12.6. WATER SUPPLY

A central question to answer, according to the Regional Water Planning Handbook, is "What is the water supply available to the region?" Without knowing the quantity of the resource, how can plans be made with confidence that future needs will be met while attaining current goals?

> The relationship between water supply and water demand is the basis for water planning alternatives for Region 6. A clear understanding of water quantity and its limitations due to quality or availability are essential for determining the ability of the region to meet future demand for water in a sustainable fashion. (Water Resource Assessment For The Planning Region, Part A - Water Quantity, Region 6 Regional Water Plan, 2003)

12.6.1. Introduction

For the Río Puerco and Río Jemez, obtaining a water supply assessment has proven to be a difficult task. The reported amount used in the Middle Río Grande Water Supply Study (Papadopolous 2000, 2003 draft) is the gauged amount as each tributary enters the Río Grande.[1] Outflow data does not provide detail about the supply available to upstream users. The data provided indicates that the Río Jemez provides an average of about 45,000 acre feet per year of surface water to the Río Grande while the Río Puerco provides about 30,000 acre feet per year (Papadopulos, Figures 5-5 and 5-7).

Contrasted with the Middle Rio Grande Valley, there is no river entering to provide a supply since the subregions include the top of their respective watersheds. This report contains available data from precipitation records as well as gauged stream flows. The surface water in both the Río Puerco and Río Jemez basins is limited. For example, the Río Jemez has “no flow for many days” beneath the Jemez Canyon Dam, and the Río Puerco has “no flow for many days” to “no flow for extended periods” along most of its length (Shomaker, p. 85 citing Waltemeyer, 1989).

One concern, expressed in the steering committee meetings as well as the workshops, has been that the watershed at the higher elevations is so overgrown that not only do the trees evapotranspire the water, but that the snow never even reaches the ground before melting. As discussed in Section 3, a high-ranking alternative is to restore the watershed. In so doing, it may be that the supply will be augmented -- but without more formal data gathering, this will be difficult to assess.

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[1] For instance, in the August 3, 2003 Interim Draft Water Supply Study, the report clearly states that *ET Toolbox Reach 2, Jemez Canyon, is omitted since it is out of the study boundaries (*emphasis added). Data on crop consumption, riparian usage and open water evaporation, contained in the Supply Study, as well as in other sources such as the Bureau of Reclamation's ET Toolbox, were used where possible.

The challenge to future planners will be to continue to fill in the gaps in assessing water quantity in the subregions. When fully researched, this section should include the following information:

- Climate and Precipitation Data and Statistics
- Surface Water
- Drainage Basins
- Return Flows, River Losses and Gains and Flood Flows

- Water Supply Facilities
- Reservoirs
- Conveyance Canals and Pipelines

- Ground Water
- Geologic Structure and Units
- Water Bearing Characteristics by Unit
- Groundwater In Storage
- Total Water in Storage

12.6.2. Reports

Several reports on water supply in the subregion are quoted, in part, below.

12.6.2.1. USGS Water-Resources Investigations Report 02-4200

A recent study was done by the USGS on groundwater flow in the Middle Río Grande Basin. Included in the study was information concerning the hydrology of the Río Jemez. The information is set out below verbatim for the relevant portions of the report.

<u>Simulation of Ground-Water Flow in the Middle Río Grande Basin</u>
<u>Between Cochiti and San Acacia, New Mexico</u>

By Douglas P. McAda, U.S. Geological Survey, and
Peggy Barroll, New Mexico Office of the State Engineer
Prepared in cooperation with the
New Mexico Office Of The State Engineer
and the
City Of Albuquerque Public Works Department
U.S. Department Of The Interior
U.S. Geological Survey
Water-Resources Investigations Report 02-4200
Albuquerque, New Mexico
2002

Summary

The Middle Río Grande Basin between Cochiti and San Acacia, also called the Albuquerque Basin, has been the focus of investigations by the USGS and other agencies to improve the understanding of the hydrology, geology, and land-surface characteristics in the basin. The Santa Fe Group aquifer system in the Middle Río Grande Basin consists of a thick sequence (as much as 14,000 feet) of Santa Fe Group and post- Santa Fe Group sediments. Population growth in the basin has increased dramatically since the 1940's.

These population increases have caused dramatic increases in ground-water withdrawals from the aquifer system, resulting in large ground-water level declines. Because the Río Grande is hydraulically connected to the aquifer system, these ground-water withdrawals have also decreased flow in the Río Grande.

This report describes a ground-water-flow model of the Middle Río Grande Basin developed (1) to integrate the components of the ground-water-flow system, including the hydrologic interaction between the surface-water systems in the basin, to better understand the geohydrology of the basin and (2) to provide a tool to help water managers plan for and administer the use of basin water resources. The three dimensional, finite-difference, ground-water-flow model of the Santa Fe Group aquifer system within the Middle Río Grande Basin was developed using MODFLOW-2000. The aquifer system is represented by nine model layers extending from the water table to the pre-Santa Fe Group basement rocks, as much as 9,000 feet below NGVD 29. The layers are divided into cells by a uniform grid containing 156 rows and 80 columns, each spaced 3,281 feet (1 kilometer) apart.

The model simulates predevelopment steady-state conditions and historical transient conditions from January 1900 to March 2000 in 1 steady-state and 52 historical stress periods. Average annual conditions are simulated prior to 1990, and seasonal (winter and irrigation season) conditions are simulated from 1990 to March 2000. The model simulates mountain-front, tributary, and subsurface recharge; canal, irrigation, and septic-field seepage; and ground-water withdrawal as specified-flow boundaries. The model simulates the Río Grande, riverside drains, Jemez River, Jemez Canyon Reservoir, Cochiti Lake, riparian evapotranspiration, and interior drains as head dependent flow boundaries.

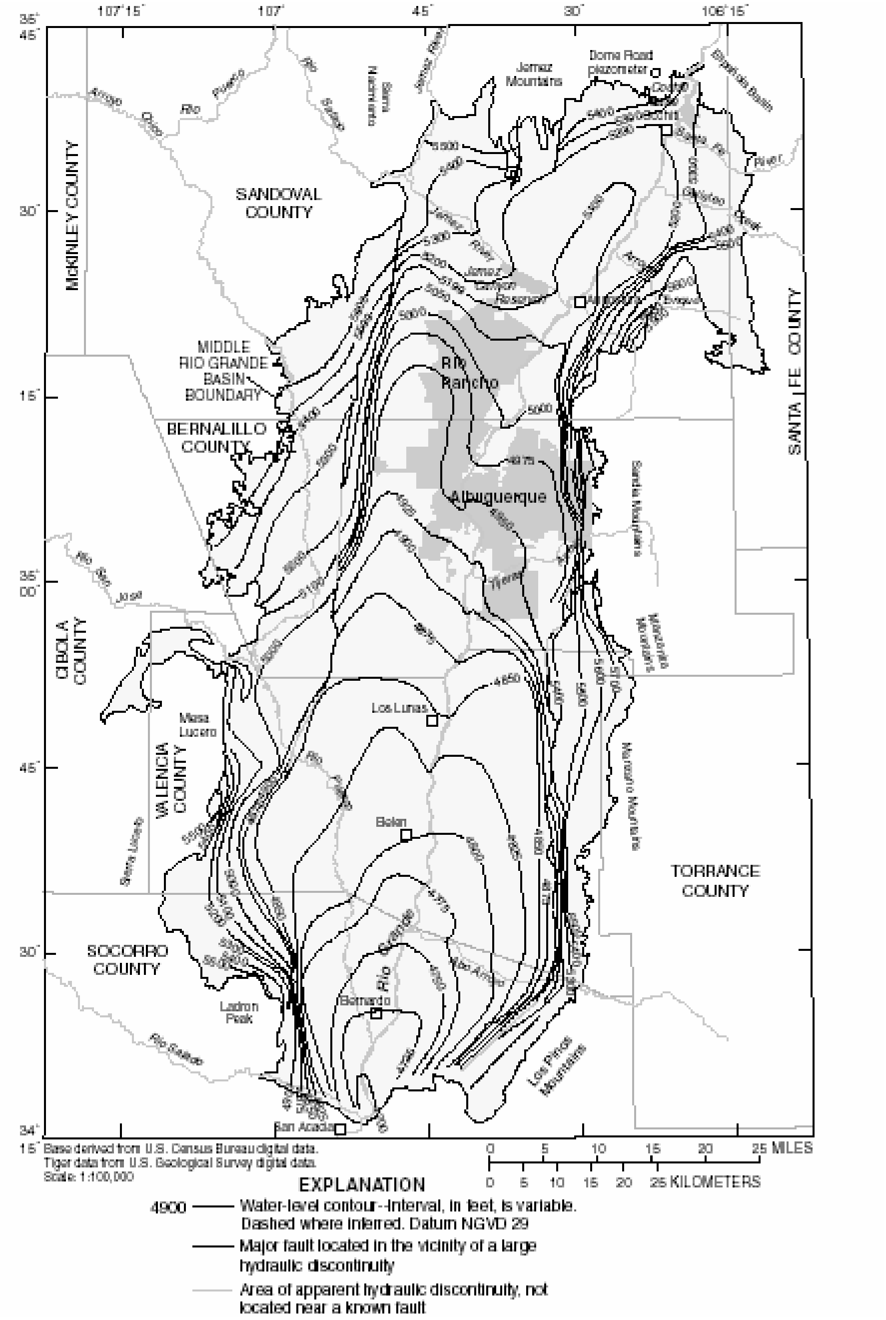
GEOHYDROLOGY OF THE MIDDLE RÍO GRANDE BASIN

Surface-Water Hydrology

The Jemez River, which is perennial through most of its length within the basin, is the largest tributary to the Río Grande within the basin and provides an average of about 45,000 acre-feet per year of surface water to the Río Grande (S.S. Papadopulos and Associates, Inc., 2000; Ortiz and others, 2001, p. 135). The Río Grande and

Jemez River predominantly lose water to the aquifer system, although some reaches gain water.

The remaining tributaries to the Río Grande within the basin are ephemeral where they enter the Río Grande, but many are perennial or intermittent at the basin margins. The Santa Fe River, Galisteo Creek, Tijeras Arroyo, Abo Arroyo, Río Puerco, and Río Salado (in the southern part of the basin) often flow at the basin margins, but only ephemeral flow from storm-water runoff reaches the Río Grande. Two of those, the Río Puerco and Río Salado, have been gauged near their confluence with the Río Grande. The Río Puerco contributes an average of about



30,000 acre-feet per year to the Río Grande (Ortiz and others, 2001, p. 184), and the Río Salado contributes about 5,900 acre-feet per year (average of 1974-84 flow; Thorn and others, 1993, p. 84). A number of arroyos are also tributary to the Río Grande.

Ground-Water Hydrology

Figure 5. Predevelopment water-level contours in the Middle Río Grande Basin (modified from Bexfield and Anderholm, 2000).

Mountain-Front and Tributary Recharge

Mountain-front recharge results from surface runoff or shallow underflow originating from mountains adjacent to the basin that infiltrates into the upper part of the aquifer system near the mountain fronts. Tributary recharge occurs as seepage from streams and arroyos tributary to the Río Grande that have surface flows extending into the Middle Río Grande Basin.

Mountain-front recharge comes from the Sandia, Manzanita, Manzano, and Los Pinos Mountains along the east side of the basin; Ladron Peak in the southwestern part of the basin; and the Sierra Nacimiento and Jemez Mountains in the northern part of the basin. Tributary streams that likely contribute substantial recharge to the aquifer system beyond the mountain front include the Santa Fe River, Galisteo Creek, Tijeras Arroyo, Abo Arroyo, Río Salado, and Río Puerco.

Recharge from the Río Puerco was estimated by Jack Dewey (U.S. Geological Survey, written commun., 1982; cited in Kernodle and Scott, 1986) to be about 10,400 acre-feet per year. A portion of that recharge was attributed to reaches of the Río Puerco beyond the boundary of the aquifer system as defined for this report. The portion of that recharge within the aquifer boundary is about 5,600 acre-feet per year. Kernodle and others (1995) applied this portion of recharge in their model along the Río Puerco and the remainder (about 4,800 acre-feet per year) to the nearby model boundary. Tiedeman and others (1998) estimated values ranging from 1,500 to 3,800 acre-feet per year for the reach within the model boundary using nonlinear-regression modeling techniques. In preliminary nonlinear-regression modeling using water ages, Sanford and others (2001) estimated Río Puerco recharge within the model to be about 2,000 acre-feet per year.

The Sierra Nacimiento and Jemez Mountains provide mountain-front recharge to the aquifer system in the northern part of the basin. Kernodle and others (1995) did not specifically estimate mountain-front recharge in this area but included recharge in this area as subsurface recharge and recharge along the Jemez River Valley north of the confluence of the Río Salado and Jemez River. These recharge amounts are discussed in the sections below. The combination of these recharge amounts specified by Kernodle and others (1995) was about 12,800 acre-feet per year.

Subsurface Recharge

Subsurface recharge occurs as ground-water inflow from adjacent basins or mountains. Subsurface recharge comes from the vicinity of the Jemez Mountains, Española Basin, and Hagan Embayment in the north-northeastern part of the basin and from Sierra Lucero to the San Juan Basin in the western part of the Middle Río Grande Basin. . . .

Estimates of recharge along the entire western aquifer margin (north of the southern Río Salado to the boundary adjacent to the Sierra Nacimiento) can be compared. These estimates exclude any recharge attributed to the Jemez River along the western aquifer margin. The recharge used by Kernodle and others (1995, fig. 5) along the entire western margin was about 13,600 acre-feet per year. This included about 4,700 acre-feet per year of recharge from the reach of the Río Puerco that was on or outside their model boundary. Tiedeman and others (1998) estimated 11,200 acre-feet per year of recharge for the entire western margin. The difference from the Kernodle and others (1995) estimate is that Tiedeman and others (1998) estimated half the amount of recharge from the reach of the Río Puerco on or outside their model boundary. Sanford and others (2001) preliminarily estimated recharge along this boundary to be about 2,000 acre-feet per year using carbon-14 ground-water age dates. . . .

DEVELOPMENT AND ADJUSTMENTS OF MODEL PARAMETERS

Jemez River

The Jemez River is in hydraulic connection with the aquifer system over most of its length in the basin, so changes in water-table altitude in the aquifer system adjacent to the river can influence seepage between the river and the aquifer system. The Jemez River is simulated as a head-dependent flow boundary using the River Package of MODFLOW-2000 (Harbaugh and others, 2000). The hydraulic conductance of the riverbed is calculated in the same manner as the riverbed hydraulic conductance shown in equation 5. However, the necessary information that would allow definition of the hydraulic-conductance value (area times riverbed hydraulic conductivity divided by riverbed thickness) of the riverbed was not specifically available. Therefore, the hydraulic conductance of the riverbed was estimated on the basis of the length of the riverbed (from the area term in eq. 5) in a model cell times a factor that incorporates channel width, riverbed hydraulic conductivity, and riverbed thickness (the remaining terms in eq. 5). Although the depth of flow varies along the river, a river stage of 1 foot above channel altitude and a riverbed bottom of 1 foot below channel altitude were assumed for the entire length of the Jemez River. The river was split into two reaches for the application of the hydraulic-conductance factor: above the confluence with the northern Río Salado below the confluence. The upper reach has a steeper gradient and a higher flow energy than the lower reach, resulting in a greater proportion of coarse material the riverbed; therefore, the upper reach was assumed have a relatively larger riverbed hydraulic conductivity than the lower reach. Downstream from the Río Salado, the riverbed tends to widen, the flow energy is decreased, and the flow is shallower than in the upper reach, resulting in finer grained riverbed material in the upper reach; therefore, the lower reach was assumed to have a smaller riverbed hydraulic conductivity than the upper reach. The factors applied to reach length for estimating riverbed hydraulic conductance were adjusted during model calibration. The resulting hydraulic-conductance values are 75 feet per day for each foot of length for the upper reach and 25 feet per day for each foot of length for the lower reach. The section of the Jemez River that would be inundated by water stored in Jemez Canyon Reservoir is simulated differently for the times that water in the reservoir is simulated, as described below.

Jemez Canyon Reservoir

Jemez Canyon Reservoir began permanently storing water in about 1979. The reservoir was built for sediment control and stored water only on a short-term basis before 1979. Only the Jemez River channel at the reservoir is simulated in the model prior to 1979. The River Package of MODFLOW-2000 was used to simulate the reservoir beginning in the 1979 stress period. The approximate average annual reservoir stage was used in the model simulation. The reservoir stage of 5,163 feet above NGVD 29 was used for 1979-84; 5,190 feet for 1985, 1990, 1996, and 1999; 5,195 feet for 1988, 1989, 1991-95, 1997, and 1998; and 5,199 feet for 1986 and 1987 (USGS Water- Data Reports for New Mexico, various years; data available at *http://nm.water.usgs.gov*). Seasonal changes in reservoir stage are not simulated—only average annual stage is used. The simulation ends March 15, 2000; therefore, only 2.5 months of 2000 are simulated, and the 1999 stage was continued for the last stress period. The reservoir-bottom area was estimated for each simulated stage using USGS 30-meter 1:24,000 Digital Elevation Models (DEM's).

Information on reservoir-bottom thickness and hydraulic conductivity was not available; therefore, hydraulic conductance of the reservoir bed was estimated as a factor of hydraulic conductivity divided by bed thickness and applied to the reservoir area. The hydraulic conductance was estimated by model calibration. Because the specific components of hydraulic conductance could not be identified individually, no attempt was made to account for differences between the reservoir-surface area and the reservoir-bottom area. The factor applied to the reservoir area for 1979-84 is 0.0015 per day (units of hydraulic conductivity, in feet per day, divided by bed thickness, in feet), and the factor applied to subsequent years is 0.001 per day. The slightly lower rate after the first 5 years of permanent storage in the reservoir is consistent with a buildup of additional sediment in the reservoir, creating a thicker, less permeable bed.

Water Budget

The Jemez River is simulated to gain water in its upper reach (above its confluence with the northern Río Salado) and to lose water in its reaches below the Río Salado confluence. Gains in the upper reach generally are consistent with measurements and seepage work by Craigg (1992). Simulated loss in the reach below the confluence is not entirely consistent with Craigg's 1992) seepage data, which indicates that the reach of the Jemez River between Zia and Santa Ana Pueblos gains water in the winter and loses water (presumably to evapotranspiration) in the summer. The model does predict a decrease in loss in this reach in winter, but no actual gain.

The inability of the model to simulate this gain may be related to the simulated heads near the Jemez River that are still too low, and there may be considerable subsurface geologic structure not represented in this model. The reach of the Jemez River below Santa Ana Pueblo is simulated to lose water, and once Jemez Canyon Reservoir is added to the model in the lower reach of the Jemez River, the reservoir loses water as well (from 4,000 acre-feet per year in years of low stage to 11,000 acre-feet per year in years of high stage). This finding is consistent with the understanding of that reach from seepage and water budget considerations (Craigg, 1992).

Phreatophyte consumption of ground water by evapotranspiration is the main simulated discharge of the model during predevelopment time. This discharge is simulated to be about 129,000 acre-feet per year in steady state (table 3). The model simulates a decrease in phreatophyte consumption over time to about 84,000 acre-feet per year in 1999, largely in response to a decrease in area covered by native riparian vegetation and wetlands and a lowering of the water table in some areas. These values are consistent with available estimates of phreatophyte consumption (Bureau of Reclamation, 1997d), but such estimates are very poorly constrained.

The model, which simulated an annual water budget for 1999, the Jemez River and Jemez Canyon Reservoir contributed 17,000 acre-feet to the Middle Río Grande Basin.[2]

Following is a brief summary of a useful report that studied decline in the aquifer system.

12.6.2.2. USGS Water-Resources Investigations Report 02-4233

Estimated Water-Level Declines in the Santa Fe Group Aquifer System
in the Albuquerque Area, Central New Mexico,
Predevelopment to 2002
By Laura M. Bexfield and Scott K. Anderholm
USGS Water-Resources Investigations Report 02-4233
December 2002

Implications for Ground-Water Flow and Response of the Aquifer System To Pumping Stress

The contours of recent water levels presented in this report indicate that ground-water-flow directions have changed considerably since predevelopment (pre-1961).

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[2] Note the difference with the gauged amounts reported in Papadopolus (2000 and 2003 draft.)

> Assuming flow is effectively perpendicular to water-level contours, the predevelopment map of Bexfield and Anderholm (2000) indicates that ground water in the Albuquerque area has historically flowed primarily from northeast to southwest on the west side of the Río Grande and primarily from north to south-southwest on the east side of the Río Grande. The recent (1999 to 2002) water levels presented in this report indicate that beneath the Albuquerque metropolitan area, ground water on either side of the Río Grande currently flows toward the major pumping centers from all directions (see map). In particular, strong northerly and easterly flow components are now present within the study area on either side of the river. The contours of recent water levels also show that hydraulic gradients directed away from the river to both the east and west are currently quite steep, especially as compared with predevelopment gradients.
>
> Estimated water-level changes calculated using the contour maps of recent and predevelopment conditions indicate that declines in the Albuquerque metropolitan area over about the past 40 years have ranged from negligible to more than 120 feet (see map). Water-level declines are smallest in the southwestern part of the study area, where relatively little ground water is pumped, and along the Río Grande, where recharge from the river reduces declines. Water-level declines are largest in the major pumping centers located several miles east and west of the river. Declines exceed 120 feet near the major basin-bounding faults on the eastern margin of the study area, probably as a result of the juxtaposition of permeable sediments in the basin with relatively impermeable materials present on the east side of these faults. The map of water-level change in the production zone of the aquifer indicates that the average water-level decline resulting from ground-water pumping over about the past 40 years has ranged from about 1 to 3 feet per year across broad parts of the Albuquerque area.

12.6.2.3. Papadopulos 2000 Middle Río Grande Water Supply Study

S.S. Papadopulos & Associates, Inc prepared a water supply study for the Middle Río Grande Basin. Included in the study was information concerning the hydrology of the Río Jemez. The relevant portions are included below. An updated study, draft date August 6, 2003, has been utilized where applicable.

> Middle Río Grande Water Supply Study
>
> S.S. PAPADOPULOS & ASSOCIATES, INC.
> Boulder, Colorado
> August 4, 2000
>
> Surface water tends to be available infrequently, and for short durations. This makes water development difficult. What surface water is available is largely used for agricultural production and stock watering. These surface water supplies are essential to agricultural users. Surface water quantity depends upon climate patterns and changes, as well as the adjudication of surface water supplies. Surface water is also

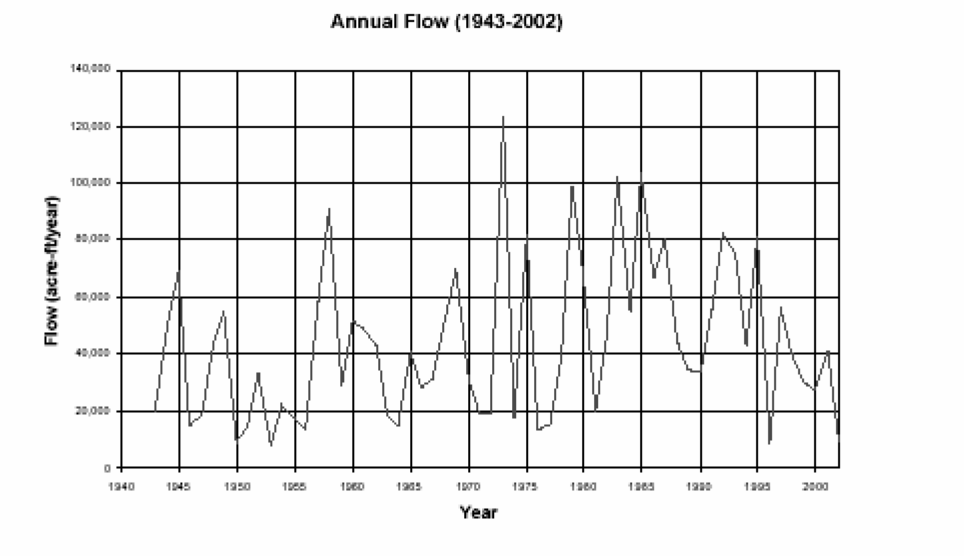
affected by groundwater withdrawals. Springs and streams may dry up if the water table drops significantly.

The quantity and accessibility of groundwater will largely determine water availability in the future. There are numerous, complex issues in quantifying groundwater resources. This section presents estimates of groundwater in storage for the significant water-bearing geologic formations in the region. These estimates show the amounts of potable and non-potable water in storage for 10 aquifers and the alluvial material in the region. These estimates also denote what volume of water is recoverable from storage. It is very important to note that this “recoverable” amount is the amount which physically can be removed from the aquifer. It does not consider the cost of obtaining this water in the analysis, nor the number and location of wells which would be required.

Jemez River Inflow

The Jemez River flows into the Río Grande downstream of the San Felipe Pueblo and upstream of Bernalillo. The flow of the Jemez River is gauged below Jemez Canyon Dam at USGS gaging station 08329000. The flow at this station generally represents the inflow to the Río Grande from the Jemez River. ... The watershed yielding water to Jemez River is located in the northern part of the state, and includes significant components of snowmelt. Correlation of the annual flow of the Jemez River to the Otowi Index Supply was evaluated, and indicated that these two variables are highly correlated.

Jemez River - Figure 4.5 (was 5.5 in 2000 study; this chart has been updated to 2002)



Station name: Jemez River below Jemez Canyon Dam
Station Number: 08329000
Latitude: 352324 N   Longitude: 1063203 W
Elevation: 5095.6 feet above NGVD
Period of Record: 1943 - present   Data Source: USGS

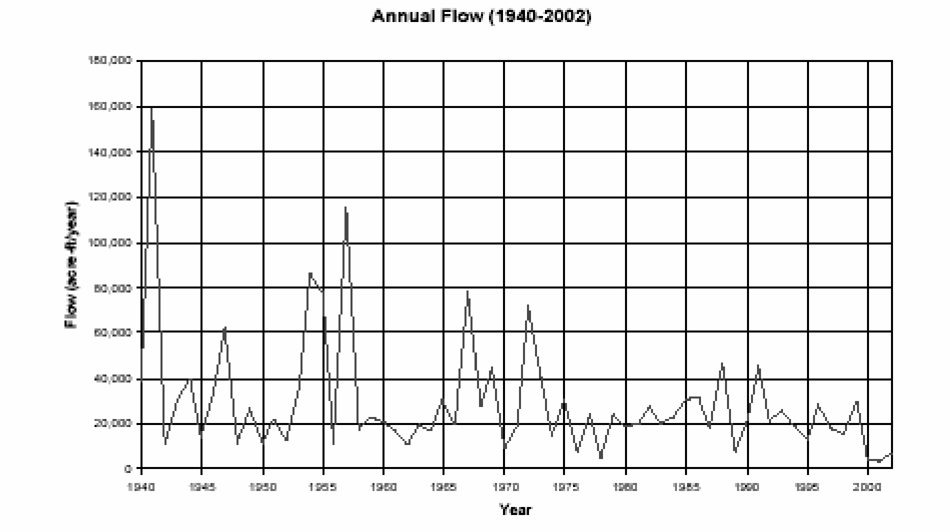
Table 4.6 in Papadopulos Draft Study sets out statistical outputs of the new model for Río Jemez, in acre feet per year:

Mean	44,750
Std Deviation	28,726
Minimum	7,740
Maximum	122,448

<u>Puerco River Inflow</u>

The Río Puerco conveys intermittent flow to the Río Grande downstream of Bernardo (Figure 4.7). The period of record used to characterize variability at this station was 1950 to 2002. ... The flow of the Río Puerco is not correlated with the Otowi Index Supply. Though a portion of the Río Puerco drainage basin lies in the northern mountains, annual flow is strongly influenced by rainfall events in its more southerly drainage basin.

<u>Puerco River - Figure 4.7</u> (was 5.7 in 2000 study; this chart has been updated to 2002)



Station Name: Río Puerco near Bernardo
Station Number: 08353000
Latitude: 342433 N Longitude: 1065109 W
Elevation: 4722.34 feet above NGVD
Period of Record: 1940 - present Data Source: USGS

Table 4.6 in Papadopulos Draft Study sets out statistical outputs of the new model for Río Jemez, in acre feet per year:

mean	125,645
Std Deviation	21,735
Minimum	913
Maximum	220,113

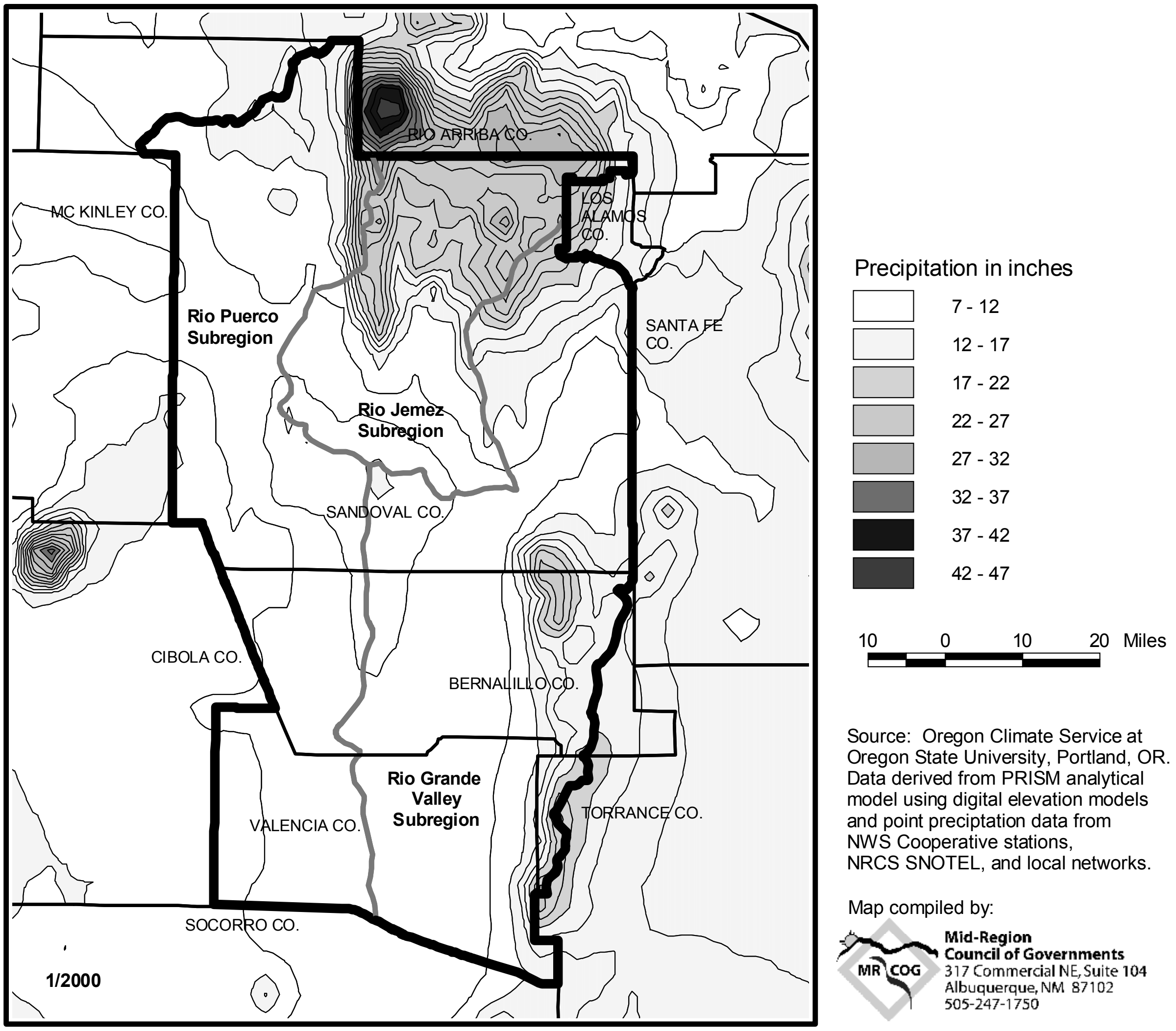
Both charts illustrate the annual fluctuation in supply.

12.6.3. Climate and Precipitation Data and Statistics

> Climate and precipitation are critical to stream flows and recharge. Region 6 (McKinley and Cibola Counties) is an arid region. Temperature, rainfall and snowfall vary in the region, creating a variety of microclimates. Evaporation rates are considerably higher than precipitation rates for the lower elevations. The higher elevations receive greater precipitation, primarily in the winter months. This snow melts in the spring and provides surface water and recharge to groundwater. (Region 6 Water Plan, Northwest New Mexico Council of Governments, 1997)

Figure 12.6-1 illustrates the variability of precipitation due to elevation.

Figure 12.6-1 Map of Average Annual Precipitation in Middle Río Grande Region



Source: Oregon Climate Service at Oregon State University, Portland, OR. Data derived from PRISM analytical model using digital elevation models and point preciptation data from NWS Cooperative stations, NRCS SNOTEL, and local networks.

Map compiled by:
MR COG
Mid-Region Council of Governments
317 Commercial NE, Suite 104
Albuquerque, NM 87102
505-247-1750

12.6.3.1. Precipitation Data

As in Region 6, which includes some of the Río Puerco watershed, temperature, rainfall and snowfall vary within Sandoval County. Table 12.6-1 indicates average annual precipitation and snowfall for certain periods of record at two locations in the Río Jemez. Table 12.6-2 provides similar information for four locations in the Río Puerco. The location of the gauge provides a different picture.

Table 12.6-1 Average Precipitation and Snowfall as Recorded in Río Jemez Basin

	Jemez Springs, New Mexico (294369)	Wolf Canyon, New Mexico (299820)
	Period of Record : 1/ 1/1914 to 3/31/2003	Period of Record : 7/ 1/1952 to 3/31/2003
Average Total Precipitation (in.)	17.32	22.74
Average Total SnowFall (in.)	30.2	121.3
Average Snow Depth (in.)	0	2

Source: Western Regional Climate Center, www.wrcc.dri.edu

Table 12.6-2 Average Precipitation and Snowfall as Recorded in Río Puerco Basin

	Regina, New Mexico (297346)	Cuba, New Mexico (292241)	Star Lake, New Mexico (298524)	Torreon Navajo Mission, New Mexico (299031)
	Period of Record: 7/ 1/1914 to 8/31/1969	Period of Record: 1/ 1/1941 to 3/31/2003	Period of Record: 1/ 1/1922 to 3/31/2003	Period of Record: 1/13/1961 to 3/31/2003
Average Total Precipitation (in.)	15.82	13.11	9.15	10.27
Average Total SnowFall (in.)	49.9	26.9	19.2	19.6
Average Snow Depth (in.)	1	0	0	0

Note: Some gauges are no longer in operation.
Source: Western Regional Climate Center, www.wrcc.dri.edu

Table 12.6-3 shows the type of information obtainable for each recording station - temperature, precipitation and snowfall. Figure 12.6-2 illustrates snowfall and precipitation patterns. Similar information for the other recording stations can be found in the appendices. See also the New Mexico Climate Center, Water Resources, Las Cruces, New Mexico for water-related resources such as hydrologic information, teaching materials, tutorials and water data.

Figure 12.6-2 Total Precipitation & Snowfall (in.), Jemez Springs, 1/1/1914 to 3/31/2003

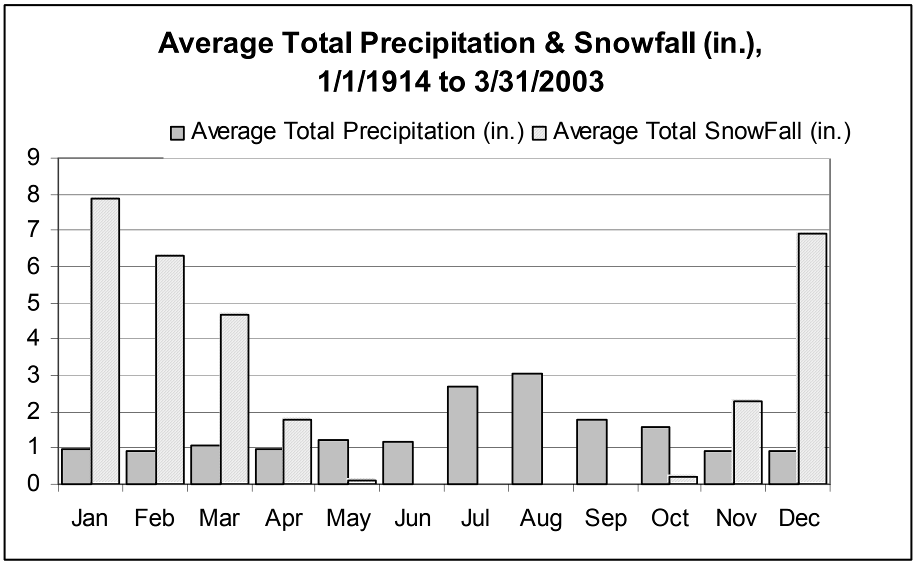


Table 12.6-3 Average Temperature, Precipitation and Snowfall, Jemez Springs 1/1/1914 to 3/31/2003

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	45.8	50.4	56.9	66.1	74.5	84	86.1	83.7	78.5	68.6	56	47	66.5
Average Min. Temperature (F)	19.6	23.3	27.8	34.4	42.6	50.4	56.2	54.8	48.4	38.2	27.7	21.1	37
Average Total Precipitation (in.)	0.96	0.91	1.08	0.99	1.22	1.16	2.7	3.06	1.79	1.56	0.94	0.92	17.29
Average Total SnowFall (in.)	7.9	6.3	4.7	1.8	0.1	0	0	0	0	0.2	2.3	6.9	30.2
Average Snow Depth (in.)	1	0	0	0	0	0	0	0	0	0	0	1	0

Percent of possible observations for period of record.
Max. Temp.: 97.6% Min. Temp.: 97.6% Precipitation: 98.1% Snowfall: 58.9% Snow Depth: 58.4%
Source: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nmjeme

12.6.3.2. Stream Gauge Records

USGS gauging stations that are reported in the Papadopulos Water Supply Study include (1) Jemez River below Jemez River Dam and (2) Río Puerco near Bernardo. Augmenting that information is gauged data from other points along the stream system.

Río Jemez - HUC 13020202

Table 12.6-4 contains the mean monthly stream flow for gauged at four locations in the Río Jemez., HUC 13020202.

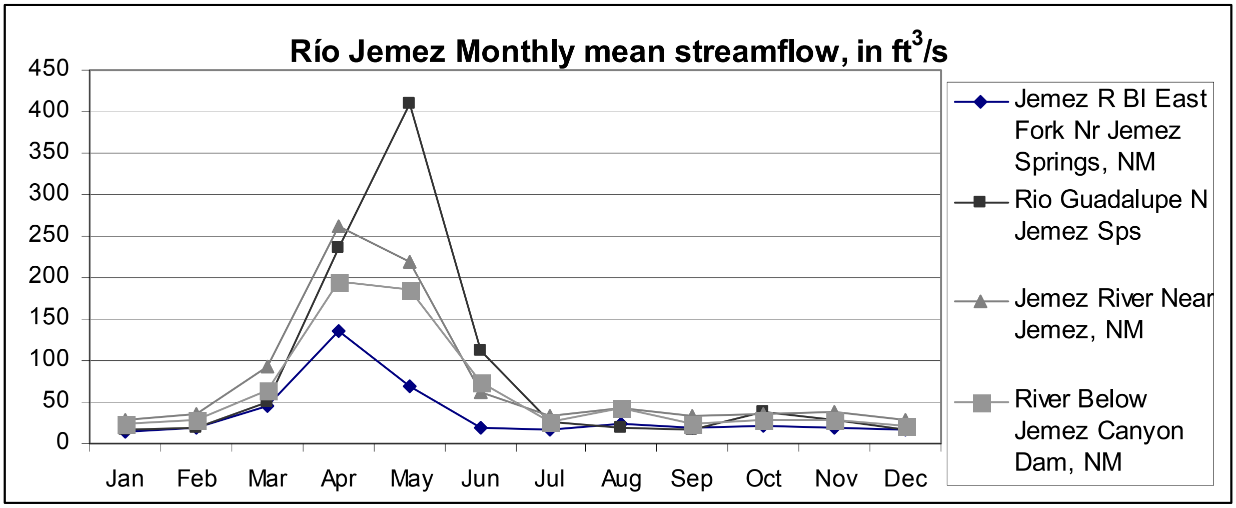
Table 12.6-4 Monthly Mean Streamflow, in ft^3/s, for Río Jemez

Gauging Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jemez R Bl East Fork Nr Jemez Springs Drainage area 173 square miles USGS 08321500	14.9	19.2	45.5	135	69.2	19.3	16.8	22.8	18.2	20.3	19.7	15.6
Río Guadalupe N Jemez Sps Drainage area 230 square miles USGS 08323500	15.7	20	49.4	236	409	113	26.6	18.6	17.3	38.3	28.6	17.4
Jemez River Near Jemez, NM 08324000 Drainage area 470 square miles. Contributing drainage area 470 square miles	28.7	36.1	92.6	262	220	62.8	32.4	43.9	34.3	36.1	37.3	29.3
Jemez River Below Jemez Canyon Dam Drainage area 1,038 square miles USGS 08329000	23.7	28.3	64.8	195	185	73.2	25.3	42.4	24.2	28.9	29.4	21.3

Source: USGS, waterdata.usgs.gov/nm/nwis/nwis

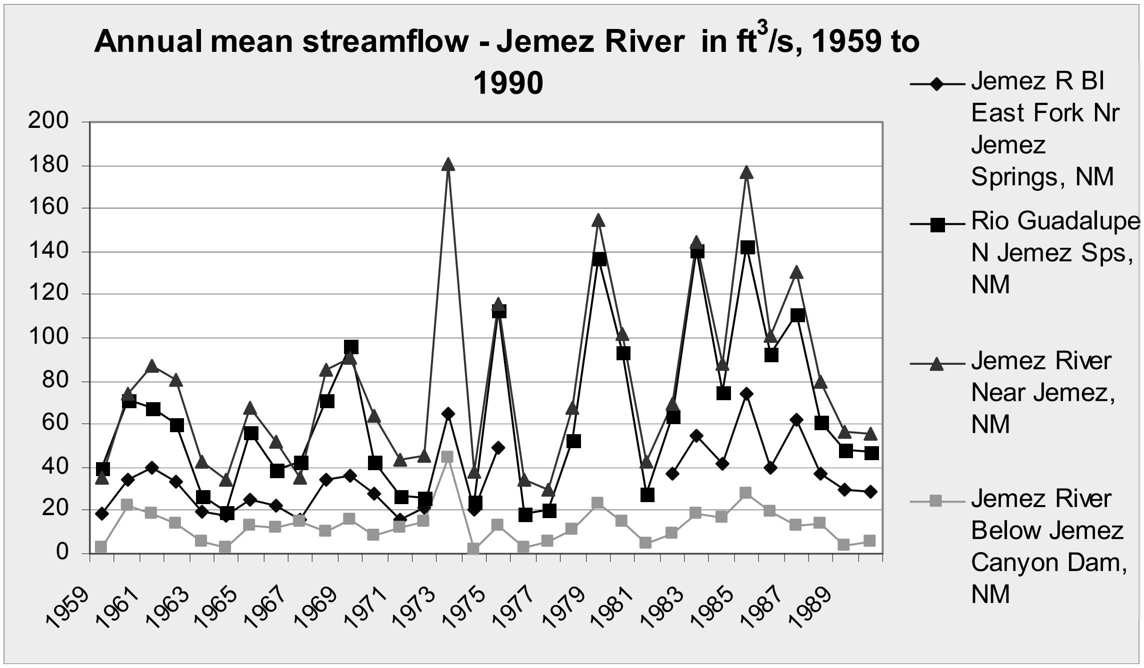
Graphing the above chart, the data in Figure 12.6-3 shows the variability in streamflow throughout the year.

Figure 12.6-3 Río Jemez Monthly Mean Streamflow, in ft^3/s



Complete data sets of Daily Streamflow Statistics, Monthly Streamflow Statistics, and Calendar Year Streamflow Statistics for each of the recording stations in the two water sheds are included in the appendices, together with charts summarizing the annual mean streamflow for each station. Figure 12.6-4 shows the four gauged flows together for the overlapping time period, highlighting the upstream/downstream streamflows, as well as the variability.

Figure 12.6-4 Annual Mean Streamflow - Jemez River Compilation, in ft^3/s, 1959 to 1990



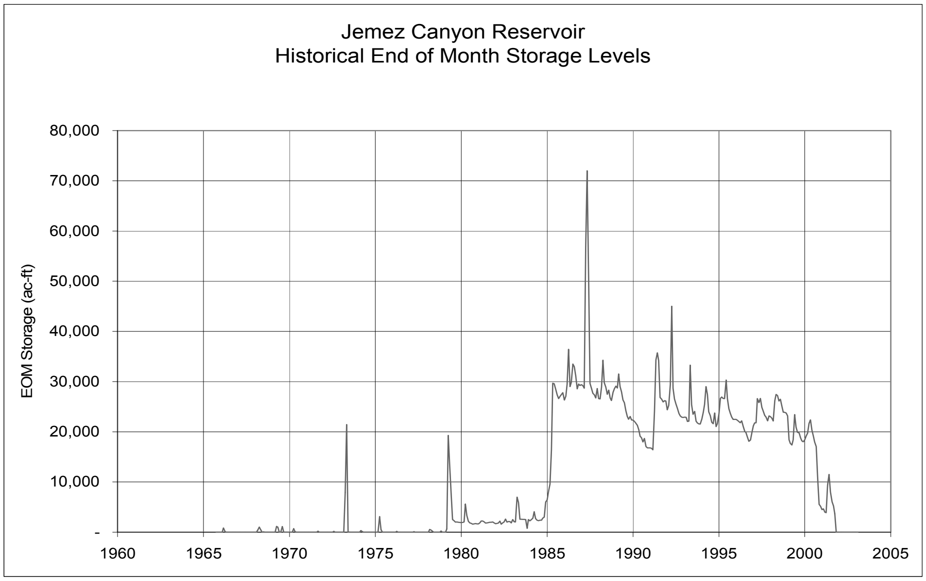
Reservoir evaporation is also a water use, as Table 12.6-5 shows. However, as Figure 12.6-9 shows, the reservoir is currently empty.

Table 12.6-5 Pan Evaporation on Jemez Dam (in inches), 04/1954 to 07/1964

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Maximum	---	---	---	12.99	14.10	16.19	22.35	13.60	13.33	8.20	4.59	2.53	107.88
Minimum	---	---	---	8.02	9.60	12.79	11.19	9.60	8.24	4.69	2.65	2.53	69.31
Average	---	---	---	9.71	12.27	13.95	14.27	11.57	9.80	6.72	3.65	---	81.94

http://weather.nmsu.edu/Pan_Evaporation/jemez_dam_evap.htm

Figure 12.6-5 Storage Levels at Jemez Canyon Reservoir



http://www.seo.state.nm.us/water-info/ISC-H2O/OSEClimate/winter02-03/reservoirs1.xls

Río Puerco - HUC 13020204

Table 12.6-6 contains the mean monthly stream flow gauged at four locations in the Río Puerco, HUC 13020204.

Table 12.6-6 Monthly Mean Streamflow, in ft^3/s, for Río Puerco

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Río Puerco Abv Arroyo Chico Nr Guadalupe, USGS 08334000 Drainage area 420 square miles	2.73	11.4	16.1	18.9	39.5	15.5	16.5	24.4	12	7.86	2.88	1.31
Arroyo Chico Nr Guadalupe, NM Drainage area 420 square miles USGS 08340500	2.44	13.1	12.2	4.25	2.61	4.47	41	104	42.3	19.1	3.15	1.68
08352500 Río Puerco At Río Puerco Valencia County, Drainage area 6,590 square miles. Contributing drainage area 5,460 square miles	3.89	18.9	24.2	17.3	52.2	19.5	84.2	259	127	63	5.8	1.12
08353000 Río Puerco Near Bernardo Socorro County, Drainage area 7,350 square miles. Contributing drainage area 6,220 square miles	2.41	14.6	17.7	14.5	40.2	19	61.8	180	83.1	47.9	6.93	1.19

Source: USGS.[3]

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[3] Río Puerco Basin -_The Arroyo Chico, located in both McKinley and Sandoval Counties, was gauged from 1943 to 1986 (Station Number 08340500). The gauge was located 4.1 miles northwest of Guadalupe. For the period of record, 1945 - 1985, there was a mean discharge of 15,290 afy (21 cfs). A duration analysis of mean daily flow indicates that no flow occurred 50% and 75% of the time (0.2 cfs was equaled or exceeded 40% of the time and 2.9 cfs was equaled or exceeded 25% of the time). The

Graphing the above chart, the data in Figure 12.6-6 show the variability in streamflow.

Figure 12.6-6 Río Puerco Monthly Mean Streamflow, in ft^3/s

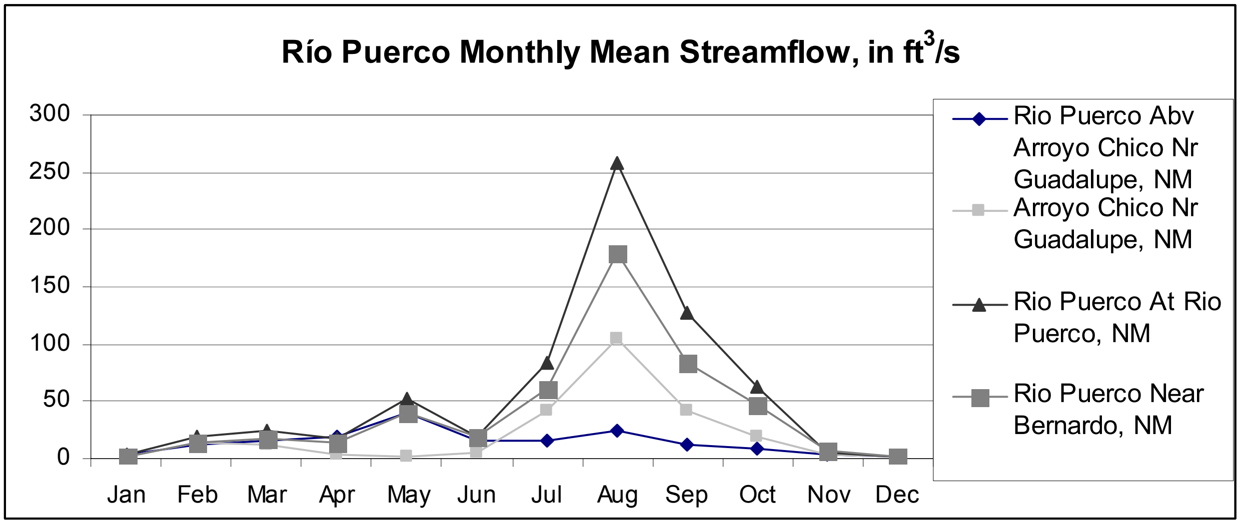
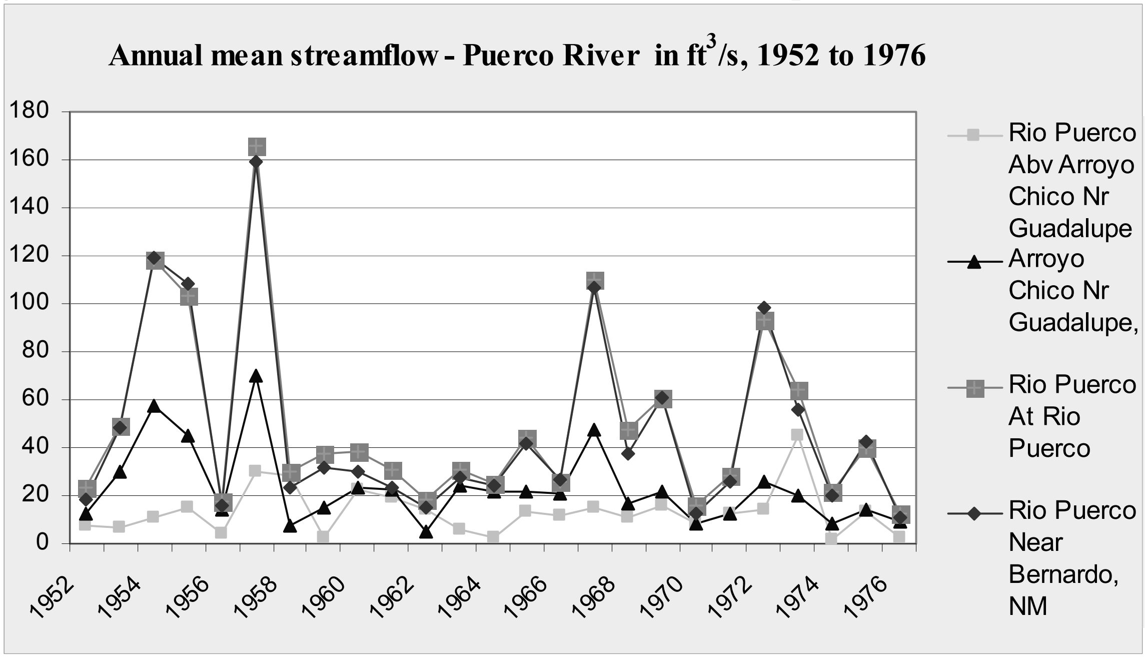


Figure 12.6.7 summarizes the annual mean streamflow for the four stations for the overlapping time period, highlighting the upstream/downstream streamflows, as well as the variability.

Figure 12.6-7 Annual Mean Streamflow, Puerco River Compilation, in ft^3/s, 1959 to 1990



Arroyo Chico is an upland tributary of the Río Puerco, and the gauge near Guadalupe is a reasonable indicator of the surface water yield for the 1,168 square miles of the basin in McKinley and a small portion of Sandoval above the gauge. Based upon the gaging records, the unit water yield is 11.0 acre-feet per square mile per year (afy). The total yield of the basin within the two counties is 12,800 afy. Region 6 Water Plan, (Northwest New Mexico Council of Governments, 1997) [Note the difference with the Papadopolous Supply Study.]

12.6.3.3. Variability

In summary, the water supply of the Middle Rio Grande is marked by limitation and variability. The successful water planning process will operate in recognition of these concepts (Papadopulos 2000).

Basin Outlook Reports

Natural Resources Conservation Service prepares a Water Supply Outlook Report for each month between January and May 1 forecasting spring runoff. This New Mexico State Basin Outlook Report includes the Río Jemez but not the Río Puerco. Table 12.6-7 provides information as to the forecast for March to July, 2004 in the Jemez, which is approximately 57% of average (in March 2003 it was 64%) at the gauge near Jemez.

Table 12.6-7 Río Jemez Streamflow Forecasts

Streamflow Forecasts - March 1, 2004 <--------- Drier ----- Future Conditions ----- Wetter -------->							
	90% (1000 AF)	70% (1000 AF)	50% (1000 AF)	Most Probable (% AVG.)	30% (1000 AF)	10% (1000 AF)	30 Year Average (1000 AF)
Jemez River near Jemez (MAR - JUL)	10.7	17.1	27	57	37	51	47
Jemez Canyon Reservoir inflow (MAR - JULY)	9.9	13.1	24	63	35	51	38

Chance of Exceeding - * 90%, 70%, 30%, and 10% chances of exceeding are the probabilities that the actual volume will exceed the volumes in the table. The average is computed for the 1971-2000 base period.

(1) - The values listed under the 10% and 90% Chance of Exceeding are actually 5% and 95% exceedance levels.

(2) - The value is natural volume - actual volume may be affected by upstream water management.

Source: Natural Resources Conservation Service, USDA, http://www.wcc.nrcs.usda.gov (last accessed 3/24/04)

Figure 12.6-8 includes two photos of the Río Jemez Reservoir illustrate the variability within the basin. The first, undated, was from an earlier water year than the second, which shows the reservoir as empty.

Figure 12.6-8 Jemez Canyon Reservoir

Source: December 2002; MRCOG Views, Spring 2003, Vol 1 Issue 2, Photo by B. Ives

What is clear is that, like other watersheds in New Mexico, in the Río Jemez and Río Puerco there is a wide variation as to water supply. Shortages may result in a water priority call on the river. If New Mexico is unable to meet its Rio Grande Compact obligations, there will be a search for available water, as has occurred in the Pecos River Basin.