34	25[b]	33[b]	
Rio Jemez Subregion total		28	64	83	89	126	
Planning Area total	57,792	70,321	119,955	133,141	139,678	154,813	138,618

Source: see Appendix 1
Note: unless indicated, source is ground water
[a] source of water was not available
[b] source is surface water

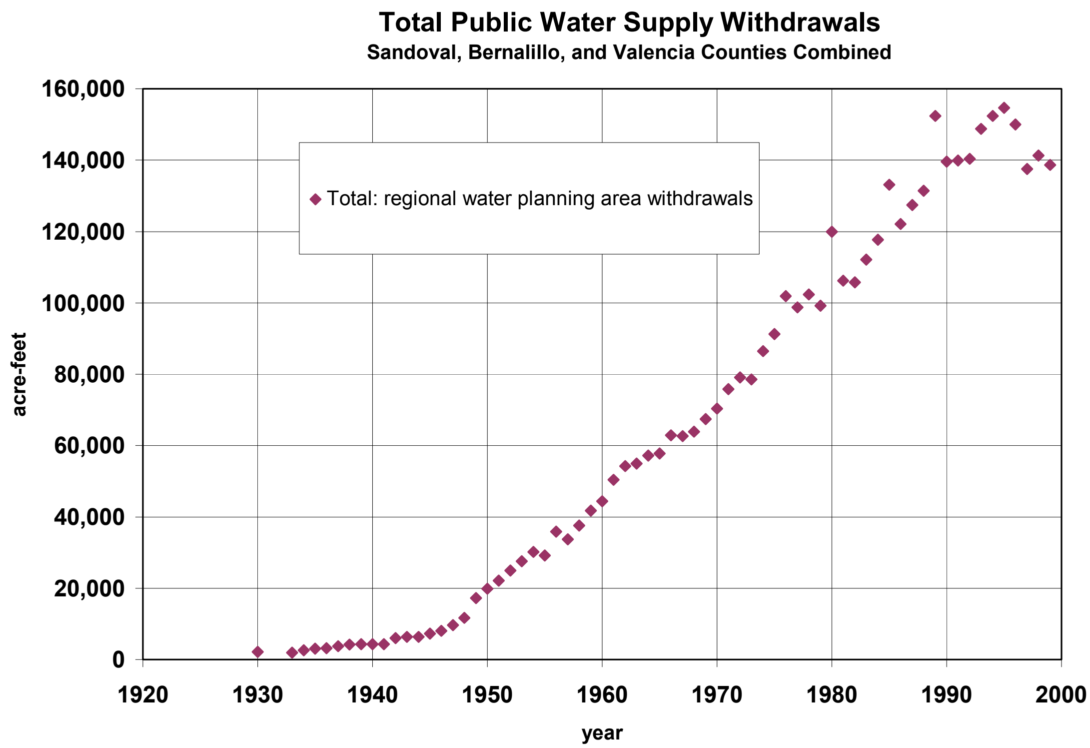

Figure 12. Total public water-supply withdrawals within the Middle Rio Grande Region.

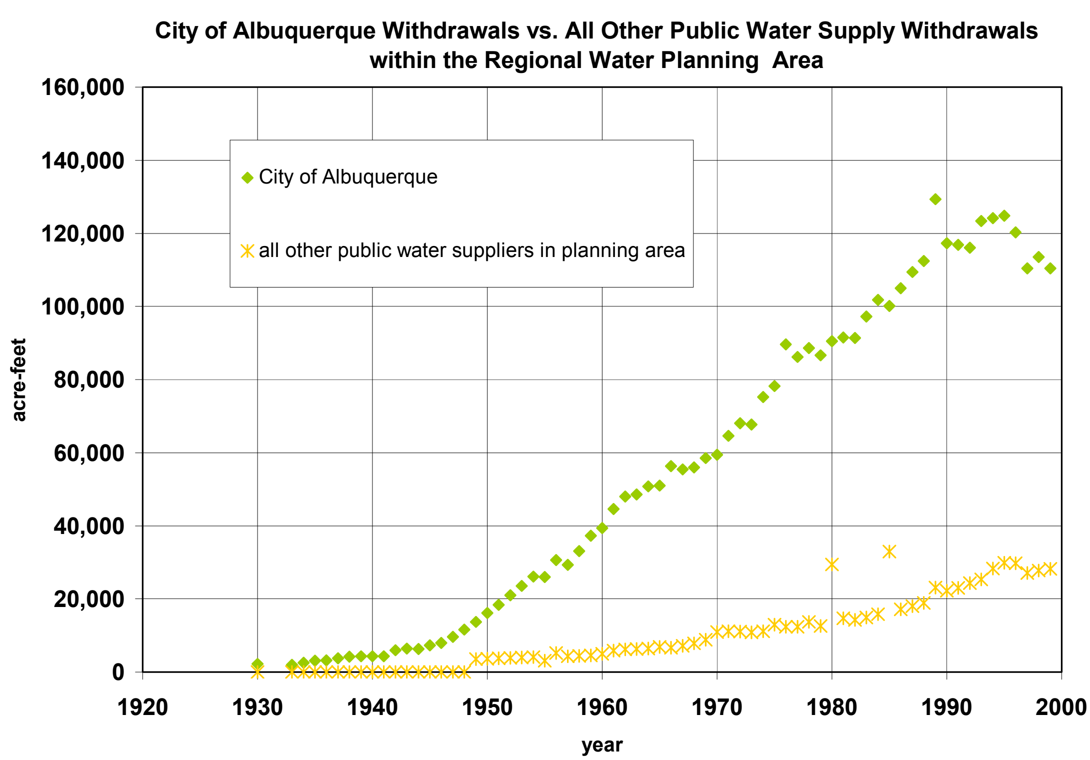

Figure 13. Total Albuquerque withdrawals compared with all other public water-supply withdrawals in the Middle Rio Grande Region.

Table 4. Summary of withdrawals by major public water-suppliers in the Middle Rio Grande Region (acre-feet)

public water supplier	1980	1985	1990	1993	1995	1996	1997	1998	1999
Sandoval County									
Rio Rancho	3,335	4,537	8,391	10,831	13,287	10,131	9,773	9,690	10,744
Bernalillo	715	786	902	716	1,044	1,563	1,120	1,160	ND
other public water suppliers	366	522	730	317	900	385	231	431	151
Bernalillo County									
Albuquerque	90,494	100,088	117,311	123,423	124,821	120,254	110,375	113,578	110,388
Kirtland AFB	5,153	5,344	4,718	4,382	3,676	3,490	2,805	3,759	3,770
New Mexico Utilities, Inc.	1,833	1,862	2,679	3,148	4,208	4,957	4,784	5,573	7,182
Sandia Peak Utility Co.	108	218	674	754	840	916	936	948	828
other public water suppliers	15,312[a]	16,787[a]	692	743	1,168	923	612	536	55
Valencia County									
Belen	1,153	1,326	1,253	1,195	1,649	3,491	2,844	1,250	1,473
Los Lunas	568	713	1,082	1,500	1,314	1,699	1,758	1,960	1,909
Rio Grande Utilities	803	559	632	931	955	1,222	1,228	1,322	1,246
Bosque Farms	NA	NA	101	328	372	396	341	380	322
National Utility Co. (Meadowlake)	58	76	111	101	144	169	175	181	183
other public water suppliers	58	273	313	387	309	401	510	568	264
Total	119,956	133,091	139,589	148,756	154,687	149,997	137,492	141,336	138,515[b]

[a] includes self-supplied domestic water use
[b] total does not include Bernalillo
NA = not applicable
ND = missing data

5.1.2.5 Distribution of Public Water Supply by Sub-Category

Several public water suppliers have kept records on the billed sales of water to different use sub-categories. Sub-category designations for the various public water suppliers include the following: residential, which is similar to the NMOSE definition of domestic; commercial and industrial, which are similar to the NMOSE definitions of these same categories; institutional, which includes schools and hospitals, and various other city-specific categories such as parks, golf courses, public authority, fire hydrants, and "other."

A final category, which is not usually quantified by public water suppliers, is *unaccounted for water*. Unaccounted for water, which is defined as the difference between total produced water and water sales, includes "measuring errors caused by inaccurate meters or incorrect meter reading, transmission losses in the distribution system, water used for fire fighting, system flushing, sewer cleaning, construction, and other miscellaneous uses that are not metered" (Wilson, and Lucero, 1997). Water lost during the treatment process is also considered unaccounted for water. Most of the following presentation of water use distribution by sub-category does not include unaccounted for water.

The largest public water supplier, the COA, has kept the most complete records for the longest period of time. Other public water suppliers, including Rio Rancho, New Mexico Utilities, Inc., Rio Grande Utilities, National Utility Company, and Los Lunas have also maintained historic records. A number of smaller public water suppliers have provided water distribution data for 1999 only. The largest sub-category for every public water-supply system is residential use.

The COA water distribution data from 1980 until the present indicates that most of COA's water is sold to residential and commercial customers (Table 5). Figure 14 is a graph of this information, and Figures 15 and 16 are bar graphs that display Albuquerque's deliveries for selected years. Figure 17 is a graph of per capita use within the COA's water service area. The higher gallons per capita per day (gpcd) rate is calculated by dividing total production by total service-area population. The plot starting in 1980 with the lower gpcd values is calculated by dividing water sales to the residential sub-category by the total service area population. The residential sub-category does not include multi-family apartments, which are currently placed in the commercial category. Figure 18 shows plots of withdrawals by the COA water system, and the service area population.

Table 5. Distribution of public water supply by sub-category, City of Albuquerque

City of Albuquerque (Bernalillo County)								
	residential (ac-ft)	**commercial (ac-ft)**	**institutional (ac-ft)**	**industrial (ac-ft)**	**park (ac-ft)**	**golf course (ac-ft)**	**other* (ac-ft)**	**total (ac-ft)**
1980	48,917	13,327	4,075	2,318				68,637
1981	50,097	14,139	5,088	2,192				71,515
1982	50,882	17,742	6,467	2,488				77,579
1983	50,139	19,392	6,863	2,752				79,145
1984	51,142	20,660	7,471	2,765				82,039
1985	51,700	22,196	7,192	2,288				83,375
1986	58,478	24,375	8,251	2,220				93,324
1987	62,128	26,101	9,143	2,342				99,715
1988	61,237	27,119	9,967	2,753				101,075
1989	73,620	30,414	11,257	3,075				118,365
1990	66,097	29,743	11,299	2,752				109,891
1991	67,154	30,387	11,289	2,937				111,768
1992	66,601	30,140	10,509	2,891				110,141
1993	70,508	31,597	11,661	2,838				116,603
1994	69,484	32,408	11,540	2,691	2,745	2,040	1,595	122,503
1995	66,402	34,108	12,007	3,182				115,700
1996	63,745	33,950	12,249	3,342	2,893	1,903	1,971	120,054
1997	58,411	32,081	11,158	3,030	2,417	1,677	1,054	109,828
1998	61,353	31,868	10,206	3,076	2,636	1,859	1,120	112,117
1999	59,104	30,847	10,378	3,104	2,696	1,855	1,100	109,084
average % total	61%	26%	9%	3%	<1%	<1%	<1%	

Source: City of Albuquerque
* includes City of Albuquerque Departments such as Police, Fire, Environmental Health, Senior Affairs, Solid Waste, Transit, and others
ac-ft acre-feet

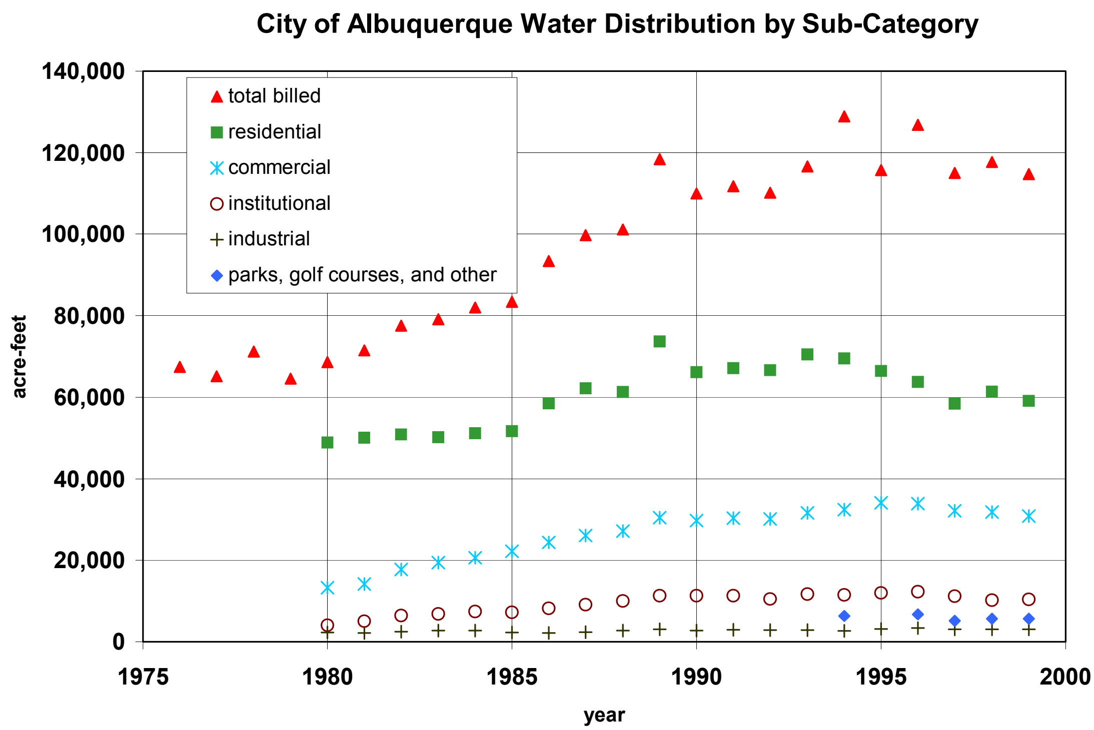

Figure 14. City of Albuquerque water distribution by sub-category.

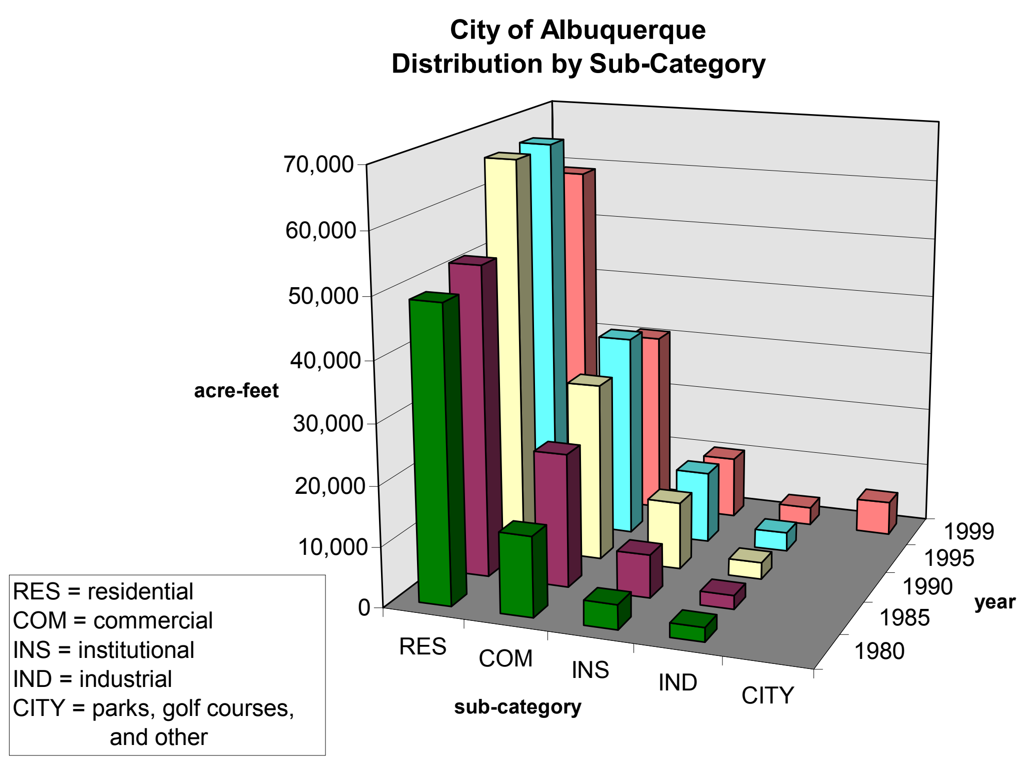

Figure 15. City of Albuquerque water distribution by sub-category for 1980, 1985, 1990, 1995, and 1999.

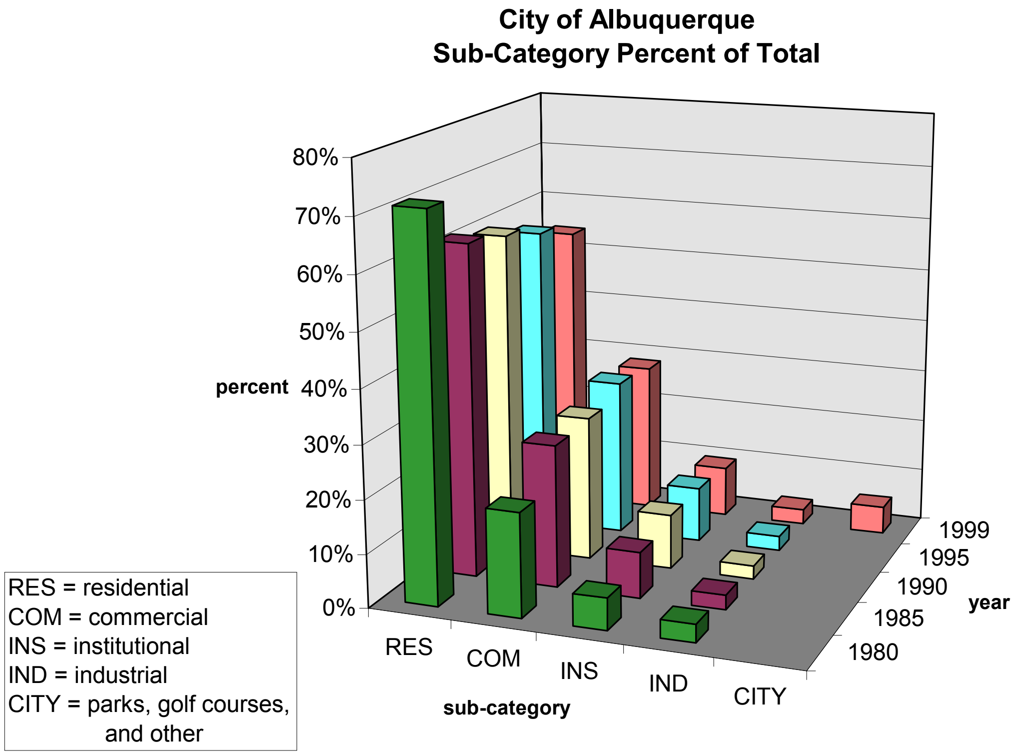

Figure 16. Percent of total deliveries by sub-category in the City of Albuquerque.

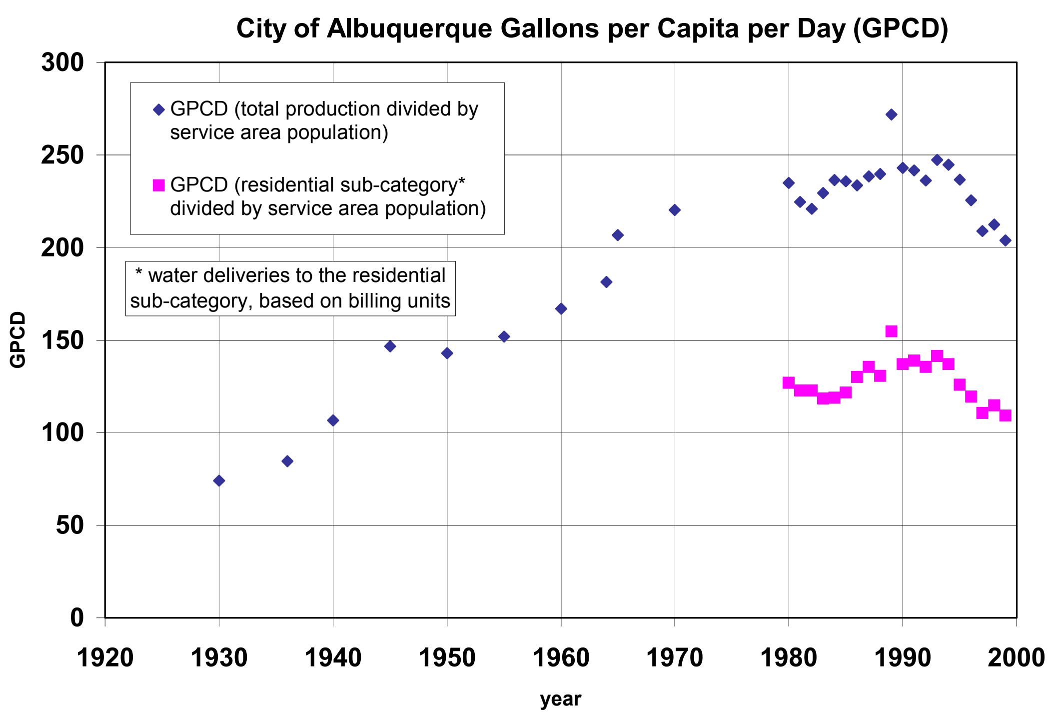

Figure 17. Per capita use per day in the City of Albuquerque.

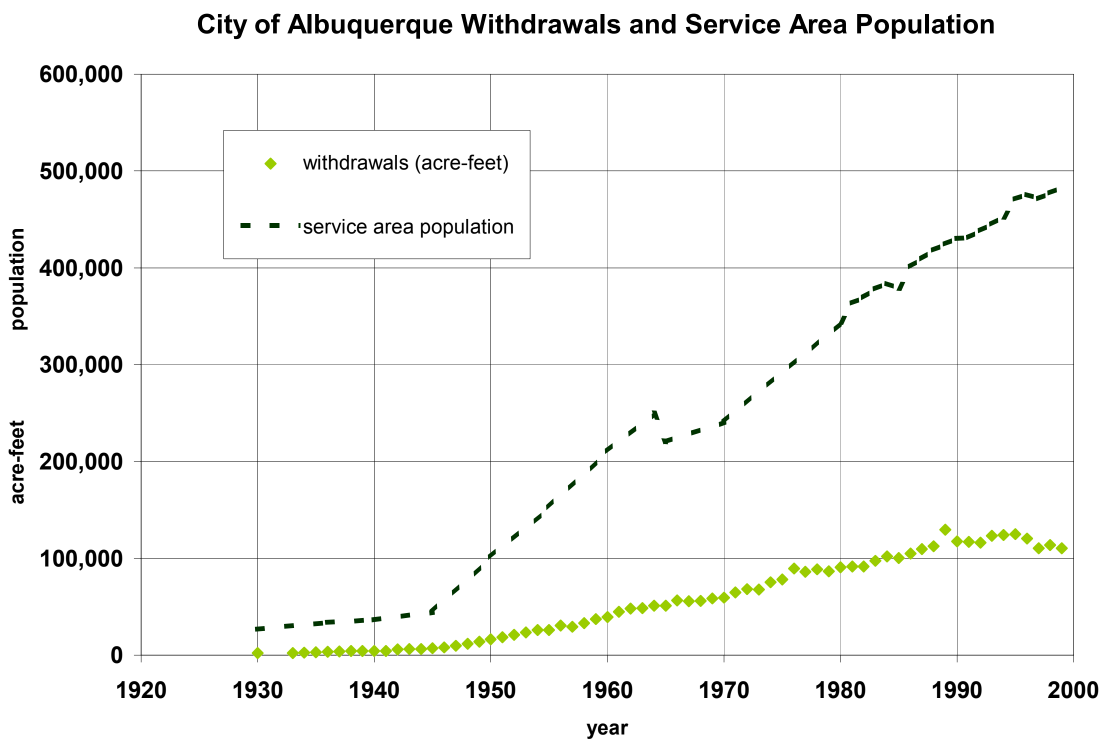

Figure 18. City of Albuquerque withdrawals and service area population.

Other major public water suppliers that provided historic data included Rio Rancho, New Mexico Utilities, Inc., Rio Grande Utilities, National Utility Company, and the Village of Los Lunas. Rio Rancho provided sub-category data from 1991 to 1999 (Table 6). Rio Rancho distributes more water to residential customers than either commercial or industrial customers, though for period of time between 1994 and 1995, a significant amount of water was sold to Intel Corporation.

Table 6. Distribution of public water supply by sub-category, Rio Rancho

Rio Rancho (Sandoval County)							
year	**residential (acre-feet)**	**commercial (acre-feet)**	**industrial (acre-feet)**	**public authority (acre-feet)**	**fire hydrants (acre-feet)**	**total delivered (acre-feet)**	**total produced (acre-feet)**
1991	4,963	1,951	1,857	307	179	9,256	9,409
1992	4,929	1,383	2,138	411	240	9,100	9,605
1993	5,153	1,554	2,637	445	239	10,028	10,830
1994	5,215	1,647	4,061	485	272	11,680	12,814
1995	5,243	1,812	4,368	563	211	12,197	13,254
1996	5,678	1,691	1,115	589	323	9,396	10,131
1997	6,131	1,608	1,034	281	ND	9,055	9,774
1998	ND	ND	ND	ND	ND	ND	9,693
1999	5,984	1,574	1,314	779	249	9,900	10,744
% of total delivered (1995)	43%	15%	36%	4%	2%		
% of total delivered (1999)	60%	16%	13%	8%	3%		

Source: The City of Rio Rancho Water and Wastewater Services. The Rio Rancho water system was operated by a private company, Rio Rancho Utility, until October of 1998. Data prior to 1998 are from the records of Rio Rancho Utility, the accuracy of which is unknown.

New Mexico Utilities, Inc. provided water distribution data (including wastewater return flows) for the years since 1977. The majority of their water has also historically been distributed to residential users (Table 7).

The following tables show the distribution of water for the smaller public water suppliers that also provided historic data. Water distribution data from Rio Grande Utilities and Los Lunas are shown in Tables 8 and 9, respectively. As described above, the totals may not equal totals presented in Table 4 or in the graphs. Since many sources of data were used in this study, often slightly different values were found. It was impossible to determine which value was more correct, so an average was calculated. Another reason for the differences in totals is that some of the distributions discussed below are based on water sales rather than water production. Unaccounted for water may or may not be specified into a category. Unaccounted for water may include system losses due to leaky pipes and storage reservoirs, or inaccuracies due to faulty or inoperable meters.

Table 7. Distribution of public water supply by sub-category, New Mexico Utilities, Inc.

New Mexico Utilities, Inc. – Paradise Hills (Bernalillo County)							
	residential (acre-feet)	**commercial (acre-feet)**	**fire protection (acre-feet)**	**irrigation (acre-feet)**	**industrial (acre-feet)**	**total (acre-feet)**	**total wastewater return* (acre-feet)**
1977	1,174	64	7	5		1,250	273
1978	1,407	75	9	5		1,496	282
1979	1,637	82	9	5		1,733	335
1980	1,704	89	9	5		1,807	338
1981	1,714	96	9	5		1,824	316
1982	1,735	100	9	5		1,849	255
1983	1,751	114	8	5		1,878	258
1984	1,894	140	11	5		2,050	304
1985	1,946	157	12	5		2,120	427
1986	2,025	177	13	5		2,220	476
1987	2,094	197	13	5		2,309	577
1988	2,190	200	13	5		2,408	660
1989	2,303	214	13	5		2,535	684
1990	2,386	223	18	5		2,632	734
1991	2,464	226	20	5		2,715	918
1992	2,562	233	20	5		2,820	982
1993	2,699	241	20	5		2,965	980
1994	2,904	273	21	5		3,203	1,148
1995	3,337	328	22	5	1	3,692	1,324
1996	3,981	424	21	5	1	4,431	542
1997	4,654	479	48	5	1	5,186	622
1998	5,590	528	65	5	1	6,188	1,665
1999	6,544	564	69	5	1	7,182	633
average % of total	91%	7%	1%	<1%	<1%		

Source: New Mexico Utilities, Inc.

*Note: wastewater return goes to the City of Albuquerque wastewater treatment facility. Intel discharges its wastewater to the Albuquerque system by way of New Mexico Utilities, Inc., however, its discharge is not included in the total wastewater return for New Mexico Utilities, Inc.

Table 8. Distribution of public water supply by sub-category, Rio Grande Utilities

Rio Grande Utilities, Inc. (Valencia County)						
	residential (acre-feet)	**commercial and industrial (acre-feet)**	**recreational (acre-feet)**	**other (acre-feet)**	**total* (acre-feet)**	**wastewater return**
1990	437	44	104	47	632	
1991	462	51	96	62	677	
1992	476	55	121	87	739	
1993	545	65	173	147	930	
1994	610	78	162	140	990	
1995	640	72	167	203	1,082	
1996	681	95	177	268	1,221	
1997	729	73	192	230	1,224	281
1998	788	86	119	262	1,255	324
average % of total	62%	7%	15%	16%		

Source: Rio Grande Utilities Corporation
*Note: includes lost water, water used for construction, and swimming pools

Table 9. Distribution of public water supply by sub-category, Village of Los Lunas

Los Lunas (Valencia County)					
	residential (acre-feet)	**commercial (acre-feet)**	**other (acre-feet)**	**total (acre-feet)**	**wastewater return**
1993	792	282	289	1,362	662
1994	921	348	209	1,479	718
1995	962	389	115	1,466	684
1996	1,016	387	295	1,699	703
1997	1,005	381	373	1,758	721
1998	1,057	423	479	1,960	828
1999	1,118	611	180	1,909	771
average % of total	59%	24%	17%		

Source: Village of Los Lunas

Table 10 summarizes the 1999 distribution of water by sub-category for Sandia Peak Utility Company, Tierra West Mobile Home Community (MHC), Village of Tijeras Water System, City of Belen, Village of Bosque Farms, and National Utility Company. The Village of Tijeras is a relatively new public water supplier; thus, it does not appear in Table 4, which summarizes historic and current withdrawals of public water suppliers. Tierra West MHC only provided data for 1999 and also does not appear in Table 4. The total quantity of water delivered by Tierra West MHC ranges from 120,000 to 330,000 gallons per day depending on the season. The present study used the average of 225,000 gallons per day (252 acre-feet per year). The total water withdrawals may not equal the total withdrawals in Table 4 above because the totals above are based on an average.

5.1.2.6 Populations Served by Public Water-supply Systems

Because the amount of water distributed by public water-supply systems is highly dependent on the size of the populations they serve, we have included population data for counties and municipalities wholly or partly within the study area (Table 11). Though a small portion of Torrance County lies within the Middle Rio Grande Region, the population of that area is negligible and not included in Table 11. The data presented in Table 11 were supplied to us from MRGCOG, and come from the U. S. Bureau of Census and MRGCOC's own population projections. Populations within the Middle Rio Grande Region have, overall, been increasing through time.

Table 10. Distribution of public water supply by sub-category, Sandia Peak Utility Co., Tierra West MHC, Village of Tijeras, Belen, Bosque Farms, and National Utility Co.

	residential (acre-feet)	commercial (acre-feet)	industrial (acre-feet)	unspecified (acre-feet)	total (acre-feet)	total returned to a wastewater treatment facility (acre-feet)
Sandia Peak Utility Co. (Bernalillo County)						
1999	763.67	34.30	22.19	7.80	827.96	320.62[a]
% of total	92%	4%	3%	1%		
Tierra West MHC (Bernalillo County)						
1999	126			126[b]	252	151[a]
% of total	50%			50%		
Village of Tijeras (Bernalillo County)						
1999	40.89	6.10		8.43	55.42	
% of total	74%	11%		15%		
Belen (Valencia County)						
1999	699.71	193.34		580.02	1,473.07	1,166.18
% of total	48%	13%		39%		
Bosque Farms (Valencia County)						
1999	289.53	25.74	6.43		321.70	257.36
% of total	90%	8%	2%			
National Utility Co. – Meadowlake (Valencia County)						
1995	130.89	1.24			132.13	
1996	150.57	2.17			152.74	
1997	163.93	1.35			165.28	
1998	179.60	1.10			180.70	
1999	182.38	1.06			183.44	
average	161.48	1.39			162.86	
% of total (average)	99%	1%				

Source: survey data
[a] wastewater returned to the City of Albuquerque wastewater treatment facility
[b] recreation (parks equal 40% and swimming pools equal 10%)

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Table 11. Summary of Population of Counties and Municipalities within, or partly within, the Regional Water Planning Area

U.S. Bureau of Census Data											
counties	**1890**	**1900**	**1910**	**1920**	**1930**	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**1991**
Bernalillo			23,606	29,855	45,430	69,391	145,673	262,199	315,774	419,700	480,577	489,191
Sandoval*			8,579	8,863	11,144	13,898	12,438	14,201	17,492	34,799	63,319	66,191
Valencia**				7,710	8,565	11,364	13,530	16,146	20,451	30,769	45,235	46,664
total population			**32,185**	**46,428**	**65,139**	**94,653**	**171,641**	**292,546**	**353,717**	**485,268**	**589,131**	**602,046**
municipalities	**1890**	**1900**	**1910**	**1920**	**1930**	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**1991**
Albuquerque	3,785	6,238	11,020	15,157	26,570	35,449	96,815	201,189	243,751	331,767	384,736	391,617
Belen				1,306	2,116	3,038	4,495	5,031	4,823	5,617	6,547	6,708
Bernalillo							1,922	2,574	2,016	3,012	5,960	6,031
Bosque Farms									1,699	3,353	3,791	3,932
Corrales									1,776	2,791	5,453	5,592
Cuba									415	609	760	783
Jemez Springs								223	356	316	413	422
Los Lunas					513	686	889	1,186	973	3,525	6,013	6,139
Los Ranchos de Albuquerque									1,900	2,702	3,955	5,112
Rio Rancho										9,985	32,505	34,603
San Ysidro									182	199	233	239
Tijeras									160	311	340	347

Source: MRGCOG
*Note: part of Sandoval County was annexed to Santa Fe County prior to 1950 and in 1949 part went to Los Alamos County.
**Note: populations for Valencia County prior to 1990 are for the current boundaries of Valencia County

Table 11. Summary of Population of Counties and Municipalities within, or partly within, the Regional Water Planning Area (concluded)

	Bureau of Census Estimates (1991-1998)								MRGCOG Estimates (1995-1999)				
counties	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1995**	**1996**	**1997**	**1998**	**1999**
Bernalillo	489,191	498,663	506,096	515,708	522,410	524,911	525,586	525,958	524,820	535,500	539,700	540,300	544,000
Sandoval*	66,191	68,768	72,238	76,141	79,803	83,162	85,852	86,049	79,268	84,000	84,500	86,700	89,500
Valencia**	46,664	48,260	50,947	53,497	57,308	60,096	62,823	64,626	56,833	60,000	62,500	64,400	64,600
total	**602,046**	**615,691**	**629,281**	**645,346**	**659,521**	**668,169**	**674,261**	**676,633**	**660,921**	**679,500**	**686,700**	**691,400**	**698,100**
municipalities	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1995**	**1996**	**1997**	**1998**	**1999**
Albuquerque	391,617	398,968	404,367	411,676	416,766	418,454	418,834	419,311	418,000	426,500	431,000	431,000	435,500
Belen	6,708	6,869	7,166	7,392	7,712	7,823	7,947	7,936	6,900	7,000	7,500	7,500	7,500
Bernalillo	6,031	6,164	6,340	6,584	6,861	7,130	7,369	7,570	7,000	7,100	7,100	7,100	7,100
Bosque Farms	3,932	4,075	4,315	4,569	4,937	5,224	5,493	5,645	4,200	4,300	4,400	4,400	4,400
Corrales	5,592	5,701	5,833	6,009	6,205	6,373	6,519	6,633	6,600	6,900	7,100	7,400	7,700
Cuba	783	799	824	856	894	929	962	991	750	750	800	900	1,000
Jemez Springs	422	429	438	450	465	479	489	499	500	500	500	500	500
Los Lunas	6,139	6,272	6,539	6,746	7,064	7,203	7,396	7,805	8,000	8,700	9,200	9,700	10,000
Los Ranchos de Albuquerque	5,112	5,167	5,190	5,204	5,170	5,114	5,054	5,019	5,700	5,800	5,800	5,800	5,900
Rio Rancho	34,603	36,582	39,283	42,120	44,589	46,848	48,620	50,041	43,800	46,000	47,000	48,000	50,200
San Ysidro	239	244	251	260	271	284	293	301	275	280	280	300	300
Tijeras	347	355	362	370	379	386	389	391	380	400	390	400	400

Source: MRGCOG
*Note: part of Sandoval County was annexed to Santa Fe County prior to 1950 and in 1949 part went to Los Alamos County.
**Note: populations for Valencia County prior to 1990 are for the current boundaries of Valencia County

5.1.2.7 Public Water-supply Return Flow and Consumptive Use

Return flow information was included in the surveys from public water suppliers, with additional data provided by the EPA. Return flow data were available for several public water suppliers, including Cuba Water and Sewer System, Bernalillo, Rio Rancho, Sandia Peak Utility Company, New Mexico Utilities, Inc., Tierra West MHC, COA, Los Lunas, Belen, Rio Grande Utilities, and Bosque Farms. In general, data were available only for recent years, and data for Cuba, Bosque Farms, Sandia Peak Utilities, and Tierra West MHC data were available only for 1999. Cuba estimated that 44 acre-feet per year of wastewater were returned through a wastewater treatment facility. Bosque Farms has a new wastewater treatment facility and projects that 80 percent of the water delivered will return to the facility, a quantity that would have been about 257 acre-feet in 1999. Sandia Peak Utility and Tierra West MHC discharge their wastewater to the COA wastewater treatment plant. In 1999, Sandia Peak Utility and Tierra West MHC discharged approximately 321 acre-feet and 151 acre-feet of wastewater, respectively, to the Albuquerque wastewater treatment plant.

The City of Rio Rancho, Bernalillo, New Mexico Utilities, Inc., COA, Los Lunas, and Rio Grande Utilities provided wastewater return flow data for multiple years, and wastewater return flow information for Belen was available from the EPA. Table 12 summarizes wastewater information for the City of Rio Rancho. Table 13 shows return flows for the Town of Bernalillo, Los Lunas, Belen, and Rio Grande Utilities. Table 14 summarizes wastewater return flow information for New Mexico Utilities, Inc. and the COA. As with Sandia Peak Utility Company and Tierra West MHC, New Mexico Utilities, Inc. returns its wastewater to COA sewer system. In addition, wastewater is returned to the COA wastewater treatment plant (WTP) by Kirtland Air Force Base and some self-supplied domestic water users. Furthermore, most self-supplied commercial, self-supplied industrial, self-supplied mining, and self-supplied power within the Albuquerque area return wastewater to the COA WTP. As a consequence, measured discharges from the COA WTP include discharges from public water suppliers, self-supplied domestic users, and other self-supplied water use categories that do not use water pumped from COA wells.

Table 12. Summary of wastewater information for Rio Rancho

Rio Rancho Wastewater (Sandoval County)					
year	influent (acre-feet)	effluent to golf course (acre-feet)	effluent to river (acre-feet)	effluent to green areas (acre-feet)	total effluent (acre-feet)
1991	3,182	1,240	1,448		2,687
1992	3,152	1,080	2,029		3,108
1993	3,386	1,021	1,737	52	2,809
1994	2,933	975	1,698	48	2,721
1995	3,201	1,002	1,884	43	2,930
1996	3,455	974	2,337	47	3,359
1997	3,592	827	2,971	30	3,828
1998					
1999		843	3,768	255	4,866

Source: The City of Rio Rancho Water and Wastewater Services. However, the Rio Rancho water system was run by a private company, Rio Rancho Utility, until October of 1998. Data prior to 1998 are from the records of Rio Rancho Utility, the accuracy of which is unknown.

Table 13. Summary of wastewater return flow data for Bernalillo, Los Lunas, Belen, and Rio Grande Utilities

year	Bernalillo	Los Lunas	Belen	Rio Grande Utilities
	wastewater discharge (acre-feet)			
1989	423	443	1,008	
1990	436	483	989	
1991	493	493	972	
1992	479	528	861	
1993	482	662	887	
1994	617	716	877	
1995	546	684	1,111	
1996	547	703	965	
1997	494	721	915	281
1998	580	823	924	324
1999		771	1,166	307

Source: survey responses and EPA

Table 14. Summary of wastewater return flow data for the New Mexico Utilities, Inc. and the City of Albuquerque wastewater treatment plant (WTP)

year	New Mexico Utilities, Inc.	Albuquerque WTP (estimated influent)	Albuquerque WTP (measured discharge to river)
	return to COA WTP (acre-feet)	(acre-feet)	(acre-feet)
1979	335	38,518	38,476
1980	338	39,502	39,460
1981	316	39,743	39,700
1982	255	42,044	42,001
1983	258	46,008	45,966
1984	304	48,852	48,809
1985	427	48,479	48,436
1986	476	47,927	47,885
1987	577	53,119	53,076
1988	660	56,935	56,893
1989	684	55,743	55,701
1990	734	57,281	57,238
1991	918	57,361	57,319
1992	982	57,029	56,986
1993	980	59,078	59,036
1994	1,148	61,027	60,984
1995	1,324	61,412	61,369
1996	1,662	61,124	61,081
1997	1,910	62,223	62,061
1998	2,179	64,244	63,810
1999		62,555	62,207

Source: City of Albuquerque and New Mexico Utilities, Inc.

Consumptive use by public water suppliers is calculated by subtracting return flow from withdrawal. This assumes that there is no storm water runoff or seepage entering the sewer system and no leakage out of the sewer system. Furthermore, water discharged to the sewer system by self-supplied water users and water discharged to septic tanks by water users supplied by public water suppliers must also be considered (Wilson and Lucero, 1997). When measured return flow data are not available, the present study estimated consumptive use by multiplying total withdrawal by 50 percent. This assumption follows the convention of the NMOSE water use inventories, which use an estimated consumptive use factor between 45 and 55 percent for public water supply (Wilson, 1992; Wilson and Lucero, 1997).

Table 15 shows consumptive use based on measured return flow for the Town of Bernalillo and Rio Rancho. Table 16 shows consumptive use based on measured return flow for New Mexico Utilities, Inc. Table 17 is a summary of consumptive use data related to COA WTP. Wastewater returned to the WTP includes return flow from Albuquerque, Kirtland AFB, Sandia Peak Utility Company, Tierra West MHC, some self-supplied domestic users, and other self-supplied water users. Total return flow to the river does not include water lost during the treatment process. Total withdrawal data includes the COA, Kirtland Air Force Base (AFB), Tierra West MHC, and Sandia Peak Utility Company. It does not include withdrawals by self-supplied domestics or other self-supplied water users that discharge their wastewater to the WTP. For 1999, the total withdrawal does not include Tierra West MHC and Sandia Peak Utility Company because return flow estimates were available to determine their consumptive use independently.

Consumptive use estimates for Sandia Peak Utility Company, Tierra West MHC, and Bosque Farms for 1999 are in Table 18. Nineteen-ninety-nine withdrawal data for Cuba were not available, so consumptive use was not calculated. Table 19 summarizes consumptive use for Los Lunas, Belen, and Rio Grande Utilities.

Table 15. Consumptive use information for the Town of Bernalillo and Rio Rancho based on measured return flow

	Town of Bernalillo			Rio Rancho*		
year	total withdrawal (acre-feet)	total return flow (acre-feet)	consumptive use (acre-feet)	total withdrawal (acre-feet)	total return flow (acre-feet)	consumptive use (acre-feet)
1989	952	423	529			
1990	902	436	466			
1991	899	493	406	9,377	2,687	6,689
1992	848	479	369	9,606	3,108	6,498
1993	716	482	234	10,831	2,757	8,074
1994	1,161	617	544	12,828	2,673	10,154
1995	1,044	546	498	13,287	2,887	10,400
1996	1,563	547	1,016	10,131	3,312	6,820
1997	1,120	494	626	9,773	3,438	6,335
1998	1,160	580	580	9,690		
1999				10,846	4,612	6,235

* Data prior to 1998 are from the records of Rio Rancho Utility, the accuracy of which is unknown.

Table 16. Consumptive use data for New Mexico Utilities, Inc.

New Mexico Utilities, Inc.			
year	total withdrawal (acre-feet)	return to Albuquerque WTP (acre-feet)	consumptive use (acre-feet)
1979	1,809	335	1,474
1980	1,833	338	1,495
1981	1,850	316	1,534
1982	1,649	255	1,394
1983	1,717	258	1,459
1984	1,818	304	1,514
1985	1,862	427	1,435
1986	2,006	476	1,530
1987	2,331	577	1,754
1988	2,523	660	1,863
1989	2,968	684	2,284
1990	2,679	734	1,945
1991	2,588	918	1,670
1992	2,946	982	1,964
1993	3,148	980	2,168
1994	3,586	1,148	2,438
1995	4,208	1,324	2,884
1996	4,957	1,662	3,295
1997	4,784	1,910	2,874
1998	5,573	2,179	3,394
1999	7,182		

Source: New Mexico Utilities, Inc.

Table 17. Consumptive use information for the City of Albuquerque wastewater treatment plant, based on measured return flows

year	COA withdrawal (acre-feet)	Kirtland AFB withdrawal (acre-feet)	Sandia Peak Util. Co. withdrawal (acre-feet)	Tierra West MHC withdrawal (acre-feet)	total withdrawal[a] (acre-feet)	total return flow[b] (acre-feet)	consumptive use [c] (acre-feet)
1979	86,601	4,063	88		90,752	38,141	52,611
1980	90,494	5,153	108		95,754	39,122	56,633
1981	91,531	5,724	174		97,429	39,384	58,045
1982	91,445	5,166	150		96,761	41,746	55,015
1983	97,214	5,452	91		102,756	45,708	57,048
1984	101,778	5,473	200		107,451	48,505	58,946
1985	100,088	5,344	218		105,650	48,009	57,641
1986	104,988	5,046	335		110,370	47,409	62,961
1987	109,400	4,595	383		114,378	52,499	61,879
1988	112,394	4,569	462	41	117,466	56,233	61,233
1989	129,327	5,704	605	173	135,808	55,017	80,791
1990	117,311	4,718	674	141	122,845	56,504	66,341
1991	116,864	5,049	643	162	122,718	56,401	66,318
1992	116,090	5,612	696	145	122,544	56,004	66,539
1993	123,423	4,382	754	179	128,738	58,056	70,683
1994	124,167	3,887	794	217	129,066	59,836	69,230
1995	124,821	3,676	840	235	129,572	60,045	69,527
1996	120,254	3,490	916	259	124,918	59,419	65,499
1997	110,375	2,805	936	180	114,296	60,151	54,145
1998	113,578	3,739	948	218	118,483	61,631	56,852
1999	110,388	3,770	see Table 16[d]	see Table 16[d]	114,158	62,207	51,952

[a] total withdrawal is the sum of Albuquerque, Kirtland AFB, Sandia Peak Utility Co., and Tierra West MHC.

[b] total return flow is the measured discharge to the river from the WTP. It includes wastewater return from Albuquerque, Kirtland AFB, Sandia Peak Utility Co., Tierra West MHC, and some self-supplied domestic users and other self-supplied water users. However, total return flow does not include New Mexico Utilities, Inc. or the amount of water that may be lost as part of the treatment process. New Mexico Utilities, Inc. has measured return flow data, so its consumptive use was calculated independently (see Table 14).

[c] consumptive use is equal to total withdrawal minus total return flow. This figure is an estimate because total withdrawal does not include all of the withdrawal that eventually could be returned to the WTP, and total return flow does not include the amount of water lost during the treatment process.

[d] return flow data were available for Sandia Peak Utility Co. and Tierra West MHC for 1999, so their consumptive use was calculated independently (see Table 16).

Table 18. Consumptive use for Sandia Peak Utility Co., Tierra West MHC, and Bosque Farms in 1999

1999	total withdrawal (acre-feet)	total return flow (acre-feet)	consumptive use (acre-feet)
Sandia Peak Utility Co.	828	321	507
Tierra West MHC	252	151	101
Bosque Farms	322	257	64

MHC mobile home community

Table 19. Consumptive use information for Los Lunas, Belen, and Rio Grande Utilities based on measured return flow

	Los Lunas			Belen			Rio Grande Utilities		
year	total with-drawal (acre-feet)	total return flow (acre-feet)	consump-tive use (acre-feet)	total with-drawal (acre-feet)	total return flow (acre-feet)	consump-tive use (acre-feet)	total with-drawal (acre-feet)	total return flow (acre-feet)	consump-tive use (acre-feet)
1989	783	443	340	1,322	1,008	314	819		
1990	1,082	483	599	1,253	989	264	632		
1991	1,133	493	640	1,138	972	166	684		
1992	1,173	528	645	1,170	861	309	758		
1993	1,500	662	838	1,195	887	308	931		
1994	1,628	716	912	1,523	877	646	989		
1995	1,314	684	630	1,649	1,111	538	955		
1996	1,699	703	996	3,491	965	2,526	1,222		
1997	1,758	721	1,037	2,844	915	1,929	1,228	281	947
1998	1,960	823	1,137	1,250	924	326	1,322	324	998
1999	1,909	771	1,138	1,473	1,166	307	1,246	307	939

Public water-supply consumptive use (withdrawal minus return flow) by county is presented in Figures 19 through 21, and Figure 22 shows the total public water-supply consumptive use for the regional water planning area. Where return flow data were not available, consumptive use is assumed to be equal to 50 percent of withdrawals.

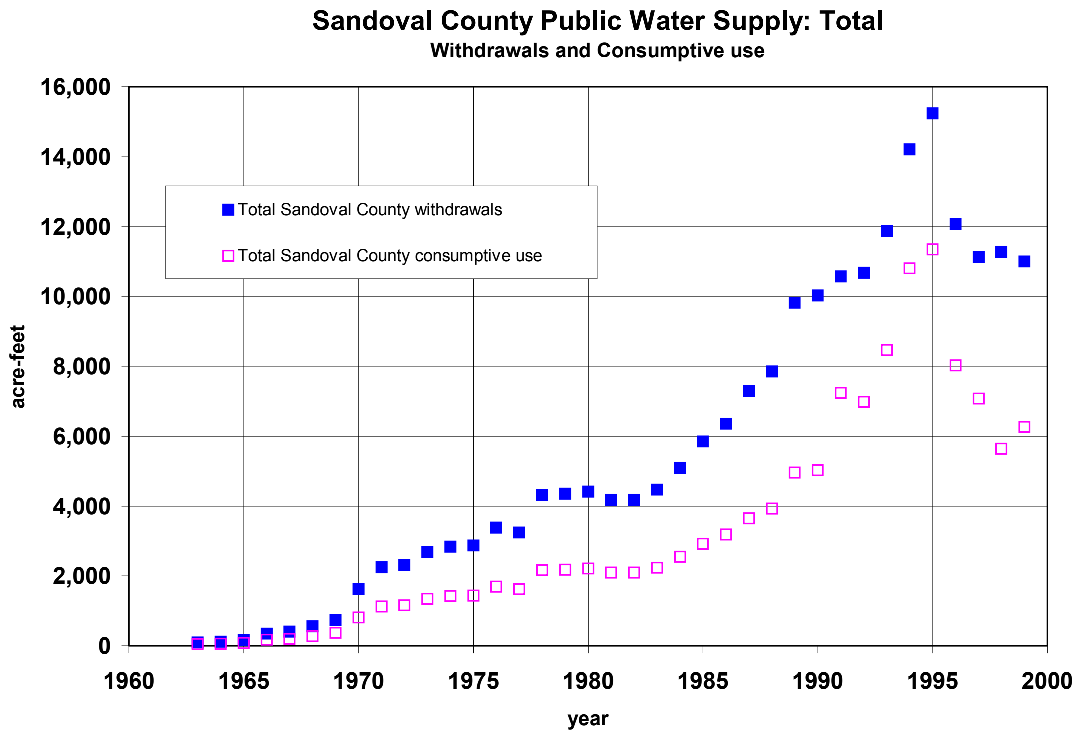

Figure 19. Public water-supply withdrawals and consumptive use for Sandoval County.

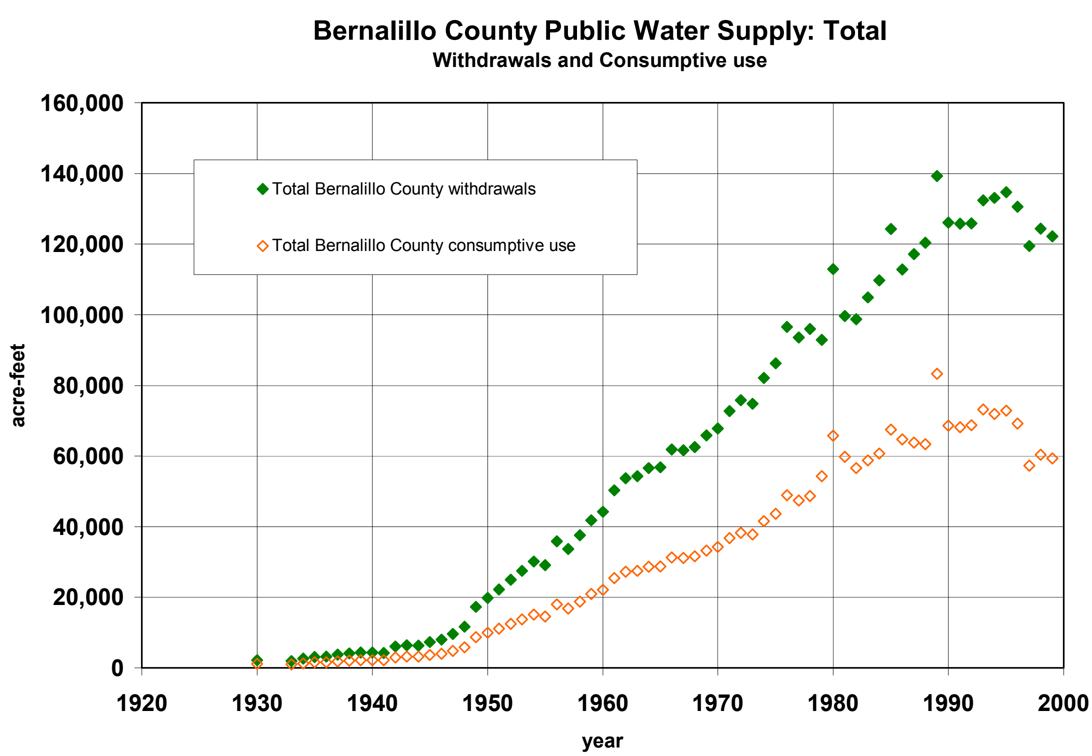

Figure 20. Public water-supply withdrawals and consumptive use for Bernalillo County.

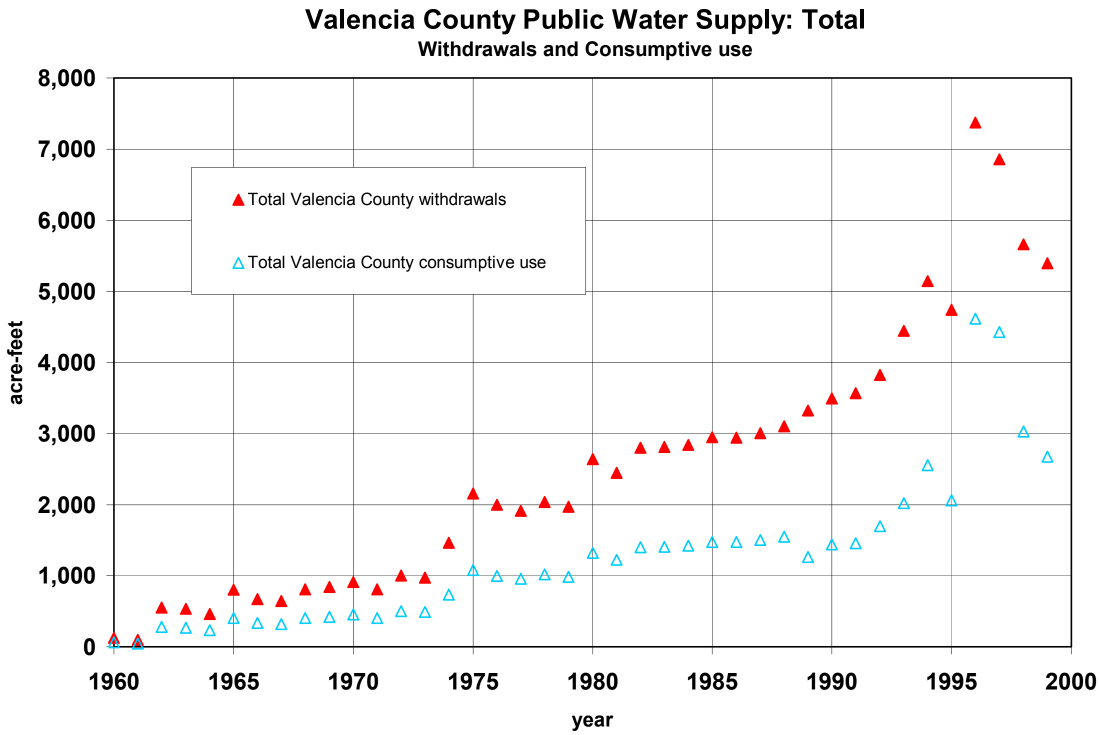

Figure 21. Public water-supply withdrawals and consumptive use for Valencia County.

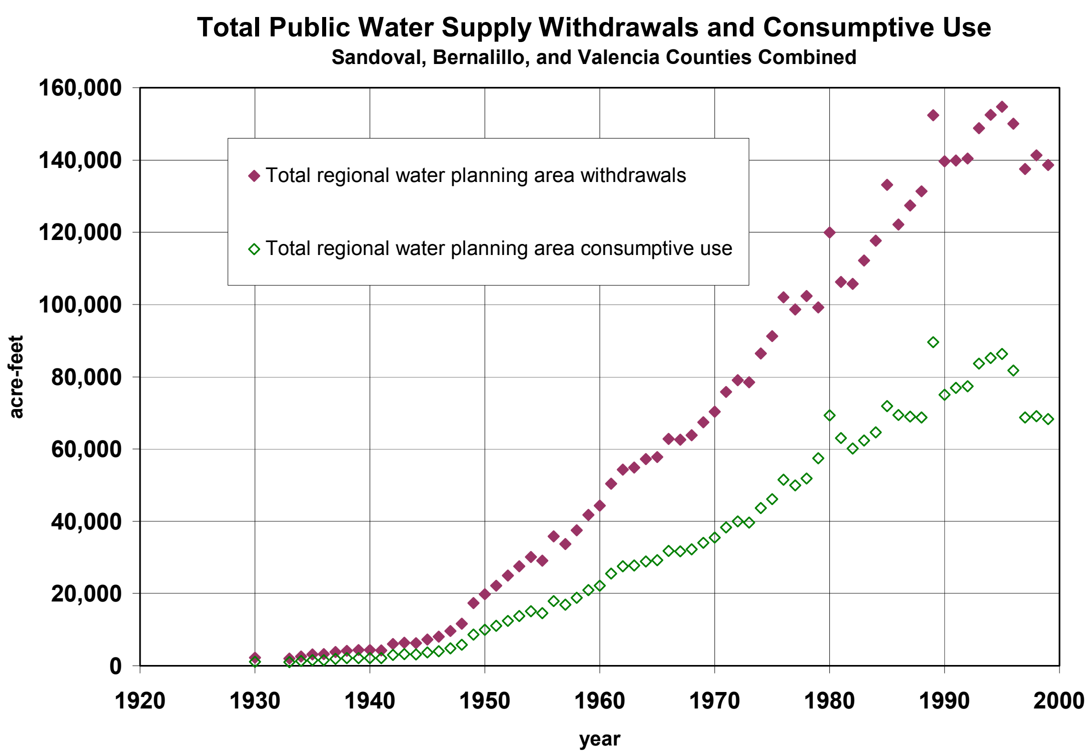

Figure 22. Public water-supply withdrawals and consumptive use for the Middle Rio Grande region.

Sub-category wastewater return data were provided only by COA. Table 20 summarizes sewer return by sub-category, and Figure 23 is a graph of sub-category wastewater return by year. Figure 24 is a bar graph of sub-category wastewater return to the City's wastewater treatment plant for 1983, 1985, 1990, 1995, and 1999. Sub-category data are based on billed units and include residential, commercial, institutional, and industrial. The “total billed contract column” contains billing amounts for self-supplied water users that use the COA WTP. Table 21 shows billed sewer and billed water data by sub-category for COA. Unaccounted for sewer is the percent difference of measured discharge from the COA WTP and sewer total.

Seasonal water use is very important to public water suppliers. Many public water suppliers estimate consumptive use and return flow based on averages of water use during winter and summer months. Moreover, estimates of indoor and outdoor water use are based on seasonal variations. Generally, four months comprise the winter months (January, February, March, and December of the previous year), and eight months comprise the summer average (April, May, June, July, August, September, October, and November). COA provided seasonal water data from 1986 to 1999, however, calculations of summer and winter averages were inconsistent because some years are based on seven summer months and some are based on eight summer months. In 1999, COA indoor use is calculated as the average water use during four winter months multiplied by 12. Outdoor use is calculated as total water sales minus indoor use. In 1999, about 35 percent of the water delivered to the residential sub-category went to outdoor uses.

Table 20. Wastewater return by sub-category to the City of Albuquerque wastewater treatment plant according to billing units

	residential sewer (ac-ft)	commercial sewer (ac-ft)	institu-tional sewer (ac-ft)	industrial sewer (ac-ft)	total sub-category sewer (ac-ft)	total contract sewer (ac-ft)	total sub-category and contract sewer (ac-ft)	total discharged to river (measured)	percent unaccounted for sewer
1983	22,709	11,306	1,887	1,574	37,477	2,210	39,686	45,966	14%
1984	25,349	12,454	2,405	1,942	42,149	2,210	44,359	48,809	9%
1985	24,279	13,058	2,128	1,540	41,006	2,210	43,215	48,436	11%
1986	26,830	12,960	2,297	1,393	43,479	2,210	45,689	47,885	5%
1987	26,193	13,095	2,276	1,333	42,896	3,010	45,906	53,076	14%
1988	28,361	14,118	2,355	1,862	46,697	3,269	49,966	56,893	12%
1989	29,222	14,851	2,677	1,928	48,678	3,520	52,198	55,701	6%
1990	28,670	15,255	2,757	1,790	48,472	3,963	52,435	57,238	8%
1991	37,279	16,045	3,511	1,871	58,705	4,372	63,077	57,319	-10%
1992	27,763	16,377	2,710	1,991	48,842	4,990	53,831	56,986	6%
1993	26,883	15,756	2,310	1,928	46,877	7,553	54,430	59,036	8%
1994	30,335	16,484	2,342	1,760	50,920	8,675	59,595	60,984	2%
1995	28,985	17,265	2,303	2,167	50,720	9,928	60,648	61,369	1%
1996	28,170	17,433	2,543	2,333	50,479	9,313	59,791	61,081	2%
1997	26,709	17,169	2,470	2,290	48,638	8,843	57,482	62,061	7%
1998	25,055	16,418	2,390	2,318	46,182	9,956	56,138	63,810	12%
1999	29,098	17,337	2,715	2,631	51,782	10,492	62,274	62,207	0%
average % total (billed sub-category and contract)	53%	28%	5%	4%			10%		

Source: City of Albuquerque
ac-ft acre-feet

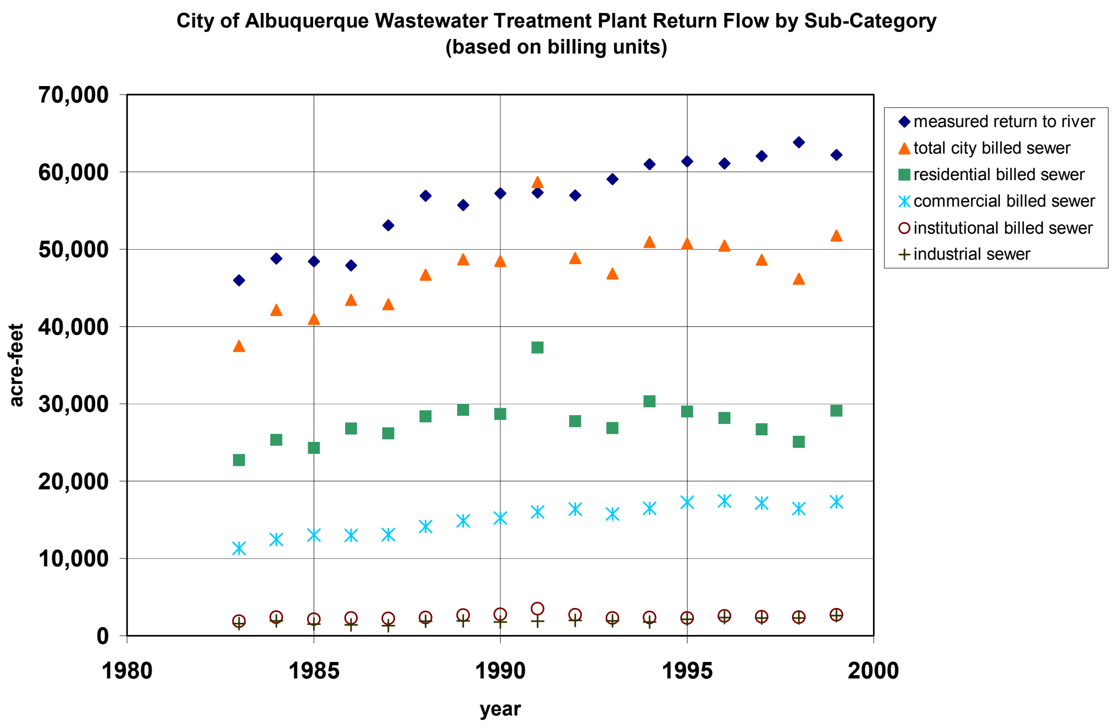

Figure 23. City of Albuquerque wastewater treatment plant return flow by sub-category (based on billing units).

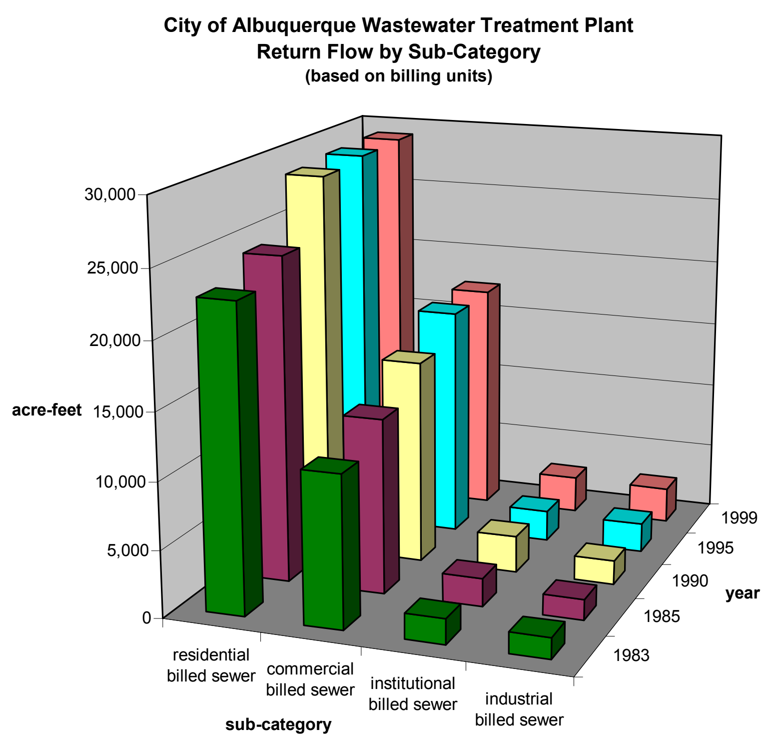

Figure 24. City of Albuquerque wastewater treatment plant return flow by sub-category for 1983, 1985, 1990, 1995, and 1999 (based on billing units).

Table 21. Summary of City of Albuquerque water sales and billed sewer data

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Residential billed water	50,139	51,142	51,700	58,478	62,128	61,237	73,620	66,097	67,154	66,601	70,508	69,484	66,402	63,745	58,411	61,353	59,104
Residential billed sewer	22,709	25,349	24,279	26,830	26,193	28,361	29,222	28,670	37,279	27,763	26,883	30,335	28,985	28,170	26,709	25,055	29,098
% returned	45%	50%	47%	46%	42%	46%	40%	43%	56%	42%	38%	44%	44%	44%	46%	41%	49%
Commercial billed water	19,392	20,660	22,196	24,375	26,101	27,119	30,414	29,743	30,387	30,140	31,597	32,408	34,108	33,950	32,081	31,868	30,847
Commercial billed sewer	11,306	12,454	13,058	12,960	13,095	14,118	14,851	15,255	16,045	16,377	15,756	16,484	17,265	17,433	17,169	16,418	17,337
% returned	58%	60%	59%	53%	50%	52%	49%	51%	53%	54%	50%	51%	51%	51%	54%	52%	56%
Institutional billed water	6,863	7,471	7,192	8,251	9,143	9,967	11,257	11,299	11,289	10,509	11,661	11,540	12,007	12,249	11,158	10,206	10,378
Institutional billed sewer	1,887	2,405	2,128	2,297	2,276	2,355	2,677	2,757	3,511	2,710	2,310	2,342	2,303	2,543	2,470	2,390	2,715
% returned	27%	32%	30%	28%	25%	24%	24%	24%	31%	26%	20%	20%	19%	21%	22%	23%	26%
Industrial billed water	2,752	2,765	2,288	2,220	2,342	2,753	3,075	2,752	2,937	2,891	2,838	2,691	3,182	3,342	3,030	3,076	3,104
Industrial billed sewer	1,574	1,942	1,540	1,393	1,333	1,862	1,928	1,790	1,871	1,991	1,928	1,760	2,167	2,333	2,290	2,318	2,631
% returned	57%	70%	67%	63%	57%	68%	63%	65%	64%	69%	68%	65%	68%	70%	76%	75%	85%
Total billed water	79,145	82,039	83,375	93,324	99,715	101,075	118,365	109,891	111,768	110,141	116,603	116,122	115,700	113,286	104,680	106,503	103,433
Total billed sewer	37,477	42,149	41,006	43,479	42,896	46,697	48,678	48,472	58,705	48,842	46,877	50,920	50,720	50,479	48,638	46,182	51,782
	47%	51%	49%	47%	43%	46%	41%	44%	53%	44%	40%	44%	44%	45%	46%	43%	50%
Total pumped water	97,214	101,778	100,088	104,988	109,400	112,394	129,327	117,311	116,864	116,090	123,423	124,167	124,821	120,254	110,375	113,578	110,388
Total billed water	79,145	82,039	83,375	93,324	99,715	101,075	118,365	109,891	111,768	110,141	116,603	116,122	115,700	113,286	104,680	106,503	103,433
unaccounted for water (total pumped minus total billed)	18,069	19,739	16,713	11,664	9,685	11,319	10,962	7,420	5,096	5,949	6,820	8,045	9,121	6,968	5,695	7,075	6,955
percent unaccounted for water	19%	19%	17%	11%	9%	10%	8%	6%	4%	5%	6%	6%	7%	6%	5%	6%	6%
Total contract billed sewer	2,210	2,210	2,210	2,210	3,010	3,269	3,520	3,963	4,372	4,990	7,553	8,675	9,928	9,313	8,843	9,956	10,492
Total measured discharge to the river	45,966	48,809	48,436	47,885	53,076	56,893	55,701	57,238	57,319	56,986	59,036	60,984	61,369	61,081	62,061	63,810	62,207
COA+contract total billed sewer use	39,686	44,359	43,215	45,689	45,906	49,966	52,198	52,435	63,077	53,831	54,430	59,595	60,648	59,791	57,482	56,138	62,274
unaccounted for sewer	6,279	4,450	5,221	2,196	7,171	6,927	3,503	4,803	-5,759	3,155	4,606	1,389	722	1,290	4,579	7,672	-67
percent unaccounted for sewer	14%	9%	11%	5%	14%	12%	6%	8%	-10%	6%	8%	2%	1%	2%	7%	12%	0%

Source: City of Albuquerque (COA)

5.1.2.8 Analysis

As shown in Figure 13, the largest public water-supplier is COA, which withdrew over four times the amount of water of all other public water suppliers in the Middle Rio Grande Region in 1998. In 1998, COA withdrew over eleven times as much water as the City of Rio Rancho, the next largest water user in the study area. When the study area is divided into smaller regions (counties or subregions), it follows that Bernalillo County and the MRGV subregion have the highest public water-supply use. Moreover, the MRGV subregion includes the majority of the other major population centers, such as Rio Rancho, Belen, Los Lunas, Bosque Farms, Meadowlake, Rio Communities, Paradise Hills, Sandia Park, and other communities. In 1995, public water supply use in the MRGV subregion was over 400 times that of the Rio Puerco and Rio Jemez subregions combined (Table 3 and Figure 11). Public water suppliers within the Rio Puerco subregion include La Jara, Regina, and Cuba, and communities within the Rio Jemez subregion include Jemez Springs, San Ysidro, and Ponderosa.

COA delivers water to commercial, industrial, residential, institutional, and other uses. In 1999, approximately 54 percent of the water delivered by COA was sold to residential users and 28 percent was sold to commercial enterprises. Institutional users used 10 percent, and industrial and uses within the city comprised the remaining 8 percent. Figure 16 illustrates that from 1980 to 1999, water sales to the residential sub-category decreased as a percentage of total deliveries. Figure 17 illustrates a decline in gpcd water-use rates starting in the early 1990s. These trends indicate that COA's water conservation efforts have had some impact in reducing water use. However, despite the fact that the average gpcd in Albuquerque has decreased in the last ten years, continued population growth has meant that the actual volume of water withdrawn for public water supply has not decreased much in that time.

5.2 Self-Supplied Domestic

Includes self-supplied residences which may be single-family dwellings or multifamily dwellings with wells permitted by the NMOSE under section 72-12-1 NMSA, where water is used for normal household purposes such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, evaporative cooling, water softener regeneration and watering lawns and gardens; and livestock watering provided that this is not the sole purpose of use. This use "also includes water used by that segment of the population that is served by small community water systems for which reliable population and water use data are unavailable (Wilson, 1992)."

Data regarding self-supplied domestic withdrawals and consumptive use were available only for the years of the NMOSE water-use inventories. Self-supplied domestic use is based on population and estimates of gpcd. Each domestic well is entitled to 3 acre-feet per year diversion, but actual average diversions are much less. Because meters are not required on domestic wells serving single families, the per capita consumption is estimated based on previous studies. The NMOSE inventories use an average daily consumption value ranging from 50 to 150 gpcd within the regional water planning area, based on varying water requirements for indoor use, landscape irrigation, and evaporative cooling (Wilson and Lucero, 1997).

Of the water withdrawn for self-supplied domestic users, much of what is consumed is a result of "outdoor" uses, such as lawn and garden irrigation and the use of evaporative coolers. Water that is used indoors (such as for showering, or washing dishes and clothes) is often discharged into either a municipal sewer system, where it is ultimately recycled or sent to the Rio Grande, or into a septic tank, where it can seep into the shallow ground-water system.

Table 22 summarizes the water withdrawal and consumption by domestic water users in the regional water planning area for the inventory years. The 1980 and 1985 inventories did not provide data for urban water use in Corrales within Bernalillo County or any estimates of ground-water consumptive use.

Table 22. Self-supplied domestic water-supply withdrawals in the regional water planning area

			1980				1985			
county	**water supplier / user**	**census class**	**1980 pop.**	**gpcd**	**ground-water withdrawal**	**ground-water depletion**	**1985 pop.**	**gpcd**	**ground-water withdrawal**	**ground-water depletion**
Sandoval	Corrales (self-supplied homes)	urban	17,538	50	982	491	ND		ND	ND
	rural self-supplied homes	rural	ND		ND	ND	17,082	60	1,148	ND
	county totals		17,538+		982+	491+	17,082+		1,148+	
Bernalillo	Corrales (self-supplied homes)	urban								
	rural self-supplied homes	rural	22,000	100	2,464	1,232	22,000	100	2,464	ND
	county totals		22,000		2,464	1,232	22,000		2,464	
Valencia	rural self-supplied homes	rural	32,813	60	2,205	992	18,164	60	1,221	ND
	county totals		32,813		2,205	992	18,164		1,221	
	REGION TOTAL		72,351+		5,651+	2,715+	57,246+		4,833+	

self-supplied domestic			**1990**				**1995**			
county	**water supplier / user**	**census class**	**1990 pop.**	**gpcd**	**ground-water withdrawal**	**ground-water depletion**	**1995 pop.**	**gpcd**	**ground-water withdrawal**	**ground-water depletion**
Sandoval	Corrales (self-supplied homes)	urban	4,918	150	826	537	5,378	150	904	479
	rural self-supplied homes	rural	15,038	64	1,078	485	16,479	80	1,477	665
	county totals		19,956		1,904	1,022	21,857		2,380	1,143
Bernalillo	Corrales (self-supplied homes)	urban	535	150	90	58	598	150	100	53
	rural self-supplied homes	rural	30,996	100	3,472	2,083	18,407	100	2,062	1,031
	county totals		31,531		3,562	2,142	19,005		2,162	1,084
Valencia	rural self-supplied homes	rural	25,820	80	2,314	1,041	29,487	100	3,303	1,651
	county totals		25,820		2,314	1,041	29,487		3,303	1,651
	REGION TOTAL		77,307		7,780	4,205	70,349		7,846	3,879

Source: Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997
pop. population (from NMOSE water use inventories)
gpcd gallons per capita per day
ND no data

5.3 Irrigated Agriculture

Includes all diversions of water for the irrigation of crops grown on farms, ranches and wildlife refuges.

Irrigated agriculture is a major water-use category in the Middle Rio Grande region. Water is withdrawn from both the surface- and ground-water systems and applied to agricultural fields. Before reaching the fields, some water seeps out of the conveyance canals and into the ground-water system, is consumed by riparian vegetation, or evaporates from the canals. Wilson (1992) and Wilson and Lucero (1997) estimate that conveyance loss constitutes about 51 percent of water withdrawn from surface-water sources within the MRGCD, and 30 percent outside of the MRGCD. Once water is applied to the fields, it is transpired by the crops, evaporates, percolates into the ground-water system, or returns to the surface-water system. The proportion of water going to each of these four pathways depends on the type of crop, the method of irrigation, and the weather. According to this report, water that is either consumed by the crops or evaporates sometime during the process of conveyance and irrigation is considered consumptive use.

The NMOSE Technical Reports, an NMOSE report on surface-water irrigation, MRGCD records, and the Bureau of Reclamation Regional Water Assessment all contributed information to this section. It is important to emphasize that some values for agricultural water withdrawals and consumptive use are calculated, not measured, and that different organizations calculate or measure agricultural water use within different study regions using different methods. The following discussion describes in more detail the methods and results of these different studies.

5.3.1 Methods

The NMOSE technical reports (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997; Wilson and Lucero, 1998) provide agricultural water withdrawal and consumption estimates, and irrigated acreage data divided by county and by basin within those counties, such as the Jemez Basin and the MRGCD. According to Wilson (1992) the procedure for calculating irrigated-agriculture statistics begins with identifying and tabulating total cropping areas within each county. The NMOSE found cropping area data in a number of different sources, including federal publications (such as those of the Bureau of Indian Affairs (BIA), BOR, U.S. Department of Agriculture (USDA), U.S. Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service, or SCS), etc.), hydrographic surveys, water-rights documents, and aerial photographs. Once cropping areas are identified, the NMOSE determines what kind of crop is being grown, what type of irrigation system (e.g., flood, drip, or sprinkler) is used in each area, and whether the water for irrigation in each area is from surface- or ground-water sources (see Appendix 3). These data, taken together with climatologic records, estimates of the amount of water consumed by the different crop types (estimated by the Blaney-Criddle method), and other factors, are then used to calculate total withdrawal and consumptive use volumes for the irrigated acreage (Blaney and Criddle, 1962; Blaney and Criddle, 1970). Please refer to Wilson (1992, p. 26-46) for a detailed discussion of the NMOSE methods.

The NMOSE has also compiled a report entitled "- water irrigation organizations in New Mexico," authored by Saavedra (1987). This report contains irrigated acreage served by various community ditch systems, or *acequias,* during 1987. A summary of the data found in Saavedra (1987) can be found in Appendix 7.

In their Middle Rio Grande Water Assessment (MRGWA), the BOR calculated yearly estimates of consumptive use requirements for irrigated agriculture within the Albuquerque Basin from 1935 to 1993. Figure 1B shows the BOR study area. Much like the NMOSE, the BOR determined which crops were grown, and used the SCS modified Blaney-Criddle method of estimating crop consumptive use for those crop acreages (Blaney and Criddle, 1970). The BOR did not estimate withdrawals or total irrigable (as opposed to actually *irrigated*) acreage in their study area. A significant difference between the BOR and the NMOSE technical reports is that the BOR considers only the portions of Sandoval, Bernalillo, and Valencia counties that are within the Middle Rio Grande basin, not the entire counties (see Figs. 1A and 1B).

The MRGCD is a political subdivision of the State of New Mexico. The MRGCD manages and keeps records of the delivery of water to irrigate lands in the MRGV. The boundaries of the MRGCD include land along the Rio Grande from Cochiti Dam to San Acacia (Fig. 1C). The MRGCD land is divided into four regions: Cochiti, Albuquerque, Belen, and Socorro. These regions roughly (but not precisely) correspond with the Rio Grande corridor in Sandoval, Bernalillo, Valencia, and Socorro counties, respectively. These regional subdivisions comprise a smaller percentage of total county areas than do the BOR's MRGWA study areas.

In order to calculate cropping areas, the MRGCD ditch-riders estimate irrigated and irrigable acreage, and note the crops being grown in different fields. They also estimate water withdrawals by metering diversions into the MRGCD-operated works. Withdrawal values for most years are provided for the entire MRGCD, which includes Socorro County. For the years between 1996 and 1998, inclusive, water withdrawal data were provided for the four individual regions within the MRGCD. Using these detailed data, we calculated the average percentage of the total withdrawals that are in Sandoval, Bernalillo, and Valencia Counties only. We then calculated that percentage of total withdrawals from all years to estimate the total amount withdrawn within the MRGCD within those three counties. It is this estimated withdrawal value, excluding Socorro County, that will be discussed in Section 5.3.2. The original data, without this calculation, can be found in Appendix 3.

5.3.2 Results

Figure 25 shows irrigated-agriculture water withdrawals, and Figure 26 shows agricultural consumptive use in the Middle Rio Grande counties, as calculated by the NMOSE. Figure 27 shows agricultural withdrawals for the three subregions. A comparison of irrigated acreage of the three counties shows that there has been consistently more water withdrawn for irrigated agriculture in Valencia County than in either Bernalillo or Sandoval counties (Fig. 28). A similar comparison of irrigated acreage in the three subregions shows that a greater area is devoted to agriculture in the Middle Rio Grande subregion than in either the Rio Puerco or Rio Jemez subregions (Fig. 29).

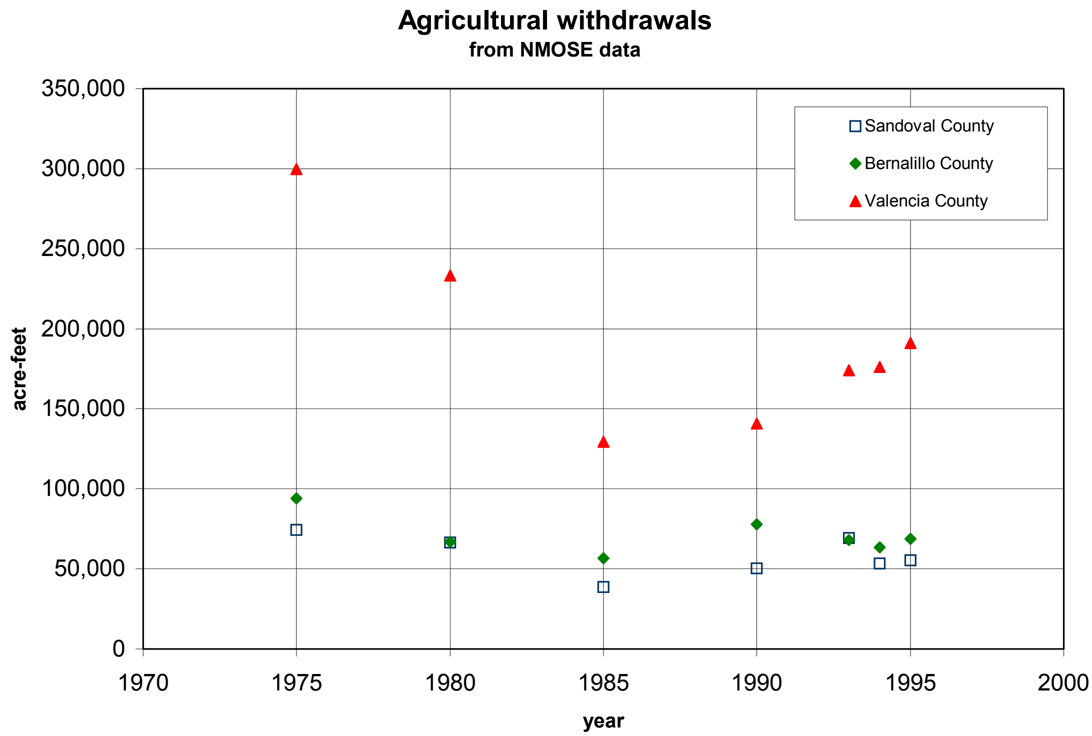

Figure 25. Withdrawals for agriculture, by county (NMOSE estimates).

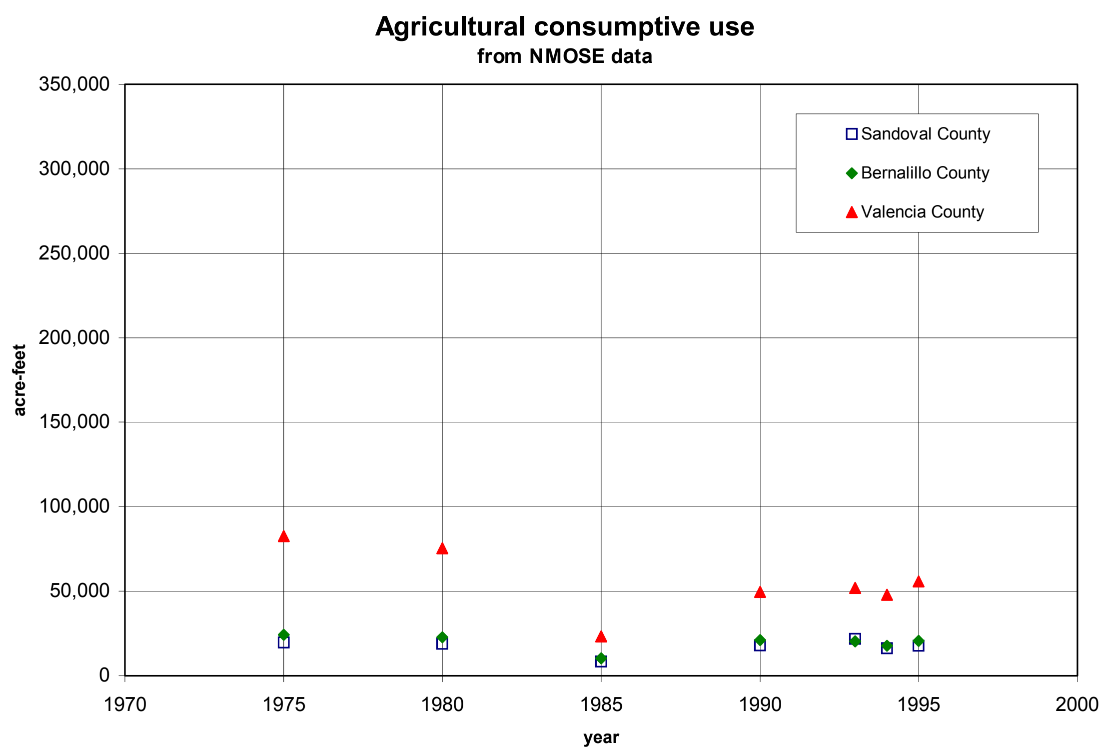

Figure 26. Consumptive use from agriculture, by county (NMOSE estimates).

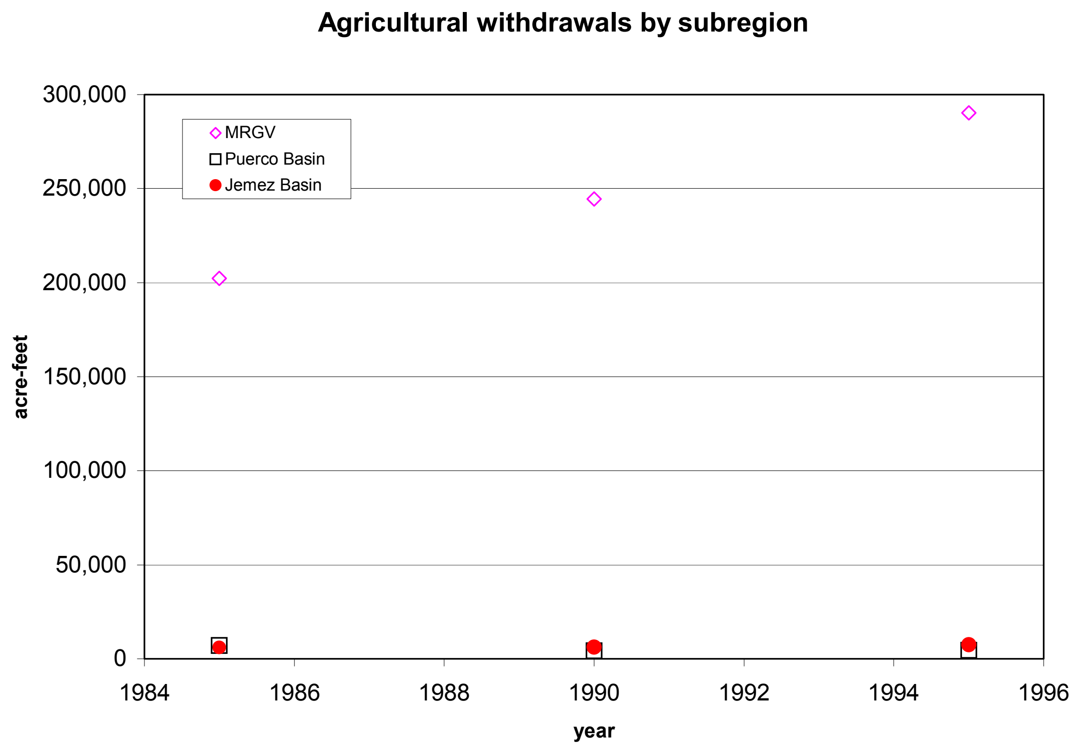

Figure 27. Withdrawals for agriculture, by subregion (NMOSE estimates).

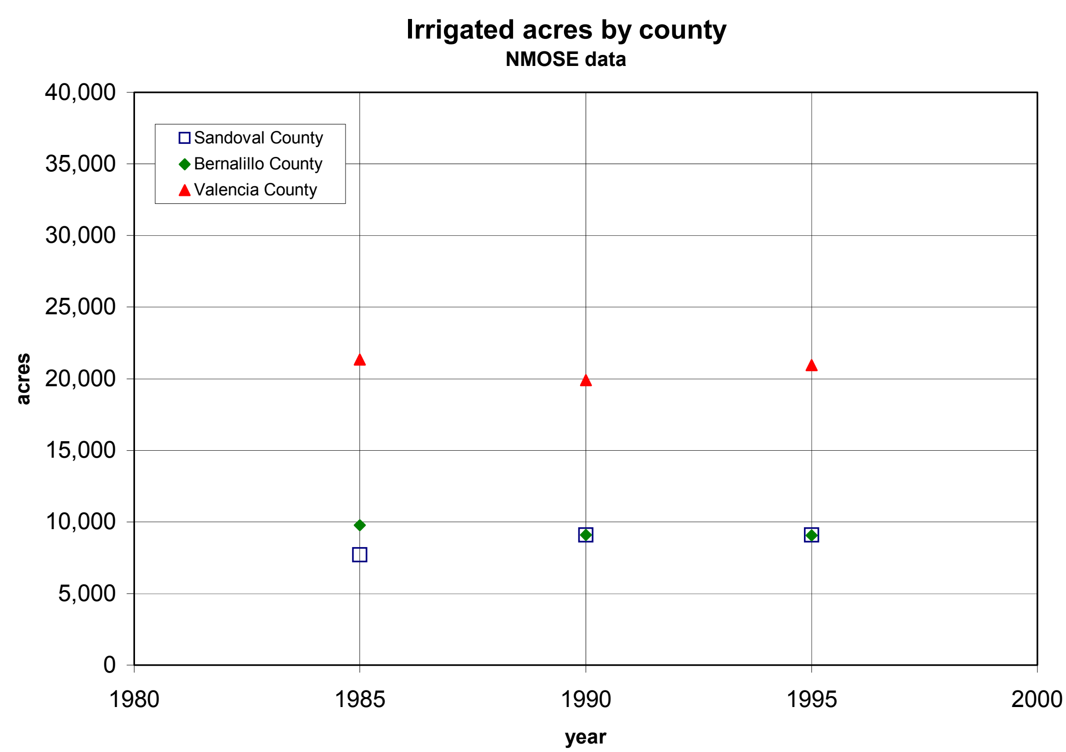

Figure 28. Irrigated acreage, by county (NMOSE estimates).

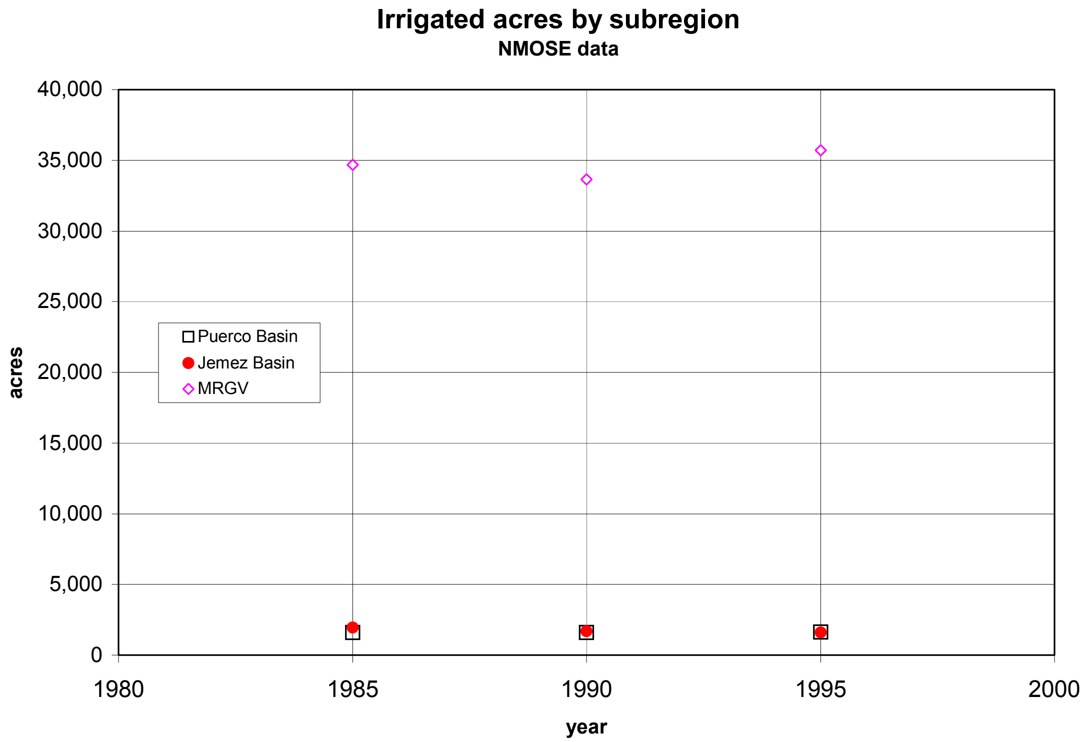

Figure 29. Irrigated acreage by subregion (NMOSE estimates).

Prior to 1981, Valencia County included what is now Cibola County. Table 23 shows the amount of water withdrawn and consumed by irrigated agriculture in 1980 and 1985 for Valencia and Cibola Counties. This table shows that the drastic decreases in withdrawals and consumptive use for Valencia County (as seen in Figs. 25 and 26) are probably not entirely a result of the reconfiguration of the county borders. In fact, only about 11 percent of combined 1985 Valencia and Cibola County agricultural withdrawals (18 percent of consumptive use) occur in Cibola County. Therefore, the 1981 reconfiguration alone probably did not result in the 45 percent decrease in withdrawals (and nearly 70 percent decrease in consumptive use) in Valencia County between 1980 and 1985; rather, this was either a real decrease in irrigated agriculture or an issue with the calculation methods. Appendix 6 contains tables comparing, for all categories, 1980 water withdrawals and consumptive use in Valencia County to 1985 withdrawals and consumptive uses in Valencia and Cibola Counties.

Table 23. Agricultural withdrawals and consumptive use in Valencia and Cibola Counties, 1980 and 1985 (NMOSE data)

	Valencia (including Cibola) 1980	Valencia and Cibola 1985	Valencia 1985	Cibola 1985
agricultural withdrawals	233,330	146,064	129,483	16,601
agricultural consumptive use	75,310	28,402	23,185	5,217

NMOSE publication (Saavedra, 1987), details the number of irrigated acres served by acequias, including the MRGCD works. Table 24 contains a summary of this report. Again, Valencia County has more acres irrigated via acequias than do Bernalillo or Sandoval Counties, and the MRGV subregion has more acres irrigated than the Rio Jemez or Rio Puerco subregions. We have not estimated consumptive use or withdrawals for these acres because the Saavedra report did not specify what kinds of crops were grown in these fields, or indicate how much water is withdrawn for a given number of acres. A table of the acequias, the counties, and subregions in which they are located, and their respective irrigated acreage, is in Appendix 7.

Table 24. Irrigated acres served by acequias for 1987

region	irrigated acres (1987)
Rio Jemez	1,223
Rio Puerco	3,267
Middle Rio Grande Valley	36,765
Sandoval County	8,170
Bernalillo County	10,975
Valencia County	22,110
Total for Middle Rio Grande	41,255

Source: Saavedra, 1987.

The BOR consumptive-use estimates are shown in Figure 30. The BOR calculated consumptive use using a different method than the NMOSE. The BOR used the SCS modified Blaney-Criddle method of calculating evapotranspiration, while the NMOSE used the original Blaney-Criddle method. Also, the BOR considered the Albuquerque Basin region rather than the three counties (Fig. 1B). Finally, before 1990, the NMOSE used long-term climate averages in their calculations, while for their entire record the BOR used yearly climate data. The results of these differences can be seen in Figure 31, a comparison of NMOSE and BOR consumptive use estimates. One can see that in 1975, 1980, and 1985, the two estimates are very different, while from 1990 to 1995, the BOR and NMOSE estimates are very similar.

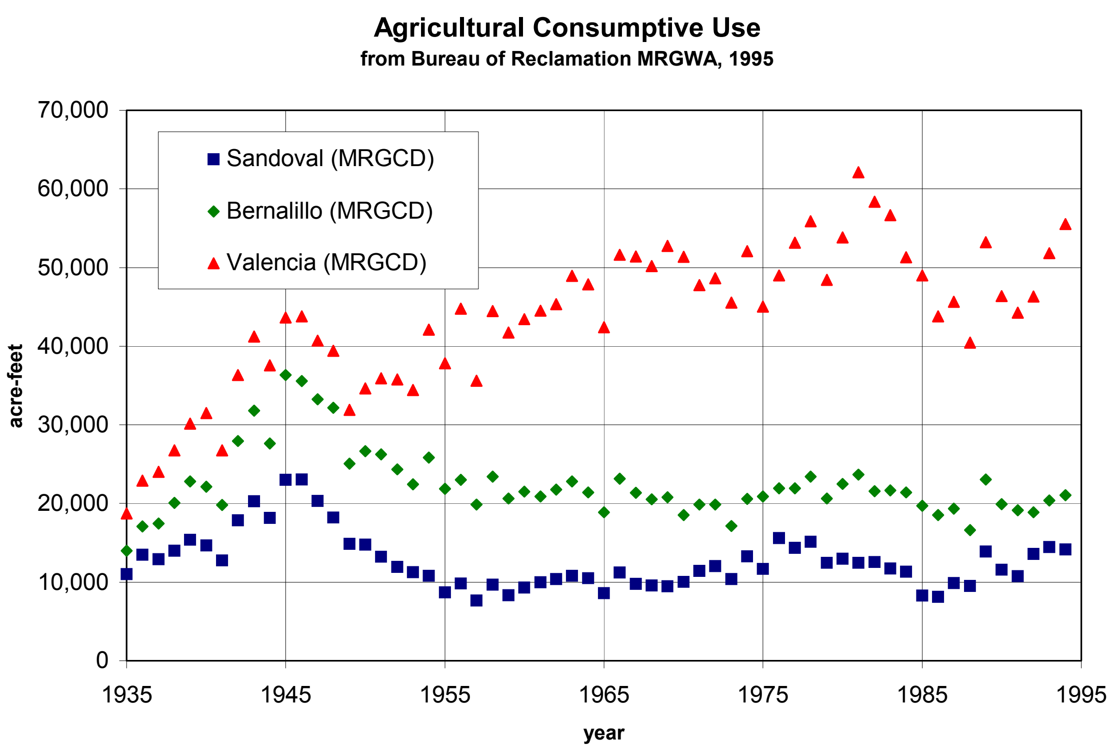

Figure 30. Agricultural consumptive use, by county (BOR estimates, Kinkel, 1995a).

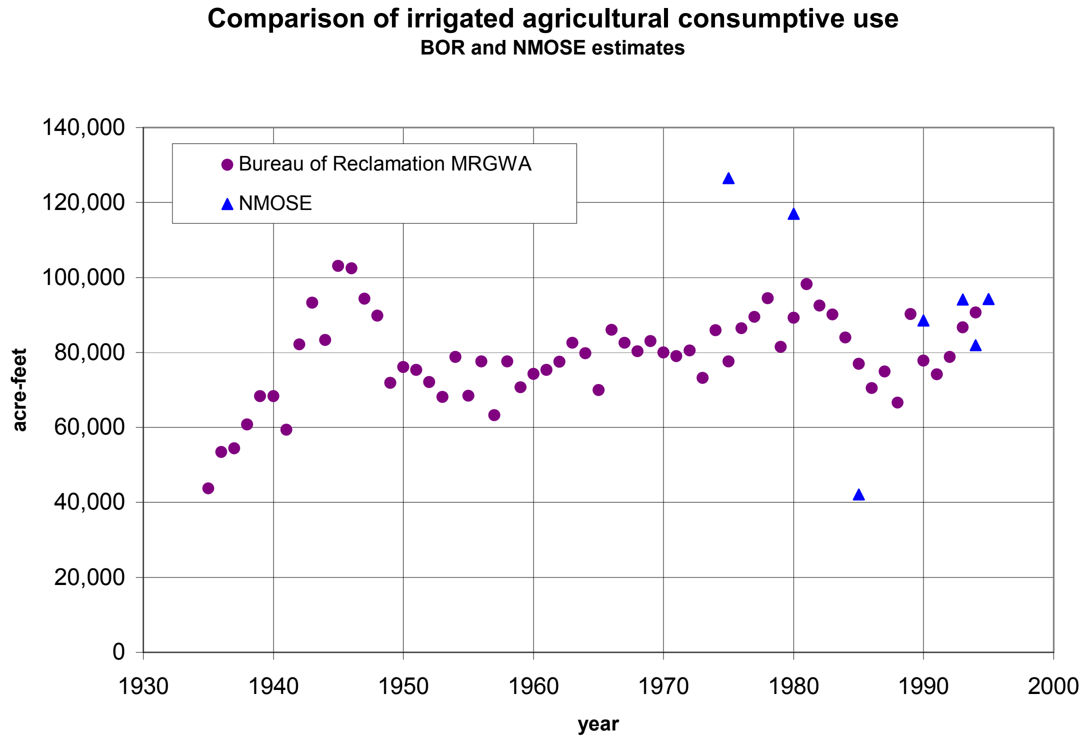

Figure 31. A comparison between NMOSE and BOR estimates of agricultural consumptive use.

The MRGCD has collected data regarding withdrawals for agriculture within its boundaries, which lie entirely within the MRGV subregion. Figure 32 shows that the agricultural withdrawal data set compiled by the MRGCD is quite different from the one calculated by the NMOSE for the MRGCD region. This difference is largely due to the fact that the MRGCD measures the total volume of water diverted from the river and delivered to the system, including water that was ordered but never used by farmers, and water used to flush out the irrigation canals. The NMOSE does not account for these "unused" water withdrawals. Instead, the NMOSE uses a calculation based on conveyance losses and weather conditions to estimate the amount of water required by the irrigation system to actually irrigate fields (Wilson, B., personal communication 2000).

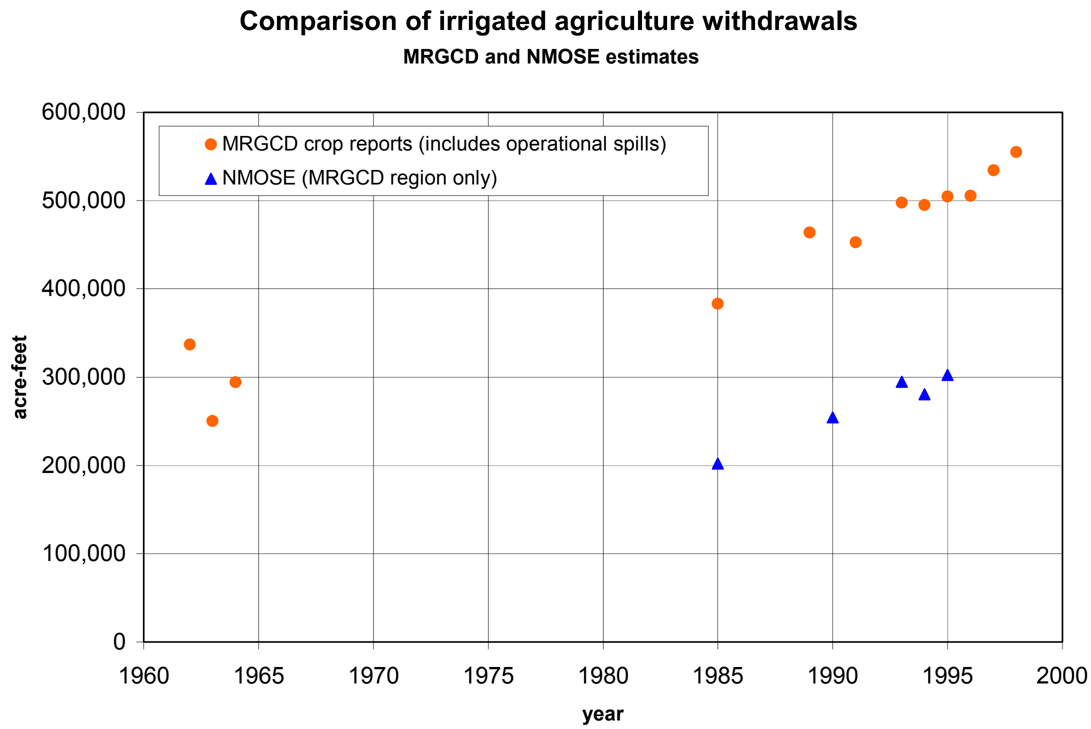

Figure 32. Comparison of MRGCD and NMOSE estimates of irrigated agricultural withdrawals within the MRGCD (Middle Rio Grande Valley subregion).

Some other comparisons can be made between different measurements and estimates used by the three agencies to quantify irrigated agricultural withdrawals and consumption. For example, each measurement of withdrawal or consumption is derived from estimates of acres of irrigated agriculture, and the types of crop grown on those acres. Figure 33 shows the estimates of irrigated agricultural acreage for each agency for the entire study region.

Similarly, when looking at the average amount of water withdrawn or consumed per acre of agriculture (ignoring the different water requirements for different kinds of crops), we can see that both the NMOSE and BOR estimate that about 2 acre-feet are consumed per acre (Fig. 34). When we compare the NMOSE and MRGCD estimates of the amount of water withdrawn per acre, we can see that including operational spills and water that is not actually used increases the amount withdrawn per acre from about 8 ac-ft/ac to over 12 ac-ft/ac.

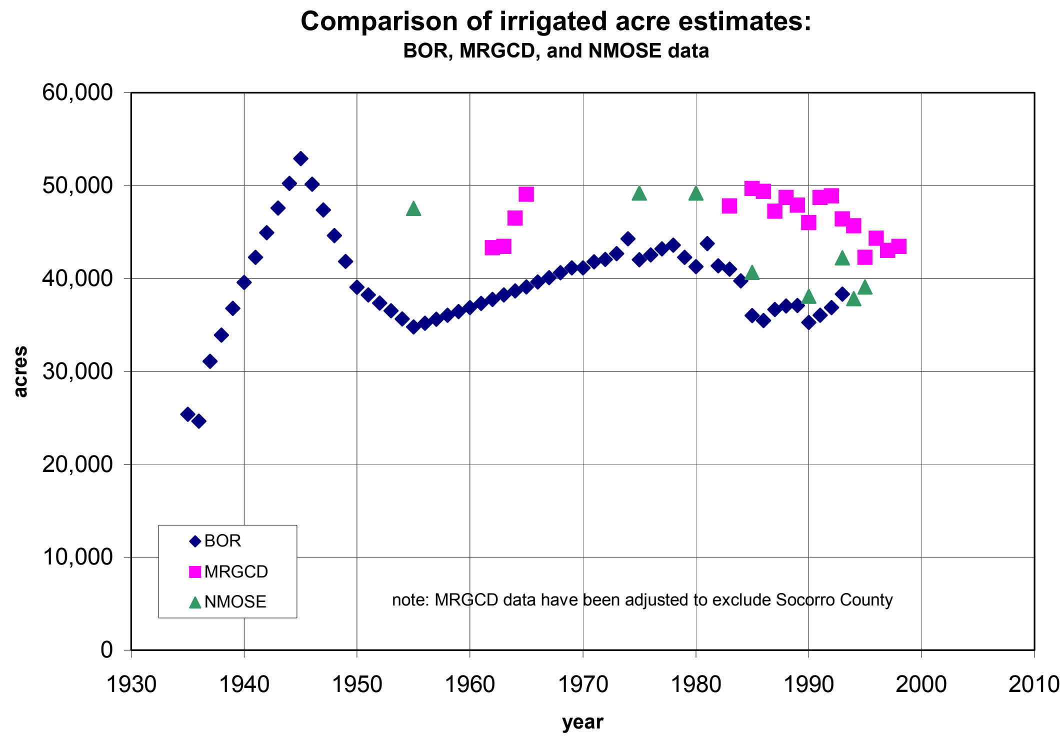

Figure 33. Comparison of irrigated acres used in measurements by the BOR, MRGCD, and NMOSE.

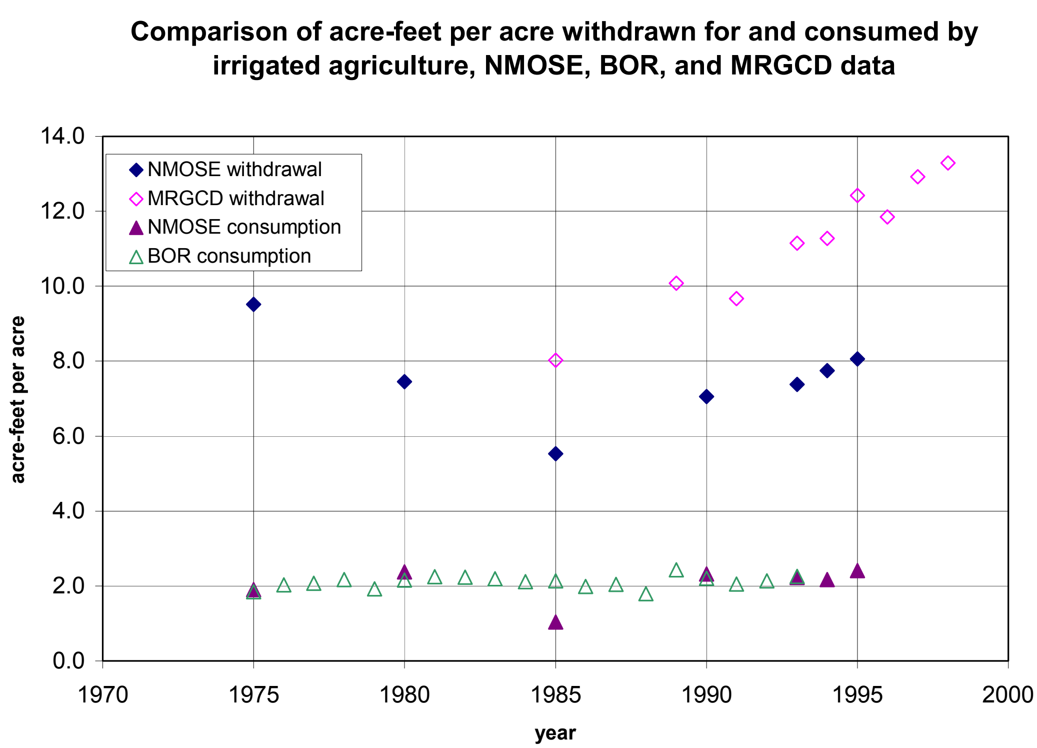

Figure 34. Comparison of acre-feet withdrawn and consumed per acre of irrigation, NMOSE, BOR, and MRGCD estimates.

5.4 Self-Supplied Livestock

Includes water used to raise livestock, maintain self supplied livestock facilities and provide for on-farm processing of poultry and dairy products. (Diversions from wells owned by dairies are placed entirely within this category, even though it is possible some of the water was used for domestic use.)

5.4.1 Methods

Water withdrawal and consumption data for self-supplied livestock were collected from NMOSE Technical Reports (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997), NMOSE databases (1990 and 1995), New Mexico State Agricultural Statistics (NMSAS) (Gore and Wilken, 1991; 1992; 1993; 1994; 1995; 1996; 1997), the USGS withdrawal database, and the NMOSE meter-record database. The 1990 and 1995 NMOSE reports and databases divide water use by livestock into different categories: beef cattle, pigs, sheep, milk cows, and chickens; populations of these animals are multiplied by species-specific per-capita water consumption (Table 25). The NMOSE also distinguishes livestock water consumption between ground- and surface-water sources. For recent years (1991-1997) not covered by the NMOSE technical reports, we have used data from the NMSAS reports to estimate livestock water use. The NMSAS provide population data for beef cattle, milk cows, and sheep only, which we then multiplied by the NMOSE per-capita daily consumption value for each species. Data from the NMOSE meter records account only for water pumped by individual farm or dairy wells, and do not include evaporation from stock ponds.

Table 25. Water requirements for different livestock species, gallons per animal per day

livestock species	gallons per animal per day
beef cattle	10
chickens	0.08
hogs	3
horses	13
milk cows	100
sheep	2.2

Source: Wilson and Lucero, 1997.

5.4.2 Results

Water consumption by livestock constitutes a relatively small portion of the total water consumption in the Middle Rio Grande. Figure 35 shows a combination of NMOSE and NMSAS-derived livestock withdrawal values; years 1975, 1980, 1985, 1990, and 1995 are from NMOSE estimates, while the others are calculated from NMSAS livestock populations. It does appear that livestock water withdrawals are increasing. This increase in water withdrawal may reflect the recent expansion in the dairy industry in New Mexico.

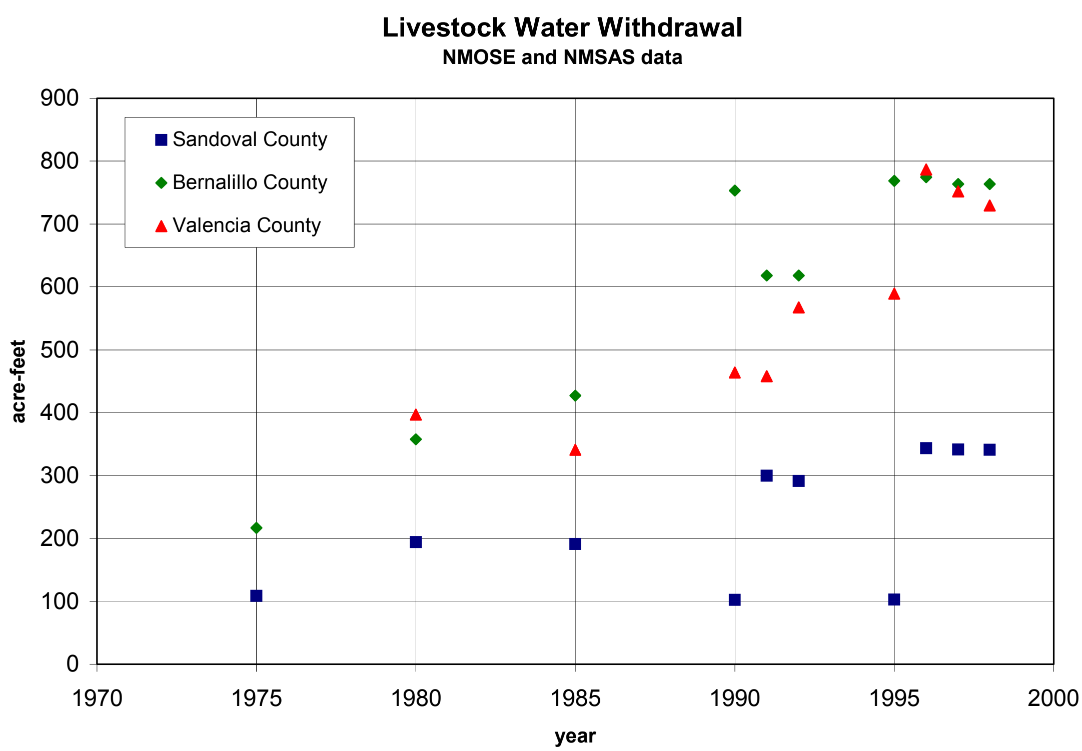

Figure 35. Livestock water withdrawals by county.

5.5 Self-Supplied Commercial

Includes self-supplied businesses (e.g. motels, restaurants, recreational resorts and campgrounds) and institutions (e.g. schools, churches, and hospitals), public or private, involved in the trade of goods or provision of services. Self-supplied golf courses which are not otherwise included in the Public Water Supply category are included, as well as cemeteries, greenhouses, and nurseries. Off-stream fish hatcheries engaged in the production of fish for release are also included.

5.5.1 Methods

Data for commercial water users were collected from NMOSE reports (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997), the NMOSE meter record database, and the USGS records related to the ground-water flow model of the Albuquerque Basin (Kernodle et al., 1995). Commercial use data provided by the NMOSE prior to 1985 (Sorensen, 1977; 1982) are based on numbers of employees and per-capita water use for individual businesses. Wilson (1986), Wilson (1992), and Wilson and Lucero (1997), as well as the 1990 and 1995 NMOSE water-use databases calculate their estimates of commercial consumption from ground-water withdrawals based on meter records. The NMOSE changed this category significantly in 1990 to better follow the divisions used nationwide by the USGS. Prior to 1990, self-supplied golf courses and parks were included in a Recreation category, and off-stream fish hatcheries were included in Fish and Wildlife. For consistency, we have rearranged the data from the early reports when possible to be consistent with the categories used in the recent ones. Commercial users are also supplied by public water suppliers (as discussed in Section 5.1). Combined self-supplied and municipally supplied commercial water use is discussed in Section 6.

5.5.2 Results

Self-supplied commercial water use is relatively small, measured in the thousands of acre-feet per year (Fig. 36). Recent data show that the largest individual self-supplied commercial water users in the MRG region are the golf courses and country clubs in the area, hospitals, cemeteries, and the University of New Mexico (Table 26). Withdrawals for the golf courses on Santa Ana and Isleta lands were estimated for inclusion in this section, as noted in Section 4. The discrepancy between the meter-record data and the NMOSE report data (most noticeable in 1985) is a result of incomplete meter records prior to 1990.

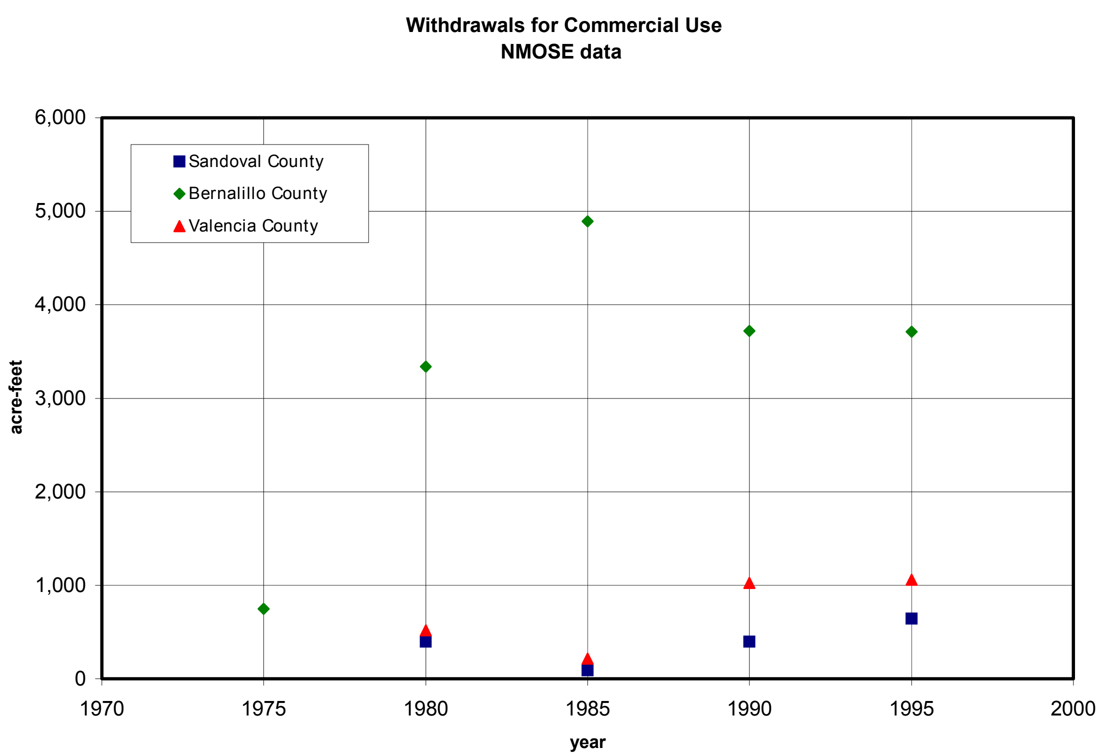

Figure 36. Self-supplied commercial water withdrawal, by county.

Table 26. Self-supplied commercial water use in the Middle Rio Grande counties for 1995 (data from NMOSE database for 1995)

commercial water user (all data in acre-feet)	withdrawal (1995)	consumptive use (1995)
Sandoval County		
golf courses	339	312
schools	145	113
churches	4	2
other private commercial use	113	37
other public commercial use	34	21
total Sandoval County commercial	647	492
Bernalillo County		
golf courses	722	539
cemeteries	200	160
hospitals	129	58
schools	90	71
churches	15	7
University of New Mexico (includes two golf courses)	2,271	1,473
other private commercial use	243	102
other public commercial use	31	22
total Bernalillo County commercial	3,711	2,440
Valencia County		
golf courses	667	493
medical facilities	135	61
schools	186	99
churches	5.16	2
other private commercial use	60	28
other public commercial use	6	3
total Valencia County commercial	1,059	686
total commercial use	5,417	3,619

5.6 Self-Supplied Industrial

Includes self-supplied enterprises engaged in the processing of raw materials (organic or inorganic-solids, liquids or gasses) or the manufacturing of durable or non-durable goods. Water used for the construction of highways, subdivisions, and other construction projects is also included.

5.6.1 Methods

Data for industrial water use come from NMOSE Technical Reports (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997), the NMOSE meter-record database, the COA, and USGS records compiled for the Albuquerque Basin ground-water flow model (Kernodle et al., 1995). Because of changes in the methodology of calculating withdrawals and consumptive uses for industrial use, some of the early NMOSE data appear to be anomalous. For example, in 1975 they estimate industrial withdrawal at over 2,000 acre-feet, while according to their meter records, none of the four or five individual industrial water users used more than 50 acre-feet during the five years before or after 1975. Wilson and Lucero (1997) also indicate that industrial water users can sometimes be delinquent in turning in meter records. Therefore, they have supplemented the available data by looking at water withdrawals for individual users in the surrounding years.

5.6.2 Results

Despite the lack of consistency among data sources, it is apparent that overall self-supplied industrial water use has increased through time. According to the NMOSE meter records, industrial water withdrawals remained fairly constant from 1963 until about 1980 and then increased slowly until 1990 (Fig. 37). In 1995, a major water user, Intel Corporation, expanded its operations and began production from three large supply wells, doubling Sandoval County's self-supplied industrial water demand. Prior to 1995, Intel was buying water from the water system that supplies the City of Rio Rancho. Intel currently (1999) purchases 1,120 acre-feet per year from the City of Rio Rancho water system. However, even with Intel's use included (and not considering the fact that a relatively high proportion of the water withdrawn is returned to the Rio Grande), when compared to other major water users, self-supplied industrial water use is relatively small.

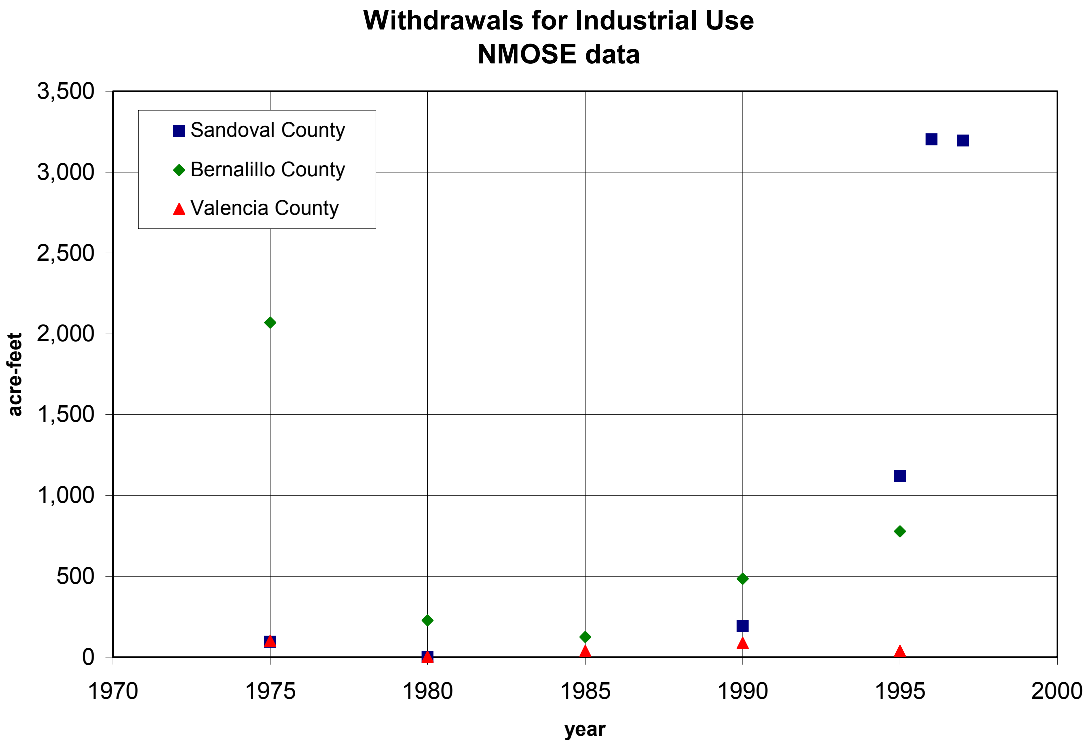

Figure 37. Self-supplied industrial water withdrawals by county.

5.7 Self-Supplied Mining

Includes self-supplied enterprises engaged in the extraction of minerals occurring naturally in the earth's crust: solids, such as coal and smelting ores; liquids, such as crude petroleum; gasses, such as natural gas. Water used for oil and gas well drilling, secondary recovery of oil, quarrying, milling (crushing, screening, washing, flotation, etc.) and other processing done at the mine site, or as part of a mining activity is included as well as water removed from underground excavations and stored in and evaporated from tailings ponds. Mining also includes water used to irrigate new vegetative covers at former mine sites that are being reclaimed. It does not include the processing of raw materials such as smelting ores unless this activity occurs as an integral part of and is physically contiguous with a mining operation.

The sources of data for water use by mining companies include NMOSE Technical Reports (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997), NMOSE meter records, and unpublished USGS records. A few major companies withdraw the majority of water for mining use: LaFarge, (previously Western Mobile and Albuquerque Materials), Calmat (previously Albuquerque Gravel Products), and Centex American Gypsum, all in Sandoval County. Valencia Travertine is the only mining operation to report meter readings in Valencia County. Overall, reported mining water use is small in the MRG (Fig. 38).

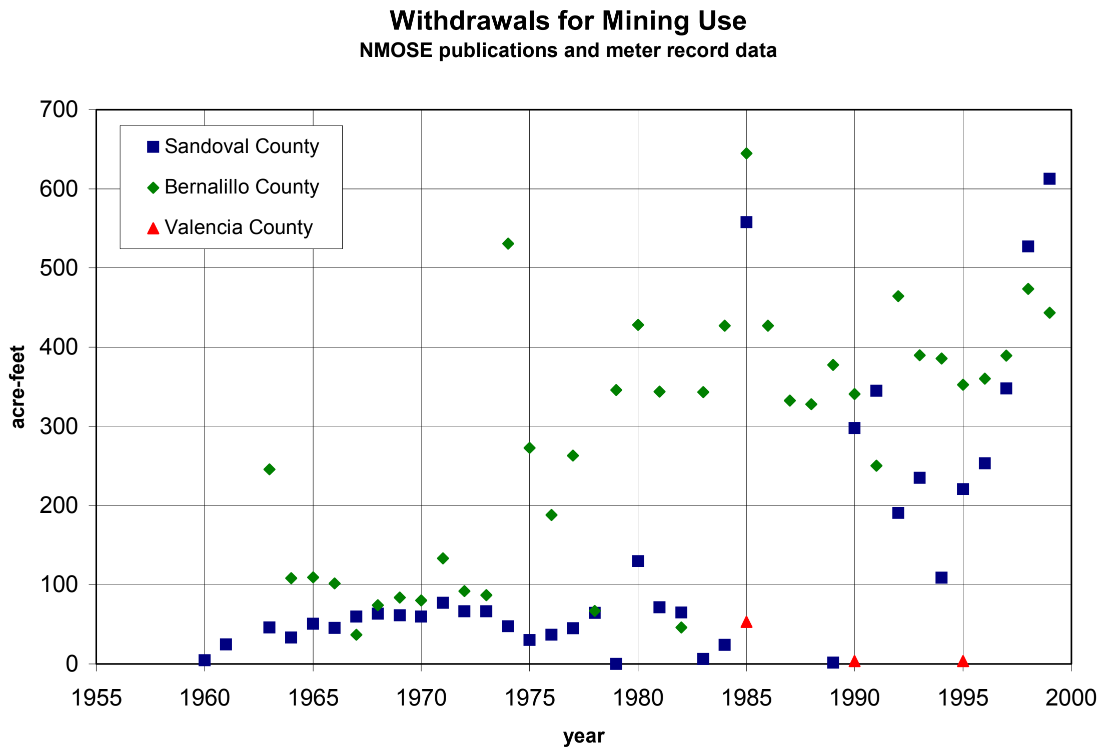

Figure 38. Self-supplied mining withdrawals.

5.8 Self-Supplied Power

Includes all self-supplied power generating facilities. Water used in conjunction with coal mining operations that are contiguous with a power generating facility that owns and/or operates the mines is also included.

Water use data for power companies were collected from three different sources: NMOSE Technical Reports (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997), NMOSE meter records, and USGS compilations of meter records (Kernodle et al., 1995). In Bernalillo County, the only self-supplied power company is Public Service Company of New Mexico (PNM). PNM started buying water from the COA in the mid-1980s to supply its power plants, causing the decline seen in Figure 39. There have not been any power companies operating in either Sandoval or Valencia counties within the past decade.

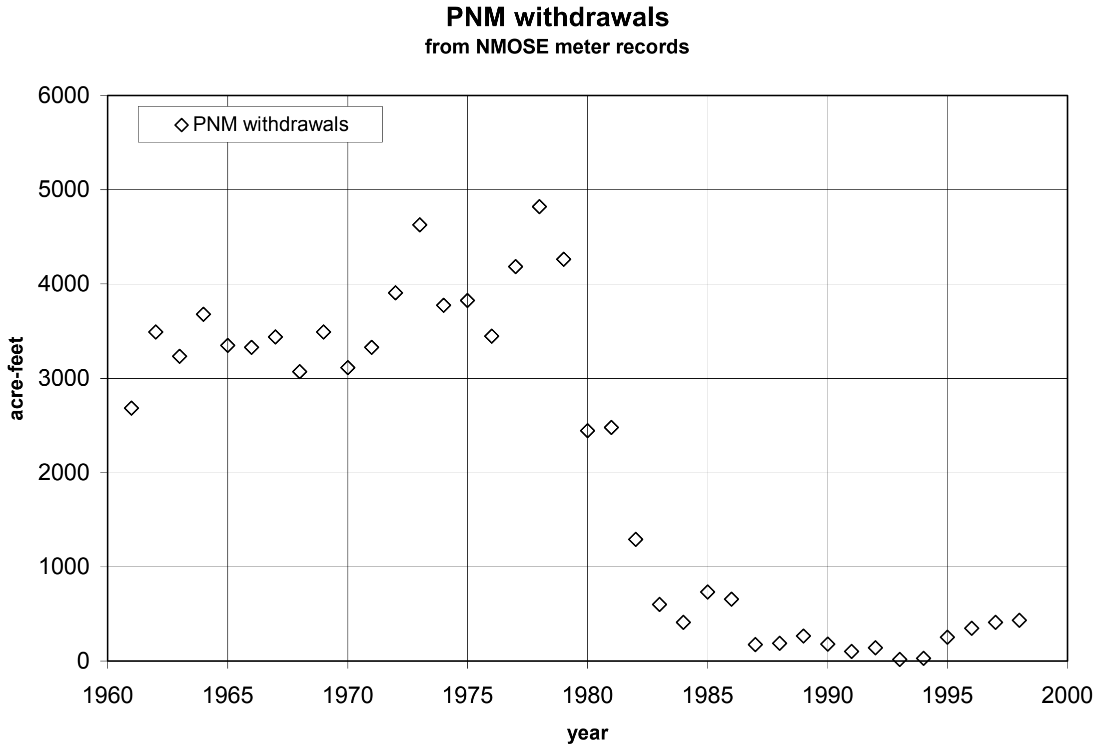

Figure 39. PNM water withdrawals, 1961 to 1998.

5.9 Open-water evaporation

Open-water evaporation: Net evaporation from man-made and natural channels and from man-made and natural reservoirs. Does not include ephemeral channels.

5.9.1 Methods

Evaporation from open-water surfaces is a significant source of water consumptive use in the Middle Rio Grande Region. The BOR MRGWA (Gould, 1995) calculated total open-water evaporation for the main channel of the Rio Grande, major tributaries, canals, and reservoirs for 1935, 1955, 1975, and 1993. The calculation used estimates of open-water surface area derived from aerial photographs and an evaporation rate derived from climate data from the studied years. This calculation does not include evaporation from ephemeral channels.

An inaccuracy in the open-water evaporation calculations is that the surface area estimates are dependent on the water level during the time at which the air photos were taken, and for the 1935 air photos in particular, the exact time of year is not known. For example, an aerial photo taken in spring will show a larger open-water surface area, and therefore result in a higher evaporation value, than an aerial photo taken in late summer. The Bureau of Reclamation states that their open-water evaporation estimates have a possible error of up to 20 percent (see Gould, 1995).

The NMOSE has also estimated open-water evaporation, but only for man-made reservoirs (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997). The only reservoirs included in the NMOSE estimates are Cochiti Dam in Sandoval County (which is not considered to be in the Middle Rio Grande study area), and Jemez Canyon. Because the evaporation from these two water bodies is so small when compared to the estimates made by Gould (1995) we have included NMOSE reservoir evaporation data only in Appendix 3, and will not discuss them further. As part of water use within Sierra County, Appendix 5 shows evaporation losses for Elephant Butte Reservoir during NMOSE inventory years.

5.9.2 Results

Evaporation from open water constitutes a major portion of total water lost from the Middle Rio Grande region. Table 27 summarizes the findings of the BOR MRGWA study on open-water evaporation. Overall, open-water evaporation has decreased through time, with the most notable decrease occurring between 1935 and 1955. This decrease in open-water evaporation may have been caused by the construction of MRGCD works that drained fields and wetlands, and the river channel modification by the BOR, which resulted in a narrower, deeper channel.

Table 27. Acre-feet of water depletion from open-water evaporation (Gould, 1995)

county	1935	1955	1975	1993
Sandoval	24,634	21,238	20,294	16,935
Bernalillo	32,355	22,808	21,755	19,243
Valencia	32,945	21,654	19,167	19,438
total	89,934	65,700	61,016	55,666

5.10 Riparian Consumptive Use

Net evapotranspiration from riparian vegetation, from both surface and ground water sources.

Values for riparian consumptive use come from the BOR MRGWA Technical Memorandum, "Estimates of consumptive use requirements for irrigated agriculture and riparian vegetation," (Kinkel, 1995a and 1995b). Kinkel estimated the water use of riparian vegetation through time (from 1935 to 1993) for the Middle Rio Grande Region using riparian vegetation acreage estimated from aerial photography; the region is divided into the same seven different subregions created for BOR estimates of agricultural consumptive use (Fig. 1B). Then she estimated consumptive use requirements for the various species of riparian vegetation and calculated evapotranspiration depletions (see Kinkel, 1997b, page 2 for details). It appears that riparian consumptive use has fluctuated through time, but is trending neither up nor down since about 1955 (Fig. 41).

Water is not actively "withdrawn" for riparian use in the same manner water is pumped from wells or diverted from surface-water systems, but it is removed from both surface- and shallow ground-water sources and transpired by plants. Therefore, riparian withdrawals equal riparian consumptive use. According to the research done by the BOR, riparian vegetation consumes even more water than irrigated agriculture consumes in the MRG counties (Kinkel, 1995a) (Fig. 40).

The BOR study differentiated between different species of riparian plants when calculating evapotranspiration. In this report, we have not distinguished between native (e.g., cottonwoods) and exotic species (e.g., salt cedar) in our presentation of riparian consumptive use. Readers are referred to the BOR MRGWA, Supporting Document 6, for detailed subdivision of consumptive use by different species.

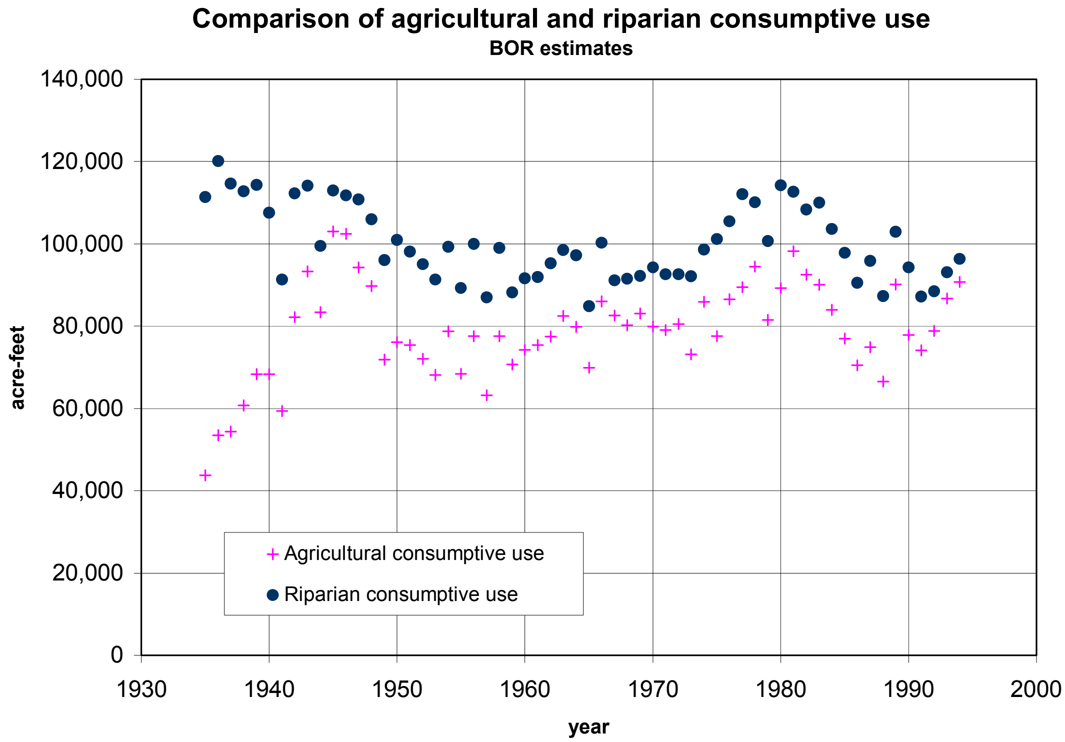

Figure 40. Comparison of consumptive use by riparian vegetation and irrigated agriculture in Sandoval, Bernalillo, and Valencia Counties, combined (Kinkel, 1995).

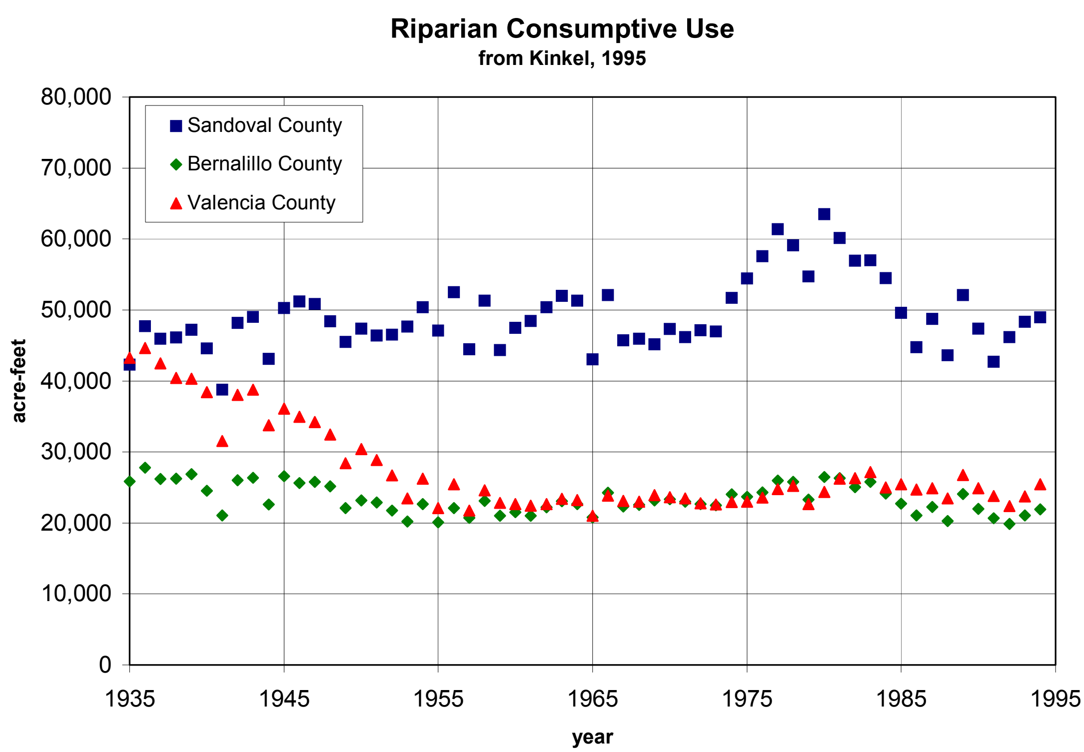

Figure 41. Riparian consumptive use by county.

6. WATER DEMAND BY REGION

Water demand distribution and volume differ significantly between different regions within the Middle Rio Grande Region. The following section discusses the distribution of water use within each of the subregions considered in this report, and compares use between the subregions. Finally, we discuss the overall distribution of water use in the entire study area.

6.1 Counties

This report has focused on three counties within the Middle Rio Grande Region: Bernalillo, Sandoval, and Valencia. These counties are very different in terms of population and economy; these differences are apparent in the volume and distribution of each county's current and historic water usage. Figures 42, 43, and 44 show the distribution of water withdrawals by category within Bernalillo, Sandoval, and Valencia Counties, respectively. Bernalillo County is dominated by the COA's municipal withdrawals, while Valencia County is dominated by irrigated agriculture withdrawals. All irrigated agriculture values presented in this section are from the NMOSE.

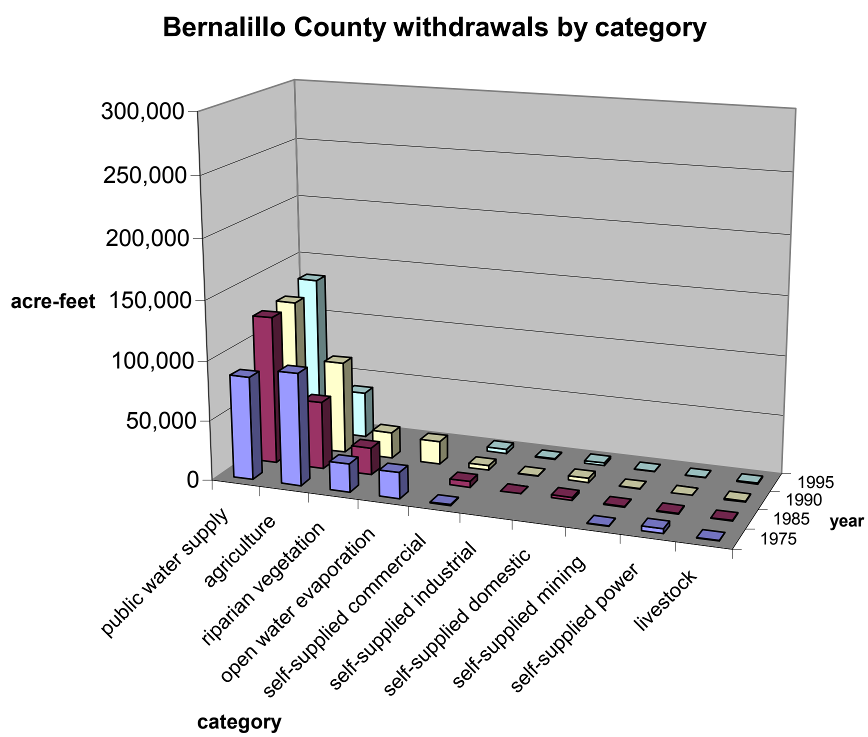

Figure 42. Bernalillo County water withdrawals by category.

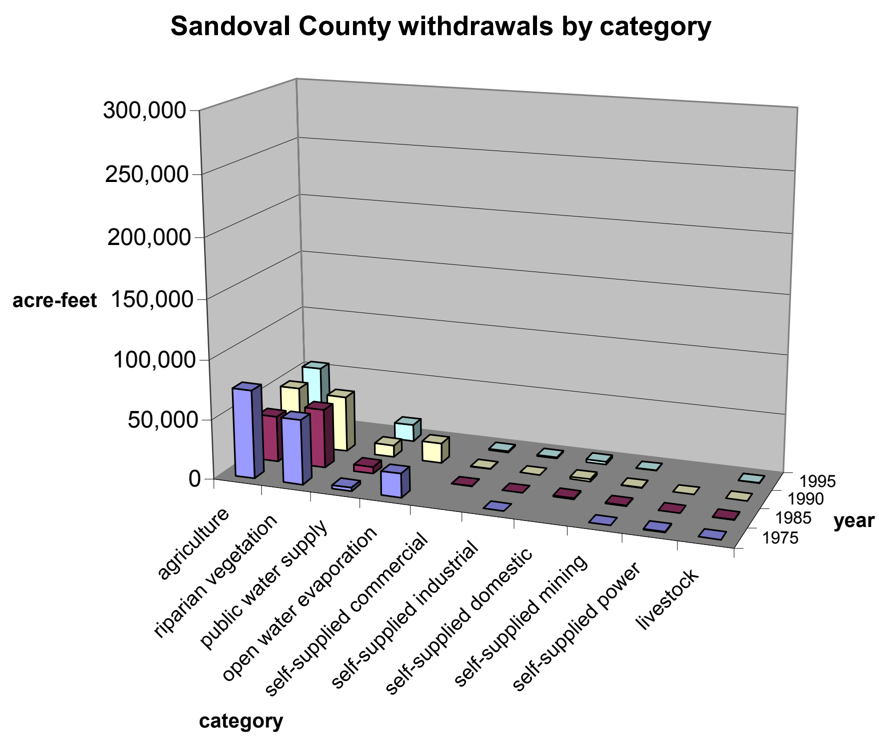

Figure 43. Sandoval County water withdrawals by category.

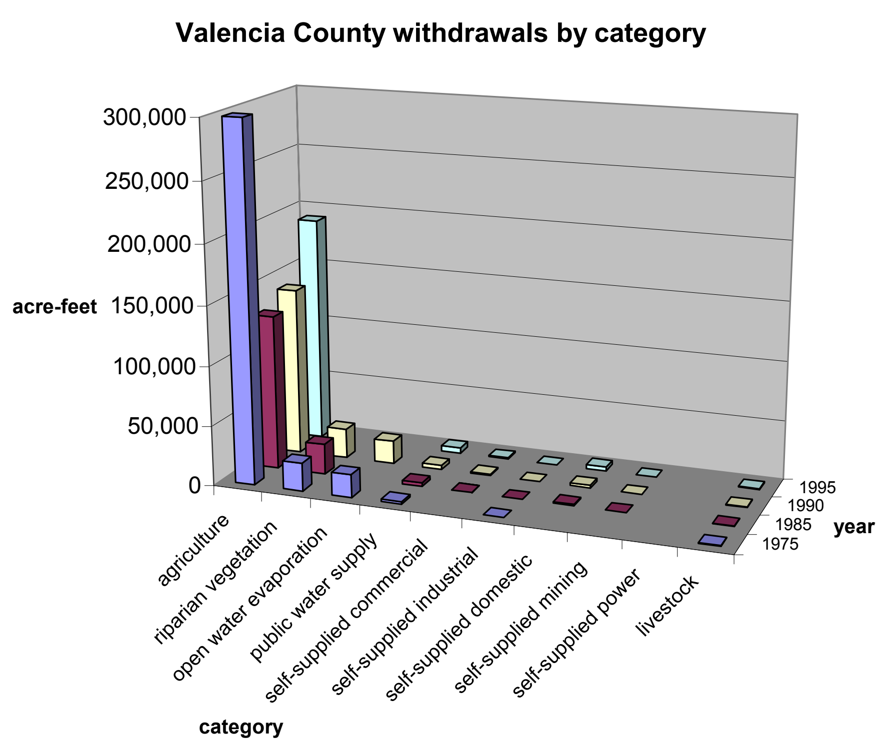

Figure 44. Valencia County withdrawals by category. In 1975 Valencia County included Cibola County.

These figures show water withdrawals for the three counties for four different years: 1975, 1985, 1993, and 1995. The largest water withdrawal categories in the MRGV are agriculture, riparian vegetation, open-water evaporation, and municipal water supply. Withdrawals for all categories except riparian vegetation and open-water evaporation for Valencia County in 1975 include withdrawal by Cibola County because Cibola County was not created as a separate county until 1981 (see the discussion in Section 5.3.2). Appendix 6 contains NMOSE water use category data for the Cibola and Valencia Counties for 1975, 1980, and 1985 (Sorensen, 1977; 1982; Wilson, 1986).

It is important to note that not all water that is withdrawn ends up being consumed. Agricultural withdrawals in part return to the surface-water system or seep back into the ground and assist in recharging the aquifer (Figs. 25 and 26). Portions of withdrawals for domestic, commercial, and industrial use are returned to surface-water systems through wastewater treatment plants (Wilson and Lucero, 1997). Figures 45, 46, and 47 show consumptive use for these same counties and categories.

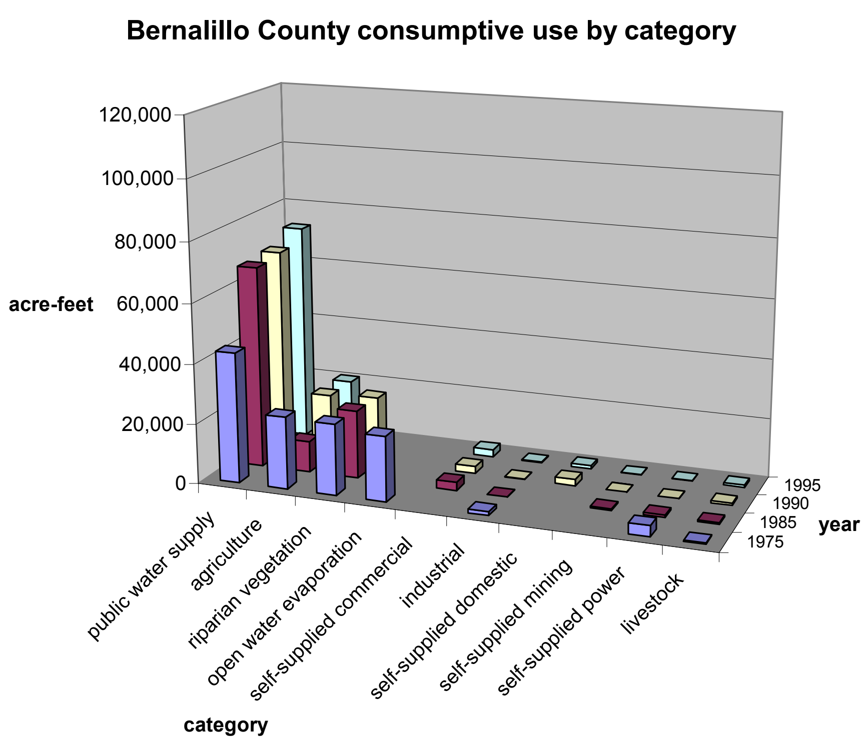

Figure 45. Bernalillo County consumptive use by category.

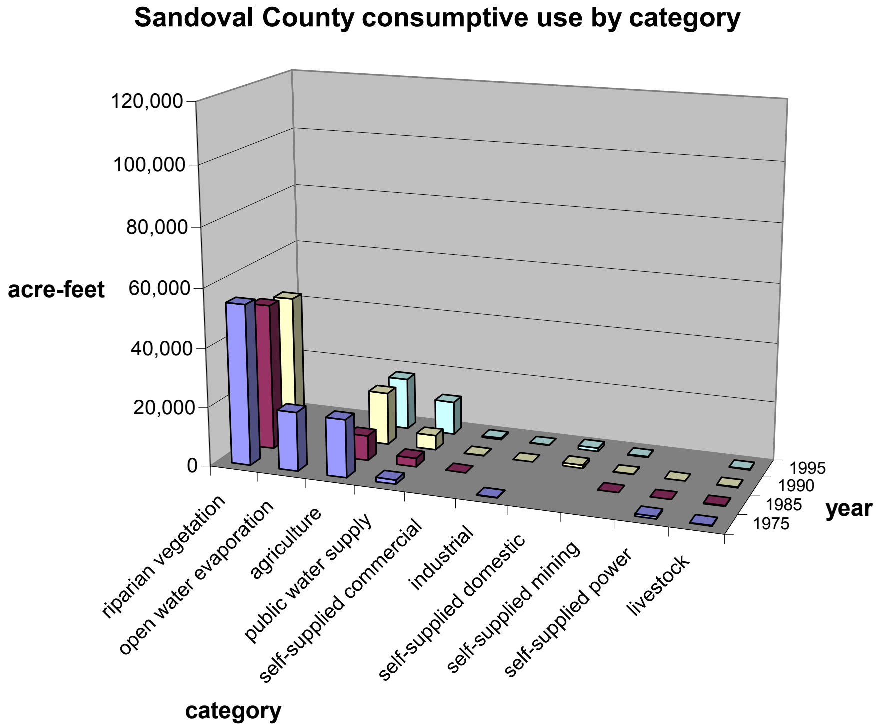

Figure 46. Sandoval County consumptive use by category.

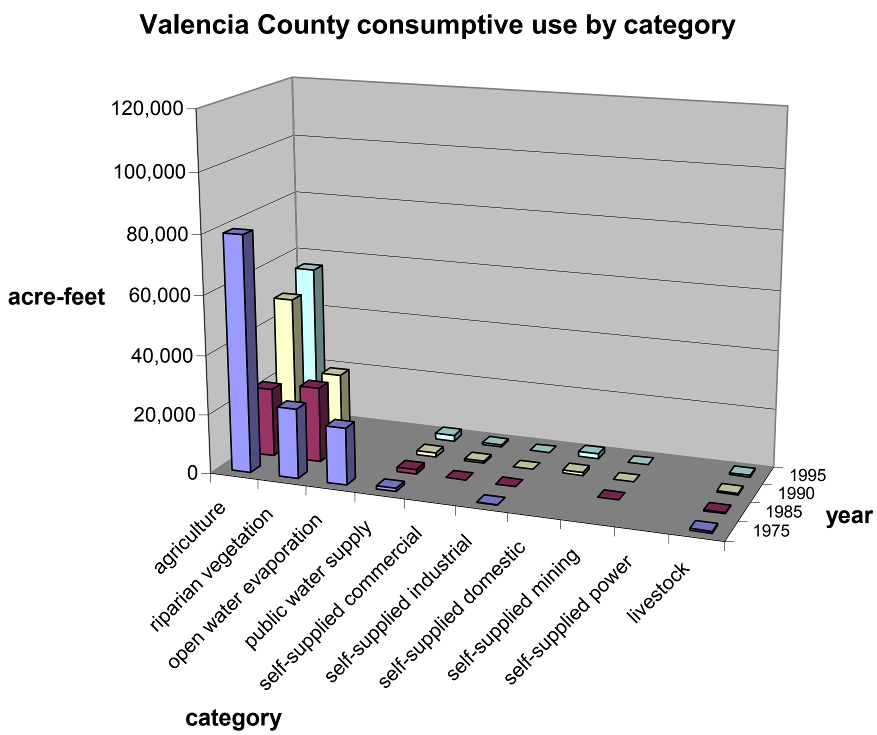

Figure 47. Valencia County consumptive use by category.

6.1.1 Bernalillo County

Roughly 250,000 acre-feet of water were withdrawn for all uses in Bernalillo County in 1993, a recent year for which we have nearly complete data. Over half of Bernalillo County withdrawals were for public water supply, which is distributed to various users such as commercial, residential, industrial, and other city functions. Agriculture, riparian vegetation, and open-water consumptive use constitute the majority of Bernalillo County's remaining water use; self supplied commercial, industrial, mining, livestock and power use form a very insignificant portion of the total county withdrawals.

The COA provides water to most commercial, industrial, and residential users in Bernalillo County. Therefore, the COA supplied quantities of water for each use were included in the data presented in Figure 48. Much of the Bernalillo County public water supply is directed toward household and commercial use (Fig. 48). In fact, domestic and residential withdrawals are as high or higher than agricultural withdrawals, especially in the most recent years.

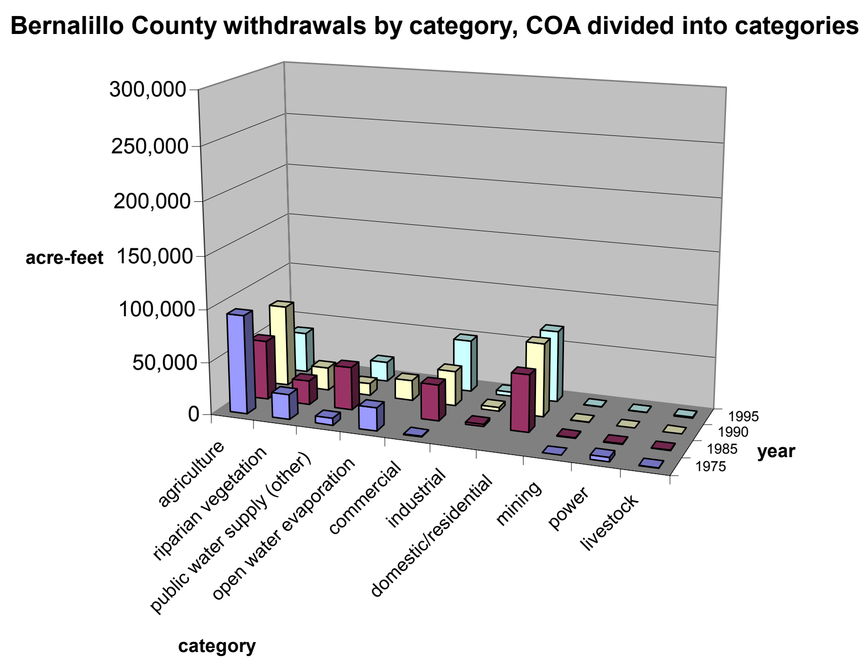

Figure 48. Bernalillo County withdrawals with COA public water supply divided into categories.

6.1.2 Sandoval County

Riparian vegetation and irrigated agriculture constitute the largest consumptive uses in Sandoval County. However, the withdrawals and consumptive uses for public water supply have been steadily increasing since 1975, due to the increasing population of towns like Rio Rancho and Bernalillo. Industrial use has also increased due to Intel Corporation, currently the largest single self-supplied water user.

Despite population and industrial growth, riparian vegetation still consumes the largest volume of water in Sandoval County, more than in either Bernalillo or Valencia Counties. Sandoval County includes a longer stretch of the Rio Grande corridor than either Bernalillo or Valencia Counties, and includes all of the Rio Jemez and most of the Rio Puerco river valleys. Also, there are fewer irrigated acres and less agricultural water consumptive uses in Sandoval County than in the other two counties. This could mean that while the floodplain region in Valencia and Bernalillo Counties have been converted to agricultural fields, much of the floodplain region in Sandoval County still is covered by riparian vegetation.

6.1.3 Valencia County

Despite its relatively small population, Valencia County withdraws more water than does either of its northern neighbors. The majority of this withdrawal is for irrigated agriculture, just under 200,000 acre-feet in 1995. In 1975 its withdrawal for irrigated agriculture, which includes what is now Cibola County, was nearly 300,000 acre-feet according to the NMOSE (Figs. 25 and 47), though this number could have a significant amount of error (Wilson, personal communication 2000). A possible source of error stems from the fact that Valencia County was separated from Cibola County in June of 1981. However, in 1985, irrigated agricultural withdrawal for Cibola County was only 16,601 acre-feet, while irrigated agricultural withdrawal in Valencia County was almost 130,000 acre-feet (Wilson, 1986). This indicates that either there was a real drop in irrigated agriculture after 1975 and 1980, or that the data from the NMOSE could contain a significant amount of error (see Appendix 1 and Section 5.3 for further discussion of possible error in the NMOSE data).

6.2 Subregions

The three different subregions of the Middle Rio Grande Region, the Middle Rio Grande Valley, and Rio Puerco and Rio Jemez (Fig. 1A), also have very distinct water-use signatures. The majority of people, businesses, industries, as well as agricultural fields are located within a few miles of the Rio Grande itself; therefore, the majority of water withdrawn and consumed is within the Middle Rio Grande Valley subregion (see Table 3, Fig. 27). The Rio Puerco basin has only one city, Cuba (1999 population less than 1,000), and little irrigated agriculture. Likewise, the Rio Jemez basin contains only the towns of Jemez Springs and San Ysidro, as well as the Jemez Pueblo, with a combined population of less than 5,000.

Though we do not have data regarding how much open-water evaporation occurs in the Rio Puerco or Rio Jemez basins with respect to the total amount in the region, it is probably safe to assume that the majority of water consumption by this category also occurs in the Middle Rio Grande Valley subregion. Data were not available regarding how much water is consumed by riparian vegetation in the Rio Puerco subregion. However, the BOR made the Rio Jemez basin a subunit in their analysis, and on average only 11.5 per cent of the total riparian consumptive use in our study area occurs in the Rio Jemez subregion (Table 28).

Table 28. Riparian vegetation consumptive use in the Rio Jemez subregion (1935 - 1994)

average riparian consumptive use in Rio Jemez subregion (acre-feet)	average riparian consumptive use in total region (acre-feet)	per cent of riparian consumptive use occurring in Rio Jemez subregion
11,500	100,000	11.5%

Source: Kinkel, 1995a

For the years 1975, 1980, and 1985, withdrawal and consumptive use data for self-supplied categories (domestic, commercial, industrial, mining, and power) were available only by county. However, the NMOSE meter record database for 1990 and 1995 included the addresses of the individual water users (not including domestic), allowing withdrawals to be subdivided into the appropriate subregions (Appendix 3). As reported in the NMOSE meter files, both the Rio Puerco and Rio Jemez subregions comprise less than 1 percent of self-supplied commercial withdrawals, and essentially no self-supplied industrial, self-supplied mining, or self-supplied power withdrawals.

Public water-supply withdrawals within the Rio Puerco and Rio Jemez subregions combined constitute less than 0.3 percent of the total amount of water withdrawn for public water suppliers in the study area. In 1995, about 231 acre-feet were withdrawn in the Rio Puerco subregion, 126 acre-feet in the Rio Jemez subregion (Table 3). The largest recorded water use category in either of these regions is irrigated agriculture; according to 1995 NMOSE data (Wilson and Lucero, 1997), 7,580 acre-feet were withdrawn in the Rio Puerco subregion and 4,610 acre-feet were withdrawn in the Rio Jemez subregion.

This report does not intend to imply that water demand within the Rio Puerco and Rio Jemez subregions is unimportant with respect to the Middle Rio Grande Valley subregion, which contains New Mexico's largest metropolitan area, as well as the productive agricultural zone located within the Rio Grande floodplain. Part of the reason why the Rio Puerco and Rio Jemez subregions are less populated and less extensively farmed may be because surface- and ground water are, and historically have been, relatively scarce when compared to the water supplies of the Middle Rio Grande Valley. For example, the Rio Jemez has "no flow for many days" beneath the Jemez Canyon Dam, and the Rio Puerco has, "no flow for many days," to, "no flow for extended periods," along most of its length (Waltemeyer, 1989). Therefore, a thorough understanding of those subregions' water use and demand remains extremely important, especially if they are experiencing growth.

6.3 Total Middle Rio Grande Study Region

6.3.1 Withdrawals

Data are incomplete (Table 29), so it can be difficult and misleading to compare total water use values from year to year. However, when considering years with relatively complete data, it is apparent that irrigated agriculture is the largest among all withdrawal categories, with riparian consumptive use, open-water evaporation, and public water supply following (Figs. 49 and 50). According to Figure 50, irrigated agriculture constitutes nearly half the withdrawals in the region, public water supply is one quarter, and riparian vegetation and open-water evaporation are another quarter, while less than two per cent of all withdrawals are by self-supplied users.

Table 29. Water withdrawals in the Middle Rio Grande Region, by category

Category (COA in Public Water Supply)	**1960**	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Self-supplied commercial[1,2]	500	767	715	711	4255	5200	5156	4680	4241	5306	4948	5427	4961	4951	5808	7171
Self-supplied industrial[1,2]	12	24	19	2263	231	164	766	525	337	851	262	1938	3495	3600	3360	103
Livestock[1,2]	ND	42	76	1308	1444	1235	1573	1428	1533	530	592	1744	2053	1902	1964	82
Mining[1,2]	5	160	140	3033	7213	1256	642	595	655	625	494	577	614	737	1001	1056
Self-supplied power[1,2]	2685	3351	3114	5841	2936	761	187	104	141	16	32	253	ND	ND	ND	ND
Agriculture[1]	ND	ND	ND	468040	366740	224937	268775	ND	ND	311407	293068	315227	ND	ND	ND	ND
Riparian consumptive use[3]	91675	84876	94256	101131	114289	97781	94273	87198	88465	93133	96328	ND	ND	ND	ND	ND
Open-water evaporation[3]	ND	ND	ND	61016	ND	ND	ND	ND	ND	55666	ND	ND	ND	ND	ND	ND
Public water supply[1,2,4]	124	57782	70683	12949	119507	133012	138976	139741	140305	145634	152442	154204	149992	137496	131628	117212
Self-supplied domestic[1]	ND	ND	ND	ND	5651	4833	7780	ND	ND	ND	ND	7846	ND	ND	ND	ND
Total	95000	147002	169003	653562	622266	469179	518129	234272	235677	613169	548166	487216	161114	148686	143761	125624
COA withdrawals separated by category																
commercial[1,2,4]	500	767	715	711	21657	34588	46199	46356	44891	48564	55276	51542	57928	53338	53497	54048
industrial[1,2,4]	12	24	19	2263	2549	2452	3418	3462	3228	3689	2952	5121	6837	6630	6436	3206
Livestock[1,2]	ND	42	76	1308	1444	1235	1573	1428	1533	530	592	1744	2053	1902	1964	82
Mining[1,2]	5	160	140	3033	7213	1256	642	595	655	625	494	577	614	737	1001	1056
power[1,2]	2685	3351	3114	5841	2936	761	187	104	141	16	32	253	ND	ND	ND	ND
Agriculture[1]	ND	ND	ND	468040	366740	224937	268775	ND	ND	311407	293068	315227	ND	ND	ND	ND
Riparian consumptive use[3]	91675	84876	94256	101131	114289	97781	94273	87198	88465	93133	96328	ND	ND	ND	ND	ND
Open-water evaporation[3]	ND	ND	ND	61016	ND	ND	ND	ND	ND	55666	ND	ND	ND	ND	ND	ND
Public water supply (not res., ind., or com.)[1,2,4]	124	57782	70683	12949	50870	49636	29085	27974	30164	29031	29939	38504	29938	27668	19510	8128
Self-supplied domestic and COA residential[1,2,4]	ND	ND	ND	ND	54568	56533	73877	67154	66601	70508	69484	74248	63745	58411	61353	59104
Total	95000	147002	169003	653562	622266	469179	518129	234272	235677	613169	548166	487216	161114	148686	143761	125624

Sources: [1] NMOSE technical reports (Sorensen, 1977; Sorensen, 1982; Wilson, 1986; Wilson, 1992; Wilson and Lucero, 1997; Wilson and Lucero, 1998)
[2] NMOSE meter record database
[3] Bureau of Reclamation MRGWA series (Kinkel, 1995a; Gould, 1995)
[4] City of Albuquerque data

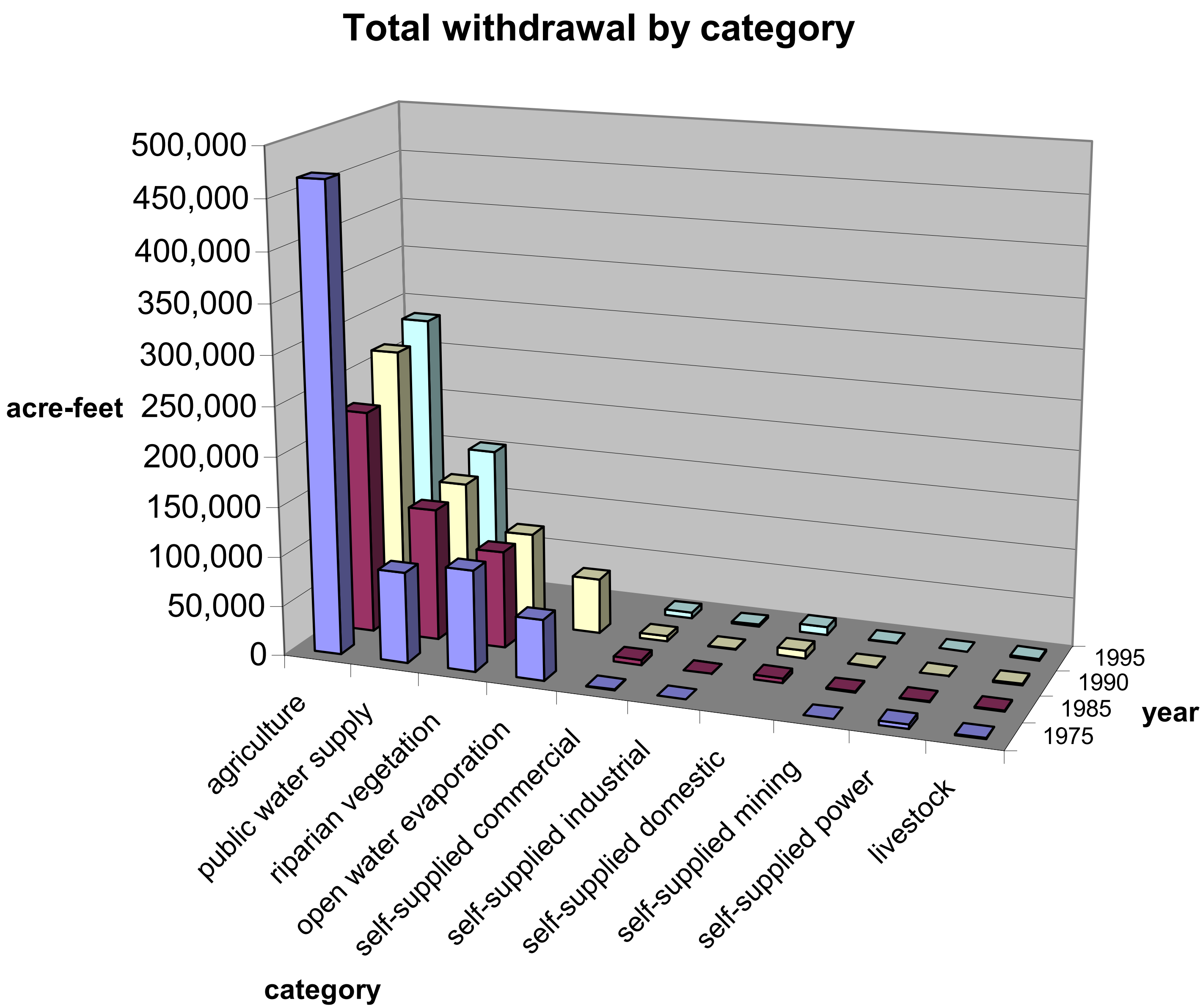

Figure 49. Water withdrawals in the entire Middle Rio Grande study area, by category.

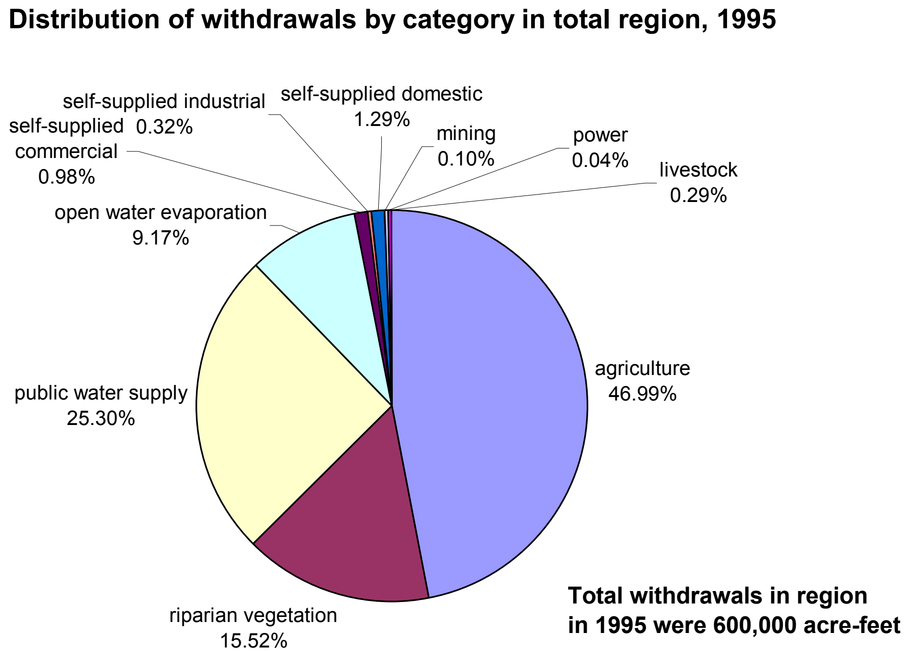

Figure 50. Withdrawal percentages in the entire Middle Rio Grande study area, by category.

6.3.2 Consumptive Use

An examination of consumptive use within the Middle Rio Grande Region presents a significantly different picture. Figure 51 shows that riparian vegetation and agriculture are the largest consumers of water, with public water supply a very close third. Open-water evaporation is also a significant source of water loss in the region. Figure 52 shows that riparian vegetation constitutes 29 percent, irrigated agriculture is 28 percent, public water supply is 25 percent, and open-water evaporation is 16 percent of total water consumption in the region.

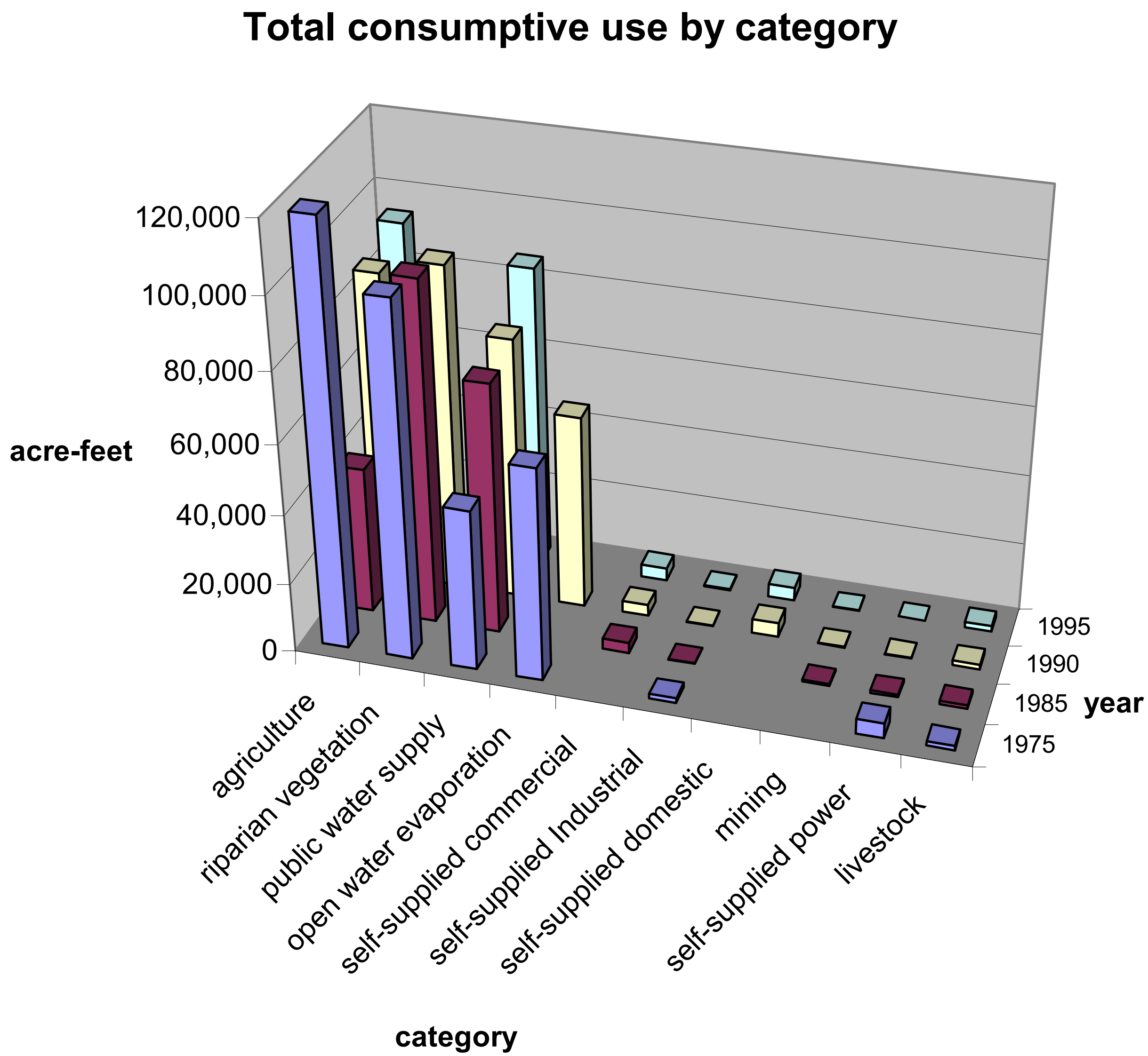

Figure 51. Total consumptive use in the Middle Rio Grande Region, by category.

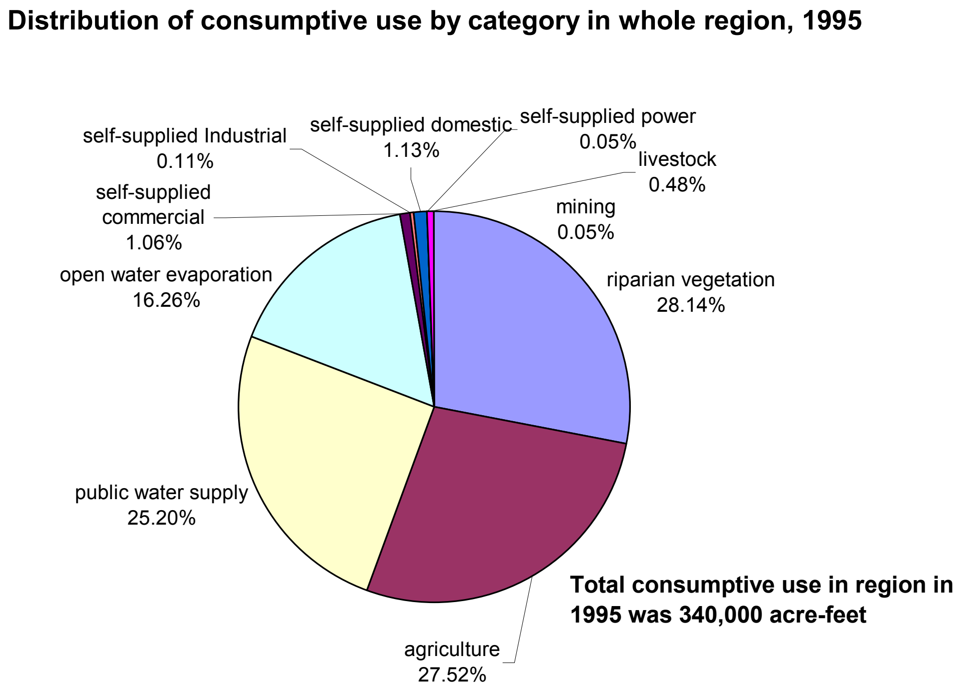

Figure 52. Percentages of consumptive use by different categories in the Middle Rio Grande Region.

We have compiled additional data from Santa Fe, Socorro, and Sierra Counties in order to place our estimates of total consumptive use in the context of the Middle Rio Grande Compact Region. The Middle Rio Grande Compact Region is defined as the area from Otowi Gage in the north to the spillway of Elephant Butte Reservoir in the south. We began with the 1990 and 1995 consumptive use totals for Sandoval, Bernalillo, and Valencia Counties (Fig. 51 and Table 29). We added consumptive use data for Santa Fe County's public water supply (Wilson, 1992; Wilson and Lucero, 1997). We also added NMOSE values for consumptive use in 1990 and 1995 by all categories for Socorro and Sierra Counties. The data presented here include reservoir evaporation from Elephant Butte but not Caballo Reservoir (B. Wilson, personal communication). Both "1990" and "1995" open-water evaporation data are actually the BOR's estimates for 1993, and now include northern Socorro County. Open-water evaporation includes evaporation from canals and river channels but not reservoirs. This estimate does not include southern Socorro County, or any part of Santa Fe or Sierra counties. Cochiti Reservoir is not included in either open-water or reservoir evaporation values. Finally, we added riparian consumptive use for the northern portion of Socorro County (Fig. 1b). Riparian consumptive use estimates also do not include any part of Santa Fe or Sierra counties, or the southern portion of Socorro County. The final estimated totals can be seen in Figures 53 and 54.

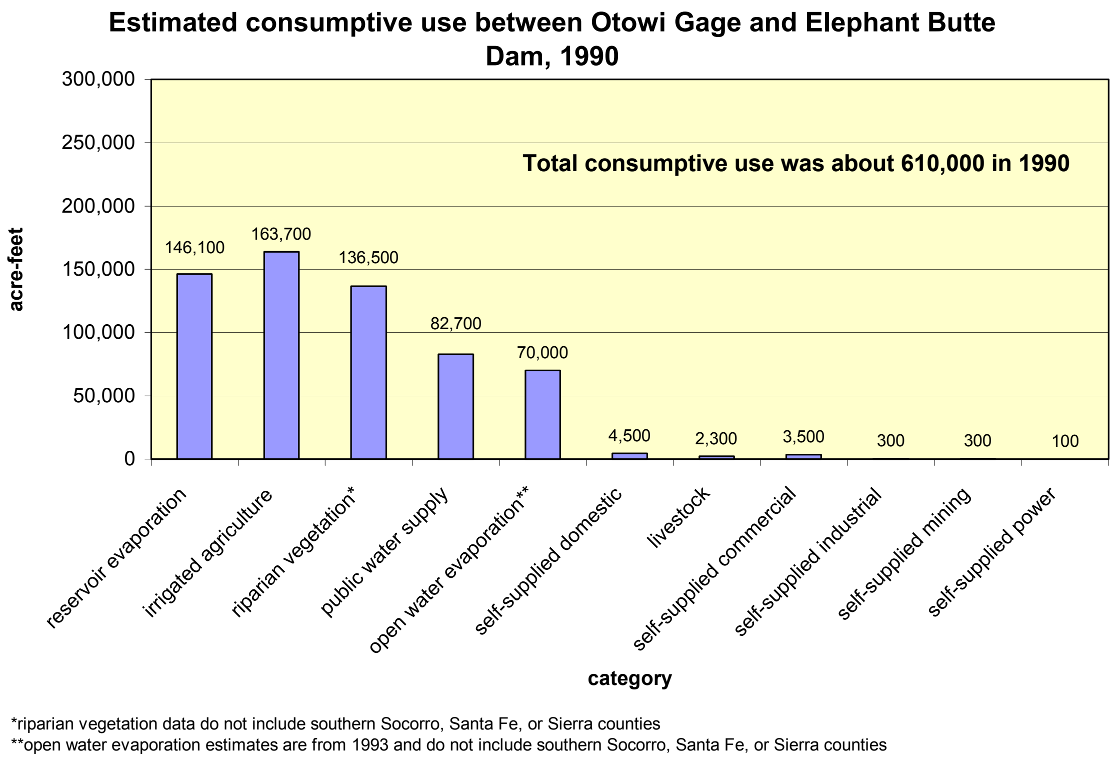

Figure 53. Estimated consumptive use between Otowi Gage and Elephant Butte Dam, 1990.

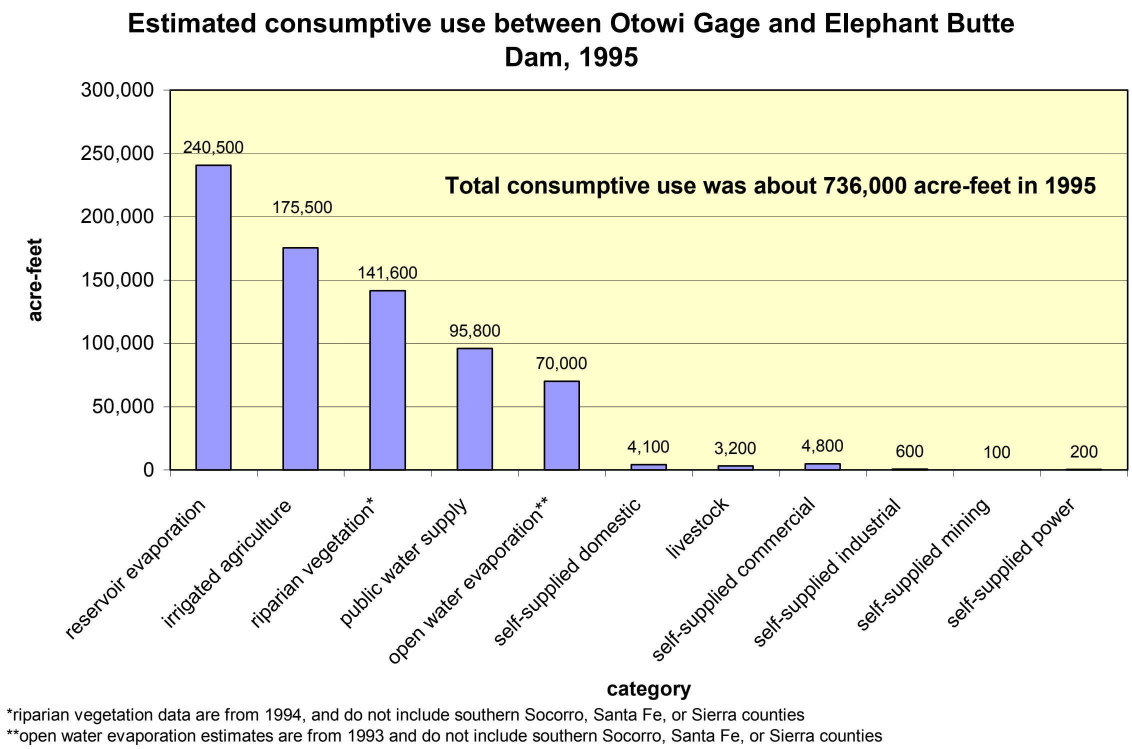

Figure 54. Estimated consumptive use between Otowi Gage and Elephant Butte Dam, 1995.

One can see from Figures 53 and 54 that more water is removed from the Middle Rio Grande Compact Region from reservoir evaporation than from any other single category. Irrigated agriculture is the second largest consumer of water, followed closely by riparian vegetation. Because we do not have data for riparian consumptive use for the southern half of Socorro County or any of Sierra County, overall riparian consumptive use may be significantly underestimated in Figures 53 and 54. Public water supply and open water (canal and channel) evaporation are the remaining significant sources of water consumption.

From year to year, evaporation from reservoirs is highly variable. The amount of water removed from reservoirs via evaporation is dependent on climatic factors such as temperature, humidity, and wind, as well as physical characteristics of the reservoir itself, such as its surface area. For example, more water will evaporate from reservoirs if the weather is hot, dry, and windy, and if the reservoir is kept full. It appears as though those factors alone may have made a difference of over 100,000 acre-feet of water consumption between 1990 and 1995.

7. LOOKING TO THE FUTURE CURRENT AND FUTURE WATER USE RESEARCH

This study of historic water use has revealed that water uses in the Middle Rio Grande Region have been well documented every five years since 1975 in the Technical Report series published by the NMOSE. A significant increase in water supply and demand research has occurred since 1990, catalyzed by the COA's determination to develop a strategy for managing water resources sustainably. Several projects and studies that are currently in progress will provide additional information and data about water use, so that during the next 3 to 5 years, some data gaps can be filled and new higher quality data can be added.

One such area where our understanding is still limited is the volume of water consumed by vegetation (both agricultural and natural) through evapotranspiration processes. The BOR's MRGWA determined that irrigated crops and riparian vegetation within the Middle Valley consume a significant share of the region's water. As a result of the MRGWA, an interagency conference was held in the Spring of 1997 to address this issue, and the outcome was a decision to consolidate research activities through a work group that began to meet regularly. Participating agencies include the BOR, New Mexico State University, New Mexico Tech, University of New Mexico, Los Alamos National Laboratories and others. These discussions resulted in field investigations using state-of-the-art technologies to measure water vapor emissions from the riparian canopy. These studies will greatly increase understanding of evapotranspiration processes for salt cedar and cottonwood, the two species that account for most riparian water use.

Consumption by crops has been calculated by the NMOSE for the Technical Reports and also by the BOR using crop coefficients and meteorological data based on irrigated acreage and cropping patterns (See Section 5.3, **Irrigated Agriculture**). In addition, the NMOSE is in the process of generating a geographic information system (GIS) database of crop coverage for the entire state of New Mexico. Meanwhile, streamflow instrumentation being installed by the MRGCD will make actual measurements of water diversions and return flows from the District's works. All of these developments will lead to more and better agricultural withdrawal and consumption data.

The BOR, MRGCD, and COA are establishing a weather monitoring network that generates real-time data for computation of evapotranspiration for crops, riparian, and urban vegetation. This new evapotranspiration monitoring network project is being completed, with many weather stations already on-line. The climatic data collected from the weather station data loggers will be combined with crop acreage data to calculate the evapotranspiration component of the water balance for the entire river.

The climatic data that is collected by this new network is made available to irrigators through the "ET Toolbox," featuring real-time weather data and a clickable map displaying daily evapotranspiration rates for various crops. The "ET Toolbox" is available on the Internet at http://www.usbr.gov/rsmg/nexrad/riogrande.html.

The NMOSE has embarked on a campaign to computerize key water records. The Water Administration Technical Engineering Resource System (WATERS) database will contain information now included only in paper files. The process is complex and will take years to complete. Information on permitted, declared and adjudicated water rights, irrigated acreage and well records including pumpage, depth to water, and well location will be included. Public access to currently populated portions of the database is available at the NMOSE web site, http://www.ose.state.nm.us/.

As the share of total water use for urban categories increases, population data provides water planners with a powerful tool to verify current use and for future projections. The population statistics included in the present study were derived from 1990 census projections but future statistics will be based on the Census 2000 population data, which will be available by December 2000.

There are many small water systems in the Middle Rio Grande region that serve populations of 25 or more people. The survey of small water systems that was done for the current study established initial contacts with the water utility managers, and many of them were quite willing to participate by sharing their water production data. As discussed further in Section 8, **Recommendations**, these water managers can be asked for additional assistance with future data gathering.

Today, the operation of the existing surface-water management structures is governed by rules and procedures under the jurisdiction of multiple agencies, including the U. S. Army Corps of Engineers (COE), the BOR, and the New Mexico ISC and Irrigation Districts. Through the Upper Rio Grande Water Operations Review, the BOR, COE, and ISC recently agreed in a Memorandum of Understanding, to explore what they can do under existing authorities to improve how they store and deliver water. This review will examine the federal water operations activities in the Rio Grande Basin above Fort Quitman, Texas, mainly storage and release of water at 4 COE reservoirs, 3 BOR reservoirs and the operation of the BOR's Low Flow Conveyance Channel, and Closed Basin Project. The data collection, compilation, and analysis that will be done by the technical teams during the review will be available to water planners.

8. RECOMMENDATIONS

Through the process of collecting and analyzing the available water use data for the Middle Rio Grande, we have developed a series of recommendations regarding both the availability and quality of water-use data, and the use of these data in projecting future water use.

8.1 Improving data availability and quality

A centralized data repository would be the first step toward increasing the availability and quality of water use data. Currently, data are collected by numerous organizations, municipal suppliers, and federal and state agencies. These different groups compile their data using different methods and spanning overlapping but non-identical regions. The result of the data-gathering inconsistencies is that much of the data from a specific group cannot be directly compared with data from others. Another reason to have a centralized data repository is to make data more readily available to the public. Right now, anyone who wants to use data from a number of sources has to spend a lot of time finding and organizing it. The ultimate end product of a centralized data repository could be a database that allows people to query a region, such as a county, a city, or a watershed, and gather the withdrawal and consumptive use data collected by all entities involved, for all the different water use categories. This database could be linked to a geographic information system (GIS), allowing the easy production of water-use and land-use maps and diagrams.

A second step toward creating a better water-use database would be to ask public water suppliers to consistently collect a standard set of data. Every year, each public water supplier could be asked to produce data regarding the population served, the volume of water produced, the volume of water delivered, a subdivision by category of water deliveries, and the volume of water returned through a wastewater system. Many public water suppliers already collect these data and are willing to share them; asking the suppliers to consistently send the data to a centralized repository should not be difficult.

Finally, as discussed in many of the previous sections, water consumptive use data are only as good as the methods used to calculate them. The **Looking to the Future** section discusses many of the steps being taken by different groups to refine and improve calculations. This continued research is essential, especially as available water resources decline, demand increases, and accurate estimates of consumption become crucial for the management of a limited water supply.

8.2 Projections for Future Water Use

We intend this document to be a starting point for developing projections for future water demand and to be used for educating the public about water use in the Middle Rio Grande study area. We have a few final recommendations for those that will be using this document for these tasks. First, we re-emphasize some of the inaccuracies in the data sets. Many of these data sets are missing substantial amounts of data; sometimes data are available for some years and not others, and data from certain water-use categories are incomplete for most years. Other data sets are based on methods that make assumptions about how very complex biological and climatological processes work, simplifying them into equations. Therefore, we recommend that people use these data for what they are; perhaps not perfectly accurate values for withdrawal and consumptive use, but a compilation of many different best estimations of water use in the Middle Rio Grande study area.

9. GLOSSARY

These definitions are taken from Wilson (1992) and Middle Rio Grande Water Assembly Action Committee (1999).

Acequia: Constructed ditches to transport water from the river and distribute it to the farm fields. Also, refers to the traditional association organized around this type of irrigation channel system.

Acre-foot: The quantity of water required to cover one acre (43,560 square feet) with one foot of water. There are 325,841 gallons in an acre-foot.

Acres irrigated: Number of acres that have had water diverted and artificially applied in a given year (as opposed to “irrigable acres”). Does not include idle or fallow lands.

Blaney-Criddle method: A numerical formula used to estimate crop consumptive use, based on crop type, mean monthly temperatures and daylight hours. An updated version is referred to as the SCS modified Blaney Criddle method.

Consumptive use: Water that is transpired or evaporated and thereby lost to the system; to be distinguished from water “consumed” by a human or animal, part of which may be returned to the system. Same as Depletion.

Conveyance loss: Water that is diverted into irrigation canals and ditches which does not reach the agricultural fields. The water is consumed by riparian vegetation, seeps into the ground-water system, or evaporates.

County: A local government jurisdiction and the largest administrative division of a U. S. state. The counties involved in this report are Bernalillo, Sandoval, and Valencia Counties.

Depletion: That part of a withdrawal that has been evaporated, transpired, or incorporated into crops or products, consumed by people or livestock, or otherwise removed from the water environment. It includes the portion of ground-water recharge resulting from seepage or deep percolation (in connection with a water use) that is not economically recoverable in a reasonable number of years, or is not usable. Same as Consumptive use. Note: this definition follows the definition used by the NMOSE and the ISC. The MRG Water Assembly Action Committee uses the term *consumptive use* for this concept, and has an entirely different definition of *depletion*.

Ditch rider: Someone who field-checks the acreage of different crops within the MRGCD.

Diversion: The removal of water from either the surface- or ground-water system. Same as Withdrawal.

Evaporation: Water that is transferred from liquid to gas phase—evaporation constitutes a net loss of water to a system.

Evapotranspiration: Combined processes of simple evaporation and plant transpiration through which liquid water is changed to water vapor and thereby lost to the system.

Ground water: Water stored underground, beneath the earth's surface. It is stored in cracks and crevices of rocks and in the pore spaces within geologic materials (rocks, sediment) that make up the earth's crust.

Irrigable acres: Number of acres that have irrigation works in place and are potentially irrigated in a given year, including idle and fallow lands.

Irrigated acres: Number of acres that actually are irrigated in a given year.

Idle and fallow: Refers to acreage plowed and cultivated during the current year but left unseeded, or acreage that is left unused for one or more years.

Middle Rio Grande Compact Region: The portion of the Rio Grande Valley from Otowi Gage in the north to the spillway of Elephant Butte Reservoir in the south.

Middle Rio Grande Conservancy District: The portion of the inner Rio Grande Valley from Cochiti Dam in the north to the Bosque del Apache Wildlife Refuge in the south (see Fig. 1B)

Middle Rio Grande Region: The portion of the Rio Grande Valley from the spillway of Cochiti Dam in the north to the southern boundary of Valencia County. Also referred to in this report as the *Middle Rio Grande study area*, and *Middle Rio Grande planning region*.

Middle Rio Grande Valley: The subregion of the Middle Rio Grande Region that excludes the Rio Puerco and Rio Jemez watersheds (see Fig. 1A).

Open-water evaporation: Water evaporated from the surface, such as from reservoirs, stream channels, and canals.

Per capita use: The average quantity of water used per person or per head of livestock per day.

Riparian: The environment adjacent to streams and rivers where water is usually relatively abundant; this term usually refers to the vegetation found alongside streams.

River basin: The entire area drained by a stream (or river) or system of connecting streams so that all the streamflow originating in the area is discharged through a single outlet.

Rural: Any community, incorporated or unincorporated with a population of less than 2,500 inhabitants and not within a larger community that is classified as urban, is classified as 'rural' by the U.S. Bureau of the Census.

Self-supplied: Adjective describing water users who withdraw water directly from a ground- or surface-water source.

Surface water: An open body of water such as a river, stream, reservoir, or lake.

Transpiration: The process by which water in plants is transferred to water vapor in the atmosphere.

Unaccounted for water: The difference between total produced water and water sales, including "measuring errors caused by inaccurate meters or incorrect meter reading, transmission losses in the distribution system, water used for fire fighting, system flushing, sewer cleaning, construction, and other miscellaneous uses that are not metered."

Urban: Any community, incorporated or unincorporated with a population of 2,500 inhabitants or more is classified as urban by the U.S. Bureau of the Census. A self-supplied subdivision or residence (single family home or multiple housing unit) with a population of less than 2,500 inhabitants is classified as urban if it is within the established boundaries of a larger community or metropolitan area which is classified as urban by the Bureau of the Census.

Withdrawal: Water that is either diverted from the surface-water system or pumped from wells. Some of this water may return to either the surface- or ground-water system. A withdrawal is the same as a diversion.

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Wilson, B. C., and Lucero, A. A., 1998, Irrigated agriculture water use and acreage in New Mexico counties and river basins, 1993-1995: New Mexico Office of the State Engineer Technical Report 50, 107 p.

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APPENDICES

Appendix 1.

Metadata

METADATA

INTRODUCTION

In general, available data for the study area, especially historic data and years that were not inventoried by the New Mexico Office of the State Engineer (NMOSE) or examined by the Bureau of Reclamation (BOR), are incomplete and at times inconsistent and contradictory. Understandably, older data are less consistent, less complete, and less available than recent data. Many sources provided withdrawal data only. As described in the text, depletion data that are available are from sources that *calculated*, not measured, consumptive use. Some major public water suppliers and industries measure return flow from which consumptive use can be calculated, and we included these numbers in the present report. As is discussed in the text, measured return flows include the amount of water returned by self-supplied users, which can skew the consumptive use estimates. The Middle Rio Grande Conservancy District (MRGCD) is in the process of measuring irrigation return flow, which will expand our understanding of consumptive use from irrigated agriculture.

The bulk of high-quality data covering longer periods of record are for users within the Middle Rio Grande Valley subregion, especially for water users within the Albuquerque Basin. Moreover, data for water users that use larger quantities of water generally are of better quality than data for water users that use less than 400 acre-feet per year.

Although data were not as complete for the Rio Jemez and Rio Puerco subregions, it is still clear by looking at population centers and agricultural areas that the Middle Rio Grande Valley subregion contains the major water users. For example, the cities of Albuquerque, Rio Rancho, Paradise Hills, Belen, and Los Lunas, and the Middle Rio Grande Conservancy District (MRGCD) are within the Middle Rio Grande Valley subregion.

Additionally, water-use data by Native American communities within the planning area are generally not available. Eleven major pueblos are located within the study area; however, they are not required to report water-use data to the State Engineer. Efforts to gain information independently were unsuccessful, although the tribal jurisdictions indicated that they wanted to be included in the planning process.

Furthermore, data for categories that involved calculations or estimates (irrigated agriculture, riparian consumption, open-water evaporation, and self-supplied domestic) were generally available only for selected years, depending on the respective studies. This study did not try to use the same calculation methods used by other studies to fill in data gaps for the period of record. Many of these calculations incorporate variables such as flow rate, river width, and climate, and data from aerial photography and field observations that were not available for this project.

INDIVIDUAL DATA SOURCES

The following will discuss the various data sources, including bibliographic citations, a summary of each source's contents, and comments on our estimation of the quality of the data.

NMOSE Technical Report Series

The NMOSE has periodically published reports on water use in New Mexico. The data collection process has been refined over time, and the most recent reports are regarded to have more accurate data than the early ones (Wilson, personal communication, 2000). References to numbered tables in this part are to tables within the published NMOSE technical reports.

Sorensen, E. F., 1977, Water use by categories in New Mexico counties and river basins, and irrigated and dry cropland acreage in 1975: New Mexico State Engineer Technical Report 41, 34 p.

NMOSE Technical Report 41 contains water withdrawals and depletions for all New Mexico counties (Tables 3 and 4), divided into different use categories (urban, rural, irrigated agriculture, manufacturing, minerals, military, livestock, stockpond evaporation, power, fish and wildlife, recreation, reservoir evaporation, and playa lake evaporation). Categories are further broken into surface- and ground-water usage, and all quantities are in acre-feet per year.

According to the inventory, urban includes towns, cities, villages, or "densely settled urban areas" that have 2,500 residents or more. Rural includes the same type of communities with 2,500 people or less, and farms and ranches (Sorensen, 1977). The 1975 inventory does not delineate specific water users that make up the urban and rural categories. The urban and rural categories of the 1975 inventory may include self-supplied domestic uses, and the rural category includes uses that are not self-supplied; however, for the purpose of this study, rural water use is placed in the domestic self-supplied category and urban is placed in public water supply. Military use is also combined into public water supply for this study.

For this study, water use in the manufacturing category is represented in the industrial category, even though manufacturing may include commercial uses. The mineral category is represented by the mining category for current inventories and in this report. Because future publications include recreation and fish and wildlife uses in the commercial category, these have been combined into commercial for this study. Recreation use is land based only. Stockpond evaporation was placed in the livestock category, and there was no playa lake evaporation for any of the counties in the water planning study area.

Table 6 contains acres of irrigated cropland (including idle and fallow land) divided into counties, every 5 years between 1940 and 1975. Table 7 contains irrigated cropland acreage and source of water used for irrigation in 1975 only, divided by counties. Finally, Table 9 contains total irrigated cropland, acreage irrigated, and irrigated depletions divided into surface-water drainage areas and counties.

Sorensen, E. F., 1982, Water use by categories in New Mexico counties and river basins, and irrigated acreage in 1980: New Mexico State Engineer Technical Report 44, 51 p.

Sorensen (1982) is the same style report as Sorensen (1977), and contains very similar data. The water use categories are generally the same as the previous inventory. The only differences in the categories are that the manufacturing category was split into commercial and industrial, and playa lake evaporation was eliminated. In addition to the types of data presented in the previous report, specific withdrawal and depletion due to irrigation data are given in Table 10, and population and water use of specific urban and rural users are in Table 12. Although, urban still included self-supplied schools, universities, and hospitals, Table 12 allowed for these quantities to be shifted to commercial for this report.

NMOSE Technical Report 44 discusses the sources of data and reliability of data in much more detail than the 1975 inventory. Table A, within this appendix, shows the percents of 1980 total withdrawals that were measured for the entire state.

Table A. Percents of 1980 total withdrawals that were measured

category	**percent measured**
irrigation	43
urban and rural*	90
commercial and industrial*	68
minerals	92
military	100
power	100

* Note: includes two water-use categories

Where measured records were not available, gallons per capita day (gpcd) rates were used to estimate livestock drinking requirements, recreational uses at parks, national monuments and campgrounds, and the withdrawals for the rural population. Unmeasured irrigation withdrawals and depletions were estimated by using the Blaney-Criddle method.

Wilson, B. C., 1986, Water use in New Mexico in 1985: New Mexico State Engineer Office Technical Report 46, 84 p.

Water use is broken into the same categories as described in Sorensen (1982), and data presented are similar, though the format is slightly different. The water use categories are defined in more detail. Self-supplied schools, universities, and hospitals that formerly were listed under urban were moved to commercial. Irrigated acreage and water use are reported for different regions within each county. Water use is separate for Valencia and Cibola Counties. Withdrawals were measured for 11 of the 13 categories. Forty-two percent of the total irrigation withdrawals and 51 percent of the total withdrawals were measured for the entire state. The Blaney-Criddle method was used to estimate unmeasured withdrawals and depletions.

Wilson, B. C., 1992, Water use by categories in New Mexico counties and river basins, and irrigated acreage in 1990: New Mexico State Engineer Technical Report 47, 141 p.

Wilson, B. C. and A. A. Lucero, 1997, Water use by categories in New Mexico counties and river basins, and irrigated acreage in 1995: New Mexico State Engineer Office Technical Report 49, 149 p.

Wilson, B. C., 1998, Irrigated agriculture water use and acreage in New Mexico counties and river basins, 1993-1995: New Mexico Office of the State Engineer Technical Report 50, 107 p.

The 1990 and 1995 NMOSE water use inventory categorizes water use into the same categories used within the present report. Military and rural community water systems are included in public water supply, self-supplied domestic is a separate category, and institutional is reported in commercial. Moreover, recreational is included in commercial, unless the recreational facilities are owned and operated by a municipality in which case it is included under public water supply. Stockpond evaporation is not reported and fish and wildlife has been shifted to commercial or irrigated agriculture. NMOSE Technical Report 50 is a water use inventory of irrigated agriculture for 1993 through 1995. Determining withdrawals and depletions for the nine water use categories is discussed in detail in NMOSE Technical Reports 47 and 49 (Sections 3 through 7).

> In addition to NMOSE Technical Reports 47 and 49, Brian C. Wilson, Chief of the Water Use and Conservation Bureau, provided the data tables from which he compiled these published reports. These data tables list for each category the specific water users and their withdrawals and depletions. They also supply State Engineer file numbers, locations, and sub-categories in addition to the same information that is within the published reports.

Different water use categories were used in the earlier inventories (Technical Report 41 and 44) than in more recent inventories. For example, in the 1975 inventory the rural category includes public water supply and self-supplied domestic, and the manufacturing category includes industrial and commercial. Although it is reasonable to place rural in the self-supplied domestic category and manufacturing in the industrial category as was done for this study, there were no data to support this action. Urban use in the 1975 inventory also includes self-supplied schools, universities, and hospitals that could not be separated out, and thus may cause the value to be artificially high. However, this may be balanced out by the fact that rural, which is placed in self-supplied domestic, does contain use by public water supply that is not included in the public water-supply category.

Another issue is that in 1975 and 1980, Valencia County included what is now Cibola County. Thus, determination of water use by each county was not possible for this report. Thus, water use data for Valencia County in 1975 and 1980 likely include areas that are now Cibola County and outside of the study area.

Although the NMOSE Technical Reports 41, 44, 46, 47, 49, and 50 are comprehensive and form the basis of much of the present report, there are several points to be made regarding data quality and accuracy. These inventories rely for the most part on data provided to the NMOSE. Data that are not reported or reported inaccurately can affect the quality of the reports. Although the inventories indicate that the majority of water use data are from measured sources, it is not known how this applies to the Middle Rio Grande regional water planning area. The District 1 Office of the State Engineer stated that compliance with metering requirements varies considerably and recently has been as low as 50 percent (personal communication with Jess Ward and Spencer Shaw, February 2000). Comparing the data tables provided by Brian Wilson for the 1990 and 1995 water use inventories, users that were listed in one inventory were not listed in the other. For irrigated agriculture, surface-water withdrawals are metered by the

MRGCD; however, the NMOSE values differ from the MRGCD values because the NMOSE does not include operational spills. Estimates are used when measured values are not available, and factors are used to determine depletions. Estimates and factors involve assumptions and thus must be mentioned when discussing data quality issues. Finally, even metered amounts may be inaccurate because of malfunctioning, leaking, or misread meters.

Additionally, the methodologies followed in developing the water use inventories have changed over time. For example, the 1975 inventory estimated water use for categories such as manufacturing and commercial based on water use factors multiplied by the number of employees. Current inventories rely primarily on measured withdrawals, with supplemental data coming from interviews, questionnaires, historic use, and water rights information. Calculations of irrigated agriculture water use have become much more sophisticated and now consider daily climate information rather than long term projections as was done previously.

NMOSE meter-record files

Another source of information was meter-record files from the District 1 Office of the State Engineer in Albuquerque, New Mexico. These records contain the date and value of initial and latest readings for self-supplied wells for the years 1993, 1994, 1996, 1997, 1998 and 1999. In many cases, these records are not complete, such that we were not able to obtain any useful information for a number of self-supplied users. As stated above, between 40 and 50 percent of meter records from the Middle Rio Grande (including Socorro and Sierra Counties) are not submitted to the NMOSE (personal communication with Jess Ward and Spencer Shaw, February 2000). Often data were available for a water user one year but not available the next or previous years. Also, some withdrawals did not represent a full year. For this study, if a value was available for part of the year, an estimate for the full year was made by determining a per month rate and multiplying it by 12. This is strictly an estimate and indicated as such in italics in the data tables.

However, the meter reports when complete did correlate fairly well with U.S. Geological Survey (USGS) data, as well as other NMOSE data.

U.S. Geological Survey data

The USGS has compiled a database of water use from the NMOSE meter files and other sources for ground-water flow modeling in the Albuquerque Basin. Douglas P. McAda, a hydrologist with the USGS, provided the database, which is their withdrawal data for the ground-water flow models. All data are preliminary and subject to revision. They have selected some of the major users in all categories and compiled all the water use data available. In some cases, these data extend back to 1933, though most records start in the 1970s or 1980s. With few exceptions (which are noted in the tables when they occur) the USGS records match the 1993 to present NMOSE meter records. The USGS abstracted the meter record files of the NMOSE and contacted individual water users in order to compile their database. The database is fairly comprehensive. It does not include all water users in the planning region as indicated by their focus on large water users within the Albuquerque Basin. The USGS database contains withdrawal data only including annual pumping data for the City of Albuquerque (COA) from 1933 to 1999. Data from 1933 to 1958 are estimated from Figure 6b in Bjorklund and Maxwell (1961). The value from 1959 also comes from Bjorklund and Maxwell (1961), page 35. Table 2 of Summers (1992) provided COA pumpage data for 1960 through 1987. Data from 1988 to current was provided as digital data from the City of Albuquerque.

Survey Data

Another source of information for this study was an informal survey sent to public water suppliers and some institutional users within the regional water planning area as part of the present study. This survey requested data regarding historic and current water use, distribution of use, and information regarding wastewater treatment and water pricing. A copy of the survey form is in Appendix 2. A total of 29 survey forms were mailed, and 14 water-supply systems and two institutions responded. Data was requested of all non-responsive systems by telephone and fax. Additional information was also collected from systems that responded via telephone and electronic mail correspondence and interviews. Results from the surveys and contact information are in Appendix 2.

Respondents generally sent information for 1999 and did not provide historic water use data. The exceptions are discussed in the text. Volume units for water use were not always included, and withdrawal totals did not always match data collected from other sources. This discrepancy may be due to the fact that some of the public water-supply totals are based on pumping averages while the discussions of survey data used reported billed values. Moreover, differences could emerge due to differences in how the amounts were converted from one unit to another. Some respondents provided per day water use in gallons, which was then converted to a yearly amount, and may not accurately reflect actual water produced. Although some respondents provided information regarding wastewater treatment, it was unclear if quantities referred to amounts delivered to or amounts returned from the wastewater treatment facilities. Overall, the response of public water suppliers was very encouraging and most respondents were willing to provide more information as requested.

NM State Agricultural Statistics

Gore, C. E., and W. W. Wilken, 1991, New Mexico State Agricultural Statistics 1991: U.S. Department of Agriculture and New Mexico Agricultural Statistics Service, 72 p.

Gore, C. E., and W. W. Wilken, 1992, New Mexico State Agricultural Statistics 1992: U.S. Department of Agriculture and New Mexico Agricultural Statistics Service, 72 p.

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Gore, C. E., and W. W. Wilken, 1997, New Mexico State Agricultural Statistics 1997: U.S. Department of Agriculture and New Mexico Agricultural Statistics Service, 71p.

These publications are produced on a yearly basis from 1990 to present by the United States Department of Agriculture. They contain information on irrigated acreage and populations of livestock in New Mexico counties. Livestock populations described by county include beef cattle, milk cows, and sheep (populations of other types of animals are counted for the entire state only). These populations are used, along with B. Wilson's estimates of gallons used per day for each type of animal, to generate estimates of water withdrawal and depletion for 1991, 1992, 1996, 1997, and 1998.

U.S. Bureau of Reclamation Middle Rio Grande Water Assessment Report series

Gould, J., 1995, Middle Rio Grande Water Assessment: Middle Rio Grande basin surface water budget for calendar years 1935, 1955, 1975, and 1993: U.S. Bureau of Reclamation Supporting Document 15.

Gould used estimates of surface-water discharge, wastewater discharge, stormwater discharge, and seepage from canals and channels, together with estimates of open-water evaporation, riparian consumptive use, agricultural consumptive use, and the consumptive use portion of public water supply to produce a surface-water budget for the Middle Rio Grande area. Most values for open-water evaporation presented in this report are from this source.

Hansen, S., and C. Gorbach, 1997, Middle Rio Grande Water Assessment Final Report, U.S. Bureau of Reclamation Albuquerque Area Office.

Hansen and Gorbach (1997) provide a wealth of information about the hydrogeology, water demands, land use patterns, and water management methods in the Middle Rio Grande. This report was used to locate the individual studies that provided useful data. Appendix 1 of this report summarizes all of the other MRGWA appendices, technical reports, and supporting documents. This is an excellent resource to gain a general understanding of the issues facing the Middle Rio Grande region with respect to water use and availability.

Kinkel, B., 1995a, Middle Rio Grande Water Assessment: Estimates of Consumptive Use Requirements for Irrigated Agriculture and Riparian Vegetation, Volume I: U.S. Bureau of Reclamation Technical Memorandum, 23 pages plus Appendix 7.

Volume I of B. Kinkel's consumptive use requirements document provides tables containing monthly riparian and agricultural consumptive use values for every year from 1935 until 1993. It also contains a description of how agricultural and riparian consumptive use values were calculated (described in Section 5.7). This document does not contain the acreage of riparian and agricultural vegetation that were used to calculate consumptive use; these data are contained in Volume II.

Kinkel, B., 1995b, Middle Rio Grande Water Assessment: Estimates of Consumptive Use Requirements for Irrigated Agriculture and Riparian Vegetation, Volume II: U.S. Bureau of Reclamation, Supporting Document 6, Appendices 1-6.

Volume II of B. Kinkel's document contains the estimates of irrigated acreage for the different subunits defined for the study area, along with details regarding the model used to calculate the consumptive use values for crops and riparian vegetation.

Summers, W. K., 1997, Middle Rio Grande Water Assessment: Land use trends and their effect on water use and the hydrologic budget in the Albuquerque Basin, New Mexico. U.S. Bureau of Reclamation Supporting Document 14, 72 p.

The surface-water budgets include the amount of water lost to open-water evaporation during 1935, 1955, 1975, and 1993 calculated from aerial photos and climatological data.

Middle Rio Grande Conservancy District Crop Production and Water Distribution reports

The MRGCD keeps track of total surface-water withdrawals and irrigable and irrigated acreage in the Middle Rio Grande region. These data are divided into the following subregions: Cochiti, Belen, Albuquerque, and Socorro. These subregions correspond approximately to Sandoval, Valencia, Bernalillo, and Socorro Counties, respectively. Irrigable and irrigated acreages were estimated by ditch riders (people who physically inspect agricultural fields within an area) to determine the identity of the crop in each field as well. Water withdrawals are measured using meters on the works operated by the MRGCD. For 1988 and 1997, the MRGCD also has Bureau of Indian Affairs annual irrigation crop reports that include acreage irrigated (but not total withdrawals) in the various pueblos around the Rio Grande. Differences in withdrawal estimates between the NMOSE and the MRGCD are discussed in the **Irrigated Agriculture** section of this report.

Appendix 2

The public water system contact database, survey, and survey responses

Appendix 3.

Water use data tables by category

PUBLIC WATER SUPPLY
AND
SELF-SUPPLIED DOMESTIC

IRRIGATED AGRICULTURE

SELF-SUPPLIED LIVESTOCK,
SELF-SUPPLIED COMMERCIAL,
SELF-SUPPLIED INDUSTRIAL,
SELF-SUPPLIED MINING, AND
SELF-SUPPLIED POWER

OPEN WATER EVAPORATION AND RIPARIAN CONSUMPTIVE USE

TOTALS

Appendix 4.

EPA list of public water systems in the study region

Appendix 5.

Baseline Data on Water Use in the Middle Rio Grande Watershed: Socorro and Sierra Counties and portions of Santa Fe County from Otowi gage within the Rio Grande Basin

Appendix 6.

Water use by category data for Cibola and Valencia Counties

Appendix 7.

Acequias: irrigated acres and estimated consumptive use